

**MEASUREMENT OF TECHNICAL CHANGE- A CASE STUDY OF**  
**MANUFACTURING INDUSTRIES IN SINGAPORE**

By

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### DECLARATION

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## ABSTRACT

Singapore's economy has been growing rapidly for the last two decades. Contrary to the conventional belief that productivity growth and technical progress are the main forces behind the rapid growth, many recent research findings point out that the rapid growth of output in Singapore has been accompanied by very little productivity growth measured by total factor productivity growth (TFPG).

Studies on productivity measurement in Singapore mainly employ the non-parametric productivity accounting approach. Firms are assumed to be operating in perfectly competitive long-run equilibrium, which is characterized by the conditions of perfect competition, full utilization of capacity and constant returns to scale. If these conditions are not met, the conventionally calculated TFPG is different from the primal and dual estimates of technical change.

We derive an expression that gives the TFPG bias when the conditions of perfectly competitive long-run equilibrium are not met. The TFPG bias can be positive or negative, depending on whether the adjusted cost share is greater than or equal to the corresponding factor payment share. Specifically, if factor payment shares are equal to cost shares, there is no bias to TFPG unless there is imperfect competition and the shares add to less than one. In this case the bias is positive and increases with the growth of inputs and with the degree of imperfect competition. However, if cost shares deviate from the factor payment shares and the latter sum to one, the direction of the bias in TFPG is ambiguous. Our second derivation shows the relationship between the primal and dual rate of technical change. It shows that the dual rate of technical change is exactly equal to the primal rate if the conditions of perfectly competitive long-run equilibrium are met. Otherwise, the two measures of technical change are different.

The results of our calculation of the TFPG and the estimate of the rate of primal technical change show that the differences between TFPG and the primal technical change in individual industries are generally small and vary in sign. There is no clear difference between TFPG and  $\dot{T}$ , as calculated for Singapore manufacturing, and on average the values are approximately equal.

In the parametric approach, we estimate a system of factor demand equations derived from a generalized Leontief cost function with equations that reflect the market demand and market equilibrium conditions. This system of simultaneous equations enables us to generate estimates for the dual rate of technical change, the degree of economies of scale and a conjectural measure of competition. Different demand specifications are fitted in the equation system to compare the results for the corresponding industry.

The main findings show that the estimation results can vary considerably from one demand specification to another, in particular this applies to the largest and fastest growing industry, the electronic products and components industry. It is perhaps difficult to make any generalizations given the estimation results are not robust. However, some industries whose results are more robust than those of other industries. It seems to illustrate that assuming a particular demand specification for all industries may lead to estimation problems and anomalies and it is well worth the time for researchers to pay more attention to the specification issue. Despite the difficulty mentioned above, a crude conclusion could be



drawn: economies of scale and perfect competition appear to be prevalent in most industries with mixed results for technical change.

An attempt is made to explain inter-industry technical change. Using an econometric model that employs a host of variables that describe market structure and industrial characteristics, we find some evidence that market concentration, direct foreign investment and direct exports contribute positively to technical change. However, these relationships are not statistically significant to allow us to draw any firm conclusion. Furthermore, we find a significant inverse relationship between technical change and returns to scale, reflecting the peculiar nature of Singapore development or mis-specification error in the equation system.

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## CHAPTER ONE

### INTRODUCTION AND LITERATURE REVIEW

#### Introduction

Singapore's economy has been growing rapidly for the past thirty years since it became a fully independent state in 1965.<sup>1</sup> Its growth rate is among the highest in the world, even surpassing many industrialized countries. Over the period 1960-92, Singapore's per capita gross national product (GNP) grew about 6.3 percent a year (Peebles and Wilson, 1996, p.3). *The World Bank Atlas 1995* ranked Singapore ninth in the world in terms of per capita GNP on a purchasing power parity basis (*The Straits Times*, 14 January 1995, p.33). Together with Hong Kong, Taiwan, and South Korea, Singapore is known as one of the "four dragons" of Asia and these four high growth economies are also referred to as the newly industrialized economies (NIEs) of Asia.

One research finding that attracts much attention recently is the low or even negative productivity growth that accompanied Singapore's rapid growth. Tsao (1985) reports that the rapid growth of manufacturing output in Singapore has not been accompanied by any significant total factor productivity growth (TFPG) for the period 1970-79. Tsao's major findings reveal that there is virtually no TFPG for the average of all industries and a negative TFPG for 17 out of 28 industries. Young (1992) in a comparative study of the development of Hong Kong and Singapore finds a negative TFPG and a negative contribution of TFPG in

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<sup>1</sup> The first chapter of Peebles and Wilson (1996) provides an excellent summary of the development of Singapore's modern economy. For a history of modern Singapore, the readers are referred to Chapter 8 and 9 of Turnbull (1989). A study of Singapore's modern economic history can be found in Huff (1994). Goh (1969) covers the early economic development of Singapore and Chen (1983) and Sandhu and Wheatley (1989) cover the more recent economic development. Chia (1986) provides a review of literature on this topic.

output growth for Singapore. This is notably different from his findings for Hong Kong, where TFPG contributes positively to output growth.

The finding of negative TFPG does not only confine to Singapore, but has also been reported for South Korea. Using a sophisticated model, Park and Kwon (1995) report a negative TFPG for South Korea. Their major findings show that South Korea experiences significant economies of scale, market imperfection, negative TFPG and a negative correlation between productivity growth and markups over the period 1967-89.

Studies on productivity measurement in Singapore mainly employ the non-parametric Divisia Index approach that imposes a number of unrealistic assumptions. This approach, introduced by Solow (1958), is based on the neoclassical production theory. Productivity change, under this framework, is a residual of output growth that cannot be accounted for by the weighted growth of labor and capital. It provides a straightforward way of measuring productivity change. However, it can also provide a misleading indication of the rate of technical progress when basic assumptions of the neoclassical theory of competitive equilibrium are not met.

The objectives of this thesis are twofold. First, since there have not been studies using methods other than the Divisia Index approach to studying productivity change in Singapore, it is reasonable to address the question: is the result of little or negative productivity growth robust in the face of different measurement techniques. If the result of negative TFPG is observed only from the Divisia Index approach and not from any other techniques, then care must be taken in interpreting the observed result. The observed negative TFPG could very well be the result of violation of the maintained hypotheses of the Divisia Index approach and may reflect very little about the change in technical efficiency of the industries in Singapore.



The thesis shows the difference between the conventional TFPG and the primal rate of technical change if the conditions of competitive long-run equilibrium are not met. We show, specifically, that the conventional TFPG and primal rate of technical rate are equal only if a firm's mark-up is zero and the firm's factor payment shares are equal to their cost shares. In practice, the two conditions are rarely met, so we should expect to observe discrepancy between TFPG and the primal rate of technical change.

Second, using a cost dual approach, we estimate directly the dual rate of technical change, the degree of economies of scale and market competition from the available data to see whether the resulting estimates represent a significant departure from the conditions of perfectly competitive long-run equilibrium. The resulting estimates of economies of scale and market competition will be of interest not only because they reveal information about the industry's structure, but also provide information about the appropriateness of the Divisia Index approach to productivity measurement.

The central focus of the present study is not only on measuring technical change or productivity growth of Singapore manufacturing. It also attempts to find determinants of the inter-industry differences in technical change in Singapore manufacturing. The question whether industrial structure and characteristics such as firm size, concentration, demand, foreign ownership, export, and technological opportunity play a significant role in influencing technical change is an interesting and important one. We formulate an econometric model to try to shed some light on this question.

This chapter is divided into two sections. Section (1.1) first discusses the concept of technical progress and productivity growth. It also gives a broad summary of the developments of productivity measurement and, finally, outlines the approach that we adopt for the present study. Section (1.2) presents an overview of the thesis.

## 1.1 Literature Review on the Measurement of Productivity Growth

Our review of literature on the measurement of productivity growth starts with a brief discussion of the connection between technical progress and productivity growth.<sup>2</sup> First, technical progress can be seen as a term encompassing the activities of invention, innovation and the process of imitation or diffusion. Innovation can be either process or product innovation. Our study is concerned primarily with the measurement of the output of innovative activities. The usual approach to measuring the output of innovative activities include using the research and development (R&D) expenditure and the number of patents. Clearly, these two measures are poor proxies of the output of innovative activities since R&D only represents innovative effort and the number of patents does not represent the significance of innovation. Alternatively, the output of innovative activities can be measured through the performance of a firm or industry, since technical progress should lead to higher productivity and, thus, reduction in cost. In a dynamic sense, firms that experience continuing technical progress should exhibit a high rate of productivity growth.<sup>3</sup>

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<sup>2</sup> Salter (1966) is a classic reference for the topics of technical change and productivity. Freeman (1994) provides a critical survey of the literature on the economics of technical change. The present study borrows heavily from the work of Davies (1986) who gives an excellent account of the studies on technical change, productivity and market structure.

<sup>3</sup> We discuss in depth the conventional measures of innovation in Chapter Seven when we formulate an empirical model to explain technical change.

However, technical progress has only an imprecise connection with productivity growth since technical progress is only one of the many factors that influence productivity and efficiency. The other factors that can be equally important include market structure, X-efficiency and the ability of firms to respond optimally to changing factor prices. It is, thus, possible for a technically advancing firm to have low productivity performance. An important seminal paper by Farrell (1957) discusses the method by which technical efficiency of a firm can be measured in empirical studies. He uses the best-practice isoquant as a benchmark by which a firm's technical efficiency can be compared. We are not able to pursue such an approach due to lack of data for individual firms.

A traditional measure of productivity that has been used widely is labor productivity. Labor productivity is defined as the volume of output per worker. It is a straightforward, but potentially misleading measure. Labor productivity does not consider non-labor inputs such as capital. An increase in labor productivity does not necessarily mean an improvement in technical efficiency or productivity. It may only be the result of an increase in capital intensity. Thus, it is not clear what does labor productivity really measure.

The most widely used measure of productivity in recent research is total factor productivity. Unlike labor productivity, total factor productivity measures the joint productivity of labor and capital. This is due to Solow (1958) who introduced the method of using a production function for measuring productivity change. Suppose a production function takes the form as:

$$(1.1) \quad Y = A(t)F(K, L)$$

where  $Y$ ,  $K$ , and  $L$  are output, capital and labor respectively.  $A(t)$  is used to capture the shift in the production function. Equation (1.1) assumes Hicks neutral disembodied technical change since  $A(t)$  is written separately from capital and labor inputs. This assumption is required when there is not enough information to allow for the coefficients on capital and labor to vary over time. Hicks neutral technical change means that the shift in the production function is independent of the allocation of capital and labor inputs. In other words, the marginal rate of technical substitution between inputs is constant along the expansion path.

Given the conditions of perfectly competitive long-run equilibrium, we can differentiate the logarithm function of Equation (1.1) with respect to time to yield

$$(1.2) \quad TFPG = \dot{A} = \dot{Y} - \omega_L \dot{L} - (1 - \omega_L) \dot{K}$$

where TFPG is total factor productivity growth which can be interpreted as the shift in the production function represented by  $\dot{A}$ .  $\dot{Y}$ ,  $\dot{K}$  and  $\dot{L}$  represent the rate of change of output, capital and labor respectively.  $\omega_L$  is the factor payment share of labor input. Equation (1.2) states that TFPG can be calculated directly as a residual of the growth rate of output and the weighted growth of capital and labor when the underlying conditions of perfectly competitive long-run equilibrium are met.

The last two terms in Equation (1.2) are known as the Divisia Input Index. The exact calculation of TFPG from Equation (1.2) requires continuous data and the standard practice is to approximate it using discrete data. One must assume a functional form for the production function for implementation of Equation (1.2). Diewert (1976) introduces the notion of

superlative index numbers and shows that the Tornquist approximation to the Divisia aggregate input index is exact for a linear homogeneous translog production function. Since then, the method of using the Tornquist approximation to the Divisia Input Index has become a standard practice in productivity studies. This approach is commonly known as the Divisia Index approach or the productivity accounting approach.

TFPG given in Equation (1.2) is a residual of the growth rate of output and weighted growth of factor inputs. Many researchers tend to overlook the assumptions underlying this approach. As Kendrick (1989) puts it:

“Some economists, overlooking the assumptions underlying the production function approach, interpreted the residual narrowly as a measure of the rate of cost-reducing technological progress. But the assumptions are clearly counter-factual, which means that variables other than technological change influence changes in TFP” (Kendrick, 1989, p.150).

Denison (1962) pioneers the growth accounting approach to explaining the changes in real output and TFPG. His objective is to explain as much as possible of the TFPG residual by major factors other than the weighted growth of capital and labor. These factors include economies of scale, changes in intensity of demand, improved resource allocation, changes in the legal and human environment, advances in knowledge and changes in labor efficiency. All these factors can be used to adjust the TFPG calculation in Equation (1.2) when appropriate weighting is found for each factor. After taking into account of all major factors, the final TFPG residual is attributed to technical progress.

TFPG can also be measured by estimating directly the shifts of a production or cost function over time.<sup>4</sup> There seems to be a consensus among economists that the shifts of a production or cost function are a good representation of technical change. Various functional forms can be used for implementation of the estimation, but the common practice is to use the so-called “flexible” functional forms. Two most widely used flexible forms are the transcendental logarithmic (translog) production function, developed by Christensen, Jorgenson, and Lau (1970) and the generalized Leontief cost function, developed by Diewert (1971). The flexible functional forms place no prior restrictions on substitution elasticities.

The choice between a production or cost function for TFPG estimation depends on whether output level and input prices can be assumed to be exogenous. If output level and input prices can be assumed to be exogenous, then it is preferable to use a cost function rather than a production function in which input quantities are regressors. As Diewert (1991) puts it: “...the use of cost functions has a major advantage over production functions in that statistical estimation of the unknown parameters that characterize technology is much more accurate using costs function technique” (Diewert, 1991, p.21). However, the assumption of competitive cost minimizing behavior on the part of the firm is required when a cost function is used.

Recent developments in productivity measurement focus on the violation of the conditions of perfectly competitive long-run equilibrium. Ohta (1975) first emphasizes the importance of economies of scale in productivity measurement, especially on the cost side. In particular, he shows that, under certain conditions, the primal rate of technical change equals the ratio of the

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<sup>4</sup> Shephard (1953) has shown that there is a unique correspondence between the production and cost functions and both functions contain information about the underlying technology.

elasticity of cost with respect to time to the elasticity of cost with respect to output.<sup>5</sup> Other researchers such as Morrison (1986) and Fuss and Waveman (1986) extend this relationship. Moreover, the “new growth theory” developed by Romer (1986, 1990), Lucas (1988, 1990) and Grossman and Helpman (1990) points to the significance of economies of scale in explaining the high growth of NIEs.

Using Solow’s productivity accounting approach, Hall (1988) attempts to estimate mark-ups. He shows that the Solow’s residual can be decomposed into a mark-up term and a technology factor term. One of his findings shows that mark-ups are significant in United States manufacturing industries. Other researchers such as Denny, Fuss and Waverman (1981), and Shapiro (1987) also study the impact of mark-up behavior or imperfect competition on Solow’s residual growth.

Another line of research focuses on the assumption of instantaneous adjustment of factor inputs to their long-run equilibrium levels. Berndt and Fuss (1986), Hulten (1986) and Morrison (1988) adopt a framework that distinguishes the variable from quasi-fixed inputs. The quasi-fixed inputs, such as capital, adjust only partially to their long-run equilibrium levels within one time period. TFPG estimation under this framework usually employs a variable cost function where variable cost is a function of the variable factor prices, output level and the quantity of fixed factors.

Some current productivity studies attempt to integrate the various factors that influence the measurement of technical and productivity change. Morrison (1992) introduces an approach

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<sup>5</sup> Park and Kwon (1995) use the term ‘generalized TFPG’ to refer to the primal rate of technical change. See Chapter Three for various definitions of productivity growth and technical change.

that uses parametric estimation to measure independently the impact of economies of scale, imperfect competition and sub-equilibrium on TFPG. The effects of various factors are then used to adjust the final TFPG measure. Using a Bayesian estimation technique, Park and Kwon (1995) apply the same approach to studying the South Korean manufacturing. Their findings, as mentioned earlier, show significant scale economies and market imperfection, as well as negative productivity growth for South Korea.

Our current study employs an integrated approach similar to Morrison (1992) and Park and Kwon (1995). We estimate a system of equations that includes the factor demand equations, an equation of market demand for output, and an equation that specifies the market equilibrium condition. We adopt the generalized Leontief cost function in the integrated model as the other researchers do. However, one major difference is that we employ various functional forms to model market demand for output. Previous researchers did not give justifications for adopting a particular market demand specification and it is important to examine whether different market demand specifications have a major impact on the estimates.

Once parametric estimates are obtained, we can calculate the elasticity of cost with respect to output, the elasticity of cost with respect to time and the conjectural measure of competition. The elasticity of cost with respect to output measures the degree of returns to scale and the elasticity of cost with respect to time gives a direct measure of technical change from the cost side. The conjectural measure of competition indexes the degree of competition from perfect competition, zero, to pure monopoly, one. Consequently, we should be able to identify the idiosyncrasy of each industry under study by knowing its rate and direction of technical change, the degree of economies of scale and the extent of market imperfection. Our



estimated results provide us with information about Singapore manufacturing industries that is unavailable from previous studies on productivity growth of Singapore. By analyzing this information, we hope to make some firm conclusions regarding the issue of little or negative TFPG growth for Singapore's manufacturing industries.

## 1.2 Thesis Overview

The thesis focuses on three major topics of study and is organized into eight chapters. The three major topics of study are:

- 1) The non-parametric approach, which is used to calculate TFPG, primal rate of technical change and the bias of TFPG calculations (Chapter Three and Four).
- 2) The parametric approach, which is used to estimate the dual rate of technical change, economies of scale and the conjectural measure of competition (Chapter Five and Six).
- 3) The determinants of inter-industry differences in technical change (Chapter Seven).

Before discussing and implementing the theory and practice of measuring technical change, we briefly look at the history of economic development and the industrial policy of Singapore in Chapter Two. Chapter Two provides the background knowledge about the development of Singapore from a small entrepot to a modern high-income city-state. In addition to setting the scene for our statistical analysis in the later chapters, a study of the history of economic development helps us to interpret the estimation results. Also, contained in this chapter is a discussion of the industrial structure and technology and skills in Singapore priority industries. Again, its purpose is to highlight the peculiar nature of Singapore industries and the Singapore government's efforts to promote technical progress. The chapter concludes that the geography of Singapore is one of the most important reasons for its rapid development.

The domination of foreign-owned firms in Singapore industries comes hand-in-hand with export-oriented and input-driven manufacturing. Finally, the chapter dismisses the myth that the high growth industries, in particular the electrical and electronics industries, engage actively in promoting technical progress through technology transfer and in-house R&D.

Chapter Three looks at the definitions as well as the relationship between TFPG, primal and dual rate of technical change. It starts from the conventional productivity accounting framework and then examines the differences between TFPG and the primal rate of technical change when the conditions of perfectly competitive long-run equilibrium are relaxed. In this section, we derive an expression that states that the extent of TFPG bias is determined by the amount of mark-up and by whether the factor inputs are paid their marginal contributions. The second part of the chapter deals with the measurement of productivity growth from the cost side. It shows that the primal rate of technical change is the same as the dual rate of technical change under the conditions of perfectly competitive long-run equilibrium. Also, TFPG is equivalent to both the primal and dual rate of technical change when the same conditions hold.

Chapter Four implements the conventional accounting approach in calculating TFPG. It first defines and describes the variables that are required for the calculation of TFPG and the sources of data for these variables. It also calculates the primal rate of technical change that does not impose the conditions of perfectly competitive long-run equilibrium. Once the primal rate of technical change is calculated we calculate the TFPG bias by subtracting the primal rate of technical change from TFPG. The results of our calculations show that there is no clear difference between TFPG and the primal rate of technical change as calculated for Singapore manufacturing, and that on average the values are each approximately zero.

In Chapter Five, we discuss the theory relating to the parametric estimation of the rate of technical change, economies of scale and the conjectural measure of competition using the dual cost approach. The chapter first looks at the individual flexible translog and generalized Leontief cost function. Then, we look at the derivation of the integrated model that allows joint estimation of the dual rate of technical change, economies of scale and conjectural measure of competition.

The empirical implementation of Chapter Five is carried out in Chapter Six. The chapter first discusses the hypothesis testing techniques and then presents the estimation results for five different models adopted in our study, the translog cost function, generalized Leontief cost function, log-log integrated, semi-log integrated, and linear integrated models. We find that if only the cost function is estimated, then the functional form of the cost function can substantially affect the results of estimation. Our results show that the generalized Leontief cost function model generates estimates of economies of scale that are in general lower than those of the translog cost function model. However, the same difference is not observed in the estimates of the dual rate of technical change between the two functional forms.

Estimation results in Chapter Six show that the different demand specifications yield different estimates of dual rate of technical change, economies of scale and conjectural measure of competition. There are some industries whose estimates are highly sensitive to the different demand specifications, while others are relatively stable. Despite the differences in estimates, it is safe to conclude that the industries are estimated to have experienced increasing returns to scale and conditions close to perfect competition. However, no generalization can be made in regard to technical change.

Chapter Seven studies the determination of innovative activity and technical change. It gives a literature review of the theoretical arguments and empirical evidence on various possible determinants of innovative activity and technical change. The possible determinants include market concentration, firm size, demand, technological opportunity and foreign ownership. It formulates an econometric model that examines the roles played by the different industrial characteristics. Despite the general low level of statistical significance, we observe that market concentration, direct foreign investment and export appear to show a positive impact on the estimated dual rate of technical change in all regressions as what we expect from the theoretical discussion. However, it is disappointing that these relationships are not statistically significant to allow us to draw any firm conclusion. The empirical model also finds evidence of a positive relationship between increasing scale and low rates of technical change. This result seems to point to the peculiar nature of Singapore industrial development or it could merely reflect mis-specification errors in our estimation equations.

The last chapter, Chapter Eight, concludes the thesis. It summarizes the main statistical findings and interprets these findings in relation to Singapore's public policy. The chapter also discusses the limitations and problems that we face in the course of our study and makes some suggestions for future research.

## **CHAPTER TWO**

### **A BRIEF HISTORY OF SINGAPORE'S ECONOMIC DEVELOPMENT AND ITS INDUSTRIAL STRUCTURE**

#### **Introduction**

The objective of this chapter is threefold. Firstly, it briefly describes the historical development of Singapore's economy. It is important to understand the historical background against which the policy makers formulate the industrial policies that have been shaping Singapore's manufacturing. The withdrawal of Singapore from the Federation of Malaysia in 1965, for example, forced Singapore to pursue an export-led industrialization program, rather than import-substitution industrialization. Furthermore, a study of the historical development of Singapore's economy should give insights into answering questions such as: (1) how did Singapore develop into a modern high-income city state and (2) is it possible for other developing nations to imitate the experience of Singapore's development?

The second theme of this chapter studies the industrial characteristics of Singapore's manufacturing. We look at the output growth rates, the shares of total manufacturing output, the extent of foreign ownership, direct exports, firm size, production scales and research and development expenditure. We identify that Electronic Products & Component (384) is the most important industry in Singapore's manufacturing in terms of output growth rate and the share of total manufacturing output. It is the largest and fastest growing industry. This industry largely consists of firms manufacturing computer peripheral equipment, disk drives, printed circuit boards with electronic parts and semi-conductor devices.

On the whole, we find that large foreign-owned firms dominate Singapore's manufacturing. This peculiar industrial structure creates a pattern of dependence for technology transfer and capital investment on foreign-owned firms. Many foreign-owned firms are subsidiaries of multinational corporations (MNCs) that carry out little research and development in Singapore. In addition, we observe that linkages between local and foreign-owned firms are largely missing. Foreign-owned firms, in general, obtain their inputs from foreign sources and export almost all their output to destinations outside of Singapore.

We elaborate on the issue of technology transfer in the wider context of technology and skills in Singapore's manufacturing in the last section of the chapter. The section focuses on many aspects of technology transfer. Firstly, it looks at what motivates MNCs to set up subsidiaries in Singapore. Then, it looks at the general pattern of setting up subsidiary plants in Singapore and the implications for indigenization of technology resulting from such arrangements. The findings of the survey show that many foreign-owned firms have been reluctant to adopt the latest and more capital intensive (such as automation) methods of production in Singapore due to the high costs involved.<sup>1</sup> Furthermore, foreign-owned firms, especially the Japanese ones, are unwilling to train local technical and professional staff involving proprietary technological know-how because of the high incidents of job-hopping in the tight Singapore labor market. It has also been found that the degree of indigenization of technology, measured by the level of managerial autonomy and the percentage of local professional and managerial staff, is particularly low in Japanese firms among all foreign-owned firms, including American and European firms.

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<sup>1</sup> Foreign-owned firms include those Singapore firms that are either wholly or majority foreign-owned.

## 2.1 A Brief History of Economic Growth of Singapore

### 2.1.1 Development before Independence- an Entrepot

The geography of Singapore can be considered as one of the most important reasons for its rapid development in the last hundred years.<sup>2</sup> It situates at the tip of the Malay Peninsula and the southern entrance to the Straits of Malacca that controls one of the two gateways between the India Ocean and the South China Sea.<sup>3</sup> With its superior harbor, Singapore quickly became a regional and international transport center since its first settlement began in 1819.

Sir Thomas Stamford Raffles, the founder of Singapore, established Singapore as a free port. The policy of free port combined with its strategic location and superior harbor enabled Singapore to become a major port of call and an entrepot for the Malayan region. However, its attempt to become an entrepot for the China trade met with only limited success. The major economic activities were in the export of a variety of tropical produce and a return flow of imports, especially British cotton piece goods and opium. By 1871, Singapore Municipality had a settlement consisted of about 65,000 inhabitants- a town which 'extends in very few points more than a mile from the beach' (Cameron, 1965, p.73).

The opening of Suez Canal in 1869 and the rapid increase in the world demand for primary products were responsible for the dramatic change in Singapore in this period. With the opening of Suez Canal, steamships could be used for the Eastern trade. Since steamships needed to stay close to the shore to obtain coal, the Straits of Malacca became a better choice

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<sup>2</sup> Our exploration of the history of economic growth of Singapore in this section borrows extensively from Huff (1994) which provides a detailed analysis of the economic growth of the Singapore economy from 1870 to 1990.

for shipping than Sunda Straits where steamships would have to travel a longer journey across the India Ocean to and from Colombo. Singapore thus became the chief port of call in the region and 'the gate to the East' with the increasing traffic of ocean-going shipping passing through the Straits of Malacca.

Netherlands India (Indonesia) was just as important to Singapore's trade as the Malay Peninsula. Located on the other side of Singapore's surrounding seas, Netherlands India provided much of the tropical commodities for export via Singapore. Singapore thus was the collecting and distributing center not only for the Malay Peninsula but also for a considerable area of central Sumatra and Borneo, where the output of tropical commodities increased substantially.

A chief port of call as well as a major entrepot for the region enabled Singapore to increase its trade enormously within a short period of time. Singapore's trade (exports plus imports) increased more than sixfold from an annual average of \$67 million to \$431 million between 1870 and 1900. It increased further in the second phase of growth beginning from 1910 onwards to reach a peak of \$1832 million in 1925 for the pre-World War II period (Huff, 1994, p.11).<sup>4</sup>

A staple port model can be used to describe Singapore's development up until 1960s. In addition to the export of a variety of tropical produce, the growth of Singapore's trade until the 1960s largely depended on the export of three major staple commodities, namely, tin, rubber and petroleum products, from the Malayan region. Tin could be considered as

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<sup>3</sup> The other gateway is the Sunda Straits.



Singapore's first staple as its production and export increased substantially during the 1880s and 1890s in response to Western demand. Later, the establishment of rubber industry in Malaya and the increase in petroleum exports from Netherlands India brought Singapore's second and third major staples, respectively. The export of rubber and petroleum products was the result of development of motorized transport in the industrial countries.

International trade served as the engine of growth for Singapore's economy. International trade was made possible because Singapore's hinterland possessed an abundant of natural resources that were greatly in demand in the industrial countries. The export of primary commodities provided an outlet or 'vent' for the abundant of natural resources. As a result, Singapore's hinterland was to undergo rapid expansion in the production of primary commodities. It also provided the opportunity for the development of the port city of Singapore with its main function to serve the new trade.

If trade is the engine of growth, then sustained growth is only possible when linkages are established between trade and the sector that provides the essential services to facilitate trade. In addition to the necessary condition of possessing a strategic location, Singapore was also characterized by its role in performing a set of economic functions in facilitating trade. These economic functions included:

- the performance of entrepreneurial, investment, management and mercantile functions connected with production of the staple;
- the provision of financial services;
- processing of the staple commodity;

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<sup>4</sup> The dollar sign, \$, refers to Straits Settlement dollar or Singapore dollar. These are current dollar figures, but still can indicate the rapid real increase in Singapore's trade.

- marketing services including the role of the port as the region's main market for the staple; and
- the close involvement of business interests in the port with hinterland production.

The four economic functions of entrepreneurial/managerial, financial, processing and marketing gave rise to the fifth characteristic of close involvement of business interests in the port with hinterland production. Singapore performed the mercantile, financial, processing and marketing functions for all part of its hinterland. However, its performance of investment and management functions was confined to the Malay Peninsula only since Netherlands India was under the control of a separate political entity.

Singapore merchants were largely responsible for the development of the Malay Peninsula. The establishment of European estate agriculture (predominantly rubber tree estates) in the Malay Peninsula was linked to the development of agency houses in Singapore. Due to the high investment cost and a period up to seven years before the first generation of plants came into bearing, European estate agriculture required overseas finance. Agency houses which formed by Singapore merchants from the turn of century provided a wide range of services from growing, processing insuring, shipping and selling the plantation product. The European rubber estate sector in the Malay Peninsula was largely established and maintained by agency houses in Singapore that assumed a central commercial role in this sector.

Singapore Chinese merchants had made a significant contribution to the development of rubber production in Netherlands India. Outport dealers who marketed their primary commodities also obtained credits, usually in the form of consumer products, from the Chinese traders in Singapore. Outport dealers were usually tied to their Chinese traders

because of the credit received from them. In the process, Chinese traders established a network of linkages that eventually provided finance to the growers in Netherlands India. Consequently, with their specific knowledge about the risk involved in the dealings and their network of contacts, Chinese traders in Singapore performed the critical functions of marketing and financing for rubber production in Netherlands India.

The pattern of economic development in Singapore changed very little even up to 1960s. It remained as a busy staple port that served the regional trade. Its location in a region that possesses rich natural resources gives a comparative advantage that few other staple ports can compete. Its services penetrated deep inside its hinterland that included all of the Malay Peninsula, Borneo and a large part of Netherlands India. In addition, a firm policy of free port made Singapore the most important port of call for international shipping in the region.

Development in Singapore was substantial even before its independence in 1959. Singapore was the hub of international transport for shipping, airlines, telecommunication, and distribution of mail. It was the largest market in the world for natural rubber, a major world oil distribution center and an important international futures market for tin. There was also a pool of local entrepreneurs available. In addition, the British administration provided a stable political climate for development. Thus, current claims by the government that Singapore was backward and undeveloped before its independence are not accurate. These attempts to stress the extent of the underdevelopment in Singapore before its independence appear to be directed to emphasize the achievements of the Singapore government.

Although Singapore was a well-developed staple port at the time of its independence in 1959, it faced two potentially serious economic difficulties. First, underemployment and

unemployment resulting from Singapore's surplus labor continued to undermine the stability of the economy. There were two reasons for the surplus labor. One was the high natural population growth and another was that surplus labor in Singapore, predominantly Chinese from southern China, could not return to Mainland China after the communist took power there in 1949. The second potentially serious economic difficulty was Singapore's low voluntary personal saving. This, in turn, contributed to low capital formation for development. These two problems presented major challenges for the post independent government.

### 2.1.2 Development after Independence

The transition from a staple port to an economy that exports primarily domestically-produced manufactured output takes place from the mid-1960s onwards. This transition coincides with the political development of Singapore. Even after Singapore obtained independence in 1959, the general consensus in the Island was that Singapore could not possibly be an independent state. The leader of the People's Action Party (PAP), Lee Kuan Yew, commented that, 'nobody in his senses believes that Singapore alone in isolation can be independent' (Singapore Legislative Assembly Debates, 1960). PAP won the 1959's elections and formed the government. The same government is still in power today. From the very beginning, PAP has firmly maintained Singapore's status as a free port.

In September 1963, together with Sarawak and Sabah, Singapore joined the Federation of Malaysia and became one of the states under Malaysia. However, due to the many differences created by the domination of Chinese in Singapore and Malays in the other states as well as

by the huge gap in levels of economic development, Malaysia and Singapore were finally divorced in August 1965.

The separation of Singapore from Malaysia changed the direction of policies that governed Singapore's development. For a brief period from 1960 to its final independence in 1965, Singapore pursued a policy of import substitution. The annual real GDP growth rate for the period from 1960 to 1966 averaged about 5.7 percent. This growth was due to the expansion of import-substituting industries in response to the re-integration and increased construction in investment of infrastructure. It was the only period that Singapore's economic growth was not export-led.

After the separation from Malaysia, Singapore moved swiftly away from import-substitution to export-oriented manufacturing. Its pace of industrialization gained new momentum while at the same time Singapore's economy continued to depend heavily on staple exports, both rubber and petroleum. Manufacturing industries expanded rapidly during the period 1965-73 under the active participation of the government. It accounted for close to 30 percent of the growth of real GDP over the period 1965-73. At the same time, the proportion of direct exports, goods with some part of their value added through manufacture in Singapore, in manufacturing output increased from about 30 percent in pre-1965 period, to 40 percent in 1970 and to 54 percent in 1973. By 1989, the proportion of direct exports in manufacturing output reached 67 percent.

Not only domestic manufactures dominated exports, but also new products were increasingly becoming the most important export items. The manufactures of machinery and transport equipment increased from 40 percent of total exports in 1971/73 to almost 75 percent in

1988/90. Electrical and electronics goods within the machinery and transport equipment divisions made up the great bulk of these exports by the 1980s. Integrated circuits emerged as the major export item between 1980 to 1984 and disk drives between 1986 to 1990. The United States was the principal export market of Singapore's electrical and electronics goods.

A major concern at the time of independence in 1965 was the labor surplus problem facing Singapore. Labor-intensive industries such as electronics, textiles and garment industries were able to offer unskilled manufacturing jobs to the unemployed and the underemployed. It was observed, 'The electronic components we make in Singapore probably require less skill than that required by barbers or cooks, consisting mostly of repetitive manual operation' (Goh, 1970, p.27). Due to the rapid expansion of these labor-intensive manufacturing industries, unemployment fell from 8.9 percent in 1966 to 4.5 percent in 1973, indicating surplus labor were effectively eliminated. Full employment was practically achieved in 1973, representing a turning point in Singapore economic development.

While manufacturing had been the leading sector in Singapore, it did not achieve any gains between 1973 and 1990 in the value-added share of gross output, a rough indicator of technical development in manufacturing. For two decades following 1970, manufacturing remained the leading sector in Singapore's economy, accounting for 24.8 percent of the real GDP in 1970, 29.5 percent in 1980, and 29.0 percent in 1990. However, as shown in Table 2.1, Singapore manufacturing value added as a percentage of output was 32 percent in 1973, 26.3 percent in 1978, 27.0 percent in 1984 and 30.3 percent in 1990. For industries such as Electronic Products and Components (384), this ratio actually decreased from 32.2 percent in 1978 to 27.7 percent in 1990.

**Table 2.1: Singapore manufacturing value added as a percentage of output, 1973-1990**

	1973	1978	1984	1990	% of total 1990 value added
Textiles (321)	38.8	32.7	32.8	32.9	0.6
Garments (322)	28.5	32.6	33.6	30.8	2.4
Printing/publishing (342)	55.1	50.8	56.6	53.5	4.3
Industrial chemicals (351)	51.9 <sup>a</sup>	35.6	23.9	33.6	4.9
Petroleum (353)	18.4	10.5	7.7	14.6	7.7
Fabricated metals (381)	36.8	34.5	38.7	34.8	6.1
Industrial Machinery (382)	39.9	49.1	45.7	37.5	5.9
Electrical (383)	39.0 <sup>b</sup>	33.7	37.6	36.1	4.1
Electronics (384)	N/A	32.2	29.9	27.7	35.7
Transport equipment (385)	46.8	47.4	51.7	42.6	7.5
Precision Equipment (386)	37.7	52.0	54.4	46.4	1.7
Others (390)	26.6	24.9	33.1	37.9	19.1
All industries	32.0	26.3	27.0	30.3	100.0

Notes:

<sup>a</sup> Refers to industrial chemical products only<sup>b</sup> Includes electronic products

Sources:

*Census of industrial production 1973, pp.35-41, 1987, 18-22, 1990, pp.18-23*

In 1979, Singapore National Wage Council implemented the three-year wage correction policy that aimed at increasing the real wages so that industries would be moving away from labor-intensive to more capital-intensive manufacturing. The average increase in real wages from 1973 to 1978 was only 1.7 percent. However, real wages increased substantially after 1979, especially between 1981 and 1982 when real wages jumped 7.2 percent. By 1990, real wages roughly doubled their 1978's level, but the average value added as a percentage of output grew only 15.2 percent for the same period. It appears that the government's wage correction policy was not effective in achieving gains in technical development of Singapore manufacturing.

**Table 2.2: Singapore, United States, Japan and Asian NICs hourly compensation costs for production workers in manufacturing, 1975-1990 (current US\$ and index, United States = 100)**

	1975		1980		1987		1990	
	\$	Index	\$	Index	\$	Index	\$	Index
United States	6.36	100	9.87	100	13.52	100	14.88	100
Japan	3.05	48	5.61	57	10.83	80	12.64	85
Singapore	0.84	13	1.49	15	2.31	17	3.78	25
South Korea	0.33	5	0.97	10	1.65	12	3.82	26
Taiwan	0.40	6	1.00	10	2.26	17	3.95	27
Hong Kong	0.76	12	1.51	15	2.09	15	3.20	22
Asian NICs	0.50	8	1.15	12	2.06	15	3.75	25

Notes:

Hourly compensation includes all direct payments to workers before any payroll deductions and employer expenditures for legally required insurance programs and contractual and private benefit plans. It may also be adjusted upwards to include taxes on payrolls or employment or downwards to reflect subsidies and so reflect labor costs. Asian NICs refers to a United States trade-weighted average level for Singapore, South Korea, Taiwan and Hong Kong.

Sources:

US Department of Labor, *International comparisons 1991*, pp.5, 6, and 12-14.

The wage correction policy that aimed at increasing the real wage was short-lived. It was soon reversed to a policy of suppressing wages from rising, especially during the period when the economy started to recover from the severe 1985 recession. As shown in Table 2.2, in 1975, the average manufacturing wage in Singapore was substantially higher than the average wage of the other Asian NICs. With the implementation of the wage correction policy, the higher wage differential largely continued into the early 1980s. However, in the later part of 1980s, wages in Singapore did not grow as much as those of the other Asian NICs. By 1990, manufacturing wages converged on the average of the Asian NICs. Singapore government's ability to exert tight control of the trade unions was a key factor in the success of a history of wage controls.

The development of Singapore's economy has been marked by significant structural changes.

Firstly, since 1970 manufacturing has taken over as the leading sector in the economy and



domestically manufactured products have become the major export items. This represents a significant departure from the development of a staple port that exclusively depends on the trading and servicing of staple commodities. The second major structural change is the growing importance of the service sector in Singapore. Service sector in Singapore comprises of three categories: transport and communications, financial and business services and community, social and personal services. The financial and business services, the largest component of the service sector, accounted for 26.2 percent of the GDP in 1990, roughly equivalent to the contribution of the manufacturing sector for the same year.

The financial and business service sector has become the engine of growth under the active planning and participation of the Singapore's government. In its aim to become one of the major financial centers in the world, Singapore's government provides a friendly and permissive environment for foreign financial institutions to establish their presence in Singapore and it encourages financial activities by reducing transaction costs through lower taxes. Singapore government also participates directly or through the government-owned Development Bank of Singapore in creating the Asian Dollar Market and Asian Dollar Bond Market. It abolishes the withholding tax of 45 percent on interest paid to non-residents if deposits were made in Asian Currency Units (ACUs). The Asian Dollar Market grew at an annual rate of 21.8 percent from US\$54.4 billion in 1980 to US\$390.4 billion in 1990.

An important feature of Singapore's economic development is its high rate of domestic savings. Singapore's saving ratio, gross national savings to GDP, grew from -2.4 percent in 1960, to 24.4 percent in 1973, 33.0 percent in 1980, and 44.7 percent in 1990. Approximately 70 percent of the gross national savings came from public sector savings and the rest from private sector savings in 1985. Singapore's public sector savings consist of the government's

budget surplus as well as the surplus realized by statutory boards such as Housing and Development Board, Jurong Town Corporation and Public Utilities Board.

Private sector savings come mainly from the Central Provident Fund (CPF), the government-forced social security scheme. Both employers and employees are required to contribute equal share to the fund. Total contributions amounted to 50 percent of employee's wage in 1984.

Upon retirement, individuals can then collect pension based on the accumulated amount that they have contributed to the fund. By borrowing from the CPF at below market interest rates, the government has a cheap and non-inflationary source of fund to finance construction of infrastructure and public projects.

It has been observed that the backbone of economic growth in Singapore for the past 25 years is government subsidization of foreign investment (Ermisch and Huff, 1999). The high saving rate makes it possible for the government to subsidize foreign investment. Some of these subsidies include providing land for factory sites at well below market prices, building world class infrastructure and maintaining a labor force that is well-educated and skilled. In addition, substantial tax concessions are given to firms that are under the pioneer status.

Pioneer firms can enjoy a tax rate of 10 percent for up to 20 years. All of these measures are aimed at reducing the cost of doing business in Singapore, making it attractive for MNCs to come to invest. Singapore public policies foster a certain type of industrial structure, which we are going to look at next.

## 2.2 Characteristics of Singapore's Manufacturing

This section aims to describe the characteristics of Singapore's manufacturing. It outlines the industrial structure of Singapore's manufacturing in the 1980s and 1990s. We examine, in turns, the output growth, the share of the total industrial output, foreign ownership, direct exports, average firm size, production scale and research and development expenditure of all industries in Singapore manufacturing. These variables are listed in Table 2.3 below.

### 2.2.1 Real Output Growth and Output Share

Average annual growth rates of real output from 1975 to 1994 are given by the third column of Table 2.3. The fastest growing industry is Electronic Products & Component (384). This industry's real output grew at an average rate of 15.6 percent per annum over the period 1975 to 1994. Industrial Chemical and Gases (351) and Electrical Machinery, Apparatus, Appliances & Supplies (383) followed at 11.8 percent and 11.3 percent, respectively. These three industries represent the fastest growing industries in Singapore's manufacturing for the past 20 years. Other industries such as Tobacco (314), Paints, Pharmaceuticals & Other Chemical Products (352) and Printing and Publishing (342) also grew at relatively high rates- 8.6 percent, 8.5 percent and 8.4 percent, respectively.

**Table 2.3: Annual Real Growth, Foreign Ownership, Direct Export, Firm Size, Production Scale and Research and Development for Singapore Manufacturing**

	O/P GROWTH %	O/P SHARE %	FOREIGN OWNED %	DIRECT EXPORT/ SALES %	FIRM SIZE	OUTPUT SCALE %	R&D/SAL E %
Food (311)	2.70	5.53	8.40	57.20	39.51	17.87	0.046
Beverage (313)	4.40	0.78	7.20	32.20	171.86	28.57	0.092
Tobacco (314)	8.60	0.61	0.00	34.00	145.75	50.00	0.000
Textiles (321)	-5.40	0.84	7.50	37.00	50.08	16.42	0.000
Garments (322)	0.00	2.40	3.20	84.10	78.24	14.52	0.000
Leather (323)	-5.10	0.12	0.00	27.00	37.74	5.26	0.000
Footwear (324)	-5.30	0.14	2.90	30.40	20.71	0.00	0.000
Sawn Timber (331)	-8.70	1.12	6.60	55.00	32.99	13.19	0.003
Furniture (332)	7.20	0.74	3.90	40.10	46.69	6.54	0.014
Paper (341)	2.20	1.23	11.20	36.70	48.78	21.35	0.000
Printing/Publishing (342)	8.40	2.16	4.60	19.90	47.22	7.41	0.000
Industrial Chemicals (351)	11.80	2.82	43.80	63.10	59.26	46.58	0.002
Pharmaceuticals (352)	8.50	2.55	37.50	77.80	53.24	30.68	0.032
Petroleum (353)	5.20	25.42	72.70	65.60	283.00	90.91	0.000
Rubber (356)	-0.40	0.16	27.59	61.18	52.62	20.69	0.003
Plastic (357)	3.20	1.54	11.50	18.50	46.64	12.59	0.004
Pottery (361)	-2.70	0.12	11.10	34.80	94.78	22.22	0.000
Mineral (369)	4.00	0.33	17.40	43.00	76.70	17.39	0.303
Iron and Steel (371)	4.90	0.70	27.30	36.10	146.82	36.36	0.044
Non-ferrous Metals (372)	1.70	0.52	26.30	42.20	38.79	42.10	0.000
Fabricated Metals (381)	4.20	4.50	15.80	30.70	58.50	17.93	0.009
Industrial Machinery (382)	7.00	4.33	21.60	62.30	58.72	14.55	0.063
Electrical (383)	11.30	3.41	41.10	59.30	173.38	34.88	0.096
Electronics (384)	15.60	30.59	46.40	84.40	498.20	57.51	0.360
Transport (385)	6.00	4.95	14.20	66.00	99.54	18.67	0.001
Precision Equipment (386)	5.20	1.16	53.10	91.90	155.80	28.57	0.700
Others (390)	-0.60	1.23	7.50	64.80	49.08	15.09	0.014

Notes:

O/P GROWTH refers output growth rates calculated over the period 1975 to 1994. Other variables are 1989 based. O/P SHARE refers to the average industry share of manufacturing output over the period 1975 to 1994. FOREIGN OWNED refers to the percentage of wholly foreign owned firms in an industry. DIRECT EXPORT/SALES gives the percentage of sales that are exported. FIRM SIZE is the average number of workers per firm. OUTPUT SCALE refers to the percentage of firms that produce ten million dollars or more output. R&D/SAL gives the research and development expenditure as a percentage of total sales.

Source:

*Census of industrial production, 1975, 1989 and 1994.*

On the other hand, industries that show the lowest growth rates are resource-based or primary products industries. For example, Sawn Timber & Other Wood Products (331) at -8.7 percent, Textiles (321) at -5.4 percent, Footwear (324) at -5.3 percent, Leather (323) at -5.1 percent, Pottery (361) at -2.7 percent and Rubber (355/6) at -0.4 percent. These declining industries reflect the efforts of the government for the past 20 years to move away from the low technology and primary products industries.

In the next column, the average shares of total industrial output over the period 1975-1994 are listed. These figures show the relative sizes of industries in terms of output shares. The largest industry of all is Electronic Products & Component (384), which alone accounted for, on the average, 31 percent of the total annual manufacturing output over the period 1975-94. There is little doubt that this industry is the most important industry in Singapore's manufacturing by virtue of its huge size and its rapid growth rate. There is no other industry that can come close to this industry except Petroleum Refineries and Petroleum Products (353).

Petroleum Refineries and Petroleum Products (353) was a leading industry before the emergence of Electronic Products & Component (384). However, since the middle of 1980s, Electronic Products & Component (384) had taken over the lead. Petroleum Refineries and Petroleum Products (353) still accounted for, on the average, nearly 25 percent of the total annual manufacturing output over the period 1975-94. Its output share shows a steadily declining trend as Electronic Products & Component (384) grew three times faster than its own growth over the past two decades.

Besides Electronic Products & Component (384) and Petroleum Refineries and Petroleum Products (353), no other industries account for a significant share of the total industrial output. Other relatively important industries in Singapore, in terms of their output shares, mostly consist of manufacturers of components of capital goods.<sup>5</sup> Fabricated Metal Products except Machinery and Equipment (381), Industrial Machinery except Electrical and Electronic (382), Electrical Machinery, Apparatus, Appliances and Supplies (383), Transport Equipment (385) and Industrial Chemicals and Gases (351) are the relatively important industries that account for three to five percent of the total manufacturing output among them.

**Table 2.4: Some Statistics of the Components of Electronic Products & Component (384), 1991**

	SIC	Net Value Added M\$	Output Share %	Workers/Firm	Direct Exports/Sales %
Computer Peripheral Equipment	38413	1285	10.2	515.8	87.8
Disk Drives	38412	1224	24.4	2307.6	90.8
Printed Circuit Boards with Electronic Parts	38464	734	9.8	213.1	66.4
Semi-conductor Devices	38441	627	12.2	686.2	90.8
Audio and Video Combination Equipment	38426	510	11.7	1232.8	86.3

Source:

*Census of Industrial Production, 1991*

Since Electronic Products & Component (384) is the most important industry in Singapore's manufacturing, it is then justified to examine the composition of this industry in some detail.

Table 2.4 below lists some of the major manufacturing activities, in terms of net value added, for 1991. Computer Peripheral Equipment (38413) and Disk Drives (38412) are the two major component industries of Electronic Products & Component (384). Both of these industries produce the highest net value added and have a combined output share of 35 percent of the total output of Electronic Products & Component (384) in 1991. It should also

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<sup>5</sup> An exception is Food (311) that accounts for 5.5 percent of the total industrial output.

be noted that large firm size (more than 100 workers per firm) and a high ratio of direct exports to sales are common to all the major component industries of Electronic Products & Component (384). For example, both Computer Peripheral Equipment (38413) and Disk Drives (38412) have a ratio of direct exports to sales close to 90 percent.<sup>6</sup> The United States is the principal market of Singapore's electronic products and by the late 1980s Singapore became the world's largest exporter of Winchester disk drives (EDB, 1990, p.26).

### 2.2.2 Foreign Ownership

As mentioned earlier, MNCs have played a significant role in Singapore's manufacturing. Besides the attractions of stable government and strategic location, MNCs were also attracted to Singapore by its relative cheap and yet productive labor. On the other hand, Singapore government saw MNCs as a main source of technology transfer in the high technology industries. However, it is questionable about the extent to which this objective has been achieved. Many foreign firms have been accused of transferring very little, if any, up-to-date technology to their counter parts in Singapore. Most technology transfers involve only process adaptation as opposed to innovative technology, product design and development as well as basic research. Furthermore, MNCs are also accused of crowding out domestic enterprises.<sup>7</sup>

We can get some idea of the extent of foreign ownership in Singapore's manufacturing by looking at the percentage of firms that are wholly foreign-owned in each industry. These figures are given in the fourth column of Table 2.3. The figures show that some industries are

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<sup>6</sup> It should be noted that this ratio of direct export to sales may underestimate the extent of exports since direct exports exclude sales to other domestic firms, which may subsequently export their final product.

dominated by wholly foreign-owned firms, especially those largest and fastest-growing industries. For example, 73 percent of the firms in Petroleum Refineries and Petroleum Products (353) are wholly foreign-owned whereas 46 percent for Electronic Products & Component (384). Wholly foreign ownership is also predominant in many capital goods industries such as Instrumentation Equipment, Photographic and Optical Goods (386) at 53 percent, Electrical Machinery, Apparatus, Appliances and Supplies (383) at 41 percent, and Industrial Chemicals and Gases (351) at 44 percent.

**Table 2.5: Singapore Manufacturing Statistics by Capital Ownership 1968-1990**

	Establishments No. and %	Workers No. and %	Output \$m and %	Direct Exports \$m and %	Capital Expenditure \$m and %
<b>1968</b>					
Total	1586	74833	2175.7	Not	89.6
Wholly Local	80.5	58.7	41.1	Available	33.2
Majority Local	7.8	15.1	12.8		24.3
Wholly or majority foreign	11.7	26.2	46.1		42.5
<b>1975</b>					
Total	2385	191528	12610.1	7200.7	622.6
Wholly local	66.9	32.8	18.0	8.9	20.7
Majority local	11.1	15.2	10.7	7.0	14.7
Wholly or majority foreign	22.0	52.0	71.3	84.1	64.6
<b>1980</b>					
Total	3355	285250	31657.9	19172.9	1861.9
Wholly local	64.2	28.2	15.6	7.1	14.2
Majority local	11.0	13.4	10.7	8.2	11.2
Wholly or majority foreign	24.8	58.4	73.7	84.7	74.6
<b>1990</b>					
Total	3703	351674	71333.2	46999.5	4184.4
Wholly local	67.7	29.0	15.1	7.8	17.8
Majority local	8.9	12.0	9.0	6.4	11.5
Wholly or majority foreign	23.4	59.0	75.9	85.8	70.7

Notes:

Figures include petroleum but exclude rubber processing and granite quarry.

Columns may not add to totals due to rounding

Sources:

*Census of industrial production 1968, p.8, 1975, p.16, 1980, p.4, 1990, p.4.*

<sup>7</sup> We examine formally the role of foreign ownership in Singapore's technical change in Chapter Seven. A review of literature on the relationship between MNCs and technical change is provided then.



In order to appreciate fully the extent of foreign ownership in Singapore's manufacturing, it is more revealing to examine some principal industrial statistics by capital ownership. Table 2.5 gives the principal industrial statistics by capital ownership over the period 1968 to 1990. From looking at Table 2.5, there is little doubt that wholly or majority foreign-owned firms have dominated Singapore's manufacturing industries since 1975. Wholly or majority foreign-owned firms hired about half of the Singapore's labor force, produced 70 percent of Singapore's total manufacturing output, and accounted for 85 percent of the direct exports and roughly 70 percent of total capital expenditure.

One of the arguments for favoring foreign investment is the establishment of linkages between foreign firms and local suppliers. From looking at the overwhelming dominance of foreign-owned firms in Singapore's manufacturing, there seems to be very little linkages established between foreign-owned firms and local-owned suppliers. As we discuss again in the next section, foreign-owned firms prefer to establish linkages with other foreign-owned firms to the local-owned firms in Singapore.

### 2.2.3 Direct Exports

A large part of Singapore's manufacturing output is destined for exports. The proportion of direct exports of manufactures in total sales of manufactures can be used to measure the extent of exports. The proportion increases from 31 percent in 1967, to 54 percent in 1973, and 66 percent in 1990. In addition, we can see from the column under direct exports in Table 2.3 that about half of all industries in Singapore's manufacturing export most of their sales. In fact, some industries sell almost exclusively abroad. These industries include Precision

Equipment or Instrumentation Equipment, Photographic and Optical Goods (386) at 92 percent, Electronic Products & Component (384) at 84 percent and Wearing Apparel except Footwear (322) at 84 percent.

It is important to recognize that foreign firms are responsible for almost all the manufactured exports. Table 2.5 shows that roughly 85 percent of all direct exports are manufactured by wholly or majority foreign-owned firms. The figure shows that foreign firms manufacture their products almost exclusively for markets abroad. Compared to local-owned firms, foreign-owned firms have acquired considerable marketing know-how and overseas distribution network. These foreign-owned firms have a distinct advantage over the local-owned firms in entering into unfamiliar foreign markets.

#### 2.2.4 Firm Size

The average number of workers per firm is used as a measure of firm size. Looking at Table 2.3, there are only eight industries that have an average number of workers per firm greater than 100. Most of the other industries, by contrast, are characterized by firm size ranged from small (10-49 workers per firm) to medium (50-99 workers per firm). The industry with the largest firm size is Electronic Products & Component (384)- averaging close to 500 workers per firm. If we look at the major component industries of Electronic Products & Component (384) as shown on Table 2.4, Disk Drives (38412) is the industry with the largest firm size- averaging 2308 workers per firm.

Table 2.6 shows Singapore manufacturing by size of firm. It can be seen from Table 2.6 that large firms as defined by those firms that employed 100 workers or more account for

increasingly larger shares of the total number of firms and workers as well as total output and value-added over the period 1963-1988. By 1988, large firms employed roughly 70 percent of the total manufacturing labor force and produced 80 percent of the total manufacturing output and value-added. Smaller firms, on the other hand, have been forced to play a much smaller role in employment of labor force and production of output and value-added. The data suggest that Singapore’s manufacturing development can be characterized by domination of large firms. The observation does not support the argument that small enterprises are the backbone of development in less developed countries.

**Table 2.6: Singapore Manufacturing by Size of Firm, 1963-1988 (%)**

	Total	Tiny (5-9 workers)	Small (10-49 workers)	Medium (50-99 workers)	Large (100 and over workers)
	No. of firms				
1963	1542	44.4	44.9	6.9	3.8
1983	5752	37.1	45.7	8.4	8.8
1988	5584	35.2	46.7	7.7	10.4
	No. of Workers				
1963	41340	11.5	36.4	17.7	34.4
1983	285742	5.1	18.4	11.7	64.8
1988	335889	3.3	15.4	9.2	72.1
	Output (\$ 000)				
1963	888841	5.1	27.9	30.4	36.6
1983	37804526	1.5	11.4	9.0	78.1
1988	56993727	0.9	9.9	7.7	81.5
	Value-added (\$ 000)				
1963	267970	5.7	23.5	23.0	47.8
1983	10035366	2.1	13.1	11.4	73.4
1988	18811207	1.1	9.6	7.7	81.6

Sources:  
*Census of industrial production 1963*, pp.7, 83, *1983*, pp.2, 133, *1988*, pp.2, 185.

A connection can also be made between foreign ownership and the size of firm from Table 2.5. By 1980, wholly or majority foreign-owned firms, in general, were twice as large as the majority local-owned firms and about five times as large as the wholly local-owned firms

(calculated from Table 2.5). These statistics reaffirm the predominance of foreign ownership in Singapore manufacturing.

### 2.2.5 Production Scale

In Table 2.3, the column marked by output scale represents the percentage of firms that produce ten million dollars or more output. A high percentage indicates that the market is dominated by large firms each producing ten million dollars or more output. A low percentage means that smaller firms in the industries produced most of the total industrial output.

This variable reflects the extent of production or output scale that characterizes the industries. We expect that those industries that could benefit from substantial economies of scale show a high production scale. Petroleum Refineries and Petroleum Products (353) has the highest production scale at 91 percent followed by Electronic Products & Component (384) at 58 percent. In 1989, for instance, eleven firms produced all the output in Petroleum Refineries and Petroleum Products (353). Out of these eleven firms, there was only one that produced an amount of output less than ten million dollars. On the other end, industries with a low production scale such as Footwear (324) and Printing and Publishing (342) consist of firms of more diversified sizes. For example, in Footwear (324), we see a spread of firms from the small (producing less than \$500,000) to the big output scale (producing between \$5,000,000 to \$9,999,999).

2.2.6 Research and Development (R&D)

The last column of Table 2.3 shows the R&D expenditure as a ratio of sales in 1989. The data shows that, on the average, industries spent less than 0.1 percent of their sales on R&D.

Precision Equipment or Instrumentation Equipment, Photographic and Optical Goods (386) is the industry with the highest ratio of R&D expenditure to sales at 0.7 percent followed by Electronic Products & Component (384) at 0.36 percent. There were 15 industries out of the total 27 industrial groups spending none or negligible amount on R&D.

**Table 2.7: A Comparison of R&D Intensity For Selected Countries and Industries**

	Australia %	Canada %	U.K. %	Singapore %
Food, Beverages & Tobacco	0.26	0.14	0.25	0.04
Professional Goods	5.56	2.64	1.57	0.70
Radio, TV, Communication Equip.	7.38	13.05	6.22	0.36
All Manufacturing	0.84	0.92	1.87	0.16

Note:  
R&D intensity corresponds to the industry R&D expenditure as a percentage of total output for 1989 (Australia and Singapore) or 1988 (UK and Canada).  
Sources:  
*Research and Development Expenditure in Industry 1974-95*, 1997 edition, OECD publication  
*Census of Industrial Production, 1989*

How far does Singapore’s industrial R&D lag behind that of the industrialized countries?

Table 2.7 gives the R&D expenditure as a percentage of output for three selected industrialized countries and industries. The three industrialized countries (Australia, Canada and United Kingdom) devote a considerably larger share of their output on R&D than that of Singapore. For all manufacturing, Singapore spends, on the average, 1.6 dollars on R&D for every 1,000 dollars of output produced, while the figures for Australia, Canada and United Kingdom are 8.4, 9.2 and 18.7 domestic dollars, respectively. Singapore industry R&D

expenditures contrast sharply with those of the industrialized countries. From the relative low-tech industries to the high-tech industries, Singapore R&D intensity consistently lags far behind that of the industrialized countries. For example, electronic products industry (radio, television, and communication equipment) in Australia, Canada and United Kingdom spend, respectively, 73.8, 130.5 and 62.2 domestic dollars on R&D for every 1,000 domestic dollars of output produced, while the Singapore's figure is only 3.6 dollars.

Many manufacturing plants in Singapore are subsidiaries of their foreign parent companies. These subsidiaries do not engage in substantial R&D. It has been observed that, '...most of the basic research, product design, product development, process development, and innovation technology are done in the home countries' (Chng Meng Kng et al, 1986, p.82). The only important element of local R&D is process adaptation. There are also some local subsidiaries involved in application technology. On the other hand, the wholly local-owned companies almost invariably do not engage in R&D at all. We have here just touched on only one component of technology and skill in Singapore's manufacturing. The next section is devoted to looking at briefly some other aspects of technology and skill in Singapore's priority industries.

### **2.3 AN OVERVIEW OF TECHNOLOGY AND SKILLS IN SINGAPORE'S PRIORITY INDUSTRIES**

Based on the findings of a survey carried out in the middle of 1980s, this section tries to summarize and describe the profile of technology and skills in the priority industries in

Singapore.<sup>8</sup> It looks at, specifically, the mechanics of technology transfer, training of technical personnel for technology transfer, factors behind further technological infusion, technical assistance rendered to local subcontractors, management practices and R&D. The priority industries that are under study can be broadly classified as components of capital goods industry.<sup>9</sup> These industries are, namely, Industrial Machinery or Machinery except Electrical & Electronics (382), Electrical Machinery, Apparatus, Appliances & Supplies (383), Electronic Products and Components (384), and Precision Equipment or Instrumentation Equipment, Photographic & Optical Goods (386).

### 2.3.1 Survey Background

Sixty-five firms from various capital goods industries participating in the survey. Table 2.8 breaks down the participating firms by the type of capital structure and nationality of the firms. Table 2.8 shows that about three-quarters of the participating firms are wholly foreign-owned firms and one-third of them are in Electronics Products and Components (384). Sixty percent of the participated firms are Japanese, while other foreign-owned firms and local Singapore firms account for approximately 26 percent and 14 percent, respectively. It can be concluded that wholly Japanese firms in Electronics Product and Components (384) represent the largest group of firms in the survey.

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<sup>8</sup> The survey was carried out by the ASEAN Secretariat and Japan Institute of International Affairs in collaboration with ASEAN Economic Research Unit of the Institute of Southeast Asian Studies. A monograph entitled *Effective Mechanisms for the Enhancement of Technology and Skills in Singapore* (1986) was written by Chng Meng Kng, Linda Low, Tay Boon Nga and Amina Tyabji to report the findings.

<sup>9</sup> The classification is based on Daniel Chudnovsky and Masafumi Nagao, *Capital Goods Production in the Third World*, 1983.

**Table 2.8: Capital Structure by Type/Nationality and Industry of Surveyed Firms**

Type/Nationality	Industrial Machinery (382)	Precision Equipment (386)	Electrical (383)	Electronics (384)	Total
Wholly Foreign (WF)	10	9	5	23	47
Wholly Local (WL)	3	0	1	1	5
Joint Venture (JV)	7	1	3	2	13
<b>Total</b>	<b>20</b>	<b>10</b>	<b>9</b>	<b>26</b>	<b>65</b>
Japanese	9	7	5	18	39
Other foreign	6	2	2	7	17
Singapore	5	1	2	1	9
<b>Total</b>	<b>20</b>	<b>10</b>	<b>9</b>	<b>26</b>	<b>65</b>

Source:

*Technology And Skills in Singapore, 1986.*

### 2.3.2 Investment Motivations of Foreign-owned Firms in the Survey

Among the questions asked in the survey is what motivates the MNCs to establish manufacturing plants in Singapore. Surveyed firms were asked to rank a list of motivations including low wages, disciplined workforce, investment incentive, good government, political stability, good infrastructure, risk-free, diversification, and few language problems. The result shows that most of the Japanese and other foreign-owned firms rank political stability as the most attractive reason for investing in Singapore. Good infrastructure is ranked second by Japanese firms while other foreign-owned firms rank investment incentive as the second most attractive reason. One major difference between the Japanese and other foreign-owned firms is the ranking of low wages. Japanese firms rank low wages as the third most attractive reason for investing in Singapore while it is the sixth for other foreign-owned firms. Other foreign-owned firms view both disciplined labor force and good infrastructure as the third most attractive reason. The finding confirms that a major reason for Japanese firms to set up plants in Singapore is to take advantage of its relatively low wages.



### 2.3.3 Mechanics of Technology Transfer- Turnkey Factories

The results of the survey show that a most common method of setting up subsidiary plant in Singapore by the parent company is the turnkey method. Almost all surveyed firms, especially those wholly foreign-owned firms, set up their plants using the turnkey method, which involves the sending of machines and engineers' from their parent companies. Expatriate engineers are usually technical managers in the parent company. It has been observed that about one to one and a half year before the setting up of a turnkey plant, the parent company sends a team of top management to Singapore to hand-pick a core of local management and technical staff. These local management and technical staff are then sent to the parent company for training. Later, they accompany the machines and expatriate engineers back to Singapore. This pattern of setting up a turnkey plant is most common among Japanese firms.

One obvious advantage for setting up a turnkey plant is that it minimizes the lead time required for commercial production since procedures are standardized and proprietary knowledge are well safe-guided. Another advantage is that expatriate engineers are standby to handle production problems and train local technical staff. However, turnkey plants are completely dependent on imported technology and expatriate engineers. Consequently, there is usually very little indigenization of technology resulting from turnkey plants.

One common question raised about the turnkey plants is whether the technology used in these plants is update and appropriate. There have been cases when the parent company sends refurbished machines or machines which are less automated to the turnkey plants in Singapore. This usually happens when the parent company decides to replace their older and more labor-intensive machines for the newer machines and when the parent company decides

to transfer the entire section of the production line overseas. In the case of Japanese firms, since Japanese labor cost is at least two-and-a-half times higher than that of Singapore, Japanese firms tend to relocate the more labor-intensive part of their production line to Singapore. It has been observed that, despite the lower labor cost, average productivity of Singapore workers are almost on par with their counterpart in Japan. Singapore workers, however, have a very different work attitude than the Japanese workers, which will be discussed later.

The dependency of turnkey plants on foreign technology and support may gradually decrease and turnkey plants may eventually develop a certain degree of technological independence and local expertise. The first stage occurs when increasing number of local staff are employed for management and technical positions. Contrary to the practice of filling the top management positions by expatriate staffs, the middle management positions are mainly filled by local staff. Local staff members are more likely to hold positions that involve dealings with government and human resources such as accounts, personnel and general administration. Key decision making power is still rested in the hands of the top managers who are either sent directly from the parent company or from other subsidiary plants overseas.

The survey also reports that a major mechanism in technology transfer is foreign training of local employees. Foreign training of local employees is widely carried out in turnkey plants, especially among the wholly foreign-owned firms. For Japanese firms, not only the technical staff is sent for training, but those who are involved in sales and administration are also sent to the parent company to familiarize the production process. This is in line with the Japanese philosophy for their non-technical employees to acquire knowledge of the production process even though the employees are not involved with production at all. Furthermore, Japanese

firms often emphasize the need for their technical workers to acquire a thorough understanding of different aspects of production by rotating and transferring them from production unit to production units. In Japanese firms, all employees, from the top management to assembly operators, are always reminded of the company's philosophy, ethics of work, team spirit and productivity consciousness.

Visits of foreign experts and expatriate engineers stationed in Singapore are both important mechanisms for technology transfer. Visits of foreign experts are usually made on contractual basis and are usually aimed at solving major technical problems or tied up with some training programs that come with the introduction of new machines, new lines of production or new products. Both foreign expert's visits and expatriate engineers stationed in Singapore lead to transfer of operational and problem-solving skills. These two forms of technical support are most important during the initial period of firms' establishment when production problems arise frequently and when technology has yet to be fully mastered.

There are fewer opportunities for local firms to send employees overseas for technical training or receive support from visits of foreign experts. For local firms, visits of foreign experts usually occur when these visits are included in the provisions under technical arrangements or license agreements for which the local firms must pay royalties. However, it is more often that the local firms get technical assistance from their suppliers of machines and other materials and components when the needs arise. Local firms can access to technical assistance through the Small Industries Technical Assistance Scheme sponsored by Economic Development Board.<sup>10</sup> Furthermore, local firms can also acquire new technology when they

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<sup>10</sup> This scheme was first started in 1983. Under this scheme, Economic Development Board bears 90% of the costs of visits of foreign experts.

undertake contracts for the MNCs. In order to make sure the local subcontractors meet their standards, MNCs usually provide them with technical specifications, instructions and technical assistance, and sometimes even with the necessary machines.

#### 2.3.4 Training of Technical Personnel for Technology Transfer

All firms provide on-the-job training to their workers with some firms even setting up in-house training courses to upgrade their workers' basic skills such as mathematics and language. The large foreign-owned firms are more inclined to apply to the Skills Development Fund (SDF) for subsidizing a part of their training cost.<sup>11</sup> They even make use of the SDF to send their technicians back to the parent company for training. The basic educational qualifications of such technicians are usually diploma holders from polytechnics.

To set up training courses in Singapore by expatriate engineers would take a much longer time than sending back the local employees to the parent company for training. The surveyed firms are satisfied with the relevance and quality of the government training courses and are likely to use government training centers and facilities.

One of the reasons that hinders the training of technical personnel is the language barrier, especially among the Japanese firms. Another main reason usually cited is the high labor turnover in Singapore. Many firms do not implement any useful training scheme because employees lack commitment and loyalty towards the firm. One Japanese managing director commented: 'training could entail the disclosure of some of our closely guarded information

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<sup>11</sup> SDF are financial schemes set up by the government to assist firms in staff training and mechanization. It provides subsidies of up to 90% of manpower costs to firms in the priority industries.

on product development and production techniques and, at present, we worry about the possibility of job-hopping by our employees' (Chng Meng Kng et al, 1986, p.73).

### 2.3.5 Factors Behind Technological Infusion

Infusion of productive technology usually takes place when the existing firms undergo changes in the scale and structure of production. The technology introduced can be of two types. One type is the introduction of the existing technology that is relatively labor-intensive. This occurs when the parent company relocates some production lines to Singapore due to the rising labor cost. Another type of technology introduced in Singapore is new technology that has not even been tried in the home country. The parent company tries out the new technology for the first time in Singapore. A comparison of the Japanese firms and other foreign-owned firms finds that Japanese firms tend to introduce fewer new technologies than other foreign-owned firms in Singapore do. The most important factors that influence the decisions of technological infusion in Singapore are tax incentives, preferential tariff treatment for exports from Singapore, use of Singapore as a distribution center, and other attractive government policies.

### 2.3.6 Changes in the Scale and Structure of Production- Automation

Changes in the scale and structure of production, as mentioned above, are usually associated with changes in productive technology. One most important development in this direction is the drive toward automation. Singapore government has been encouraging firms to adopt capital-intensive production in order to increase productivity and to avoid increasing wage costs. Also, competition within the industry is another inducing factor for the firms, especially

the electronic firms, to adopt automation. However, many firms are reluctant to adopt full automation because of the very high costs of such technology and of the small market base that can hardly justify the increased volume of output due to automation. Furthermore, some large foreign-owned firms would rather spend the heavy investment expenditure in the home countries than in offshore plants regardless how favorable the local conditions are.

The use of local research centers has been found unimportant as a factor for inducing technology transfer. The main reason is that R&D are invariably carried out in the parent companies. Local research centers might well have the capability to conduct the relevant R&D, but foreign-owned firms are not interested in engaging such R&D efforts.

### 2.3.7 Technical Assistance Rendered to Local Subcontractors

A common method for technology transfer is when the local subcontractors, usually small indigenous firms, are provided with technical assistance by the foreign-owned firms. The survey reveals that most of the foreign-owned firms source less than 25 percent of their inputs from domestic subcontractors, reflecting the low technological capacity of the local supporting industries. The most common complaints of the foreign-owned firms are poor quality of the components and poor delivery dates of the local subcontractors. Poor quality and delivery dates, which may both be the result of the tight labor market, persist even when the foreign-owned firms provide substantial technical assistance to their local subcontractors. Some foreign-owned firms are then forced to engage in internal backward integration in order to avoid using the unreliable local subcontractors.

Foreign-owned firms prefer to source input components from subcontractors of their nationalities rather than from the indigenous subcontractors. It has been observed that some foreign subcontractors follow the subsidiaries of MNCs into Singapore in order to continue the role of supporting and subcontracting, as what they have been doing in their home countries. Foreign subcontractors have advantages over the indigenous subcontractors because they share the same cultural background, work attitude and style of management as the foreign-owned firms. A Japanese subcontractor, for instance, would be more willing to meet the urgent order of another Japanese firm than an indigenous subcontractor who faces difficulty in motivating the staff to work over-time.

### 2.3.8 Management Practices and Autonomy

The survey reports differences in management practices and the degrees of decentralization between Japanese firms and other foreign-owned firms. The differences may be largely due to the different organization structures and personnel practices. In general, Japanese firms are the least decentralized among all the foreign-owned firms including the American and European firms. The percentage distribution of nationality of professional and management staff shows that Japanese firms in the Precision Equipment (386) and Electrical (383) industries employ more expatriates than locals in their professional staff compared to other foreign-owned firms in these industries. The degree of technology transfer is thus correspondingly lower in Japanese firms than the other foreign-owned firms. Japanese firms appear to practice a more autocratic management style and less delegation of authority, compared to other foreign-owned firms.

The survey also reports the degrees of autonomy of the firms in marketing, financing, employment, and production technique. Marketing is the area where most foreign-owned firms, except those in Precision Equipment (386), enjoy a high degree of autonomy. For employment, there seem to be little restrictions set by parent companies on their subsidiary firms in Singapore. Most foreign-owned firms in the surveyed industries report a high degree of autonomy in employment decisions. Financing is the area that all foreign-owned firms are subject to some kind of restrictions set by their parent companies. In Electrical (383) and Electronic (384) industries, Japanese firms have less autonomy than the other foreign-owned firms do. However, Japanese firms in Electrical (383) industries enjoy greater flexibility in choosing their production techniques than the other foreign-owned firms. In general, the degree of autonomy is expected to vary with the age of the firm and the nature of industry. Older firms and firms in competitive markets are expected to be more decentralized.

### 2.3.9 Research and Development (R&D)

The types of R&D can be classified into: basic research, product design, product development, process development, innovation technology, application technology and process adaptation. The survey results show that parent companies are responsible for choosing and supplying product specifications and new technologies. Basic research, product design, product development, process development and innovation technology are all done in the parent companies. The only significant element in local R&D is process adaptation with a few subsidiaries are also involved in application technology. Wholly owned local firms invariably carried out very little or no R&D and the main factor of this appears to be the lack of resources facing the Singapore firms.



## 2.4 Conclusion

The first part of this chapter traces the economic development of Singapore from the early beginning to the 1990s. Singapore's strategic location contributed significantly to its rapid economic growth both before and after its full independence in 1965. The theory of staple port can be used to describe Singapore's development from the early beginning to the 1960s. From the early 1970s onwards, manufacturing has taken over as the leading sector in the economy. As development progresses, the objective of industrialization also switched from creation of full employment to promotion of high technology and high value-added industries.

To a large extent, the industrial structure of Singapore is a product of the government's emphasis on export-led industrialization. Foreign-owned firms, mostly in Electronic Products and Components (384), produce and export most of Singapore's manufacturing output. These firms are very large firms that, on the average, each firm employs about 500 workers and produces more than ten million dollars worth of output each year. It would be wrong, however, to conclude that the large electronic firms contributed significantly to innovative research and development in Singapore's manufacturing. It has been observed that little skill is required of the assembly-line workers in the electronic firms and that only negligible amount is spent on research and development. Furthermore, the type of research and development carried out is mainly on process adaptation and not on basic research, product design, product development, process development and innovation technology.

The last part of the chapter focuses on the question of technology transfer and skill level in Singapore manufacturing industries. The findings of a survey carried out by the research units of ASEAN and Japan Industrial Co-operation unit show that technology and skills in

Singapore's wholly or majority foreign-owned firms lag behind their parent companies. This can be attributed to a number of reasons: (1) low wages, (2) turnkey plant, (3) high cost of full automation, (4) job-hopping, (5) protection of proprietary technological know-how, (5) minimal local R&D, (6) dissatisfaction with local subcontractors, and (7) highly autocratic style of management.

### CHAPTER THREE

## TECHNICAL PROGRESS IN THE MEASUREMENT OF TOTAL FACTOR

### PRODUCTIVITY GROWTH

#### Introduction

The aim of this chapter is to analyze the effects of imperfect competition, economies of scale and capacity under-utilization on the measurement of productivity growth. Technical change contributes directly to productivity growth since new production methods, improvements on existing production processes and improvements on labor and managerial skills allow output to be produced more efficiently.<sup>1</sup> The conventional measure of total factor productivity growth, TFPG, is often used to proxy the rate of technical change or productivity growth. However, TFPG is not an appropriate measure of technical change if the long-run equilibrium conditions under perfect competition are invalid. We see in this chapter the difference between technical change and TFPG when the assumption of perfectly competitive long-run equilibrium is relaxed.

In addition to the primal measure of technical change, another approach to measuring technical change or productivity growth employs duality theory. Under duality theory, cost diminution associated with the shift in the cost function represents the dual rate of technical change. In the later half of the chapter, we look at the difference between primal and dual technical change when the long-run equilibrium conditions under perfect competition are relaxed.

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<sup>1</sup> Since we are assuming away factors such as X-efficiency, technical change can then be linked directly to productivity growth. In this chapter, we are using the two terms interchangeably.

The model presented in this chapter is related to recent research done by Morrison (1992, 1986) and Kwon (1986). These recent studies look at the importance of returns to scale, market imperfection and capacity under-utilization in productivity measurement from the cost side. Ohta (1975) first points out that the primal measure of technical change is equal to the ratio of elasticity of cost with respect to time to the elasticity of cost with respect to output. Morrison (1986) and Fuss and Waverman (1986) elaborate on this relationship. Other researchers, such as Berndt and Fuss (1986), Hulten (1986), and Morrison (1988), attempt to correct productivity measurement for changes of capacity utilization by relaxing the assumption that market price captures the true marginal return of the fixed input. They use an approach that distinguishes short-run and long run cost curves. In the short-run, capacity utilization is measured by the ratio of shadow price of the fixed input to its market price. This measure is then used to adjust the elasticity of cost with respect to output in the measurement of productivity growth.

Hall (1988) focuses on the measurement of the gap between price and marginal cost and its relation to the measurement of productivity change. Other researchers such as Denny, Fuss and Waverman (1981), Shapiro (1987), Domowitz, Hubbard and Peterson (1988) and Harrison (1994) are more concerned with evaluating the extent of bias associated with the violation of the assumption of perfect competition in the conventional measure of productivity growth.

Morrison (1992) adjusts the measure of primal and dual technical change for market imperfection, economies of scale and sub-equilibrium. Similar to her work, the present study tries to capture the effects of market imperfection, economies of scale and capacity under-

utilization on the primal measure of technical change. In her study, capital and labor are the two quasi-fixed inputs that are subjected to capacity under-utilization. However, capacity utilization, in the present study, directly enters into the cost function as an exogenous variable and, thus, it affects all inputs equally. We see in the latter half of the chapter that the primal and dual technical changes are not equal if capacity is not fully utilized.

Although we discuss the effect of capacity utilization in this chapter, unfortunately it is not included in our empirical implementation of the model in the subsequent chapters. One common approach to measuring the rate of capacity utilization is to use the ratio of the actual consumption of electricity to the maximum possible consumption by installed electric motors (Kwon, 1986). Data for the consumption of electricity by industry and information relating to maximum possible consumption are unavailable, so we only focus on the possible effect of capacity utilization in the model.

Section (3.1) of this chapter discusses the conventional accounting approach of measuring productivity change, TFPG, when the standard neoclassical assumptions are used. We then look at the derivation of a residual term that isolates the primal rate of technical change,  $\dot{T}$ , from the production function in Section (3.2). In Section (3.3) the element of imperfect competition is introduced and incorporated into the measurement of  $\dot{T}$ . We see that if the assumption of perfectly competitive long-run equilibrium is met, *ceteris paribus*, the conventional accounting measure of productivity growth, TFPG, is the same as the primal measure of technical change,  $\dot{T}$ . We see, in this section, the possible bias associated with the accounting measure of productivity growth, TFPG, when the assumption of perfect competition is not valid. Section (3.4) discusses the measurement of productivity growth

using the dual cost approach. In this section, we show the difference between the primal and dual measures of technical change if conditions of long-run equilibrium under perfect competition are invalid. We discuss the elements of imperfect competition, non-constant returns to scale and capacity under-utilization, which affect a firm's measure of productivity growth or technical change in this section.

### 3.1 An Accounting Approach

A straightforward and widely used method to calculate productivity change is the Solow (1958) accounting approach which defines productivity growth as the residual between the rate of output growth and the weighted average of the factor inputs growth. This can be stated as

$$(3.1) \quad TFPG = \dot{Y} - \sum_i \omega_i \dot{X}_i$$

where  $\dot{Y}$  and  $\dot{X}_i$  represent the proportionate growth of output and input respectively.  $\omega_i$  is the share of the  $i$ th factor input in total value of output or revenue.<sup>2</sup> Equation (3.1) allows us to conveniently calculate productivity change without resorting to parametric estimation since, for each time period, the data for  $i$ th factor share of total value of output and quantities of output and most inputs are directly observable. It is then straightforward to calculate productivity change once the relevant data are collected. For example, if capital and labor are the only factor inputs, then (3.1) becomes

$$(3.2) \quad TFPG = \dot{Y} - \omega_K \dot{X}_K - \omega_L \dot{X}_L$$

where  $\omega_K$  and  $\omega_L$  are, respectively, the share of capital and labor input in total revenue and  $\dot{X}_K$  and  $\dot{X}_L$  are, respectively, the proportionate growth of capital and labor input. In practice, the shares of capital and labor input in total revenue or output are often constrained to equal to one because there is no direct measure of the rental price and share of capital, so capital share is measured as a residual. Thus, (3.2) can be simplified to

$$(3.3) \quad TFPG = \dot{Y} - (1 - \omega_L) \dot{X}_K - \omega_L \dot{X}_L$$

To calculate TFPG using (3.3), one only needs to find data on output, capital input, labor input, and the value share of labor in total revenue or output.<sup>3</sup>

### 3.2 Derivation of the Measure For Technical Change

Suppose the production function is specified as

$$(3.4) \quad Y = f(X_i, T)$$

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<sup>2</sup>  $\omega_i$  is sometimes referred to as the payment share of factor i. It does not necessarily equal to the cost share of factor i, as we discuss later in Section 3.3.

<sup>3</sup> When the conditions of long-run competitive equilibrium do not hold, we must consider error in the measurement of  $\omega_K$ . Specifically, in a capitalist system, we might expect that monopoly rent,  $\mu$ , which is usually unobservable, to be measured along with returns to capital. If so, the observed share of capital in revenue will actually be  $\omega_K = (\alpha_K + \mu)$ , where  $\alpha_K$  is the real cost share of capital. We will incorporate this source of error when we relax the assumption of perfect competition in Section 3.3.

where  $Y$  is output,  $X_i$  is a vector of factor inputs and  $T$  is an index of time representing technical change. We assume that the production function specified in Equation (3.4) is a real-valued function, which is monotonically increasing in  $X_i$ , continuous from above and quasi-concave. In addition, as in most empirical work, the production function is assumed to be twice differentiable.

By total differentiating Equation (3.4) with respect to  $T$  and dividing through by  $Y$ , we obtain

$$(3.5) \quad \frac{dY}{dT} \frac{1}{Y} = \sum_i \left[ \frac{\partial f}{\partial X_i} \frac{X_i}{Y} * \frac{dX_i}{X_i} \frac{1}{dT} \right] + \frac{\partial f}{\partial T} \frac{1}{Y}$$

Rearranging Equation (3.5) we get

$$(3.6) \quad \dot{T} = \dot{Y} - \sum_i \varepsilon_i \dot{X}_i$$

where  $\dot{Y} = \frac{dY}{dT} \frac{1}{Y}$ ,  $\varepsilon_i = \frac{\partial f}{\partial X_i} \frac{X_i}{Y}$ ,  $\dot{X}_i = \frac{dX_i}{X_i} \frac{1}{dT}$ , and  $\dot{T} = \frac{\partial f}{\partial T} \frac{1}{Y}$ .  $\dot{Y}$  is the proportionate growth

of output and  $\dot{X}_i$  is the proportionate growth of  $i$ th factor input.  $\varepsilon_i$  is the elasticity of output

with respect to  $i$ th factor input.<sup>4</sup>  $\dot{T}$  is the elasticity of output with respect to time and it

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<sup>4</sup> Constant returns to scale technology implies  $\sum_i \varepsilon_i = 1$ . If technology exhibits constant returns to scale, its production function is homogeneous of degree 1. That is,

$$\lambda Y = f(\lambda X_1, \dots, \lambda X_N)$$

This shows that doubling inputs will result in doubling output. For this type of production function, Euler's theorem specifies

$$Y = f_1 X_1 + \dots + f_N X_N$$

Since  $f_i = \frac{\partial f}{\partial X_i} = \frac{P_i}{P}$ , for  $i = 1, \dots, n$ , we can rewrite the above equation as



represents the proportionate growth of output that cannot be explained by total factor inputs.

$\dot{T}$  can be interpreted as the shift in the isoquant towards the origin over time. Thus, a given level of output can be produced by a lesser quantity of total factor inputs due to technical progress when economies of scale are absent. Note that here an index of time is used to indicate technical change.

Productivity growth measured by the accounting approach, TFPG, in Equation (3.1) does not necessarily equal to the measure for technical change,  $\dot{T}$ . The necessary requirement for TFPG defined in Equation (3.1) to be equal to  $\dot{T}$  is the existence of the perfectly competitive long-run equilibrium in the product and factor markets. The assumption of perfectly competitive long-run equilibrium implies that the inputs are paid the value of their marginal products.<sup>5</sup> Hence, the elasticity of output with respect to any input is equal to their cost share of revenue, which, in turn, is equal to their payment share,  $\omega_i$ . If the assumption of perfectly competitive long-run equilibrium is not met, then TFPG defined by Equation (3.1) cannot be interpreted as the (primal) rate of technical change,  $\dot{T}$ , given by Equation (3.6). We investigate this in more depth in the next section.

### 3.3 Relaxing the Assumption of Perfect Competition

In an industrial setting where firms have some control over the price of their output it is not appropriate to impose the assumption of perfect competition. Firms under imperfect

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$$Y = \frac{P_1 X_1}{P} + \dots + \frac{P_N X_N}{P}$$

or equivalently,

$$1 = \frac{P_1 X_1}{PY} + \dots + \frac{P_N X_N}{PY} = \alpha_1 + \dots + \alpha_N = \sum_i \varepsilon_i$$

competition face a downward sloping demand function. The price of output charged by these firms is not determined by the costs of production alone, but also by the demand that each of these firms is facing. Under this environment, total revenue as a function of the factor inputs,  $R(X_i)$ , facing a firm can be expressed as

$$(3.7) \quad R(X_i) = P(f(X_i))f(X_i)$$

where  $P(f(X_i))$  is the inverse demand function and  $y = f(X_i)$  is the firm's production function. The marginal revenue product,  $MRP_i$ , of the firm can be obtained by differentiating  $R(X_i)$  with respect to  $X_i$  as follows:

$$(3.8) \quad MRP_i = \frac{\partial R(X_i)}{\partial X_i} = P(y)f'(X_i) + f(X_i)P'(y)f'(X_i) = [P(y) + f(X_i)P'(y)]f'(X_i)$$

The term  $P(y) + f(X_i)P'(y)$  on the right-hand side of Equation (3.8) is the firm's marginal revenue,  $MR$ , and the term  $f'(X_i)$  is the firm's marginal product,  $MP$ . Thus, the marginal revenue product of the firm,  $MRP_i$ , is simply equal to the product of its marginal revenue,  $MR$ , and marginal product,  $MP$ . Marginal revenue product gives the incremental revenue that goes to the firm as a result of hiring an additional unit of factor input. Alternatively, we can express Equation (3.8) as

$$(3.9) \quad MRP_i = P(y) \left[ 1 - \frac{1}{|\eta|} \right] f'(X_i)$$

---

<sup>5</sup> Long-run perfect competitive equilibrium also implies that monopoly rent is zero.

where  $|\eta|$  is (the absolute value of) the elasticity of the firm's demand function. It is clear from Equation (3.9) that the demand condition facing a firm affects the quantity of factor inputs employed by this firm.

To consider the effect of imperfect competition on productivity measurement, let us define  $\mu$  as the proportional excess of price over marginal cost or the price-cost margin as follows:

$$(3.10) \quad \mu = \frac{P(y) - MC}{P(y)}$$

$\mu$  indicates the amount a firm raises price over marginal cost and, thus, can be used as a proxy for the degree of competition faced by this firm in the product market. The price-cost margin is often referred to as the Lerner index. Since profit is maximized when marginal revenue equals to marginal cost,  $MR = MC$ , and marginal revenue can be expressed as

$P(y) \left[ 1 - \frac{1}{|\eta|} \right]$ , the price-cost margin of a profit-maximizing firm can be shown to be related

to the firm's elasticity of demand as follows:<sup>6</sup>

$$(3.11) \quad \mu = \frac{P - MC}{P} = \frac{1}{|\eta|}$$

The price-cost margin is equal to the inverse of the (absolute value of) elasticity of demand,  $|\eta|$ . It can be easily seen that if the product market is perfectly competitive, firms are facing a perfectly elastic market demand which forces the price-cost margin to zero. A price-setting

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<sup>6</sup> To simplify notation, we now write  $P(y)$  as  $P$ .

firm facing a downward sloping demand function, however, can enjoy a positive amount of price-cost margin.

With Equation (3.11), we can rewrite marginal revenue product as follows:

$$(3.12) \quad MRP_i = P[1 - \mu]f'(X_i)$$

A firm facing a competitive factor market can hire as many units of factor inputs as it requires at a constant factor price,  $P_i$ . Then, a profit-maximizing firm would hire an additional unit of input only when this unit of input can increase the firm's revenue to cover the additional cost. That is, the firm would continue to hire a factor input until the marginal revenue product of the last unit employed is equal to the price of this factor input. Thus,  $MRP_i = P_i$  and we can rewrite Equation (3.12) as

$$(3.13) \quad f'(X_i) = \frac{\partial f}{\partial X_i} = \left( \frac{1}{1 - \mu} \right) \frac{P_i}{P}$$

Equation (3.13) incorporates the effect of imperfect competition into the marginal product of the  $i$ th factor input. The marginal product of the  $i$ th factor input is now related to the price-cost margin, which indicates the degree of competition faced by a firm. If the market is perfectly competitive, a firm cannot mark up its price over marginal cost ( $\mu = 0$ ). Thus, the

marginal product of the  $i$ th factor input is equal to the ratio of wage over price. Equation (3.13) then reduces to the special case of perfect competition represented by<sup>7</sup>

$$(3.14) \quad \frac{\partial \mathcal{F}}{\partial X_i} = \frac{P_i}{P}$$

If, however, a firm has certain degree of market power to set its own price above marginal cost ( $\mu > 0$ ), the marginal product of the  $i$ th factor input is now equal to an adjustment factor,  $\frac{1}{(1-\mu)}$ , times the ratio of wage over price.

Using Equation (3.13), the elasticities of output with respect to  $i$ th factor inputs can then be expressed as

$$(3.15) \quad \varepsilon_i = \frac{\partial \mathcal{F}}{\partial X_i} \frac{X_i}{Y} = \left[ \frac{1}{1-\mu} \right] \frac{P_i}{P} \frac{X_i}{Y} = \left[ \frac{1}{1-\mu} \right] \alpha_i$$

where  $\alpha_i$  is the share of the  $i$ th factor input in total revenue. We often refer  $\alpha_i$  as the cost share of factor input. Substituting Equation (3.15) into (3.6), we obtain

$$(3.16) \quad \dot{T} = \dot{Y} - \frac{1}{(1-\mu)} \sum_i \alpha_i \dot{X}_i$$

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<sup>7</sup> Alternatively, we can express Equation (3.14) as  $VMP = P \frac{\partial \mathcal{F}}{\partial X_i} = P_i$ , where  $VMP$  stands for the value of marginal product.

It can be seen from Equation (3.16) that TFPG in the conventional accounting approach will be different from the technical change concept of productivity growth,  $\dot{T}$ , unless the conditions of long run perfectly competitive equilibrium are met, *ceteris paribus*. Equation (3.16) represents the calculation of productivity growth after having taken into account the fact that a firm may possess a certain degree of market power in raising its price over marginal cost.

We can see more clearly the difference between TFPG and  $\dot{T}$  by deriving an expression that express TFPG in terms of the price-cost margin and the difference between the payment share of factor input,  $\omega_i$ , and the cost share of factor input,  $\alpha_i$ . Let us define

$$(3.17) \quad \omega_i = \alpha_i + \theta_i$$

where  $\theta_i$  stands for the error terms that exist because of imperfect competition, economies of scale, imperfect information and disequilibrium.

Substituting (3.17) into (3.1) to get

$$(3.18) \quad TFPG = \dot{Y} - \sum_i (\alpha_i + \theta_i) \dot{X}_i = \dot{Y} - \sum_i \alpha_i \dot{X}_i - \sum_i \theta_i \dot{X}_i$$

From (3.15) we get  $\alpha_i = (1 - \mu)\varepsilon_i$ , which can be substituted into (3.18) to get

$$(3.19) \quad TFPG = \dot{Y} - (1 - \mu) \sum_i \varepsilon_i \dot{X}_i - \sum_i \theta_i \dot{X}_i$$

Under the conditions of perfectly competitive long-run equilibrium, TFPG given by (3.19) is equivalent to the primal rate of technical change,  $\dot{T} = \dot{Y} - \sum_i \varepsilon_i \dot{X}_i$ , since the price-cost margin is zero and each of the error terms in  $\omega_i$  is zero. It is clear from looking at (3.19) that whether TFPG equals to the primal rate of technical change depends on the price-cost margin and the error terms in measuring  $\omega_i$ .

We can now move on to derive an expression for the amount of possible bias that is introduced by the erroneous assumption of perfectly competitive long-run equilibrium. If a firm under study is able to mark up its price over marginal cost and/or paying a factor not equal to its marginal contribution, then the firm's calculated TFPG is different from its primal rate of technical change,  $\dot{T}$ . We can derive the TFPG bias by subtracting Equation (3.16) from (3.1) and rearranging to get

$$(3.20) \quad TFPG - \dot{T} = \sum_i \left( \frac{\alpha_i}{(1-\mu)} - \omega_i \right) \dot{X}_i$$

It can be seen from (3.20) that the TFPG bias can be positive or negative. If all the factors are paid their marginal contribution, the factor payment shares are equal to the cost shares and each parenthesis in (3.20) is positive. Under this condition, there is no bias to TFPG unless there is imperfect competition and the shares add to less than one. In this case the bias is positive and increases with the growth of inputs and with the degree of imperfect competition. However, if cost shares deviate from the factor payment shares and the latter sum to one, the direction of the bias in TFPG is ambiguous.

We now consider a special case of TFPG bias using Equation (3.20). First, rewrite (3.20) as

$$(3.21) \quad TFPG - \dot{T} = \sum_j \left( \frac{\alpha_j}{(1-\mu)} - \omega_j \right) \dot{X}_j + \left( \frac{\alpha_K}{(1-\mu)} - \omega_K \right) \dot{X}_K$$

If we have an environment where constant returns to scale prevails and all the monopoly rent goes to capital, then

$$(3.22) \quad \omega_K = \alpha_K + \mu \text{ and } \sum_j \alpha_j + \alpha_K + \mu = 1$$

where the subscript  $j$  stands for all inputs except capital. We also impose the condition that the cost share of factor input  $j$  is equal to its payment share,

$$(3.23) \quad \alpha_j = \omega_j \text{ for all } j \ (j \neq K)$$

Substituting (3.22) and (3.23) into (3.21) and rearrange, we get

$$(3.24) \quad TFPG - \dot{T} = \sum_j \left( \frac{\mu}{(1-\mu)} \alpha_j \right) \dot{X}_j - \left( \frac{\mu}{(1-\mu)} \sum_j \alpha_j \right) \dot{X}_K \quad (j \neq K)$$

It can be seen clearly from (3.24) that the growth of capital input has a negative impact on TFPG bias whereas the growth of all other factor inputs has a positive impact on TFPG bias.



If the growth of capital input dominates the growth of all other factors, then we should expect to find a net negative TFPG bias, *ceteris paribus*.

Equation (3.16) gives the primal rate of technical change under the condition that a firm may possess some kind of market power. In the next section, we look at how the dual rate of technical change (productivity growth) is derived and how it relates to the primal rate of technical change.

### 3.4 Technical Change, Economies of Scale and Capacity Utilization - A Cost Dual Approach

The purpose of this section is to derive an expression, which decomposes the major components of dual technical change into the primal technical change, economies of scale and capacity utilization when the long-run equilibrium conditions of perfect competition do not hold. First, we extend a framework employed by Kwon (1986) and Denny, Fuss, and Waverman (1981).

Under the assumption of cost-minimizing behavior, duality theory implies that for any production function there exists a unique cost function that provides an equivalent description of the technology given that certain regularity conditions (maintained hypotheses) are met (Shephard, 1953). For a cost function specified as

$$(3.19) \quad C = g(Y, P_i, T, D)$$

where  $C$  is total cost,  $Y$  is output,  $P_i$  is a vector of factor input prices,  $T$  represents other exogenous factors such as technical change and  $D$  is the rate of capacity utilization, the regularity conditions can be summarized as follows:<sup>8</sup>

1. Domain:  $g$  is a real valued function defined for all positive prices and all positive producible outputs. In addition,  $C = g(0, P_i, T, D) = 0$ .
2. Monotonicity:  $g$  is non-decreasing in outputs and factor prices.
3. Continuity:  $g$  is a continuous function in  $Y$  and  $P_i$ .
4. Concavity:  $g$  is a concave function in  $P_i$ .
5. Homogeneity:  $g$  is a linear homogeneous function in  $P_i$ .

An additional assumption often applied in empirical work is

6. Differentiability:  $g$  is to be twice differentiable in  $P_i$ .

Condition 6 allows the cost function to generate a system of factor demand functions. Also, the symmetry property derived from Condition 6 is useful in reducing the number of parameters to be estimated, thus conserving degrees of freedom and possibly eliminating multicollinearity problems (Fuss, MacFadden and Mundlak, 1978).

If the regularity conditions are satisfied, the cost function will, then, embody the technological specification of the underlying production function provided the production function is well behaved as defined in Equation (3.4).

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<sup>8</sup> See detailed discussion by Shephard (1953) and Uzawa (1964). Also, Fuss, MacFadden and Mundlak (1978) provides a concise description of the dual transformation of the production function.

We adopt the cost function specified by Equation (3.19) in our present study. Totally differentiating Equation (3.19) with respect to  $T$  and dividing through by  $C$ , we get

$$(3.20) \quad \frac{dC}{dT} \frac{1}{C} = \frac{\partial g}{\partial Y} \frac{dY}{dT} \frac{1}{C} + \sum_i \frac{\partial g}{\partial P_i} \frac{dP_i}{dT} \frac{1}{C} + \frac{\partial g}{\partial T} \frac{1}{C} + \frac{\partial g}{\partial D} \frac{dD}{dT} \frac{1}{C}$$

Shephard's Lemma (1970) states that the cost-minimizing optimal demand for input  $i$  can be derived by differentiating the cost function with respect to the factor price of input  $i$ ,

$\frac{\partial g}{\partial P_i} = X_i$ . Making use of Shephard's Lemma and rewriting Equation (3.20) yields

$$(3.21) \quad \dot{C} = E_{CY} \dot{Y} + \sum_i \frac{P_i X_i}{C} \dot{P}_i + \dot{\beta} + E_{CD} \dot{D}$$

where  $\dot{C} = \frac{dC}{dT} \frac{1}{C}$ ,  $E_{CY} = \frac{\partial g}{\partial Y} \frac{Y}{C}$ ,  $E_{CD} = \frac{\partial g}{\partial D} \frac{D}{C}$ ,  $\dot{P}_i = \frac{dP_i}{dT} \frac{1}{P_i}$ ,  $\dot{\beta} = \frac{\partial g}{\partial T} \frac{1}{C}$  and  $\dot{D} = \frac{dD}{dT} \frac{1}{D}$ .

$\dot{C}$  is the proportionate change in total cost.  $E_{CY}$  and  $E_{CD}$  are the elasticities of cost with respect to output and capacity utilization, respectively.  $\dot{\beta}$  is the proportionate change in total cost due to time.  $\dot{P}_i$  and  $\dot{D}$  are the proportionate change in factor prices and capacity utilization, respectively.

Equation (3.21) describes the total proportionate change in cost over time. The total proportionate change in cost over a given time period is determined by the joint effects of various factors. First, it is determined by the proportionate change in output weighted by the cost elasticity of output,  $E_{CY}$ . It is obvious that, with constant returns to scale,  $E_{CY} = 1$ , an

increase in the rate of production will lead to a proportionate increase in cost over time given all other factors remain unchanged. With increasing (decreasing) returns to scale,  $E_{cy}$  is less (greater) than one and, consequently, the amount of increase in cost due to the increase in the rate of production would be less (more) than those under constant returns to scale. Similarly, the same observation applies to factor prices. When the rates of change of factor prices increase, total cost increases at the same rate keeping all other factors unchanged.

$\dot{\beta}$ , the dual measure of technical change, is the rate of cost diminution due to time and it can be represented by the shift in an iso-cost function towards the origin.<sup>9</sup>  $\dot{\beta}$  can be shown to be equal to the primal rate of technical progress,  $\dot{T}$ , if the assumption of perfectly competitive long-run equilibrium is met. Under this condition, technical change translates to a negative  $\dot{\beta}$ , since technological advances imply new production methods and/or improvements on existing production processes which make cost savings possible in the production of any given quantity of output.

The effect of capacity utilization on the proportionate change in cost should be negative when the firm is below capacity. That is, if there is an increase in the rate of utilization of existing capacity, the proportionate change in cost should diminish accordingly. The cost diminution associated with increasing rate of utilization of capacity simply reflects the fact that the cost of inputs per unit of output diminishes as the rate of utilization increases.<sup>10</sup>

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<sup>9</sup> Note that  $\dot{\beta}$  can also be referred to as the elasticity of cost with respect to time, ECT. In Chapter Six, we switch to the notation ECT instead of  $\dot{\beta}$  when we discuss the estimation results.

<sup>10</sup> In general, the sign of the relationship between utilization and cost depends on the difference between the shadow price of inputs and their market prices. It is negative when the firm is below capacity and positive when beyond capacity.

It is possible now to derive an expression for the rate of cost diminution from Equation

(3.21). First, total differentiating  $C = \sum_i P_i X_i$  with respect to time and rearranging, we get

$$(3.22) \quad \sum_i \frac{P_i X_i}{C} \dot{P}_i = \dot{C} - \sum_i \frac{P_i X_i}{C} \dot{X}_i$$

Substituting Equation (3.22) into (3.21) we get

$$(3.23) \quad \sum_i \frac{P_i X_i}{C} \dot{X}_i = E_{CY} \dot{Y} + \dot{\beta} + E_{CD} \dot{D}$$

From Section (3.3), we recall Equation (3.16), which gives the expression for  $\dot{T}$  under imperfect competition. It can be rewritten as

$$(3.24) \quad \sum_i P_i X_i \dot{X}_i = PY(1 - \mu)[\dot{Y} - \dot{T}]$$

An expression for  $\dot{\beta}$  in terms of the effects of imperfect competition, returns to scale, primal technical change and capacity utilization can be derived by combining Equation (3.23) and (3.24). Substituting Equation (3.24) into (3.23) and rearranging, we get

$$(3.25) \quad \dot{\beta} = \left[ \frac{PY(1 - \mu)}{C} - E_{CY} \right] \dot{Y} - \frac{PY}{C}(1 - \mu)\dot{T} - E_{CD}\dot{D}$$

Since average cost,  $AC$ , is defined as cost per unit of output,  $C/Y$ , and  $(1 - \mu) = MC/P$ ,

Equation (3.25) can be rewritten as

$$(3.26) \quad \dot{\beta} = \left[ \frac{MC}{AC} - E_{CY} \right] \dot{Y} - \frac{MC}{AC} \dot{T} - E_{CD} \dot{D}$$

Furthermore, the elasticity of cost with respect to output,  $E_{CY}$ , is defined as

$$(3.27) \quad E_{CY} = \frac{\partial \ln C}{\partial \ln Y} = \frac{\partial C / \partial Y}{C/Y} = \frac{MC}{AC}$$

Thus, it can be seen from Equation (3.27) that a firm's returns to scale is directly related the cost structure of the firm at the optimum level of production. Substituting Equation (3.27) into (3.26) yields

$$(3.28) \quad \dot{\beta} = -\frac{MC}{AC} \dot{T} - E_{CD} \dot{D}$$

Equation (3.28) summarizes the roles of capital utilization and perfect competition in the measurement of dual measure of productivity growth or technical change. Under the conditions of long-run competitive equilibrium, we can see that the dual rate of technical change is equal to the primal rate of technical change.<sup>11</sup> That is

$$(3.29) \quad \dot{\beta} = -\dot{T}$$

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<sup>11</sup> A recent study done by Roeger (1995) has shown that the primal and dual rate of productivity change are highly correlated after controlling the presence of a mark-up component.

Thus, with the neoclassical assumptions of perfect competition and full utilization of capacity, the dual rate of technical change,  $\dot{\beta}$ , is then equal to the (negative) primal rate of technical change,  $\dot{T}$ . For a given primal rate of technical change,  $\dot{T} > 0$ , it translates to an equivalent (negative) rate of cost diminution,  $\dot{\beta} < 0$ . Under this condition, the rate of cost diminution isolates technical progress.

We have yet to discuss the effect of returns to scale on the measurement of dual technical change. For our convenience, we can rewrite Equation (3.28) as

(3.30)  $\dot{\beta} = -E_{CY}\dot{T} - E_{CD}\dot{D}$

Equation (3.30) provides us with a way to look at how economies of scale affects the measurement of dual technical change. A perfectly competitive firm must be facing constant returns to scale technology. On the other hand, an oligopolistic firm can either face increasing, decreasing or constant returns to scale. Table (3.1) summarizes the effect of economies of scale on the measurement of dual technical change.

**Table 3.1: The Effect of Returns to Scale on the Measurement of Dual Technical Change**

	$\dot{T} > 0$	$\dot{T} < 0$
Increasing Returns to Scale ( $E_{CY} < 1$ )	Making $\dot{\beta}$ less negative implies underestimating $\dot{T}$	Making $\dot{\beta}$ less positive implies underestimating $\dot{T}$
Constant Returns to Scale ( $E_{CY} = 1$ )	None	None
Decreasing Returns to Scale ( $E_{CY} > 1$ )	Making $\dot{\beta}$ more negative implies overestimating $\dot{T}$	Making $\dot{\beta}$ more positive implies overestimating $\dot{T}$

Increasing (decreasing) returns to scale technology reduces (increases) the magnitude of the dual technical change, while the direction of this effect is determined by the sign of primal technical change. Hence, using the dual measure results in a smaller estimate of technical change compared to that of the primal measure when the industry or firm under study faces imperfect competition and increasing returns to scale. On the other hand, the effect is just the opposite when the industry or firm under study faces imperfect competition and decreasing returns to scale. Constant returns to scale technology has no effect on the dual technical change or productivity change.

In concluding this chapter, we assert that in general the primal and dual technical changes are not equal due to the violation of the neoclassical conditions of perfectly competitive long-run equilibrium. As shown in (3.30), when the assumption of long-run equilibrium is not met, firms could experience economies of scale and/or under-utilization that lead to disparate rates of primal and dual technical changes. It is under the assumption of perfectly competitive long-run equilibrium, where constant returns to scale and full utilization prevail, that the two measures of technical changes can be treated as the same one. Furthermore, if the conditions of perfectly competitive long-run equilibrium are met, the conventional accounting TFPG is equal to both the primal and dual rate of technical change.

We have completed the discussion on the bias of the conventional TFPG and the decomposition of the dual measure of technical change. In the next chapter, we look at the calculation of the conventional accounting TFPG.



## **CHAPTER FOUR**

### **CONVENTIONAL MEASUREMENT OF TECHNICAL PROGRESS USING THE ACCOUNTING APPROACH**

#### **Introduction**

The accounting approach stated in Equation (3.1) is widely used in the calculation of productivity growth. This approach offers a convenient way to calculate productivity growth without resorting to parametric estimation of either a production or cost function. Hence, it is particularly attractive when estimation is constrained by limited degrees of freedom. Furthermore, it has the added advantage that it imposes less stringent data requirements than those of the parametric techniques. This is because, in using the accounting approach for intertemporal studies, observations are required for the base and end period only. On the other hand, any parametric techniques would require a complete set of time-series data for the relevant variables.

In this chapter, we calculate the conventional TFPG by using the accounting approach. The method of Tornqvist index will be adopted to implement the accounting approach. Furthermore, we will calculate the primal rate of technical change,  $\dot{T}$ , by using Equation (3.16). The gross profit margin will be computed from the industrial data and used to proxy the price-cost margin,  $\mu$ . We can then use the proxy for the price-cost margin to calculate the primal rate of technical change.

Section (4.1) presents the form of Tornqvist index number that we adopt for our analysis. Data requirements and sources of data for the implementation of the TFPG calculation are discussed in Section (4.2). In this section, we also discuss briefly the movements of the observed data series for the period under study. A recurring theme in our empirical study, which is emphasized under this section, is the possible sources of measurement errors posed by limited and inadequate data. We present and discuss briefly the results of our TFPG calculation in Section (4.3). Section (4.4) discusses the calculation of the gross profit margin and the calculation of  $\dot{T}$ . Finally, some concluding remarks are made in Section (4.5).

#### 4.1 The Tornqvist Index

The Tornqvist index belongs to a class of “superlative” index numbers that represent that class of equations that are exact for quadratic functional forms.<sup>1</sup> The notion of superlative index numbers is introduced by Diewert (1976). Diewert shows that for intertemporal comparisons, the Tornqvist index approximation to a Divisia aggregate input index is exact for a linear homogeneous translog production function.<sup>2</sup> Denny and Fuss (1980), Denny, Fuss and May (1981) and Caves, Christensen and Diewert (1982) have since extended the superlative index numbers to analysis relating to interspatial studies of efficiency and cases where constant returns to scale is not a maintained hypothesis.

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<sup>1</sup> See Diewert (1976) for a discussion of exact and superlative index numbers. The quadratic form is taken to be the translog function, which is the most frequently used flexible function in empirical work. The translog function is a second-order Taylor series expansion of  $\ln f(p)$  about the point  $\ln p$  (Greene, 1993).

Equation (4.1) gives the specific form of Tornqvist index for the calculation of TFPG, when capital and labor are the only two factor inputs. Note that only the factor share of labor is used in Equation (4.1), since the conventional simplifying practice is to treat capital share as residually determined.

$$(4.1) \quad TFPG = [\ln Y(T) - \ln Y(T-1)] - \frac{1}{2} [\omega_L(T) + \omega_L(T-1)] [\ln L(T) - \ln L(T-1)] - \frac{1}{2} [(1 - \omega_L(T)) + (1 - \omega_L(T-1))] [\ln K(T) - \ln K(T-1)]$$

where  $(T)$  and  $(T-1)$  represent current and previous time period.  $\ln Y$ ,  $\ln L$  and  $\ln K$  are logarithm of output, labor and capital, respectively.  $\omega_L$  corresponds to the factor payment share of labor, which is different from the cost share of labor. As what we explained in the last chapter, the factor payment shares normally sum to one in accordance with the conventional accounting practice, while the same cannot be applied to the cost shares. Equation (4.1) shows that TFPG is the residual difference of the growth of real output and the weighted growth of capital and labor input.

If, now, we include materials and energy with the primary inputs of capital and labor and maintain the conventional simplifying practice of a residually determined capital share, then Equation (4.1) can be rewritten as

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<sup>2</sup> Recall from Chapter One that the Divisia index is a continuous index, which cannot be calculated from

(4.2)

$$\begin{aligned}
TFPG = & [\ln Y(T) - \ln Y(T-1)] - \frac{1}{2} [\omega_L(T) + \omega_L(T-1)] [\ln L(T) - \ln L(T-1)] - \\
& \frac{1}{2} [\omega_M(T) + \omega_M(T-1)] [\ln M(T) - \ln M(T-1)] - \frac{1}{2} [\omega_E(T) + \omega_E(T-1)] [\ln E(T) - \ln E(T-1)] - \\
& \frac{1}{2} [(1 - \omega_L(T) - \omega_M(T) - \omega_E(T)) + (1 - \omega_L(T-1) - \omega_M(T-1) - \omega_E(T-1))] [\ln K(T) - \ln K(T-1)]
\end{aligned}$$

where  $M$  and  $E$  denote material and energy input, respectively. The factor payment share of the  $i$ th input is denoted by  $\omega_i$  with  $i = K, L, M, E$ . Again, the factor payment shares sum to one so that the capital payment share,  $\omega_K$ , can be calculated residually.

Equation (4.2) defines TFPG as the residual difference between output growth and the weighted growth of total factor inputs, all measured in real terms. This is the appropriate form, which we will employ for the calculation of TFPG. In the next section, definition, sources and description of data will be discussed for each of the required variables in the calculation of TFPG.

## 4.2 Data Requirements and Sources of Data

Our calculation of TFPG using Equation (4.2) requires input and output data. Time-series data at the 3-digit Singapore Standard Industrial Classification (SSIC) industrial level are taken from the following published government sources:<sup>3</sup>

1. *Census of Industrial Production (CIP)*- Economic Development Board (EDB), various issues.
2. *Yearbook of Statistics of Singapore (YSS)*- Department of Statistics, various issues.
3. *Economic and Social Statistics of Singapore 1960-1982 (ESSS)*- Department of Statistics.
4. *Monthly Digest of Statistics (MDS)*- Department of Statistics, various issues.

Twenty-seven industries are included in the study and the period under study is from 1975 to 1994.<sup>4</sup> All data in current dollars are deflated to 1985 constant dollars. All data series that have been used in the calculation of TFPG in this chapter are listed in the appendix.

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<sup>3</sup> In addition to the published sources of data listed below, some data are supplied by the Economic Development Board upon request. Their support is gratefully acknowledged by the author.

<sup>4</sup> It is more desirable to use a longer time series in the present study. However, an extension of time series to pre-1970 years is difficult due to the reclassification of industries in 1971.

#### 4.2.1. Output

In this study, output is defined as the total industrial gross output measured in constant dollars.<sup>5</sup> The total industrial gross output refers to, as defined by CIP, “the total value of all commodities produced (including by-products) and industrial services rendered during the year. The valuation of commodities produced is at ex-factor price, excluding outward transport charges and excise duties, if any”.

The Annual Index of Industrial Production taken from various issues of YSS gives the growth of gross output in real terms for industries under study. The growth of real output data series is, then, calculated from first deflating the nominal gross output to 1985 constant dollar gross output.

It should be noted that serious upward or downward biases can be introduced through the adaptation of an inappropriate method in deflating current dollar output to constant dollar output (Kendrick, 1989). The most common source of bias is introduced from price deflators, which do not take into account quality improvement in products. It is argued by some authors (for example, Trajtenberg, 1989) that the conventional price index approach cannot capture quality improvement in price changes. For industries which are undergoing a fast pace of technological innovation, it is likely that the level and/or trend of productivity growth will be understated if the price index fails to reflect the decline in prices due to influx of technological innovations and diffusion.

It has been generally recognized that output and productivity estimates do not adequately reflect changes in quality of goods and services, although shifts among different quality of a product are reflected. For example, the official United States price and real product estimates reflect quality improvements only to the extent that the real unit costs of new models exceed those of the supplanted models. Denison (1979) thinks this is appropriate. However, starting from 1986, the Bureau of Economic Analysis in the United States introduces a new computer price index, based on a hedonic regression method, into the national accounts and revises them back to 1972 (Cole et al., 1986). This index is falling by about 15 percent per year or more as compared to the assumed value of zero before. This new price index makes the apparent recovery in manufacturing productivity in the 1980s in the United States much stronger, with about one-third of the total coming from the introduction of this price index alone (Gordon, 1993).<sup>6</sup> Unfortunately, adjusting price indices for quality improvements is almost never practiced elsewhere. Hence, this source of possible measurement error is difficult, if not impossible, to avoid.

The choice of an output measure between real gross output and real value added in our study is made in view of the possible sources of biases associated with using real value added. Although the use of real value added as an output measure offers the convenience that intermediate inputs can be excluded from the calculation, it should only be used

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<sup>5</sup> Industries are defined according to the Singapore Standard Industrial Classification (SSIC).

<sup>6</sup> The Bureau of Economic Analysis has come under criticism that the quality adjustment made for computer prices is unique. No other high-tech product has received the same adjustment. Indeed, no other good or service has received the same treatment.

when certain restrictive assumptions are met.<sup>7</sup> Due to the difficulties usually encountered in using real value added as an output measure for TFPG measurement, most researchers (for example, Kendrick, 1989) recommend the use of real gross output in industry or firm level studies. Measuring TFPG from real gross output also allows us to examine the degrees of substitution among the intermediate, as well as the basic, factor inputs. In addition, the question of input-saving technical progress can be studied for all classes of factor inputs.

Table (4.1) shows that the rate of growth of real output has experienced major fluctuations since the mid-1970s. Singapore's manufacturing industries experienced a high growth period in the 1970s due to favorable external market demand and an abundant supply of labor. We can see that the growth of real output over the 1975-80 period averages 9.0% per annum for the industries under study. However, the favorable conditions facing Singapore manufacturing industries ceased to exist by the end of 1970s as the world recession started to dampen the demand for Singapore's manufacturing products. More importantly, the pool of domestic labor became increasingly depleted, adding more pressure to increase further the already large amount of foreign labor from the neighboring countries.<sup>8</sup> The growth of real output in Table (4.1) shows an industrial

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<sup>7</sup> Bruno (1978) and Diewert (1978) show that the value added output measure is valid only when the underlying production function is additive-separable of the form  $Y = VA + M$  where  $VA$  is real value added,  $M$  is intermediate input and  $Y$  is gross output or, equivalently, in cases where prices of outputs and intermediate inputs vary in strict proportion.

<sup>8</sup> Malaysia and Indonesia are the main sources of unskilled labor for Singapore's economy. The proportion of non-residents in the manufacturing labor force reached 11.3% in 1980 (Tsao, 1985).



average of 1.2% over the period 1980-85. This modest growth rate is largely the effect of the severe depression facing Singapore in 1985.<sup>9</sup>

Singapore made a remarkable recovery from the severe depression of 1985. After the implementation of a series of policies aimed at technological advance and structural change, Singapore's real output growth bounced back to 10.3% per annum over the period 1985-1990. Real output continued to grow at an average of 6.2% in Singapore over the period 1990-94.

#### 4.2.2 Labor Inputs

Labor input refers to the total number of paid employees in the industry. Since the total number of hours worked for each industry is unavailable, we, thus, are not able to control for the variation in labor intensity across the different phases of business cycle. The consequence of this possible source of measurement error is that the resulting TFPG measure will be biased either upward or downward depending on whether the labor input measure understates or overstates the actual labor intensity.

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<sup>9</sup> In 1985, the real output declined for the first time in Singapore. It declined by 6.6% from the previous year.

**Table 4.1: Per Annum Real Output Growth- 1975-94**

Industry	SSIC	Per Annum Real Output Growth (x100%)				
		75-80	80-85	85-90	90-94	75-94
Food	311/2	0.067	-0.027	0.033	0.022	0.027
Beverage	313	0.074	-0.009	0.063	0.026	0.044
Tobacco	314	-0.005	0.028	0.166	0.127	0.086
Textiles & Textile Manufactures	321	0.017	-0.182	0.032	-0.036	-0.054
Wearing Apparel except Footwear	322	0.026	0.003	0.055	-0.092	0.000
Leather & Leather Products	323	-0.029	-0.109	-0.019	-0.015	-0.051
Footwear	324	-0.106	-0.121	0.068	-0.005	-0.053
Sawn Timber & Other Wood Products except Furniture	331	-0.029	-0.142	-0.066	-0.060	-0.087
Furniture & Fixtures except primarily of Metal, Stone & Plastics	332	0.150	0.032	0.015	0.058	0.072
Paper & Paper Products	341	0.083	-0.092	0.096	-0.003	0.022
Printing & Publishing	342	0.100	0.051	0.075	0.063	0.084
Industrial Chemicals & Gases	351	0.081	0.208	0.078	0.038	0.118
Paints, Pharmaceuticals & Other Chemical Products	352	0.084	0.061	0.093	0.051	0.085
Petroleum Refineries & Petroleum Products	353/4	0.059	0.028	0.053	0.039	0.052
Rubber Products, Jelutong & Gum Damar	355/6	0.041	-0.051	-0.034	0.042	-0.004
Plastic Products	357	0.047	-0.025	0.042	0.052	0.032
Pottery, China, Earthenware & Glass Products	361/2	0.068	-0.165	-0.022	0.055	-0.027
Non-metallic Mineral Products	369	0.050	-0.053	0.129	0.018	0.040
Iron and Steel	371	0.074	0.042	0.036	0.012	0.049
Non-ferrous Metals	372	0.044	-0.029	0.010	0.041	0.017
Fabricated Metal Products except Machinery & Equipment	381	0.039	-0.005	0.072	0.043	0.042
Machinery except Electrical & Electronic	382	0.108	0.008	0.076	0.051	0.070
Electrical Machinery, Apparatus, Appliances & Supplies	383	0.230	0.013	0.105	0.046	0.113
Electronic Products & Components	384	0.230	0.032	0.178	0.102	0.156
Transport Equipment	385	0.082	-0.012	0.116	0.021	0.060
Instrumentation Equipment, Photographic & Optical Goods	386	0.054	-0.074	0.122	0.100	0.052
Other Manufacturing Industries	390	0.054	-0.074	0.075	-0.079	-0.006
Industrial Average		0.090	0.012	0.103	0.062	0.083

Notes:

Industrial average refers to the sum of growth rates of the 27 industries weighted by their respective output share.

Sources:

*Census of industrial production*, various issues.

*Yearbook of Statistics of Singapore*, various issues.

*Economic and Social Statistics of Singapore 1960-1982*.

Another possible source of measurement error is posed by treating all labor as a homogeneous input. The simplifying assumption that labor is homogeneous ignores the fact that an hour of work done by skilled workers would contribute more to the total value of output than by those who are less skilled. Thus, the composition of labor input and the change of this composition can also affect TFPG. A straightforward method in adjusting the quantity of labor input for heterogeneity in quality of labor is to weight the hours of work in each type of labor by the ratio of the average hourly wage for all types.

Unfortunately, information about different types of labor input in each industry is unavailable and it is, thus, not possible to carry out the appropriate adjustment in this study.

Table (4.2) shows the growth of labor input over the period and sub-periods of 1975-1994. Singapore manufacturing industries employed an increasing number of workers over the period 1975-94. The growth of labor input averages 3.6% per annum from 1975 to 1994. The period that experienced the highest growth of labor input is 1975-1980. The growth of labor input averages 5.1% per annum for the manufacturing industries over this period. This is the period when labor intensive, low technologically based industries were mainly responsible for the rapid growth of output in Singapore. After the implementation of the high-wage policy in 1979, labor growth declined in the 1980s and the early 1990s.

**Table 4.2: Per Annum Growth Rates of Labor Input- 1975-94**

Industry	SSIC	Per Annum Growth Rates of Labor Input (x100%)				
		75-80	80-85	85-90	90-94	75-94
Food	311/2	0.024	0.000	0.009	0.025	0.016
Beverage	313	0.001	-0.028	0.014	-0.024	-0.010
Tobacco	314	-0.003	-0.088	-0.005	0.026	-0.022
Textiles & Textile Manufactures	321	-0.026	-0.192	0.017	-0.042	-0.071
Wearing Apparel except Footwear	322	0.069	-0.004	0.007	-0.082	0.001
Leather & Leather Products	323	0.061	-0.069	-0.033	0.018	-0.008
Footwear	324	-0.037	-0.059	-0.052	-0.128	-0.077
Sawn Timber & Other Wood Products except Furniture	331	0.016	-0.154	-0.079	-0.074	-0.083
Furniture & Fixtures except primarily of Metal, Stone & Plastics	332	0.142	0.044	-0.034	-0.003	0.045
Paper & Paper Products	341	0.041	-0.044	0.056	0.032	0.024
Printing & Publishing	342	0.059	0.024	0.020	0.031	0.039
Industrial Chemicals & Gases	351	0.053	0.068	0.065	0.028	0.063
Paints, Pharmaceuticals & Other Chemical Products	352	0.031	0.014	0.017	0.020	0.023
Petroleum Refineries & Petroleum Products	353/4	0.001	0.006	-0.008	0.035	0.008
Rubber Products, Jelutong & Gum Damar	355/6	0.047	-0.067	0.036	0.024	0.011
Plastic Products	357	0.107	-0.014	0.082	0.045	0.064
Pottery, China, Earthenware & Glass Products	361/2	0.056	-0.044	0.014	0.041	0.018
Non-metallic Mineral Products	369	-0.043	0.012	0.007	0.004	-0.006
Iron and Steel	371	0.031	-0.037	0.024	0.002	0.006
Non-ferrous Metals	372	0.005	0.083	0.013	-0.026	0.024
Fabricated Metal Products except Machinery & Equipment	381	0.076	0.018	0.062	0.031	0.054
Machinery except Electrical & Electronic	382	0.032	0.013	0.017	0.016	0.022
Electrical Machinery, Apparatus, Appliances & Supplies	383	0.043	-0.009	0.063	-0.021	0.024
Electronic Products & Components	384	0.180	-0.010	0.100	0.001	0.081
Transport Equipment	385	0.016	-0.020	0.012	0.056	0.016
Instrumentation Equipment, Photographic & Optical Goods	386	0.068	-0.090	0.051	0.005	0.010
Other Manufacturing Industries	390	0.078	-0.060	0.072	-0.062	0.011
Industrial Average		0.051	-0.006	0.044	0.014	0.036

Notes:

Industrial average refers to the sum of growth rates of the 27 industries weighted by their respective output share.

Sources:

*Census of industrial production*, various issues.

*Yearbook of Statistics of Singapore*, various issues.

*Economic and Social Statistics of Singapore 1960-1982*.

### 4.2.3 Capital Input

Capital input refers to the annual flow of capital service to the industry under study. The interpretation and the calculation of the flow of capital service remain among the controversial areas in economics.<sup>10</sup> To calculate the flow of capital service we must first consider the stock of capital. A measure of capital stock can be calculated from detailed information on the different types of capital assets. In this study, capital stock is given by the Net Fixed Capital Assets (NFCA) series, which is supplied by the Research and Statistics Unit of EDB.

The data on NFCA are only available from 1980 onwards. The missing data from 1975 to 1979 are calculated by using the following equation:  $K_t = (1 - d)K_{t-1} + I_t$ , where  $K$  is the NFCA for the current and past time period,  $t$  and  $t - 1$ , respectively,  $d$  is the rate of depreciation and  $I_t$  is the amount invested at current time period. It is assumed that the rate of depreciation,  $d$ , is a constant given by an average ratio of the amount of depreciation to the total capital stock. Data on the amount of depreciation for each industry can be found in CIP. The rate of depreciation ranges from 6.2 percent for Beverage (313) to 23.6 percent for Electronic Products and Components (384).  $I_t$  is approximated by data on net investment commitments in manufacturing (1972-1982)

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<sup>10</sup> Some economists, most noticeably Robinson (1969), attack the conventional interpretation of capital as one of the basic inputs. They argue that when the economy is viewed as a whole, capital input should be treated as an intermediate input. This issue raises questions about differentiating the movement along a production function and shift of a production function (See Sudit and Finger, 1981).

found in ESSS. Finally, the current dollar NFCA is deflated to constant dollar NFCA using the Deflator of Expenditure on Gross Fixed Capital Formation found in YSS.

The flow of capital service is the product of the rental price of capital and the net capital stock at constant prices. The price of a dollar worth of capital services is defined by Jorgenson and Griliches (1967) as

$$(4.3) \quad P_s = (r + \delta)$$

where  $P_s$  is the rental price of capital,  $r$  is an interest rate and  $\delta$  is the rate of replacement. In this study,  $r$  is the average lending rate of interest and  $\delta$  is the average rate of depreciation in each industry over the period under study. This provides a constant rental price of capital, so that changes in the capital measure reflect only changes in the quantity of input.<sup>11</sup> Data on the average lending rate,  $r$ , are available on various issues of ESSS, YSS and MDS. The average rate of depreciation for each industry,  $\delta$ , is given by  $d$  described in the last paragraph.

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<sup>11</sup> Hall and Jorgenson (1967) suggest to incorporate the corporate tax system in computing the rental price of capital. This procedure is ignored here on the ground that the actual effect of the inclusion of corporate tax and depreciation allowances on TFPG measurement would be minimal. The logarithmic difference of capital input at different time periods remains the same when a constant proportion of tax or allowances is included over the period under study.

**Table 4.3: Per Annum Growth Rates of Capital Input- 1975-94**

Industry	SSIC	Per Annum Growth Rates of Capital Input (x100%)				
		75-80	80-85	85-90	90-94	75-94
Food	311/2	-0.009	0.086	0.011	0.045	0.038
Beverage	313	-0.012	0.170	0.121	-0.075	0.065
Tobacco	314	-0.107	0.161	-0.029	0.098	0.032
Textiles & Textile Manufactures	321	-0.111	-0.161	0.014	-0.067	-0.094
Wearing Apparel except Footwear	322	-0.101	0.059	0.061	-0.092	-0.017
Leather & Leather Products	323	-0.095	0.011	0.023	0.119	0.011
Footwear	324	-0.129	-0.090	-0.025	-0.082	-0.094
Sawn Timber & Other Wood Products except Furniture	331	-0.092	-0.049	-0.121	-0.080	-0.099
Furniture & Fixtures except primarily of Metal, Stone & Plastics	332	-0.120	0.031	-0.017	0.093	-0.008
Paper & Paper Products	341	-0.114	0.137	0.032	0.076	0.035
Printing & Publishing	342	-0.127	0.140	0.049	0.049	0.031
Industrial Chemicals & Gases	351	0.099	0.425	-0.010	0.001	0.154
Paints, Pharmaceuticals & Other Chemical Products	352	0.124	0.141	0.047	0.035	0.102
Petroleum Refineries & Petroleum Products	353/4	-0.055	-0.002	0.004	0.067	0.001
Rubber Products, Jelutong & Gum Damar	355/6	-0.178	0.044	0.008	0.047	-0.026
Plastic Products	357	0.027	0.125	0.027	0.063	0.070
Pottery, China, Earthenware & Glass Products	361/2	-0.111	-0.099	0.307	-0.004	0.028
Non-metallic Mineral Products	369	-0.192	0.093	-0.090	0.055	-0.043
Iron and Steel	371	-0.116	0.098	0.003	0.033	0.004
Non-ferrous Metals	372	-0.142	0.252	0.071	0.037	0.064
Fabricated Metal Products except Machinery & Equipment	381	-0.104	0.095	0.030	0.062	0.022
Machinery except Electrical & Electronic	382	0.009	0.049	0.036	0.038	0.038
Electrical Machinery, Apparatus, Appliances & Supplies	383	0.048	0.104	0.053	-0.016	0.057
Electronic Products & Components	384	0.347	0.119	0.136	0.053	0.194
Transport Equipment	385	-0.108	0.035	0.000	0.063	-0.006
Instrumentation Equipment, Photographic & Optical Goods	386	-0.007	-0.020	0.157	0.006	0.041
Other Manufacturing Industries	390	0.126	0.061	0.087	0.029	0.089
Industrial Average		0.017	0.069	0.059	0.047	0.075

**Notes:**

Industrial average refers to the sum of growth rates of the 27 industries weighted by their respective output share.

**Sources:**

*Census of industrial production, various issues*

*Yearbook of Statistics of Singapore, various issues*

*Economic and Social Statistics of Singapore 1960-1982*

*Monthly Digest of Statistics, various issues*

Table (4.3) shows the growth of capital input in real terms over the period and sub-periods of 1975-94. The industrial average rate of growth of capital input shows an overall increase of 7.5% per annum over the period 1975-94.<sup>12</sup> This average growth rate reflects the extent of capital deepening that the Singapore industries have been undergoing for the past decade. Over the period 1975-80, the average growth rate of capital input is 1.7%, which is much lower than the 5.1% for the average growth rate of labor input. This shows that Singapore's manufacturing sector in the period of high output growth still heavily relied upon the labor intensive, low technologically based industries. Capital input grew at a much faster rate (6.9% for 80-85, 5.9% for 85-90 and 4.7% for 90-94) than that of labor input (-0.6% for 80-85, 4.4% for 85-90 and 1.4% for 90-94) after the implementation of a series of policies aimed at promoting the growth of the high-tech industries in the 1980s and 1990s.

#### 4.2.4 Material Input

Materials used in the production are defined as "raw or basic materials, chemicals and packing materials consumed in the production. They refer to the actual consumption during the year. Where information on materials consumed is not directly available, it is derived from total purchases of materials and changes in stocks. Valuation is at cost, including delivery charges, commissions and duties." (CIP, 1989). Own-industry

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<sup>12</sup> The weighted average for the entire period is larger than the weighted average of any sub-period due to two factors: the rapid increase in the output share of Industry 384 and the rapid growth of capital input in this industry, especially during the 75-80 period.



Domestic Supply Price Index is used as deflator to deflate the current dollar material input. The Domestic Supply Price Index can be found in various issues of YSS.

Table (4.4) shows the growth of material input for the period and sub-periods of 1975-94. Material input has been the largest and fastest growing factor input for the past two decades. The industrial average shows a 10.2% per annum growth over the period from 1975 to 1994.

#### 4.2.5 Energy Input

Energy input refers to the total value of electricity and fuel used in production. Electricity, on the average, accounts for roughly around 70% of the energy input. (CIP, 1989). The Research and Statistics Unit of EDB provides the data series on energy input. The Domestic Supply Price Index on electricity and fuel taken from various issues of YSS is used to deflate the current dollar energy input.

Table (4.5) shows the growth of energy input for the period and sub-periods of 1975-94. Over the entire period of 1975-94, energy input in the manufacturing sector increased by 1.3% per annum. However, the sub-period 1975-80 shows a growth rate of -9.2% per annum. This negative growth rate is largely the result of the petroleum crisis occurred in 1979. The price index of electricity jumped 23 points from 1979 to 1980.

**Table 4.4: Per Annum Growth Rates of Material Input- 1975-94**

Industry	SSIC	Per Annum Growth Rates of Material Input (x100%)				
		75-80	80-85	85-90	90-94	75-94
Food	311/2	0.075	0.059	-0.054	0.033	0.032
Beverage	313	0.075	-0.054	0.072	-0.020	0.023
Tobacco	314	-0.022	-0.067	0.044	0.027	-0.007
Textiles & Textile Manufactures	321	0.006	-0.122	0.120	-0.024	-0.005
Wearing Apparel except Footwear	322	0.104	0.025	0.063	-0.060	0.043
Leather & Leather Products	323	0.053	-0.035	-0.009	0.076	0.022
Footwear	324	0.021	-0.057	0.042	-0.047	-0.010
Sawn Timber & Other Wood Products except Furniture	331	0.085	-0.121	-0.022	-0.059	-0.032
Furniture & Fixtures except primarily of Metal, Stone & Plastics	332	0.193	0.080	0.058	0.030	0.107
Paper & Paper Products	341	0.111	0.054	0.090	0.025	0.083
Printing & Publishing	342	0.050	0.064	0.108	0.049	0.079
Industrial Chemicals & Gases	351	0.025	0.306	0.067	0.035	0.128
Paints, Pharmaceuticals & Other Chemical Products	352	0.021	0.056	0.112	0.070	0.074
Petroleum Refineries & Petroleum Products	353/4	0.002	0.020	0.056	0.089	0.046
Rubber Products, Jelutong & Gum Damar	355/6	0.086	-0.038	0.055	0.026	0.037
Plastic Products	357	0.127	0.037	0.119	0.090	0.107
Pottery, China, Earthenware & Glass Products	361/2	0.016	-0.100	0.246	0.099	0.073
Non-metallic Mineral Products	369	-0.033	0.003	-0.029	0.077	0.002
Iron and Steel	371	0.018	0.045	0.075	0.042	0.052
Non-ferrous Metals	372	0.228	0.047	-0.075	0.000	0.060
Fabricated Metal Products except Machinery & Equipment	381	0.079	0.073	0.087	0.068	0.089
Machinery except Electrical & Electronic	382	0.100	0.007	0.081	0.025	0.063
Electrical Machinery, Apparatus, Appliances & Supplies	383	0.134	0.041	0.115	0.083	0.108
Electronic Products & Components	384	0.247	0.083	0.226	0.154	0.205
Transport Equipment	385	0.025	-0.063	0.125	0.012	0.029
Instrumentation Equipment, Photographic & Optical Goods	386	0.052	-0.065	0.177	0.056	0.063
Other Manufacturing Industries	390	0.104	0.009	0.144	0.007	0.079
Industrial Average		0.081	0.038	0.121	0.095	0.102

**Notes:**

Industrial average refers to the sum of growth rates of the 27 industries weighted by their respective output share.

**Sources:**

*Census of industrial production, various issues*

*Yearbook of Statistics of Singapore, various issues*

*Economic and Social Statistics of Singapore 1960-1982*

**Table 4.5: Per Annum Growth Rates of Energy Input- 1975-94**

Industry	SSIC	Per Annum Growth Rates of Energy Input (x100%)				
		75-80	80-85	85-90	90-94	75-94
Food	311/2	-0.081	0.005	0.024	0.040	-0.006
Beverage	313	-0.116	0.025	0.013	-0.063	-0.039
Tobacco	314	-0.079	0.007	0.092	0.068	0.023
Textiles & Textile Manufactures	321	-0.066	-0.176	0.083	-0.069	-0.065
Wearing Apparel except Footwear	322	-0.090	0.020	0.044	-0.052	-0.021
Leather & Leather Products	323	-0.089	-0.049	-0.007	0.216	0.010
Footwear	324	-0.081	-0.035	-0.047	-0.119	-0.079
Sawn Timber & Other Wood Products except Furniture	331	-0.067	-0.137	-0.038	-0.160	-0.113
Furniture & Fixtures except primarily of Metal, Stone & Plastics	332	-0.088	0.040	0.014	0.009	-0.008
Paper & Paper Products	341	-0.101	-0.004	0.106	0.030	0.008
Printing & Publishing	342	-0.097	0.079	0.076	0.068	0.034
Industrial Chemicals & Gases	351	-0.101	0.246	0.061	0.047	0.073
Paints, Pharmaceuticals & Other Chemical Products	352	-0.099	0.064	0.057	0.040	0.017
Petroleum Refineries & Petroleum Products	353/4	-0.104	0.015	0.000	-0.011	-0.030
Rubber Products, Jelutong & Gum Damar	355/6	-0.059	-0.070	0.055	0.007	-0.021
Plastic Products	357	-0.089	0.029	0.084	0.088	0.029
Pottery, China, Earthenware & Glass Products	361/2	-0.082	-0.208	0.247	0.030	-0.006
Non-metallic Mineral Products	369	-0.095	-0.018	0.060	-0.025	-0.022
Iron and Steel	371	-0.088	0.019	0.033	-0.017	-0.015
Non-ferrous Metals	372	-0.072	0.035	0.050	0.010	0.007
Fabricated Metal Products except Machinery & Equipment	381	-0.100	0.048	0.092	0.057	0.026
Machinery except Electrical & Electronic	382	-0.096	-0.001	0.067	0.047	0.003
Electrical Machinery, Apparatus, Appliances & Supplies	383	-0.089	0.030	0.073	0.034	0.012
Electronic Products & Components	384	-0.090	0.069	0.152	0.071	0.057
Transport Equipment	385	-0.088	-0.022	0.081	0.049	0.003
Instrumentation Equipment, Photographic & Optical Goods	386	-0.039	-0.060	0.121	0.023	0.013
Other Manufacturing Industries	390	-0.086	0.020	0.088	-0.046	-0.005
Industrial Average		-0.092	0.027	0.078	0.039	0.013

**Notes:**

Industrial average refers to the sum of growth rates of the 27 industries weighted by their respective output share.

**Sources:**

The Research and Statistics Unit of EDB

*Census of industrial production, various issues*

*Yearbook of Statistics of Singapore, various issues*

4.3     Results

Singapore’s manufacturing sector has, traditionally, been dominated by a few large industries.<sup>13</sup> The largest industry, using the measure of either the output share or the employment share, is Electronic Products and Components (384). This industry produced roughly 31% of total industrial output and employed about 28% of the total industrial employment for the past two decades. Table (4.6) shows the five most important manufacturing industries in terms of their average output share over the period 1975-94 in Singapore. In addition, the average shares of employment over the same period for these five industries are also listed in the table.

**Table 4.6: Average Output and Employment Shares for the Top 5 Industries- 75-94**

Rank	Industry	SSIC	1975-1994	
			Average Output Share (%)	Average Employment Share (%)
1	Electronic Products & Components	384	30.6	28.3
2	Petroleum Refineries & Petroleum Products	353/4	25.4	1.2
3	Food	311/2	5.5	3.6
4	Transport Equipment	385	5.0	9.2
5	Machinery except Electrical & Electronic	382	4.3	7.4
	Total Share of 5 Industries		66.5	49.7

Sources:  
*Census of Industrial Production*, various issues.

Table (4.6) shows that for the past two decades the two largest industries produced an average of approximately 56% of the total industrial output. The largest five industries, on the other hand, accounted for an average of 66.5% of the total industrial output. In

terms of employment share, the largest industry- the Electronic Products and Components industry (384)- employed an average of 28.3% of the manufacturing labor force over the period 1975-94. The second largest industry- the Petroleum Refineries & Petroleum Products industry (353/4)- only accounted for an average of only 1.2% of the manufacturing labor force over the same period. The largest five industries employed an average of approximately 50% of the manufacturing labor force over the period 1975-94.

Table (4.7) shows the per annum TFPG for Singapore manufacturing industries over the past two decades. The figures shown on Table (4.7) are the results of calculation using Equation (4.2) that take perfect competition and constant returns to scale as maintained hypotheses. Industrial average TFPG refers to the sum of all 27 industries' per annum TFPG weighted by their respective output share.

Table (4.7) shows that TFPG had been declining at a rate of 0.8% annually over the entire period from 1975 to 1994 for Singapore's manufacturing industries as a whole. The table shows that TFPG increased at a rate of 3.5% per annum for the sub-period 1975 to 1980 which coincides with the high output growth that occurred during this period and then fell at a rate of 3.7% per annum during the recession sub-period from 1980 to 1985. However, it continued to fall at a rate of 0.1% per annum for the sub-period from 1985 to 1990, despite the strong recovery taking place during this time. In the first half of 1990s, TFPG continued to fall at a rate 2.3% per annum.

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<sup>13</sup> We discuss briefly the largest five industries here because, later in this section, we focus on the TFPG.

**Table 4.7: Per annum TFPG for Singapore's Manufacturing Industries- 1975-94**

Industry	SSIC	Per Annum TFPG				
		75-80	80-85	85-90	90-94	75-94
Food	311/2	0.038	-0.09	0.06	-0.02	-0.007
Beverage	313	0.053	-0.06	-0.02	0.07	0.007
Tobacco	314	0.034	0.04	0.15	0.05	0.072
Textiles & Textile Manufactures	321	0.076	-0.05	-0.07	-0.02	-0.021
Wearing Apparel except Footwear	322	0.032	-0.03	0.00	-0.03	-0.014
Leather & Leather Products	323	0.006	-0.09	0.00	-0.03	-0.068
Footwear	324	-0.033	-0.06	0.06	0.07	0.014
Sawn Timber & Other Wood Products except Furniture	331	-0.022	-0.04	-0.04	0.00	-0.037
Furniture & Fixtures except Metal, Stone & plastics	332	0.128	-0.02	-0.01	0.03	0.018
Paper & Paper Products	341	0.141	-0.18	0.02	-0.04	-0.031
Printing & Publishing	342	0.144	-0.04	0.01	0.02	0.034
Industrial Chemicals & Gases	351	0.024	-0.13	0.01	0.00	-0.017
Paints, Pharmaceuticals & Other Chemical Products	352	0.001	-0.04	0.02	0.00	-0.005
Petroleum Refineries & Petroleum Products	353/4	0.067	0.01	0.01	-0.04	0.026
Rubber Products, Jelutong & Gum Damar	355/6	0.030	-0.01	-0.10	0.04	-0.047
Plastic Products	357	-0.011	-0.08	-0.07	-0.03	-0.057
Pottery, China, Earthenware & Glass Products	361/2	0.114	-0.08	-0.09	-0.26	-0.111
Non-metallic Mineral Products	369	0.146	-0.09	0.17	-0.03	0.057
Iron and Steel	371	0.091	0.00	-0.02	-0.02	0.015
Non-ferrous Metals	372	0.047	-0.13	0.04	0.03	-0.043
Fabricated Metal Products except Machinery & Equipment	381	0.071	-0.08	-0.01	-0.02	-0.024
Machinery except Electrical & Electronic	382	0.053	-0.02	0.02	0.02	0.020
Electrical Machinery, Apparatus, Appliances & Supplies	383	0.113	-0.04	0.01	0.00	0.023
Electronic Products & Components	384	-0.081	-0.06	-0.03	-0.03	-0.046
Transport Equipment	385	0.111	-0.01	0.07	-0.02	0.044
Instrumentation Equipment, Photographic & Optical Goods	386	0.033	-0.03	-0.03	0.06	0.007
Other Manufacturing Industries	390	-0.062	-0.10	-0.06	-0.06	-0.072
Industrial Average		0.035	-0.037	-0.001	-0.023	-0.008

Notes:

TFPG are calculated using Equation (4.2).

Industrial average refers to the sum of all 27 industries' per annum TFPG weighted by their respective output share.

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estimates of these largest industries.

**Table 4.8: Per Annum TFPG for the Top 5 Industries- 75-94**

Industry	SSIC	Per Annum TFPG				
		75-80	80-85	85-90	90-94	75-94
Electronic Products & Components	384	-0.081	-0.06	-0.03	-0.03	-0.046
Petroleum Refineries & Petroleum Products	353/4	0.067	0.01	0.01	-0.04	0.026
Food	311/2	0.038	-0.09	0.06	-0.02	-0.007
Transport Equipment	385	0.111	-0.01	0.07	-0.02	0.044
Machinery except Electrical & Electronic	382	0.053	-0.02	0.02	0.02	0.020
Industrial Average		0.018	-0.018	-0.000	-0.022	-0.005

Notes:

TFPG are calculated using Equation (4.2).

Industrial average refers to the sum of all 5 industries' per annum TFPG weighted by their respective output share.

In Table 4.8, we list separately the per annum TFPG results for the largest five industries.

The largest industry, Electronic Products and Components (384), shows a negative per annum TFPG for the whole period and all the sub-periods under study. The industry's largest productivity decline takes place over the period 1975-80. This does not seem to fit well with the fairly strong productivity growth experienced by the other four largest industries over the same period.

We see from Table 4.8 that productivity growth has never recovered to the 1975-80's level since the beginning of 1980 in Singapore's largest industries. The downward trend of productivity growth continues into the middle of 1990s, although it has improved to a level of zero growth over the latter half of the 1980s. Transport Equipment (385) records the highest productivity growth at 4.4% per annum for the whole period under study. It is

followed by Petroleum Refineries and Petroleum Products (353), which records a per annum TFPG of 2.6%.

In essence, the phenomena of negative TFPG reflect the sum of weighted growth of total factor inputs greater than the growth of output. Since TFPG corresponds to what is left of output growth after taking into account the weighted growth of all factor inputs, it appears that the weighted growth of all factor inputs outstrips output growth for those industries that exhibit a negative TFPG. Our negative TFPG seems to suggest that the rapid output growth in certain Singapore's industries, especially Electronic Products and Components (384), is the result of increasing utilization of factor inputs and not the result of improvement in productivity.

**Table 4.9: Results of Recent Studies on Singapore's TFPG**

	Fischer (1993)	World Bank <sup>14</sup> (1993)	National Productivity Board (1992)	Young (1992)	Elias (1990)	Tsao (1985)
Per Annum TFPG (%)	-0.60 (1960-89)	1.20 & -3.01 (1960-89)	0.57 (1981-91)	-0.29 (1971-91)	1.80 (1960-89)	0.08 (1970-79)

Sources:

Fischer, Stanley (1993), "Macroeconomic Factors in Growth," World Bank Discussion Paper

World Bank (1993), *Global Economic Prospects and Developing Countries*.

National Productivity Board (1992), *Productivity Movements in the 1980s*.

Young, Alwyn (1992), "Factor Accumulation and Technical Change in Hong Kong and Singapore," *NBER Macroeconomics Annual*.

Elias, Victor (1990), "The Role of Total Factor Productivity on Economic Growth," *World Development Report 1991*.

Tsao, Yuan (1985), "Growth Without Productivity," *Journal of Development Economics*.

<sup>14</sup> The result of 1.20% is based on the estimation using a full sample of economies (87) and the result of negative 3.01% is based on the estimation using only the high-income economies.



It is useful to compare our results with the results of recent studies on Singapore's TFPG. The results of TFPG calculation from studies by Fisher (1993), World Bank (1993), National Productivity Board of Singapore (1992), Young (1992), Elias (1990) and Tsao (1985) are presented in Table (4.9). The time period under study by each analyst is indicated in the parentheses. Although the table shows different results of TFPG, the striking similarity across studies is the small magnitude of TFPG.

Our result of -0.8% TFPG seems to fit well with the results of the recent studies listed above. The discrepancies shown between our result and the results of other studies do not seem to be larger than the discrepancies shown among the results of these different studies. We should keep in mind that these TFPG calculations are not directly comparable because different studies employ slightly different methodologies and approaches. First, Fischer, World Bank, and Elias are interested in cross economies comparison of TFPG and their calculation of TFPG is based on economy-wide data. Second, all studies involve different time periods under study. Third, studies carried out by Fischer, World Bank, Young and Elias use only capital and labor as factor inputs. Furthermore, instead of using income shares of capital and labor as approximations to the elasticities of output with respect to capital and labor, Fischer, World Bank and Elias estimate the output elasticity coefficients of a Cobb-Douglas production function across countries. Hence, their results are sensitive to the estimated values of output elasticities of capital and labor.

In all of the recent studies shown, Tsao's is the one that most resembles the present study. We both employ four factor inputs and the Tornqvist index method, with income shares

of factor inputs used as the proxies for elasticities of output respect to factor inputs. The difference in our TFPG results can be contributed mainly to the difference in time periods under study and differences in defining and gathering certain input variables.<sup>15</sup> Another factor that causes the difference between our estimates is the different methods of calculating the share of capital input. Tsao does not use the residually determined method to determine the cost share of capital input, whereas we do in Equation (4.2). This has the effect of lowering our TFPG estimates compared to Tsao's estimates so long as the sum of shares of all factor inputs adds up to less than one and this is what we observe for Singapore industries.

The question of why TFPG fell in the face of rapid output growth remains to be answered. Tsao (1985) offers several hypotheses. One of his hypotheses is that the predominance of foreign investment in Singapore may contribute to a smaller rate of TFPG. His argument is that foreign firms are less willing to adopt technology that most suits local environment and to involve in minor adjustment at the local plant since research and development is only carried out in the parent company. In addition, foreign firms usually employ technology that is close to best practice frontier and thus there is little room for technical progress and hence productivity improvement. The question of what causes the negative productivity growth and/or technical regress in Singapore industries will be discussed formally in Chapter Seven in the context of explaining inter-industry differences in technical change. An empirical model will be introduced to

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<sup>15</sup> Tsao's capital input is constructed using 7 different categories of capital assets and his labor input has been adjusted for differences in occupational status and gender.

examine the role of various factors such as output growth, foreign ownership and R&D in determining productivity and technical change.

#### 4.4 Adjusting TFPG For Market Imperfection

It is possible to use Equation (3.16) to calculate the primal technical change. Equation (3.16) states that the primal rate of technical change is calculated by taking the difference between output growth and the (weighted) growth of total factor inputs, adjusted for the degree of imperfect competition.

$$(3.16) \quad \dot{T} = \dot{Y} - \frac{1}{(1-\mu)} \sum_i \alpha_i \dot{X}_i$$

Under the conditions of perfect competitive equilibrium, we have  $\mu = 0$  (and  $\sum_i \alpha_i = 1$ )

so the primal rate of technical change,  $\dot{T}$ , is equal to TFPG. Once the conditions are relaxed, the primal rate of technical change does not necessarily equal to TFPG. The greater the degree of imperfect competition, measured by  $\mu$ , the greater is the amount of bias in using TFPG to measure the primal rate of technical change,  $\dot{T}$ . In addition, an important source of discrepancy between TFPG and  $\dot{T}$  is due to that the sum of cost shares in (3.16) does not necessarily equal to one, as what we assume in Equation (4.1) and (4.2). This can introduce substantial differences between TFPG and  $\dot{T}$  depending whether the sum of cost shares is greater or less than one. We observe that the sum of

cost shares is less than one for the majority of Singapore industries, so we expect that the TFPG bias should be mostly negative, *ceteris paribus*. However, the bias associated with imperfect competition,  $\mu > 0$ , is positive, so the net bias for any industry must be determined empirically.

If we know the degree of market imperfection indicated by the price-cost margin, then we can calculate the primal rate of technical change by using Equation (3.16). The price-cost margin,  $\mu$ , is usually unobservable, but can be approximated by the gross profit margin, GPM, which is given by

$$(4.4) \quad GPM = \frac{VA - W}{Y}$$

where  $VA$ ,  $W$ , and  $Y$  stand for nominal value added, wage bill and nominal output, respectively. The gross profit margin, which is essentially the capital's share of gross output is at best a crude proxy of the price-cost margin. The price-cost margin is supposed to measure the extent of economic profit, that is, the excess amount of price over marginal cost. The problem with using the capital's share of gross output as a proxy measure is that it tends to overestimate the price-cost margin because the capital's share of gross output, among other things, consists of depreciation and interest payment, which are not parts of economic profit.<sup>16</sup>

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<sup>16</sup> See Fisher (1987) for a critique of the typical price-cost margin.

The results of our calculation for GPM, TFPG,  $\dot{T}$ , and the bias of TFPG, BIAS, are shown in Table (4.10). GPM varies from 0.109 to 0.490 with the industrial average of 0.195. The industries with the lowest and highest GPM are Petroleum Refineries and Products (353) and Paints, Pharmaceuticals and Other Chemicals (352), respectively. The results of our calculation of the primal rate of technical change are shown in the column under  $\dot{T}$ . It is clear that the primal rate of technical change is different from the TFPG calculated for the corresponding industry. The difference,  $(TFPG - \dot{T})$ , is referred to as the TFPG bias and is listed in the last column of Table (4.10).

The industrial average indicates the primal rate of technical change for Singapore's industries declines by 0.5% per annum over the period of study, compared to the 0.8% decline in TFPG. It suggests that TFPG, in general, under-estimates the primal rate of technical change under the period of study. However, with a couple notable exceptions, the differences between TFPG and  $\dot{T}$  in individual industries are generally small and vary in sign. Thus, the valid conclusion should be that there is no clear difference between TFPG and  $\dot{T}$  as calculated for Singapore manufacturing, and that on average the values are approximately equal.

**Table 4.10: Gross Profit Margin, Per Annum TFPG and Primal Technical Change-1975-94**

Industry	SSIC	GPM	TFPG	$\dot{T}$	TFPG BIAS
Food	311/2	0.141	-0.007	0.007	-0.014
Beverage	313	0.347	0.007	0.027	-0.020
Tobacco	314	0.292	0.072	0.087	-0.015
Textiles & Textile Manufactures	321	0.163	-0.021	-0.019	-0.002
Wearing Apparel except Footwear	322	0.127	-0.014	-0.022	0.008
Leather & Leather Products	323	0.141	-0.068	-0.074	0.006
Footwear	324	0.149	0.014	-0.035	0.049
Sawn Timber & Other Wood Products except Furniture	331	0.149	-0.037	-0.042	0.005
Furniture & Fixtures except primarily of Metal, Stone & Plastics	332	0.155	0.018	0.006	0.012
Paper & Paper Products	341	0.259	-0.031	-0.034	0.003
Printing & Publishing	342	0.305	0.034	0.029	0.005
Industrial Chemicals & Gases	351	0.251	-0.017	-0.010	-0.007
Paints, Pharmaceuticals & Other Chemical Products	352	0.490	-0.005	0.022	-0.027
Petroleum Refineries & Petroleum Products	353/4	0.109	0.026	0.023	0.003
Rubber Products, Jelutong & Gum Damar	355/6	0.233	-0.047	-0.040	-0.007
Plastic Products	357	0.208	-0.057	-0.079	0.022
Pottery, China, Earthenware & Glass Products	361/2	0.254	-0.111	-0.209	0.098
Non-metallic Mineral Products	369	0.261	0.057	0.046	0.011
Iron and Steel	371	0.269	0.015	0.003	0.013
Non-ferrous Metals	372	0.159	-0.043	-0.006	-0.037
Fabricated Metal Products except Machinery & Equipment	381	0.213	-0.024	-0.038	0.014
Machinery except Electrical & Electronic	382	0.252	0.020	0.013	0.008
Electrical Machinery, Apparatus, Appliances & Supplies	383	0.218	0.023	-0.002	0.025
Electronic Products & Components	384	0.206	-0.046	-0.029	-0.017
Transport Equipment	385	0.287	0.044	0.037	0.007
Instrumentation Equipment, Photographic & Optical Goods	386	0.297	0.007	0.011	-0.004
Other Manufacturing Industries	390	0.161	-0.072	-0.105	0.033
Industrial Average		0.195	-0.008	-0.005	-0.003

Notes:

Industrial average refers to the sum of growth rates of the 27 industries weighted by their respective output share.

GPM corresponds to gross profit margin and BIAS corresponds to  $(TFPG - \dot{T})$ .

## 4.5 Conclusion

This chapter sets out to measure TFPG for Singapore manufacturing industries using the conventional Tornqvist index number approach. Output and input data were collected from different government sources. We first define the meaning of output and four different factor inputs and then describe their growth rate over the period and sub-periods under study. Real output grew 8.3% per annum for the past two decade from 1975 to 1994. Out of the four factor inputs, material input grew the fastest at a rate of 10.2%, followed by capital input at 7.5%, labor input at 3.6% and energy input at 1.3% over the period 1975-94.

The results of TFPG calculation using Equation (4.2) are given in Table (4.7). The following observations can be drawn from these results:

- On the average, TFPG declined at a rate of 0.8% per annum for all industries over the past two decades. Our results do not seem to differ substantially from the results of recent studies that employed similar methodology in the literature.
- It is observed that the industrial average TFPG is determined largely by the TFPG performance of the five largest industries. Among the five largest industries, Electronic Products and Components (384) is a single most important industry that affects the industrial average TFPG.
- An industry exhibits a negative rate of TFPG because it uses factor inputs at a higher rate than the rate at which it produces output. Real output grew by 15.6% per annum from 1975 to 1994 for Electronic Products and Components (384). Its factor inputs,

however, grew at even higher rates (capital- 19.4%, labor- 8.1%, materials- 20.5% and energy- 5.7%) over the same period of time, resulting in a negative TFPG for the entire period under study.

- Using the gross profit margin, GPM, as a proxy for the price-cost margin, we calculate the primal rate of technical change. We find no clear difference between TFPG and  $\dot{T}$  as calculated for Singapore manufacturing and on average the values are approximately equal.

We have finished the discussion and calculation of the conventional productivity measurement, TFPG, and the primal rate of technical change,  $\dot{T}$ . In the next two chapters, we shift our attention to look at the issues of estimating the dual rate of technical change. We discuss the model that we adopt for this purpose and the relating estimation procedures in Chapter Five. Chapter Six presents and discusses the estimation results of the dual rate of technical change, economies of scales and the conjectural measure of competition. Chapter Seven offers a formal econometric model to explain the regression results of Chapter Six and, finally, Chapter Eight gives conclusions and summaries for the thesis.



## **CHAPTER FIVE**

### **ESTIMATING DUAL TECHNICAL CHANGE AND MARKET IMPERFECTION**

#### **USING A SYSTEM OF SIMULTANEOUS EQUATIONS**

##### **Introduction**

The main objective of this chapter is to present a model that estimates the dual rate of technical change along with the degree of market competition and economies of scale directly from a system of equations that describes the cost and market structure of the industry. Firms are assumed to be maximising profit in an oligopolistic market. The system of equations allows us to estimate the parameters of the cost function and to estimate the degree of economies of scale and market competitiveness for all the industries under study.

In the first part of this chapter, we will explore the two popular functional forms currently in use in the literature of productivity research. These two functional forms are the translog and generalised Leontief cost functions. After the initial study of the translog and generalised Leontief cost function, we switch our focus in the second part of this chapter to an integrated simultaneous equations model which extends the generalised Leontief cost function to include equations that describe market demand and the market equilibrium condition.

Section (5.1) and (5.2) discuss the specification and some important characteristics of the translog and generalised Leontief cost function, respectively. Estimation techniques are discussed in section (5.3). Section (5.4) discusses the integrated model of a system of simultaneous equations. Results from our parametric estimation will be presented and discussed in the following chapter.

### 5.1 The Translog Cost Function

The dual cost translog function is introduced by Christensen, Jorgenson and Lau (1970). The nonhomothetic translog cost function is a second-order's Taylor series expansion in logarithms to an arbitrary cost function (Berndt, 1991). The specification of the nonhomothetic translog cost function is as follows:

$$\begin{aligned}
 \ln C(Y, P_i, T) \equiv & a_0 + \sum_i^N a_i \ln P_i + a_Y \ln Y + a_T T \\
 (5.1) \quad & + \left(\frac{1}{2}\right) \sum_i^N \sum_j^N a_{ij} \ln P_i \ln P_j + \sum_i a_{iY} \ln P_i \ln Y + \sum_i^N a_{iT} T \ln P_i \\
 & + \left(\frac{1}{2}\right) a_{YY} (\ln Y)^2 + a_{YT} T \ln Y + \left(\frac{1}{2}\right) a_{TT} T^2
 \end{aligned}$$

where  $a_{ij} = a_{ji}$  for  $i, j = 1, 2, \dots, N$ , factor input.  $Y$  is the level of output.  $P_i$  is the price for  $i$ th input and  $T$  is an index of time capturing technical progress. Recall the discussion in Section (3.4) that a well-behaved cost function must be linearly homogeneous in input prices. Necessary and sufficient conditions for linear homogeneity in input prices for the translog cost function are

$$(5.2) \quad \sum_i^N a_i = 1, \quad \sum_i^N \sum_j^N a_{ij} = 0$$

$$\sum_i^N a_{iY} = 0, \quad \sum_i^N a_{iT} = 0$$

$$\left\{ \begin{array}{l} a_K + a_L + a_M = 1 \\ a_{KK} + a_{KL} + a_{KM} = 0 \\ a_{LL} + a_{KL} + a_{LM} = 0 \\ a_{MM} + a_{KM} + a_{LM} = 0 \end{array} \right\}$$

$$\left\{ \begin{array}{l} a_{KY} + a_{LY} + a_{MY} = 0 \\ a_{KT} + a_{LT} + a_{MT} = 0 \end{array} \right\}$$

Woodland (1976) and Khaled (1978) show that the nonhomothetic translog cost function defined by Equation (5.1) is a flexible functional form. A flexible functional form is defined by Diewert as: “one which could provide a second order differential approximation to an arbitrary twice continuously differentiable cost function  $C^*$  that satisfies the linear homogeneity in prices property at any point in an admissible domain” (Diewert, 1974, p.115).

The nonhomothetic translog cost function defined in Equation (5.1) allows us to estimate the degree of economies of scale and technical progress (regress). The elasticity of cost with respect to output,  $E_{CY}$ , can be derived from Equation (5.1) as follows:

$$(5.3) \quad E_{CY} \equiv \frac{\partial \ln C}{\partial \ln Y} = a_Y + a_{YY} \ln Y + a_{YT} T + \sum_i^N a_{iY} \ln P_i$$

$E_{CY}$  gives the percentage change in cost in response to a percentage change in output.

For a production technology experiencing increasing (decreasing) returns to scale,  $E_{CY}$  is less (greater) than one.  $E_{CY}$  is equal to one when the production technology exhibits constant returns to scale. In this case, the cost function is said to be linearly homogeneous

in output. Alternatively, one can impose a priori linear restrictions for constant returns to scale on the translog cost function as follows:

$$(5.4) \quad \begin{aligned} a_Y &= 1, & a_{iY} &= 0 \\ a_{YY} &= 0, & a_{YT} &= 0 \end{aligned}$$

Technical change can also be estimated from the nonhomothetic translog cost function defined in Equation (5.1). The elasticity of cost with respect to time,  $E_{CT}$ , is defined as

$$(5.5) \quad E_{CT} \equiv \frac{\partial \ln C}{\partial T} = a_T + a_{TT}T + a_{YT} \ln Y + \sum_i^N a_{iT} \ln P_i$$

$E_{CT}$  gives the annual percentage change in cost due to the passage of time.  $E_{CT}$  is the dual rate of technical change. The linear restrictions that one can impose a priori for the translog cost function to be independent of time are

$$(5.6) \quad \begin{aligned} a_T &= 0, & a_{YT} &= 0 \\ a_{TT} &= 0, & a_{iT} &= 0 \end{aligned}$$

If one were to impose a further restriction that  $a_{ij} = 0$  ( $i, j = 1 \dots N$ ) in addition to the restrictions (5.4) and (5.6), then the nonhomothetic translog cost function in (5.1) becomes a standard Cobb-Douglas function. In other words, the Cobb-Douglas cost function can be viewed as a restricted form of the nonhomothetic translog cost function

which does not allow for economies of scale, technical progress, and substitution between factor inputs.

## 5.2 The Generalised Leontief Cost Function

The generalised Leontief cost function, introduced by Diewert in 1971, is the first dual cost function that does not impose a priori restrictions on the production technology or substitution elasticities, and yet is consistent with the regularity conditions of a well behaved cost function. The generalised Leontief cost function with a time variable,  $T$ , representing technical progress is defined as follows:

$$(5.7) \quad C(P_i, Y, T) \equiv \sum_i^N \sum_j^N a_{ij} P_i^{\frac{1}{2}} P_j^{\frac{1}{2}} Y + \sum_i^N a_i P_i + \sum_i^N a_{iT} P_{iT} TY + a_T \left( \sum_i^N \alpha_i P_i \right) T + a_{YY} \left( \sum_i^N \beta_i P_i \right) Y^2 + a_{TT} \left( \sum_i^N \gamma_i P_i \right) T^2 Y$$

where  $a_{ij} = a_{ji}$ . Diewert (1971) shows that (5.7) is linearly homogeneous in input prices.

The number of independent parameters equals to  $N(N+1)/2 + 2N + 3$ , where  $N$  stands for the number of factor inputs. It has just the right number of independent parameters to be a flexible form as defined in the last section. Researchers can choose arbitrarily the values of  $\alpha_i$ ,  $\beta_i$ , and  $\gamma_i$  in (5.7). This implies that (5.7) consists of a family of flexible functional forms instead of only one flexible functional form. However, Diewert suggests that when one is constrained by the degrees of freedom, a

straightforward method to adopt is to assume that  $\alpha_i = \beta_i = \gamma_i = \bar{X}_i$  for  $i = 1, 2, \dots, N$ , where  $\bar{X}_i$  is the average amount of factor input  $i$  used over the sampled period. This approach results in the elasticities generated by the cost function that are invariant to the scale changes in the units of measurement (Diewert and Wales, 1987).

The degree of returns to scale can be calculated from the parametric estimates of the generalised Leontief cost function defined in (5.7). The elasticity of cost with respect to output,  $E_{CY}$ , for the generalised Leontief cost function is defined as follow:

$$(5.8) \quad E_{CY} \equiv \frac{\partial \ln C}{\partial \ln Y} = \frac{\partial C / \partial Y}{C/Y}$$

$$= \frac{\sum_i^N \sum_j^N a_{ij} P_i^{\frac{1}{2}} P_j^{\frac{1}{2}} + \sum_i^N a_{iT} P_i T + 2a_{YY} (\sum_i^N \beta_i P_i) Y + a_{TT} (\sum_i^N \gamma_i P_i) T^2}{\sum_i^N \sum_j^N a_{ij} P_i^{\frac{1}{2}} P_j^{\frac{1}{2}} + \sum_i^N a_i P_i (\frac{1}{Y}) + \sum_i^N a_{iT} P_i T + a_T (\sum_i^N \alpha_i P_i) \frac{T}{Y} + a_{YY} (\sum_i^N \beta_i P_i) Y + a_{TT} (\sum_i^N \gamma_i P_i) T^2}$$

It can be seen from (5.8) that the generalised Leontief cost function is linearly homogeneous in output if and only if the following linear restrictions are imposed:

$$(5.9) \quad \begin{aligned} a_i &= 0 \\ a_T &= 0, \quad a_{YY} = 0 \end{aligned} \quad \text{for all } i.$$

The rate of technical change can also be calculated from parametric estimates of the generalised Leontief cost function defined in (5.7). The elasticity of cost with respect to time,  $E_{CT}$ , is defined as follows:

$$(5.10) \quad E_{CT} \equiv \frac{\partial \ln C}{\partial T} = \frac{\partial}{\partial T} \frac{1}{C}$$

$$= \frac{\sum_i^N a_{iT} P_i Y + a_T (\sum_i^N \alpha_i P_i) + 2a_{TT} (\sum_i^N \gamma_i P_i) TY}{\sum_i^N \sum_j^N a_{ij} P_i^{\frac{1}{2}} P_j^{\frac{1}{2}} Y + \sum_i^N a_i P_i + \sum_i^N a_{iT} P_i TY + a_T (\sum_i^N \alpha_i P_i) T + a_{TY} (\sum_i^N \beta_i P_i) Y^2 + a_{TT} (\sum_i^N \gamma_i P_i) T^2 Y}$$

It is clear from (5.10) that the generalised Leontief cost function will be independent of time if the following linear restrictions are imposed:

$$(5.11) \quad \begin{array}{ll} a_{iT} = 0 & \text{for all } i. \\ a_T = 0, \quad a_{TT} = 0 \end{array}$$

Finally, if we impose both restrictions (5.9) and (5.11), the generalised Leontief cost function specified in (5.7) reduces to (5.12), which does not allow for either economies of scale or technical change.<sup>1</sup>

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<sup>1</sup> This is the original form of generalised Leontief function introduced by Diewert in 1971.

$$(5.12) \quad C(P_i, Y) = \sum_i^N \sum_j^N a_{ij} P_i^{\frac{1}{2}} P_j^{\frac{1}{2}} Y$$

where  $a_{ij} = a_{ji}$ . Since we are interested in estimating the degree of returns to scale and technical progress, we should then adopt the generalised Leontief cost function defined by (5.7). We now turn our attention to look at estimation procedures that we adopt for estimating the translog and generalised Leontief cost function.

### 5.3 Estimation Techniques

Both the translog and generalised Leontief cost function can be directly estimated using the least squares method. However, single equation estimation is not preferred because efficiency can be gained if one is to estimate the translog cost function in a system of cost share equations or the generalised Leontief cost function in a system of derived factor demand equations. We first turn our attention to the translog and then to the generalised Leontief cost function.

#### 5.3.1 The Translog Cost Function

The translog cost function defined by Equation (5.1) can be directly estimated using least squares method. However, as to be seen below, this approach is not preferred since efficiency can be realised by estimating a system of optimal cost-minimising cost share equations that can be derived from the translog cost function (Berndt, 1991). Using



Shephard's Lemma,  $(\partial C / \partial P_i) = X_i$ , a system of optimal cost-minimising cost share equations can be derived as follows:

$$(5.13) \quad S_i \equiv \frac{\partial \ln C}{\partial \ln P_i} = \frac{\partial C}{\partial P_i} \frac{P_i}{C} = \frac{P_i X_i}{C} = a_i + \sum_j^N a_{ij} \ln P_j + a_{iY} \ln Y + a_{iT} T$$

where  $\sum_i^N P_i X_i = C$ . The cost shares in Equation (5.13) must add up to one,  $\sum_i^N S_i = 1$ . This

“adding up” condition has important implications for the estimation of the translog cost function.

We adopt a stochastic framework in order to implement the estimation of the translog cost function. One common approach is to assume that firms make random errors in choosing their cost-minimising input bundles and, thus, an additive disturbance term can be appended to each of the cost share equations and the translog cost function (Berndt, 1991).

Since the disturbances are considered to be contemporaneously correlated across equations, equation-by-equation least squares estimation of the cost shares and the translog cost function waste the information that the same set of parameters appears in all of the equations (Greene, 1993). Another problem associated with equation-by-equation least squares estimation is that estimates of the same parameter across different equations generally are not equal.

With the disturbances contemporaneously correlated across equations but uncorrelated across observations, Zellner's (1963) seemingly unrelated regressions model (SUR) can be applied to obtain efficient estimates of the parameters. The method of SUR in essence is iterated generalised least squares estimation, in which it first obtains an estimate of the disturbance covariance matrix,  $\Omega$ , by using equation-by-equation least squares estimation. Given the initial estimate of  $\Omega$ , generalised least squares is then applied on an appropriately "stacked" set of equations. The estimated  $\Omega$  is iterated until the changes to the estimated parameters and estimated  $\Omega$  become arbitrarily small (Berndt, 1991). The iterated generalised least squares or SUR has been shown to produce equivalent results to those of the maximum likelihood estimator.<sup>2</sup>

However, the "adding-up" condition of the cost share equations in (5.15) and linear restrictions of (5.2) cause the disturbance covariance and residual cross-products matrix to be singular and non-diagonal, thus, making the estimation of the system of equations non-operational. To make the estimation of SUR operational, we first divide  $N - 1$  prices by the  $N$ th price, eliminating the last term in each column and row of the parametric matrix. Then, we drop the  $N$ th cost share equation from the system to obtain a non-singular system (Greene, 1993).

Dropping one of the cost share equations from the system raises the question of whether the estimates are invariant to the choice of which cost share equations is dropped.

Fortunately, it has been shown that as long as maximum likelihood estimation is adopted for estimation of the remaining set of equations, parameter estimates as well as log-likelihood values and estimated standard errors are invariant to the choice of which cost share equation is dropped (Barten, 1969).<sup>3</sup>

In our empirical study, we employ capital, labour, and materials as the factor inputs.<sup>4</sup>

Thus, the translog cost function consists of 21 parameters to be estimated. We drop the cost share equation for capital and divide all prices by the price of capital. This reduces the number of parameters to be estimated to 15. The system of equations to be estimated then consists of the translog cost function,

$$(5.14) \quad \ln C(Y, P_i, T) =$$

$$\begin{aligned} & a_0^{\checkmark} + a_Y^{\checkmark} \ln Y + a_L^{\checkmark} \ln \left( \frac{P_L}{P_K} \right) + a_M^{\checkmark} \ln \left( \frac{P_M}{P_K} \right) + \frac{1}{2} a_{YY}^{\checkmark} (\ln Y)^2 + \frac{1}{2} a_{LL}^{\checkmark} \left( \ln \left( \frac{P_L}{P_K} \right) \right)^2 + \\ & a_{LM}^{\checkmark} \ln \left( \frac{P_L}{P_K} \right) \ln \left( \frac{P_M}{P_K} \right) + \frac{1}{2} a_{MM}^{\checkmark} \left( \ln \left( \frac{P_M}{P_K} \right) \right)^2 + a_{LY}^{\checkmark} \ln \left( \frac{P_L}{P_K} \right) \ln Y + a_{MY}^{\checkmark} \ln \left( \frac{P_M}{P_K} \right) \ln Y + \\ & a_{LT}^{\checkmark} \left( \frac{P_L}{P_K} \right) \ln T + a_{MT}^{\checkmark} \left( \frac{P_M}{P_K} \right) \ln T + a_{YT}^{\checkmark} T \ln Y + a_T^{\checkmark} T + \frac{1}{2} a_{TT}^{\checkmark} T^2 \end{aligned}$$

and the cost share equations,

<sup>2</sup> See Oberhofer and Kmenta (1974) for detailed proof.

<sup>3</sup> The iterated generalised least squares method will also give invariant results as long as the initial estimate of  $\Omega$  is based on equation-by-equation least squares estimation without a symmetry condition imposed (Berndt, 1991).

<sup>4</sup> We omit energy as our factor input in the estimation on the ground that it only represents a small fraction of the total cost (no more than 5%). We have tried estimating the translog cost function with and without energy. On the whole, dropping energy increases the log-likelihood value of the fitted function and results in more significant t-ratios for the estimates.

$$S_L = a_L + a_{LL} \ln\left(\frac{P_L}{P_K}\right) + a_{LM} \ln\left(\frac{P_M}{P_K}\right) + a_{LY} \ln Y + a_{LT} T$$

$$S_M = a_M + a_{MM} \ln\left(\frac{P_M}{P_K}\right) + a_{LM} \ln\left(\frac{P_L}{P_K}\right) + a_{MY} \ln Y + a_{MT} T$$

Given that maximum likelihood estimation results in equivalent parametric estimates as SUR and that it has the advantage of ensuring the estimates are invariant to which cost share equation is dropped, we adopt the method of non-linear maximum likelihood estimation.<sup>5</sup> The missing parameters for capital in the system are calculated using restriction (5.2) once estimates for other parameters are found.<sup>6</sup> We now look at issues regarding the estimation of the generalised Leontief cost function.

### 5.3.2 The Generalised Leontief Cost Function

Similar to the translog cost function, the generalised Leontief cost function can be estimated directly by least squares method. Again, this approach is not preferred because a system of optimal cost-minimising factor demand equations can be derived from the generalised Leontief cost function, providing additional information to the estimation. The system of optimal factor demand equations can then be estimated by SUR since disturbances are considered to be contemporaneously correlated across equations but uncorrelated across observations.

Using Shephard's Lemma, the cost-minimising optimal demand for input  $i$  can be derived by differentiating the cost function with respect to the factor price of input  $i$ . In the case of the generalised Leontief cost function, the derived optimal factor demand for input  $i$  is

$$(5.15) \quad X_i = \frac{\partial C}{\partial P_i} = a_i + \sum_j^N a_{ij} \left( \frac{P_j}{P_i} \right)^{\frac{1}{2}} Y + a_{iT} TY + a_{iT} \bar{X}_i T + a_{iY} \bar{X}_i Y^2 + a_{iT} \bar{X}_i T^2 Y$$

where  $a_{ij} = a_{ji}$  and  $\bar{X}_i = \alpha_i = \beta_i = \gamma_i$  for  $i = 1, 2, \dots, N$ , factor inputs. Since we employ three factor inputs, the number of parameters to be estimated in the generalised Leontief cost function defined in Equation (5.7) is 15. The system of factor demand equations to be estimated with three factor inputs is, thus, given below.

(5.16)

$$\begin{aligned} \frac{X_K}{Y} &= a_{KK} + a_{KL} \left( \frac{P_L}{P_K} \right)^{\frac{1}{2}} + a_{KM} \left( \frac{P_M}{P_K} \right)^{\frac{1}{2}} + a_K \frac{1}{Y} + a_{KT} T + a_T \frac{\bar{X}_K T}{Y} + a_{iY} \bar{X}_K Y + a_{iT} \bar{X}_K T^2 \\ \frac{X_L}{Y} &= a_{LL} + a_{KL} \left( \frac{P_K}{P_L} \right)^{\frac{1}{2}} + a_{LM} \left( \frac{P_M}{P_L} \right)^{\frac{1}{2}} + a_L \frac{1}{Y} + a_{LT} T + a_T \frac{\bar{X}_L T}{Y} + a_{iY} \bar{X}_L Y + a_{iT} \bar{X}_L T^2 \\ \frac{X_M}{Y} &= a_{MM} + a_{KM} \left( \frac{P_K}{P_M} \right)^{\frac{1}{2}} + a_{LM} \left( \frac{P_L}{P_M} \right)^{\frac{1}{2}} + a_M \frac{1}{Y} + a_{MT} T + a_T \frac{\bar{X}_M T}{Y} + a_{iY} \bar{X}_M Y + a_{iT} \bar{X}_M T^2 \end{aligned}$$

---

<sup>5</sup> It has been shown that maximum likelihood estimates enjoy no advantages over SUR in asymptotic properties. Whether maximum likelihood estimation or SUR is preferable in small sample, unfortunately, depends on a particular data set (Greene, 1993).

The system of factor demand equations in (5.16) contains all the parameters that appear in the generalised Leontief cost function. It is then unnecessary to include the generalised Leontief cost function with the equation system of (5.16) in the estimation. As for the translog cost function, the parameters in this system of equations are estimated using the method of non-linear maximum likelihood estimation.

#### 5.4 An Integrated Model of Estimating Market Imperfection and A Cost Function

In this section, we adopt a framework developed by Appelbaum (1982) which attempts to estimate the degree of oligopoly power and market competitiveness for firms operating in a general oligopolistic market. The approach can be applied to industry level study provided some usual aggregation conditions are satisfied. Recent studies of productivity measurement that consider the effect of market imperfection also employ techniques similar to this approach (see, for example, Kwon and Park, 1995 and Morrison, 1992).

Suppose the market demand function facing a firm is given by

$$(5.17) \quad Y = J(P, Z)$$

---

<sup>6</sup> We adopt the algorithm provided by the computer software program SHAZAM.

where  $P$  is the price of output,  $Y$ , and  $Z$  is a vector of exogenous variables. The input demand functions of the  $j$ th firm can be derived from its cost function by Shephard's Lemma as

$$(5.18) \quad X_i^j = \frac{\partial C^j(Y^j, P_i)}{\partial P_i}$$

where  $P_i$  is a vector of factor prices. An individual firm supplies  $Y^j$  amount to the industrial supply such that  $Y = \sum_{j=1} Y^j$ . The profit-maximising problem facing the  $j$ th firm is then

$$(5.19) \quad \text{Max} [PY^j - C^j(Y^j, P_i)]$$

The optimality condition corresponding to this profit-maximisation problem is given by

$$(5.20) \quad P[1 - \theta^j \kappa] = \frac{\partial C^j(Y^j, P_i)}{\partial Y^j}$$

where  $\theta^j$ , defined by

$$(5.21) \quad \theta^j = \left[ \frac{\partial Y}{\partial Y^j} \frac{Y^j}{Y} \right]$$

is the conjectural elasticity of total industry output with respect to the output of the  $j$ th firm, and  $\kappa$  is the inverse market demand elasticity, defined by

$$(5.22) \quad \kappa = -\left(\frac{\partial P}{\partial Y} \frac{Y}{P}\right)$$

The optimality condition in (5.20) states that the firm equates its marginal cost with its perceived marginal revenue. The conjectural elasticity,  $\theta^j$ , consists of  $j$ th firm's output share in the industry,  $Y^j/Y$ , and a conjectural variation term,  $\partial Y/\partial Y^j$ . In the special case of Cournot behaviour, the conjectural variation term is equal to one,  $\partial Y/\partial Y^j = 1$ , thereby reducing the conjectural elasticity,  $\theta^j$ , to the output share of the  $j$ th firm. Furthermore, under perfect competition,  $\theta^j$  for the  $j$ th firm is 0 since  $\partial Y/\partial Y^j = 0$ , and under perfect implicit collusion,  $\theta^j$  for the  $j$ th firm is 1 since  $\frac{\partial Y}{\partial Y^j} = \frac{Y}{Y^j}$ . Thus, the conjectural elasticity,  $\theta^j$ , identifies the underlying market competitiveness.

Furthermore, one can define the degree of oligopoly power of the  $j$ th firm as

$$(5.23) \quad \mu_j = \left[ \frac{P - MC^j}{P} \right] = \theta^j \kappa$$

where  $MC^j$  is the marginal cost of the  $j$ th firm,  $\partial C^j(Y^j, P_i)/\partial Y^j$ . The degree of oligopoly power,  $\mu_j$ , varies between 0 and 1 due to  $P \geq MC^j$ . The degree of oligopoly



power of a firm is defined by the product of the firm's market competitiveness,  $\theta^j$ , and the demand condition facing the firm,  $\kappa$ . Furthermore, making use of (5.23), the degree of oligopoly power for the industry is given by

$$(5.24) \quad L = \sum_{j=1} \left[ \frac{P - MC^j}{P} \right] S_j = \sum_{j=1} \mu_j S_j = \sum_{j=1} \theta^j S_j \kappa = \sum_{j=1} \frac{\partial Y}{\partial X_j} S_j^2 \kappa$$

where  $S_j = Y^j / Y$ . The industry's measure of oligopoly power is a weighted sum of the squared shares of the firms in the industry multiplied by the inverse demand elasticity. Given input and output time series data of individual firms in an industry, it is now possible to estimate the system of equations given by (5.17), (5.18) and (5.20). Results from this system of equations enable us to identify the degree market competitiveness as well as oligopoly power for a firm.

Since firm data are usually difficult to obtain, the technique described above is modified to apply to industry level studies. To do this, it is necessary to assume that an aggregate cost function exists. Also, the optimality conditions of (5.18) and (5.20) need to be reformulated on an aggregate level. As in other aggregate models, certain aggregation conditions have to be satisfied for the aggregation to be consistent. Similarly here, we have to make a certain assumption in order to consider the optimality conditions of (5.18) and (5.20) on an aggregate level. First, we deal with the aggregate input demand for the industry as a whole. Summing the input demand functions over  $j$  firms for the  $i$ th input yields

$$(5.25) \quad X_i = \sum_j X_i^j = \sum_j \frac{\partial C^j(Y^j, P_i)}{\partial P_i}$$

A usual necessary aggregation condition is that the cost functions for all firms in the oligopolistic market take the form of

$$(5.26) \quad C^j(Y^j, P_i) = Y^j C(P_i) + G^j(P_i)$$

The cost function in (5.26) is usually referred to as the Gorman polar form type, which is a common assumption for the aggregation over firms (or consumers) in most empirical studies.<sup>7</sup> The assumption is equivalent to saying that the firms have linear and parallel expansion paths, so that marginal costs are constant and equal across firms.<sup>8</sup> Given this assumption, then the industry's input demand function can be written as

$$(5.27) \quad X_i = Y \left[ \frac{\partial C(P_i)}{\partial P_i} \right] + \sum_j \frac{\partial G^j(P_i)}{\partial P_i}$$

It should be noted that the assumption made in (5.26) is a very common one. The assumption is usually an implicit maintained hypothesis in most empirical studies, which allows different firms to have different cost functions but the functions are all linear and

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<sup>7</sup> See Gorman (1953) and Blackorby, Primont and Russell (1978).

<sup>8</sup> Since the degree of scale economies is given by the ratio of the marginal to average cost, a constant marginal cost does not necessarily give rise to constant returns to scale. If the marginal cost is a constant,

parallel.<sup>9</sup> With the assumption given in (5.26) and a further assumption that  $\theta^j = \theta$  for all  $j$  firms, we can reformulate (5.20) as

$$(5.28) \quad P[1 - \theta\kappa] = C(P_i)$$

The assumption  $\theta^j = \theta$  appears to be not very appealing since it restricts all firms to behave in exactly the same way. From (5.20), we can see that if all firms have the same marginal costs, then their conjectural elasticities must be the same too at equilibrium. In equilibrium, all firms equate their marginal costs with their perceived marginal revenues and since marginal costs are the same, the perceived marginal revenues are also the same for all firms. Alternatively, Clarke and Davies (1982) show that variation in conjectural elasticities across firms is consistent with profit maximisation in equilibrium, provided that the variation in conjectural elasticities is such as to exactly offset variation in marginal cost across the firms. They assume that the cost variation is of form consistent with (5.26), so no additional assumption on the firm cost functions is necessary to accommodate variation in conjectures while maintaining an assumption of equilibrium with profit maximisation.

The whole model consists of the market demand equation (5.17), the industry's input demand functions (5.27) and industry's optimality condition (5.28). We need only industry level data for empirical implementation of the model. One new element in the

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the degree of scale economies is determined by the magnitude of the average cost relative to the marginal cost at the equilibrium output level.

present study is that we adopt three different forms of market demand: the logarithmic, semi-logarithmic and linear. Unlike previous studies that employ only one particular functional form, we want to examine whether the estimation results generated by the different forms of market demand are consistent with each other.

The introduction of alternative demand functions is a way of explaining variation in the mark-up term without relying on the necessary conditions for equilibrium, which do not appear to be consistent with the estimation procedure that allows explicitly for errors in optimisation to justify the disturbance terms.<sup>10</sup> Appelbaum (1982) assumes that industrial demand takes the logarithmic functional form.<sup>11</sup> It is common in empirical studies of demand to assume logarithmic functional forms, so price elasticity of demand is invariant to changes in price or quantity, implying constant mark-ups over time. This use of the logarithmic functional form is justified only as a convenient approximation (Bloch, 1992). In view of the restrictive nature of the assumption of constant mark-ups, we adopt the alternative demand functional forms for allowing time-varying mark-ups. Note that the semi-logarithmic demand function allows changes in price to affect mark-ups, while the linear demand function allows both changes in price and quantity to affect mark-ups.

The logarithmic market demand function has the form as follows:

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<sup>9</sup> See Berndt and Wood (1975), Hudson and Jorgenson (1974) and Jorgenson et al. (1973).

<sup>10</sup> The mark-up term is defined as  $\theta\kappa$ .

<sup>11</sup> Although Appelbaum (1982) adopts the logarithmic demand function, he assumes that the conjectural term,  $\theta$ , is a function of factor prices to allow for a time-varying mark-up term. This approach is not

$$(5.29) \quad \ln Y = a + \eta \ln\left(\frac{P}{W}\right) + \rho \ln\left(\frac{Q}{W}\right)$$

where  $W$  is the implicit GNP price index and  $Q$  is GNP in current dollars. The price elasticity of demand in (5.29) is  $\eta$ , which remains constant throughout. The constant elasticity demand model in (5.29) means that the change in  $\ln(Y)$  per unit change in  $\ln(P/W)$  remains the same no matter at which  $\ln(P/W)$  we measure the elasticity.

The semi-logarithmic market demand function has the form

$$(5.30) \quad Y = a + \eta \ln\left(\frac{P}{W}\right) + \rho \ln\left(\frac{Q}{W}\right)$$

The semi-logarithmic model in (5.30) is also referred to as the lin-log model. It measures the absolute change in  $Y$  for a given proportional change in  $\ln(P/W)$ . For the lin-log model, the price elasticity of demand is  $\eta(1/Y)$ , which varies depending on the value taken by  $Y$ .

The linear market demand function has the form

$$(5.31) \quad Y = a + \eta\left(\frac{P}{W}\right) + \rho\left(\frac{Q}{W}\right)$$

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followed here since it is generally not acceptable to assume that the conjectural term is a function of factor

The demand elasticity for the linear specification is given by  $\eta\left(\frac{P/W}{Y}\right)$ . It varies

depending on the value taken by the variable  $P$ ,  $W$  and  $Y$ . The linear demand specification gives a constant quantity change per unit change in price.

The industry cost function is given by a generalised Leontief cost function stated by (5.7). The full model to be estimated consists of one of the industry demand functions in (5.29), (5.30) or (5.31), three factor demand functions derived from the generalised Leontief cost function in (5.16) and one of the optimality conditions that corresponds to the logarithmic, semi-logarithmic or linear market demand function. The optimality condition that corresponds to the logarithmic market demand function is

5.12  
(13)

$$(5.32) \quad P = [a_{KK}P_K + a_{LL}P_L + a_{MM}P_M + 2a_{KL}P_K^{\frac{1}{2}}P_L^{\frac{1}{2}} + 2a_{KM}P_K^{\frac{1}{2}}P_M^{\frac{1}{2}} + 2a_{LM}P_L^{\frac{1}{2}}P_M^{\frac{1}{2}} + a_{KT}P_KT + a_{LT}P_LT + a_{MT}P_MT + 2a_{YY}(\bar{X}_K P_K + \bar{X}_L P_L + \bar{X}_M P_M)Y + a_{TT}(\bar{X}_K P_K + \bar{X}_L P_L + \bar{X}_M P_M)T^2] / (1 - \theta/\eta)$$

The optimality condition that corresponds to the semi-logarithmic market demand function is

5.12  
(14)

$$(5.33) \quad P = [a_{KK}P_K + a_{LL}P_L + a_{MM}P_M + 2a_{KL}P_K^{\frac{1}{2}}P_L^{\frac{1}{2}} + 2a_{KM}P_K^{\frac{1}{2}}P_M^{\frac{1}{2}} + 2a_{LM}P_L^{\frac{1}{2}}P_M^{\frac{1}{2}} + a_{KT}P_KT + a_{LT}P_LT + a_{MT}P_MT + 2a_{YY}(\bar{X}_K P_K + \bar{X}_L P_L + \bar{X}_M P_M)Y + a_{TT}(\bar{X}_K P_K + \bar{X}_L P_L + \bar{X}_M P_M)T^2] / (1 - (\theta/\eta)Y)$$

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prices.

The optimality condition that corresponds to the linear market demand function is

$$(5.34) \quad P = [a_{KK}P_K + a_{LL}P_L + a_{MM}P_M + 2a_{KL}P_K^{\frac{1}{2}}P_L^{\frac{1}{2}} + 2a_{KM}P_K^{\frac{1}{2}}P_M^{\frac{1}{2}} + 2a_{LM}P_L^{\frac{1}{2}}P_M^{\frac{1}{2}} + a_{KT}P_KT + a_{LT}P_LT + a_{MT}P_MT + 2a_{YY}(\bar{X}_K P_K + \bar{X}_L P_L + \bar{X}_M P_M)Y + a_{TT}(\bar{X}_K P_K + \bar{X}_L P_L + \bar{X}_M P_M)T^2] / (1 - (\theta/\eta)(WY/P))$$

In general, the conjectural market competition,  $\theta$ , is a function of variables that influence the possibility of market collusion such as the number of firms, the degree of import competition and the changes in market structure. Since we have little or no information about these variables, we choose to treat  $\theta$  as a constant, which is estimated directly from (5.32), (5.33) or (5.34).

In order to implement estimation for this system of equations, we append a stochastic disturbance term in each of the five equations in the system. The additive disturbance term in each equation can be taken as errors in optimisation. We assume that the vector of disturbances is multivariate normally distributed with mean zero and non-singular covariance matrix  $\Omega$ .

We use non-linear maximum likelihood estimation method for estimating this system of five equations. The number of free parameters to be estimated in the system is 19 with 81 degrees of freedom. Once maximum likelihood estimates are obtained, we can then

compute measures that indicate the degree of market competitiveness, returns to scale and technical change.

In the following chapter, we present and discuss the estimation results for the translog cost function model, the generalised Leontief cost function model and the integrated models that consist of three different systems of equations.



## CHAPTER SIX

### ESTIMATION RESULTS

#### Introduction

In this chapter, we present and discuss the estimation results for all the industries under study. As we present the estimation results, we attempt to address the main issue that has been raised in the previous chapters. The issue of measuring technical change, economies of scale and market imperfection is the subject matter of the present study. A question that deserves attention here is whether the estimation results allow us to make any generalizations about the magnitude and direction of technical change as well as the degree of market imperfection and returns to scale for Singapore industries.

Section (6.1) discusses the hypothesis test procedures for the SUR model as well as for the presence of technical change and returns to scale. Section (6.2) and (6.3) present and discuss the estimation results for the translog and generalized Leontief cost function models, respectively. Section (6.4) looks at the results of the integrated models. Under this section, we first look at the hypothesis test procedures in Section (6.4.1) and then present the estimation results for the log-log demand specification in Section (6.4.2), the semi-log demand specification in Section (6.4.3), and the linear demand specification in Section (6.4.4).<sup>1</sup> In Section (6.5), we compare the estimation results generated by the

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<sup>1</sup> We use the term log-log instead of logarithmic market demand function in this chapter.

different demand specifications regarding technical change, economies of scale and market competition. Finally, we summarize and make some conclusions in Section (6.6).

## 6.1 Model Testing and Testing for the Presence of Scale Effect and Technical Change

The elasticity of cost with respect to output, ECY, and time, ECT, computed using parametric estimates of the translog and generalized Leontief cost function are given below in Table (6.1) and Table (6.2), respectively. LRT gives the likelihood ratio test statistic for testing whether the covariance matrix of the disturbances is diagonal. We will look at the meaning as well as the implications of this test in the following paragraph. The two values given in the brackets are the chi-square statistics. As will be explained below, these two test statistics are used to test the presence of returns to scale and technical change.

The likelihood ratio test is a test of whether the covariance matrix of the disturbances is diagonal. The discussion in Chapter Five indicates that SUR estimation is appropriate when the disturbances of an equation system are correlated across equations but not correlated across observations. Under this situation, efficiency can be gained by estimating the equations jointly using SUR estimation, which is, in essence, iterated generalized least squares estimation. In fact, it has been shown that the greater the correlation of the disturbances, the greater the efficiency gain accruing to SUR (Greene, 1993). Thus, testing whether the covariance matrix of the disturbances is diagonal is

equivalent to testing whether SUR estimation is valid for the data at hand. If the hypothesis is not rejected, there is insignificant correlation among the disturbances across equations to warrant the use of SUR estimation.<sup>2</sup>

To identify the presence of non-constant returns to scale, we should test whether  $ECY = 1$ . In the translog case, for instance, the first test of the presence of non-constant returns to scale is to test the null hypothesis:  $a_Y = 1$  and

$a_{KY} = a_{LY} = a_{MY} = a_{TY} = a_{YY} = 0$ . The alternative hypothesis is that not all of the coefficients are equal to the values specified above. However, the rejection of the above null hypothesis does not necessarily mean the rejection of  $ECY = 1$  since  $ECY$  is not a constant but a function of the output level, time and factor prices. In other words, the condition that  $a_Y = 1$  and  $a_{KY} = a_{LY} = a_{MY} = a_{TY} = a_{YY} = 0$  is sufficient, but not necessary, to establish  $ECY = 1$ . Our second testing involves the evaluation of the value of  $ECY$  at the mean point of the variables and test whether the mean value of  $ECY$  is significantly different from one.<sup>3</sup> The first of our tests is referred to as the restricted test and the second one as the less restricted test. We employ the chi-square test statistic for both the restricted and the less restricted tests. The degrees of freedom for the critical chi-square statistic are equal to the number of restrictions imposed on the cost function.

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<sup>2</sup> The likelihood ratio statistic is generated by the Shazam output. This statistic is asymptotically distributed as chi-square with 3 degrees of freedom.

<sup>3</sup> There are two methods of averaging. One method is to evaluate estimates at the mean value of each variable. Another method is to evaluate estimates at each year first and then average them over the 20 years period. In this study, the estimates and their corresponding hypothesis tests are evaluated using the first method of averaging.

To identify the presence of technical change, we should test whether  $ECT = 0$ . Again, as in the tests of non-constant returns to scale, we should carry out both the restricted and less restricted test. For example, in the translog cost function case, the restricted test involves the global condition that all coefficients in the ECT expression equal to zero simultaneously. That is,  $a_T = a_{YT} = a_{TT} = a_{KT} = a_{LT} = a_{MT} = 0$ . The alternative hypothesis is that not all coefficients stated above are equal to zero. Again, the rejection of the above condition does not necessarily mean that ECT is non-zero. It is possible that ECT itself equals to zero even when the set of coefficients stated above is statistically significantly different from zero. Thus, we should also test the necessary condition that ECT itself equals zero. If we can reject both hypotheses, we can then conclude that there is strong evidence pointing to technical change over the observed time frame. As in the tests of the presence of non-constant returns to scale, the statistic employed for testing both the global and local conditions is the chi-square test statistic.

## 6.2 Estimation Results For The Translog Cost Function Model

Table (6.1) shows the estimation results for the translog cost function model. The system of equations used for the estimation of the translog cost function is given by Equation (5.14) in Chapter Five. The system consists of the translog cost function and its derived cost share equations for labor and material. The estimation technique employed is linear SUR.

We first turn our attention to the likelihood ratio test for the validity of the SUR model.

Using a critical chi-square statistic with three degrees of freedom at five percent level,

$\chi^2_{3,0.05} = 7.8$ , we can reject the hypothesis that the covariance matrix of the disturbances is diagonal for all the industries under study except the Furniture and Fixtures industry (332). Therefore, the method of SUR estimation is adequate for the translog cost function model.

The column under ECY in Table (6.1) represents the estimated elasticity of cost with respect to output. The estimated ECY indicates the extent of returns to scale facing the industries. There are twelve industries that show an estimated value of ECY greater than one and fourteen industries less than one. Thus, from the first glance, the results seem to indicate that about half of all the industries exhibit decreasing returns to scale and the other half exhibit increasing returns to scale over the period of analysis.

Out of the twelve industries that exhibit decreasing returns to scale, four of them are significant at five-percent level. On the other hand, out of the fourteen industries that exhibit increasing returns to scale, seven of them are significant. Thus, the proportion of industries that experiences significant decreasing returns to scale is 15% and increasing returns to scale is 27%. The remaining 58% of industries experience neither significant increasing nor decreasing returns to scale.

The Electronic Products and Components industry (384), the largest industry, has an estimated ECY of 1.20 with the chi-square test statistics of 10.3 and 3.1 for the restricted

and less restricted tests of non-constant returns to scale, respectively. We thus cannot reject the null hypotheses that  $ECY = 1$  at five percent level ( $\chi^2_{5,0.05} = 11.1, \chi^2_{1,5\%} = 3.8$ ).

The tests, thus, reveal that the Electronic Products and Components industry (384) experiences neither significant increasing nor decreasing scale economies. In fact, four out of five largest industries exhibit an estimated ECY greater than one, indicating decreasing returns to scale. However, on checking the significance of their ECY estimates, the tests reveal that only the Petroleum Refineries and Petroleum Products (353/4) and Machinery except Electrical and Electronics (382) can be said to have experienced significant decreasing returns to scale among the five largest industries. Their estimated ECY are 1.681 and 1.180, respectively.

We now turn our attention to the estimated elasticity of cost with respect to time, ECT, which is a direct estimate of technical change in Table (6.1). As mentioned earlier, a cost reduction (increase) associated with the shift in the isoquant over time, when factor prices and output level are kept constant, represents technical progress (regress). From the first glance, there are ten industries that show a negative value of ECT (technical progress) and sixteen that show a positive value of ECT (technical regress).<sup>4</sup>

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<sup>4</sup> There is no clear-cut explanation for a positive ECT or technical regress. We find it difficult to attribute technical regress to X-efficiency or managerial inefficiency since optimizing behavior is the maintained hypothesis in our estimation strategy. It could be that some estimation results are due to sampling (type one) error, rejecting the null hypothesis when it is true. Over all the industries, the suggestion is an absence of technical change.

**Table 6.1: Estimates of Elasticity of Cost With Respect to Output (ECY) and Time (ECT)- The Translog Cost Function Model**

(Critical Values) Industry	ECY ( $\chi^2_{5,0.05} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	ECT ( $\chi^2_{5,0.05} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	LRT ( $\chi^2_{3,0.05} = 7.8$ )
Food (311/2)	0.008 (20.3, 4.0)	0.027 (72.3, 6.2)	49.7
Beverage (313)	1.578 (56.1, 3.4)	-0.051 (25.0, 14.7)	30.4
Tobacco (314)	0.582 (184.0, 6.5)	-0.108 (407.2, 67.0)	41.6
Textiles & Textile Manufactures (321)	0.950 (4.5, 0.2)	0.037 (50.1, 14.3)	36.8
Wearing Apparel except Footwear (322)	0.657 (22.5, 2.4)	0.013 (34.5, 3.9)	30.7
Leather & Leather Products (323)	0.907 (5.4, 0.1)	0.045 (5.6, 3.7)	55.6
Footwear (324)	0.613 (45.0, 7.8)	-0.016 (122.1, 3.3)	27.9
Sawn Timber & Other Wood Products except Furniture (331)	1.277 (17.4, 2.3)	0.078 (34.6, 13.5)	51.7
Furniture & Fixtures (332)	0.540 (63.7, 5.3)	0.031 (28.9, 9.5)	5.5
Paper & Paper Products (341)	0.826 (127.5, 2.7)	0.060 (730.1, 543.4)	20.1
Printing & Publishing (342)	2.410 (58.3, 30.2)	-0.138 (64.4, 44.5)	45.1
Industrial Chemicals & Gas (351)	1.583 (32.6, 11.0)	-0.048 (39.8, 4.0)	41.2
Paints, Pharmaceuticals & Other Chemical Products (352)	0.420 (17.1, 7.7)	0.032 (9.6, 3.4)	23.3
Petroleum Refineries & Petroleum Products (353/4)	1.681 (14.6, 8.3)	-0.048 (41.9, 23.0)	67.0
Rubber Products, Jelutong & Gum Damar (355/6)	0.401 (14.2, 6.6)	0.0274 (34.1, 23.7)	19.7
Plastic Products (357)	1.120 (29.8, 0.3)	0.065 (368.6, 142.3)	23.6
Pottery, China, Earthenware & Glass Products (361/2)	1.134 (9.9, 0.3)	0.101 (30.9, 14.2)	31.6
Iron and Steel (371)	1.058 (47.4, 0.0)	-0.012 (16.7, 0.4)	27.0
Non-ferrous Metals (372)	1.440 (9.8, 0.8)	0.033 (99.5, 11.1)	41.0
Fabricated Metal Products except Machinery & Equipment (381)	0.756 (6.5, 0.6)	0.044 (51.2, 10.1)	8.2
Machinery except Electrical & Electronic (382)	1.180 (35.2, 4.3)	-0.031 (41.5, 26.2)	49.7
Electrical Machinery, Apparatus, Appliances & Supplies (383)	0.807 (21.7, 2.3)	0.006 (9.5, 0.2)	56.0
Electronic Products & Components (384)	1.201 (10.3, 3.1)	0.021 (9.7, 1.8)	23.8
Transport Equipment (385)	1.086 (2.2, 0.1)	-0.066 (19.2, 14.2)	46.1
Instrumentation Equipment, (386) Photographic & Optical Goods	0.853 (12.0, 0.6)	-0.006 (18.1, 0.3)	53.1
Other Manufacturing Industries (390)	0.402 (59.1, 13.3)	0.070 (144.3, 128.8)	58.3

Notes: Chi-square test statistic and asymptotic normal values are in parentheses. ECY corresponds to the estimated elasticity of cost with respect to output, a measure of the degree of economies of scale. ECT corresponds to the estimated elasticity of cost with respect to time, a measure of technical change. LRT corresponds to the likelihood ratio test statistic for testing whether the covariance matrix of the disturbances is diagonal. All estimated elasticities are evaluated at the mean value of each variable. Appendix F lists the complete Shazam output.

Out of the ten industries that show technical progress, seven of them are significant at five-percent level. Out of the sixteen industries that show technical regress, twelve of them are significant. The remaining seven ECT estimates are not significantly different from zero. Thus, the proportion of industries that experiences significant technical progress is 27% and technical regress is 46%. The remaining 27% of industries do not seem to have experienced any significant technical change at all.

Among the five largest industries, the Electronic Products and Components industry (384) is the only industry that shows neither significant technical progress nor regress. Petroleum Refineries and Petroleum Products (353/4), Transport Equipment (385) and Machinery except Electrical and Electronic (382) all exhibit significant technical progress. Food (311/2) is the only industry that exhibits significant technical regress among the five largest industries.

To sum up the results generated by the translog cost function model, we conclude that four industries are estimated to have experienced significant decreasing returns to scale, while the remaining twenty-two industries are split between constant to increasing returns to scale. Twelve industries are estimated to have experienced significant technical regress, while the remaining fourteen industries are split between no significant technical change and technical progress. When we look at the largest industries alone, we find that the largest industries are typically characterized by constant to decreasing returns to scale and technical progress.



### 6.3 Estimation Results For The Generalized Leontief Cost Function Model

In Table (6.2), the likelihood ratio test for the diagonal covariance matrix of the disturbances shows that three industries have a test statistic less than the critical chi-square value of 7.8 at five-percent level. Consequently, we cannot reject the hypothesis that the covariance matrix is diagonal for these industries. Then, SUR estimation for these industries does not offer any significant improvement in efficiency over estimating the single cost function alone. Moreover, in general, the magnitudes of the likelihood ratio test statistics under the generalized Leontief cost function model are lower than those under the translog cost function model. Thus, the likelihood ratio test seems to suggest that there is more efficiency gained in the translog cost function model than the generalized Leontief cost function model when SUR estimation is used.

The magnitudes of the estimated ECY generated under the generalized Leontief cost function model are, in general, lower than those generated under the translog cost function model. From the first glance, all the industries under study show an estimated value of ECY less than one.<sup>5</sup> However, the significance test reveals that twenty-one industries have an estimated ECY significantly lower than one at five-percent level. The remaining five industries show an estimated ECY not significantly different from one. Therefore, the proportion of industries that experience significant increasing returns to

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<sup>5</sup> Note that the estimated ECY generated by the generalized Leontief cost function for four industries are negative. These are anomalous results since ECY should be non-negative as the cost function is assumed to be concave in output.

scale is about 81%. The remaining 19% of industries experience neither significant increasing nor decreasing economies of scale.

We turn to the estimated elasticity of cost with respect to time, ECT. The results in Table (6.2) show that ten industries exhibit a negative estimated ECT and the remaining sixteen exhibit a positive estimated ECT. Out of the ten industries that show a negative estimated ECT, only two of them are significant at five-percent level. On the other hand, out of the sixteen industries that show a positive value of estimated ECT, ten of them are significant. Consequently, the proportion of industries that experience significant technical progress is 7.7% and technical regress is 39%. The remaining 49% of industries do not show any significant technical change.

Similar to its results under the translog cost function model, Electronic Products and Components (384), the largest industry, is estimated to have constant returns to scale. The other largest industries such as Petroleum Products and Petroleum Refineries (353/4), Food (311/2), Machinery except Electrical & Electronic (382) and Transport Equipment (385) all exhibit significant increasing returns to scale. On the other hand, with the exception of Food (311/2) that shows significant technical regress, the other four largest industries all exhibit no significant technical change.

**Table 6.2: Estimates of Elasticity of Cost With Respect to Output (ECY) and Time (ECT)- The Generalized Leontief Cost Function**

(Critical Values) Industry	ECY ( $\chi^2_{5,0.05} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	ECT ( $\chi^2_{5,0.05} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	LRT ( $\chi^2_{3,0.05} = 7.8$ )
Food (311/2)	-0.513 (175.3, 43.7)	0.042 (230.6, 55.1)	9.5
Beverage (313)	0.602 (82.4, 2.9)	-0.001 (16.2, 0.0)	27.5
Tobacco (314)	0.064 (358.5, 47.4)	-0.023 (229.8, 1.8)	7.1
Textiles & Textile Manufactures (321)	0.849 (23.9, 0.7)	-0.015 (55.0, 3.3)	12.5
Wearing Apparel except Footwear (322)	0.672 (39.2, 26.1)	0.009 (36.5, 15.2)	44.8
Leather & Leather Products (323)	0.405 (19.0, 4.1)	0.021 (13.8, 1.6)	29.3
Footwear (324)	0.413 (104.4, 36.9)	-0.039 (223.1, 36.6)	15.0
Sawn Timber & Other Wood Products except Furniture (331)	0.298 (84.6, 13.8)	-0.025 (23.8, 8.4)	25.4
Furniture & Fixtures (332)	0.636 (791.8, 14.1)	-0.006 (102.1, 1.9)	41.0
Paper & Paper Products (341)	0.287 (411.4, 110.0)	0.049 (1162.7, 762.9)	21.7
Printing & Publishing (342)	0.267 (177.7, 6.2)	-0.006 (146.5, 0.0)	27.6
Industrial Chemicals & Gas (351)	0.707 (164.2, 1.9)	0.016 (84.6, 0.5)	18.5
Paints, Pharmaceuticals & Other Chemical Products (352)	0.359 (102.0, 14.8)	0.034 (62.0, 5.6)	14.7
Petroleum Refineries & Petroleum Products (353/4)	0.410 (91.4, 28.5)	-0.003 (77.8, 0.3)	9.8
Rubber Products, Jelutong & Gum Damar (355/6)	-0.056 (66.1, 48.2)	0.008 (165.6, 4.9)	14.0
Plastic Products (357)	0.643 (31.5, 9.2)	0.074 (1111.1, 353.1)	7.2
Pottery, China, Earthenware & Glass Products (361/2)	0.612 (3.3, 1.3)	0.054 (36.0, 2.1)	59.5
Iron and Steel (371)	-0.337 (109.4, 40.4)	0.048 (30.2, 25.0)	26.7
Non-ferrous Metals (372)	-0.342 (36.7, 28.9)	0.059 (242.8, 97.4)	4.7
Fabricated Metal Products except Machinery & Equipment (381)	0.089 (51.4, 20.1)	0.054 (111.9, 20.7)	22.5
Machinery except Electrical & Electronic (382)	0.605 (151.4, 21.0)	-0.003 (9.2, 0.2)	8.5
Electrical Machinery, Apparatus, Appliances & Supplies (383)	0.445 (1207.8, 33.0)	0.016 (38.0, 3.3)	33.9
Electronic Products & Components (384)	0.877 (46.8, 3.0)	0.009 (86.1, 0.4)	11.5
Transport Equipment (385)	0.453 (74.1, 14.2)	-0.013 (22.5, 1.1)	10.3
Instrumentation Equipment, (386)	0.441 (33.7, 14.1)	0.020 (20.0, 1.4)	15.6
Photographic & Optical Goods			
Other Manufacturing Industries (390)	0.244 (299.3, 68.8)	0.057 (399.4, 203.5)	24.8

Notes: Chi-square test statistic and asymptotic normal values are in parentheses. ECY corresponds to the estimated elasticity of cost with respect to output, a measure of the degree of economies of scale. ECT corresponds to the estimated elasticity of cost with respect to time, a measure of technical change. LRT corresponds to the likelihood ratio test statistic for testing whether the covariance matrix of the disturbances is diagonal. All estimated elasticities are evaluated at the mean value of each variable. Appendix G lists the complete Shazam output.

In conclusion, the generalized Leontief cost function model generates results that indicate the majority of Singapore industries experience significant increasing returns to scale, but no significant technical change. In addition, three out of five largest industries show some evidence of technical progress, although the evidence is not statistically significant.

We can now turn our attention to the integrated models which include not only the generalized Leontief cost function but also the equations that capture the market demand and market equilibrium conditions. The integrated models represent an improvement over the individual cost function models since they allow technical change and economies of scale to be estimated jointly with the market demand condition. It will be interesting to see whether the results generated under the integrated models are comparable to those under the separate cost function models.

#### **6.4 Estimation Results For the Integrated Models**

The estimation results for the integrated models are listed in Table (6.3), (6.4) and (6.5). Each of the three integrated models consists of three derived input demand equations from the generalized Leontief cost function as well as a market demand and market equilibrium equations. We have three different specifications for the market demand condition- the log-log, semi-log and linear demand function. We show in each table the results of fitting the different demand specifications in the integrated model.

Since we have a system of simultaneous equations with non-linear coefficients, an efficient estimation method is the three stage least square estimation. We, therefore, employ the non-linear iterated three stage least square estimation method for our system of simultaneous equations.<sup>6</sup>

In the tables, we present the estimates for the elasticity of cost with respect to output, ECY, the elasticity of cost with respect to time, ECT, the conjectural measure of competition, THETA, and a measure of overall goodness-of-fit for the equation systems, R-square. Also, the chi-square test statistics for the significance of the estimates are given in the brackets. Before we look at the results, we first discuss the hypothesis test procedures in Section (6.4.1).

#### 6.4.1 Statistical Tests For the Integrated Models

Statistical tests for the significance of the estimates in this section resemble closely those tests discussed in Section (6.1). The two figures given in the brackets following the estimates of ECY and ECT are the chi-square test statistics. The first chi-square test statistic is to test the significance of the elasticity terms globally. For example, the generalized Leontief cost function is linearly homogeneous in output if

$a_K = a_L = a_M = a_T = a_{YY} = 0$ . That is, we have constant returns to scale ( $ECY = 1$ ) if the coefficients stated above all jointly equal zero. Our first test then tests the null hypothesis:

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<sup>6</sup> Another possible estimation technique that can be used is the full information maximum likelihood estimation (FIML) method. It can be shown that with normally distributed disturbances FIML is efficient

$a_K = a_L = a_M = a_T = a_{YY} = 0$  against the alternative hypothesis that at least one of the coefficients is not zero. In the ECT case, the first figure in the brackets is the chi-square test statistic for testing whether the generalized Leontief cost function is independent of time ( $ECT = 0$ ). Here, we test the null hypothesis:  $a_{KT} = a_{LT} = a_{MT} = a_T = a_{TT} = 0$  against the alternative hypothesis that at least one of the coefficients is not zero.

As discussed in Section (6.1), the hypothesis tests stated above test only the sufficient condition for the hypothesized values. It is possible that the elasticity terms equal to the hypothesized values even without meeting the sufficient condition. Thus, we should also take into account the necessary condition that the elasticity terms are themselves equal to the hypothesized values. The second figure in the brackets following the estimates of ECY and ECT is the chi-square test statistic that test whether ECY and ECT each evaluated at its mean equal to one and zero, respectively. We will only reject the hypothesized values if both chi-square test statistics for the sufficient and necessary conditions are greater than the critical chi-square values.<sup>7</sup>

We can test the significance of our estimated conjectural measure of competition, THETA, given in the tables. In our estimation, THETA is a parametric constant that gives the industry conjectural elasticity of competition. The chi-square test statistic tests

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among all estimators. However, because of its simplicity, three stage least square estimation is used almost exclusively in the literature for simultaneous equations (Greene, 1993).

<sup>7</sup> Since the number of restrictions for the generalized Leontief cost function to be linearly homogeneous in output and independent of time is five, the critical chi-square value for testing the sufficient condition has five degrees of freedom. With 5% level, the critical chi-square value is 11.1. For testing the necessary condition, the critical chi-square value has one degree of freedom, which equals to 3.8 at 5% level for both ECY and ECT.

whether the conjectural measure of competition is significantly different from zero. We will reject the hypothesis that the conjectural measure of competition is significantly different from zero if the chi-square test statistic is greater than the corresponding critical values.<sup>8</sup>

Our results also contain a measure of overall goodness-of-fit, R-square, for the individual equation systems. The overall R-square measure is calculated using  $R^2 = 1 - \frac{|E'E|}{|y'y|}$  where  $|E'E|$  is the determinant of the residual cross-products matrix and  $|y'y|$  is the determinant of  $y'y$  or  $(Y - \bar{Y})'(Y - \bar{Y})$ . The R-square measure should be bounded in the interval between zero and one.<sup>9</sup> In the brackets that follow the R-square measures contain the likelihood ratio test statistics.<sup>10</sup> Given the null hypothesis that all the slope coefficients in all equations are simultaneously equal to zero, the likelihood ratio statistic is distributed as a chi-square random variable with degrees of freedom equal to the number of independent slope coefficients in the equation system (Berndt, 1991). In our case, with the number of independent slope coefficients in the model equals to 19, the corresponding critical chi-square value is 30.1 at five-percent level.

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<sup>8</sup> The critical chi-square value has the same number of degrees of freedom as the number of restrictions imposed on the function of the conjectural measure of competition. The test thus has one degree of freedom and at 5% level the critical chi-square value is 3.8.

<sup>9</sup> It is often problematic to interpret the R-square measure in the equation systems context. This is usually stamped from the fact that the (adjusted) R-square measure does not capture the variation in goodness-of-fit between equations in the system. It is then possible to have a very high R-square measure even though some equations in the system have very poor goodness-of-fit. In addition, if the equations do not contain a constant term, then there is no guarantee that the R-square measure will be bounded by the interval between zero and one. It is suggested then this measure can only be used as a descriptive measure and not as one used to compare different models (Greene, 1993).

<sup>10</sup> The likelihood ratio test statistic is calculated as follows:

#### 6.4.2 Estimation Results For the Integrated Model Using the Log-Log Market Demand Function

We show in Table (6.3) the estimation results for the integrated model that uses a log-log market demand specification. Firstly, there is only one industry, Machinery (382), whose results are unavailable due to non-convergence.<sup>11</sup> The measure of overall goodness-of-fit of the equation system, R-square, indicates that the equation system fit most industries under study very well. We can reject the null hypothesis that the slope coefficients in the equation system jointly equal to zero at five percent level for all industries except Electronic Products and Components (384), the largest industry, that has a relatively low R-square at 0.7040.

The results in Table (6.3) show the estimated elasticity of cost with respect to output, ECY, and time, ECT, the estimated conjectural measure of competition, THETA, and the (adjusted) R-square for the equation systems. The two figures below the estimates in the brackets are the chi-square test statistics. Firstly, our results show that out of the twenty-five industries that have converged, twenty-four of them show an estimated ECY less than one while only one industry shows an estimated ECY greater than one.

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$$LR = -T * \ln(1 - R^2)$$

where  $T$  denotes the number of observations in each equation.

<sup>11</sup> It is well known that in non-linear estimation, there is no guarantee that the algorithm will lead to convergence of the model. Even if the model converges, there is no guarantee that the maximum reached is a global maximum rather than a local maximum. Setting a set of 'appropriate' initial values is important in reaching the global maximum. In an effort to find the 'appropriate' sets of initial values, we first estimate



**Table 6.3: Estimation Results For the Integrated Model (Log-Log Demand)**

(Critical Values) Industry	ECY ( $\chi^2_{5,5\%} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	ECT ( $\chi^2_{5,5\%} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	THETA ( $\chi^2_{1,5\%} = 3.8$ )	R-sq ( $\chi^2_{19,5\%} = 30.1$ )
Food (311)	0.1160 (1483.4, 55.4)	0.0265 (103.9, 44.4)	-0.1456 (2.2)	0.971 (70.5)
Beverage (313)	0.5254 (46.9, 7.0)	0.0057 (31.3, 0.4)	0.2007 (1.0)	0.999 (139.1)
Tobacco (314)	0.2827 (345.2, 219.6)	-0.0520 (185.7, 17.9)	-0.1615 (0.5)	0.999 (224.5)
Textiles & Textile Manufactures (321)	0.6238 (134.8, 12.2)	-0.0197 (40.9, 5.5)	0.9166 (4.9)	0.999 (136.0)
Wearing Apparel except Footwear (322)	0.5776 (192.0, 67.7)	0.0068 (66.8, 20.0)	-0.4012 (6.3)	0.999 (138.8)
Leather & Leather Products (323)	0.8788 (29.0, 0.1)	0.0547 (37.1, 3.7)	-0.1085 (0.2)	0.994 (103.7)
Footwear (324)	0.2359 (751.8, 149.4)	-0.0542 (283.6, 184.4)	-0.2083 (1.9)	0.999 (172.5)
Sawn Timber & Other Wood Products (331)	-0.0283 (586.9, 603.5)	-0.0904 (160.5, 121.1)	-0.4983 (8.8)	0.889 (44.0)
Furniture & Fixtures (332)	0.3605 (554.0, 25.5)	0.0039 (10.3, 0.2)	-0.3665 (0.5)	0.995 (107.2)
Paper & Paper Products (341)	0.2993 (2149.0, 180.4)	0.0449 (528.0, 303.1)	-0.1000 (0.8)	0.999 (155.0)
Printing & Publishing (342)	-4.9655 (46.6, 5.3)	0.5704 (15.6, 4.5)	-3.0386 (0.9)	0.991 (94.5)
Industrial Chemicals & Gases (351)	1.0299 (79.1, 0.1)	-0.0362 (61.4, 3.2)	-0.9766 (8.6)	0.997 (115.7)
Paints, Pharmaceuticals & Other Chemical (352)	0.2108 (970.6, 205.8)	0.0510 (283.2, 69.4)	-0.2136 (2.9)	0.999 (178.2)
Petroleum Refineries & Petroleum Products (353/4)	0.6372 (275.4, 12.2)	-0.0106 (178.0, 4.3)	-0.0500 (0.6)	0.999 (194.6)
Rubber Products (356)	0.1265 (974.7, 310.9)	0.0114 (103.4, 6.4)	-0.2869 (4.4)	0.952 (60.9)
Plastic Products (357)	0.8754 (54.6, 1.3)	0.0605 (1411.2, 402.6)	0.4536 (10.1)	0.999 (171.3)
Pottery, China, Earthenware & Glass Products (361/2)	0.8821 (4.8, 0.6)	0.0972 (39.8, 5.5)	0.0820 (0.1)	0.994 (101.9)
Iron and Steel (371)	0.7343 (52.1, 0.6)	-0.0089 (29.3, 0.4)	0.3666 (1.5)	0.998 (127.9)
Non Ferrous Metal (372)	0.5700 (48.1, 6.1)	0.0484 (189.9, 82.0)	0.1238 (1.4)	0.986 (85.7)
Fabricated Metal Products (381)	0.3852 (167.8, 29.7)	0.0435 (207.4, 61.9)	0.0090 (0.0)	0.998 (127.8)
Electrical Machinery, (383) Apparatus & Appliances	0.1072 (1711.6, 929.9)	0.0574 (995.0, 526.7)	-0.9132 (28.6)	0.999 (152.2)

the linear version of the integrated model for each industry under study and use the resulting estimates as the initial values for the search of the global maximum.

Electronic Products & Components (384)	-0.7565 (47.7, 15.1)	0.2555 (39.6, 11.8)	0.5982 (0.4099)	0.704 (24.4)
Transport Equipment (385)	0.3999 (281.7, 37.6)	-0.0105 (57.2, 2.1)	0.1592 (0.8)	0.997 (113.3)
Instrumentation Equipment, Photographic Goods (386)	0.4149 (359.0, 91.1)	0.0307 (62.9, 44.3)	0.4914 (2.4)	0.999 (179.0)
Other Manufacturing Industries (390)	0.2635 (778.3, 97.8)	0.0600 (400.2, 317.1)	-0.1960 (2.0)	0.997 (117.4)

Notes: Chi-square test statistics are in parentheses. ECY corresponds to the estimated elasticity of cost with respect to output, a measure of the degree of economies of scale. ECT corresponds to the estimated elasticity of cost with respect to time, a measure of technical change. R-square provides a measure of overall goodness-of-fit of the equation system. All estimates are evaluated at the mean value of each variable. Appendix H lists the complete Shazam output.

The results from the log-log demand specification seem to suggest that most industries face significant increasing returns to scale. Only five industries show an estimated ECY not significantly different from one, indicating constant returns to scale. None of the ECY estimates are significantly greater than one, indicating decreasing returns to scale. The largest industry, Electronic Products & Components (384), shows an ECY estimate of negative 0.7565, which is an anomalous result. A negative value here violates the maintained hypothesis that the cost function is concave in output. However, the industry's R-square is relatively low with the chi-square test statistic insignificant at five-percent level. Consequently, it is difficult to conclude the degree of economies of scale for Electronic Products and Components (384) based on the results of the log-log demand specification.

Turning our attention to the elasticity of cost with respect to time, ECT, in Table (6.3), our results are not notably different from the results generated under the translog or generalized Leontief cost function model. The results show that there are eight industries

with an estimated ECT less than zero and seventeen industries with an estimated ECT greater than zero. Out of the eight industries that indicate technical progress, five are significant at five-percent level. Out of the seventeen industries that indicate technical regress, fourteen of them are significant at five-percent level. Thus, the proportion of industries that experience significant technical progress is 20 percent and technical regress is 56 percent. The remaining 24 percent of industries do not show any significant technical change. The results are, in general, consistent with estimates of the translog and generalized Leontief cost function model.

Table (6.3) shows the estimated conjectural measure of competition, THETA. In our model construction, the conjectural elasticity should be bounded by the interval  $[0,1]$ . We do not expect the conjectural elasticity to be either less than zero or greater than one, since a value of zero represents perfect competition and one represents pure monopoly. Our results show that fifteen industries exhibit the anomalous result of a negative THETA, while the remaining ten show a THETA within the bound of  $[0,1]$ . Applying the chi-square test, we find that eighteen industries face a market environment not significantly different from perfect competition. Only two industries can be said to have faced imperfect market competition. Finally, we are unable to interpret the results of the remaining five industries that show a THETA significantly less than zero.

In sum, the results of the log-log demand specification of the integrated model suggest that the majority of industries (80 percent) experience significant economies of scale. The results for technical change are mixed, with about 56 percent of the industries showing

technical regress and the rest of the industries showing either technical progress or insignificant technical change. Furthermore, the hypothesis of perfect competition cannot be rejected for the majority of industries (72 percent) included in the study.

#### 6.4.3 Estimation Results For the Integrated Model Using the Semi-Log Market Demand Function

Table (6.4) shows the estimation results of the integrated model that uses a semi-log functional form to capture the market demand. Firstly, none of the industries under the study fail to converge. Also, the R-square measure indicates that all industries pass the chi-square test for the significance of the model.

Under the semi-log demand specification, twenty-four industries have an ECY estimate less than one and two industries have an ECY estimate greater than one. Out of the twenty-four industries that show an estimated ECY less than one, twenty-one of them are significant at five-percent level. On the other hand, Industrial Chemicals and Gases (351) is the only industry that shows significant decreasing returns to scale. Consequently, 81 percent of the industries experience significant increasing returns to scale, four percent experience significant decreasing returns to scale, and the remaining 15 percent experience constant returns to scale.

**Table 6.4: Estimation Results For the Integrated Model (Semi-Log Demand)**

(Critical Value) Industry	ECY ( $\chi^2_{5,5\%} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	ECT ( $\chi^2_{5,5\%} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	THETA ( $\chi^2_{1,5\%} = 3.8$ )	R-sq ( $\chi^2_{19,5\%} = 30.1$ )
Food (311)	0.0771 (295.9, 82.3)	0.0277 (90.5, 51.9)	-0.2008 (4.6)	0.889 (44.0)
Beverage (313)	0.5158 (75.6, 10.3)	0.0055 (35.7, 0.4)	0.3386 (1.6)	0.999 (139.1)
Tobacco (314)	0.3607 (669.4, 223.4)	-0.0728 (197.4, 24.1)	0.3387 (1.2)	0.999 (190.4)
Textiles & Textiles Manufactures (321)	0.6015 (37.6, 14.9)	-0.0158 (26.1, 2.4)	0.8221 (5.5)	0.998 (122.9)
Wearing Apparel except Footwear (322)	0.5821 (794.7, 64.8)	0.0066 (61.1, 18.8)	-0.3964 (6.0)	0.998 (126.2)
Leather & Leather Products (323)	-0.5616 (20.7, 6.6)	-0.0290 (3.4, 0.3)	0.1916 (0.0)	0.968 (69.0)
Footwear (324)	0.4081 (213.9, 67.0)	-0.0466 (231.6, 84.9)	0.2860 (1.5)	0.999 (182.8)
Sawn Timber & Other Wood Prod. Furniture (331)	0.7332 (349.2, 12.9)	0.0132 (54.8, 1.3)	0.6953 (7.1)	0.998 (121.7)
Furniture & Fixtures (332)	0.7602 (153.4, 0.1)	-0.0298 (5.6, 0.4)	-0.5509 (0.5)	0.897 (45.5)
Paper & Paper Products (341)	0.3153 (856.3, 399.8)	0.0443 (513.3, 307.5)	-0.0618 (0.9)	0.999 (141.7)
Printing & Publishing (342)	0.7213 (505.7, 5.7)	-0.0026 (43.0, 0.1)	2.0615 (8.7)	0.999 (158.4)
Industrial Chemicals & Gases (351)	1.4990 (104.2, 5.1)	-0.0769 (49.3, 5.5)	-0.4284 (0.8)	0.997 (115.1)
Paints, Pharmaceuticals & Other Chemical Prod. (352)	0.2394 (522.4, 268.8)	0.0465 (221.7, 75.1)	-0.2634 (2.9)	0.999 (154.6)
Petroleum Refineries & Petroleum Products (353/4)	0.6295 (408.1, 11.5)	-0.0112 (170.8, 4.0)	0.0290 (0.1)	0.999 (181.1)
Rubber Products, Jelutong & Gum Damar (355/6)	0.2853 (68.6, 33.2)	0.0147 (68.0, 10.8)	-0.1285 (1.2)	0.899 (45.9)
Plastic Products (357)	0.7871 (273.0, 11.2)	0.0624 (1440.5, 770.4)	0.3880 (16.7)	0.999 (180.6)
Pottery, China, Earthenware and Glass (361)	0.5067 (43.7, 15.3)	0.0753 (47.1, 3.0)	0.0976 (0.7)	0.9534 (61.5)
Iron and Steel (371)	0.8922 (44.3, 0.1)	-0.0013 (14.5, 0.0)	0.1766 (0.5)	0.975 (73.9)
Non Ferrous Products(372)	0.7038 (16.8, 2.1)	0.0460 (190.9, 69.1)	0.1986 (1.9)	0.992 (96.7)
Fabricated Metal Products (381)	0.3887 (374.2, 63.8)	0.0430 (201.9, 122.7)	0.0169 (0.0)	0.998 (126.3)
Machinery except Electrical & Electronic (382)	0.7003 (1170.0, 10.4)	-0.0093 (12.6, 1.5)	0.1236 (0.3)	0.999 (130.4)
Electrical Machinery (383)	1.5161 (787.7, 2.1)	-0.0584 (15.6, 3.4)	0.1632 (0.1)	0.999 (143.8)
Electronic Products & Components (384)	0.4243 (934.1, 117.6)	0.0684 (359.8, 79.5)	0.3234 (1.4)	0.995 (107.8)

Transport Equipment (385)	0.5416 (611.8, 16.1)	-0.0195 (73.9, 5.5)	0.0031 (0.0)	0.998 (126.8)
Instrumentation Equip. (386) Photographic & Optical	0.4181 (379.9, 99.9)	0.0294 (71.9, 42.3)	0.5377 (2.9)	0.999 (171.8)
Other Manufacturing Industries (390)	0.2474 (545.0, 305.3)	0.0598 (394.5, 315.0)	-0.2119 (3.1)	0.990 (91.9)

Notes: Chi-square test statistics are in parentheses. ECY corresponds to the estimated elasticity of cost with respect to output, a measure of the degree of economies of scale. ECT corresponds to the estimated elasticity of cost with respect to time, a measure of technical change. R-square provides a measure of overall goodness-of-fit of the equation system. All estimates are evaluated at the mean value of each variable. Appendix I lists the complete Shazam output.

The results for ECT under the semi-log demand specification are mixed. Fourteen industries show an ECT estimate greater than zero, while twelve industries show an ECT estimate less than zero. Out of the fourteen industries that show a positive estimated ECT, eleven are significant at five-percent level. Out of the twelve industries that show a negative estimated ECT, five of them are significant. Consequently, 19 percent of the industries experience significant technical progress, 42 percent experience technical regress, and the remaining 39 percent do not show any significant technical change.

The estimated conjectural measure of competition, THETA, shows that twenty out of the total twenty-six industries do not face conditions significantly different from perfect competition. On the other hand, there are only four industries that are estimated to experience significant imperfect competition (Industry 321, 331, 342, 357). Out of these four industries, two industries also show significant imperfect competition in the log-log demand specifications. These two industries are Textiles & Textiles Manufactures (321) and Plastic Products (357). Finally, we have three industries whose estimates of

conjectural elasticity fall significantly outside the normal bound of  $[0,1]$  so no interpretation can be made regarding their degree of market competition.

In sum, the results of the semi-log demand specification of the integrated model suggest that the majority of industries experience significant increasing returns to scale (81 percent) and a market structure close to perfect competition (77 percent). There are only about 20 percent of the industries experience significant technical progress, while the rest of the industries are split between no significant technical change to technical regress.

#### 6.4.4 Estimation Results For the Integrated Model Using the Linear Market Demand Function

Table (6.5) presents the estimation results for the integrated model that uses a linear market demand specification. We have seven industries failing to converge under the linear demand specification. Furthermore, the (adjusted) R-square measure reveals that two industries have a chi-square test statistic lower than the critical value, suggesting poor goodness-of-fit for the equation systems.

**Table 6.5: Estimation Results For the Integrated Model (Linear Demand)**

(Critical Value) Industry	ECY ( $\chi^2_{5,5\%} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	ECT ( $\chi^2_{5,5\%} = 11.1$ , $\chi^2_{1,5\%} = 3.8$ )	THETA ( $\chi^2_{1,5\%} = 3.8$ )	R-sq ( $\chi^2_{19,5\%} = 30.1$ )
Tobacco (314)	0.2662 (318.6, 27.9)	-0.0380 (203.9, 1.3)	0.1287 (0.1)	0.999 (130.7)
Textiles & Textile Manufactures (321)	0.5347 (27.1, 7.5)	-0.0299 (44.5, 6.1)	1.3453 (0.6)	0.995 (103.9)
Footwear (324)	0.2657 (2422.3, 6144.8)	-0.0553 (297.3, 287.8)	-0.2440 (57.5)	0.999 (194.7)
Sawn Timber & Other Wood Products (331)	0.7770 (823.3, 8.9)	0.0186 (71.9, 2.6)	1.2575 (13.4)	0.998 (124.0)
Paper & Paper Products (341)	0.3410 (303.7, 236.0)	0.0453 (834.2, 339.2)	-0.0133 (0.0)	0.999 (138.7)
Printing & Publishing (342)	0.6000 (480.2, 14.2)	0.0109 (63.5, 1.3)	0.0380 (0.1)	0.999 (183.7)
Industrial Chemicals and Gases (351)	0.8404 (119.1, 0.1)	0.0043 (99.0, 0.0)	0.9664 (0.1)	0.997 (113.7)
Paints, Pharmaceuticals & Other Chemical Prod. (352)	0.1969 (447.6, 382.5)	0.0492 (190.4, 75.6)	-0.5035 (0.2)	0.939 (56.0)
Petroleum Refineries and Petroleum Products (353)	0.3761 (36.0, 7.5)	-0.0012 (25.8, 0.0)	1.0000 (0.5)	0.903 (46.6)
Plastic Products (357)	0.6879 (19.9, 7.1)	0.0666 (1004.0, 342.6)	0.3354 (2.6)	0.997 (119.0)
Pottery, China, Earthenware & Glass Products (361/2)	0.5590 (27.4, 4.8)	0.0789 (51.5, 4.2)	-0.0828 (0.1)	0.954 (61.5)
Iron and Steel (371)	0.5581 (53.8, 2.5)	0.0013 (30.4, 0.0)	0.2448 (0.5)	0.460 (12.3)
Non-ferrous Metals (372)	-1.3557 (114.0, 60.1)	0.0565 (251.2, 60.7)	10.3190 (0.3)	0.555 (16.2)
Machinery except Electrical & Electronic (382)	0.5942 (138.6, 10.3)	0.0042 (9.4, 0.1)	0.0580 (0.1)	0.990 (91.2)
Electrical Machinery, (383) Apparatus & Appliances	0.3538 (2540.3, 219.6)	0.0432 (252.2, 167.5)	0.0175 (0.1)	0.999 (207.3)
Electronic Products & Components (384)	0.9350 (59.4, 0.6)	-0.0141 (82.1, 0.8)	2.9149 (0.6)	0.9550 (62.0)
Transport Equipment (385)	0.5684 (94.0, 5.2)	-0.0167 (67.8, 0.9)	0.3340 (1.3)	0.851 (38.1)
Instrumentation Equip. (386) Photographic & Optical	0.3298 (46.9, 18.3)	0.0429 (18.3, 5.9)	0.1610 (0.1)	0.995 (107.5)
Other Manufacturing Industries (390)	0.3831 (919.2, 178.0)	0.0597 (391.2, 315.2)	-0.0098 (0.0)	0.999 (135.4)

Notes: Chi-square test statistics are in parentheses. ECY corresponds to the estimated elasticity of cost with respect to output, a measure of the degree of economies of scale. ECT corresponds to the estimated elasticity of cost with respect to time, a measure of technical change. R-square provides a measure of overall goodness-of-fit of the equation system. All estimates are evaluated at the mean value of each variable. Appendix J lists the complete Shazam output.



From the first glance, the estimation results of the linear demand specification are not notably different from those of the other demand specifications. All nineteen industries that have converged show an estimated ECY less than one. Out of these nineteen industries, sixteen of them are significant at five-percent level. Consequently, roughly 84 percent of the industries are estimated to have experienced increasing returns to scale and the remaining industries constant returns to scale.

We find six negative and thirteen positive ECT estimates in the linear specification. Out of the six negative ECT estimates, two of them are significant, suggesting 11 percent of the industries experiencing significant technical progress. Out of the thirteen positive ECT estimates, eight of them are significant, suggesting 42 percent of the industries experiencing significant technical regress.

On the estimation of the conjectural measure of competition, the linear demand specification does not appear to generate results that are different from those of the other specifications. All except two of the estimated THETA are not significantly different from zero, suggesting that these industries experience conditions close to perfect competition. For the two industries that pass the statistical tests, their estimated THETA are not contained within the bound of  $[0,1]$ . Consequently, there is no strong statistical evidence to conclude that market imperfection is prevalent in Singapore under the linear demand specification model.

In conclusion, we note that results generated from the linear demand specification are roughly in line with the results generated from other specifications. It shows that the majority of industries are estimated to have experienced significant increasing returns to scale and also to have faced a market structure that is not significantly different from perfect competition. On the other hand, the ECT estimates show that only a few industries enjoy technical progress (11 percent), while the majority of the industries experience either no significant technical change or technical regress.

## **6.5 Comparing the Estimation Results of Different Market Demand Specifications in the Integrated Model**

In the previous sections, we have presented the estimation results generated from the integrated models that use different demand specifications.<sup>12</sup> Our objective in using the different demand specifications is to investigate whether the resulting estimates from different specifications are consistent with each other. In other words, we want to answer the question: does the demand specification affect the results of estimation in the integrated model? If the different demand specifications fit the data well and generate results that are, in general, significant and comparable with each other, then we can draw

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<sup>12</sup> Ideally, the robustness of the estimates should also be checked against estimates that are generated from an integrated model that uses a translog cost function. To implement such a model, one needs to incorporate into the equation system of the cost-share equations for factor inputs that derived from the translog cost function, the market demand function and a function that characterizes the market equilibrium condition. The difficulty arises from formulating the market equilibrium condition. More specifically, we cannot derive the marginal cost function independently from the translog cost function because of the logarithmic terms. Even if we try using the exponential constant to derive the marginal cost function, it is doubtful that the resulting function would be valid for estimation. Recent studies such as Morrison (1988) and Park and Kwon (1995) have all employed the generalized Leontief cost function in their equation systems.

some firm conclusions about the Singapore manufacturing sector based on the results of the integrated model.

We can conclude that all three demand specifications fit the data reasonably well for the majority of industries under study. The goodness-of-fit measure, R-square, is usually around 90 percent, for most industries across all three demand specifications. However, basing on the number of non-convergent industries, the linear demand specification, which is widely assumed in empirical research, does not seem to perform as well as the two alternative demand specifications. The linear demand specification results in seven non-convergent estimations compared to one for the log-log demand specification and none for the semi-log demand specification. The R-square measure shows that two industries have poor goodness-of-fit compared to one for the log-log demand specification and none for the semi-log demand specification.

On the whole, the semi-log demand specification has the highest values of R-square and a smaller number of industries that are non-convergent compared to the log-log and linear demand specifications. Thus, if one is based only on the criteria of convergent estimation and goodness-of-fit, then the semi-log demand specification should be picked as the most appropriate model, at least for the data set under study.

Table (6.6) summarizes the estimation results for the integrated models. For the purpose of comparison, the results for the translog and generalized Leontief cost function models are also listed. The table lists the percentage of industries that exhibit increasing returns

to scale (IRS), decreasing returns to scale (DRS), technical progress (T. Progress), technical regress (T. Regress) and imperfect competition (Imperfect C.). Note that the figures in the brackets represent results that are statistically significant at five-percent level.

Looking at the first two rows only in Table (6.6), one can immediately identify the difference in the estimation results of ECY between the translog and generalized Leontief cost function models. The generalized Leontief cost function model gives ECY estimates that are in general lower than that under the translog cost function model, as can be seen from the percentage of industries that exhibit increasing returns to scale. Under the generalized Leontief cost function model, all industries exhibit an ECY estimate less than one whereas only fifty-four percent showing the same under the translog cost function model. The same difference, however, is not observed in the estimates of ECT between the translog and generalized Leontief cost function models. The percentage of industries showing technical progress is thirty-nine percent, the same for the two models. Although, our intention in this study is not about investigating the differences between the translog and generalized Leontief cost function models, it is still important to note that there are differences in the estimation results, especially in the estimation of the degree of returns to scale. The estimation results suggest that the estimates of the degree of returns to scale are subject to change depending on the functional form of the model, whereas estimates of technical change are more invariant to the functional form of the model.

**Table 6.6: A Summary of the Estimation Results- Percentage of (Significant) Industries**

	ECY < 1 IRS	ECY > 1 DRS	ECT < 0 T. Progress	ECT > 0 T. Regress	THETA > 0 Imperfect C.
<b>Translog Cost Function</b>	53.9 (26.9)	46.2 (15.4)	38.5 (26.9)	61.5 (46.2)	NA
<b>G. Leontief Cost Function</b>	100.0 (80.8)	0.0 (0.0)	38.5 (7.7)	61.5 (38.5)	NA
<b>Integrated Log-log</b>	96.0 (80.0)	4.0 (0.0)	32.0 (20.0)	68.0 (56.0)	40.0 (8.0)
<b>Integrated Semi-log</b>	92.3 (80.7)	7.7 (3.9)	46.2 (19.2)	53.9 (42.3)	69.2 (11.5)
<b>Integrated Linear</b>	100.0 (84.2)	0.0 (0.0)	31.6 (10.5)	68.4 (42.1)	73.7 (0.0)

Notes: ECY and ECT correspond to estimated elasticity of cost with respect to output and with respect to time, respectively. IRS and DRS correspond to increasing and decreasing returns to scale, respectively. T. Progress and T. Regress correspond to technical progress and technical regress, respectively. Imperfect C. corresponds to imperfect competition. Numbers in parentheses represent the percentage of significant industries.

If we focus on the integrated models only in Table (6.6), the estimation results seem to be roughly comparable across the three demand specifications. All three demand specifications give roughly the same percentage of industries (around 80 percent) that exhibit significant increasing returns to scale. On the estimation of technical change, the linear demand specification gives a lower percentage of industries (about 11 percent) that exhibit significant technical progress as compared to the other two alternative demand specifications. On the estimation of the degree of competition, the linear demand specification also gives a slightly different result from those of the log-log and semi-log demand specifications. Both the log-log and semi-log demand specifications give roughly around ten percent of the industries experiencing significant imperfect competition, whereas the linear demand specification shows that none of the industries experience significant imperfect competition.

Table (6.6) summarizes the overall estimation results in percentages for the different models. However, it may be misleading since it does not show the differences in estimates across the models for the same industries. It would be useful to focus on the largest industries to see whether their estimates are substantial differences across the three demand specifications. We show in Table (6.7) the estimation results of ECY and ECT generated by the three demand specifications for the largest industries. It shows that the estimation results vary from specification to specification. For example, depending on the specification, Electronic Products and Components (384), the largest industry, is estimated to have experienced constant to significant decreasing returns to scale and no technical change to significant technical regress. The second largest industry, Petroleum Refineries and Petroleum Products (353), is estimated to have experienced significant increasing returns to scale consistently in all demand specifications. Furthermore, the same industry is estimated to have experienced technical progress consistently in all demand specifications, but significant only in the log-log and semi-log specifications.

The other largest industries, namely Transport Equipment (385), Food (311) and Machinery (382), consistently show significant increasing returns to scale in Table (6.7). Their ECY estimates are all significant and roughly similar. The ECT estimates of these industries are also consistent with each other for the same industry, although not all of them are statistically significant. A prominent exception is the ECT estimates for Machinery (382), which show technical progress in the semi-log demand specification

and technical regress in the linear demand specification. However, both of these estimates are not statistical significant.

**Table 6.7: Comparisons of the Estimation Results Across Different Demand Specifications for the Largest Industries**

	ECY			ECT		
	Log-log	Semi-log	Linear	Log-log	Semi-log	Linear
384	-0.7565	0.4243*	0.9350	0.2555*	0.0684*	-0.0141
353	0.6372*	0.6295*	0.3761*	-0.0106*	-0.0112*	-0.0012
385	0.3999*	0.5416*	0.5684*	-0.0105	-0.0195*	-0.0167
311	0.1160*	0.0771*	-	0.0265*	0.0277*	-
382	-	0.7003*	0.5942*	-	-0.0093	0.0042
	THETA					
	Log-log	Semi-log	Linear			
384	0.5982	0.3234	2.9149			
353	-0.0500	0.0290	1.0000			
385	0.1592	0.0031	0.3340			
311	-0.1456	-0.2008*	-			
382	-	0.1236	0.0580			

Note: ECY stands for the estimated elasticity of cost with respect to output. ECT stands for the estimated elasticity of cost with respect to time. THATA is the estimated conjectural measure of competition. Asterisks represent statistical significance at 5 percent level. The values for industry 384 under the log-log specification are not listed, since the estimation fails the chi-square test for the overall goodness-of-fit. Other missing values correspond to non-convergent estimations.

On the results of the conjectural measure of competition, THETA, in Table (6.7), all five largest industries show substantial differences across the three demand specifications. However, all estimates are statistically insignificant at five-percent level. Consequently, little evidence of imperfect competition is suggested from our estimation for the largest industries.

Table (6.7) shows that estimation results could vary from specification to specification. It is difficult to make generalization regarding the impact of demand specification on the

estimation results. Estimation results show that the different demand specifications yield different estimates of dual rate of technical change, economies of scale and conjectural measure of competition. There are some industries whose estimates are highly sensitive to the different demand specifications. In particular, this applies to the largest and fastest growing industry, Electronic Products and Components (384). Other industries' results are more robust. It seems to illustrate that assuming a particular demand specification for all industries may lead to estimation problems and anomalies and it is well worth the time for researchers to pay more attention to the specification issue. Despite the difficulty mentioned above, a crude conclusion could be drawn: economies of scale and perfect competition appear to be prevalent in most industries with mixed results for technical change.

We can also look at how different assumptions of mark-up affect the estimation results of technical change and economies of scale. An underlying assumption about the log-log demand specification is that it implies constant mark-ups for profit-maximization. This assumption is generally unacceptable to researchers and can only be justified as a convenient approximation. In this study, in addition to the log-log demand specification, we employ the semi-log and linear demand specifications that allow time-varying mark-ups. We find that, for individual industries, considerable differences exist between the log-log demand specification estimates and those of the semi-log and linear demand specifications. However, over all industries, the differences are not large enough to alter the conclusions that there is strong evidence of increasing returns to scale, but little evidence of either technical progress or imperfect competition.



## 6.6 Conclusions

This chapter presents and discusses the main findings of our present study. We present the estimation results for five different models adopted in our study- the translog cost function, generalized Leontief cost function, log-log integrated, semi-log integrated, and linear integrated models. We find that if only the cost function is estimated, then the functional form of the cost function can substantially affect the results of estimation. Our result shows that the generalized Leontief cost function model generates estimates of ECY that are in general lower than those of the translog cost function model. However, the same difference is not observed in the estimates of ECT between the two functional forms.

One of the main focuses of the study is to compare the estimation results of the different demand specifications in the integrated model. Our results show that the goodness-of-fit is high for almost all industries under different demand specifications. The adoption of the linear demand specification results in the most non-convergent estimations compared to the other demand specifications. On the whole, when we consider the percentage of industries that exhibit economies of scale and technical progress, the three demand specifications generate results that are in general comparable. However, when we consider estimation results on the industry basis across different demand specifications, we find that there are considerable differences across the demand specifications. Thus, it

is clear that demand specification does make a difference and one should be careful to choose a demand specification that gives robust estimation results in an empirical study.

If we focus on the largest industries, we find that Electronic Products and Components (384) is estimated to have experienced constant to increasing returns to scale and no technical change to technical regress. The second largest industry, Petroleum Refineries and Petroleum Products (353) is found to have experienced increasing returns to scale and no technical change to technical progress. In general, it is safe to conclude that the largest industries are estimated to have experienced increasing returns to scale and conditions close to perfect competition. However, no generalization can be made in regard to technical change.

After having presented the estimation results of our models in this chapter, we seek to explain the inter-industry differences in the estimated rates of technical change. The next chapter presents an econometric model that attempts to examine industrial characteristics such as market structure, firm size, demand, technological opportunity and foreign ownership as possible explanations of the inter-industry differences in the estimated rates of technical change.

## **CHAPTER SEVEN**

### **AN EMPIRICAL MODEL OF TECHNICAL CHANGE**

#### **Introduction**

We have discussed the estimation technique and presented the estimates for technical change, economies of scale and market imperfection in the previous chapters. A question remains to be addressed is what accounts for the inter-industry differences in the estimated rates of technical change. In this chapter, we attempt to address this question by formulating an empirical model that examines the roles played by certain industrial characteristics such as market structure, firm size, demand, technological opportunity, and foreign ownership.

An inherent problem confronting empirical studies of the determinants of technical change is the absence of satisfactory measures of innovative activity. The practice of using R&D expenditures or patent count as a proxy measure of technical change is prevalent in empirical studies on the topic. However, given the limitations of such an approach, it can be difficult to interpret the empirical findings in these studies. In this study, we avoid this measurement problem by employing direct estimates of the rate of technical change in our empirical model. This approach departs from the usual practice of employing proxy measures of technical change. In the first section of this chapter, we discuss in some detail the traditional proxy measures of technical change and their limitations.

Our analysis of the roles of industrial characteristics on technical change starts with a brief literature review of a rich body of theories and empirical evidence on this topic.<sup>1</sup> A review of literature is necessary because it allows us to formulate expectations regarding the nature of relationships between variables that describe industrial characteristics and innovative activity. In the literature review, we first look at how market structure influences innovative activity. Then we look at the roles of firm size, demand, technological opportunity, and foreign ownership.

Later in the chapter, we present an empirical model to explain the inter-industry differences in technical change. Drawing upon the theories and empirical studies discussed earlier, we formulate a multiple regression model that regresses the estimated rate of technical change on an array of explanatory variables corresponding to certain key industry characteristics. The model is then under close examination for possible violation of the basic regression assumptions, particularly multicollinearity. In the final section of the chapter, we present the estimation results and conclude on what we can possibly learn from our empirical model.

## 7.1 Measurement of Technical Change

In empirical research on the determinants of technical change, researchers are faced with the problem of coming up with an appropriate measure of technical change.<sup>2</sup> As Kuznets

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<sup>1</sup> Our literature review borrows primarily from three excellent sources: Davies (1986), Cohen and Levin (1989) and Scherer and Ross (1990).

<sup>2</sup> The present discussion is largely based on a discussion of the limitations of the proxy measures of technical change by Acs and Audretsch (1991, pp. 3-10).

(1962) observes that: “perhaps the greatest obstacle to understanding the role of innovation in economic processes has been the lack of meaningful measures of innovative inputs and outputs” (p.19). More recently, Cohen and Levin (1989, p. 1062) warn that: “A fundamental problem in the study of innovation and technical change in industry is the absence of satisfactory measures of new knowledge and its contribution to technological progress. There exists no measure of innovation that permits readily interpretable cross-industry comparisons.”

There are two types of proxy measures of technical change most commonly used in the literature. The first type is a measure of innovative input, such as R&D expenditures or the share of total workforce involved in R&D activities. The second type is a measure of intermediate innovative output, such as the number of patents. Both types of proxy measures suffer from their limitations. First, R&D activity is only inputs, not outputs, in the process of innovative activity. It only reflects the resources allocated for attempting to produce innovative outputs. Second, using the share of employees engaging in R&D activity as a proxy measure ignores the service inputs provided by the research and laboratory materials (Cohen and Levin, 1989). Moreover, R&D expenditures include additional bias if long-lived equipment is considered as a part of R&D purchases, rather than capital stock under the standard accounting rules.

Another traditional proxy measure of technical change is the number of inventions that have been patented. The number of patents is, “without a doubt the most widespread proxy measure of innovative activity” (Acs and Audretsch, 1991, p. 4). However, many

practitioners have warned the potential flaws in using this proxy measure. The basic problem with using the patent count is that not all inventions are patented and not all patents have the same economic significance. Mansfield (1984, p.462) comments: “The value and cost of individual patents vary enormously within and across industries... Many inventions are not patented. And in some industries, like electronics, there is considerable speculation that the patent system is being bypassed to a greater extent than in the past.”

A third measure of the innovative activity is the direct measure of innovative output. This approach involves identifying the significant innovations, in terms of their technological importance and economic and social impact. One example is the United States Small Business Administration Innovation Data Base (SBIDB) that compiles a database that consists of 8,074 innovations introduced into the United States in 1982. In an interesting study of the relationship between the direct measure of innovative outputs, such as SBIDB, and the two other more traditional measures, R&D expenditures and patent count, Acs and Audretsch (1991) finds that there are distinct differences between all three measures. In sum, the study shows that the correlation between total industry R&D expenditures and total industry innovations is 0.481 and between patents and the total industry innovations is 0.467. These low correlation coefficients point to the biases and inadequacy in using the traditional proxy measures of innovative activity.

It is relatively rare to find empirical studies that use direct estimates of the rate of technical change or productivity as innovative activity in the literature on the

determinants of technical change. Early studies such as Stigler (1956), Phillips (1956) and Allen (1969) find contradicting results regarding the impact of market concentration on labor productivity growth. The findings of these studies are difficult to interpret because the role of capital has been ignored. A number of more recent studies such as Peltzman (1977), Lustgarten (1979), Kendrick and Grossman (1980) and Gisser (1982 and 1984) regress total factor productivity on only concentration and find a significant relationship between the two. Unfortunately, in addition to the criticism of not including other explanatory variables in the regression, these studies also suffer from a general low explanatory power in their regression and the lack of control for inter-industry differences in technological opportunity.

Employing a system of simultaneous equations that examine both productivity levels and growth rates for nearly 100 industries for 1977 and 1968, Davies and Caves (1987, p. 235) conclude that: "...contrary to Schumpeterian expectations, concentration and large scale are not particularly conducive to rapid technical change, at least as far as it is reflected in productivity. The degree of competition does matter, but more in international than domestic terms."

## 7.2 Market Structure and Technical Change

In his book *The Theory of Economic Development* (1912), Joseph A. Schumpeter identifies the innovator with the entrepreneur who provides the source of all dynamic change in the economy. Schumpeter believes that the possession of monopoly power is

conducive to innovation in a dynamic society where technological progress is the engine of growth. It is said that the existing market structure determines the pace of innovation, although it must be recognized that there will be feedback from innovation to market structure.

The belief that the possession of monopoly power is conducive to innovation is based on the hypothesis that profit accumulated through exercising monopoly power is a major source of funds for financing costly and risky innovation. However, empirical tests using profit rate as an explanatory variable for innovation run into difficulties because an increase in profit rate can be the cause or the effect of increased innovation. In addition, increases in demand are believed to have a positive 'pull' on innovation and to increase short term profits. It has often been observed that increases in demand have led to increase in R&D expenditure with relatively short lags. Thus, a valid test of Schumpeterian hypothesis must involve a proper identification of the time lag between profit and innovation and it must be able to disentangle the demand-pull and the financing influence on innovation.

A large volume of literature on how monopoly and oligopolistic rivalry influence innovation is available. In general, the theoretical analysis predicts that more rivalry, measured by lower concentration indices, leads to an increase in R&D expenditure up to a point. Beyond that point, incentives for innovation fall, as the market becomes increasingly competitive because potential innovators are uncertain to capture enough benefit to generate profit for their innovation. This is referred to as the "inverted-U"



hypothesis. Another prediction is that rivalry is believed to be more conducive to innovation over a period of rapid advances in basic science and technology when potential innovators can expect to receive a large short run profit or quasi-rent for their innovation.

Empirical studies have generally produced mixed results. Firstly, a number of empirical studies have shown that there is a positive and statistically significant relationship between productivity growth, the product of innovation, and market concentration. However, when the amount of industrial spending on process and product innovation per dollar of sales is added as an explanatory variable, the R&D expenditure variable erodes the explanatory power of market concentration, making it insignificant. Thus, it appears that the cause of productivity growth is R&D expenditure and not market concentration.

Secondly, empirical evidence has so far been inconclusive in establishing a precise relationship between market concentration and innovation. Early studies (see, for example, Scherer 1965a, 1967) do not provide conclusive support for the Schumpeterian hypothesis. Some studies report a positive effect of concentration on innovative effort, while others fail to find support for this hypothesis. On the whole, support for the Schumpeterian hypothesis in empirical studies appears to be weaker when the dependent variable is the number of patents rather than the R&D intensity.

Some recent studies have found that the positive effect of concentration on innovation is weak or non-existent when controlling for the industry effects. Scott (1984) uses the

Federal Trade Commission's Line of Business data and finds that the effect of concentration on R&D expenditure disappears after controlling fixed sector and firm effects. Also using the FTC data, Levin and Reiss (1984) finds an inverted-U relationship between concentration and R&D expenditure when dummy variables are added to the regressors at the sector level. He, however, finds no relationship when dummy variables are used to control for inter-industry differences in appropriability and technological opportunity.<sup>3</sup>

Geroski (1990), in the United Kingdom, finds a negative effect of concentration on innovation counts when controlling for industry effects. Recognizing the inadequacy of using concentration to represent market power only, Geroski explicitly incorporates six different measures of market power. His measures of market power include the extent of market penetration by entrants, the market share of imports, the relative number of firms, the change in concentration, the market share of exiting firms and finally the concentration ratio. He finds that only the effect of concentration ratio is negative and significant, but the effects of all other measures of market power are positive and insignificant.

Those empirical tests that explore the possibility of the two-way direction of causality between market structure and innovation have also produced mixed results. Using simultaneous-equation models, Farber (1981), Lunn (1986) and Levin and Reiss (1988) find no significant two-way relationship between market structure and innovative

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<sup>3</sup> Appropriability refers to the ability of the innovator to capture the gains of his innovation. We will discuss technological opportunity and its effects at a later section.

activity. However, when using the number of patents as a measure of innovative activity and distinguishing between process and product innovation, Lunn finds a significant two-way relationship between process innovation and concentration, but finds no such relationship between product innovation and concentration.

In sum, the question on the impact of market structure of innovative activity is still far from settled. Scherer concludes: “Although much remains to be learned on this important question, the weight of existing evidence favors a conclusion that innovation under late twentieth-century conditions has tended to be more concentration-reducing than the opposite. This in turn implies possible underestimation of concentration’s R&D-supporting role if the statistical controls for technological opportunity are inadequate” (Scherer, 1990, p.651).

### **7.3 Firm Size and Technical Change**

Similar to the theoretical analysis of the link between market structure and innovation, theoretical analysis of the link between firm size and innovation has also yielded mixed predictions. In general, relatively small firms or new entrants with zero market shares would rigorously engage in innovative activity if they anticipate gaining first-mover advantages and capturing considerable chunks of market share. However, the theory predicts that the dominant firms would not sit passively when they are subject to such threats. Instead, they would respond aggressively by minimizing the small firms’ lead or even driving them out of the market.

It is perceived that relatively large firms can afford to set up formal R&D laboratories, which offer a number of cost-saving advantages due to economies of scale. Firstly, large R&D laboratories are able to engage simultaneously in more than one research project, knowing perfectly well that any research project could fail at any given time. Secondly, if research in one research unit is bogged down by technical problems that are outside of its usual domain of competence, experts from other research units can offer help. Large laboratories provide the opportunities for exchanging ideas and temporary assistance among research staff of different research units. Thirdly, large laboratories can justify purchasing costly and highly specialized equipment such as supercomputers. Fourthly, large corporations can attract capital at a lower cost to finance ambitious R&D projects than their smaller counterparts can. Fifthly, the large corporations have a well-established network of marketing, advertising and distribution channels. Any new products developed by the large corporations can more easily penetrate the market than those developed by smaller firms. Finally, there would be higher incentive for large corporations to engage in process innovations. This is because the total cost saving made possible by process improvements would be larger for large corporations than that of the smaller firms.

It can be argued that large research laboratories also suffer a number of disadvantages. Firstly, large laboratories may be overstaffed. Research staff spends more time on writing memoranda to each other than on productive research if too many of them are involved in a project. Secondly, since those positions in large corporations that offer higher pay and

better benefits are generally in managerial ranks, there are incentives for the most talented research staff to be supervising research rather than actively engaging in creative research themselves. Another well-documented argument against large laboratories is that small firms may be less risk-averse when taking on ambitious projects than larger corporations. This arises partly because smaller firms may have fewer commitments to accepted technology than the larger corporations. More importantly, the decision of approving an ambitious project may be bogged down by a long line of command in large corporations. In large corporations, it is believed that invariably there will be someone in the long line of command objecting to projects or ideas that are untried and stray too far from the accepted ways of doing business. One consequence of this is that totally imaginative innovations will not get approved in large corporations. This explains the phenomenon that many frustrated researchers from large laboratories have left to set up their own ventures.

Some empirical evidence appears to support the theory that small firms are responsible for a substantial share of the really revolutionary new industrial processes and products. Jewkes, Sawers, and Stillerman (1969) compile case studies of seventy important twentieth-century "inventions" and find that only twenty-four were originated from formal research laboratories. Individuals who are independent of any formal research organizations or in academic environment are responsible for more than half of the important inventions in their study.

Despite many of the early empirical studies suffering from the lack of adequate control for industry effects, these studies in general find that there is little support for the Schumpeterian hypothesis. They find no evidence of a more than proportionate effect of firm size on either R&D expenditure or innovative output (Kamien and Schwartz, 1982). Some early studies (for example, Scherer 1965a, 1965b) find an inverted-U relationship between firm size and R&D intensity or between firm size and the ratio of patents to size. Others find a positive relationship up to a certain firm size and no significant effect for larger firms.

Some researchers are less inclined to reject the Schumpeterian hypothesis. These researchers (for example, see Freeman 1982, and Rothwell and Zegveld 1982) argue that the vast majority of small firms performing no formal R&D are excluded from much of the empirical studies. An observation that appears to support the Schumpeterian hypothesis is that small firms with less than 100 employees typically do not perform any formal R&D and produce a less than proportionate number of innovations. Once the vast majority of small firms that do not perform formal R&D are excluded from the analysis, the relationship between firm size and innovative activity is weak, non-existent or even negative.

A number of recent studies find little support for the Schumpeterian hypothesis. Acs and Audretsch (1987, 1990) argue that the whole debate about what firm size is more conducive to innovation is pointless. The real issue, they believe, is how certain industrial characteristics favor either large or small innovators. In the United Kingdom, Pavitt et al.

(1987) find that R&D intensity is greater for larger firms (more than 10,000 employees) and small firms (between 100 and 2,000 employees), but is smaller for medium-sized and very small firms. In their study, Pavitt et al. reveal the existence of important sectoral differences in appropriability conditions and scope for diversification.

Studies carried out in the U.S. generally find either weak or no relationship between firm size and innovative activity or R&D, despite using richer data sets and more sophisticated estimation techniques. Bound et al. (1984) find that both small and large US firms are more R&D-intensive than medium-size firms. Scherer (1984) examines the relationship between business unit size and business R&D intensity and finds that the majority of industries (about seventy percent) exhibit proportionality between size and either R&D intensity or number of patents. Cohen et al. (1987) use the FTC data to study the relationship between firm size and business unit size. The study finds no significant relationship between R&D intensity and either firm size or business unit size. Much of the variance in R&D intensity between firms can be explained by inter-industry differences in appropriability and technological opportunity.

#### **7.4 Demand and Technical Change**

The debate about the role of demand in technical change can be traced back to Schmookler (1962, 1966), who proposes that demand, rather than the state of technological and scientific knowledge, determines the rate and direction of inventive activity. He observes that cycles in capital investment in downstream industries and

cycles in the output of capital goods lead cycles in relevant capital goods patents. Thus, he argues that inventive activity is 'demand-pull' rather than 'technology-push'. The debate now has turned to the relative importance of demand and technological opportunity in determining innovation.

Schmookler acknowledges that, at any given point in time, a stock of generic technological and scientific knowledge provides the basis for further innovation in a number of industries. However, he emphasizes that those industries that face large and increasing market are the ones that make further investment in applied research in process and product development. In general, Schmookler's argument has been refuted by empirical analysis. Parker (1972) and Rosenberg (1974) document some historical cases of important applications of technological ideas that are determined not by demand but by the state of scientific knowledge and technological opportunity specific to the industry. Scherer (1982) offers statistical evidence that shows the importance of both demand and technological opportunity. He finds that dummy variables representing demand conditions and technological opportunity are statistically significant in explaining the inter-industry differences in business patenting activity. However, the dummy variables representing technological opportunity explain considerable more variance than those representing demand conditions.

Using both time series methods and case studies, Walsh (1984) finds that production series does lead the patent series in several chemical industries, but the growth of production tends to follow one or several major innovations rather than a large number of



patents. The finding of the Walsh study appears to indicate that major innovations induce the increase in demand, which in turn give incentives for second stage developments in refining and improving the original innovations.

In sum, there are two aspects of demand that are expected to influence incentives for innovations. Firstly, as Schmookler emphasized, both the size of market and the rate of growth of the market represent the static and dynamic demand conditions in influencing incentives for innovation. Investments in lowering unit cost and improving the quality of products are independent of the level of output. The expected benefits accruing to the innovating firm, however, would be higher the larger the size of the market and the higher the rate of growth of the market facing the firm. Thus, given two markets of equal size, more innovative activity would be expected from the market that experiences higher rate of growth. Conversely, given two markets that are expected to grow at the same rate, more innovative activity would be expected from the market that is larger.

Secondly, the elasticity of demand is supposed to have an influence on the incentive for innovation. Kamien and Schwartz (1970) establish that the gains from process innovation or reducing the cost of production are greater the more elastic is demand. On the other hand, Spence (1975) demonstrates that, under many circumstances, the gains from product innovation or improving the product quality are greater the more inelastic is demand. This is because a rightward shift of demand gives a larger gain when demand is less elastic. The influence of elasticity of demand on innovative activity is thus ambiguous.

## 7.5 Technological Opportunity and Technical Change

Inter-industry differences in innovative activity may be influenced by the technological opportunity facing different industries. In the standard neoclassical framework, technological opportunity can be referred to “the technological possibilities for translating research resources into new techniques of production that employ conventional inputs” (Cohen and Levin 1989, p.1083). This formulation allows technological opportunity to be treated as one or more parameters in a production function relating research resource to the stock of knowledge, which in turn is included along with other conventional inputs in the production function for output.

Scherer (1965a) pioneered the most widely used method to represent technological opportunity as a determinant of innovative activity in regression analysis, which is to classify industries according to their technological and scientific field. The classification of industries into different technological groups (chemical, electrical, mechanical) can include unspecified industrial practices and demand conditions not captured by other regressors, but this method has explained much of the variance in patenting activity (Scherer 1965a, 1982) and R&D intensity (Scott 1984).

It has been argued that there is a close link between scientific advance and technological innovation. Rosenberg (1974) gives a good account of why some technological advances would not have taken place without certain fundamental progress in scientific knowledge.

However, the stronger claim that scientific advances lead to technological innovation cannot be established. Nelson (1962) believes that the link between scientific advances and technological innovation is more complex. There can be a substantial time gap between scientific advances and technological innovation, citing an example that the invention of transistor took more than fifteen years after the essential scientific knowledge required for its invention had been in place. Also, there are cases when the invention itself triggers a full scientific inquiry to understand how the invention actually works.

In sum, technological opportunity refers to the advance of scientific knowledge that makes technological innovation less costly by limiting the research to the most productive approaches. Nelson (1982) suggests that there will be less trial-and-error and fewer approaches to be evaluated as the stock of scientific knowledge grows, thereby increasing the productivity of applied research.

## 7.6 Foreign Ownership and Technical Change

As discussed in Chapter Two, multinational corporations (MNCs) have played a significant role in Singapore's manufacturing. In this section, we consider the theoretical arguments and empirical evidence that link MNCs and technical change.<sup>4</sup> First, a question that relates directly to technical change is what are the main factors that determine MNCs to decentralize R&D activities in the host countries? If MNCs are able

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<sup>4</sup> A good discussion on the theories and empirical evidence of the link between MNCs and technological transfer is provided by Caves (1996, Chapter 7).

to transfer innovative outputs costlessly across borders, then R&D activities will only be located in the cost-minimizing location in the world. We, however, typically see MNCs decentralizing their R&D to some extent. First, the inducements provided by the host governments pull the MNCs' R&D to the host countries. Second, the need for effective executions of R&D requires continuous exchange of information with the manufacturing plants and the requirement that R&D outputs be operational push the decentralization of R&D activities to the host countries.

To weigh against the arguments for the decentralization of R&D activities, there are also important reasons for the centralization of R&D activities. First, for strategic reasons and effective communications with the top management, most R&D activities are carried out close to the headquarters of MNCs. Second, scale economies in R&D function are likely to be an important consideration in the decision to centralize R&D activities. Empirical evidence largely supports the centralization argument. Hakanson and Noble (1993) find that there is a strong tendency for research to remain at the corporate headquarters. They find that not much more than 10 percent of the MNCs' R&D is done abroad. They also find that R&D abroad is oriented towards development and less towards basic research than the R&D done at home. This is consistent with the view that R&D abroad is only aimed to modify products and services to suit the host country's market conditions. Other studies such as Zejan (1990) and Hakanson (1983) find that, among other things, the share of R&D outlays carried on abroad increases with the share of the MNC's global sales made by their subsidiaries and decreases with the importance of scale economies in research in the firm.

Recent theoretical studies concerning the link between MNCs and technical change examine the technology spillovers from inflows of MNCs capital to the host countries. It is pointed out that positive externalities provide a good reason for the host countries to subsidize inflows of MNCs capital (Gehrels, 1983). While domestic firms benefit from the spillage generated by MNCs, positive externalities can also generate microeconomic interactions between the domestic firms and MNCs. Das (1987) considers the case of a MNC subsidiary competing as a dominant firm with a fringe of domestic firms which can costlessly increase their productivity in proportion to the share of the subsidiary output. Under this framework, the costless infusion of technology from the MNC's parent reduces the product price for the subsidiary and increases its market share. As a result, the rate of productivity growth increases for the domestic firms while at the same time the foreign subsidiary also benefits from the technology infusion.

Wang and Blomstrom et al. (1992) argue that beyond a point, domestic rivals must invest in order to appropriate further productivity gains from the foreign subsidiaries.

Investment made by the domestic rival pulls demand towards its differentiated product. Similarly, technology infusion from the MNC's parent pulls demand towards the foreign subsidiary's brand. The model's Nash equilibrium exists with the domestic rival and foreign subsidiary both making a positive rate of investment to infuse and to appropriate knowledge. When the domestic rival narrows the technological gap, the provoked response of the foreign subsidiary is to increase technology infusion. The rate of

technology infusion increases with the efficiency of the domestic rival's learning activities and the sensitivity of the demand to the technological gap.

Empirical evidence on the role of MNCs as a transfer agent of technology confirms the positive technology spillovers of foreign subsidiaries. Using disaggregated data from Mexico, Blomstrom (1983, 1989) finds that white-collar productivity appears to be higher for the foreign units. The productivity residuals, on the average, are smaller for domestic firms than those of foreign subsidiaries, but they increase with the share of foreign subsidiaries' industry employment. This positive correlation holds even after controlling for the quality of labor, concentration and tariff protection. Kokko (1992) distinguishes industries with large average gaps in productivity levels between the domestic firms and foreign subsidiaries from industries with small gaps. His findings show that domestic productivity is more sensitive to the foreign presence in industries where the productivity gap is small and this sensitivity increases in industries where foreign share is small. The result seems to suggest that the marginal effect of foreign subsidiaries may be close to zero in industries that are dominated by foreign presence.

The positive technology spillovers are also confirmed in a number of studies for different countries. For example, Haddad and Harrison (1993) replicate the positive relationship between productivity of domestic firms and the share of foreign subsidiaries using Morocco data. However, they cannot find any interdependence in the rates of productivity growth between domestic firms and foreign subsidiaries. Liang (1994) finds that the Chinese state-owned firms exhibit higher productivity levels when foreign

investors are more prevalent in a province. Her study does not include joint ventures that link directly to MNCs. She finds that the spillovers are geographically localized at the province and that they are most pronounced in non-coastal provinces where foreign investment is small and new.

Using Indian industry data, Basant and Fikkert (forthcoming) examine the effect of the domestic firms' own R&D, spillovers from foreign subsidiaries, and both licenses and spillovers from R&D in the same industry abroad on domestic firms' productivity. They find that the spillovers from foreign subsidiaries are independent of other channels of technology transfer and that the effect of domestic R&D is mainly to absorb the spillovers from abroad.<sup>5</sup> In sum, there is consistent evidence in the literature pointing to the technology spillovers of foreign subsidiaries. Productivity of domestic firms increases with the prevalence of foreign subsidiaries. However, the marginal effect seems to be negligible if the industry is largely dominated by foreign subsidiaries and, furthermore, it varies with the industry overall rate of technical progress and the closeness of competition between the domestic firms and their foreign rivals.

## 7.7 An Empirical Model of Technical Change

We have reviewed the theories and the empirical evidence for the determinants of technical change in the literature. We proceed to examine the Singapore data to see

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<sup>5</sup> There are many studies showing that MNCs are more productive and profitable than the local firms in the less developed countries (LCDs). A survey carried out by Lall's (1978) concludes that most studies find a difference in productivity and profitability between MNCs and local firms, although in the more careful inquiries it has not always proved statistically significant.

whether evidence can be found to support the theories and empirical findings in the literature. We first introduce our empirical model and discuss the theoretical grounding of the explanatory variables in the model. Next, we look at the construction of data set and estimation issues. Then, we present and interpret the results and make some concluding remarks.

The empirical implementation is undertaken with an econometric model that employs the estimated rate of technical change as a direct measure of technical change in the dependent variable. As discussed in Section (7.1), interpretation problems plague the use of proxy measures of technical change because it is uncertain that how close the proxy measures relate to technical change. However, the estimated rate of technical change corresponds to the rate of cost diminution over time when all other things are being held constant. It then reflects accurately the pace of technical change and allows correct interpretations about the determinants of technical change to be drawn from the results.<sup>6</sup>

Our econometric model, Equation (7.1), consists of the estimated rate of technical change (ECT) as the dependent variable and ten explanatory variables. These explanatory variables include:

1. INVNUM- the inverse of the number of firms in the industry, expressed in percentage.
2. FIRM- the average number of workers per firm in the industry.
3. Y- average industrial real output over the period of study.
4. YGROW- the average annual growth rate of real output over the period of study.



5. FOREIGN- the percentage of firms in the industry that are either wholly or majority foreign-owned.
6. EXPORT- the percentage of direct exports in total sales.
7. KAP- the capital-labor ratio.
8. ECY- the estimated elasticity of cost with respect to output.
9. DUM1- is equal to one if R&D expenditure in sales in 1989 is greater than zero, but less than 0.01%. It is zero if the industry has zero R&D expenditure.
10. DUM2- is equal to one if R&D expenditure in sales in 1989 is at least 0.01% and it is equal to zero otherwise.

$$(7.1) \quad ECT = \beta_0 + \beta_1(INVNUM) + \beta_2(FIRM) + \beta_3(Y) + \beta_4(YGROW) + \beta_5(FOREIGN) + \beta_6(EXPORT) + \beta_7(KAP) + \beta_8(ECY) + \beta_9(DUM1) + \beta_{10}(DUM2) + \mu_t$$

In Equation (7.1), we postulate that the industry estimated rate of technical change is determined by the industry's characteristics. First, market concentration is expected to exert an influence on ECT. Our literature review in Section (7.2) shows that the theories and empirical evidence offer no definitive predictions about the influence of market concentration on technical change. If the Schumpeterian hypothesis holds, we expect that the proxy measure of market concentration (INVNUM) takes on a statistically significant negative estimated coefficient, meaning increasing market concentration generates a higher rate of technical progress, *ceteris paribus*.

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<sup>6</sup> Reduction in X-inefficiency can also lead to cost diminution over time (Davies, 1986, p. 233).

Second, we cannot offer any definitive prediction as well for the role of firm size on ECT for the same reason. If the Schumpeterian hypothesis holds, we expect the estimated coefficient for FIRM to be significantly negative. Third, the discussion on the role of market demand points to its unambiguous positive effect on technical change. We thus expect that the estimated coefficients for output (Y) and output growth (YGROW) to be negative. Fourth, foreign ownership should exert a positive effect on technical change as discussed in Section (7.6). Therefore, a negative estimated coefficient is expected for FOREIGN.

Although there is little theoretical analysis of the relationship between export and technical change, empirical evidence appears to support a positive effect of export on the rate of technical progress. Using the frontier production approach, Chen and Tang (1986) conclude that the average efficiency of export processing businesses in Taiwan is about one-fifth higher than the average efficiency of businesses serving the local market. They also find that the foreign subsidiaries in Taiwan exporting most of their output are about the same size as those serving primarily the local market, but substantially more labor intensive, which corresponds to Taiwan's comparative advantage.

We include direct exports (EXPORT) in the model to test the hypothesis that industries that export a relatively large share of their output experience a higher rate of technical progress. The rationale behind this hypothesis is that those industries that export a large share of their output are required to compete effectively in the world market and thus are forced to produce at the technological frontier. In this sense, we can view EXPORT as a

proxy of international competition and a negative estimated coefficient is expected for EXPORT, *ceteris paribus*.

The capital-labor ratio (KAP) is included to control for the inter-industry differences in capital intensity. Since the arrangement of our data set follows the Standard Industrial Classification (SIC), which essentially starts from the light industrial groups to the heavy industrial groups. Adding the capital-labor ratio can thus eliminate the potential problem of spatial correlation among the residuals,  $\mu_i$ . Another variable, the estimated elasticity of cost with respect to output (ECY) is added to the model to explore the possible effect of economies of scale on the rate of technical change. Specifically, it is believed that increasing returns to scale would enhance a higher rate of technical progress. Thus, a positive estimated coefficient for ECY is expected.

The last two variables in Equation (7.1) are DUM1 and DUM2. These two variables are included to make allowance for the inter-industry differences in technological opportunity. As discussed in Section (7.5), the signs of DUM1 and DUM2 are expected to be negative since industries that face with more technological possibilities are expected to experience a higher rate of technical progress.

### 7.7.1 Data

The dependent variable in our model is the estimated elasticity of cost with respect to time (ECT) that represents the rate of technical change. A negative ECT corresponds to a

reduction in cost over time or technical progress, while a positive ECT corresponds to an increase in cost over time or technical regress. ECT estimates are presented in the last chapter on estimation results. Since we have three sets of ECT estimates that correspond to the different demand specifications (ECT1, ECT2 and ECT3 correspond to the log-log, semi-log and linear specification, respectively), we adopt these three sets of ECT estimates respectively for the dependent variable in Equation (7.1).

**Table 7.1: Number of firms, Firm Size, Output and Output growth**

	INVNUM %	FIRM No.	Y M\$	YGROW %
Food (311)	0.38	39.51	2599.12	2.70
Beverage (313)	7.14	171.86	367.63	4.40
Tobacco (314)	25.00	145.75	286.17	8.60
Textiles (321)	1.49	50.08	392.55	-5.40
Garments (322)	0.27	78.24	1128.14	0.00
Leather (323)	5.26	37.74	54.2	-5.10
Footwear (324)	2.86	20.71	67.61	-5.30
Sawn Timber (331)	1.10	32.99	526.95	-8.70
Furniture (332)	0.65	46.69	347.8	7.20
Paper (341)	1.12	48.78	580.07	2.20
Printing/Publishing (342)	0.31	47.22	1013.36	8.40
Industrial Chemicals (351)	1.37	59.26	1324.45	11.80
Pharmaceuticals (352)	1.14	53.24	1198.11	8.50
Petroleum (353)	9.09	283.00	11945.03	5.20
Rubber (355/6)	20.00	52.62	73.14	-0.40
Plastic (357)	0.36	46.64	723.73	3.20
Pottery (361)	11.11	94.78	58.31	-2.70
Iron and Steel (371)	9.09	146.82	327.21	4.90
Non-ferrous Metals (372)	5.26	38.79	246.42	1.70
Fabricated Metals (381)	0.22	58.50	2117.02	4.20
Industrial Machinery (382)	0.26	58.72	2034.5	7.00
Electrical (383)	0.78	173.38	1604.66	11.30
Electronics (384)	0.43	498.20	14373.56	15.60
Transport (385)	0.44	99.54	2327.59	6.00
Precision Equipment (386)	2.04	155.80	545.44	5.20
Others (390)	0.63	49.08	578.1	-0.60

Notes:

INVNUM- the inverse of the number of firm. FIRM- the average number of workers per firm. Y- the average annual output. YGROW- the average annual growth rate of output. Y and YGROW are calculated over the period 1975 to 1994. Other variables are 1989 based.

Source: *Census of industrial production, 1975, 1989 and 1994.*

**Table 7.2: Foreign Ownership, Direct Exports, Capital-Labor Ratio and Types of Technological Opportunity (1989)**

	FOREIGN %	EXPORT %	KAP \$1000/WKR	DUM1	DUM2
Food (311)	17.50	57.20	57.49	0	1
Beverage (313)	21.50	32.20	169.62	0	1
Tobacco (314)	50.00	34.00	129.46	0	0
Textiles (321)	15.00	37.00	30.30	0	0
Garments (322)	6.70	84.10	9.70	0	0
Leather (323)	5.30	27.00	14.61	0	0
Footwear (324)	5.80	30.40	16.44	0	0
Sawn Timber (331)	13.20	55.00	31.04	1	0
Furniture (332)	8.50	40.10	18.27	0	1
Paper (341)	20.20	36.70	60.49	0	0
Printing/Publishing (342)	6.80	19.90	35.00	1	0
Industrial Chemicals (351)	60.20	63.10	448.42	1	0
Pharmaceuticals (352)	44.30	77.80	73.13	0	1
Petroleum (353)	81.80	65.60	916.32	0	0
Rubber (355/6)	33.40	61.18	30.57	1	0
Plastic (357)	18.00	18.50	33.60	1	0
Pottery (361)	11.10	34.80	225.69	0	0
Iron and Steel (371)	36.40	36.10	101.02	0	1
Non-ferrous Metals (372)	31.60	42.20	79.10	0	0
Fabricated Metals (381)	21.90	30.70	39.55	1	0
Industrial Machinery (382)	28.10	62.30	41.67	0	1
Electrical (383)	51.20	59.30	32.60	0	1
Electronics (384)	59.70	84.40	29.91	0	1
Transport (385)	20.90	66.00	50.01	1	0
Precision Equipment (386)	61.30	91.90	27.90	0	1
Others (390)	13.80	64.80	26.22	0	1

Notes:

FROEGIN- the percentage of wholly or majority owned firms. EXPORT- the percentage of direct export in sales. KAP- the capital-labor ratio. DUM1- is equal to one if the industry's R&D expenditure in sales is above zero but below 0.01% (zero otherwise). DUM2- is equal to one if the industry's R&D expenditure in sales is above 0.01% (zero otherwise).

Source: *Census of industrial production, 1989.*

Table (7.1) and (7.2) list all the explanatory variables that we employ in the model.<sup>7</sup>

INVNUM is the inverse of the number of firms in the industry, expressed in percentage.

Without knowing data at the firm level, INVNUM is used as a proxy measure for the degree of market concentration.<sup>8</sup> A high INVNUM reflects a high degree of market concentration. Market demand is measured by the industrial real output (Y) and the average annual growth rate of real output from 1975 to 1994 (YGROW). Firm size (FIRM) is measured by the average number of workers per firm in the industry. Foreign ownership (FOREIGN) is measured by the percentage of firms in the industry that are either wholly or majority foreign-owned. The percentage of direct exports in total sales (EXPORT) measures the extent of exports in the industry.

The capital-labor ratio (KAP) is measured by the net value of fixed assets divided by the total number of workers in the industry. Following Scherer's (1965a) technique in controlling for the inter-industry differences in technological opportunity, we classify the industries into three technological groups according to their R&D intensity. Those industries that have a relatively large share of R&D to sales (the R&D to sales ratio is at least 0.01 percent) fall into the high technological opportunity group (DUM2 = one). Those industries with an R&D to sales ratio above zero but less than 0.01 percent fall into the intermediate technological opportunity group (DUM1 = one). As we have seen in Chapter Two, Table 2.7, that Singapore industry R&D expenditure is very low by the standard of the industrialized countries. Consequently, we can only use a very low cutoff such as 0.01 percent for classification of R&D intensity. If we use a higher cutoff that

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<sup>7</sup> The three sets of estimated elasticity of cost with respect to output (ECY) that corresponds to scale economies are listed in Chapter Six.

reflects those R&D intensity in the industrialized countries, then very few, if any, industries in Singapore would be classified as high technological opportunity group.

7.7.2 Estimation and Model Selection

Given the set of explanatory variables that we are interested in, our main concern is to search for a specific model that enhances the overall goodness-of-fit, indicated by the F-ratio, and simultaneously satisfies the classical least square estimation assumptions such as homoskedasticity and no multicollinearity. We first estimate Equation (7.1) by using the ordinary least squares (OLS) method and perform a number of diagnostic tests to assess the OLS results. Since we have a large number of explanatory variables in the model, we pay close attention to the potential problem of multicollinearity. In Table (7.3), the OLS estimation results and some diagnostic test statistics are presented for the three regressions involving ECT1, ECT2 and ECT3 as the dependent variable.

In Table (7.3), we show the OLS estimation results as well as the F-ratio, the coefficient of determination ( $R^2$ ), the Breusch-Pagan tests (LM) statistic and the average variance-inflation factors (VIF). Also, in Table (7.3), we show the squared multiple correlation coefficients that result from regressing the explanatory variable in the row on all other explanatory variables,  $R_i^2$ . For example, under the log-log demand specification where ECT1 and ECY1 are generated, the squared multiple correlation coefficient for regressing INVNUM on all other explanatory variables is 0.7028. The variance-inflation factors

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<sup>8</sup> Calculations of four-firm concentration index or Herfindahl index require data at the firm level.

(VIFs) are given in the parentheses under the  $R_i^2$ . Similarly, the columns under ECT2 and ECT3 show the squared multiple correlation coefficients, the VIFs and OLS estimation results for the semi-log and linear demand specification, respectively.

**Table 7.3: OLS Estimation Results and Diagnostic Checks**

	ECT1		ECT2		ECT3	
	$R_i^2$ (VIF)	OLS (t-value)	$R_i^2$ (VIF)	OLS (t-value)	$R_i^2$ (VIF)	OLS (t-value)
INVNUM	0.6289 (2.6947)	-0.0056 (-1.4130)	0.7028 (3.3647)	-0.0023 (-0.7019)	0.6566 (2.9121)	-0.0027 (-0.8973)
FIRM	0.8735 (7.9051)	0.0004 (1.1820)	0.8770 (8.1301)	0.0001 (0.5420)	0.9427 (17.452)	0.0004 (1.0170)
Y	0.8783 (8.2169)	-0.0000 (-0.5431)	0.8955 (9.5694)	0.0000 (0.0235)	0.9368 (15.823)	-0.0000 (-1.1780)
YGROW	0.6456 (2.8217)	0.0046 (1.2430)	0.6422 (2.7949)	-0.0018 (-0.6540)	0.6891 (3.2170)	0.0003 (0.1079)
FOREIGN	0.8030 (5.0761)	-0.0009 (-0.6321)	0.7988 (4.9702)	-0.0001 (0.0780)	0.8976 (9.7660)	-0.0012 (-0.8115)
EXPORT	0.5572 (2.2584)	-0.0009 (-0.9387)	0.5672 (2.3105)	-0.0001 (-0.1513)	0.7310 (3.7180)	0.0001 (0.1043)
KAP	0.6959 (3.2884)	0.0001 (0.3946)	0.7334 (3.7509)	-0.0000 (-0.0490)	0.8355 (6.0790)	0.0002 (1.3490)
ECY	0.3080 (1.4451)	-0.0887 (-6.3620)	0.4710 (1.8904)	-0.0352 (-1.1000)	0.4714 (1.8920)	-0.0422 (-1.3570)
DUM1	0.5025 (2.0101)	-0.0495 (-1.2620)	0.4986 (1.9944)	0.0312 (0.4665)	0.6744 (3.0710)	0.0235 (0.5666)
DUM2	0.6314 (2.7130)	-0.0293 (-0.6439)	0.6486 (2.8458)	0.0179 (0.5503)	0.7715 (4.3760)	0.0392 (0.8671)
F-ratio		8.352		0.597		0.678
B-P		10.418		10.21		8.588
Ave. VIF		3.843		4.1621		6.831
R-sq.		0.8496		0.2879		0.3725
No. of observ.		25		26		19

NOTES:

$R_i^2$  corresponds to the squared multiple correlation coefficient that results from regressing the  $i$ th independent variable on all other independent variables. B-P corresponds to the Breusch-Pagan test (LM) statistic. VIF corresponds to the variance-inflation factors. ECT1, ECT2 and ECT3 correspond to the estimated elasticity of cost respect to time that are generated by the log-log, semi-log and linear demand function, respectively.

To detect multicollinearity, it is useful to look at the squared multiple correlation coefficients or, equivalently, the variance-inflation factors. The variance-inflation factor



for the explanatory variable,  $X_i$ , is given by  $VIF_i = 1/(1 - R_i^2)$  and we can also compute the average VIF for the whole regression model by summing the individual VIFs and dividing it by the number of explanatory variables in the model. Although it is not completely clear how large should the VIFs be to suggest a serious problem with multicollinearity, there are certain guidelines that we can follow. First, any individual VIFs larger than 10 indicate that multicollinearity may be influencing the least squares estimates of the regression coefficients. Second, if the average VIF is considerably larger than one, then multicollinearity could be substantial. This is because the average VIF indicates the number of times that multicollinearity increases the error sum of squares for the regression. It must be noted, however, that detection of multicollinearity based only on the squared multiple coefficients or the variance-inflation factors can be misleading. It has been suggested that, in addition to examining the  $R_i^2$ s or VIFs, we should also examine the stability of estimated coefficients when some observations in the model are deleted. This is what we follow in detecting multicollinearity in our selected model.

Looking at our individual VIFs and the average VIFs for all the specifications in Table (7.3), there are signs of multicollinearity in certain explanatory variables, especially for the regression involving ECT3 as the dependent variable. First, all specifications have an average VIF larger than one. The average VIF for the log-log, semi-log and linear specification is 3.843, 4.1621 and 6.831, respectively. Second, some variables, particularly FIRM and Y, show a VIF either close to or greater than ten. However, we must stress that neither sign indicates serious problems of multicollinearity if the estimated coefficients are stable when certain observations are deleted. Multicollinearity

results in high standard errors that underestimate t-values and causes imprecise estimation of the regression coefficients. One method in dealing with multicollinearity is to delete those variables that are highly correlated with other explanatory variables. However, it can be shown that by dropping a collinear nuisance variable, the omitted variable estimator for the remaining explanatory variables is biased but has a smaller standard error.

We first adopt the so-called simplification search for a simple and useful model by eliminating those explanatory variables that contribute very little to the explanation of technical change, the dependent variable. In the regression involving ECT1, we first drop KAP and then Y from the model since their estimated coefficient is close to zero and their t-value is the least of all estimated coefficients. Dropping these two variables increases the F-ratio from 8.352 to 11.379. The results of the OLS estimation for the model without KAP and Y are listed in Table 7.4. The calculated standard errors for all the remaining estimated coefficients become smaller and the estimates do not change very much after dropping KAP and Y. Hence, it is safe to conclude that both of these variables contribute very little to the explanation of ECT1.

We could continue to drop insignificant variables to maximize the F-ratio. The next two explanatory variables that are in line for elimination are DUM2 and FOREIGN. However, we decline to continue the elimination process since maximization of the F-ratio is not the goal in our model selection process. We are more interested in investigating the possible effects of some meaningful explanatory variables on technical

change regardless whether they are statistically significant. In this respect, we only drop those variables that show a negligible influence on the dependent variable.

**Table 7.4: Final Estimation Results**

Dependent Var. Indep. Var.	ECT1 (t-value)		ECT2 (t-value)		ECT3 (t-value)	
	OLS	WLS	OLS	WLS	OLS	WLS
INVNUM	-0.0044* (-1.430)	-0.0043 (-1.315)	-0.0023 (-1.018)	-0.0024 (-1.074)	-0.0027 (-1.044)	-0.0006 (-0.065)
FIRM	0.0003* (1.489)	0.0002 (0.552)	0.0002 (1.204)	0.0002 (1.135)	0.0004 (1.132)	0.0003 (0.556)
Y	N/A	N/A	N/A	N/A	-0.0000 (-1.326)	-0.0000 (-0.738)
YGROW	0.0047* (1.343)	0.0049* (1.402)	-0.0017 (-0.706)	-0.0018 (-0.739)	N/A	N/A
FOREIGN	-0.0007 (-0.686)	-0.0007 (-0.590)	-0.0001 (-0.134)	-0.0001 (-0.114)	-0.0011 (-1.115)	-0.0008 (-0.427)
EXPORT	-0.0009 (-1.043)	-0.0010 (-1.148)	-0.0001 (-0.158)	-0.0001 (-0.214)	N/A	N/A
KAP	N/A	N/A	N/A	N/A	0.0002* (1.551)	0.0001 (0.511)
ECY	-0.0868# (-6.784)	-0.0823# (-5.601)	-0.0357* (-1.358)	-0.0382* (-1.437)	-0.0423* (-1.523)	-0.0359 (-0.797)
DUM1	-0.0450 (-1.258)	-0.0501* (-1.390)	0.0132 (0.513)	0.0119 (0.463)	0.0254 (0.756)	0.0282 (0.820)
DUM2	-0.0268 (-0.678)	-0.0258 (-0.648)	0.0183 (0.649)	0.0172 (0.610)	0.0420 (1.179)	0.0405 (0.962)
<b>F-ratio</b>	11.379	6.073	0.827	0.838	1.032	0.730
<b>B-P</b>	9.381	8.444	9.587	10.371	7.965	8.561
<b>Ave. VIF</b>	2.214	-	2.248	-	6.581	-
<b>R-sq.</b>	0.8464	0.7557	0.2878	0.2965	0.3713	0.2463

Note: \* represents statistical significant at ten-percent level and # represents statistical significant at 5-percent level.

The next important question is whether the selected model for ECT1 (the model without KAP and Y) seriously violates the standard assumptions of OLS estimation. First, looking at the VIF for the explanatory variables and the average VIF for the selected model of ECT1, we detect little evidence of multicollinearity. The VIFs are all substantially below ten and the average VIF is 2.238. In order to make certain that

multicollinearity does not cause serious problems, we also delete certain observations from the data set to test for the stability of the estimated coefficients. Deleting the last two observations from the regression of the model results in estimates that possess the same sign and similar magnitude as those estimates that are generated from the estimation using the full set of data. Thus, it is safe to conclude that multicollinearity does not appear to cause serious problems for the selected model of ECT1.

For detecting the potential problem of heteroskedasticity in a small sample, we use the Breusch-Pagan test.<sup>9</sup> The Chi-square critical value at five-percent significance level and eight degrees of freedom is 15.5 and the LM test statistic is 9.381 for the selected model of ECT1. Since the hypothesis of homoskedasticity is only rejected when the Breusch-Pagan test statistic (LM) is greater than the critical value, we cannot reject the hypothesis of homoskedasticity for the selected model of ECT1. However, the observations that the calculated standard error of estimate varies substantially and that the dependent variable is itself an estimate provide a conceptual argument for using weighted least squares (WLS) in the regressions. Thus, we adopt the WLS estimation if this estimation method reduces the calculated standard errors of estimates and, at the same time, the resulting WLS regression residuals are not heteroskedastic.

In selecting a simple and useful model for ECT2, we follow procedures similar to those for ECT1. The estimation results of the selected model of ECT2 are listed in Table 7.4. First, the calculated t-values in the original model listed in Table 7.3 show that KAP and

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<sup>9</sup> We do not discuss in length the mechanics of these tests since they can be found in standard econometrics texts.

Y are again found to have the least impact on the dependent variable. After deleting these two variables from the model, we observed that the F-ratio has increased from 0.597 to 0.827. However, the overall goodness-of-fit is substantially lower than that of the regression involving ECT1. The diagnostic checks reveal no serious problems of multicollinearity and heteroskedasticity for the selected model of ECT2 in Table 7.4. All individual VIFs are below ten and the average VIFs is 2.2483. More importantly, the estimated coefficients are stable with the same sign and similar magnitude when the last two observations of data set are deleted in the regression. In respect to heteroskedasticity, the Breusch-Pagan LM test statistic is 9.587, well below the critical value of 15.5. Furthermore, we adopt the WLS estimation if it reduces the calculated standard errors of estimates and at the same time their residuals are heteroskedastic.

For the regression involving ECT3 as the dependent variable, the OLS estimation results shown in Table 7.3 indicate low overall goodness-of-fit and evidence of serious problems of multicollinearity. Specifically, the two variables, FIRM and Y, possess a VIF greater than ten and, more importantly, the estimated coefficients do not appear to be stable in the face of deleting some observations from the regression. We observe that the sign of EXPORT changes from positive (shown in Table 7.3) to negative (not shown) when we delete the last two observations from the regression. We propose to drop the least statistically significant variables, EXPORT and YGROW, from the model. After dropping these two variables from the model, we observe that the F-ratio increases from 0.678 to 1.032. The individual VIFs and the average VIF decrease slightly, but FIRM and Y still possess a VIF greater than ten. The stability test shows that all remaining

estimated coefficients are stable. The Breusch-Pagan LM test statistic is 7.965, well below the critical value of 15.5 and smaller than the corresponding figure for the OLS regression using the full set of variables.

### 7.7.3 Discussion of Results

The results of our search for a model that describes the estimated rate of technical change are presented in Table (7.4). We present two sets of final estimates, the OLS and WLS. Note that we have come to the conclusion that the estimation results presented in Table (7.4) are robust to a change in the data set. That is, the estimates do not vary substantially when certain observations are deleted from the data set, giving weight to the conclusion that multicollinearity does not impose serious problems in the regression.

The WLS estimation results do not appear to differ substantially from those of the OLS results for the three regressions. Based on the overall F-ratio and the individual t-values, WLS estimation appears to offer not very substantial reduction in the calculated standard errors of estimates and increase in the overall goodness-of-fit. Furthermore, the Breusch-Pagan LM test statistic of the WLS estimation is only slightly lower than the OLS's LM test statistic for ECT1. It, in fact, exceeds that of the OLS estimation for ECT2 and ECT3. With all of these taken together, there seems to be little evidence supporting the use of WLS estimation over the OLS estimation.

In Table (7.4), those variables that have been deleted are indicated by N/A. The regression using ECT1 as the dependent variable shows that Y and KAP have been deleted. The ECT1 results show that the overall goodness-of-fit is relatively high, as indicated by both the calculated R-square (0.8464) and F-ratio (11.379). A number of estimated coefficients are statistically significant at either the five-percent or ten-percent significance level. The estimated elasticity of cost with respect to output, ECY, is the most significant variable followed by firm size (FIRM), concentration (INVNUM), and output growth (YGROW) in the OLS estimation. For the WLS estimation of ECT1, only ECY, YGROW and DUM1 are statistically significant.

The regression involving ECT2 as the dependent variable shows a much lower overall goodness-of-fit as indicated by the calculated R-square (0.2878) and F-ratio (0.827). Again, we delete Y and KAP from the regression because they appear to offer the least impact on technical change. None of the estimated coefficients except ECY are statistically significant at the ten-percent significance level. The WLS estimation offers very similar results. The only variable that reaches the ten-percent statistical significance level is ECY.

For the regression that uses ECT3 as the dependent variable, we drop YGROW and EXPORT from the estimation. The overall goodness-of-fit improves slightly, but the individual estimated coefficients are largely statistically insignificant, except KAP and ECY, which are statistically significant at ten-percent significance level. The WLS estimation results, however, show no statistically significant variables.

The signs of the estimated coefficients are generally consistent with the theoretical discussions in the first part of the chapter. For example, market concentration, INVNUM, shows a negative estimated coefficient in all three regressions, suggesting that increasing market concentration tends to associate with higher rates of technical change. FOREIGN and EXPORT also show a negative sign consistently across all three regressions, suggesting that the higher the percentage of foreign ownership and industry direct exports in sales the higher is the rate of technical change, *ceteris paribus*.

Some estimated coefficients possess signs that are inconsistent across the regressions or contrary to what we expect in the earlier discussions. DUM1 and DUM2 have estimated coefficients that change sign across regressions. The unstable sign of estimates for DUM1 and DUM2 and their generally low significance are perhaps not surprising given the low levels of R&D expenditure. The estimated coefficient for ECY, the elasticity of cost with respect to output, is consistently negative across all three regressions. The largely statistically significant negative relationship between ECY and ECT suggests that those industries that experience increasing returns to scale tend to have lower rates of technical change. Other variables such as Y and YGROW also show contradicting signs in the estimated coefficients across regressions. Thus, little can be said about the direction of association between these variables and the estimated rate of technical change.



## 7.8 Conclusions and Interpretations

In this chapter we attempt to examine the determinants of inter-industry differences in technical change. In the first part of the chapter, we review the theories and empirical evidence on the links between inventive activity and market structure. Specifically, we look at the role of market concentration, firm size, demand, technological opportunities and foreign ownership in determining the rate of technical change. There is little conclusive evidence substantiating the claim that there is a direct link between market concentration and technical change. The same holds for the role of firm size. On the other hand, the theories and empirical evidence indicate a positive impact of demand and technological opportunities on technical change. There is also evidence supporting a direct relationship between higher productivity levels of domestic firms and larger share of foreign subsidiaries in the industry. Finally, export is believed to exert a positive influence on a firm's productivity, as suggested by some empirical studies.

A few key results can be drawn from our regression studies in the previous section. Firstly, the high standard errors or low computed t-values for almost all estimates in the three regressions make the interpretation of results difficult. It is difficult to conclude with any degree of confidence of how the explanatory variables affect the dependent variable, ECT, in any systematic way. However, even with the general low level of statistical significance, we observe that some estimated coefficients are negative across all three regressions. Specifically, INVNUM, FOREIGN and EXPORT all show a negative sign in all regressions as what we expect from the theoretical discussion. A

negative sign indicates a positive link between technological progress and the variable concerned. In sum, our results seem to show that, on the average, market concentration, foreign ownership and direct exports contribute positively to technical change. However, it must be stressed that these relationships are not statistically significant to allow us to draw any firm conclusion.

The only variable that consistently passes the statistical significance tests is ECY. Its negative relationship with ECT is contrary to the expectation that increasing returns to scale enhances or stimulates technical change. What could possibly explain the observation of significant negative relationship between ECY and ECT? Similar to what Park and Kwon (1995) argue for the South Korean economy, the rapid growth of output for Singapore industries is mainly due to two factors- increasing returns to scale and rapid growth of factor inputs. Singapore industries are dominated by large MNCs that are allowed to exploit scale economies, especially in the environment of the export-oriented growth policy. These large MNCs, however, have little interest in investing in indigenous R&D to promote technical change or enhance technology transfer. On the other hand, rapid growth of factor inputs, encouraged by favorable public policy such as tax breaks and forced savings, contribute substantially to the rapid output growth and also the peculiar observation of negative TFPG. In the concluding chapter, we reiterate this in more detail and incorporate analysis from a most recent research by Ermisch and Huff (1999).

We should not, however, ignore the possible mis-specification error that can result in the observed statistically significant relationship between ECT and ECY. Given that output is growing, there is a positive relationship between time and output in each industry. If ECY is overestimated due to mis-specification of the estimating equations in Chapter Six, then ECT will tend to be underestimated. Over-predicting the effect of output on cost tends to leads to under-predicting the effect of time. With this interpretation, the ECT1 results would appear to be most dubious as they produce the stronger negative relationship between ECT and ECY. The fact that the negative relationship reappears in ECT2 and ECT3 results as well may suggest that none of the functional forms is quite right. This would not be surprising, given that none of the demand functions needs be exactly right for any industry, much less for all industries. What it shows is that functional form matters and that there needs to be more research into the choice of functional forms.

In sum, the failure to find statistically significant determinants of the inter-industry differences in estimated rate of technical change appears to suggest that the existing industrial structure contributes little, if any, to technical progress in Singapore. A question should be raised about the continuation of the public policy of heavy subsidization of foreign subsidiaries if this key policy does not result in any significant improvement in the rate of technical change in the industrial sector. This question seems to be more relevant and urgent when input-driven growth is steadily slowing down as we approach the new millenium.

## **CHAPTER EIGHT**

### **CONCLUSIONS AND INTERPRETATIONS**

#### **Introduction**

The objective of this last chapter is to conclude and interpret the main findings in the thesis. The role that public policy plays in industrial development, economic growth and technical progress in Singapore is under examination. It has been generally agreed that “the debate is not about whether public policy mattered, but over which measures paid off” (Collins and Bosworth, 1996, p.171). To conclude this thesis, we ask a couple of important questions in this chapter. The first question is how creditable is our result of low estimates of productivity change, measured by TFPG, primal and dual rate of technical change and the second one is how to explain such a result? Is it true that the observed low TFPG and technical progress are merely the by-products of a certain public policy, which the government has actively promoted for the last thirty-five years in Singapore?<sup>1</sup>

The chapter is organized into three sections. First, we interpret the major findings of the thesis in relation to the growth experience and the role of public policy in Singapore. Second, we discuss the major limitations and problems involved in the implementation of the present thesis study. Third, we suggest directions for future research before ending the thesis.

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<sup>1</sup> Ermisch and Huff (1999) analyse the impact of public policy and capital accumulation in Singapore. This chapter draws some important points from their article.

### 8.1 Forced Savings, High Investment, High Growth and Low TFPG

We have seen that Singapore's economic growth is among the highest in the world. The real growth of GDP averages 6.5 percent per annum for the past 35 years and its per capita GNP (\$US\$26,730 in 1995) exceeds that of United Kingdom, Canada and Italy. Despite its high growth, the government acknowledges that "Singapore reached a developed country's income level before having become a fully developed economy" (Singapore, Ministry of Trade and Industry, 1986, p.60) and that according to the Ministry for Finance, "our economic structure is very much that of a developing country. We depend heavily on foreign technology" (Hu, 1994, p.4).

There seems to be a consensus among researchers that the spectacular growth rate of Singapore is mainly the result of massive factor accumulation with little technical progress. Studies from Tsao (1985), Young (1992, 1994 and 1995), Krugman (1994), Kim and Lau (1994), Collin and Bosworth (1996) and the World Bank (1993) all come up with a similar conclusion; factor accumulation, in particular capital growth, accounts for almost all the rapid output growth. Technical progress measured by TFPG is either close to nil or negative for significant parts of the period under study.

Our results largely confirm the findings of these previous studies, despite the fact that we use more sophisticated measurement techniques and disaggregated industry data. What is interesting is that we duplicate the negative TFPG estimate that Young (1992) finds for his study of Singapore economy-wide growth, using the conventional accounting

technique. When we employ various parametric estimation techniques, we come up with results that suggest increasing returns to scale, close to nil or negative technical progress and insignificant market imperfection for the overall Singapore manufacturing. These results seem to fit well into what researchers such as Kwon and Park (1995) call the model of input-driven growth that seems to characterize the rapidly growing Asian NIEs.

We cannot totally ascertain that the results generated from the various parametric estimation techniques are not statistical artifacts. Apart from the serious limitations imposed by the data set, which we turn to later in the chapter, we could also face misspecification errors in the estimation equations in Chapter Six. Although there is an economic explanation for the statistically significant relationship between ECT and ECY, as researchers such as Park and Kwon (1995) conclude, the fact that we find such a relationship might suggest erroneous specifications of the demand and cost functions. The result is that we could over-estimate the degree of economies of scale and under-estimate technical change. One can argue that the ECT estimates largely conform to the calculated TFPG measures and results from other studies. However, a definitive defense must come from more research into the impact of functional forms on productivity measurement.

A question remains to be addressed is how did Singapore achieve such a rapid growth without the accompanying technical progress. In particular, many researchers are perplexed by Singapore's extraordinary high saving rate and investment ratio. Singapore's investment ratio was regularly the highest in the world in the 1980s, averaging about 42.5 percent of GDP. The government assumes a crucial role in determining savings, either

public or private. Investment, on the other hand, remains to be largely determined by the private sector and direct foreign investment.

Singapore's savings mechanism is unique for its forced nature. First, it consists of the government's continuous effort to depress private consumption. The government successfully reduced private consumption expenditure from 89.4 percent of the GDP in 1960 to 40.9 percent of the GDP in 1995, compared to the lowest rate of 55 percent ever reached in the Soviet Union (Ofer, 1987, p.1790). Savings accumulated largely from involuntary public and private sources, with only a small fraction of total savings coming from voluntary private savings. Government statutory boards are the principle sources of public savings, which makes up close to 70 percent of the total savings. Statutory boards oversee monopolies in public utilities and telecommunications that accumulate monopoly rent by forcing workers to pay a relative high price compared to their wages. Another source of forced savings is the involuntary social security scheme, the Central Provident Fund, which makes up roughly about 25 percent of the total savings. Voluntary private savings, both household and corporate, contribute no more than eight percent to total savings.

Large savings provide a cheap source of funds for government subsidization of private and direct foreign investment. Starting from 1967, the government has been granting "pioneer" status to most direct foreign investment. In addition to a host of other incentives for new investments by firms, pioneer status under the 1967 Act gives tax exemption on profit to investors for two to five years. The pioneer status effectively reduces by about a

fifth the cost of each dollar of new investment and is “as generous as anyone could ask” (Manring, 1971, p.21). The amount of subsidies associated with pioneer status increase progressively over the past two decades. By 1975, foreign investors under pioneer status pay zero tax on profit for a full 10 years, which is approximately equivalent to a subsidy of more than 50 percent of the value of new investment.

In addition to tax exemption under pioneer status, other types of subsidies attract foreign investors to Singapore. One of these subsidies is the heavily subsidized rental for factory sites in the many industrial zones around Singapore. Under the scheme, the government leases land to new investors for 30 years at a rate substantially below the market price. The land is initially acquired by the government through the Land Acquisition Act that allows the government to pay a substantially below market price for the acquired land. What the government effectively does is to tax the landlords to subsidize new investment. Investors can continue to enjoy cheap rentals even without making any further investment.

Singapore provides world class infrastructure to direct foreign investors such as an excellent network of roads and highways, mass rapid transit system, satellite communications and Changi Airport. Modern infrastructure is a significant part of public investment that aims to increase the marginal product of capital for foreign investors. It is difficult for a first time visitor to Singapore not to notice its modern facilities, in particular, its efficient transportation system. On top of all that, its population is largely English educated and a foreign investor would not face such a language barrier as he or she faces even in Hong Kong. Real expenditure on educational provision has increased by



eight-fold since 1967 in Singapore. We see a pattern of heavy public investment on infrastructure by the government to attract foreign investment. In effect, public investment on infrastructure corresponds to indirect subsidies to foreign investors to increase their marginal product of capital invested in Singapore. An estimate of the ratio of infrastructure expenditure to foreign investment indicates that Singapore government spends roughly three dollars for every dollar of foreign investment (Ermisch and Huff, 1999).

In sum, the government imposes forced savings to subsidize direct foreign investment and capital accumulation. Direct foreign investment and export-oriented manufacturing, in turn, are responsible for the rapid growth in output and income in Singapore over the past two decades. There seems to be very little reason for the government to change its strategy in promoting economic growth if it has been working so successfully in the past.

However, the immediate challenge for the government is that in order to continue the rate of growth that Singapore has been enjoying over the past two decades, an increasing amount of subsidies must be provided if the same policy of attracting direct foreign investment is pursued. Furthermore, the government would have to continue to suppress private consumption when the population of Singapore starts to enjoy the fruits of their hard work. The fact that the population has to consume a fraction of their output sets an upper limit for growth in Singapore if the same strategy of development is pursued.

All of the above discussion point to one direction- technical progress, which the government has admitted publicly minimal. In 1989, electronics goods industries such as

radio, television and communication equipment in Singapore spend an average of 3.6 dollars on R&D for every 1000 dollars of output. This figure pales in comparison to the amount spent by those of the industrialized countries, such as 74 domestic dollars, 130 domestic dollars and 62.2 domestic dollars spent by Australia, Canada and United Kingdom, respectively.

Foreign investors, in particular, the Japanese, come to Singapore largely for its relatively cheap labor, strategic location and stable political environment. Attracted by the generous government subsidies, the so-called foot-loose high-tech MNCs pour into Singapore to take advantage of its reliable labor force, especially women workers, and pay a considerably lower wage rate compared to what they would have to pay in their own countries. They find that it is more cost effective to employ labor-intensive assembly-line production than investing in automation. In 1990, 72 percent of those in electronics production are female, compared to 42 percent in the rest of manufacturing. Despite the fact that Singapore accounts for more than half of the world exports of disk drives, approximately 75 percent of the content of the final product is imported (Ermisch and Huff, 1999).

The government has realized the problem of low TFPG and started to formulate policy to promote technical progress. It has explicitly stated an official target of 2 percent TFPG per annum and set up an agency specially to fulfill its target (Rao and Lee, 1995, p.97; Wilson, 1995, p.242). It seems vital now, more than ever, for Singapore to catch up the industrialized countries in technical progress. Singapore's comparative advantage is under

threat by other upcoming developing nations in the region such as Malaysia. How successful is the government's effort in promoting technical progress is probably one of the most important determinants in shaping Singapore as a truly industrialized country in the new millennium.

## **8.2 Limitations and Problems in the Implementation of the Model**

Despite great care taken to ensure the correctness of the methods and steps involved in the implementation of the model, we still face some intrinsic difficulties and limitations imposed by the data series, model and estimation procedures. In this section, we discuss limitations and problems arising from three main aspects of our study: data, the underlying assumptions and estimation. It is hoped that the discussion in this section lays the foundation for further research in the future.

### **8.2.1 Data Constraints**

We have already discussed in Chapter Four some of the possible sources of measurement errors posed by limited and inadequate data. The basic problem is that data series are simply unavailable for some variables required in the computation. And even if they are available, they do not extend back in time enough for the present study. There is also a major reclassification of industries in 1970. This poses a major question whether industries are comparable if one is to extend the time series to pre-1970 years. Our desire

to extend the period of the present study is constrained by non-comparability of the data.

We summarize some data problems in the following paragraphs.

First, data for net fixed capital asset over the 1975-79 period have to be estimated from investment data, which are not reliable. Investment commitments are used as a proxy for actual investment data, since the latter are not available. Furthermore, investment commitments data are only available for 2-digit industry level. It is then questionable whether the estimated net fixed capital asset is a good estimator of the true series.

Second, data on hours of work and types of labor by 3-digit industry level are not available. As discussed in Chapter Four, the resulting TFPG measure will be biased either upward or downward depending on whether the labor input measure understates or overstates the actual labor intensity.

Third, deflators may not accurately capture the change in price. Specifically, factor inputs such as capital, materials and energy are deflated by using Domestic Supply Price indexes, which may not adequately capture the changes in prices of these inputs. The problem here is that the required input price indexes by industry are not available.<sup>2</sup> Furthermore, prices of output are derived from real or nominal output growth series. It is doubtful that the underlying implicit output price index takes into account quality improvement in products.

It is difficult to draw firm conclusions from the resulting measurements when the data used are less than ideal. Also, it is believed that data problems contribute to some of the

anomalous estimation results. It should prove to be fruitful for further studies to look into ways to improve the data series beyond those available in the existing government publications.

### 8.2.2 Assumptions

Our estimation approach assumes that all inputs adjust to their long-run equilibrium level instantaneously. Many recent studies (see, for example, Kwon, 1995; Morrison, 1992 and 1988) distinguish between variable and fixed inputs and allow the fixed inputs to be only partially adjusted to long-run equilibrium in each time period.<sup>3</sup> The implicit assumption of instantaneous adjustment contradicts economic theory of short-run and long-run cost due to fixity of certain factor inputs. Hence, there are increasing number of empirical researchers adopting the short-run sub-equilibrium approach.<sup>4</sup>

It is uncertain to what extent the results of the present study would differ had the short-run sub-equilibrium approach been adopted.<sup>5</sup> Our theoretical model captures the effect of the changes in capacity utilization by adding an exogenous variable in the cost function. This measure of capacity utilization affects all inputs equally and has been shown to have a direct impact on the cost diminution in the model. Unfortunately, empirical

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<sup>2</sup> Deflating material input posed one of the most difficult tasks in the present study.

<sup>3</sup> Capital input usually is treated as the only quasi-fixed input in this type of studies.

<sup>4</sup> This approach in essence involves estimation of the (variable) cost function using the variable input prices, output, and quantities of quasi-fixed inputs as the right-hand variables.

<sup>5</sup> In Morrison's (1992) study, empirical results corrected for sub-equilibrium or fixity of certain inputs show that biases associated with the assumption of instantaneous adjustment can either be positive or negative. That is, the conventional productivity measures with instantaneous adjustment can either over-estimate or under-estimate the "true" productivity measurement.

implementation of this method is not possible due to the lack of suitable proxy for capacity utilization.

As we mentioned in the last chapter and earlier in this chapter, another likely source of error comes from specification of the equation systems. We assume that the adopted equation systems are correct in representing the industrial cost and demand structure. We have not used other specifications such as the translog cost function in our equation systems. It is very likely that a change of specification of the cost function in the integrated model would change the estimation results, just as what we observed in the individual cost function models.

Our estimation results show that estimates are sensitive to the specification of the demand function that we adopt. In general, different demand specifications give rise to different estimates and the extent of difference varies from one industry to another. In this respect, empirical studies about productivity measurement must not make simplifying assumption regarding the demand specification. One must examine closely the estimation results to check for anomalies before deciding on the specifications of either the cost and demand functions in the equation system.

### 8.2.3 Estimation Procedures

The method of maximum likelihood estimation for the system of simultaneous equations requires iterative optimization procedures that may not lead to convergence or a global maximum. As Greene (1993) suggests that when an algorithm fails to find a maximum (non-convergence), it may indicate that the model is not appropriate for this body of data. As indicated in the results, we face the problem of non-convergence for a few of the 26 industries in the study. Also, results for some industries are sensitive to the initial values that are the starting points for the optimization search. This sensitivity indicates that the maximum reached may be local rather than global. The nature of trial-and-error characterizes the procedure of specifying different initial values until a relatively stable log-likelihood function value is reached.

### 8.3 Suggested Future Studies

We suggest three directions for future research in this last section of thesis. The first direction relates to the explanation of the result of low productivity measurement. We mention in the beginning of this chapter that public policy plays an important role in explaining the rapid growth and low technical progress in Singapore, but it is still largely unclear about its degree of influence. A study to quantify the link between public policy and investment, growth and technical progress should prove to be valuable for academic researchers as well as for policy makers.

The second direction for future research relates to the implementation of the model. Specifically, we need to investigate more about the functional forms in the equation system. It has been observed that the demand specification does matter in the equation system. We observe very different estimates in some industries when different demand specifications are used. It appears that different industries have different demand structures that should lead to different demand specifications. Furthermore, we have not examined the impact of adopting a different cost function in the equation system. We have followed the standard practice in the literature and employed the generalized Leontief cost function in our equation system. There is scope for developing other flexible functional forms that can be used in equation systems. We note that our estimates of separate cost functions show that the translog cost function estimates differ notably from the generalized leontief estimates.

An improvement over the present study is the incorporation of the sub-equilibrium technique in the model. The sub-equilibrium approach distinguishes the variable from quasi-fixed inputs. The quasi-fixed inputs, such as capital, adjust only partially to their long-run equilibrium levels within one time period. Since the assumption of instantaneous adjustment of capital stock is unrealistic, this approach may reflect more accurately the time lags involved in adjusting capital stock.

Perhaps, the last suggested direction for future research is the most essential, namely, improvements in the data set. Improvements in the quantity and quality of the data set are needed. In terms of quantity, we need to extend the time series into pre-1970 period and to



collect 4-digit or even 5-digit industrial data for the complete set of variables under study. In terms of quality, we need to look into ways to refine the data set such as making quality improvements in labor and capital and finding price deflators that take into account quality improvement in output. It has been pointed out that data constraints remain to be a great challenge for practitioners of productivity measurement. Griliches (1994, p.2) states that "... inadequate attention to how [data] are produced and that the same inattention by us to the sources of our data helps explain why progress [in understanding productivity] is so slow".

**APPENDIX A****SHAZAM PROGRAM FOR TRANSLOG COST FUNCTION MODEL**

READ(C:\EXCEL\IND311.DIF)/DIF

\*\*\*\*\*

\* LINEAR TRASLOG WITH K, L AND M INPUTS

\*\*\*\*\*

GENR C=WK+WL+WM

GENR SL=WL/C

GENR SM=WM/C

GENR LC=LOG(C)

GENR LY=LOG(Y)

GENR LPL=LOG(PL/PK)

GENR LPM=LOG(PM/PK)

GENR LYSQ=0.5\*(LY\*\*2)

GENR LPLSQ=0.5\*(LPL\*\*2)

GENR LPLPM=LPL\*LPM

GENR LPMSQ=0.5\*(LPM\*\*2)

GENR LPLY=LPL\*LY

GENR LPMY=LPM\*LY

GENR LPLT=LPL\*T

GENR LPMT=LPM\*T

GENR LYT=LY\*T

GENR TSQ=0.5\*(T\*\*2)

STAT LY/MEAN=ELY

GENR LOGPK=LOG(PK)

GENR LOGPL=LOG(PL)

GENR LOGPM=LOG(PM)

STAT LOGPK/MEAN=ELPK

STAT LOGPL/MEAN=ELPL

STAT LOGPM/MEAN=ELPM

STAT T/MEAN=ET

GENR CONST=1

SAMPLE 1 20

SYSTEM 3/ DN NOCONSTANT RESTRICT  
 OLS LC CONST LY LPL LPM LYSQ LPLSQ LPLPM LPMSQ LPLY LPMY LPLT LPMT LYT T TSQ

OLS SL CONST LPL LPM LY T

OLS SM CONST LPM LPL LY T

RESTRICT LPL:1=CONST:2

RESTRICT LPM:1=CONST:3

RESTRICT LPLSQ:1=LPL:2

RESTRICT LPMSQ:1=LPM:3

RESTRICT LPLPM:1=LPM:2

RESTRICT LPLPM:1=LPL:3

RESTRICT LPLY:1=LY:2

RESTRICT LPMY:1=LY:3

RESTRICT LPLT:1=T:2

RESTRICT LPMT:1=T:3

END

\*\*\*\*\*

\*TESTING FOR RETURNS TO SCALE

\*\*\*\*\*

```
TEST
TEST LY:1=1
TEST LYSQ:1=0
TEST LPLY:1=0
TEST LPMY:1=0
TEST LYT:1=0
END
TEST (LY:1)+(LYSQ:1*ELY)+((-LPLY:1-LPMY:1)*ELPK)+(LPLY:1*ELPL)+(LPMY:1*ELPM)+ &
(LYT:1*ET)=1
*****
*TESTING FOR TECHNICAL PROGRESS
*****
TEST
TEST T:1=0
TEST LYT:1=0
TEST LPLT:1=0
TEST LPMT:1=0
TEST TSQ:1=0
END
TEST T:1+((-LPLT:1-LPMT:1)*ELPK)+(LPLT:1*ELPL)+(LPMT:1*ELPM)+(LYT:1*ELY)+ &
(TSQ:1*ET)=0
STOP
```

**APPENDIX B****SHAZAM PROGRAM FOR GENERALIZED LEONTIEF COST FUNCTION  
MODEL**

\* VARIABLES IN INPUT DEMAND EQUATIONS

GENR XKY=XK/Y

GENR XLY=XL/Y

GENR XMY=XM/Y

GENR PLPK=(PL/PK)\*\*0.5

GENR PMPK=(PM/PK)\*\*0.5

GENR PKPL=(PK/PL)\*\*0.5

GENR PMPL=(PM/PL)\*\*0.5

GENR PKPM=(PK/PM)\*\*0.5

GENR PLPM=(PL/PM)\*\*0.5

SAMPLE 1 1

GENR AXK=(SUM(XK,20))/20

GENR AXL=(SUM(XL,20))/20

GENR AXM=(SUM(XM,20))/20

SAMPLE 1 20

GENR AXKTY=(AXK\*T)/Y

GENR AXLTY=(AXL\*T)/Y

GENR AXMTY=(AXM\*T)/Y

GENR AXKY=AXK\*Y

GENR AXLY=AXL\*Y

GENR AXMY=AXM\*Y

GENR INVY=1/Y

GENR AXKTT=AXK\*(T\*\*2)

GENR AXLTT=AXL\*(T\*\*2)

GENR AXMTT=AXM\*(T\*\*2)

\*\*\*\*\*

\*\*\*\*\*

STAT Y/MEAN=YM

STAT PLPK/MEAN=MPLOK

STAT PMPK/MEAN=MPMOK

STAT INVY/MEAN=MINVY

STAT T/MEAN=TM

STAT AXKTY/MEAN=MAXKTY

STAT AXKY/MEAN=MAXKY

STAT AXKTT/MEAN=MAXKTT

STAT PKPL/MEAN=MPKOL

STAT PMPL/MEAN=MPMOL

STAT AXLTY/MEAN=MAXLTY

STAT AXLY/MEAN=MAXLY

STAT AXLTT/MEAN=MAXLTT

STAT PKPM/MEAN=MPKOM

STAT PLPM/MEAN=MPLOM

STAT AXMTY/MEAN=MAXMTY

STAT AXMY/MEAN=MAXMY

STAT AXMTT/MEAN=MAXMTT

GENR PKL=((PK\*PL)\*\*0.5)

GENR PKM=((PK\*PM)\*\*0.5)

GENR PLM=((PL\*PM)\*\*0.5)

GENR PKT=(PK\*T)

GENR PLT=(PL\*T)

```

GENR PMT=(PM*T)
GENR PKOY=PK/Y
GENR PLOY=PL/Y
GENR PMOY=PM/Y
STAT PKOY/MEAN=MPKOY
STAT PLOY/MEAN=MPLOY
STAT PMOY/MEAN=MPMOY
GENR SAXPY=((AXK*PK)+(AXL*PL)+(AXM*PM))*Y
GENR SAXPTT=((AXK*PK)+(AXL*PL)+(AXM*PM))*T*T
STAT PK/MEAN=MPK
STAT PL/MEAN=MPL
STAT PM/MEAN=MPM
STAT PKL/MEAN=MPKL
STAT PKM/MEAN=MPKM
STAT PLM/MEAN=MPLM
STAT PKT/MEAN=MPKT
STAT PLT/MEAN=MPLT
STAT PMT/MEAN=MPMT
STAT SAXPY/MEAN=MSAXPY
STAT SAXPTT/MEAN=MSAXPTT
GENR PKY=PK*Y
GENR PLY=PL*Y
GENR PMY=PM*Y
GENR SAXP=(AXK*PK)+(AXL*PL)+(AXM*PM)
GENR SAXPTOY=SAXP*(T/Y)
GENR SAXPTY=((AXK*PK)+(AXL*PL)+(AXM*PM))*T*Y
STAT PKY/MEAN=MPKY
STAT PLY/MEAN=MPLY
STAT PMY/MEAN=MPMY
STAT SAXP/MEAN=MSAXP
STAT SAXPTOY/MEAN=MSAXPTOY
STAT SAXPTY/MEAN=MSAXPTY
GENR CONST=1
SAMPLE 1 20
*****
* LINEAR GL ESTIMATION
*****

SYSTEM 3/ DN NOCONSTANT RESTRICT
OLS XKY CONST PLPK PMPK INVY T AXKTY AXKY AXKTT
OLS XLY CONST PKPL PMPL INVY T AXLTY AXLY AXLTT
OLS XMY CONST PKPM PLPM INVY T AXMTY AXMY AXMTT
RESTRICT PLPK:1=PKPL:2
RESTRICT PMPK:1=PKPM:3
RESTRICT PMPL:2=PLPM:3
RESTRICT AXKTY:1=AXLTY:2
RESTRICT AXKTY:1=AXMTY:3
RESTRICT AXKY:1=AXLY:2
RESTRICT AXKY:1=AXMY:3
RESTRICT AXKTT:1=AXLTT:2
RESTRICT AXKTT:1=AXMTT:3
END

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

TEST
TEST INVY:1=0
TEST INVY:2=0
TEST INVY:3=0
TEST AXKTY=0
TEST AXKY=0
END

```

```

TEST ((CONST:1*MPK)+(CONST:2*MPL)+(CONST:3*MPM)+(2*PLPK:1*MPKL)+ &
(2*PMPK:1*MPKM)+(2*PMPL:2*MPLM)+(T:1*MPKT)+(T:2*MPLT)+(T:3*MPMT)+ &
(2*AXKY:1*MSAXPY)+(AXKTT:1*MSAXPTT))/ &
(((CONST:1+(PLPK:1*MPLOK)+(PMPK:1*MPMOK)+(INVY:1*MINVY)+(T:1*TM)+ &
(AXKTY:1*MAXKTY)+(AXKY:1*MAXKY)+(AXKTT:1*MAXKTT))*MPK)+ &
((CONST:2+(PLPK:1*MPKOL)+(PMPL:2*MPMOL)+(INVY:2*MINVY)+(T:2*TM)+ &
(AXLTY:2*MAXLTY)+(AXLY:2*MAXLY)+(AXLTT:2*MAXLTT))*MPL)+ &
((CONST:3+(PKPM:3*MPKOM)+(PLPM:3*MPLOM)+(INVY:3*MINVY)+(T:3*TM)+ &
(AXMTY:3*MAXMTY)+(AXMY:3*MAXMY)+(AXMTT:3*MAXMTT))*MPM))=1

```

```

*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****

```

```

TEST
TEST T:1=0
TEST T:2=0
TEST T:3=0
TEST AXKTY=0
TEST AXKTT=0
END

```

```

TEST (((T:1*MPKY)+(T:2*MPLY)+(T:3*MPMY)+(AXKTY:1*MSAXP)+ &
(2*AXKTT:1*MSAXPTY)))/ &
(((CONST:1+(PLPK:1*MPLOK)+(PMPK:1*MPMOK)+(INVY:1*MINVY)+(T:1*TM)+ &
(AXKTY:1*MAXKTY)+(AXKY:1*MAXKY)+(AXKTT:1*MAXKTT))*MPK)+ &
((CONST:2+(PLPK:1*MPKOL)+(PMPL:2*MPMOL)+(INVY:2*MINVY)+(T:2*TM)+ &
(AXLTY:2*MAXLTY)+(AXLY:2*MAXLY)+(AXLTT:2*MAXLTT))*MPL)+ &
((CONST:3+(PKPM:3*MPKOM)+(PLPM:3*MPLOM)+(INVY:3*MINVY)+(T:3*TM)+ &
(AXMTY:3*MAXMTY)+(AXMY:3*MAXMY)+(AXMTT:3*MAXMTT))*MPM))*YM)=0

```

```

STOP

```

**APPENDIX C****SHAZAM PROGRAM FOR INTEGRATED MODEL (LOG-LOG)**

\*\*\*\*\*  
 \* VARIABLES IN INPUT DEMAND EQUATIONS  
 \*\*\*\*\*

GENR XKY=XK/Y  
 GENR XLY=XL/Y  
 GENR XMY=XM/Y  
 STAT XK/MEAN=AXK  
 GENR VAXK=DUM\*AXK  
 STAT XL/MEAN=AXL  
 GENR VAXL=DUM\*AXL  
 STAT XM/MEAN=AXM  
 GENR VAXM=DUM\*AXM

\*\*\*\*\*  
 \* VARIABLES IN SUM(Y - YBAR)  
 \*\*\*\*\*

STAT XKY/MEAN=MXKY  
 STAT XLY/MEAN=MXLY  
 STAT XMY/MEAN=MXMY  
 STAT P/MEAN=MP  
 STAT Y/MEAN=MY  
 GENR DXKY=(XKY-MXKY)  
 GENR DXLY=(XLY-MXLY)  
 GENR DXMY=(XMY-MXMY)  
 GENR DP=(P-MP)  
 GENR DY=(Y-MY)  
 COPY DXKY DXLY DXMY DP DY V  
 MATRIX SSV=V'V  
 MATRIX DSSV=DET(SSV)

\*\*\*\*\*  
 \* HYPOTHESIS TESTING VARIABLES  
 \*\*\*\*\*

\* EQUATION XK/Y  
 \*\*\*\*\*  
 GENR PLOK=((PL/PK)\*\*0.5)  
 GENR PMOK=((PM/PK)\*\*0.5)  
 GENR INY=(1/Y)  
 GENR AXKTY=((AXK\*T)/Y)  
 GENR AXKY=(AXK\*Y)  
 GENR AXKTT=(AXK\*T\*T)  
 STAT PLOK/MEAN=MPLOK  
 STAT PMOK/MEAN=MPMOK  
 STAT INY/MEAN=MINY  
 STAT T/MEAN=TM  
 STAT AXKTY/MEAN=MAXKTY  
 STAT AXKY/MEAN=MAXKY  
 STAT AXKTT/MEAN=MAXKTT

\*\*\*\*\*  
 \*EQUATION XL/Y  
 \*\*\*\*\*

GENR PKOL=((PK/PL)\*\*0.5)  
 GENR PMOL=((PM/PL)\*\*0.5)

```

GENR AXLTY=((AXL*T)/Y)
GENR AXLY=(AXL*Y)
GENR AXLTT=(AXL*T*T)
STAT PKOL/MEAN=MPKOL
STAT PMOL/MEAN=MPMOL
STAT AXLTY/MEAN=MAXLTY
STAT AXLY/MEAN=MAXLY
STAT AXLTT/MEAN=MAXLTT
*****
* EQUATION XM/Y
*****
GENR PKOM=((PK/PM)**0.5)
GENR PLOM=((PL/PM)**0.5)
GENR AXMTY=((AXM*T)/Y)
GENR AXMY=(AXM*Y)
GENR AXMTT=(AXM*T*T)
STAT PKOM/MEAN=MPKOM
STAT PLOM/MEAN=MPLOM
STAT AXMTY/MEAN=MAXMTY
STAT AXMY/MEAN=MAXMY
STAT AXMTT/MEAN=MAXMTT
*****
* EQUATION MC=P
*****
GENR PKL=((PK*PL)**0.5)
GENR PKM=((PK*PM)**0.5)
GENR PLM=((PL*PM)**0.5)
GENR PKT=(PK*T)
GENR PLT=(PL*T)
GENR PMT=(PM*T)
GENR SAXPY=((AXK*PK)+(AXL*PL)+(AXM*PM))*Y
GENR SAXPTT=((AXK*PK)+(AXL*PL)+(AXM*PM))*T*T
STAT PK/MEAN=MPK
STAT PL/MEAN=MPL
STAT PM/MEAN=MPM
STAT PKL/MEAN=MPKL
STAT PKM/MEAN=MPKM
STAT PLM/MEAN=MPLM
STAT PKT/MEAN=MPKT
STAT PLT/MEAN=MPLT
STAT PMT/MEAN=MPMT
STAT SAXPY/MEAN=MSAXPY
STAT SAXPTT/MEAN=MSAXPTT
*****
* EQUATION MT
*****
GENR PKY=PK*Y
GENR PLY=PL*Y
GENR PMY=PM*Y
GENR SAXP=((AXK*PK)+(AXL*PL)+(AXM*PM))
GENR SAXPTY=((AXK*PK)+(AXL*PL)+(AXM*PM))*T*Y
STAT PKY/MEAN=MPKY
STAT PLY/MEAN=MPLY
STAT PMY/MEAN=MPMY
STAT SAXP/MEAN=MSAXP
STAT SAXPTY/MEAN=MSAXPTY

```



```

*****
* EQUATION C
*****
GENR PKLY=PKL*Y
GENR PKMY=PKM*Y
GENR PLMY=PLM*Y
GENR PKTY=PKT*Y
GENR PLTY=PLT*Y
GENR PMTY=PMT*Y
GENR SAXPT=SAXP*T
GENR SAXPY=SAXP*Y
GENR SAXPTY=SAXPT*Y
STAT PKLY/MEAN=MPKLY
STAT PKMY/MEAN=MPKMY
STAT PLMY/MEAN=MPLMY
STAT PKTY/MEAN=MPKTY
STAT PLTY/MEAN=MPLTY
STAT PMTY/MEAN=MPMTY
STAT SAXPT/MEAN=MSAXPT
STAT SAXPY/MEAN=MSAXPY
STAT SAXPTY/MEAN=MSAXPTY
*****
* VARIABLES IN DEMAND EQUATION
*****
GENR LY=LOG(Y)
GENR LPS=LOG(P/S)
GENR LQS=LOG(GNP/S)
GENR PS=P/S
GENR QS=GNP/S
SAMPLE 1 20
*****
* LOG-LOG DEMAND FUNCTION
* FULL MODEL- HYPOTHESIS TESTING
*****

NL 5 PK PL PM T LPS LQS/DN NC=22 ITER=300 CONV=0.001
EQ XKY=AKK+(AKL*((PL/PK)**0.5))+(AKM*((PM/PK)**0.5))+(AK*(1/Y))+ &
(AKT*T)+(AT*((VAXK*T)/Y))+(AYY*(VAXK*Y))+(ATT*(VAXK*T*T))
EQ XLY=ALL+(AKL*((PK/PL)**0.5))+(ALM*((PM/PL)**0.5))+(AL*(1/Y))+ &
(ALT*T)+(AT*((VAXL*T)/Y))+(AYY*(VAXL*Y))+(ATT*(VAXL*T*T))
EQ XMY=AMM+(AKM*((PK/PM)**0.5))+(ALM*((PL/PM)**0.5))+(AM*(1/Y))+ &
(AMT*T)+(AT*((VAXM*T)/Y))+(AYY*(VAXM*Y))+(ATT*(VAXM*T*T))
EQ P=((AKK*PK)+(ALL*PL)+(AMM*PM)+(2*AKL*((PK*PL)**0.5))+ &
(2*AKM*((PK*PM)**0.5))+(2*ALM*((PL*PM)**0.5))+ &
(AKT*(PK*T))+(ALT*(PL*T))+(AMT*(PM*T))+ &
(2*AYY*((VAXK*PK)+(VAXL*PL)+(VAXM*PM))*Y)+ &
(ATT*((VAXK*PK)+(VAXL*PL)+(VAXM*PM))*T*T))/ &
(1-(C0+(CK*PK)+(CL*PL)+(CM*PM))/ADA))
EQ LY=A+(ADA*LPS)+(RHO*LQS)
COEF AKK 0.50166 AKL -1.3684 AKM -0.067426 AK 0.77739 &
AKT 0.099375 AT 0.027813 AYY -0.19237 ATT 0.0002205 &
ALL 0.40710 ALM 1.939 AL 0.14592 ALT -0.016598 &
AMM -0.18262 AM -0.40167 AMT -0.019433 A -6.1579 ADA -0.69277 &
RHO 0.6046 C0 0.05 CK 0.05 CL 0.05 CM 0.05
END

```

\*\*\*\*\*

\* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

TEST

TEST AK1=0

TEST AL1=0

TEST AM1=0

TEST AT1=0

TEST AYY1=0

END

TEST

((AKK1\*MPK)+(ALL1\*MPL)+(AMM1\*MPM)+(2\*AKL1\*MPKL)+(2\*AKM1\*MPKM)+(2\*ALM1\*MPL  
M)+ &

(AKT1\*MPKT)+(ALT1\*MPLT)+(AMT1\*MPMT)+(2\*AYY1\*MSAXPY)+(ATT1\*MSAXPTT))/ &

((AKK1+(AKL1\*MPLOK)+(AKM1\*MPMOK)+(AK1\*MINY)+(AKT1\*TM)+(AT1\*MAXKTY)+ &

(AYY1\*MAXKY)+(ATT1\*MAXKTT))\*MPK)+((ALL1+(AKL1\*MPKOL)+(ALM1\*MPMOL)+ &

(AL1\*MINY)+(ALT1\*TM)+(AT1\*MAXLTY)+(AYY1\*MAXLY)+(ATT1\*MAXLTT))\*MPL)+ &

((AMM1+(AKM1\*MPKOM)+(ALM1\*MPLOM)+(AM1\*MINY)+(AMT1\*TM)+(AT1\*MAXMTY)+ &

(AYY1\*MAXMY)+(ATT1\*MAXMTT))\*MPM))=1

\*\*\*\*\*

\* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

TEST

TEST AKT1=0

TEST ALT1=0

TEST AMT1=0

TEST AT1=0

TEST ATT1=0

END

TEST ((AKT1\*MPKY)+(ALT1\*MPLY)+(AMT1\*MPMY)+(AT1\*MSAXP)+(2\*ATT1\*MSAXPTY))\* &

(1/((AKK1\*MPKY)+(ALL1\*MPLY)+(AMM1\*MPMY)+(2\*AKL1\*MPKLY)+(2\*AKM1\*MPKMY)+ &

(2\*ALM1\*MPLMY)+(AK1\*MPK)+(AL1\*MPL)+(AM1\*MPM)+(AKT1\*MPKTY)+(ALT1\*MPLTY)+ &

(AMT1\*MPMTY)+(AT1\*MSAXPT)+(AYY1\*MSAXPY)+(ATT1\*MSAXPTY)))=0

\*\*\*\*\*

\*TESTING THE PRESENCE OF CONJECTURAL COMPETITION- THETA

\*\*\*\*\*

TEST

TEST C01=0

TEST CK1=0

TEST CL1=0

TEST CM1=0

END

TEST (C01+(CK1\*MPK)+(CL1\*MPL)+(CM1\*MPM))=0

STOP

**APPENDIX D****SHAZAM PROGRAM FOR INTEGRATED MODEL (SEMI-LOG)**

\*\*\*\*\*

\* SEMI-LOG DEMAND FUNCTION

\* FULL MODEL- HYPOTHESIS TESTING

\*\*\*\*\*

NL 5 PK PL PM T LPS LQS/DN NC=22 ITER=300 CONV=0.001

EQ XKY=AKK1+(AKL1\*((PL/PK)\*\*0.5))+(AKM1\*((PM/PK)\*\*0.5))+(AK1\*(1/Y))+ &

(AKT1\*T)+(AT1\*((VAXK\*T)/Y))+(AYY1\*(VAXK\*Y))+(ATT1\*(VAXK\*T\*T))

EQ XLY=ALL1+(AKL1\*((PK/PL)\*\*0.5))+(ALM1\*((PM/PL)\*\*0.5))+(AL1\*(1/Y))+ &

(ALT1\*T)+(AT1\*((VAXL\*T)/Y))+(AYY1\*(VAXL\*Y))+(ATT1\*(VAXL\*T\*T))

EQ XMY=AMM1+(AKM1\*((PK/PM)\*\*0.5))+(ALM1\*((PL/PM)\*\*0.5))+(AM1\*(1/Y))+ &

(AMT1\*T)+(AT1\*((VAXM\*T)/Y))+(AYY1\*(VAXM\*Y))+(ATT1\*(VAXM\*T\*T))

EQ P=((AKK1\*PK)+(ALL1\*PL)+(AMM1\*PM)+(2\*AKL1\*((PK\*PL)\*\*0.5))+ &

(2\*AKM1\*((PK\*PM)\*\*0.5))+(2\*ALM1\*((PL\*PM)\*\*0.5))+ &

(AKT1\*(PK\*T))+(ALT1\*(PL\*T))+(AMT1\*(PM\*T))+ &

(2\*AYY1\*((VAXK\*PK)+(VAXL\*PL)+(VAXM\*PM))\*Y)+ &

(ATT1\*((VAXK\*PK)+(VAXL\*PL)+(VAXM\*PM))\*T\*T))/ &

(1-(((C01+(CK1\*PK)+(CL1\*PL)+(CM1\*PM))/GAM1)\*Y))

EQ Y=A1+(GAM1\*LPS)+(RHO1\*LQS)

COEF AKK1 0.52378 AKL1 -1.3716 AKM1 -0.075749 AK1 0.7713 AKT1 0.09985 AT1 0.027983 &

AYY1 -0.19953 ATT1 0.000203 ALL1 0.45265 ALM1 1.9392 AL1 0.1063 ALT1 -0.01638 &

AMM1 -0.14147 AM1 -0.42894 AMT1 -0.019165 A1 -7.0013 GAM1 -0.87479 RHO1 0.78499 &

C01 0.05 CK1 0.05 CL1 0.05 CM1 0.05

END

\*\*\*\*\*

\* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

TEST

TEST AK1=0

TEST AL1=0

TEST AM1=0

TEST AT1=0

TEST AYY1=0

END

TEST

((AKK1\*MPK)+(ALL1\*MPL)+(AMM1\*MPM)+(2\*AKL1\*MPKL)+(2\*AKM1\*MPKM)+(2\*ALM1\*MP

LM))+ &

(AKT1\*MPKT)+(ALT1\*MPLT)+(AMT1\*MPMT)+(2\*AYY1\*MSAXPY)+(ATT1\*MSAXPTT))/ &

((AKK1+(AKL1\*MPLOK)+(AKM1\*MPMOK)+(AK1\*MINY)+(AKT1\*TM)+(AT1\*MAXKTY)+ &

(AYY1\*MAXKY)+(ATT1\*MAXKTT))\*MPK)+((ALL1+(AKL1\*MPKOL)+(ALM1\*MPMOL)+ &

(AL1\*MINY)+(ALT1\*TM)+(AT1\*MAXLTY)+(AYY1\*MAXLY)+(ATT1\*MAXLTT))\*MPL)+ &

((AMM1+(AKM1\*MPKOM)+(ALM1\*MPLOM)+(AM1\*MINY)+(AMT1\*TM)+(AT1\*MAXMTY)+ &

(AYY1\*MAXMY)+(ATT1\*MAXMTT))\*MPM)=1

\*\*\*\*\*

\* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

TEST

TEST AKT1=0

TEST ALT1=0  
TEST AMT1=0  
TEST AT1=0  
TEST ATT1=0  
END

TEST (((AKT1\*MPKY)+(ALT1\*MPLY)+(AMT1\*MPMY)+(AT1\*MSAXP)+(2\*ATT1\*MSAXPTY))\* &  
(1/((AKK1\*MPKY)+(ALL1\*MPLY)+(AMM1\*MPMY)+(2\*AKL1\*MPKLY)+(2\*AKM1\*MPKMY)+ &  
(2\*ALM1\*MPLMY)+(AK1\*MPK)+(AL1\*MPL)+(AM1\*MPM)+(AKT1\*MPKTY)+(ALT1\*MPLTY)+ &  
(AMT1\*MPMTY)+(AT1\*MSAXPT)+(AYY1\*MSAXPY)+(ATT1\*MSAXPTY))))=0

\*\*\*\*\*  
\*TESTING THE PRESENCE OF CONJECTURAL COMPETITION- THETA  
\*\*\*\*\*

TEST  
TEST C01=0  
TEST CK1=0  
TEST CL1=0  
TEST CM1=0  
END

TEST (C01+(CK1\*MPK)+(CL1\*MPL)+(CM1\*MPM))=0

STOP

**APPENDIX E****SHAZAM PROGRAM FOR INTEGRATED MODEL (LINEAR)**

\*\*\*\*\*

\* LINEAR DEMAND FUNCTION

\* FULL MODEL- HYPOTHESIS TESTING

\*\*\*\*\*

NL 5 PK PL PM T PS QS/DN NC=22 ITER=300 CONV=0.001

EQ XKY=AKK2+(AKL2\*((PL/PK)\*\*0.5))+(AKM2\*((PM/PK)\*\*0.5))+(AK2\*(1/Y))+ &

(AKT2\*T)+(AT2\*((VAXK\*T)/Y))+(Ayy2\*(VAXK\*Y))+(ATT2\*(VAXK\*T\*T))

EQ XLY=ALL2+(AKL2\*((PK/PL)\*\*0.5))+(ALM2\*((PM/PL)\*\*0.5))+(AL2\*(1/Y))+ &

(ALT2\*T)+(AT2\*((VAXL\*T)/Y))+(Ayy2\*(VAXL\*Y))+(ATT2\*(VAXL\*T\*T))

EQ XMY=AMM2+(AKM2\*((PK/PM)\*\*0.5))+(ALM2\*((PL/PM)\*\*0.5))+(AM2\*(1/Y))+ &

(AMT2\*T)+(AT2\*((VAXM\*T)/Y))+(Ayy2\*(VAXM\*Y))+(ATT2\*(VAXM\*T\*T))

EQ P=((AKK2\*PK)+(ALL2\*PL)+(AMM2\*PM)+(2\*AKL2\*((PK\*PL)\*\*0.5))+ &

(2\*AKM2\*((PK\*PM)\*\*0.5))+(2\*ALM2\*((PL\*PM)\*\*0.5))+ &

(AKT2\*(PK\*T))+(ALT2\*(PL\*T))+(AMT2\*(PM\*T))+ &

(2\*Ayy2\*((VAXK\*PK)+(VAXL\*PL)+(VAXM\*PM))\*Y)+ &

(ATT2\*((VAXK\*PK)+(VAXL\*PL)+(VAXM\*PM))\*T\*T))/ &

(1-(((C02+(CK2\*PK)+(CL2\*PL)+(CM2\*PM))/GAM2)\*(PS/Y)))

EQ Y=A2+(GAM2\*PS)+(RHO2\*QS)

COEF AKK2 0.50739 AKL2 -1.3743 AKM2 -0.076896 AK2 0.78014 AKT2 0.10039 AT2 0.028121 &

Ayy2 -0.1926 ATT2 0.00018 ALL2 0.41675 ALM2 1.9557 AL2 0.11232 ALT2 -0.015728 &

AMM2 -0.17006 AM2 -0.41927 AMT2 -0.019417 A2 1.5942 GAM2 -0.86781 RHO2 0.000015 &

C02 1 CK2 1 CL2 1 CM2 1

END

\*\*\*\*\*

\* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

TEST

TEST AK1=0

TEST AL1=0

TEST AM1=0

TEST AT1=0

TEST Ayy1=0

END

TEST

((AKK1\*MPK)+(ALL1\*MPL)+(AMM1\*MPM)+(2\*AKL1\*MPKL)+(2\*AKM1\*MPKM)+(2\*ALM1\*MP

LM))+ &

(AKT1\*MPKT)+(ALT1\*MPLT)+(AMT1\*MPMT)+(2\*Ayy1\*MSAXPY)+(ATT1\*MSAXPTT))/ &

((AKK1+(AKL1\*MPLOK)+(AKM1\*MPMOK)+(AK1\*MINY)+(AKT1\*TM)+(AT1\*MAXKTY)+ &

(Ayy1\*MAXKY)+(ATT1\*MAXKTT))\*MPK)+((ALL1+(AKL1\*MPKOL)+(ALM1\*MPMOL)+ &

(AL1\*MINY)+(ALT1\*TM)+(AT1\*MAXLTY)+(Ayy1\*MAXLY)+(ATT1\*MAXLTT))\*MPL)+ &

((AMM1+(AKM1\*MPKOM)+(ALM1\*MPLOM)+(AM1\*MINY)+(AMT1\*TM)+(AT1\*MAXMTY)+ &

(Ayy1\*MAXMY)+(ATT1\*MAXMTT))\*MPM)=1

\*\*\*\*\*

\* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

TEST

TEST AKT1=0  
TEST ALT1=0  
TEST AMT1=0  
TEST AT1=0  
TEST ATT1=0  
END

TEST ((AKT1\*MPKY)+(ALT1\*MPLY)+(AMT1\*MPMY)+(AT1\*MSAXP)+(2\*ATT1\*MSAXPTY))\* &  
(1/((AKK1\*MPKY)+(ALL1\*MPLY)+(AMM1\*MPMY)+(2\*AKL1\*MPKLY)+(2\*AKM1\*MPKMY)+ &  
(2\*ALM1\*MPLMY)+(AK1\*MPK)+(AL1\*MPL)+(AM1\*MPM)+(AKT1\*MPKTY)+(ALT1\*MPLTY)+ &  
(AMT1\*MPMTY)+(AT1\*MSAXPT)+(AYY1\*MSAXPY)+(ATT1\*MSAXPTY)))=0

\*\*\*\*\*  
\*TESTING THE PRESENCE OF CONJECTURAL COMPETITION- THETA  
\*\*\*\*\*

TEST  
TEST C01=0  
TEST CK1=0  
TEST CL1=0  
TEST CM1=0  
END

TEST (C01+(CK1\*MPK)+(CL1\*MPL)+(CM1\*MPM))=0

STOP

## APPENDIX F

### EDITED SHAZAM COMPUTER OUTPUT FOR TRANSLOG COST FUNCTION MODEL

This appendix gives the edited Shazam output for estimates and test statistics presented in Table 6.1. We add one to the test value of ECY to obtain the ECY estimate. All other estimates are given directly by the test values.

#### INDUSTRY 311

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 49 718 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 20 337560 WITH 5 D F P-VALUE= 00108
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 24585
TEST VALUE = -99241 STD ERROR OF TEST VALUE 49748
ASYMPTOTIC NORMAL STATISTIC = -1 9948967 P-VALUE= 97697
WALD CHI-SQUARE STATISTIC = 3 9796130 WITH 1 D F P-VALUE= 04605
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 25128
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 72.311390 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 06915
TEST VALUE = 26538E-01 STD ERROR OF TEST VALUE 10698E-01
ASYMPTOTIC NORMAL STATISTIC = 2.4806966 P-VALUE= 00656
WALD CHI-SQUARE STATISTIC = 6 1538560 WITH 1 D F P-VALUE= 01311
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 16250
[*STOP

```

#### INDUSTRY 313

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 30 382 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 56 092140 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .08914
TEST VALUE = 57796 STD ERROR OF TEST VALUE 31585
ASYMPTOTIC NORMAL STATISTIC = 1 8298705 P-VALUE= 03363
WALD CHI-SQUARE STATISTIC = 3 3484260 WITH 1 D F P-VALUE= 06727
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 29865
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 24 980020 WITH 5 D F P-VALUE= 00014
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 20016
TEST VALUE = -50931E-01 STD ERROR OF TEST VALUE 13295E-01
ASYMPTOTIC NORMAL STATISTIC = -3 8309102 P-VALUE= 99994
WALD CHI-SQUARE STATISTIC = 14 675870 WITH 1 D F P-VALUE= 00013
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 06814
[*STOP

```

#### INDUSTRY 314

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 41 581 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE

```

```

*****
WALD CHI-SQUARE STATISTIC = 184 02150 WITH 5 D F P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 02717
TEST VALUE = -41818 STD ERROR OF TEST VALUE 16370
ASYMPTOTIC NORMAL STATISTIC = -2 5545530 P-VALUE= 99468
WALD CHI-SQUARE STATISTIC = 6 5257410 WITH 1 D F P-VALUE= .01063
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 15324
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 407 19610 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 01228
TEST VALUE = -10829 STD ERROR OF TEST VALUE .13233E-01
ASYMPTOTIC NORMAL STATISTIC = -8 1833912 P-VALUE= 1 00000
WALD CHI-SQUARE STATISTIC = 66.967900 WITH 1 D.F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 01493
[_STOP

```

### INDUSTRY 321

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 36 830 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 4.4534420 WITH 5 D F P-VALUE= 48614
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
TEST VALUE = -.50139E-01 STD. ERROR OF TEST VALUE 12830
ASYMPTOTIC NORMAL STATISTIC = -39080291 P-VALUE= 65203
WALD CHI-SQUARE STATISTIC = 15272690 WITH 1 D F P-VALUE= 69594
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 50.122210 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 09976
TEST VALUE = 36564E-01 STD. ERROR OF TEST VALUE 96807E-02
ASYMPTOTIC NORMAL STATISTIC = 3.7769393 P-VALUE= 00008
WALD CHI-SQUARE STATISTIC = 14 265270 WITH 1 D.F P-VALUE= 00016
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07010
[_STOP

```

### INDUSTRY 322

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 30 664 WITH 3 D.F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 22 510870 WITH 5 D F P-VALUE= 00042
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 22211
TEST VALUE = -34338 STD ERROR OF TEST VALUE 22410
ASYMPTOTIC NORMAL STATISTIC = -1 5322519 P-VALUE= 93727
WALD CHI-SQUARE STATISTIC = 2 3477960 WITH 1 D F P-VALUE= 12546
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 42593
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 34.473870 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 14504
TEST VALUE = 13336E-01 STD. ERROR OF TEST VALUE .67620E-02
ASYMPTOTIC NORMAL STATISTIC = 1 9721360 P-VALUE= 02430
WALD CHI-SQUARE STATISTIC = 3 8893200 WITH 1 D F P-VALUE= 04859
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 25711
[_STOP

```



## INDUSTRY 323

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 55 612 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 5.3968360 WITH 5 D F P-VALUE= 36939
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 92647
TEST VALUE = -93346E-01 STD ERROR OF TEST VALUE 32123
ASYMPTOTIC NORMAL STATISTIC = -29059351 P-VALUE= 61432
WALD CHI-SQUARE STATISTIC = 84444580E-01 WITH 1 D F P-VALUE= 77136
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 5 5628660 WITH 5 D F P-VALUE= 35110
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 89882
TEST VALUE = 44620E-01 STD ERROR OF TEST VALUE 23196E-01
ASYMPTOTIC NORMAL STATISTIC = 1.9236149 P-VALUE= 02720
WALD CHI-SQUARE STATISTIC = 3 7002940 WITH 1 D F P-VALUE= 05440
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 27025
[_STOP

```

## INDUSTRY 324

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 27 925 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 45 034530 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 11103
TEST VALUE = -38725 STD ERROR OF TEST VALUE 13903
ASYMPTOTIC NORMAL STATISTIC = -2 7852933 P-VALUE= 99733
WALD CHI-SQUARE STATISTIC = 7 7578590 WITH 1 D F P-VALUE= 00535
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 12890
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 122 10560 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 04095
TEST VALUE = -15696E-01 STD ERROR OF TEST VALUE 85925E-02
ASYMPTOTIC NORMAL STATISTIC = -1 8267251 P-VALUE= 96613
WALD CHI-SQUARE STATISTIC = 3 3369250 WITH 1 D F P-VALUE= 06774
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 29968
[_STOP

```

## INDUSTRY 331

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 51 657 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 17 383100 WITH 5 D F P-VALUE= 00383
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 28764
TEST VALUE = 27737 STD ERROR OF TEST VALUE 18174
ASYMPTOTIC NORMAL STATISTIC = 1 5261436 P-VALUE= 06349
WALD CHI-SQUARE STATISTIC = 2 3291140 WITH 1 D F P-VALUE= 12697
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 42935
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 34.637220 WITH 5 D F P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 14435
TEST VALUE = 78165E-01 STD ERROR OF TEST VALUE .21263E-01
ASYMPTOTIC NORMAL STATISTIC = 3.6761611 P-VALUE= 00012
WALD CHI-SQUARE STATISTIC = 13 514160 WITH 1 D F P-VALUE= 00024

```

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07400  
 \_STOP

### INDUSTRY 332

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 5 5203 WITH 3 D F

```

*****
_*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 63.725320 WITH 5 D F P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07846
TEST VALUE = -46018 STD ERROR OF TEST VALUE 20055
ASYMPTOTIC NORMAL STATISTIC = -2.2946006 P-VALUE= 98912
WALD CHI-SQUARE STATISTIC = 5.2651920 WITH 1 D F P-VALUE= 02176
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 18993
*****
_*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 28.898860 WITH 5 D F P-VALUE= 00002
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .17302
TEST VALUE = 30903E-01 STD ERROR OF TEST VALUE 10050E-01
ASYMPTOTIC NORMAL STATISTIC = 3.0749048 P-VALUE= 00105
WALD CHI-SQUARE STATISTIC = 9.4550390 WITH 1 D F P-VALUE= 00211
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 10576
_STOP

```

### INDUSTRY 341

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 20 057 WITH 3 D F

```

*****
_*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 127.47560 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 03922
TEST VALUE = -17385 STD ERROR OF TEST VALUE .10512
ASYMPTOTIC NORMAL STATISTIC = -1.6538021 P-VALUE= 95092
WALD CHI-SQUARE STATISTIC = 2.7350610 WITH 1 D F P-VALUE= 09817
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 36562
*****
_*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 730.06770 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 00685
TEST VALUE = 60273E-01 STD ERROR OF TEST VALUE .25857E-02
ASYMPTOTIC NORMAL STATISTIC = 23.310148 P-VALUE= 00000
WALD CHI-SQUARE STATISTIC = 543.36300 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 00184
_STOP

```

### INDUSTRY 342

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 45 113 WITH 3 D F

```

*****
_*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 58.317830 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .08574
TEST VALUE = 1.4099 STD ERROR OF TEST VALUE 25638
ASYMPTOTIC NORMAL STATISTIC = 5.4992097 P-VALUE= .00000
WALD CHI-SQUARE STATISTIC = 30.241310 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .03307
*****
_*TESTING FOR TECHNICAL PROGRESS
*****

```

```

WALD CHI-SQUARE STATISTIC = 64 399380 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07764
TEST VALUE = - 13818 STD ERROR OF TEST VALUE 20706E-01
ASYMPTOTIC NORMAL STATISTIC = -6.6733943 P-VALUE= 1 00000
WALD CHI-SQUARE STATISTIC = 44 534190 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 02245
_STOP

```

#### INDUSTRY 351

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 41 203 WITH 3 D F

```

_*TESTING FOR RETURNS TO SCALE
WALD CHI-SQUARE STATISTIC = 32 570530 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 15351
TEST VALUE = 58284 STD ERROR OF TEST VALUE 17587
ASYMPTOTIC NORMAL STATISTIC = 3 3139178 P-VALUE= 00046
WALD CHI-SQUARE STATISTIC = 10 982050 WITH 1 D F P-VALUE= 00092
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 09106
_*TESTING FOR TECHNICAL PROGRESS
WALD CHI-SQUARE STATISTIC = 39.816280 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 12558
TEST VALUE = - 47840E-01 STD ERROR OF TEST VALUE 23795E-01
ASYMPTOTIC NORMAL STATISTIC = -2 0105312 P-VALUE= 97781
WALD CHI-SQUARE STATISTIC = 4 0422350 WITH 1 D.F. P-VALUE= 04438
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 24739
_STOP

```

#### INDUSTRY 352

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 23 275 WITH 3 D F

```

_*TESTING FOR RETURNS TO SCALE
WALD CHI-SQUARE STATISTIC = 17 051890 WITH 5 D F P-VALUE= 00440
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 29322
TEST VALUE = - 58047 STD ERROR OF TEST VALUE 20944
ASYMPTOTIC NORMAL STATISTIC = -2 7715387 P-VALUE= 99721
WALD CHI-SQUARE STATISTIC = 7 6814270 WITH 1 D F P-VALUE= 00558
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 13018
_*TESTING FOR TECHNICAL PROGRESS
WALD CHI-SQUARE STATISTIC = 9 6122670 WITH 5 D F P-VALUE= 08700
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 52017
TEST VALUE = .32309E-01 STD ERROR OF TEST VALUE 17660E-01
ASYMPTOTIC NORMAL STATISTIC = 1 8294994 P-VALUE= 03366
WALD CHI-SQUARE STATISTIC = 3 3470680 WITH 1 D F P-VALUE= 06732
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 29877
_STOP

```

#### INDUSTRY 353

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 66 945 WITH 3 D F

```

_*TESTING FOR RETURNS TO SCALE
WALD CHI-SQUARE STATISTIC = 14.555580 WITH 5 D F P-VALUE= 01244
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .34351
TEST VALUE = 68133 STD ERROR OF TEST VALUE .23635
ASYMPTOTIC NORMAL STATISTIC = 2 8827718 P-VALUE= 00197

```

```

WALD CHI-SQUARE STATISTIC = 8 3103730 WITH 1 D F P-VALUE= 00394
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .12033
| *****
| *TESTING FOR TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 41 944090 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 11921
TEST VALUE = -.48440E-01 STD ERROR OF TEST VALUE 10108E-01
ASYMPTOTIC NORMAL STATISTIC = -4 7924100 P-VALUE= 1 00000
WALD CHI-SQUARE STATISTIC = 22 967190 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .04354
| STOP

```

#### INDUSTRY 356

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 19 664 WITH 3 D F

```

| *****
| *TESTING FOR RETURNS TO SCALE
| *****
WALD CHI-SQUARE STATISTIC = 14.174090 WITH 5 D F P-VALUE= 01454
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 35276
TEST VALUE = -.59911 STD ERROR OF TEST VALUE 23310
ASYMPTOTIC NORMAL STATISTIC = -2 5701791 P-VALUE= 99492
WALD CHI-SQUARE STATISTIC = 6 6058210 WITH 1 D F P-VALUE= 01016
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 15138
| *****
| *TESTING FOR TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 34 083340 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 14670
TEST VALUE = .27379E-01 STD. ERROR OF TEST VALUE 56263E-02
ASYMPTOTIC NORMAL STATISTIC = 4 8662593 P-VALUE= 00000
WALD CHI-SQUARE STATISTIC = 23.680480 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 04223
| STOP

```

#### INDUSTRY 357

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 23 548 WITH 3 D F

```

| *****
| *TESTING FOR RETURNS TO SCALE
| *****
WALD CHI-SQUARE STATISTIC = 29 809240 WITH 5 D F P-VALUE= 00002
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 16773
TEST VALUE = 11966 STD ERROR OF TEST VALUE 22709
ASYMPTOTIC NORMAL STATISTIC = 52690896 P-VALUE= 29913
WALD CHI-SQUARE STATISTIC = .27763300 WITH 1 D F P-VALUE= 59826
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
| *****
| *TESTING FOR TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 368.60490 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 01356
TEST VALUE = 64551E-01 STD ERROR OF TEST VALUE 54105E-02
ASYMPTOTIC NORMAL STATISTIC = 11 930657 P-VALUE= 00000
WALD CHI-SQUARE STATISTIC = 142.34060 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 00703
| STOP

```

#### INDUSTRY 361

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 31 557 WITH 3 D F

```

| *****
| *TESTING FOR RETURNS TO SCALE

```

```

| *****
WALD CHI-SQUARE STATISTIC = 9 9262920 WITH 5 D F P-VALUE= 07735
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 50371
TEST VALUE = .13417 STD ERROR OF TEST VALUE .24172
ASYMPTOTIC NORMAL STATISTIC = 55507731 P-VALUE= 28942
WALD CHI-SQUARE STATISTIC = 30811080 WITH 1 D F P-VALUE= 57884
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
| *****
| *TESTING FOR TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 30.867290 WITH 5 D F P-VALUE= 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 16198
TEST VALUE = 10128 STD ERROR OF TEST VALUE 26847E-01
ASYMPTOTIC NORMAL STATISTIC = 3 7723985 P-VALUE= 00008
WALD CHI-SQUARE STATISTIC = 14 230990 WITH 1 D F P-VALUE= 00016
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07027
| STOP

```

### INDUSTRY 371

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 27.038 WITH 3 D F

```

| *****
| *TESTING FOR RETURNS TO SCALE
| *****
WALD CHI-SQUARE STATISTIC = 47 398200 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 10549
TEST VALUE = 57786E-01 STD ERROR OF TEST VALUE 45893
ASYMPTOTIC NORMAL STATISTIC = 12591406 P-VALUE= 44990
WALD CHI-SQUARE STATISTIC = 15854350E-01 WITH 1 D F P-VALUE= 89980
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
| *****
| *TESTING FOR TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 16 730490 WITH 5 D F P-VALUE= 00504
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 29886
TEST VALUE = -.12081E-01 STD. ERROR OF TEST VALUE .20028E-01
ASYMPTOTIC NORMAL STATISTIC = - 60320919 P-VALUE= 72682
WALD CHI-SQUARE STATISTIC = 36386130 WITH 1 D F P-VALUE= 54637
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
| STOP

```

### INDUSTRY 372

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 41 025 WITH 3 D F

```

| *****
| *TESTING FOR RETURNS TO SCALE
| *****
WALD CHI-SQUARE STATISTIC = 9 7608460 WITH 5 D F P-VALUE= 08230
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 51225
TEST VALUE = .44012 STD ERROR OF TEST VALUE 48033
ASYMPTOTIC NORMAL STATISTIC = 91628672 P-VALUE= 17976
WALD CHI-SQUARE STATISTIC = 83958140 WITH 1 D F P-VALUE= 35952
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
| *****
| *TESTING FOR TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 99.451630 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 05028
TEST VALUE = 33034E-01 STD ERROR OF TEST VALUE 99167E-02
ASYMPTOTIC NORMAL STATISTIC = 3.3311325 P-VALUE= 00043
WALD CHI-SQUARE STATISTIC = 11 096440 WITH 1 D F P-VALUE= 00086
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 09012
| STOP

```

## INDUSTRY 381

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 8 1506 WITH 3 D F.

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 6 4588610 WITH 5 D.F P-VALUE= 26409
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .77413
TEST VALUE = -24445 STD ERROR OF TEST VALUE 30563
ASYMPTOTIC NORMAL STATISTIC = -79984138 P-VALUE= 78810
WALD CHI-SQUARE STATISTIC = 63974620 WITH 1 D F P-VALUE= 42380
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 51 177660 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .09770
TEST VALUE = 43793E-01 STD ERROR OF TEST VALUE 13769E-01
ASYMPTOTIC NORMAL STATISTIC = 3 1806145 P-VALUE= 00073
WALD CHI-SQUARE STATISTIC = 10 116310 WITH 1 D F P-VALUE= .00147
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .09885
_STOP

```

## INDUSTRY 382

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 49 688 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 35.162630 WITH 5 D.F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .14220
TEST VALUE = 18018 STD. ERROR OF TEST VALUE 86659E-01
ASYMPTOTIC NORMAL STATISTIC = 2 0791568 P-VALUE= .01880
WALD CHI-SQUARE STATISTIC = 4 3228930 WITH 1 D.F. P-VALUE= .03760
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 23133
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 41 447960 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 12063
TEST VALUE = -31287E-01 STD ERROR OF TEST VALUE 61100E-02
ASYMPTOTIC NORMAL STATISTIC = -5.1205479 P-VALUE= 1 00000
WALD CHI-SQUARE STATISTIC = 26 220010 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .03814
_STOP

```

## INDUSTRY 383

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 56 021 WITH 3 D F

```

*****
[*TESTING FOR RETURNS TO SCALE
*****
WALD CHI-SQUARE STATISTIC = 21 733040 WITH 5 D F P-VALUE= .00059
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 23006
TEST VALUE = -19298 STD ERROR OF TEST VALUE 12640
ASYMPTOTIC NORMAL STATISTIC = -1 5267003 P-VALUE= .93658
WALD CHI-SQUARE STATISTIC = 2.3308140 WITH 1 D F P-VALUE= 12684
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 42903
*****
[*TESTING FOR TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 9.4514630 WITH 5 D F P-VALUE= 09236
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 52902
TEST VALUE = .56864E-02 STD ERROR OF TEST VALUE 11837E-01
ASYMPTOTIC NORMAL STATISTIC = .48038082 P-VALUE= .31548

```

WALD CHI-SQUARE STATISTIC = 23076570 WITH 1 D F P-VALUE= 63096  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000  
 \_STOP

#### INDUSTRY 384

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 23 823 WITH 3 D F

```
[ *****
[*TESTING FOR RETURNS TO SCALE
[ *****
WALD CHI-SQUARE STATISTIC = 10 251870 WITH 5 D F P-VALUE= 06841
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 48772
TEST VALUE = .20087 STD ERROR OF TEST VALUE 11353
ASYMPTOTIC NORMAL STATISTIC = 1 7692708 P-VALUE= .03842
WALD CHI-SQUARE STATISTIC = 3 1303190 WITH 1 D F P-VALUE= 07685
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 31946
[ *****
[*TESTING FOR TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 9.7331100 WITH 5 D F P-VALUE= 08316
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .51371
TEST VALUE = 20536E-01 STD. ERROR OF TEST VALUE 15300E-01
ASYMPTOTIC NORMAL STATISTIC = 1.3422116 P-VALUE= 08976
WALD CHI-SQUARE STATISTIC = 1 8015320 WITH 1 D F P-VALUE= 17953
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 55508
_STOP
```

#### INDUSTRY 385

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 46 131 WITH 3 D F

```
[ *****
[*TESTING FOR RETURNS TO SCALE
[ *****
WALD CHI-SQUARE STATISTIC = 2 2047290 WITH 5 D F P-VALUE= 82015
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
TEST VALUE = 85964E-01 STD ERROR OF TEST VALUE 25450
ASYMPTOTIC NORMAL STATISTIC = 33777672 P-VALUE= 36777
WALD CHI-SQUARE STATISTIC = 11409310 WITH 1 D F P-VALUE= 73553
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
[ *****
[*TESTING FOR TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 19.181400 WITH 5 D F P-VALUE= 00178
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 26067
TEST VALUE = -.66407E-01 STD ERROR OF TEST VALUE 17634E-01
ASYMPTOTIC NORMAL STATISTIC = -3.7658542 P-VALUE= 99992
WALD CHI-SQUARE STATISTIC = 14 181660 WITH 1 D F P-VALUE= 00017
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07051
_STOP
```

#### INDUSTRY 386

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 53 064 WITH 3 D F

```
[ *****
[*TESTING FOR RETURNS TO SCALE
[ *****
WALD CHI-SQUARE STATISTIC = 11 980890 WITH 5 D F P-VALUE= .03505
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 41733
TEST VALUE = -14694 STD ERROR OF TEST VALUE 18428
ASYMPTOTIC NORMAL STATISTIC = - 79738617 P-VALUE= 78739
WALD CHI-SQUARE STATISTIC = .63582470 WITH 1 D F P-VALUE= 42523
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
[ *****
[*TESTING FOR TECHNICAL PROGRESS
```

```
[ *****
WALD CHI-SQUARE STATISTIC = 18 076950 WITH 5 D F P-VALUE= 00285
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 27660
TEST VALUE = - 63385E-02 STD ERROR OF TEST VALUE 12271E-01
ASYMPTOTIC NORMAL STATISTIC = - 51652985 P-VALUE= 69726
WALD CHI-SQUARE STATISTIC = 26680310 WITH 1 D F P-VALUE= 60548
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
[ STOP
```

INDUSTRY 390

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 58 317 WITH 3 D F

```
[ *****
[ *TESTING FOR RETURNS TO SCALE
[ *****
WALD CHI-SQUARE STATISTIC = 59 077730 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 08463
TEST VALUE = -.59782 STD ERROR OF TEST VALUE 16368
ASYMPTOTIC NORMAL STATISTIC = -3 6524488 P-VALUE= 99987
WALD CHI-SQUARE STATISTIC = 13.340380 WITH 1 D F P-VALUE= .00026
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 07496
[ *****
[ *TESTING FOR TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 144 26400 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 03466
TEST VALUE = 69910E-01 STD ERROR OF TEST VALUE 61607E-02
ASYMPTOTIC NORMAL STATISTIC = 11 347749 P-VALUE= 00000
WALD CHI-SQUARE STATISTIC = 128 77140 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .00777
[ STOP
```



## APPENDIX G

### EDITED SHAZAM COMPUTER OUTPUT FOR THE GENERALIZED LEONTIEF COST FUNCTION MODEL

This appendix gives the edited Shazam output for estimates and test statistics presented in Table 6.2. We add one to the test value of ECY to obtain the ECY estimate. All other estimates are given directly by the test values.

#### INDUSTRY 311

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 9 4645 WITH 3 D F

```

| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 175 34466 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02852
TEST VALUE = -1 5132 STD ERROR OF TEST VALUE 0 22889
ASYMPTOTIC NORMAL STATISTIC = -6 6109922 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 43.705218 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02288
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 230.60480 WITH 5 D F P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .02168
TEST VALUE = 41624E-01 STD ERROR OF TEST VALUE 56072E-02
ASYMPTOTIC NORMAL STATISTIC = 7 4233037 P-VALUE= .00000
WALD CHI-SQUARE STATISTIC = 55 105440 WITH 1 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .01815
| STOP

```

#### INDUSTRY 313

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 27 527 WITH 3 D F.

```

| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 82.437669 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06065
TEST VALUE = -0 39843 STD ERROR OF TEST VALUE 0 23578
ASYMPTOTIC NORMAL STATISTIC = -1.6897941 P-VALUE= 0 09107
WALD CHI-SQUARE STATISTIC = 2 8554040 WITH 1 D F P-VALUE= 0 09107
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 35021
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 16.179790 WITH 5 D F P-VALUE= 00635
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .30903
TEST VALUE = - 65965E-03 STD ERROR OF TEST VALUE 11912E-01
ASYMPTOTIC NORMAL STATISTIC = -.55378740E-01 P-VALUE= 52208
WALD CHI-SQUARE STATISTIC = .30668050E-02 WITH 1 D F P-VALUE= 95584
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
| STOP

```

#### INDUSTRY 314

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 7 0544 WITH 3 D F

```

| *****
| * TESTING THE PRESENCE OF SCALE EFFECT

```

```

*****
WALD CHI-SQUARE STATISTIC = 358.47936 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01395
TEST VALUE = -0.93609 STD ERROR OF TEST VALUE 0.13600
ASYMPTOTIC NORMAL STATISTIC = -6.8828778 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 47.374007 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02111
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 229.82860 WITH 5 D.F. P-VALUE= 0.0000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.2176
TEST VALUE = -2.3411E-01 STD ERROR OF TEST VALUE 1.7243E-01
ASYMPTOTIC NORMAL STATISTIC = -1.3577043 P-VALUE= 0.1272
WALD CHI-SQUARE STATISTIC = 1.8433610 WITH 1 D.F. P-VALUE= 0.17456
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.54249
[STOP

```

## INDUSTRY 321

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 12.472 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 23.892001 WITH 5 D.F. P-VALUE= 0.00023
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.20928
TEST VALUE = -0.15062 STD ERROR OF TEST VALUE 0.18079
ASYMPTOTIC NORMAL STATISTIC = -0.83311351 P-VALUE= 0.40478
WALD CHI-SQUARE STATISTIC = 0.69407811 WITH 1 D.F. P-VALUE= 0.40478
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 54.953190 WITH 5 D.F. P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.9099
TEST VALUE = -.15258E-01 STD ERROR OF TEST VALUE 8.3552E-02
ASYMPTOTIC NORMAL STATISTIC = -1.8261267 P-VALUE= .96608
WALD CHI-SQUARE STATISTIC = 3.3347380 WITH 1 D.F. P-VALUE= 0.06783
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.29987
[STOP

```

## INDUSTRY 322

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 44.801 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 39.241306 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.12742
TEST VALUE = -0.32840 STD. ERROR OF TEST VALUE 0.64293E-01
ASYMPTOTIC NORMAL STATISTIC = -5.1078595 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 26.090229 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03833
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 36.504560 WITH 5 D.F. P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.13697
TEST VALUE = .87461E-02 STD ERROR OF TEST VALUE .22404E-02
ASYMPTOTIC NORMAL STATISTIC = 3.9038175 P-VALUE= 0.00005
WALD CHI-SQUARE STATISTIC = 15.239790 WITH 1 D.F. P-VALUE= 0.00009
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.06562
[STOP

```

## INDUSTRY 323

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 29.302 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 18.956062 WITH 5 D.F. P-VALUE= 0.00196
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.26377
TEST VALUE = -0.59519 STD. ERROR OF TEST VALUE 0.29514
ASYMPTOTIC NORMAL STATISTIC = -2.0166470 P-VALUE= 0.04373
WALD CHI-SQUARE STATISTIC = 4.0668650 WITH 1 D.F. P-VALUE= 0.04373
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.24589
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 13.790270 WITH 5 D.F. P-VALUE= 0.01700
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .36257
TEST VALUE = 2.0851E-01 STD. ERROR OF TEST VALUE .16265E-01
ASYMPTOTIC NORMAL STATISTIC = 1.2819543 P-VALUE= .09993
WALD CHI-SQUARE STATISTIC = 1.6434070 WITH 1 D.F. P-VALUE= .19986
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 60849
[STOP

```

## INDUSTRY 324

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 15.038 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 104.43226 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.04788
TEST VALUE = -0.58663 STD. ERROR OF TEST VALUE 0.96537E-01
ASYMPTOTIC NORMAL STATISTIC = -6.0767380 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 36.926745 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02708
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 223.04560 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.2242
TEST VALUE = -3.8852E-01 STD. ERROR OF TEST VALUE 6.4188E-02
ASYMPTOTIC NORMAL STATISTIC = -6.0529033 P-VALUE= 1.00000
WALD CHI-SQUARE STATISTIC = 36.637640 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.2729
[STOP

```

## INDUSTRY 331

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 25.423 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 84.643497 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.05907
TEST VALUE = -0.70236 STD. ERROR OF TEST VALUE 0.18930
ASYMPTOTIC NORMAL STATISTIC = -3.7103488 P-VALUE= 0.00021
WALD CHI-SQUARE STATISTIC = 13.766689 WITH 1 D.F. P-VALUE= 0.00021
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07264
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 23.839710 WITH 5 D.F. P-VALUE= 0.00023
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 20973
TEST VALUE = -2.4861E-01 STD. ERROR OF TEST VALUE 8.5574E-02
ASYMPTOTIC NORMAL STATISTIC = -2.9051800 P-VALUE= 0.99816

```

WALD CHI-SQUARE STATISTIC = 8 4400710 WITH 1 D F P-VALUE= 00367  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 11848  
\_STOP

INDUSTRY 332

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 40 971 WITH 3 D F

\*\*\*\*\*  
\_\* TESTING THE PRESENCE OF SCALE EFFECT  
\*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 791 74883 WITH 5 D F P-VALUE= 0 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00632  
TEST VALUE = -0 36377 STD ERROR OF TEST VALUE 0 96811E-01  
ASYMPTOTIC NORMAL STATISTIC = -3.7575657 P-VALUE= 0 00017  
WALD CHI-SQUARE STATISTIC = 14.119300 WITH 1 D F P-VALUE= 0 00017  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 07083  
\*\*\*\*\*  
\_\* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
\*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 102.10650 WITH 5 D F P-VALUE= 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 04897  
TEST VALUE = - 63817E-02 STD ERROR OF TEST VALUE .46338E-02  
ASYMPTOTIC NORMAL STATISTIC = -1.3772131 P-VALUE= 91578  
WALD CHI-SQUARE STATISTIC = 1 8967160 WITH 1 D F P-VALUE= 16845  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 52723  
\_STOP

INDUSTRY 341

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 21 667 WITH 3 D.F

\*\*\*\*\*  
\_\* TESTING THE PRESENCE OF SCALE EFFECT  
\*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 411.35083 WITH 5 D F P-VALUE= 0.00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01216  
TEST VALUE = -0 71338 STD. ERROR OF TEST VALUE 0.68008E-01  
ASYMPTOTIC NORMAL STATISTIC = -10.489621 P-VALUE= 0 00000  
WALD CHI-SQUARE STATISTIC = 110 03216 WITH 1 D F. P-VALUE= 0 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00909  
\*\*\*\*\*  
\_\* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
\*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 1162 7320 WITH 5 D F P-VALUE= .00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 00430  
TEST VALUE = 48697E-01 STD. ERROR OF TEST VALUE 17630E-02  
ASYMPTOTIC NORMAL STATISTIC = 27.620965 P-VALUE= 00000  
WALD CHI-SQUARE STATISTIC = 762 91770 WITH 1 D F P-VALUE= 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 00131  
\_STOP

INDUSTRY 342

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 27 599 WITH 3 D F

\*\*\*\*\*  
\_\* TESTING THE PRESENCE OF SCALE EFFECT  
\*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 177.65894 WITH 5 D.F. P-VALUE= 0 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02814  
TEST VALUE = -0.73307 STD. ERROR OF TEST VALUE 0 29383  
ASYMPTOTIC NORMAL STATISTIC = -2.4949078 P-VALUE= 0.01260  
WALD CHI-SQUARE STATISTIC = 6.2245650 WITH 1 D.F P-VALUE= 0 01260  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.16065  
\*\*\*\*\*  
\_\* TESTING THE PRESENCE OF TECHNICAL PROGRESS

```

*****
WALD CHI-SQUARE STATISTIC = 146.54110 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .03412
TEST VALUE = - .60955E-02 STD ERROR OF TEST VALUE 34786E-01
ASYMPTOTIC NORMAL STATISTIC = - .17522783 P-VALUE= 56955
WALD CHI-SQUARE STATISTIC = 30704790E-01 WITH 1 D F P-VALUE= 86090
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
STOP

```

#### INDUSTRY 351

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 18 486 WITH 3 D F

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 164 19787 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03045
TEST VALUE = -0.29289 STD ERROR OF TEST VALUE 0.21158
ASYMPTOTIC NORMAL STATISTIC = -1.3843026 P-VALUE= 0 16627
WALD CHI-SQUARE STATISTIC = 1.9162937 WITH 1 D F P-VALUE= 0 16627
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 52184
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 84.571000 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 05912
TEST VALUE = 15971E-01 STD ERROR OF TEST VALUE .23215E-01
ASYMPTOTIC NORMAL STATISTIC = 68796474 P-VALUE= 24574
WALD CHI-SQUARE STATISTIC = .47329550 WITH 1 D F P-VALUE= 49147
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
STOP

```

#### INDUSTRY 352

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 14 659 WITH 3 D F

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 102.01851 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04901
TEST VALUE = -0.64154 STD ERROR OF TEST VALUE 0.16671
ASYMPTOTIC NORMAL STATISTIC = -3.8482721 P-VALUE= 0.00012
WALD CHI-SQUARE STATISTIC = 14.809198 WITH 1 D F P-VALUE= 0.00012
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06753
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 61 962300 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 08069
TEST VALUE = .33781E-01 STD. ERROR OF TEST VALUE 14218E-01
ASYMPTOTIC NORMAL STATISTIC = 2.3759164 P-VALUE= .00875
WALD CHI-SQUARE STATISTIC = 5.6449790 WITH 1 D F P-VALUE= 01751
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .17715
STOP

```

#### INDUSTRY 353

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 9 8072 WITH 3 D F

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 91.414835 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05470
TEST VALUE = -0 58997 STD ERROR OF TEST VALUE 0 11057

```

ASYMPTOTIC NORMAL STATISTIC = -5.3357641 P-VALUE= 0.00000  
 WALD CHI-SQUARE STATISTIC = 28.470378 WITH 1 D.F. P-VALUE= 0.00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03512

\*\*\*\*\*

└ \* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 77.801480 WITH 5 D.F. P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.06427

TEST VALUE = -3.1557E-02 STD. ERROR OF TEST VALUE .60701E-02

ASYMPTOTIC NORMAL STATISTIC = -5.1986446 P-VALUE= .69842

WALD CHI-SQUARE STATISTIC = .27025910 WITH 1 D.F. P-VALUE= 60316

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000

#### INDUSTRY 356

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 13.966 WITH 3 D.F.

\*\*\*\*\*

└ \* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 66.118211 WITH 5 D.F. P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07562

TEST VALUE = -1.0562 STD. ERROR OF TEST VALUE 0.15221

ASYMPTOTIC NORMAL STATISTIC = -6.9391035 P-VALUE= 0.00000

WALD CHI-SQUARE STATISTIC = 48.151157 WITH 1 D.F. P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02077

\*\*\*\*\*

└ \* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 165.56000 WITH 5 D.F. P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03020

TEST VALUE = 7.6763E-02 STD. ERROR OF TEST VALUE 3.4708E-02

ASYMPTOTIC NORMAL STATISTIC = 2.2116471 P-VALUE= 0.1350

WALD CHI-SQUARE STATISTIC = 4.8913830 WITH 1 D.F. P-VALUE= 0.02699

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.20444

└ STOP

#### INDUSTRY 357

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 7.2014 WITH 3 D.F.

\*\*\*\*\*

└ \* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 31.519409 WITH 5 D.F. P-VALUE= 0.00001

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.15863

TEST VALUE = -0.35728 STD. ERROR OF TEST VALUE 0.11777

ASYMPTOTIC NORMAL STATISTIC = -3.0337703 P-VALUE= 0.00242

WALD CHI-SQUARE STATISTIC = 9.2037620 WITH 1 D.F. P-VALUE= 0.00242

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.10865

\*\*\*\*\*

└ \* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 1111.1370 WITH 5 D.F. P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00450

TEST VALUE = 7.3480E-01 STD. ERROR OF TEST VALUE 3.9102E-02

ASYMPTOTIC NORMAL STATISTIC = 18.792012 P-VALUE= .00000

WALD CHI-SQUARE STATISTIC = 353.13970 WITH 1 D.F. P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .00283

└ STOP

#### INDUSTRY 361

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 59.481 WITH 3 D.F.

\*\*\*\*\*

└ \* TESTING THE PRESENCE OF SCALE EFFECT

```

*****
WALD CHI-SQUARE STATISTIC = 3.3234077 WITH 5 D.F. P-VALUE= 0.65026
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
TEST VALUE = -0.38839 STD. ERROR OF TEST VALUE 0.33532
ASYMPTOTIC NORMAL STATISTIC = -1.1582746 P-VALUE= 0.24675
WALD CHI-SQUARE STATISTIC = 1.3416000 WITH 1 D.F. P-VALUE= 0.24675
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.74538
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 36.011180 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 13885
TEST VALUE = .53700E-01 STD. ERROR OF TEST VALUE 37047E-01
ASYMPTOTIC NORMAL STATISTIC = 1.4495068 P-VALUE= 0.7360
WALD CHI-SQUARE STATISTIC = 2.1010700 WITH 1 D.F. P-VALUE= 0.14720
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .47595
[STOP

```

### INDUSTRY 371

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 26.655 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 109.43794 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.04569
TEST VALUE = -1.3371 STD. ERROR OF TEST VALUE 0.21039
ASYMPTOTIC NORMAL STATISTIC = -6.3553748 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 40.390789 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02476
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 30.245500 WITH 5 D.F. P-VALUE= .00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 16531
TEST VALUE = 47822E-01 STD. ERROR OF TEST VALUE 95664E-02
ASYMPTOTIC NORMAL STATISTIC = 4.9990140 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 24.990140 WITH 1 D.F. P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.4002
[STOP

```

### INDUSTRY 372

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 4.7172 WITH 3 D.F.

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 36.657557 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.13640
TEST VALUE = -1.3421 STD. ERROR OF TEST VALUE 0.24968
ASYMPTOTIC NORMAL STATISTIC = -5.3752539 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 28.893354 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03461
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 242.75310 WITH 5 D.F. P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .02060
TEST VALUE = 58572E-01 STD. ERROR OF TEST VALUE .59362E-02
ASYMPTOTIC NORMAL STATISTIC = 9.8669179 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 97.356070 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.1027

```

### INDUSTRY 381

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 22 509 WITH 3 D F

```
| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 51 357848 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09736
TEST VALUE = -0.91083 STD ERROR OF TEST VALUE 0.20298
ASYMPTOTIC NORMAL STATISTIC = -4.4872880 P-VALUE= 0 00001
WALD CHI-SQUARE STATISTIC = 20 135754 WITH 1 D F P-VALUE= 0 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04966
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 111.88350 WITH 5 D F P-VALUE= 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .04469
TEST VALUE = 53903E-01 STD ERROR OF TEST VALUE 11839E-01
ASYMPTOTIC NORMAL STATISTIC = 4 5530468 P-VALUE= 00000
WALD CHI-SQUARE STATISTIC = 20.730240 WITH 1 D F P-VALUE= 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .04824
| STOP
```

INDUSTRY 382

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 8 5235 WITH 3 D F

```
| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 151 34674 WITH 5 D.F. P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03304
TEST VALUE = -0.39459 STD ERROR OF TEST VALUE 0 86135E-01
ASYMPTOTIC NORMAL STATISTIC = -4.5810977 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 20.986456 WITH 1 D.F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04765
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 9 2243020 WITH 5 D F P-VALUE= 10045
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .54205
TEST VALUE = - 28618E-02 STD. ERROR OF TEST VALUE .72750E-02
ASYMPTOTIC NORMAL STATISTIC = - 39337314 P-VALUE= 65298
WALD CHI-SQUARE STATISTIC = .15474240 WITH 1 D F P-VALUE= .69404
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
```

INDUSTRY 383

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 33 880 WITH 3 D F

```
| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 1207.8062 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00414
TEST VALUE = -0.55492 STD. ERROR OF TEST VALUE 0 96538E-01
ASYMPTOTIC NORMAL STATISTIC = -5 7481867 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 33 041650 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03026
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 37.967960 WITH 5 D F P-VALUE= .00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .13169
TEST VALUE = 16334E-01 STD ERROR OF TEST VALUE 90379E-02
ASYMPTOTIC NORMAL STATISTIC = 1.8072774 P-VALUE= 03536
WALD CHI-SQUARE STATISTIC = 3 2662520 WITH 1 D.F P-VALUE= 07072
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = .30616
| STOP
```



## INDUSTRY 384

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 11.448 WITH 3 D F

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 46.831984 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.10676
TEST VALUE = -0.12284 STD ERROR OF TEST VALUE 0.70929E-01
ASYMPTOTIC NORMAL STATISTIC = -1.7318697 P-VALUE= 0.08330
WALD CHI-SQUARE STATISTIC = 2.9993726 WITH 1 D F P-VALUE= 0.08330
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.33340
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 86.133970 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.5805
TEST VALUE = 8.9441E-02 STD ERROR OF TEST VALUE 1.3573E-01
ASYMPTOTIC NORMAL STATISTIC = .65894945 P-VALUE= .25496
WALD CHI-SQUARE STATISTIC = 4.3421440 WITH 1 D F P-VALUE= .50993
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000

```

## INDUSTRY 385

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 10.291 WITH 3 D F

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 74.139206 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.06744
TEST VALUE = -0.54724 STD ERROR OF TEST VALUE 0.14510
ASYMPTOTIC NORMAL STATISTIC = -3.7713699 P-VALUE= 0.00016
WALD CHI-SQUARE STATISTIC = 14.223231 WITH 1 D F P-VALUE= 0.00016
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07031
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 22.448140 WITH 5 D F P-VALUE= 0.00043
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.22274
TEST VALUE = -0.13118E-01 STD ERROR OF TEST VALUE 1.2340E-01
ASYMPTOTIC NORMAL STATISTIC = -1.0630555 P-VALUE= .85612
WALD CHI-SQUARE STATISTIC = 1.1300870 WITH 1 D F P-VALUE= .28776
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.88489

```

## INDUSTRY 386

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 15.630 WITH 3 D F

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 33.737629 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.14820
TEST VALUE = -0.55930 STD ERROR OF TEST VALUE 0.14883
ASYMPTOTIC NORMAL STATISTIC = -3.7580473 P-VALUE= 0.00017
WALD CHI-SQUARE STATISTIC = 14.122920 WITH 1 D F P-VALUE= 0.00017
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07081
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 20.048790 WITH 5 D F P-VALUE= 0.0122
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.24939
TEST VALUE = 2.0224E-01 STD ERROR OF TEST VALUE .17289E-01
ASYMPTOTIC NORMAL STATISTIC = 1.1697666 P-VALUE= .12105

```

WALD CHI-SQUARE STATISTIC = 1 3683540 WITH 1 D F P-VALUE= 24209  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 73081  
\_STOP

INDUSTRY 390

LIKELIHOOD RATIO TEST OF DIAGONAL COVARIANCE MATRIX = 24 748 WITH 3 D F

[ \*\*\*\*\*  
[ \* TESTING THE PRESENCE OF SCALE EFFECT  
[ \*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 299.29700 WITH 5 D F P-VALUE= 0.00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01671  
TEST VALUE = -0 75626 STD ERROR OF TEST VALUE 0 91157E-01  
ASYMPTOTIC NORMAL STATISTIC = -8 2962275 P-VALUE= 0 00000  
WALD CHI-SQUARE STATISTIC = 68.827390 WITH 1 D.F P-VALUE= 0 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01453  
[ \*\*\*\*\*  
[ \* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
[ \*\*\*\*\*  
WALD CHI-SQUARE STATISTIC = 399.34710 WITH 5 D F P-VALUE= 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 01252  
TEST VALUE = .57034E-01 STD ERROR OF TEST VALUE .39985E-02  
ASYMPTOTIC NORMAL STATISTIC = 14.263734 P-VALUE= 00000  
WALD CHI-SQUARE STATISTIC = 203 45410 WITH 1 D F P-VALUE= 00000  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 00492

## APPENDIX H

### EDITED SHAZAM COMPUTER OUTPUT FOR THE INTEGRATED MODEL (LOG-LOG DEMAND)

This appendix gives the edited Shazam output for estimates and test statistics presented in Table 6.3. We add one to the test value of ECY to obtain the ECY estimate. All other estimates are given directly by the test values.

#### INDUSTRY 311

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 1483.4412 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00337
TEST VALUE = -0 88401 STD. ERROR OF TEST VALUE 0 11882
ASYMPTOTIC NORMAL STATISTIC = -7.4396760 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 55 348779 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01807
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 103 90025 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04812
TEST VALUE = 0 26537E-01 STD. ERROR OF TEST VALUE 0 39819E-02
ASYMPTOTIC NORMAL STATISTIC = 6.6644140 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 44 414415 WITH 1 D.F. P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 02252
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 14564 STD. ERROR OF TEST VALUE 0.98495E-01
ASYMPTOTIC NORMAL STATISTIC = -1.4786514 P-VALUE= 0 13923
WALD CHI-SQUARE STATISTIC = 2 1864101 WITH 1 D F P-VALUE= 0 13923
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.45737
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0.9705705 70 51516
STOP

```

#### INDUSTRY 313

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 46.861786 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 10670
TEST VALUE = -0.47457 STD ERROR OF TEST VALUE 0 17918
ASYMPTOTIC NORMAL STATISTIC = -2 6485168 P-VALUE= 0 00808
WALD CHI-SQUARE STATISTIC = 7.0146410 WITH 1 D.F. P-VALUE= 0 00808
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 14256
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 31 319067 WITH 5 D F. P-VALUE= 0 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.15965
TEST VALUE = 0.57018E-02 STD ERROR OF TEST VALUE 0 96952E-02
ASYMPTOTIC NORMAL STATISTIC = 0.58810926 P-VALUE= 0 55646
WALD CHI-SQUARE STATISTIC = 0 34587250 WITH 1 D F. P-VALUE= 0.55646
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 20073 STD ERROR OF TEST VALUE 0 20332
ASYMPTOTIC NORMAL STATISTIC = 0.98724534 P-VALUE= 0 32352

```

WALD CHI-SQUARE STATISTIC = 0.97465337 WITH 1 D.F. P-VALUE= 0.32352  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000

\*\*\*\*\*  
 \* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE  
 \*\*\*\*\*

\_PRINT RSQ TESTFUL  
       RSQ      TESTFUL  
 0.9990481    139.1412  
 \_STOP

#### INDUSTRY 314

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF SCALE EFFECT  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 345.16198 WITH 5 D.F. P-VALUE= 0.00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01449  
 TEST VALUE = -0.71730 STD. ERROR OF TEST VALUE 0.48406E-01  
 ASYMPTOTIC NORMAL STATISTIC = -14.818404 P-VALUE= 0.00000  
 WALD CHI-SQUARE STATISTIC = 219.58511 WITH 1 D.F. P-VALUE= 0.00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00455

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 185.66016 WITH 5 D.F. P-VALUE= 0.00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02693  
 TEST VALUE = -0.51979E-01 STD. ERROR OF TEST VALUE 0.12295E-01  
 ASYMPTOTIC NORMAL STATISTIC = -4.2276523 P-VALUE= 0.00002  
 WALD CHI-SQUARE STATISTIC = 17.873044 WITH 1 D.F. P-VALUE= 0.00002  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.05595

\*\*\*\*\*  
 \* TESTING THETA = 0  
 \*\*\*\*\*

TEST VALUE = -0.16149 STD. ERROR OF TEST VALUE 0.23994  
 ASYMPTOTIC NORMAL STATISTIC = -0.67305806 P-VALUE= 0.50091  
 WALD CHI-SQUARE STATISTIC = 0.45300715 WITH 1 D.F. P-VALUE= 0.50091  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000

\*\*\*\*\*  
 \* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE  
 \*\*\*\*\*

\_PRINT RSQ TESTFUL  
       RSQ      TESTFUL  
 0.9999867    224.5127  
 \_STOP

#### INDUSTRY 321

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF SCALE EFFECT  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 134.82409 WITH 5 D.F. P-VALUE= 0.00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03709  
 TEST VALUE = -0.37619 STD. ERROR OF TEST VALUE 0.10782  
 ASYMPTOTIC NORMAL STATISTIC = -3.4892180 P-VALUE= 0.00048  
 WALD CHI-SQUARE STATISTIC = 12.174642 WITH 1 D.F. P-VALUE= 0.00048  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.08214

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 40.917920 WITH 5 D.F. P-VALUE= 0.00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.12220  
 TEST VALUE = -0.19672E-01 STD. ERROR OF TEST VALUE 0.83752E-02  
 ASYMPTOTIC NORMAL STATISTIC = -2.3488202 P-VALUE= 0.01883  
 WALD CHI-SQUARE STATISTIC = 5.5169564 WITH 1 D.F. P-VALUE= 0.01883  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.18126

\*\*\*\*\*  
 \* TESTING THETA = 0  
 \*\*\*\*\*

TEST VALUE = 0.91657 STD. ERROR OF TEST VALUE 0.41476  
 ASYMPTOTIC NORMAL STATISTIC = 2.2098832 P-VALUE= 0.02711  
 WALD CHI-SQUARE STATISTIC = 4.8835837 WITH 1 D.F. P-VALUE= 0.02711  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.20477

```

*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
  RSQ      TESTFUL
0 9988839  135.9591
STOP

```

### INDUSTRY 322

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 191.97557 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 02604
TEST VALUE = -0 42236 STD. ERROR OF TEST VALUE 0.51343E-01
ASYMPTOTIC NORMAL STATISTIC = -8.2262321 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 67 670894 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01478
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 66 813289 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 07484
TEST VALUE = 0.68342E-02 STD. ERROR OF TEST VALUE 0 15299E-02
ASYMPTOTIC NORMAL STATISTIC = 4 4671032 P-VALUE= 0 00001
WALD CHI-SQUARE STATISTIC = 19.955011 WITH 1 D F P-VALUE= 0 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05011
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 40118 STD ERROR OF TEST VALUE 0 15999
ASYMPTOTIC NORMAL STATISTIC = -2 5075699 P-VALUE= 0 01216
WALD CHI-SQUARE STATISTIC = 6 2879066 WITH 1 D F P-VALUE= 0 01216
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 15904
*****
[* GENERATING OVERALL GOODNESS-OF-FIT: R-SQUARE
*****
PRINT RSQ TESTFUL
  RSQ      TESTFUL
0 9990298  138 7592
STOP

```

### INDUSTRY 323

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 28 951911 WITH 5 D F P-VALUE= 0 00002
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 17270
TEST VALUE = -0 12121 STD. ERROR OF TEST VALUE 0.40441
ASYMPTOTIC NORMAL STATISTIC = -0 29972278 P-VALUE= 0 76439
WALD CHI-SQUARE STATISTIC = 0 89833746E-01 WITH 1 D F P-VALUE= 0 76439
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 37 094563 WITH 5 D F, P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.13479
TEST VALUE = 0 54689E-01 STD ERROR OF TEST VALUE 0 28299E-01
ASYMPTOTIC NORMAL STATISTIC = 1 9325644 P-VALUE= 0.05329
WALD CHI-SQUARE STATISTIC = 3 7348052 WITH 1 D F P-VALUE= 0 05329
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 26775
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 10847 STD. ERROR OF TEST VALUE 0 26294
ASYMPTOTIC NORMAL STATISTIC = -0.41252781 P-VALUE= 0 67995
WALD CHI-SQUARE STATISTIC = 0 17017919 WITH 1 D F P-VALUE= 0 67995
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE

```

```

*****
PRINT RSQ TESTFUL
  RSQ      TESTFUL
  0 9944120  103 7426
STOP

```

INDUSTRY 324

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*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 751.78491 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00665
TEST VALUE = -0 76413 STD. ERROR OF TEST VALUE 0 62522E-01
ASYMPTOTIC NORMAL STATISTIC = -12 221728 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 149 37063 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00669
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 283 56495 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01763
TEST VALUE = -0 54231E-01 STD ERROR OF TEST VALUE 0.39933E-02
ASYMPTOTIC NORMAL STATISTIC = -13 580724 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 184 43607 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00542
*****
* TESTING THETA = 0
*****
TEST VALUE = -0 20826 STD ERROR OF TEST VALUE 0 15080
ASYMPTOTIC NORMAL STATISTIC = -1.3810845 P-VALUE= 0 16725
WALD CHI-SQUARE STATISTIC = 1 9073945 WITH 1 D F P-VALUE= 0 16725
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 52428
*****
* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ TESTFUL
  RSQ      TESTFUL
  0 9998205  172 5064
STOP

```

INDUSTRY 331

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 586 90017 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00852
TEST VALUE = -1.0283 STD ERROR OF TEST VALUE 0.41857E-01
ASYMPTOTIC NORMAL STATISTIC = -24.566232 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 603 49975 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00166
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 160.52056 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03115
TEST VALUE = -0 90361E-01 STD ERROR OF TEST VALUE 0 82129E-02
ASYMPTOTIC NORMAL STATISTIC = -11.002350 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 121.05171 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00826
*****
* TESTING THETA = 0
*****
TEST VALUE = -0.49830 STD ERROR OF TEST VALUE 0 16769
ASYMPTOTIC NORMAL STATISTIC = -2 9716344 P-VALUE= 0 00296
WALD CHI-SQUARE STATISTIC = 8 8306112 WITH 1 D F P-VALUE= 0 00296
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 11324
*****
* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL

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```

      RSQ      TESTFUL
0 8893420    44.02622
└STOP

```

### INDUSTRY 332

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└*****
└* TESTING THE PRESENCE OF SCALE EFFECT
└*****
WALD CHI-SQUARE STATISTIC = 553.99054 WITH 5 D.F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00903
TEST VALUE = -0.63948 STD ERROR OF TEST VALUE 0 12653
ASYMPTOTIC NORMAL STATISTIC = -5.0541646 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 25 544580 WITH 1 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03915
└*****
└* TESTING THE PRESENCE OF TECHNICAL PROGRESS
└*****
WALD CHI-SQUARE STATISTIC = 10.282968 WITH 5 D.F P-VALUE= 0 06760
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.48624
TEST VALUE = 0.39427E-02 STD. ERROR OF TEST VALUE 0 81249E-02
ASYMPTOTIC NORMAL STATISTIC = 0 48525777 P-VALUE= 0 62749
WALD CHI-SQUARE STATISTIC = 0 23547510 WITH 1 D.F P-VALUE= 0 62749
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└*****
└* TESTING THETA = 0
└*****
TEST VALUE = -0.36653 STD ERROR OF TEST VALUE 0 52678
ASYMPTOTIC NORMAL STATISTIC = -0.69580507 P-VALUE= 0.48655
WALD CHI-SQUARE STATISTIC = 0.48414469 WITH 1 D.F P-VALUE= 0 48655
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└*****
└* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
└*****
└PRINT RSQ TESTFUL
      RSQ      TESTFUL
0 9953027    107 2152
└STOP

```

### INDUSTRY 341

```

└*****
└* TESTING THE PRESENCE OF SCALE EFFECT
└*****
WALD CHI-SQUARE STATISTIC = 2148.9465 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00233
TEST VALUE = -0 70075 STD ERROR OF TEST VALUE 0 52168E-01
ASYMPTOTIC NORMAL STATISTIC = -13 432486 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 180.43169 WITH 1 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00554
└*****
└* TESTING THE PRESENCE OF TECHNICAL PROGRESS
└*****
WALD CHI-SQUARE STATISTIC = 527.98146 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00947
TEST VALUE = 0.44846E-01 STD ERROR OF TEST VALUE 0.25759E-02
ASYMPTOTIC NORMAL STATISTIC = 17 409590 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 303 09384 WITH 1 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00330
└*****
└* TESTING THETA = 0
└*****
TEST VALUE = -0 10002 STD. ERROR OF TEST VALUE 0 10989
ASYMPTOTIC NORMAL STATISTIC = -0.91019010 P-VALUE= 0.36272
WALD CHI-SQUARE STATISTIC = 0 82844602 WITH 1 D.F P-VALUE= 0.36272
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└*****
└* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
└*****
└PRINT RSQ TESTFUL
      RSQ      TESTFUL
0 9995693    155.0042

```

\_STOP

# INDUSTRY 342

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 46 571035 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 10736
TEST VALUE = -5 9655 STD. ERROR OF TEST VALUE 2.5935
ASYMPTOTIC NORMAL STATISTIC = -2.3001814 P-VALUE= 0 02144
WALD CHI-SQUARE STATISTIC = 5 2908347 WITH 1 D F P-VALUE= 0 02144
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 18901
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 15 641663 WITH 5 D F P-VALUE= 0.00795
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 31966
TEST VALUE = 0 57040 STD ERROR OF TEST VALUE 0 26957
ASYMPTOTIC NORMAL STATISTIC = 2.1159402 P-VALUE= 0 03435
WALD CHI-SQUARE STATISTIC = 4 4772031 WITH 1 D F P-VALUE= 0 03435
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.22335
*****
[* TESTING THETA = 0
*****
TEST VALUE = -3.0386 STD ERROR OF TEST VALUE 3 2031
ASYMPTOTIC NORMAL STATISTIC = -0.94863632 P-VALUE= 0 34281
WALD CHI-SQUARE STATISTIC = 0.89991088 WITH 1 D F P-VALUE= 0.34281
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0 9911130 94 46328
_STOP

```

# INDUSTRY 351

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 79.116619 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06320
TEST VALUE = 0 29875E-01 STD. ERROR OF TEST VALUE 0.13435
ASYMPTOTIC NORMAL STATISTIC = 0 22235833 P-VALUE= 0 82403
WALD CHI-SQUARE STATISTIC = 0.49443226E-01 WITH 1 D F P-VALUE= 0 82403
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 61 352101 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.08150
TEST VALUE = -0 36146E-01 STD. ERROR OF TEST VALUE 0 20281E-01
ASYMPTOTIC NORMAL STATISTIC = -1 7823083 P-VALUE= 0 07470
WALD CHI-SQUARE STATISTIC = 3 1766230 WITH 1 D F P-VALUE= 0 07470
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 31480
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 97656 STD. ERROR OF TEST VALUE 0 33332
ASYMPTOTIC NORMAL STATISTIC = -2.9297930 P-VALUE= 0 00339
WALD CHI-SQUARE STATISTIC = 8.5836868 WITH 1 D F P-VALUE= 0.00339
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 11650
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0 9969285 115 7116
_STOP

```



## INDUSTRY 352

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 970 63349 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00515
TEST VALUE = -0 78924 STD ERROR OF TEST VALUE 0 55015E-01
ASYMPTOTIC NORMAL STATISTIC = -14 345832 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 205 80289 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00486
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 283 23025 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01765
TEST VALUE = 0 51023E-01 STD. ERROR OF TEST VALUE 0.61228E-02
ASYMPTOTIC NORMAL STATISTIC = 8 3332622 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 69 443259 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01440
*****
* TESTING THETA = 0
*****
TEST VALUE = -0 21357 STD ERROR OF TEST VALUE 0 12576
ASYMPTOTIC NORMAL STATISTIC = -1 6983246 P-VALUE= 0 08945
WALD CHI-SQUARE STATISTIC = 2 8843063 WITH 1 D.F P-VALUE= 0 08945
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 34670
*****
* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
      RSQ      TESTFUL
0 9998649    178 1973
STOP

```

## INDUSTRY 353

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 275 41860 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01815
TEST VALUE = -0 36278 STD. ERROR OF TEST VALUE 0.10387
ASYMPTOTIC NORMAL STATISTIC = -3 4925815 P-VALUE= 0 00048
WALD CHI-SQUARE STATISTIC = 12 198126 WITH 1 D F P-VALUE= 0 00048
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 08198
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 177 97983 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02809
TEST VALUE = -0.10642E-01 STD. ERROR OF TEST VALUE 0 51332E-02
ASYMPTOTIC NORMAL STATISTIC = -2 0731922 P-VALUE= 0 03815
WALD CHI-SQUARE STATISTIC = 4 2981261 WITH 1 D F P-VALUE= 0 03815
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 23266
*****
* TESTING THETA = 0
*****
TEST VALUE = -0 49950E-01 STD. ERROR OF TEST VALUE 0 67583E-01
ASYMPTOTIC NORMAL STATISTIC = -0 73908192 P-VALUE= 0 45986
WALD CHI-SQUARE STATISTIC = 0 54624209 WITH 1 D.F. P-VALUE= 0.45986
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
      RSQ      TESTFUL
0 9999405    194 6050
STOP

```

INDUSTRY 356

```
[ *****
[ * TESTING THE PRESENCE OF SCALE EFFECT
[ *****
WALD CHI-SQUARE STATISTIC = 974.74241 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00513
TEST VALUE = -0 87354 STD ERROR OF TEST VALUE 0.49540E-01
ASYMPTOTIC NORMAL STATISTIC = -17 633185 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 310.92923 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00322
[ *****
[ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 103 34908 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04838
TEST VALUE = 0.11420E-01 STD ERROR OF TEST VALUE 0 45145E-02
ASYMPTOTIC NORMAL STATISTIC = 2 5297365 P-VALUE= 0.01141
WALD CHI-SQUARE STATISTIC = 6 3995670 WITH 1 D F P-VALUE= 0 01141
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 15626
[ *****
[ * TESTING THETA = 0
[ *****
TEST VALUE = -0 28693 STD. ERROR OF TEST VALUE 0 13711
ASYMPTOTIC NORMAL STATISTIC = -2 0926614 P-VALUE= 0 03638
WALD CHI-SQUARE STATISTIC = 4.3792316 WITH 1 D F P-VALUE= 0 03638
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 22835
[ *****
[ * GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
[ *****
[ PRINT RSQ TESTFUL
RSQ TESTFUL
0 9524036 60 89995
[ STOP
```

INDUSTRY 357

```
[ *****
[ * TESTING THE PRESENCE OF SCALE EFFECT
[ *****
WALD CHI-SQUARE STATISTIC = 54 631974 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.09152
TEST VALUE = -0 12458 STD ERROR OF TEST VALUE 0.10911
ASYMPTOTIC NORMAL STATISTIC = -1 1418095 P-VALUE= 0 25353
WALD CHI-SQUARE STATISTIC = 1.3037289 WITH 1 D F P-VALUE= 0 25353
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 76703
[ *****
[ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 1411.2020 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00354
TEST VALUE = 0 60449E-01 STD ERROR OF TEST VALUE 0 30129E-02
ASYMPTOTIC NORMAL STATISTIC = 20 063539 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 402.54558 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00248
[ *****
[ * TESTING THETA = 0
[ *****
TEST VALUE = 0 45361 STD. ERROR OF TEST VALUE 0 14271
ASYMPTOTIC NORMAL STATISTIC = 3.1786245 P-VALUE= 0 00148
WALD CHI-SQUARE STATISTIC = 10.103654 WITH 1 D F P-VALUE= 0.00148
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09897
[ *****
[ * GENERATING OVERALL GOODNESS-OF-FIT: R-SQUARE
[ *****
[ PRINT RSQ TESTFUL
RSQ TESTFUL
0 9998093 171.2921
[ STOP
```

```
INDUSTRY 361
*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 4 7929500 WITH 5 D F P-VALUE= 0 44167
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
TEST VALUE = -0 11791 STD. ERROR OF TEST VALUE 0 14933
ASYMPTOTIC NORMAL STATISTIC = -0.78960958 P-VALUE= 0.42976
WALD CHI-SQUARE STATISTIC = 0 62348329 WITH 1 D F P-VALUE= 0 42976
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 39 826182 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 12555
TEST VALUE = 0 97173E-01 STD. ERROR OF TEST VALUE 0 41355E-01
ASYMPTOTIC NORMAL STATISTIC = 2.3497251 P-VALUE= 0 01879
WALD CHI-SQUARE STATISTIC = 5 5212079 WITH 1 D F P-VALUE= 0 01879
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 18112
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 81964E-01 STD ERROR OF TEST VALUE 0 25841
ASYMPTOTIC NORMAL STATISTIC = 0 31718805 P-VALUE= 0.75110
WALD CHI-SQUARE STATISTIC = 0 10060826 WITH 1 D F P-VALUE= 0 75110
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0 9938688 101 8873
STOP
```

```
INDUSTRY 371
*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 52 091072 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09599
TEST VALUE = -0.26575 STD ERROR OF TEST VALUE 0 33459
ASYMPTOTIC NORMAL STATISTIC = -0 79424494 P-VALUE= 0 42705
WALD CHI-SQUARE STATISTIC = 0 63082502 WITH 1 D F P-VALUE= 0 42705
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 29.268001 WITH 5 D.F. P-VALUE= 0 00002
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.17084
TEST VALUE = -0 88527E-02 STD ERROR OF TEST VALUE 0 14460E-01
ASYMPTOTIC NORMAL STATISTIC = -0 61222248 P-VALUE= 0.54039
WALD CHI-SQUARE STATISTIC = 0 37481636 WITH 1 D F P-VALUE= 0.54039
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.36662 STD ERROR OF TEST VALUE 0 30342
ASYMPTOTIC NORMAL STATISTIC = 1 2083101 P-VALUE= 0 22693
WALD CHI-SQUARE STATISTIC = 1 4600134 WITH 1 D F P-VALUE= 0 22693
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 68493
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0 9983324 127 9269
STOP
```

```
INDUSTRY 372
| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 48.143283 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.10386
TEST VALUE = -0.42999 STD ERROR OF TEST VALUE 0.17407
ASYMPTOTIC NORMAL STATISTIC = -2.4702417 P-VALUE= 0.01350
WALD CHI-SQUARE STATISTIC = 6.1020939 WITH 1 D F P-VALUE= 0.01350
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.16388
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 189.84300 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02634
TEST VALUE = 0.48349E-01 STD. ERROR OF TEST VALUE 0.53398E-02
ASYMPTOTIC NORMAL STATISTIC = 9.0543351 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 81.980984 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01220
| *****
| * TESTING THETA = 0
| *****
TEST VALUE = 0.12384 STD ERROR OF TEST VALUE 0.10657
ASYMPTOTIC NORMAL STATISTIC = 1.1621223 P-VALUE= 0.24519
WALD CHI-SQUARE STATISTIC = 1.3505281 WITH 1 D F P-VALUE= 0.24519
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.74045
| *****
| * GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
| *****
| PRINT RSQ TESTFUL
| RSQ TESTFUL
| 0.9862201 85.69095
| STOP
```

```
INDUSTRY 381
| *****
| * TESTING THE PRESENCE OF SCALE EFFECT
| *****
WALD CHI-SQUARE STATISTIC = 167.78718 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02980
TEST VALUE = -0.61484 STD ERROR OF TEST VALUE 0.11278
ASYMPTOTIC NORMAL STATISTIC = -5.4514899 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 29.718742 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03365
| *****
| * TESTING THE PRESENCE OF TECHNICAL PROGRESS
| *****
WALD CHI-SQUARE STATISTIC = 207.41890 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02411
TEST VALUE = 0.43459E-01 STD ERROR OF TEST VALUE 0.55242E-02
ASYMPTOTIC NORMAL STATISTIC = 7.8670520 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 61.890507 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01616
| *****
| * TESTING THETA = 0
| *****
TEST VALUE = 0.86924E-02 STD ERROR OF TEST VALUE 0.16814
ASYMPTOTIC NORMAL STATISTIC = 0.51697506E-01 P-VALUE= 0.95877
WALD CHI-SQUARE STATISTIC = 0.26726322E-02 WITH 1 D F P-VALUE= 0.95877
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
| *****
| * GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
| *****
| PRINT RSQ TESTFUL
| RSQ TESTFUL
| 0.9983203 127.7829
| STOP
```

## INDUSTRY 383

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 1711 5585 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00292
TEST VALUE = -0 89285 STD ERROR OF TEST VALUE 0 29279E-01
ASYMPTOTIC NORMAL STATISTIC = -30 494482 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 929.91342 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00108
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 994 97814 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00503
TEST VALUE = 0.57384E-01 STD ERROR OF TEST VALUE 0.25004E-02
ASYMPTOTIC NORMAL STATISTIC = 22.949956 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 526.70048 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00190
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0.91324 STD ERROR OF TEST VALUE 0.17080
ASYMPTOTIC NORMAL STATISTIC = -5.3467203 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 28.587418 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03498
*****
[* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0.9995053 152.2316
STOP

```

## INDUSTRY 384

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 47.675483 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 10488
TEST VALUE = -1.7565 STD ERROR OF TEST VALUE 0 45232
ASYMPTOTIC NORMAL STATISTIC = -3 8834087 P-VALUE= 0 00010
WALD CHI-SQUARE STATISTIC = 15.080863 WITH 1 D F P-VALUE= 0.00010
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06631
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 39 580798 WITH 5 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 12632
TEST VALUE = 0 25546 STD ERROR OF TEST VALUE 0 74531E-01
ASYMPTOTIC NORMAL STATISTIC = 3.4276204 P-VALUE= 0.00061
WALD CHI-SQUARE STATISTIC = 11 748581 WITH 1 D F P-VALUE= 0.00061
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 08512
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 59822 STD ERROR OF TEST VALUE 0 93442
ASYMPTOTIC NORMAL STATISTIC = 0.64020175 P-VALUE= 0 52204
WALD CHI-SQUARE STATISTIC = 0 40985828 WITH 1 D F P-VALUE= 0 52204
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0 7040055 24 34829
STOP

```

INDUSTRY 385

```
[ *****
[ * TESTING THE PRESENCE OF SCALE EFFECT
[ *****
WALD CHI-SQUARE STATISTIC = 281.67049 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01775
TEST VALUE = -0.60007 STD. ERROR OF TEST VALUE 0.97828E-01
ASYMPTOTIC NORMAL STATISTIC = -6.1339575 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 37.625435 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02658
[ *****
[ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 57.214456 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.08739
TEST VALUE = -0.10525E-01 STD. ERROR OF TEST VALUE 0.73416E-02
ASYMPTOTIC NORMAL STATISTIC = -1.4335707 P-VALUE= 0.15169
WALD CHI-SQUARE STATISTIC = 2.0551250 WITH 1 D F P-VALUE= 0.15169
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.48659
[ *****
[ * TESTING THETA = 0
[ *****
TEST VALUE = 0.15920 STD. ERROR OF TEST VALUE 0.17932
ASYMPTOTIC NORMAL STATISTIC = 0.88781140 P-VALUE= 0.37464
WALD CHI-SQUARE STATISTIC = 0.78820908 WITH 1 D F P-VALUE= 0.37464
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
[ *****
[ * GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
[ *****
[ PRINT RSQ TESTFUL
      RSQ      TESTFUL
      0.9965395  113.3266
[ STOP
```

INDUSTRY 386

```
[ *****
[ * TESTING THE PRESENCE OF SCALE EFFECT
[ *****
WALD CHI-SQUARE STATISTIC = 359.03015 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01393
TEST VALUE = -0.58507 STD. ERROR OF TEST VALUE 0.61314E-01
ASYMPTOTIC NORMAL STATISTIC = -9.5422118 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 91.053806 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01098
[ *****
[ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
[ *****
WALD CHI-SQUARE STATISTIC = 62.918470 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07947
TEST VALUE = 0.30696E-01 STD. ERROR OF TEST VALUE 0.46109E-02
ASYMPTOTIC NORMAL STATISTIC = 6.6572790 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 44.319363 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02256
[ *****
[ * TESTING THETA = 0
[ *****
TEST VALUE = 0.49143 STD. ERROR OF TEST VALUE 0.32061
ASYMPTOTIC NORMAL STATISTIC = 1.5327728 P-VALUE= 0.12533
WALD CHI-SQUARE STATISTIC = 2.3493923 WITH 1 D F P-VALUE= 0.12533
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.42564
[ *****
[ * GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
[ *****
[ PRINT RSQ TESTFUL
      RSQ      TESTFUL
      0.9998701  178.9772
[ STOP
```

```
INDUSTRY 390
*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 778.34055 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00642
TEST VALUE = -0 73647 STD. ERROR OF TEST VALUE 0.74491E-01
ASYMPTOTIC NORMAL STATISTIC = -9.8867995 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 97 748805 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01023
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 400.24458 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01249
TEST VALUE = 0.59947E-01 STD ERROR OF TEST VALUE 0 33667E-02
ASYMPTOTIC NORMAL STATISTIC = 17.805773 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 317 04553 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00315
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 19569 STD ERROR OF TEST VALUE 0 13905
ASYMPTOTIC NORMAL STATISTIC = -1.4073020 P-VALUE= 0 15934
WALD CHI-SQUARE STATISTIC = 1 9804989 WITH 1 D.F P-VALUE= 0 15934
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.50492
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ TESTFUL
RSQ TESTFUL
0 9971746 117 3820
STOP
```

## APPENDIX I

### EDITED SHAZAM COMPUTER OUTPUT FOR THE INTEGRATED MODEL (SEMI-LOG DEMAND)

This appendix gives the edited Shazam output for estimates and test statistics presented in Table 6.4. We add one to the test value of ECY to obtain the ECY estimate. All other estimates are given directly by the test values.

#### INDUSTRY 311

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 295.90138 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01690
TEST VALUE = -0.92287 STD ERROR OF TEST VALUE 0.10171
ASYMPTOTIC NORMAL STATISTIC = -9.0735795 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 82 329845 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01215
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 90 483741 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05526
TEST VALUE = 0 27685E-01 STD ERROR OF TEST VALUE 0.38424E-02
ASYMPTOTIC NORMAL STATISTIC = 7 2050664 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 51 912982 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01926
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0.20080 STD ERROR OF TEST VALUE 0 93182E-01
ASYMPTOTIC NORMAL STATISTIC = -2.1549622 P-VALUE= 0 03116
WALD CHI-SQUARE STATISTIC = 4 6438622 WITH 1 D F P-VALUE= 0 03116
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 21534
*****
[* GENERATING GOODNESS-OF-FIT. R-SQUARE
*****
[PRINT RSQ1 TESTFUL1
RSQ1 TESTFUL1
0 8889962 43.96381
[STOP

```

#### INDUSTRY 313

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 75 548965 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06618
TEST VALUE = -0 48417 STD ERROR OF TEST VALUE 0 15055
ASYMPTOTIC NORMAL STATISTIC = -3 2161152 P-VALUE= 0.00130
WALD CHI-SQUARE STATISTIC = 10.343397 WITH 1 D F P-VALUE= 0 00130
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09668
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 35 738771 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 13990
TEST VALUE = 0 54852E-02 STD ERROR OF TEST VALUE 0 88163E-02
ASYMPTOTIC NORMAL STATISTIC = 0 62216663 P-VALUE= 0.53383
WALD CHI-SQUARE STATISTIC = 0.38709131 WITH 1 D F P-VALUE= 0 53383
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 33857 STD ERROR OF TEST VALUE 0 26693
ASYMPTOTIC NORMAL STATISTIC = 1 2684023 P-VALUE= 0 20465

```



WALD CHI-SQUARE STATISTIC = 1.6088444 WITH 1 D F P-VALUE= 0.20465  
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.62156

\*\*\*\*\*

\* GENERATING GOODNESS-OF-FIT R-SQUARE

\*\*\*\*\*

PRINT RSQ1 TESTFUL1

RSQ1 TESTFUL1

0.9990451 139.0788

STOP

#### INDUSTRY 314

\*\*\*\*\*

\* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 669.36691 WITH 5 D F P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00747

TEST VALUE = -0.63933 STD. ERROR OF TEST VALUE 0.42770E-01

ASYMPTOTIC NORMAL STATISTIC = -14.947924 P-VALUE= 0.00000

WALD CHI-SQUARE STATISTIC = 223.44042 WITH 1 D F P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00448

\*\*\*\*\*

\* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 197.40843 WITH 5 D F P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02533

TEST VALUE = -0.72811E-01 STD. ERROR OF TEST VALUE 0.14833E-01

ASYMPTOTIC NORMAL STATISTIC = -4.9088022 P-VALUE= 0.00000

WALD CHI-SQUARE STATISTIC = 24.096339 WITH 1 D F P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.04150

\*\*\*\*\*

\* TESTING THETA = 0

\*\*\*\*\*

TEST VALUE = 0.33866 STD. ERROR OF TEST VALUE 0.31244

ASYMPTOTIC NORMAL STATISTIC = 1.0839435 P-VALUE= 0.27839

WALD CHI-SQUARE STATISTIC = 1.1749334 WITH 1 D F P-VALUE= 0.27839

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.85111

\*\*\*\*\*

\* GENERATING GOODNESS-OF-FIT R-SQUARE

\*\*\*\*\*

PRINT RSQ1 TESTFUL1

RSQ1 TESTFUL1

0.9999267 190.4267

STOP

#### INDUSTRY 321

\*\*\*\*\*

\* TESTING THE PRESENCE OF SCALE EFFECT

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 37.566027 WITH 5 D F P-VALUE= 0.00000

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.13310

TEST VALUE = -0.39847 STD. ERROR OF TEST VALUE 0.10310

ASYMPTOTIC NORMAL STATISTIC = -3.8650145 P-VALUE= 0.00011

WALD CHI-SQUARE STATISTIC = 14.938337 WITH 1 D F P-VALUE= 0.00011

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.06694

\*\*\*\*\*

\* TESTING THE PRESENCE OF TECHNICAL PROGRESS

\*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 26.118535 WITH 5 D F P-VALUE= 0.00008

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.19143

TEST VALUE = -0.15798E-01 STD. ERROR OF TEST VALUE 0.10151E-01

ASYMPTOTIC NORMAL STATISTIC = -1.5563944 P-VALUE= 0.11961

WALD CHI-SQUARE STATISTIC = 2.4223635 WITH 1 D F P-VALUE= 0.11961

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.41282

\*\*\*\*\*

\* TESTING THETA = 0

\*\*\*\*\*

TEST VALUE = 0.82206 STD. ERROR OF TEST VALUE 0.35084

ASYMPTOTIC NORMAL STATISTIC = 2.3430982 P-VALUE= 0.01912

WALD CHI-SQUARE STATISTIC = 5.4901090 WITH 1 D F P-VALUE= 0.01912

UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.18215

```

*****
[*] * GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0 9978588      122 9277
[*] STOP

```

#### INDUSTRY 322

```

*****
[*] * TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 794 66559 WITH 5 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00629
TEST VALUE = -0 41786 STD. ERROR OF TEST VALUE 0 51917E-01
ASYMPTOTIC NORMAL STATISTIC = -8.0486880 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 64 781379 WITH 1 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01544
*****
[*] * TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 61 099402 WITH 5 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 08183
TEST VALUE = 0 66379E-02 STD. ERROR OF TEST VALUE 0 15293E-02
ASYMPTOTIC NORMAL STATISTIC = 4 3405429 P-VALUE= 0.00001
WALD CHI-SQUARE STATISTIC = 18.840312 WITH 1 D.F P-VALUE= 0 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05308
*****
[*] * TESTING THETA = 0
*****
TEST VALUE = -0 39644 STD. ERROR OF TEST VALUE 0 16130
ASYMPTOTIC NORMAL STATISTIC = -2.4578553 P-VALUE= 0 01398
WALD CHI-SQUARE STATISTIC = 6 0410527 WITH 1 D.F P-VALUE= 0 01398
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 16553
*****
[*] * GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0.9981807      126 1865
[*] STOP

```

#### INDUSTRY 323

```

*****
[*] * TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 20.657829 WITH 5 D.F P-VALUE= 0 00094
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 24204
TEST VALUE = -1 5616 STD. ERROR OF TEST VALUE 0 60878
ASYMPTOTIC NORMAL STATISTIC = -2.5650719 P-VALUE= 0 01032
WALD CHI-SQUARE STATISTIC = 6.5795936 WITH 1 D.F P-VALUE= 0.01032
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 15199
*****
[*] * TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 3 3685070 WITH 5 D.F P-VALUE= 0 64337
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
TEST VALUE = -0.28976E-01 STD. ERROR OF TEST VALUE 0 53386E-01
ASYMPTOTIC NORMAL STATISTIC = -0 54276053 P-VALUE= 0.58729
WALD CHI-SQUARE STATISTIC = 0 29458899 WITH 1 D.F P-VALUE= 0 58729
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*] * TESTING THETA = 0
*****
TEST VALUE = 0 19156 STD. ERROR OF TEST VALUE 0.97735
ASYMPTOTIC NORMAL STATISTIC = 0.19600301 P-VALUE= 0 84461
WALD CHI-SQUARE STATISTIC = 0 38417179E-01 WITH 1 D.F P-VALUE= 0 84461
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*] * GENERATING GOODNESS-OF-FIT R-SQUARE

```

```

*****
PRINT RSQ1 TESTFUL1
  RSQ1      TESTFUL1
  0 9682846  69 01908
STOP

```

#### INDUSTRY 324

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 213 92967 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02337
TEST VALUE = -0 59187 STD ERROR OF TEST VALUE 0 72327E-01
ASYMPTOTIC NORMAL STATISTIC = -8 1832966 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 66 966344 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01493
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 231 59749 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02159
TEST VALUE = -0.46644E-01 STD ERROR OF TEST VALUE 0 50611E-02
ASYMPTOTIC NORMAL STATISTIC = -9 2161962 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 84 938272 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01177
*****
* TESTING THETA = 0
*****
TEST VALUE = 0.28598 STD. ERROR OF TEST VALUE 0 23488
ASYMPTOTIC NORMAL STATISTIC = 1 2175223 P-VALUE= 0.22341
WALD CHI-SQUARE STATISTIC = 1.4823606 WITH 1 D F P-VALUE= 0 22341
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.67460
*****
* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
  RSQ1      TESTFUL1
  0 9998928  182 8216
STOP

```

#### INDUSTRY 331

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 349 19729 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01432
TEST VALUE = -0.26685 STD ERROR OF TEST VALUE 0 74306E-01
ASYMPTOTIC NORMAL STATISTIC = -3 5912967 P-VALUE= 0 00033
WALD CHI-SQUARE STATISTIC = 12.897412 WITH 1 D F P-VALUE= 0.00033
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 07753
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 54 829909 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09119
TEST VALUE = 0.13173E-01 STD ERROR OF TEST VALUE 0 11654E-01
ASYMPTOTIC NORMAL STATISTIC = 1 1303682 P-VALUE= 0 25832
WALD CHI-SQUARE STATISTIC = 1 2777323 WITH 1 D F P-VALUE= 0 25832
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 78264
*****
* TESTING THETA = 0
*****
TEST VALUE = 0.69534 STD ERROR OF TEST VALUE 0 26134
ASYMPTOTIC NORMAL STATISTIC = 2.6606450 P-VALUE= 0 00780
WALD CHI-SQUARE STATISTIC = 7 0790319 WITH 1 D F P-VALUE= 0 00780
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.14126
*****
* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1

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```

      RSQ1      TESTFUL1
0 9977218    121 6876
└ STOP

```

### INDUSTRY 332

```

└ *****
└ * TESTING THE PRESENCE OF SCALE EFFECT
└ *****
WALD CHI-SQUARE STATISTIC = 153 35738 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03260
TEST VALUE = -0 23980 STD ERROR OF TEST VALUE 0 73234
ASYMPTOTIC NORMAL STATISTIC = -0 32743836 P-VALUE= 0 74334
WALD CHI-SQUARE STATISTIC = 0 10721588 WITH 1 D F P-VALUE= 0 74334
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└ *****
└ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
└ *****
WALD CHI-SQUARE STATISTIC = 5 6040115 WITH 5 D F P-VALUE= 0 34668
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 89222
TEST VALUE = -0.29798E-01 STD ERROR OF TEST VALUE 0 50720E-01
ASYMPTOTIC NORMAL STATISTIC = -0 58749170 P-VALUE= 0 55687
WALD CHI-SQUARE STATISTIC = 0 34514650 WITH 1 D F P-VALUE= 0.55687
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└ *****
└ * TESTING THETA = 0
└ *****
TEST VALUE = -0.55089 STD. ERROR OF TEST VALUE 0.74984
ASYMPTOTIC NORMAL STATISTIC = -0.73468363 P-VALUE= 0 46253
WALD CHI-SQUARE STATISTIC = 0 53976003 WITH 1 D F P-VALUE= 0 46253
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└ *****
└ * GENERATING GOODNESS-OF-FIT R-SQUARE
└ *****
└ PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0.8969566    45 45210
└ STOP

```

### INDUSTRY 341

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└ *****
└ * TESTING THE PRESENCE OF SCALE EFFECT
└ *****
WALD CHI-SQUARE STATISTIC = 856 32899 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00584
TEST VALUE = -0 68475 STD ERROR OF TEST VALUE 0 34248E-01
ASYMPTOTIC NORMAL STATISTIC = -19.994040 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 399 76164 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00250
└ *****
└ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
└ *****
WALD CHI-SQUARE STATISTIC = 513 30785 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00974
TEST VALUE = 0 44297E-01 STD ERROR OF TEST VALUE 0.25260E-02
ASYMPTOTIC NORMAL STATISTIC = 17 536013 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 307 51175 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00325
└ *****
└ * TESTING THETA = 0
└ *****
TEST VALUE = -0.61783E-01 STD ERROR OF TEST VALUE 0 63637E-01
ASYMPTOTIC NORMAL STATISTIC = -0.97087551 P-VALUE= 0 33161
WALD CHI-SQUARE STATISTIC = 0.94259925 WITH 1 D F P-VALUE= 0 33161
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└ *****
└ * GENERATING GOODNESS-OF-FIT R-SQUARE
└ *****
└ PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0 9991622    141.6939

```

\_STOP

#### INDUSTRY 342

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 505.71197 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00989
TEST VALUE = -0.27874 STD ERROR OF TEST VALUE 0 11719
ASYMPTOTIC NORMAL STATISTIC = -2 3785041 P-VALUE= 0 01738
WALD CHI-SQUARE STATISTIC = 5.6572817 WITH 1 D F P-VALUE= 0 01738
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 17676
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 42 964902 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.11637
TEST VALUE = -0.25449E-02 STD ERROR OF TEST VALUE 0 10679E-01
ASYMPTOTIC NORMAL STATISTIC = -0 23830411 P-VALUE= 0 81165
WALD CHI-SQUARE STATISTIC = 0 56788851E-01 WITH 1 D F P-VALUE= 0.81165
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
* TESTING THETA = 0
*****
TEST VALUE = 2 0615 STD ERROR OF TEST VALUE 0 69782
ASYMPTOTIC NORMAL STATISTIC = 2.9541477 P-VALUE= 0 00314
WALD CHI-SQUARE STATISTIC = 8 7269888 WITH 1 D F P-VALUE= 0 00314
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 11459
*****
* GENERATING GOODNESS-OF-FIT: R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0.9996364  158 3891
_STOP

```

#### INDUSTRY 351

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 104.22441 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04797
TEST VALUE = 0.49903 STD ERROR OF TEST VALUE 0 22007
ASYMPTOTIC NORMAL STATISTIC = 2 2676295 P-VALUE= 0 02335
WALD CHI-SQUARE STATISTIC = 5 1421438 WITH 1 D F P-VALUE= 0 02335
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.19447
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 49 319031 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 10138
TEST VALUE = -0 76927E-01 STD. ERROR OF TEST VALUE 0 32913E-01
ASYMPTOTIC NORMAL STATISTIC = -2.3372897 P-VALUE= 0 01942
WALD CHI-SQUARE STATISTIC = 5.4629231 WITH 1 D F P-VALUE= 0.01942
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 18305
*****
* TESTING THETA = 0
*****
TEST VALUE = -0 42836 STD ERROR OF TEST VALUE 0 48070
ASYMPTOTIC NORMAL STATISTIC = -0.89112009 P-VALUE= 0 37286
WALD CHI-SQUARE STATISTIC = 0.79409502 WITH 1 D F P-VALUE= 0 37286
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
* GENERATING GOODNESS-OF-FIT: R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0.9968372  115.1261
_STOP

```

## INDUSTRY 352

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 522.39146 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00957
TEST VALUE = -0.76058 STD. ERROR OF TEST VALUE 0.46388E-01
ASYMPTOTIC NORMAL STATISTIC = -16.396264 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 268.83748 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00372
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 221.66646 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02256
TEST VALUE = 0.46542E-01 STD. ERROR OF TEST VALUE 0.53710E-02
ASYMPTOTIC NORMAL STATISTIC = 8.6655079 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 75.091027 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01332
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0.26335 STD. ERROR OF TEST VALUE 0.15605
ASYMPTOTIC NORMAL STATISTIC = -1.6876036 P-VALUE= 0.09149
WALD CHI-SQUARE STATISTIC = 2.8480058 WITH 1 D.F. P-VALUE= 0.09149
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.35112
*****
[* GENERATING GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0.9995609    154.6138
STOP

```

## INDUSTRY 353

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 408.11702 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01225
TEST VALUE = -0.37047 STD. ERROR OF TEST VALUE 0.10913
ASYMPTOTIC NORMAL STATISTIC = -3.3947732 P-VALUE= 0.00069
WALD CHI-SQUARE STATISTIC = 11.524485 WITH 1 D.F. P-VALUE= 0.00069
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.08677
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 170.77698 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02928
TEST VALUE = -0.11234E-01 STD. ERROR OF TEST VALUE 0.56358E-02
ASYMPTOTIC NORMAL STATISTIC = -1.9933771 P-VALUE= 0.04622
WALD CHI-SQUARE STATISTIC = 3.9735524 WITH 1 D.F. P-VALUE= 0.04622
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.25166
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.28927E-01 STD. ERROR OF TEST VALUE 0.93365E-01
ASYMPTOTIC NORMAL STATISTIC = 0.30982822 P-VALUE= 0.75669
WALD CHI-SQUARE STATISTIC = 0.95993524E-01 WITH 1 D.F. P-VALUE= 0.75669
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0.9998834    181.1430
STOP

```

## INDUSTRY 356

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 68.625553 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 07286
TEST VALUE = -0 71473 STD ERROR OF TEST VALUE 0 12414
ASYMPTOTIC NORMAL STATISTIC = -5 7575578 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 33 149472 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 03017
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 68.009250 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 07352
TEST VALUE = 0.14735E-01 STD ERROR OF TEST VALUE 0 44824E-02
ASYMPTOTIC NORMAL STATISTIC = 3 2872684 P-VALUE= 0 00101
WALD CHI-SQUARE STATISTIC = 10 806134 WITH 1 D F P-VALUE= 0 00101
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09254
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 12854 STD ERROR OF TEST VALUE 0 11624
ASYMPTOTIC NORMAL STATISTIC = -1 1058226 P-VALUE= 0 26880
WALD CHI-SQUARE STATISTIC = 1 2228435 WITH 1 D F P-VALUE= 0.26880
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 81777
*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0 8991450 45.88143
STOP

```

## INDUSTRY 357

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 272.95048 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01832
TEST VALUE = -0.21286 STD ERROR OF TEST VALUE 0 63556E-01
ASYMPTOTIC NORMAL STATISTIC = -3 3492267 P-VALUE= 0 00081
WALD CHI-SQUARE STATISTIC = 11.217319 WITH 1 D F P-VALUE= 0 00081
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 08915
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 1440.5304 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00347
TEST VALUE = 0 62405E-01 STD ERROR OF TEST VALUE 0 22484E-02
ASYMPTOTIC NORMAL STATISTIC = 27 755740 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 770 38111 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00130
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 38804 STD ERROR OF TEST VALUE 0.94987E-01
ASYMPTOTIC NORMAL STATISTIC = 4 0852003 P-VALUE= 0 00004
WALD CHI-SQUARE STATISTIC = 16.688861 WITH 1 D F P-VALUE= 0 00004
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05992
*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0 9998805 180 6356
STOP

```

## INDUSTRY 361

```

*****
[*] * TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 43.699339 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 11442
TEST VALUE = -0 49333 STD ERROR OF TEST VALUE 0 12620
ASYMPTOTIC NORMAL STATISTIC = -3.9089488 P-VALUE= 0 00009
WALD CHI-SQUARE STATISTIC = 15.279881 WITH 1 D F P-VALUE= 0 00009
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06545
*****
[*] * TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 47.057193 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 10625
TEST VALUE = 0 75317E-01 STD ERROR OF TEST VALUE 0.43407E-01
ASYMPTOTIC NORMAL STATISTIC = 1.7351564 P-VALUE= 0 08271
WALD CHI-SQUARE STATISTIC = 3.0107679 WITH 1 D F P-VALUE= 0 08271
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 33214
*****
[*] * TESTING THETA = 0
*****
TEST VALUE = 0.97630E-01 STD ERROR OF TEST VALUE 0 11319
ASYMPTOTIC NORMAL STATISTIC = 0 86250019 P-VALUE= 0.38841
WALD CHI-SQUARE STATISTIC = 0 74390658 WITH 1 D F P-VALUE= 0 38841
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*] * GENERATING GOODNESS-OF-FIT R-SQUARE
*****
[PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0 9537747  61.48457
[STOP

```

## INDUSTRY 371

```

*****
[*] * TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 44.327997 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.11280
TEST VALUE = -0.10780 STD ERROR OF TEST VALUE 0 47151
ASYMPTOTIC NORMAL STATISTIC = -0 22862273 P-VALUE= 0.81916
WALD CHI-SQUARE STATISTIC = 0.52268354E-01 WITH 1 D F P-VALUE= 0 81916
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*] * TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 14 500754 WITH 5 D F P-VALUE= 0 01272
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 34481
TEST VALUE = -0 12728E-02 STD. ERROR OF TEST VALUE 0.20253E-01
ASYMPTOTIC NORMAL STATISTIC = -0.62844826E-01 P-VALUE= 0.94989
WALD CHI-SQUARE STATISTIC = 0 39494722E-02 WITH 1 D F P-VALUE= 0.94989
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*] * TESTING THETA = 0
*****
TEST VALUE = 0.17662 STD. ERROR OF TEST VALUE 0 26174
ASYMPTOTIC NORMAL STATISTIC = 0 67478328 P-VALUE= 0 49981
WALD CHI-SQUARE STATISTIC = 0.45533248 WITH 1 D F P-VALUE= 0 49981
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[*] * GENERATING GOODNESS-OF-FIT R-SQUARE
*****
[PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0 9750976  73.85578
[STOP

```



## INDUSTRY 372

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 16.809337 WITH 5 D.F P-VALUE= 0.00488
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.29745
TEST VALUE = -0.29617 STD. ERROR OF TEST VALUE 0.20420
ASYMPTOTIC NORMAL STATISTIC = -1.4503986 P-VALUE= 0.14695
WALD CHI-SQUARE STATISTIC = 2.1036560 WITH 1 D.F P-VALUE= 0.14695
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.47536
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 190.87080 WITH 5 D.F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02620
TEST VALUE = 0.46019E-01 STD. ERROR OF TEST VALUE 0.55346E-02
ASYMPTOTIC NORMAL STATISTIC = 8.3146620 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 69.133604 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01446
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.19862 STD. ERROR OF TEST VALUE 0.14482
ASYMPTOTIC NORMAL STATISTIC = 1.3715062 P-VALUE= 0.17022
WALD CHI-SQUARE STATISTIC = 1.8810293 WITH 1 D.F. P-VALUE= 0.17022
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.53162
*****
[* GENERATING GOODNESS-OF-FIT: R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0.9920693  96.74035
STOP

```

## INDUSTRY 381

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 374.18180 WITH 5 D.F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01336
TEST VALUE = -0.61134 STD. ERROR OF TEST VALUE 0.76540E-01
ASYMPTOTIC NORMAL STATISTIC = -7.9871933 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 63.795257 WITH 1 D.F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01568
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 201.87649 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02477
TEST VALUE = 0.42963E-01 STD. ERROR OF TEST VALUE 0.38785E-02
ASYMPTOTIC NORMAL STATISTIC = 11.077253 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 122.70553 WITH 1 D.F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00815
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.16887E-01 STD. ERROR OF TEST VALUE 0.13602
ASYMPTOTIC NORMAL STATISTIC = 0.12415330 P-VALUE= 0.90119
WALD CHI-SQUARE STATISTIC = 0.15414043E-01 WITH 1 D.F P-VALUE= 0.90119
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
      0.9981908  126.2974
STOP

```

## INDUSTRY 382

```

*****

```

```

[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 1170 0290 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00427
TEST VALUE = -0 29970 STD. ERROR OF TEST VALUE 0 93100E-01
ASYMPTOTIC NORMAL STATISTIC = -3.2191607 P-VALUE= 0 00129
WALD CHI-SQUARE STATISTIC = 10.362996 WITH 1 D F P-VALUE= 0 00129
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09650
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 12.574623 WITH 5 D F P-VALUE= 0 02771
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 39763
TEST VALUE = -0.93359E-02 STD. ERROR OF TEST VALUE 0.75519E-02
ASYMPTOTIC NORMAL STATISTIC = -1.2362339 P-VALUE= 0.21637
WALD CHI-SQUARE STATISTIC = 1.5282743 WITH 1 D F P-VALUE= 0 21637
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 65433
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.12362 STD. ERROR OF TEST VALUE 0 24678
ASYMPTOTIC NORMAL STATISTIC = 0 50092871 P-VALUE= 0 61642
WALD CHI-SQUARE STATISTIC = 0 25092957 WITH 1 D F P-VALUE= 0 61642
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0 9985259      130 3940
STOP

```

#### INDUSTRY 383

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 787 71794 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00635
TEST VALUE = 0.51610 STD. ERROR OF TEST VALUE 0.36013
ASYMPTOTIC NORMAL STATISTIC = 1.4330635 P-VALUE= 0 15184
WALD CHI-SQUARE STATISTIC = 2.0536709 WITH 1 D F P-VALUE= 0 15184
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.48693
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 15 593933 WITH 5 D F P-VALUE= 0 00810
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.32064
TEST VALUE = -0 58391E-01 STD. ERROR OF TEST VALUE 0.31786E-01
ASYMPTOTIC NORMAL STATISTIC = -1 8370363 P-VALUE= 0 06620
WALD CHI-SQUARE STATISTIC = 3 3747025 WITH 1 D F P-VALUE= 0 06620
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 29632
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 16315 STD. ERROR OF TEST VALUE 0 64679
ASYMPTOTIC NORMAL STATISTIC = 0.25224171 P-VALUE= 0 80085
WALD CHI-SQUARE STATISTIC = 0 63625881E-01 WITH 1 D F P-VALUE= 0 80085
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0.9992467      143.8205
STOP

```

#### INDUSTRY 384

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

WALD CHI-SQUARE STATISTIC = 934 08419 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00535
TEST VALUE = -0 57572 STD. ERROR OF TEST VALUE 0 53087E-01
ASYMPTOTIC NORMAL STATISTIC = -10 844918 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 117.61224 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00850

```

```

*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****

```

```

WALD CHI-SQUARE STATISTIC = 359 82010 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01390
TEST VALUE = 0.68391E-01 STD. ERROR OF TEST VALUE 0 76719E-02
ASYMPTOTIC NORMAL STATISTIC = 8 9145183 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 79 468636 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01258

```

```

*****
[* TESTING THETA = 0
*****

```

```

TEST VALUE = 0 32339 STD ERROR OF TEST VALUE 0 27147
ASYMPTOTIC NORMAL STATISTIC = 1.1912336 P-VALUE= 0 23356
WALD CHI-SQUARE STATISTIC = 1 4190376 WITH 1 D F P-VALUE= 0 23356
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.70470

```

```

*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****

```

```

PRINT RSQ1 TESTFUL1
RSQ1 TESTFUL1
0 9954370 107 7954
STOP

```

#### INDUSTRY 385

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

WALD CHI-SQUARE STATISTIC = 611.82014 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00817
TEST VALUE = -0 45840 STD ERROR OF TEST VALUE 0 11410
ASYMPTOTIC NORMAL STATISTIC = -4 0177061 P-VALUE= 0 00006
WALD CHI-SQUARE STATISTIC = 16.141962 WITH 1 D F P-VALUE= 0 00006
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06195

```

```

*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****

```

```

WALD CHI-SQUARE STATISTIC = 73.952669 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.06761
TEST VALUE = -0 19477E-01 STD ERROR OF TEST VALUE 0 83300E-02
ASYMPTOTIC NORMAL STATISTIC = -2.3382035 P-VALUE= 0 01938
WALD CHI-SQUARE STATISTIC = 5 4671958 WITH 1 D F P-VALUE= 0 01938
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 18291

```

```

*****
[* TESTING THETA = 0
*****

```

```

TEST VALUE = 0 31312E-02 STD ERROR OF TEST VALUE 0 19197
ASYMPTOTIC NORMAL STATISTIC = 0.16311150E-01 P-VALUE= 0 98699
WALD CHI-SQUARE STATISTIC = 0 26605363E-03 WITH 1 D F P-VALUE= 0 98699
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000

```

```

*****
[* GENERATING GOODNESS-OF-FIT R-SQUARE
*****

```

```

PRINT RSQ1 TESTFUL1
RSQ1 TESTFUL1
0 9982370 126 8152
STOP

```

#### INDUSTRY 386

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

WALD CHI-SQUARE STATISTIC = 379.91488 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01316

```

```
TEST VALUE = -0.58186   STD. ERROR OF TEST VALUE 0.58215E-01
ASYMPTOTIC NORMAL STATISTIC = -9.9951139   P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 99.902301   WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01001
```

```
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
```

```
WALD CHI-SQUARE STATISTIC = 71.910700   WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.06953
TEST VALUE = 0.29398E-01   STD. ERROR OF TEST VALUE 0.45179E-02
ASYMPTOTIC NORMAL STATISTIC = 6.5070716   P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 42.341981   WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02362
```

```
*****
[* TESTING THETA = 0
*****
```

```
TEST VALUE = 0.53771   STD. ERROR OF TEST VALUE 0.31473
ASYMPTOTIC NORMAL STATISTIC = 1.7085110   P-VALUE= 0.08754
WALD CHI-SQUARE STATISTIC = 2.9190098   WITH 1 D.F. P-VALUE= 0.08754
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.34258
```

```
*****
[* GENERATING GOODNESS-OF-FIT: R-SQUARE
*****
```

```
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0.9998143      171.8328
STOP
```

#### INDUSTRY 390

```
*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
```

```
WALD CHI-SQUARE STATISTIC = 544.98398   WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00917
TEST VALUE = -0.75258   STD. ERROR OF TEST VALUE 0.43071E-01
ASYMPTOTIC NORMAL STATISTIC = -17.473125   P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 305.31010   WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00328
```

```
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
```

```
WALD CHI-SQUARE STATISTIC = 394.47253   WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01268
TEST VALUE = 0.59807E-01   STD. ERROR OF TEST VALUE 0.33698E-02
ASYMPTOTIC NORMAL STATISTIC = 17.747861   P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 314.98658   WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00317
```

```
*****
[* TESTING THETA = 0
*****
```

```
TEST VALUE = -0.21185   STD. ERROR OF TEST VALUE 0.11975
ASYMPTOTIC NORMAL STATISTIC = -1.7690737   P-VALUE= 0.07688
WALD CHI-SQUARE STATISTIC = 3.1296218   WITH 1 D.F. P-VALUE= 0.07688
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.31953
```

```
*****
[* GENERATING GOODNESS-OF-FIT: R-SQUARE
*****
```

```
PRINT RSQ1 TESTFUL1
      RSQ1      TESTFUL1
0.9898774      91.85966
STOP
```

## APPENDIX J

### EDITED SHAZAM COMPUTER OUTPUT FOR THE INTEGRATED MODEL (LINEAR DEMAND)

This appendix gives the edited Shazam output for estimates and test statistics presented in Table 6.5. We add one to the test value of ECY to obtain the ECY estimate. All other estimates are given directly by the test values.

#### INDUSTRY 314

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 318.57391 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01569
TEST VALUE = -0.73380 STD ERROR OF TEST VALUE 0.13902
ASYMPTOTIC NORMAL STATISTIC = -5.2782244 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 27.859653 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03589
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 203.94201 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02452
TEST VALUE = -0.37915E-01 STD ERROR OF TEST VALUE 0.33629E-01
ASYMPTOTIC NORMAL STATISTIC = -1.1274434 P-VALUE= 0.25956
WALD CHI-SQUARE STATISTIC = 1.2711286 WITH 1 D.F. P-VALUE= 0.25956
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.78670
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.12870 STD ERROR OF TEST VALUE 0.50381
ASYMPTOTIC NORMAL STATISTIC = 0.25544723 P-VALUE= 0.79838
WALD CHI-SQUARE STATISTIC = 0.65253287E-01 WITH 1 D.F. P-VALUE= 0.79838
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT: R-SQUARE
*****
PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
      0.9985464    130.6741
STOP

```

#### INDUSTRY 321

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 27.051262 WITH 5 D.F. P-VALUE= 0.00006
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.18483
TEST VALUE = -0.46535 STD ERROR OF TEST VALUE 0.17047
ASYMPTOTIC NORMAL STATISTIC = -2.7298125 P-VALUE= 0.00634
WALD CHI-SQUARE STATISTIC = 7.4518761 WITH 1 D.F. P-VALUE= 0.00634
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.13419
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 44.533939 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.11227
TEST VALUE = -0.29849E-01 STD ERROR OF TEST VALUE 0.12051E-01
ASYMPTOTIC NORMAL STATISTIC = -2.4768276 P-VALUE= 0.01326
WALD CHI-SQUARE STATISTIC = 6.1346747 WITH 1 D.F. P-VALUE= 0.01326
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.16301
*****
[* TESTING THETA = 0
*****
TEST VALUE = 1.3453 STD ERROR OF TEST VALUE 1.6865
ASYMPTOTIC NORMAL STATISTIC = 0.79766502 P-VALUE= 0.42506

```

WALD CHI-SQUARE STATISTIC = 0 63626948 WITH 1 D F P-VALUE= 0 42506  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000

\*\*\*\*\*  
 \* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE  
 \*\*\*\*\*

\_PRINT RSQ2 TESTFUL2  
       RSQ2      TESTFUL2  
 0 9944550      103 8973  
 \_STOP

#### INDUSTRY 324

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF SCALE EFFECT  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 2422 3166 WITH 5 D F P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00206  
 TEST VALUE = -0 73426 STD ERROR OF TEST VALUE 0 93669E-02  
 ASYMPTOTIC NORMAL STATISTIC = -78.388717 P-VALUE= 0 00000  
 WALD CHI-SQUARE STATISTIC = 6144 7909 WITH 1 D F P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00016

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 297 34174 WITH 5 D.F. P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01682  
 TEST VALUE = -0.55331E-01 STD ERROR OF TEST VALUE 0.32617E-02  
 ASYMPTOTIC NORMAL STATISTIC = -16 963555 P-VALUE= 0 00000  
 WALD CHI-SQUARE STATISTIC = 287 76219 WITH 1 D F P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00348

\*\*\*\*\*  
 \* TESTING THETA = 0  
 \*\*\*\*\*  
 TEST VALUE = -0.24401 STD. ERROR OF TEST VALUE 0 32174E-01  
 ASYMPTOTIC NORMAL STATISTIC = -7.5839171 P-VALUE= 0 00000  
 WALD CHI-SQUARE STATISTIC = 57 515798 WITH 1 D F P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01739

\*\*\*\*\*  
 \* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE  
 \*\*\*\*\*

\_PRINT RSQ2 TESTFUL2  
       RSQ2      TESTFUL2  
 0.9999409      194.7241  
 \_STOP

#### INDUSTRY 331

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF SCALE EFFECT  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 823 29820 WITH 5 D F P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00607  
 TEST VALUE = -0.22298 STD. ERROR OF TEST VALUE 0 74561E-01  
 ASYMPTOTIC NORMAL STATISTIC = -2 9906331 P-VALUE= 0 00278  
 WALD CHI-SQUARE STATISTIC = 8.9438863 WITH 1 D F P-VALUE= 0 00278  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 11181

\*\*\*\*\*  
 \* TESTING THE PRESENCE OF TECHNICAL PROGRESS  
 \*\*\*\*\*

WALD CHI-SQUARE STATISTIC = 71 850692 WITH 5 D F P-VALUE= 0 00000  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06959  
 TEST VALUE = 0 18565E-01 STD ERROR OF TEST VALUE 0 11624E-01  
 ASYMPTOTIC NORMAL STATISTIC = 1 5970983 P-VALUE= 0 11024  
 WALD CHI-SQUARE STATISTIC = 2 5507231 WITH 1 D F P-VALUE= 0 11024  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 39205

\*\*\*\*\*  
 \* TESTING THETA = 0  
 \*\*\*\*\*

TEST VALUE = 1 2575 STD. ERROR OF TEST VALUE 0 34309  
 ASYMPTOTIC NORMAL STATISTIC = 3 6652513 P-VALUE= 0 00025  
 WALD CHI-SQUARE STATISTIC = 13 434067 WITH 1 D F P-VALUE= 0 00025  
 UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 07444

```

*****
* GENERATING OVERALL GOODNESS-OF-FIT: R-SQUARE
*****
PRINT RSQ2 TESTFUL2
  RSQ2      TESTFUL2
0 9979656   123 9511
_STOP

```

#### INDUSTRY 341

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 303.68884 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01646
TEST VALUE = -0.65903 STD ERROR OF TEST VALUE 0.42903E-01
ASYMPTOTIC NORMAL STATISTIC = -15.360746 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 235.95252 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00424
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 834.17253 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00599
TEST VALUE = 0.45262E-01 STD. ERROR OF TEST VALUE 0.24576E-02
ASYMPTOTIC NORMAL STATISTIC = 18.416898 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 339.18214 WITH 1 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00295
*****
* TESTING THETA = 0
*****
TEST VALUE = -0.13278E-01 STD ERROR OF TEST VALUE 0.64772E-01
ASYMPTOTIC NORMAL STATISTIC = -0.20500376 P-VALUE= 0.83757
WALD CHI-SQUARE STATISTIC = 0.42026542E-01 WITH 1 D F P-VALUE= 0.83757
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ2 TESTFUL2
  RSQ2      TESTFUL2
0.9990269   138 6997
_STOP

```

#### INDUSTRY 342

```

*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 480.14466 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01041
TEST VALUE = -0.40001 STD ERROR OF TEST VALUE 0.10624
ASYMPTOTIC NORMAL STATISTIC = -3.7652304 P-VALUE= 0.00017
WALD CHI-SQUARE STATISTIC = 14.176960 WITH 1 D F P-VALUE= 0.00017
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07054
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 63.504017 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07874
TEST VALUE = 0.10882E-01 STD ERROR OF TEST VALUE 0.94353E-02
ASYMPTOTIC NORMAL STATISTIC = 1.1533125 P-VALUE= 0.24878
WALD CHI-SQUARE STATISTIC = 1.3301296 WITH 1 D F P-VALUE= 0.24878
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.75181
*****
* TESTING THETA = 0
*****
TEST VALUE = 0.38007E-01 STD. ERROR OF TEST VALUE 0.10354
ASYMPTOTIC NORMAL STATISTIC = 0.36706223 P-VALUE= 0.71357
WALD CHI-SQUARE STATISTIC = 0.13473468 WITH 1 D F P-VALUE= 0.71357
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE

```

```

*****
PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
0 9998972      183 6542
STOP

INDUSTRY 351
*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 119 08759 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 04199
TEST VALUE = -0.15962 STD. ERROR OF TEST VALUE 0.49293
ASYMPTOTIC NORMAL STATISTIC = -0.32382830 P-VALUE= 0 74607
WALD CHI-SQUARE STATISTIC = 0 10486477 WITH 1 D F P-VALUE= 0 74607
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 98.999755 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05051
TEST VALUE = 0 42640E-02 STD. ERROR OF TEST VALUE 0 44882E-01
ASYMPTOTIC NORMAL STATISTIC = 0 95003889E-01 P-VALUE= 0 92431
WALD CHI-SQUARE STATISTIC = 0 90257389E-02 WITH 1 D F P-VALUE= 0.92431
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
* TESTING THETA = 0
*****
TEST VALUE = 0 96635 STD. ERROR OF TEST VALUE 3 1125
ASYMPTOTIC NORMAL STATISTIC = 0 31047096 P-VALUE= 0 75620
WALD CHI-SQUARE STATISTIC = 0.96392216E-01 WITH 1 D F P-VALUE= 0 75620
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
0 9965956      113.6540
STOP

```

```

INDUSTRY 352
*****
* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 447 55219 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01117
TEST VALUE = -0.80315 STD. ERROR OF TEST VALUE 0.41064E-01
ASYMPTOTIC NORMAL STATISTIC = -19.558426 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 382 53203 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00261
*****
* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 190.38415 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.02626
TEST VALUE = 0 49199E-01 STD. ERROR OF TEST VALUE 0 56577E-02
ASYMPTOTIC NORMAL STATISTIC = 8 6959935 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 75 620303 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01322
*****
* TESTING THETA = 0
*****
TEST VALUE = -0.50345 STD. ERROR OF TEST VALUE 1 0967
ASYMPTOTIC NORMAL STATISTIC = -0 45905234 P-VALUE= 0 64620
WALD CHI-SQUARE STATISTIC = 0 21072905 WITH 1 D F P-VALUE= 0 64620
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ2 TESTFUL2

```



```

      RSQ2      TESTFUL2
0 9391757    55.99531
└ STOP

```

### INDUSTRY 353

```

└ *****
└ * TESTING THE PRESENCE OF SCALE EFFECT
└ *****
WALD CHI-SQUARE STATISTIC = 35 999563 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.13889
TEST VALUE = -0 62394 STD ERROR OF TEST VALUE 0.22723
ASYMPTOTIC NORMAL STATISTIC = -2.7458476 P-VALUE= 0 00604
WALD CHI-SQUARE STATISTIC = 7 5396789 WITH 1 D F P-VALUE= 0 00604
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 13263
└ *****
└ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
└ *****
WALD CHI-SQUARE STATISTIC = 25.782539 WITH 5 D F P-VALUE= 0 00010
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 19393
TEST VALUE = -0.11939E-02 STD. ERROR OF TEST VALUE 0.10064E-01
ASYMPTOTIC NORMAL STATISTIC = -0.11862382 P-VALUE= 0.90557
WALD CHI-SQUARE STATISTIC = 0.14071611E-01 WITH 1 D F P-VALUE= 0.90557
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
└ *****
└ * TESTING THETA = 0
└ *****
TEST VALUE = 1.0000 STD. ERROR OF TEST VALUE 1.3638
ASYMPTOTIC NORMAL STATISTIC = 0.73322450 P-VALUE= 0.46342
WALD CHI-SQUARE STATISTIC = 0.53761816 WITH 1 D F P-VALUE= 0 46342
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
└ *****
└ * GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
└ *****
└ PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
0.9024549    46.54881
└ STOP

```

### INDUSTRY 357

```

└ *****
└ * TESTING THE PRESENCE OF SCALE EFFECT
└ *****
WALD CHI-SQUARE STATISTIC = 19 934356 WITH 5 D F P-VALUE= 0 00129
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 25082
TEST VALUE = -0.31206 STD. ERROR OF TEST VALUE 0 11708
ASYMPTOTIC NORMAL STATISTIC = -2.6653498 P-VALUE= 0 00769
WALD CHI-SQUARE STATISTIC = 7 1040893 WITH 1 D F P-VALUE= 0 00769
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.14076
└ *****
└ * TESTING THE PRESENCE OF TECHNICAL PROGRESS
└ *****
WALD CHI-SQUARE STATISTIC = 1004 0531 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00498
TEST VALUE = 0.66575E-01 STD ERROR OF TEST VALUE 0 35968E-02
ASYMPTOTIC NORMAL STATISTIC = 18.509438 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 342 59931 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00292
└ *****
└ * TESTING THETA = 0
└ *****
TEST VALUE = 0.33535 STD ERROR OF TEST VALUE 0 21015
ASYMPTOTIC NORMAL STATISTIC = 1.5957122 P-VALUE= 0 11055
WALD CHI-SQUARE STATISTIC = 2.5462974 WITH 1 D F P-VALUE= 0 11055
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.39273
└ *****
└ * GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
└ *****
└ PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
0 9973963    119 0163

```

\_STOP

#### INDUSTRY 361

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 27 444114 WITH 5 D F P-VALUE= 0 00005
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 18219
TEST VALUE = -0 44099 STD ERROR OF TEST VALUE 0 20184
ASYMPTOTIC NORMAL STATISTIC = -2.1849024 P-VALUE= 0 02890
WALD CHI-SQUARE STATISTIC = 4 7737984 WITH 1 D F P-VALUE= 0 02890
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 20948
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 51.506190 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09708
TEST VALUE = 0.78936E-01 STD. ERROR OF TEST VALUE 0 38367E-01
ASYMPTOTIC NORMAL STATISTIC = 2.0573814 P-VALUE= 0 03965
WALD CHI-SQUARE STATISTIC = 4.2328181 WITH 1 D F P-VALUE= 0 03965
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 23625
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0 82799E-01 STD ERROR OF TEST VALUE 0 37600
ASYMPTOTIC NORMAL STATISTIC = -0.22020937 P-VALUE= 0 82571
WALD CHI-SQUARE STATISTIC = 0.48492168E-01 WITH 1 D F P-VALUE= 0 82571
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ2 TESTFUL2
  RSQ2      TESTFUL2
0.9537672  61.48131
_STOP

```

#### INDUSTRY 371

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 53 797498 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09294
TEST VALUE = -0 44195 STD ERROR OF TEST VALUE 0 27989
ASYMPTOTIC NORMAL STATISTIC = -1.5790323 P-VALUE= 0 11433
WALD CHI-SQUARE STATISTIC = 2 4933431 WITH 1 D F P-VALUE= 0.11433
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 40107
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 30 375894 WITH 5 D F P-VALUE= 0 00001
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 16460
TEST VALUE = 0 12736E-02 STD ERROR OF TEST VALUE 0.14622E-01
ASYMPTOTIC NORMAL STATISTIC = 0 87102124E-01 P-VALUE= 0 93059
WALD CHI-SQUARE STATISTIC = 0 75867800E-02 WITH 1 D F P-VALUE= 0 93059
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 24479 STD ERROR OF TEST VALUE 0 33946
ASYMPTOTIC NORMAL STATISTIC = 0 72110984 P-VALUE= 0 47084
WALD CHI-SQUARE STATISTIC = 0.51999940 WITH 1 D F P-VALUE= 0.47084
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ2 TESTFUL2
  RSQ2      TESTFUL2
0.4601505  12.32930
_STOP

```

INDUSTRY 372

```
*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 114 04090 WITH 5 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.04384
TEST VALUE = -2.3557 STD. ERROR OF TEST VALUE 0 30398
ASYMPTOTIC NORMAL STATISTIC = -7.7494587 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 60 054110 WITH 1 D.F. P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01665
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 251 19404 WITH 5 D F P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01990
TEST VALUE = 0.56488E-01 STD ERROR OF TEST VALUE 0 72479E-02
ASYMPTOTIC NORMAL STATISTIC = 7.7937683 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 60.742824 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01646
*****
[* TESTING THETA = 0
*****
TEST VALUE = 10.319 STD. ERROR OF TEST VALUE 19.751
ASYMPTOTIC NORMAL STATISTIC = 0.52244688 P-VALUE= 0 60136
WALD CHI-SQUARE STATISTIC = 0.27295075 WITH 1 D F. P-VALUE= 0 60136
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ2 TESTFUL2
RSQ2 TESTFUL2
0.5547418 16 18202
STOP
```

INDUSTRY 382

```
*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 138.57219 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.03608
TEST VALUE = -0 40583 STD ERROR OF TEST VALUE 0 12641
ASYMPTOTIC NORMAL STATISTIC = -3 2103782 P-VALUE= 0 00133
WALD CHI-SQUARE STATISTIC = 10.306528 WITH 1 D F P-VALUE= 0 00133
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 09703
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 9.3712406 WITH 5 D F P-VALUE= 0 09514
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 53355
TEST VALUE = 0.42140E-02 STD ERROR OF TEST VALUE 0 12681E-01
ASYMPTOTIC NORMAL STATISTIC = 0 33232000 P-VALUE= 0.73965
WALD CHI-SQUARE STATISTIC = 0.11043658 WITH 1 D F P-VALUE= 0 73965
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0.57935E-01 STD ERROR OF TEST VALUE 0 18483
ASYMPTOTIC NORMAL STATISTIC = 0 31345363 P-VALUE= 0.75394
WALD CHI-SQUARE STATISTIC = 0 98253179E-01 WITH 1 D F P-VALUE= 0 75394
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
PRINT RSQ2 TESTFUL2
RSQ2 TESTFUL2
0.9895277 91 18034
STOP
```

INDUSTRY 383

```
*****
```

```

[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 2540.2907 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00197
TEST VALUE = -0 64623 STD ERROR OF TEST VALUE 0 43612E-01
ASYMPTOTIC NORMAL STATISTIC = -14.817757 P-VALUE= 0 00000
WALD CHI-SQUARE STATISTIC = 219 56593 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00455
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 252.20367 WITH 5 D.F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 01983
TEST VALUE = 0 43177E-01 STD ERROR OF TEST VALUE 0 33357E-02
ASYMPTOTIC NORMAL STATISTIC = 12.943735 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 167.54028 WITH 1 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00597
*****
[* TESTING THETA = 0
*****
TEST VALUE = 0 17466E-01 STD ERROR OF TEST VALUE 0 58522E-01
ASYMPTOTIC NORMAL STATISTIC = 0.29844616 P-VALUE= 0 76536
WALD CHI-SQUARE STATISTIC = 0.89070113E-01 WITH 1 D F P-VALUE= 0 76536
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ2 TESTFUL2
RSQ2 TESTFUL2
0.9999685 207.3077
STOP

```

#### INDUSTRY 384

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****
WALD CHI-SQUARE STATISTIC = 59 423290 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 08414
TEST VALUE = -0.64971E-01 STD ERROR OF TEST VALUE 0 85153E-01
ASYMPTOTIC NORMAL STATISTIC = -0.76298898 P-VALUE= 0 44547
WALD CHI-SQUARE STATISTIC = 0 58215219 WITH 1 D F P-VALUE= 0 44547
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 82 134314 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 06088
TEST VALUE = -0 14141E-01 STD ERROR OF TEST VALUE 0.16185E-01
ASYMPTOTIC NORMAL STATISTIC = -0.87370647 P-VALUE= 0 38228
WALD CHI-SQUARE STATISTIC = 0 76336299 WITH 1 D.F P-VALUE= 0 38228
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* TESTING THETA = 0
*****
TEST VALUE = 2 9149 STD. ERROR OF TEST VALUE 3 7616
ASYMPTOTIC NORMAL STATISTIC = 0 77492887 P-VALUE= 0 43838
WALD CHI-SQUARE STATISTIC = 0 60051475 WITH 1 D.F. P-VALUE= 0 43838
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT. R-SQUARE
*****
PRINT RSQ2 TESTFUL2
RSQ2 TESTFUL2
0 9549526 62 00081
STOP

```

#### INDUSTRY 385

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

WALD CHI-SQUARE STATISTIC = 93.981887 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.05320
TEST VALUE = -0.43161 STD ERROR OF TEST VALUE 0 19004
ASYMPTOTIC NORMAL STATISTIC = -2.2711324 P-VALUE= 0 02314
WALD CHI-SQUARE STATISTIC = 5 1580425 WITH 1 D F P-VALUE= 0 02314
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 19387

```

```

*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****

```

```

WALD CHI-SQUARE STATISTIC = 67 847234 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.07369
TEST VALUE = -0 16684E-01 STD ERROR OF TEST VALUE 0 17897E-01
ASYMPTOTIC NORMAL STATISTIC = -0.93221003 P-VALUE= 0 35123
WALD CHI-SQUARE STATISTIC = 0 86901554 WITH 1 D F P-VALUE= 0 35123
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000

```

```

*****
[* TESTING THETA = 0
*****

```

```

TEST VALUE = 0 33396 STD ERROR OF TEST VALUE 0 29448
ASYMPTOTIC NORMAL STATISTIC = 1 1340738 P-VALUE= 0.25676
WALD CHI-SQUARE STATISTIC = 1 2861235 WITH 1 D F P-VALUE= 0 25676
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.77753

```

```

*****
[* GENERATING OVERALL GOODNESS-OF-FIT: R-SQUARE
*****

```

```

PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
0.8509111  38 06425
STOP

```

#### INDUSTRY 386

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

WALD CHI-SQUARE STATISTIC = 46.931064 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 10654
TEST VALUE = -0 67019 STD ERROR OF TEST VALUE 0.15670
ASYMPTOTIC NORMAL STATISTIC = -4.2769678 P-VALUE= 0 00002
WALD CHI-SQUARE STATISTIC = 18 292453 WITH 1 D F P-VALUE= 0 00002
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 05467

```

```

*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****

```

```

WALD CHI-SQUARE STATISTIC = 18 299179 WITH 5 D F P-VALUE= 0 00259
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.27324
TEST VALUE = 0.42927E-01 STD. ERROR OF TEST VALUE 0 17633E-01
ASYMPTOTIC NORMAL STATISTIC = 2 4344456 P-VALUE= 0 01491
WALD CHI-SQUARE STATISTIC = 5.9265255 WITH 1 D F P-VALUE= 0 01491
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 16873

```

```

*****
[* TESTING THETA = 0
*****

```

```

TEST VALUE = 0.16098 STD ERROR OF TEST VALUE 0 71856
ASYMPTOTIC NORMAL STATISTIC = 0 22403011 P-VALUE= 0.82273
WALD CHI-SQUARE STATISTIC = 0 50189492E-01 WITH 1 D F P-VALUE= 0 82273
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1 00000

```

```

*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****

```

```

PRINT RSQ2 TESTFUL2
      RSQ2      TESTFUL2
0.9953708  107 5074
STOP

```

#### INDUSTRY 390

```

*****
[* TESTING THE PRESENCE OF SCALE EFFECT
*****

```

```

WALD CHI-SQUARE STATISTIC = 919 22082 WITH 5 D F P-VALUE= 0 00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0 00544

```

```
TEST VALUE = -0.61611 STD. ERROR OF TEST VALUE 0.46183E-01
ASYMPTOTIC NORMAL STATISTIC = -13.340601 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 177.97163 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00562
*****
[* TESTING THE PRESENCE OF TECHNICAL PROGRESS
*****
WALD CHI-SQUARE STATISTIC = 391.18965 WITH 5 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.01278
TEST VALUE = 0.59742E-01 STD. ERROR OF TEST VALUE 0.33649E-02
ASYMPTOTIC NORMAL STATISTIC = 17.754231 P-VALUE= 0.00000
WALD CHI-SQUARE STATISTIC = 315.21271 WITH 1 D.F. P-VALUE= 0.00000
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 0.00317
*****
[* TESTING THETA = 0
*****
TEST VALUE = -0.97665E-02 STD. ERROR OF TEST VALUE 0.68761E-01
ASYMPTOTIC NORMAL STATISTIC = -0.14203617 P-VALUE= 0.88705
WALD CHI-SQUARE STATISTIC = 0.20174273E-01 WITH 1 D.F. P-VALUE= 0.88705
UPPER BOUND ON P-VALUE BY CHEBYCHEV INEQUALITY = 1.00000
*****
[* GENERATING OVERALL GOODNESS-OF-FIT R-SQUARE
*****
[* PRINT RSQ2 TESTFUL2
RSQ2 TESTFUL2
0.9988501 135.3623 [* STOP
```

**INDUSTRIAL DATA: FOOD (SSIC#: 311/2)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.798	0.457	45.66	47.90	693.80	39.72	0.993	0.353	0.838	0.627	0.630	0.868	0.449	1.576
1976	0.862	0.471	43.13	51.80	780.50	39.6	0.976	0.388	0.888	0.694	0.572	0.852	0.477	1.420
1977	1.045	0.504	42.95	58.20	1020.20	39.51	0.990	0.406	0.982	0.705	0.563	0.915	0.564	1.395
1978	1.053	0.505	39.77	65.80	1022.20	40.05	1.025	0.439	0.902	0.709	0.511	0.958	0.615	1.405
1979	1.141	0.551	42.07	79.10	1207.50	39.24	1.128	0.499	0.953	0.782	0.515	1.013	0.688	1.248
1980	1.176	0.611	54.12	87.80	1334.45	39.24	1.361	0.561	1.029	1.008	0.596	1.000	0.704	0.969
1981	1.129	0.648	70.41	103.40	1274.83	41.67	1.261	0.659	1.047	1.060	0.717	1.002	0.661	0.980
1982	1.094	0.712	73.84	115.20	1416.73	36.82	1.120	0.725	0.999	1.086	0.752	1.015	0.770	0.844
1983	1.012	0.826	90.56	129.70	1511.93	39.44	1.100	0.808	0.979	1.031	0.907	1.025	0.838	0.953
1984	1.000	0.968	102.89	148.30	1790.22	39.82	1.124	0.927	1.007	1.008	1.030	1.022	0.965	0.984
1985	1.000	0.999	97.59	156.50	1842.59	40.15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.094	0.869	97.57	149.40	1739.18	31.14	0.938	0.999	0.999	0.884	1.017	0.955	0.945	0.877
1987	1.109	0.731	93.78	154.20	1372.88	30.52	0.938	0.975	1.009	0.803	0.953	1.011	0.738	0.947
1988	1.208	0.756	102.96	167.40	1534.88	31.13	0.940	1.033	1.056	0.806	0.993	1.025	0.789	0.962
1989	1.244	0.775	107.55	186.60	1604.90	32.06	0.946	1.154	1.087	0.741	1.002	1.033	0.801	1.077
1990	1.212	0.729	117.04	206.90	1402.70	36.36	1.030	1.252	1.053	0.784	1.067	1.056	0.723	1.155
1991	1.278	0.712	129.58	235.60	1410.79	33.18	0.994	1.363	1.041	0.775	1.154	1.104	0.736	1.066
1992	1.313	0.705	141.25	256.70	1420.96	33.87	0.908	1.426	1.039	0.712	1.231	1.150	0.742	1.184
1993	1.363	0.717	152.17	280.20	1468.51	34.47	0.895	1.516	1.006	0.725	1.301	1.181	0.792	1.184
1994	1.353	0.745	160.09	303.80	1615.25	40.25	0.960	1.623	1.028	0.711	1.338	1.196	0.853	1.409

**CODE:**  
 Y- index of industrial production  
 P- implicit output price index  
 Wi- cost of factor input i in millions of current dollars  
 Pi- price index of factor input i.  
 Xi- quantity index of factor input i

**INDUSTRIAL DATA: BEVERAGE (SSIC#: 313)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.686	0.595	7.560	22.30	73.30	8.49	0.991	0.456	0.591	0.628	0.388	1.178	0.881	1.732
1976	0.728	0.648	7.350	22.90	83.80	8.64	0.969	0.469	0.604	0.695	0.362	1.177	0.986	1.593
1977	0.789	0.667	7.400	24.30	99.10	8.18	0.987	0.524	0.611	0.706	0.360	1.118	1.152	1.485
1978	0.947	0.679	7.090	26.50	124.10	8.65	1.034	0.551	0.635	0.710	0.338	1.158	1.389	1.561
1979	0.947	0.726	7.390	29.90	127.80	9.10	1.170	0.590	0.656	0.783	0.336	1.222	1.384	1.488
1980	1.053	0.741	8.810	34.60	139.79	6.79	1.477	0.705	0.720	1.008	0.361	1.182	1.379	0.862
1981	1.126	0.909	15.240	40.00	172.99	10.07	1.345	0.788	0.776	1.059	0.577	1.224	1.584	1.218
1982	1.021	0.972	21.650	35.30	162.16	10.43	1.159	0.735	0.828	1.086	0.819	1.157	1.391	1.229
1983	1.063	0.936	23.140	36.50	156.57	9.74	1.133	0.791	0.880	1.031	0.861	1.112	1.264	1.210
1984	0.947	1.023	25.900	40.60	145.49	8.21	1.164	0.915	0.977	1.008	0.963	1.070	1.058	1.043
1985	1.000	1.000	26.270	41.50	140.75	7.81	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.021	1.120	27.810	40.70	164.35	6.61	0.918	0.971	1.019	0.884	1.077	1.010	1.146	0.957
1987	1.221	1.048	28.730	39.70	194.46	4.89	0.918	0.950	1.048	0.803	1.085	1.007	1.318	0.780
1988	1.368	1.063	37.610	45.20	212.24	5.45	0.920	1.060	1.072	0.806	1.348	1.028	1.407	0.866
1989	1.330	1.265	57.090	49.50	280.18	5.73	0.929	1.111	1.143	0.741	1.976	1.073	1.742	0.990
1990	1.441	1.109	61.130	63.70	248.86	6.62	1.039	1.411	1.151	0.784	2.070	1.088	1.536	1.081
1991	1.454	1.130	61.840	72.80	250.53	5.93	0.993	1.612	1.174	0.775	2.045	1.088	1.516	0.980
1992	1.628	1.068	62.480	70.80	269.45	6.09	0.878	1.659	1.206	0.712	2.023	1.029	1.587	1.096
1993	1.604	1.089	59.480	67.80	258.72	6.22	0.862	1.673	1.228	0.725	1.890	0.977	1.497	1.098
1994	1.635	1.102	45.790	70.10	241.48	4.38	0.947	1.752	1.233	0.711	1.422	0.964	1.391	0.788

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i



**INDUSTRIAL DATA: TOBACCO (SSIC#: 314)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.873	0.879	7.18	8.80	109.80	1.23	0.992	0.254	0.591	0.628	0.721	1.723	1.708	1.540
1976	0.820	0.994	6.61	9.50	118.90	1.23	0.972	0.303	0.604	0.695	0.637	1.562	1.809	1.397
1977	0.873	1.012	6.09	10.50	129.40	1.23	0.988	0.322	0.611	0.706	0.580	1.623	1.947	1.375
1978	0.881	1.030	5.60	11.60	130.10	1.22	1.030	0.345	0.635	0.710	0.523	1.673	1.883	1.352
1979	0.881	1.000	5.16	13.20	123.20	1.25	1.151	0.400	0.656	0.783	0.459	1.641	1.726	1.254
1980	0.847	1.073	4.75	15.30	117.32	1.23	1.423	0.450	0.720	1.008	0.380	1.691	1.498	0.961
1981	0.864	1.189	8.74	15.60	124.24	1.18	1.306	0.600	0.776	1.059	0.647	1.293	1.472	0.877
1982	1.025	1.135	9.12	17.30	126.90	1.33	1.141	0.737	0.828	1.086	0.675	1.168	1.409	0.964
1983	0.856	1.281	8.38	19.20	115.81	1.37	1.118	0.834	0.880	1.031	0.611	1.146	1.210	1.047
1984	0.822	1.191	12.92	21.10	103.66	1.33	1.145	0.980	0.977	1.008	0.940	1.072	0.975	1.039
1985	1.000	1.000	13.42	20.10	108.79	1.27	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.771	1.212	13.98	18.80	96.28	1.07	0.927	0.939	1.015	0.884	1.059	0.996	0.872	0.953
1987	0.654	1.402	12.97	17.90	82.98	0.82	0.927	0.948	1.094	0.803	0.959	0.939	0.697	0.804
1988	1.176	0.851	12.07	18.90	98.30	1.02	0.929	1.259	1.088	0.806	0.847	0.747	0.830	0.997
1989	1.723	0.679	11.85	21.50	120.99	1.15	0.937	1.385	1.147	0.741	0.803	0.772	0.970	1.222
1990	2.516	0.607	12.69	25.40	169.40	1.73	1.035	1.305	1.196	0.784	0.841	0.968	1.302	1.738
1991	2.800	0.626	15.75	28.90	200.45	1.30	0.993	1.330	1.365	0.775	1.020	1.081	1.350	1.320
1992	3.161	0.621	20.56	30.20	209.99	1.39	0.892	1.506	1.424	0.712	1.303	0.997	1.356	1.540
1993	3.262	0.626	23.00	33.60	200.90	1.47	0.877	1.656	1.518	0.725	1.430	1.009	1.217	1.601
1994	4.573	0.536	22.56	39.80	249.28	2.20	0.953	1.793	1.541	0.711	1.371	1.105	1.487	2.435

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: TEXTILES & TEXTILE MANUFACTURES (SSIC#: 321)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	3.019	0.445	75.06	47.80	181.10	28.10	0.994	0.350	0.837	0.628	5.133	3.701	2.004	4.272
1976	3.925	0.474	66.13	56.00	242.70	27.75	0.980	0.402	0.881	0.695	4.341	3.779	2.552	3.811
1977	3.955	0.453	57.39	52.60	237.80	28.40	0.991	0.416	0.926	0.706	3.724	3.423	2.379	3.841
1978	3.532	0.516	51.85	54.60	237.30	28.16	1.021	0.465	0.958	0.710	3.297	3.184	2.295	3.786
1979	3.200	0.688	47.77	63.00	288.80	26.69	1.109	0.520	1.094	0.783	2.896	3.280	2.445	3.253
1980	3.333	0.758	48.21	71.70	261.67	30.34	1.305	0.615	1.166	1.008	2.631	3.158	2.079	2.872
1981	2.967	0.736	39.04	68.80	233.36	27.45	1.221	0.725	1.184	1.059	1.970	2.571	1.826	2.473
1982	2.200	0.744	35.60	60.50	170.17	22.29	1.102	0.793	1.134	1.086	1.796	2.068	1.390	1.958
1983	1.667	0.835	24.79	49.90	139.56	16.45	1.085	0.901	1.098	1.031	1.230	1.501	1.177	1.523
1984	1.400	0.917	21.70	47.10	135.72	14.54	1.105	0.992	1.066	1.008	1.075	1.287	1.179	1.376
1985	1.000	1.023	19.71	36.90	107.95	10.48	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.000	1.237	15.23	32.90	135.81	8.94	0.948	1.030	0.965	0.884	0.786	0.866	1.304	0.965
1987	1.148	1.428	17.62	39.30	183.65	9.81	0.948	1.122	1.025	0.803	0.887	0.949	1.660	1.166
1988	1.232	1.513	21.93	45.20	208.61	14.50	0.949	1.133	1.037	0.806	1.048	1.081	1.864	1.717
1989	1.285	1.591	21.89	51.30	234.82	10.99	0.955	1.274	1.029	0.741	1.010	1.091	2.114	1.415
1990	1.206	1.692	24.03	55.20	226.62	13.50	1.025	1.351	1.023	0.784	1.085	1.108	2.052	1.643
1991	1.293	1.606	23.07	60.40	235.03	13.00	0.995	1.506	1.016	0.775	1.017	1.087	2.143	1.600
1992	1.183	1.697	21.86	61.80	228.60	12.50	0.922	1.567	0.994	0.712	0.943	1.069	2.130	1.674
1993	1.045	1.821	20.35	62.60	214.00	13.00	0.911	1.682	0.898	0.725	0.862	1.008	2.208	1.710
1994	1.005	1.833	18.76	57.60	177.40	8.66	0.966	1.739	0.903	0.711	0.777	0.898	1.820	1.162

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: WEARING APPAREL EXCEPT FOOTWEAR (SSIC#: 322)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.843	0.328	35.75	53.80	193.90	10.20	0.993	0.326	0.744	0.628	1.287	0.676	0.463	1.526
1976	0.944	0.416	32.69	69.80	270.20	10.26	0.975	0.368	0.763	0.695	1.129	0.778	0.629	1.386
1977	0.876	0.528	30.17	87.00	322.80	10.08	0.989	0.408	0.817	0.706	1.030	0.875	0.702	1.342
1978	1.045	0.585	27.83	118.00	426.60	10.28	1.027	0.444	0.835	0.710	0.931	1.091	0.907	1.359
1979	1.020	0.698	25.48	136.30	506.80	10.42	1.138	0.507	0.928	0.783	0.813	1.101	0.970	1.249
1980	0.980	0.836	24.46	150.70	528.45	9.55	1.388	0.604	1.089	1.008	0.702	1.023	0.862	0.890
1981	0.912	0.980	27.09	179.30	535.42	10.86	1.281	0.701	1.078	1.059	0.719	1.049	0.882	0.963
1982	0.902	0.995	30.02	203.40	518.26	10.84	1.129	0.775	1.053	1.086	0.797	1.076	0.874	0.937
1983	0.941	0.963	34.88	216.10	497.90	11.34	1.108	0.865	1.066	1.031	0.910	1.025	0.830	1.033
1984	1.059	0.990	37.26	236.90	587.12	11.23	1.133	1.004	1.033	1.008	0.972	0.967	1.009	1.046
1985	1.000	1.000	37.45	243.90	563.07	10.65	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.157	1.036	37.25	225.50	729.43	9.39	0.933	0.990	1.015	0.884	1.012	0.934	1.276	0.997
1987	1.361	1.109	39.80	258.40	914.98	9.88	0.933	1.016	1.046	0.803	1.054	1.043	1.554	1.156
1988	1.447	1.131	46.24	292.20	946.99	10.33	0.935	1.083	1.078	0.806	1.163	1.106	1.560	1.204
1989	1.475	1.172	48.12	318.80	994.13	10.31	0.942	1.194	1.126	0.741	1.168	1.095	1.568	1.306
1990	1.377	1.213	60.57	323.40	936.16	10.84	1.032	1.272	1.139	0.784	1.439	1.042	1.460	1.298
1991	1.371	1.225	62.95	322.00	934.03	10.49	0.994	1.354	1.101	0.775	1.460	0.975	1.507	1.271
1992	1.244	1.267	58.72	314.60	876.20	10.55	0.900	1.463	1.076	0.712	1.333	0.882	1.446	1.390
1993	0.988	1.300	43.41	282.80	711.19	10.63	0.887	1.478	1.085	0.725	0.968	0.785	1.164	1.376
1994	0.851	1.281	41.75	259.00	645.40	7.57	0.957	1.532	1.058	0.711	0.909	0.693	1.083	0.999

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: LEATHER & LEATHER PRODUCTS (SSIC#: 323)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	2.383	0.257	1.61	3.10	17.40	0.29	0.991	0.357	0.840	0.628	1.660	1.047	0.900	2.283
1976	2.693	0.322	1.51	4.00	22.10	0.29	0.970	0.410	0.880	0.695	1.488	1.175	1.085	2.074
1977	3.360	0.366	1.40	5.10	31.50	0.28	0.987	0.414	0.930	0.706	1.372	1.484	1.472	2.011
1978	2.454	0.572	1.31	6.10	37.10	0.29	1.032	0.448	0.960	0.710	1.255	1.640	1.676	2.027
1979	2.240	0.639	1.22	6.80	38.20	0.29	1.164	0.526	1.090	0.783	1.117	1.558	1.511	1.873
1980	2.000	0.655	1.14	7.40	33.33	0.27	1.461	0.591	1.170	1.008	0.938	1.510	1.237	1.339
1981	1.920	0.720	1.24	8.00	36.05	0.30	1.334	0.670	1.180	1.059	0.944	1.439	1.318	1.416
1982	1.340	0.983	1.40	8.50	31.61	0.31	1.154	0.733	1.130	1.086	1.066	1.398	1.206	1.427
1983	1.000	1.148	1.46	8.20	27.06	0.29	1.128	0.838	1.100	1.031	1.087	1.178	1.066	1.407
1984	1.420	0.787	1.60	8.70	24.80	0.29	1.159	0.909	1.070	1.008	1.194	1.153	1.007	1.438
1985	1.000	1.000	1.31	8.30	23.11	0.20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.040	0.919	1.15	6.10	22.54	0.13	0.921	1.050	0.990	0.884	0.895	0.700	0.985	0.735
1987	1.166	0.908	1.18	6.50	23.90	0.12	0.921	1.079	1.120	0.803	0.893	0.726	0.922	1.748
1988	1.094	1.481	1.37	8.90	39.52	0.14	0.923	1.288	1.360	0.806	0.984	0.833	1.256	0.869
1989	0.922	1.882	1.51	10.60	38.34	0.14	0.932	1.468	1.460	0.741	1.049	0.870	1.133	0.944
1990	0.894	1.708	1.69	10.40	33.62	0.15	1.038	1.525	1.530	0.784	1.150	0.822	0.950	0.957
1991	0.728	2.399	2.19	13.20	38.93	0.14	0.993	1.663	1.640	0.775	1.452	0.956	1.028	0.924
1992	0.837	2.517	2.76	15.40	46.48	0.14	0.882	1.829	1.620	0.712	1.795	1.015	1.243	1.014
1993	0.877	2.481	3.04	17.00	43.32	0.15	0.866	2.043	1.420	0.725	1.940	1.002	1.324	1.006
1994	0.828	2.562	3.34	16.70	46.81	0.40	0.949	2.240	1.460	0.711	2.850	0.898	1.392	2.812

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: FOOTWEAR (SSIC#: 324)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	4.267	0.208	8.33	7.10	18.70	0.77	0.993	0.587	0.744	0.628	3.730	1.780	1.248	2.004
1976	3.841	0.259	7.47	7.90	22.40	0.77	0.976	0.714	0.763	0.695	3.210	1.627	1.458	1.808
1977	2.774	0.326	6.70	6.40	19.90	0.76	0.990	0.683	0.817	0.706	2.845	1.377	1.209	1.777
1978	2.390	0.426	6.01	6.80	22.10	0.77	1.026	0.691	0.835	0.710	2.500	1.448	1.314	1.781
1979	2.304	0.655	5.38	7.90	34.70	0.76	1.130	0.760	0.928	0.783	2.137	1.529	1.857	1.598
1980	2.174	0.723	4.81	9.70	30.96	0.76	1.365	1.000	1.089	1.008	1.718	1.427	1.412	1.236
1981	2.370	0.679	5.36	10.10	32.55	0.79	1.264	1.111	1.078	1.059	1.769	1.337	1.499	1.223
1982	1.696	0.783	5.71	10.70	25.22	0.74	1.121	1.194	1.053	1.086	1.884	1.318	1.189	1.117
1983	1.565	0.828	6.05	10.30	22.97	0.77	1.101	1.296	1.066	1.031	1.965	1.169	1.070	1.225
1984	1.565	0.901	6.28	10.90	25.80	0.91	1.125	1.398	1.033	1.008	2.038	1.147	1.240	1.480
1985	1.000	1.041	3.01	6.80	20.14	0.61	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.087	1.023	2.85	7.00	22.68	0.46	0.937	1.192	1.121	0.884	0.964	0.863	1.005	0.853
1987	1.299	0.959	2.49	7.30	25.97	0.39	0.937	1.212	1.149	0.803	0.820	0.886	1.122	0.797
1988	1.558	0.849	2.13	7.30	28.64	0.34	0.939	1.378	1.144	0.806	0.667	0.779	1.243	0.692
1989	1.401	1.034	2.16	8.40	31.48	0.28	0.946	1.820	1.134	0.741	0.652	0.679	1.378	0.619
1990	1.480	0.998	2.91	9.10	30.13	0.36	1.030	1.830	1.160	0.784	0.860	0.731	1.290	0.753
1991	2.112	0.730	2.83	8.40	33.38	0.33	0.994	2.068	1.147	0.775	0.816	0.597	1.445	0.691
1992	1.756	0.802	2.37	8.90	29.43	0.32	0.906	2.608	1.124	0.712	0.669	0.502	1.300	0.742
1993	1.570	0.850	2.29	8.00	25.98	0.34	0.894	2.737	1.124	0.725	0.635	0.430	1.148	0.760
1994	1.447	0.849	2.10	7.70	22.49	0.18	0.960	2.942	1.095	0.711	0.570	0.385	1.020	0.415

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: SAWN TIMBER & OTHER WOOD PRODUCTS EXCEPT FURNITURE (SSIC#: 331)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	2.980	0.308	56.19	48.10	230.70	17.42	0.994	0.439	0.987	0.628	2.327	2.286	1.245	3.402
1976	3.218	0.387	50.05	48.90	292.90	17.23	0.980	0.480	0.881	0.695	1.990	2.128	1.502	3.039
1977	2.205	0.585	44.21	55.80	296.60	17.60	0.991	0.543	0.926	0.706	1.737	2.147	1.447	3.058
1978	3.218	0.504	39.98	67.50	369.60	17.44	1.022	0.578	0.958	0.710	1.539	2.437	1.743	3.010
1979	2.950	0.796	40.57	81.80	575.20	16.65	1.110	0.617	1.094	0.783	1.489	2.767	2.375	2.606
1980	2.500	0.884	40.64	80.10	535.00	18.72	1.308	0.665	1.166	1.008	1.343	2.514	2.073	2.276
1981	2.350	0.804	39.97	77.40	427.77	16.94	1.223	0.804	1.184	1.059	1.221	2.009	1.632	1.960
1982	2.000	0.784	43.07	69.00	367.74	14.29	1.102	0.827	1.134	1.086	1.316	1.742	1.465	1.612
1983	1.525	0.915	36.69	64.80	305.60	12.54	1.086	0.938	1.098	1.031	1.102	1.442	1.257	1.491
1984	1.250	0.940	36.71	56.40	258.54	10.15	1.106	0.982	1.066	1.008	1.102	1.199	1.096	1.234
1985	1.000	0.996	32.54	47.90	221.36	8.16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.750	1.153	26.32	38.40	191.24	6.30	0.947	1.011	1.013	0.884	0.823	0.793	0.853	0.873
1987	0.808	1.171	20.67	38.10	218.26	5.94	0.947	1.086	1.099	0.803	0.630	0.732	0.897	0.907
1988	0.800	1.439	19.62	42.40	269.00	6.09	0.949	1.151	1.268	0.806	0.568	0.769	0.958	0.926
1989	0.707	1.653	19.91	46.60	260.16	5.86	0.954	1.337	1.237	0.741	0.556	0.727	0.950	0.969
1990	0.663	1.556	17.65	43.60	226.94	5.09	1.025	1.459	1.169	0.784	0.482	0.624	0.877	0.796
1991	0.563	1.556	14.70	41.90	197.58	5.68	0.995	1.638	1.094	0.775	0.393	0.534	0.816	0.898
1992	0.567	1.523	13.94	42.60	192.68	5.54	0.921	1.742	1.102	0.712	0.364	0.511	0.790	0.954
1993	0.526	1.628	13.54	38.60	192.49	5.44	0.911	1.784	1.217	0.725	0.347	0.452	0.715	0.919
1994	0.488	1.700	12.92	41.40	175.83	2.08	0.966	2.004	1.218	0.711	0.324	0.431	0.652	0.358

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: FURNITURE & FIXTURES EXCEPT PRIMARILY OF METAL, STONE & PLASTICS (SSIC#: 332)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.358	0.374	24.86	12.70	27.30	4.42	0.994	0.460	0.744	0.628	1.705	0.328	0.195	1.332
1976	0.376	0.449	22.05	14.80	34.50	4.45	0.978	0.479	0.763	0.695	1.451	0.367	0.241	1.209
1977	0.447	0.486	19.49	16.70	47.90	4.38	0.991	0.463	0.817	0.706	1.268	0.428	0.312	1.174
1978	0.648	0.496	17.38	24.40	73.50	4.44	1.023	0.493	0.835	0.710	1.108	0.587	0.468	1.183
1979	0.777	0.570	16.24	34.00	101.60	4.51	1.117	0.569	0.928	0.783	0.987	0.709	0.582	1.090
1980	0.826	0.757	15.19	44.40	126.84	4.19	1.328	0.686	1.089	1.008	0.831	0.767	0.620	0.786
1981	1.058	0.721	16.77	54.80	156.48	4.62	1.237	0.793	1.078	1.059	0.848	0.819	0.772	0.825
1982	0.983	0.740	20.39	58.30	139.22	4.73	1.109	0.826	1.053	1.086	1.031	0.838	0.703	0.823
1983	1.041	0.736	18.15	63.70	147.44	4.89	1.091	0.883	1.066	1.031	0.903	0.856	0.736	0.897
1984	1.083	0.892	22.93	73.50	185.61	5.39	1.113	0.934	1.033	1.008	1.139	0.934	0.956	1.011
1985	1.000	0.990	19.65	84.30	188.00	5.29	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.099	0.884	27.42	76.60	184.25	4.65	0.944	0.983	1.049	0.884	1.419	0.925	0.934	0.994
1987	1.065	0.967	25.77	78.40	206.26	4.55	0.944	0.999	1.076	0.803	1.301	0.931	1.020	1.072
1988	1.131	1.130	25.37	92.50	264.27	4.76	0.945	1.138	1.117	0.806	1.216	0.964	1.258	1.117
1989	1.098	1.223	26.21	93.80	272.01	4.49	0.951	1.247	1.111	0.741	1.212	0.892	1.302	1.145
1990	1.091	1.302	19.99	99.30	294.61	4.52	1.027	1.447	1.106	0.784	0.905	0.814	1.417	1.090
1991	1.157	1.231	20.34	103.20	292.21	4.59	0.995	1.517	1.120	0.775	0.899	0.807	1.388	1.119
1992	1.171	1.249	22.82	106.50	293.15	4.53	0.916	1.603	1.121	0.712	0.987	0.788	1.391	1.203
1993	1.284	1.321	29.67	116.20	351.99	4.55	0.905	1.740	1.126	0.725	1.260	0.792	1.663	1.186
1994	1.448	1.317	34.74	123.70	359.74	4.29	0.964	1.825	1.160	0.711	1.442	0.804	1.650	1.140

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: PAPER & PAPER PRODUCTS (SSIC#: 341)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	1.105	0.227	27.18	13.90	65.00	12.89	0.993	0.265	0.837	0.628	0.873	1.021	0.372	1.874
1976	1.315	0.226	24.20	16.00	74.90	13.12	0.977	0.284	0.881	0.695	0.746	1.097	0.407	1.723
1977	1.470	0.224	21.73	17.60	81.50	12.67	0.990	0.314	0.926	0.706	0.662	1.093	0.421	1.638
1978	1.614	0.255	19.29	21.30	104.40	12.88	1.024	0.360	0.958	0.710	0.576	1.153	0.521	1.656
1979	1.625	0.334	17.59	27.00	136.00	13.82	1.124	0.430	1.094	0.783	0.501	1.223	0.595	1.611
1980	1.786	0.396	17.18	34.70	176.05	11.30	1.348	0.520	1.166	1.008	0.440	1.302	0.722	1.023
1981	1.839	0.426	33.83	44.20	195.33	13.52	1.252	0.632	1.184	1.059	0.801	1.363	0.789	1.165
1982	1.696	0.528	43.03	51.40	196.68	16.64	1.116	0.743	1.134	1.086	1.019	1.349	0.830	1.398
1983	1.214	0.762	44.12	51.50	190.20	11.11	1.097	0.875	1.098	1.031	1.028	1.148	0.829	0.984
1984	1.089	0.944	44.35	52.00	211.57	11.49	1.120	0.930	1.066	1.008	1.032	1.089	0.950	1.040
1985	1.000	1.058	41.96	51.30	209.01	10.96	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.107	1.028	42.58	54.70	227.74	9.07	0.940	1.061	1.057	0.884	1.032	1.005	1.031	0.936
1987	1.472	1.040	43.05	64.20	326.24	12.52	0.940	1.150	1.153	0.803	1.018	1.089	1.354	1.423
1988	1.619	1.122	44.84	75.70	402.24	12.55	0.942	1.189	1.260	0.806	1.006	1.241	1.527	1.421
1989	1.653	1.191	49.78	87.80	434.47	13.69	0.948	1.300	1.299	0.741	1.078	1.316	1.600	1.685
1990	1.733	1.221	57.04	98.60	439.70	16.21	1.029	1.377	1.229	0.784	1.209	1.396	1.712	1.886
1991	1.807	1.246	63.81	115.00	474.61	14.15	0.995	1.499	1.221	0.775	1.321	1.495	1.860	1.665
1992	1.595	1.303	73.52	124.30	415.22	14.68	0.911	1.588	1.153	0.712	1.490	1.526	1.723	1.881
1993	1.605	1.378	87.80	136.60	415.29	15.01	0.899	1.694	1.107	0.725	1.746	1.572	1.795	1.889
1994	1.709	1.385	91.00	148.10	446.16	17.09	0.961	1.759	1.102	0.711	1.769	1.641	1.937	2.192

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i



# INDUSTRIAL DATA: PRINTING & PUBLISHING (SSIC#: 342)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.419	0.578	57.75	54.10	100.30	7.36	0.994	0.368	0.744	0.628	0.923	0.609	0.504	1.114
1976	0.461	0.677	50.22	61.70	144.30	7.45	0.980	0.394	0.763	0.695	0.770	0.649	0.707	1.018
1977	0.528	0.683	44.16	70.20	163.60	7.24	0.991	0.413	0.817	0.706	0.669	0.704	0.748	0.974
1978	0.599	0.673	38.28	86.50	184.70	7.40	1.022	0.451	0.835	0.710	0.569	0.794	0.827	0.990
1979	0.607	0.763	34.37	97.50	214.10	7.71	1.111	0.491	0.928	0.783	0.487	0.823	0.862	0.936
1980	0.741	0.798	33.81	118.60	198.62	6.60	1.312	0.568	1.089	1.008	0.431	0.865	0.682	0.622
1981	0.815	0.889	47.63	140.50	239.74	7.88	1.226	0.652	1.078	1.059	0.561	0.893	0.831	0.707
1982	0.822	0.926	59.96	171.90	239.65	8.66	1.104	0.740	1.053	1.086	0.707	0.962	0.850	0.757
1983	0.874	0.999	71.42	248.20	245.30	10.26	1.087	1.041	1.066	1.031	0.828	0.987	0.860	0.945
1984	0.985	0.996	81.93	234.70	269.25	10.40	1.107	0.957	1.033	1.008	0.948	1.016	0.974	0.980
1985	1.000	0.962	84.36	241.40	267.62	10.53	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.044	0.979	88.41	237.30	291.18	10.51	0.946	1.067	1.078	0.884	1.066	0.921	1.009	1.129
1987	1.143	1.052	92.41	246.00	362.98	9.80	0.946	1.094	1.121	0.803	1.087	0.931	1.210	1.160
1988	1.264	1.134	102.00	288.80	464.34	10.79	0.948	1.178	1.147	0.806	1.139	1.015	1.513	1.272
1989	1.400	1.190	112.76	348.10	543.94	10.96	0.954	1.318	1.108	0.741	1.215	1.094	1.834	1.404
1990	1.544	1.213	127.54	378.90	543.76	13.03	1.026	1.389	1.063	0.784	1.345	1.130	1.911	1.578
1991	1.677	1.236	144.76	462.60	578.70	11.59	0.995	1.592	1.048	0.775	1.491	1.204	2.063	1.420
1992	1.798	1.275	158.56	487.70	611.35	11.86	0.920	1.638	1.019	0.712	1.598	1.234	2.242	1.581
1993	1.952	1.267	171.48	532.70	617.31	12.16	0.909	1.716	0.996	0.725	1.697	1.286	2.316	1.593
1994	2.100	1.283	177.81	575.30	643.26	16.59	0.965	1.808	0.983	0.711	1.719	1.318	2.445	2.215

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: INDUSTRIAL CHEMICALS & GASES (SSIC#: 351)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.202	0.509	10.51	13.30	109.60	23.89	0.993	0.292	0.650	0.628	0.043	0.484	0.137	0.420
1976	0.250	0.558	10.35	14.10	158.20	24.17	0.975	0.310	0.714	0.695	0.041	0.483	0.180	0.384
1977	0.256	0.589	10.19	16.10	167.70	23.35	0.989	0.362	0.713	0.706	0.040	0.473	0.192	0.365
1978	0.304	0.400	11.63	17.80	118.00	24.16	1.026	0.360	0.687	0.710	0.044	0.525	0.140	0.376
1979	0.323	0.525	11.44	22.30	169.40	25.01	1.133	0.400	0.877	0.783	0.042	0.593	0.157	0.353
1980	0.323	0.712	23.88	28.90	220.20	20.87	1.374	0.462	1.126	1.008	0.078	0.665	0.159	0.229
1981	0.368	0.657	30.94	33.40	219.53	26.59	1.270	0.555	1.176	1.059	0.094	0.640	0.152	0.277
1982	0.384	0.734	48.29	41.10	230.05	27.57	1.124	0.620	1.144	1.086	0.146	0.704	0.164	0.280
1983	0.365	0.952	48.76	43.20	298.02	27.68	1.104	0.648	1.063	1.031	0.145	0.708	0.228	0.297
1984	0.739	1.114	314.07	85.70	845.28	64.40	1.129	0.911	1.030	1.008	0.934	1.000	0.668	0.706
1985	1.000	1.123	328.23	94.10	1227.82	90.54	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.019	1.123	316.53	91.40	1061.57	73.91	0.936	0.982	0.998	0.884	0.981	0.989	0.866	0.923
1987	1.214	1.306	306.94	99.30	1384.56	73.11	0.936	1.025	1.063	0.803	0.928	1.030	1.061	1.006
1988	1.297	1.669	291.36	117.10	1790.00	74.49	0.938	1.077	1.188	0.806	0.836	1.155	1.227	1.021
1989	1.382	1.474	347.13	150.30	1777.10	84.81	0.945	1.187	1.128	0.741	0.961	1.345	1.283	1.264
1990	1.570	1.332	347.17	195.30	1955.70	102.38	1.031	1.405	1.068	0.784	0.941	1.477	1.491	1.442
1991	1.597	1.285	359.95	213.50	1984.59	87.23	0.994	1.516	1.055	0.775	0.953	1.497	1.532	1.243
1992	1.517	1.157	333.22	227.20	1664.07	91.47	0.904	1.597	0.983	0.712	0.863	1.512	1.379	1.418
1993	1.591	1.108	389.98	265.20	1624.24	93.69	0.891	1.718	0.953	0.725	0.992	1.674	1.388	1.427
1994	1.889	1.068	380.87	284.80	2042.29	117.47	0.959	1.778	0.934	0.711	0.946	1.702	1.781	1.824

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: PAINTS, PHARMACEUTICALS & OTHER CHEMICAL PRODUCTS (SSIC#: 352)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.430	0.597	9.22	25.70	137.40	10.57	0.994	0.306	0.650	0.628	0.203	0.766	0.630	1.233
1976	0.456	0.640	8.17	30.00	157.30	10.74	0.977	0.366	0.714	0.695	0.173	0.746	0.657	1.131
1977	0.559	0.577	7.25	35.10	172.40	10.40	0.990	0.397	0.713	0.706	0.152	0.806	0.721	1.079
1978	0.623	0.616	6.43	37.70	185.10	10.58	1.024	0.422	0.687	0.710	0.132	0.814	0.804	1.091
1979	0.580	0.692	5.70	43.20	205.30	11.23	1.123	0.481	0.877	0.783	0.111	0.819	0.698	1.050
1980	0.699	0.780	24.34	53.40	269.72	9.38	1.346	0.528	1.126	1.008	0.428	0.921	0.714	0.681
1981	0.734	0.845	28.00	62.40	308.92	11.13	1.250	0.619	1.176	1.059	0.455	0.919	0.783	0.769
1982	0.769	0.821	48.29	76.40	309.75	13.19	1.115	0.721	1.144	1.086	0.785	0.966	0.807	0.889
1983	0.874	0.818	56.93	90.50	296.19	12.52	1.096	0.843	1.063	1.031	0.911	0.979	0.831	0.889
1984	0.888	0.990	62.96	99.40	328.52	12.96	1.119	0.919	1.030	1.008	1.006	0.986	0.951	0.941
1985	1.000	0.833	61.11	109.70	335.32	13.66	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.056	0.968	58.94	98.20	377.65	10.49	0.941	0.980	0.988	0.884	0.981	0.913	1.140	0.869
1987	1.064	1.121	56.45	100.90	442.34	11.29	0.941	0.977	0.962	0.803	0.916	0.941	1.371	1.030
1988	1.101	1.214	58.34	112.10	525.76	11.75	0.942	1.039	0.958	0.806	0.899	0.984	1.637	1.067
1989	1.305	1.141	65.37	127.30	613.81	11.75	0.949	1.156	1.007	0.741	0.972	1.004	1.818	1.160
1990	1.701	0.974	91.12	155.50	649.26	15.09	1.029	1.280	0.986	0.784	1.327	1.107	1.964	1.409
1991	2.228	0.945	82.90	171.40	728.97	12.86	0.995	1.381	0.994	0.775	1.179	1.132	2.187	1.215
1992	2.042	1.049	88.06	192.60	773.15	13.23	0.911	1.488	0.977	0.712	1.225	1.180	2.360	1.360
1993	2.108	1.053	89.23	207.00	758.60	13.73	0.900	1.618	0.956	0.725	1.219	1.166	2.366	1.386
1994	2.179	1.038	118.21	228.50	825.83	16.70	0.962	1.701	0.885	0.711	1.578	1.225	2.783	1.719

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: PETROLEUM REFINERIES & PETROLEUM PRODUCTS (SSIC#: 353/4)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.600	0.719	458.07	66.10	4148.30	404.02	0.990	0.440	0.490	0.630	1.406	0.964	0.872	1.705
1976	0.707	0.784	420.90	67.20	5420.30	408.02	0.970	0.470	0.530	0.690	1.240	0.916	1.060	1.556
1977	0.803	0.792	395.21	67.00	6248.20	393.18	0.990	0.480	0.560	0.710	1.151	0.895	1.145	1.477
1978	0.857	0.793	415.15	73.50	6711.30	410.87	1.030	0.530	0.530	0.710	1.185	0.892	1.305	1.534
1979	0.881	0.957	416.01	87.10	8392.10	420.00	1.140	0.610	0.710	0.780	1.132	0.929	1.212	1.421
1980	0.847	1.232	412.76	99.70	9670.55	348.69	1.400	0.670	1.120	1.010	1.011	0.967	0.885	0.916
1981	0.992	1.321	468.92	114.70	12248.50	463.91	1.290	0.730	1.280	1.060	1.062	1.016	0.983	1.161
1982	1.017	1.305	488.89	138.60	12493.63	447.39	1.130	0.820	1.210	1.090	1.107	1.095	1.061	1.091
1983	1.034	1.154	491.53	148.00	11227.73	467.50	1.110	0.880	1.070	1.030	1.094	1.087	1.079	1.202
1984	1.110	1.017	473.84	151.40	10944.30	457.41	1.140	0.940	1.020	1.010	1.054	1.043	1.109	1.202
1985	1.000	1.000	439.05	155.00	9725.26	377.43	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.085	0.584	417.27	148.80	5929.11	233.03	0.930	0.990	0.540	0.880	0.967	0.974	1.125	0.698
1987	1.008	0.674	402.97	148.40	6433.50	265.52	0.930	1.020	0.660	0.800	0.911	0.939	1.004	0.877
1988	1.055	0.658	429.55	154.20	6362.42	263.07	0.930	1.100	0.520	0.810	0.921	0.904	1.263	0.865
1989	1.200	0.662	469.24	174.30	7146.07	300.14	0.940	1.250	0.590	0.740	0.972	0.901	1.250	1.073
1990	1.361	0.757	504.98	204.00	9328.49	295.99	1.030	1.380	0.690	0.780	1.023	0.952	1.398	1.000
1991	1.407	0.727	525.75	241.50	9004.36	286.40	0.990	1.450	0.560	0.780	1.040	1.078	1.659	0.979
1992	1.418	0.657	623.94	252.70	8247.90	294.18	0.900	1.480	0.500	0.710	1.208	1.102	1.706	1.094
1993	1.626	0.625	717.57	288.10	8959.03	292.19	0.880	1.650	0.440	0.730	1.364	1.127	2.075	1.068
1994	1.648	0.590	770.42	314.00	8745.38	253.78	0.960	1.790	0.410	0.710	1.431	1.132	2.177	0.945

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: RUBBER PRODUCTS, JELUTONG & GUM DAMAR (SSIC#: 355/6)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	1.077	0.987	21.32	9.70	29.50	4.91	0.995	0.428	0.837	0.630	2.233	1.126	0.749	2.172
1976	1.088	0.973	18.02	9.90	31.40	4.85	0.981	0.432	0.881	0.690	1.812	1.139	0.757	1.940
1977	1.206	0.981	15.23	10.80	34.70	5.02	0.992	0.479	0.926	0.710	1.514	1.121	0.796	1.976
1978	1.293	0.950	12.87	11.80	38.60	4.86	1.020	0.488	0.958	0.710	1.254	1.203	0.856	1.901
1979	1.260	1.276	10.88	15.60	51.80	4.68	1.101	0.551	1.094	0.780	1.010	1.408	1.006	1.660
1980	1.370	1.204	9.20	17.20	68.87	5.52	1.282	0.572	1.166	1.010	0.769	1.495	1.255	1.521
1981	1.274	1.170	9.35	13.30	61.06	4.37	1.204	0.632	1.184	1.060	0.723	1.047	1.096	1.146
1982	1.164	1.229	10.22	14.70	56.11	4.15	1.094	0.738	1.134	1.090	0.790	0.992	1.051	1.061
1983	0.932	1.561	13.52	17.00	56.30	3.75	1.078	0.856	1.098	1.030	1.027	0.988	1.090	1.011
1984	1.041	1.435	15.67	19.60	54.66	4.02	1.097	0.968	1.066	1.010	1.190	1.007	1.090	1.108
1985	1.000	1.294	12.87	20.10	47.06	3.60	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.904	1.436	11.57	17.80	45.61	2.86	0.951	0.993	1.068	0.880	0.915	0.892	0.907	0.899
1987	0.948	1.724	12.68	21.50	60.21	2.59	0.951	1.060	1.101	0.800	0.978	1.009	1.162	0.896
1988	0.917	2.164	13.06	25.20	74.92	3.44	0.953	1.078	1.153	0.810	0.956	1.163	1.381	1.186
1989	0.915	2.533	12.36	28.10	88.48	3.61	0.958	1.189	1.166	0.740	0.873	1.176	1.612	1.353
1990	0.814	2.572	15.18	32.20	75.73	3.92	1.023	1.291	1.158	0.780	1.049	1.241	1.390	1.389
1991	0.923	2.493	18.17	38.40	78.06	3.66	0.996	1.409	1.193	0.780	1.227	1.356	1.390	1.310
1992	0.855	2.714	18.33	40.60	75.78	3.73	0.928	1.550	1.187	0.710	1.211	1.303	1.357	1.454
1993	0.891	2.684	20.32	42.70	71.89	3.77	0.918	1.567	1.220	0.730	1.318	1.356	1.252	1.444
1994	0.997	2.668	20.91	44.80	92.61	3.69	0.969	1.593	1.242	0.710	1.326	1.399	1.584	1.441

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: PLASTIC PRODUCTS (SSIC#: 357)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.881	0.232	26.18	20.30	80.00	24.88	0.995	0.351	0.650	0.630	0.402	0.573	0.374	1.248
1976	1.189	0.229	24.74	23.90	110.60	24.96	0.982	0.375	0.714	0.690	0.365	0.632	0.471	1.110
1977	1.189	0.291	22.76	30.00	132.10	24.57	0.992	0.395	0.713	0.710	0.332	0.752	0.563	1.110
1978	1.392	0.339	22.27	39.00	180.80	25.11	1.019	0.421	0.687	0.710	0.318	0.918	0.800	1.120
1979	1.163	0.555	26.83	48.50	246.50	25.20	1.097	0.485	0.877	0.780	0.365	0.989	0.854	0.940
1980	1.163	0.727	38.56	63.90	296.72	23.39	1.271	0.581	1.126	1.010	0.473	1.090	0.801	0.812
1981	1.151	0.765	50.71	71.80	303.95	26.75	1.196	0.660	1.176	1.060	0.575	1.077	0.785	0.786
1982	1.163	0.774	63.24	79.90	294.34	25.45	1.090	0.753	1.144	1.090	0.716	1.050	0.782	0.512
1983	1.198	0.821	71.73	86.50	321.42	27.70	1.075	0.847	1.063	1.030	0.799	1.011	0.919	0.599
1984	1.221	0.931	87.50	98.50	373.24	30.88	1.093	0.964	1.030	1.010	0.974	1.012	1.101	0.801
1985	1.000	1.039	87.73	101.00	329.14	27.53	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.907	1.143	58.43	102.50	327.57	23.94	0.953	1.059	1.017	0.880	0.678	0.958	0.979	0.885
1987	1.125	1.271	73.13	122.50	469.12	26.32	0.953	1.029	1.135	0.800	0.827	1.179	1.256	0.958
1988	1.293	1.620	91.21	161.60	723.51	32.01	0.955	1.109	1.360	0.810	0.979	1.443	1.616	1.179
1989	1.295	1.767	105.17	195.00	748.81	32.51	0.960	1.260	1.214	0.740	1.090	1.523	1.874	1.148
1990	1.283	1.889	116.22	229.90	743.30	35.76	1.022	1.388	1.105	0.780	1.179	1.640	2.044	1.349
1991	1.417	1.925	130.82	270.60	839.16	33.43	0.996	1.463	1.083	0.780	1.295	1.832	2.354	1.230
1992	1.383	1.959	139.01	301.70	792.53	33.90	0.930	1.616	0.999	0.710	1.347	1.848	2.410	1.339
1993	1.485	2.117	159.82	366.30	900.06	34.36	0.921	1.815	0.977	0.730	1.521	1.999	2.799	1.363
1994	1.656	2.110	173.70	399.60	1012.20	50.50	0.970	1.924	0.959	0.710	1.615	2.057	3.207	1.421

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: POTTERY, CHINA, EARTHENWARE & GLASS PRODUCTS (SSIC#: 361/2)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	1.984	0.483	11.05	6.10	16.50	11.73	0.992	0.993	0.744	0.630	3.530	0.931	1.656	5.717
1976	2.044	0.614	10.12	6.90	22.70	11.71	0.973	0.971	0.763	0.690	3.104	1.076	2.222	5.156
1977	2.084	0.667	9.27	7.20	23.40	11.66	0.968	0.979	0.817	0.710	2.810	1.114	2.139	5.054
1978	2.937	0.574	8.49	8.50	24.60	11.83	1.029	1.149	0.835	0.710	2.523	1.121	2.200	5.097
1979	3.294	0.627	7.78	9.90	33.60	11.65	1.146	1.235	0.928	0.780	2.203	1.215	2.704	4.551
1980	2.941	0.784	7.13	12.40	26.60	11.50	1.410	1.446	1.089	1.010	1.816	1.299	1.824	3.489
1981	3.882	0.788	7.22	13.50	33.16	12.34	1.297	1.328	1.078	1.060	1.700	1.541	2.297	3.563
1982	4.118	0.599	8.02	14.40	34.31	11.11	1.137	1.521	1.053	1.090	1.890	1.434	2.433	3.128
1983	3.500	0.913	11.19	16.30	40.88	14.82	1.114	1.828	1.066	1.030	2.593	1.351	2.864	4.398
1984	3.647	0.750	7.22	17.80	28.44	13.57	1.141	1.963	1.033	1.010	1.671	1.374	2.056	4.117
1985	1.000	1.000	4.22	6.60	13.39	3.27	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.676	0.782	1.50	3.20	6.82	1.42	0.929	1.529	1.078	0.880	0.362	0.317	0.472	0.491
1987	0.732	0.495	1.06	2.00	3.76	0.56	0.929	1.547	1.121	0.800	0.250	0.196	0.250	0.213
1988	0.805	0.573	1.38	2.40	6.03	0.55	0.931	1.640	1.147	0.810	0.309	0.222	0.393	0.209
1989	0.758	4.840	31.11	12.70	70.84	8.74	0.939	1.658	1.108	0.740	6.703	1.161	4.775	3.606
1990	0.877	5.626	29.96	18.30	62.18	11.27	1.034	2.554	1.063	0.780	6.317	1.086	4.369	4.396
1991	0.927	5.449	29.66	22.40	60.59	6.85	0.994	2.835	1.048	0.780	6.108	1.197	4.318	2.704
1992	1.070	5.577	32.77	25.40	60.56	8.95	0.895	3.146	1.019	0.710	6.604	1.223	4.438	3.844
1993	1.108	6.205	31.55	25.80	70.09	9.03	0.881	2.968	0.996	0.730	6.241	1.317	5.256	3.807
1994	1.145	6.429	31.97	27.90	94.56	11.87	0.954	3.170	0.983	0.710	6.180	1.333	7.184	5.103

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: NON-METALLIC MINERAL PRODUCTS (SSIC#: 369)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	1.039	0.863	15.85	12.40	51.40	4.14	0.995	0.488	0.837	0.630	1.809	1.203	1.199	1.974
1976	1.102	0.783	13.18	14.40	46.30	4.15	0.983	0.556	0.881	0.690	1.444	1.228	1.026	1.787
1977	1.393	0.706	10.95	11.40	53.80	4.05	0.993	0.530	0.926	0.710	1.186	1.019	1.135	1.719
1978	1.226	0.739	9.11	11.70	49.10	4.22	1.019	0.549	0.958	0.710	0.967	1.010	1.001	1.781
1979	1.528	0.682	7.57	12.40	56.80	4.17	1.095	0.689	1.094	0.780	0.766	0.853	1.014	1.593
1980	1.389	0.843	6.30	14.60	58.61	3.76	1.266	0.744	1.166	1.010	0.573	0.931	0.982	1.117
1981	1.556	0.901	6.94	18.90	71.26	4.74	1.192	1.004	1.184	1.060	0.584	0.892	1.176	1.340
1982	1.597	0.834	7.14	19.50	61.93	4.00	1.089	1.041	1.134	1.090	0.601	0.887	1.067	1.103
1983	1.625	0.856	9.88	24.30	69.37	3.91	1.074	1.017	1.098	1.030	0.808	1.132	1.234	1.136
1984	1.306	0.884	10.82	20.50	54.80	3.48	1.091	0.963	1.066	1.010	0.895	1.008	1.004	1.034
1985	1.000	0.996	11.81	21.10	51.20	3.34	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.875	1.141	11.21	21.40	48.91	2.79	0.954	1.033	0.956	0.880	0.966	0.982	0.999	0.945
1987	1.292	0.869	11.15	21.80	48.03	3.47	0.954	0.993	0.948	0.800	0.937	1.040	0.990	1.294
1988	1.344	1.028	11.33	26.10	62.07	3.76	0.956	0.960	0.955	0.810	0.904	1.288	1.269	1.397
1989	2.042	0.689	11.19	27.80	68.49	3.78	0.961	1.055	1.082	0.740	0.862	1.248	1.236	1.527
1990	2.067	0.619	7.74	27.60	51.10	3.75	1.022	1.253	1.186	0.780	0.583	1.044	0.842	1.432
1991	2.063	0.654	11.47	31.60	56.36	3.76	0.996	1.589	1.234	0.780	0.844	0.943	0.892	1.453
1992	2.267	0.700	11.45	35.60	60.69	3.76	0.932	1.369	1.207	0.710	0.825	1.232	0.982	1.582
1993	2.369	0.744	10.40	37.20	69.98	3.76	0.923	1.695	1.194	0.730	0.735	1.040	1.145	1.552
1994	2.258	0.744	11.13	38.80	75.28	3.00	0.970	1.730	1.188	0.710	0.769	1.063	1.238	1.263

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i



**INDUSTRIAL DATA: IRON & STEEL (SSIC#: 371)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.510	0.863	25.59	13.40	96.80	52.70	0.994	0.338	0.837	0.630	1.113	1.037	0.685	1.516
1976	0.526	0.861	25.59	14.20	98.10	52.93	0.978	0.366	0.881	0.690	1.068	1.013	0.659	1.375
1977	0.531	0.811	22.77	14.80	78.70	52.15	0.991	0.399	0.926	0.710	1.939	0.969	0.503	1.335
1978	0.679	0.844	20.58	17.70	100.90	53.03	1.024	0.457	0.958	0.710	0.832	1.011	0.624	1.349
1979	0.766	1.056	18.15	22.40	160.20	53.60	1.120	0.487	1.094	0.780	0.700	1.200	0.867	1.236
1980	0.781	1.285	16.01	27.40	150.36	49.83	1.337	0.572	1.166	1.010	0.555	1.250	0.764	0.893
1981	0.852	1.197	16.89	30.20	144.66	55.66	1.244	0.617	1.184	1.060	0.542	1.278	0.724	0.949
1982	1.109	0.962	20.60	32.50	160.72	55.30	1.112	0.741	1.134	1.090	0.661	1.145	0.839	0.919
1983	1.047	0.952	20.65	36.30	153.76	50.14	1.094	0.864	1.098	1.030	0.651	1.097	0.829	0.878
1984	1.008	0.991	33.16	38.80	150.00	54.28	1.116	0.943	1.066	1.010	1.045	1.074	0.833	0.972
1985	1.000	1.010	31.00	38.30	168.87	55.38	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.016	1.100	28.93	33.80	203.43	44.38	0.942	0.983	1.013	0.880	0.949	0.898	1.189	0.907
1987	1.053	1.079	24.67	33.20	189.59	42.39	0.942	0.980	1.098	0.800	0.790	0.885	1.022	0.954
1988	1.119	1.135	25.79	37.10	209.60	39.38	0.944	0.960	1.267	0.810	0.783	1.009	0.980	0.882
1989	1.151	1.357	31.88	45.00	279.02	45.78	0.960	1.093	1.335	0.740	0.935	1.075	1.238	1.115
1990	1.239	1.394	35.50	48.80	338.70	52.99	1.028	1.106	1.282	0.780	1.019	1.152	1.564	1.220
1991	1.179	1.352	33.04	53.20	303.65	46.05	0.995	1.168	1.235	0.780	0.926	1.190	1.456	1.073
1992	1.216	1.280	41.66	58.30	273.18	48.27	0.914	1.302	1.126	0.710	1.143	1.169	1.437	1.224
1993	1.337	1.255	47.31	62.70	353.97	49.10	0.902	1.435	1.097	0.730	1.274	1.141	1.911	1.223
1994	1.318	1.322	45.62	67.50	345.55	44.16	0.963	1.513	1.061	0.710	1.200	1.165	1.929	1.121

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: NON-FERROUS METALS (SSIC#: 372)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.917	0.190	2.83	3.70	30.10	2.84	0.994	0.445	0.837	0.630	0.516	0.589	0.193	1.248
1976	1.027	0.139	2.50	1.10	26.60	2.80	0.978	0.424	0.881	0.690	0.437	0.184	0.162	1.110
1977	1.018	0.223	2.21	4.70	40.30	2.84	0.990	0.488	0.926	0.710	0.381	0.683	0.233	1.110
1978	1.073	0.221	1.95	5.60	42.60	2.89	1.024	0.484	0.958	0.710	0.330	0.821	0.238	1.120
1979	1.119	0.512	1.72	5.90	116.40	2.67	1.120	0.646	1.094	0.780	0.278	0.648	0.570	0.940
1980	1.190	0.677	1.52	7.90	164.53	2.97	1.338	0.922	1.166	1.010	0.221	0.608	0.756	0.812
1981	1.024	0.539	2.77	7.40	99.64	3.02	1.245	0.882	1.184	1.060	0.372	0.595	0.451	0.786
1982	0.857	0.731	4.35	10.10	124.56	2.02	1.113	0.824	1.134	1.090	0.584	0.869	0.589	0.512
1983	0.881	0.683	5.88	10.70	112.04	2.24	1.094	0.891	1.098	1.030	0.777	0.852	0.547	0.599
1984	1.107	0.754	7.84	12.90	153.09	2.93	1.116	0.951	1.066	1.010	1.034	0.962	0.770	0.801
1985	1.000	0.951	7.40	14.10	186.56	3.63	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.893	1.164	7.45	9.20	208.78	2.84	0.942	1.085	0.894	0.880	1.024	0.601	1.252	0.885
1987	0.968	0.731	9.95	11.20	118.76	2.79	0.942	0.974	0.959	0.800	1.334	0.816	0.664	0.958
1988	0.986	0.881	11.00	14.30	144.05	3.45	0.943	1.143	1.268	0.810	1.400	0.887	0.609	1.179
1989	0.920	0.850	11.36	17.30	121.20	3.09	0.950	1.257	1.355	0.740	1.395	0.976	0.479	1.148
1990	1.063	0.860	12.70	21.10	134.73	3.84	1.028	1.386	1.135	0.780	1.527	1.079	0.636	1.349
1991	1.101	0.762	14.18	23.00	123.76	3.46	0.995	1.495	1.022	0.780	1.664	1.091	0.649	1.230
1992	1.230	0.716	13.76	25.60	123.97	3.46	0.913	1.740	0.933	0.710	1.581	1.044	0.712	1.339
1993	1.176	0.714	16.09	22.90	117.36	3.59	0.902	1.762	0.971	0.730	1.814	0.922	0.648	1.363
1994	1.297	0.728	16.68	24.20	120.85	3.67	0.962	1.815	1.020	0.710	1.838	0.946	0.635	1.421

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: FABRICATED METAL PRODUCTS EXCEPT MACHINERY & EQUIPMENT (SSIC#: 381)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.821	0.352	154.00	68.90	333.80	35.84	0.994	0.382	0.837	0.630	1.057	0.570	0.401	1.362
1976	0.780	0.371	135.59	77.80	327.90	36.36	0.981	0.407	0.881	0.690	0.893	0.605	0.374	1.248
1977	0.854	0.399	117.61	86.00	385.30	35.19	0.992	0.422	0.926	0.710	0.766	0.645	0.418	1.190
1978	0.936	0.456	103.76	116.90	490.60	35.97	1.021	0.497	0.958	0.710	0.662	0.744	0.515	1.209
1979	1.010	0.545	101.29	126.70	640.00	37.92	1.106	0.490	1.094	0.780	0.616	0.818	0.588	1.155
1980	1.031	0.683	103.46	157.30	746.76	31.68	1.297	0.553	1.166	1.010	0.566	0.900	0.644	0.750
1981	1.113	0.765	133.54	202.00	832.98	38.32	1.215	0.645	1.184	1.060	0.676	0.992	0.707	0.863
1982	1.010	0.978	168.27	259.10	916.52	43.75	1.099	0.747	1.134	1.090	0.852	1.097	0.812	0.961
1983	0.918	1.180	201.19	276.50	1024.58	44.56	1.083	0.812	1.098	1.030	1.001	1.077	0.938	1.031
1984	1.072	1.082	212.00	303.10	1089.39	46.45	1.102	0.908	1.066	1.010	1.054	1.056	1.027	1.099
1985	1.000	1.046	196.44	316.00	995.12	41.92	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.103	1.001	186.69	293.00	1071.38	36.28	0.949	0.964	1.063	0.880	0.967	0.962	1.013	0.979
1987	1.258	1.080	200.88	338.00	1355.61	40.11	0.949	0.983	1.102	0.800	1.014	1.088	1.236	1.192
1988	1.483	1.196	221.75	413.60	1779.71	48.80	0.950	0.989	1.175	0.810	1.063	1.324	1.522	1.445
1989	1.540	1.314	237.05	491.60	2044.40	50.91	0.956	1.128	1.258	0.740	1.097	1.379	1.633	1.638
1990	1.519	1.429	264.26	563.40	2169.66	57.24	1.025	1.231	1.297	0.780	1.197	1.448	1.681	1.742
1991	1.530	1.540	295.11	653.50	2268.08	52.32	0.995	1.328	1.294	0.780	1.305	1.557	1.761	1.610
1992	1.617	1.539	324.89	702.60	2314.75	53.49	0.924	1.446	1.277	0.710	1.406	1.537	1.822	1.791
1993	1.682	1.658	367.36	795.30	2576.20	54.35	0.914	1.516	1.285	0.730	1.561	1.660	2.015	1.788
1994	1.875	1.677	392.60	840.60	2997.54	68.90	0.967	1.576	1.276	0.710	1.630	1.688	2.361	2.311

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# **INDUSTRIAL DATA: MACHINERY EXCEPT ELECTRICAL & ELECTRONIC (SSIC#: 382)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.514	0.814	92.41	127.80	424.70	34.45	0.995	0.403	1.017	0.628	0.704	0.765	0.525	1.798
1976	0.426	0.879	89.21	125.80	333.70	34.64	0.983	0.418	0.945	0.695	0.652	0.728	0.444	1.634
1977	0.488	0.795	93.27	129.20	344.50	33.74	0.993	0.461	0.956	0.706	0.674	0.677	0.453	1.567
1978	0.591	0.792	88.43	152.60	429.70	34.96	1.018	0.465	0.861	0.710	0.626	0.792	0.627	1.614
1979	0.781	0.839	111.34	186.50	656.80	35.23	1.092	0.522	0.876	0.783	0.752	0.864	0.943	1.474
1980	0.952	0.967	122.50	228.70	746.79	31.03	1.259	0.597	0.980	1.008	0.744	0.926	0.958	1.009
1981	1.067	1.290	164.45	323.80	1072.51	38.63	1.187	0.715	1.030	1.059	0.924	1.095	1.309	1.195
1982	1.105	1.133	182.33	346.50	1055.22	36.02	1.086	0.770	0.997	1.086	1.024	1.087	1.331	1.087
1983	1.238	0.882	212.85	365.30	971.41	31.17	1.072	0.861	0.958	1.031	1.176	1.025	1.275	0.991
1984	1.190	0.852	171.84	393.50	847.81	31.10	1.089	0.972	1.024	1.008	0.948	0.978	1.041	1.011
1985	1.000	0.980	176.93	413.90	795.41	30.52	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.867	1.056	166.60	321.40	763.30	23.22	0.956	0.996	1.089	0.884	0.958	0.780	0.881	0.861
1987	1.011	1.074	188.82	338.00	1034.84	25.73	0.956	0.968	1.179	0.803	1.059	0.844	1.103	1.050
1988	1.217	1.129	218.00	406.20	1302.92	28.51	0.957	1.038	1.264	0.806	1.160	0.946	1.296	1.159
1989	1.435	1.180	238.23	490.70	1623.46	29.64	0.962	1.148	1.279	0.741	1.224	1.033	1.596	1.310
1990	1.548	1.210	247.24	569.30	1764.34	35.78	1.021	1.245	1.362	0.784	1.243	1.105	1.629	1.495
1991	1.747	1.180	253.67	630.70	1903.46	31.31	0.996	1.383	1.415	0.775	1.246	1.102	1.691	1.323
1992	1.737	1.234	288.88	736.90	1866.83	32.24	0.934	1.501	1.429	0.712	1.388	1.186	1.642	1.483
1993	1.641	1.258	313.69	768.20	1766.60	33.11	0.925	1.599	1.472	0.725	1.480	1.161	1.509	1.496
1994	1.986	1.253	325.54	843.50	2166.10	41.13	0.971	1.700	1.477	0.711	1.501	1.199	1.844	1.895

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

# INDUSTRIAL DATA: ELECTRICAL MACHINERY, APPARATUS, APPLIANCES & SUPPLIES (SSIC#: 383)

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.267	1.197	36.73	70.60	263.80	24.56	0.995	0.385	1.017	0.630	0.402	0.813	0.349	1.427
1976	0.406	1.011	37.57	73.80	347.80	24.66	0.982	0.362	0.945	0.690	0.394	0.904	0.496	1.295
1977	0.486	0.859	37.20	80.60	334.80	24.27	0.992	0.407	0.956	0.710	0.386	0.877	0.472	1.255
1978	0.569	0.986	45.26	99.10	481.90	24.75	1.019	0.436	0.861	0.710	0.460	1.007	0.754	1.272
1979	0.740	0.791	50.11	110.10	471.20	24.94	1.096	0.500	0.876	0.780	0.486	0.976	0.725	1.162
1980	0.925	0.813	61.28	133.60	568.97	23.11	1.270	0.561	0.980	1.010	0.534	1.056	0.782	0.836
1981	0.971	0.834	75.54	154.50	621.51	26.21	1.195	0.640	1.030	1.060	0.609	1.069	0.813	0.903
1982	0.923	0.851	93.75	172.20	561.59	25.51	1.090	0.800	0.997	1.090	0.756	0.954	0.759	0.857
1983	0.981	0.963	107.47	193.40	695.48	27.83	1.075	0.844	0.958	1.030	0.852	1.016	0.978	0.985
1984	1.156	0.989	119.60	224.70	828.86	30.45	1.093	0.953	1.024	1.010	0.947	1.045	1.091	1.102
1985	1.000	1.032	123.29	225.60	742.23	27.41	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.093	1.029	125.51	221.30	836.75	23.87	0.954	0.912	1.043	0.880	1.036	1.076	1.081	0.985
1987	1.445	0.984	139.63	246.20	1093.13	25.93	0.954	0.875	1.050	0.800	1.124	1.248	1.403	1.179
1988	1.724	0.977	157.77	304.10	1306.42	29.10	0.955	0.922	1.044	0.810	1.205	1.462	1.686	1.318
1989	1.963	0.990	177.16	340.70	1514.82	29.09	0.960	1.019	1.025	0.740	1.306	1.482	1.991	1.432
1990	1.818	1.033	189.92	368.00	1425.20	33.23	1.022	1.120	0.963	0.780	1.370	1.457	1.994	1.546
1991	1.982	1.028	194.21	409.10	1513.80	30.47	0.996	1.318	0.905	0.780	1.369	1.376	2.254	1.434
1992	1.984	1.029	193.75	428.40	1460.35	30.93	0.931	1.440	0.890	0.710	1.336	1.319	2.211	1.584
1993	2.056	1.053	193.83	478.50	1584.21	31.54	0.922	1.652	0.835	0.730	1.312	1.284	2.556	1.587
1994	2.274	1.075	191.04	522.10	1863.78	35.65	0.970	1.763	0.831	0.710	1.264	1.312	3.022	1.829

## CODE:

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: ELECTRONIC PRODUCTS & COMPONENTS (SSIC#: 384)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.239	0.559	20.92	128.90	827.10	58.23	0.996	0.379	1.017	0.628	0.061	0.361	0.138	1.136
1976	0.364	0.516	15.98	186.80	1165.30	58.62	0.986	0.374	0.945	0.695	0.045	0.530	0.209	1.033
1977	0.436	0.534	42.39	223.00	1493.80	57.59	0.994	0.387	0.956	0.706	0.117	0.612	0.265	1.000
1978	0.510	0.544	105.74	264.30	1728.20	58.47	1.015	0.399	0.861	0.710	0.285	0.704	0.341	1.009
1979	0.663	0.651	144.48	393.30	2762.60	59.79	1.074	0.446	0.876	0.783	0.372	0.937	0.536	0.935
1980	0.829	0.702	210.81	510.70	3514.35	54.52	1.208	0.510	0.980	1.008	0.488	1.064	0.609	0.662
1981	0.871	0.717	254.97	557.00	3916.97	61.10	1.150	0.575	1.030	1.059	0.546	1.029	0.646	0.707
1982	0.802	0.706	286.04	616.70	3564.12	63.75	1.069	0.727	0.997	1.086	0.613	0.901	0.607	0.719
1983	0.879	0.854	340.90	752.10	4767.49	72.63	1.058	0.817	0.958	1.031	0.718	0.978	0.845	0.863
1984	1.036	1.006	418.18	943.10	6361.70	80.81	1.071	0.922	1.024	1.008	0.880	1.087	1.055	0.982
1985	1.000	0.982	464.21	941.10	5886.68	81.66	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.279	0.955	540.01	976.20	7217.27	83.02	0.964	1.017	0.922	0.884	1.183	1.020	1.330	1.150
1987	1.682	1.063	727.55	1188.90	10969.65	97.92	0.964	1.003	0.915	0.803	1.555	1.259	2.037	1.494
1988	2.154	1.092	902.05	1559.90	14628.00	118.45	0.965	1.002	0.901	0.806	1.830	1.654	2.758	1.800
1989	2.369	1.135	1088.95	1836.20	17052.49	137.66	0.969	1.133	0.902	0.741	2.133	1.722	3.212	2.274
1990	2.678	1.134	1178.29	2160.10	19357.24	159.58	1.017	1.260	0.849	0.784	2.258	1.821	3.873	2.493
1991	2.678	1.178	1168.66	2325.90	20022.43	138.56	0.997	1.351	0.813	0.775	2.187	1.829	4.184	2.189
1992	2.914	1.198	1273.28	2539.50	22115.00	145.27	0.947	1.485	0.772	0.712	2.332	1.818	4.866	2.497
1993	3.579	1.212	1427.77	2657.40	27631.02	147.80	0.940	1.619	0.771	0.725	2.567	1.744	6.088	2.496
1994	4.354	1.235	1675.89	2894.00	34478.15	206.85	0.977	1.681	0.701	0.711	2.945	1.830	8.355	3.561

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: TRANSPORT EQUIPMENT (SSIC#: 385)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	0.669	0.883	228.77	220.10	555.20	50.95	0.993	0.469	1.017	0.628	1.550	1.026	1.260	1.937
1976	0.655	0.953	204.97	223.00	609.10	51.27	0.976	0.487	0.945	0.695	1.333	1.002	1.488	1.761
1977	0.596	1.174	190.11	266.20	656.30	50.51	0.990	0.548	0.956	0.706	1.222	1.062	1.585	1.708
1978	0.689	1.089	170.22	282.70	706.50	51.07	1.025	0.570	0.861	0.710	1.072	1.085	1.895	1.717
1979	0.849	1.018	155.79	304.30	745.60	52.24	1.129	0.620	0.876	0.783	0.936	1.073	1.965	1.592
1980	1.075	1.062	150.13	363.50	620.51	48.23	1.362	0.704	0.980	1.008	0.811	1.130	1.462	1.142
1981	1.355	0.917	164.37	433.20	584.85	52.74	1.262	0.807	1.030	1.059	0.821	1.174	1.311	1.188
1982	1.204	0.962	191.44	486.90	607.71	55.75	1.121	0.841	0.997	1.086	0.957	1.268	1.407	1.225
1983	1.118	0.933	219.12	467.70	575.30	52.78	1.101	0.918	0.958	1.031	1.077	1.115	1.387	1.222
1984	1.204	0.907	223.20	476.70	568.96	47.47	1.125	1.021	1.024	1.008	1.096	1.022	1.283	1.124
1985	1.000	0.999	198.93	457.00	433.11	41.91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.097	0.919	174.97	337.60	423.95	36.29	0.938	1.050	1.256	0.884	0.895	0.703	0.779	0.980
1987	1.186	0.986	169.20	352.10	544.47	35.52	0.938	1.072	1.360	0.803	0.844	0.719	0.924	1.056
1988	1.429	1.063	192.80	418.30	704.63	43.36	0.939	1.096	1.460	0.806	0.913	0.835	1.114	1.284
1989	1.740	1.016	204.08	543.10	887.49	45.34	0.946	1.287	1.411	0.741	0.933	0.923	1.452	1.459
1990	1.935	1.095	223.17	630.40	1174.83	53.33	1.030	1.281	1.285	0.784	0.998	1.077	2.111	1.623
1991	2.028	1.106	240.64	730.10	1132.35	47.34	0.994	1.303	1.289	0.775	1.051	1.226	2.028	1.457
1992	2.024	1.214	262.60	902.60	1239.09	48.67	0.907	1.511	1.329	0.712	1.123	1.307	2.153	1.630
1993	2.007	1.277	281.16	984.50	1314.49	49.78	0.895	1.591	1.446	0.725	1.180	1.354	2.099	1.638
1994	2.147	1.301	334.28	1078.10	1435.83	61.71	0.960	1.659	1.481	0.711	1.371	1.422	2.238	2.070

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

**INDUSTRIAL DATA: INSTRUMENTATION EQUIPMENT, PHOTOGRAPHIC & OPTICAL GOODS (SSIC#: 386)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	1.161	0.482	26.57	37.50	94.50	8.09	0.995	0.419	0.744	0.630	1.178	1.141	1.082	1.805
1976	1.219	0.487	24.01	39.20	104.30	7.94	0.981	0.412	0.763	0.690	1.022	1.214	1.164	1.600
1977	1.509	0.375	22.15	41.60	90.40	8.53	0.992	0.408	0.817	0.710	0.932	1.300	0.942	1.693
1978	1.335	0.547	26.55	48.30	114.00	7.80	1.020	0.456	0.835	0.710	1.094	1.351	1.163	1.540
1979	1.556	0.546	29.74	59.90	146.60	7.48	1.102	0.502	0.928	0.780	1.169	1.522	1.345	1.338
1980	1.587	0.741	31.88	76.00	188.74	10.30	1.287	0.564	1.089	1.010	1.128	1.719	1.476	1.431
1981	1.349	0.662	26.36	47.30	172.17	5.63	1.208	0.677	1.078	1.060	0.862	0.891	1.360	0.845
1982	1.016	0.871	33.87	53.90	156.37	6.51	1.095	0.725	1.053	1.090	1.107	0.948	1.265	0.839
1983	0.905	0.915	36.24	59.90	137.48	7.19	1.080	0.894	1.066	1.030	1.165	0.855	1.098	0.977
1984	1.095	0.842	33.66	68.70	123.25	7.75	1.099	0.994	1.033	1.010	1.081	0.881	1.016	1.077
1985	1.000	1.011	30.40	78.40	117.41	7.14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.190	0.969	32.68	68.30	132.96	6.21	0.951	1.009	1.067	0.880	1.094	0.864	1.061	0.984
1987	1.391	1.009	36.75	83.70	177.02	6.97	0.951	1.055	1.114	0.800	1.199	1.012	1.353	1.216
1988	1.713	1.034	41.13	99.50	236.93	7.60	0.952	1.044	1.157	0.810	1.274	1.216	1.744	1.321
1989	1.725	1.197	48.72	119.40	304.55	8.31	0.957	1.213	1.123	0.740	1.457	1.255	2.310	1.570
1990	1.992	1.208	87.79	158.30	378.10	11.59	1.024	1.486	1.111	0.780	2.569	1.359	2.899	2.070
1991	2.651	0.997	89.53	183.60	417.71	9.17	0.996	1.660	1.108	0.780	2.559	1.410	3.211	1.656
1992	2.781	1.045	92.83	199.00	430.96	9.69	0.926	1.746	1.075	0.710	2.596	1.454	3.414	1.905
1993	3.132	1.066	91.27	201.60	480.71	10.15	0.917	1.884	1.101	0.730	2.506	1.365	3.719	1.960
1994	3.207	1.063	98.74	209.70	497.48	11.78	0.968	1.922	1.103	0.710	2.649	1.392	3.841	2.319

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i



**INDUSTRIAL DATA: OTHER MANUFACTURING INDUSTRIES (SSIC#: 390)**

YR	Y	P	WK	WL	WM	WE	PK	PL	PM	PE	XK	XL	XM	XE
1975	1.161	0.301	6.69	18.10	113.80	6.57	0.994	0.328	0.744	0.630	0.325	0.901	0.507	1.487
1976	1.219	0.334	5.79	20.50	128.70	6.60	0.980	0.364	0.763	0.690	0.270	0.920	0.559	1.350
1977	1.509	0.309	5.02	24.70	148.50	6.53	0.991	0.385	0.817	0.710	0.231	1.050	0.602	1.314
1978	1.335	0.396	8.68	27.50	160.70	6.58	1.022	0.445	0.835	0.710	0.392	1.011	0.638	1.316
1979	1.556	0.501	14.28	37.70	231.00	6.70	1.111	0.504	0.928	0.780	0.615	1.222	0.825	1.216
1980	1.587	0.663	17.89	47.60	310.80	6.30	1.311	0.542	1.089	1.010	0.693	1.436	0.946	0.888
1981	1.349	0.865	25.45	54.30	354.83	6.73	1.225	0.639	1.078	1.060	0.912	1.388	1.091	0.903
1982	1.016	1.049	28.04	54.60	294.73	7.08	1.103	0.684	1.053	1.090	1.004	1.304	0.927	0.926
1983	0.905	1.236	28.91	55.10	307.01	7.12	1.086	0.828	1.066	1.030	1.018	1.087	0.954	0.981
1984	1.095	1.173	28.68	61.70	365.41	7.43	1.107	0.907	1.033	1.010	1.009	1.111	1.172	1.047
1985	1.000	1.142	27.75	61.20	301.82	7.04	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	1.190	1.109	27.92	72.90	352.93	6.67	0.947	0.954	1.078	0.880	1.024	1.249	1.085	1.072
1987	1.949	0.959	33.28	85.50	497.36	7.20	0.947	0.940	1.121	0.800	1.190	1.486	1.470	1.274
1988	2.063	1.108	38.91	96.50	649.50	7.57	0.948	1.005	1.147	0.810	1.320	1.569	1.876	1.334
1989	1.451	1.619	43.26	109.20	679.06	8.38	0.954	1.133	1.108	0.740	1.417	1.574	2.031	1.606
1990	1.541	1.644	52.46	119.90	759.42	9.34	1.026	1.275	1.063	0.780	1.682	1.536	2.367	1.692
1991	1.521	1.526	49.62	119.40	697.33	8.43	0.995	1.429	1.048	0.780	1.553	1.365	2.205	1.545
1992	1.214	1.680	47.95	115.40	604.55	8.72	0.920	1.523	1.019	0.710	1.469	1.238	1.966	1.738
1993	1.022	1.968	60.77	117.50	599.27	8.83	0.910	1.632	0.996	0.730	1.828	1.177	1.993	1.730
1994	1.019	2.012	66.07	125.70	726.39	6.72	0.966	1.824	0.983	0.710	1.942	1.126	2.448	1.342

**CODE:**

Y- index of industrial production

P- implicit output price index

Wi- cost of factor input i in millions of current dollars

Pi- price index of factor input i.

Xi- quantity index of factor input i

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