THE APPLICABILITY OF THE PORTFOLIO BALANCE MODEL OF EXCHANGE RATE DETERMINATION TO THE AUSTRALIAN DOLLAR

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DECLARATION

This thesis contains no material which has been accepted for the award of any other higher degree or graduate diploma in any tertiary institution and to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except when due reference is made in the text of the thesis.

Sandra E. Hopkins

June, 1992

ABSTRACT

Two issues represent a substantial and continuing challenge to the central bank of a small open economy. The first relates to the correct identification of the mix of domestic and external influences on the exchange rate. Correct identification is a first step toward the formulation of a coherent domestic commercial policy: one which provides desired domestic and external policy outcomes. The second requires a clear understanding of the mechanisms of control; the channels of influence open to the central bank if they are able to meet policy targets.

In order to address these two issues, the analysis develops a portfolio balance model of exchange rate determination incorporating the role of central bank foreign exchange market intervention behavior. The portfolio balance model is a short term one, restricted to periods of less than one year where the exchange rate is viewed as an asset price influenced by changes in the demand and supply of domestic money, domestic and foreign currency denominated financial assets. Incorporation of central bank behaviour into the model expands a private sector driven view of exchange rate determination into one where there is a role for both private and public sector foreign exchange market behaviour.

A further issue, which builds on the first mentioned above, is the impact of public sector behaviour on private sector participants in the exchange rate determination process. The relationship between the two sets of participants in the foreign exchange market - public and private - is reflected in the effects of central bank intervention on the decisions made by private sector investors. The risk premium required by for

example, foreign investors holding a domestically denominated asset may alter with central bank action in the foreign exchange market. The influence of intervention activity is not confined to the relationship between central bank intervention and the foreign exchange risk premium but also to the more fundamental issue of whether there is a risk premium or not.

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Chapter 1: INTRODUCTION

Two issues represent a substantial and continuing challenge to the central bank of a small open economy. The first relates to the correct identification of the mix of domestic and external influences on the exchange rate. Correct identification is a first step toward the formulation of a coherent domestic commercial policy: one which provides desired domestic and external policy outcomes. The second requires a clear understanding of the mechanisms of control; the channels of influence open to the central bank if they are to meet policy targets. These are issues subject to an ongoing worldwide debate, as there are regular reviews of exchange rate practices by such bodies as the Group of Five with its Plaza Accord of September 1985, and a recent International Monetary Fund study on exchange rate choice by developing countries (Quirk,1987). An important local example is to be found in the Economic Planning Advisory Council Background Paper (1991) on exchange rate policy[1]. There is no question about the relevance of the issues, however there is no clear-cut consensus in relation to the treatment of such issues.

The objective of the analysis follows from these introductory remarks and is briefly stated: to develop and apply a model of Australia's foreign exchange market, which accommodates the effects of various policy initiatives of the government and the central bank. The application of the model focuses on the foreign exchange relationships between the United States and Australia for simplicity and in order to capture the relevant institutional characteristics.

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[1]This background paper addresses amongst others these very issues.

1.1 The background to the research questions

The move to generalised floating exchange rates by major developed economies in the early 1970's and by the Australian government in 1983 has initiated considerable debate as to the determinants of a floating exchange rate. In particular, the recent exchange rate literature has been directed towards an explanation of exchange rate changes in terms of identifiable economy-wide changes. Prior to the adoption of flexible regimes, the popular models of exchange rate determination were based on relative price levels and trade flows[2]. But the adoption of flexible regimes brought with it an apparent exchange rate volatility, not explained entirely by economic fundamentals. This volatility aroused a substantial debate in the exchange rate literature, a debate joined by Branson and Halttunen (1979), Frankel (1983) and Baillie and McMahon (1989). With respect to the Australian currency, Trevor and Donald (1986) find that the exchange rate was relatively less volatile under the fixed rate regime prior to December 1983 than under the floating rate regime since that date. Matthews and Valentine (1986) however conclude that the volatility of the Australian exchange rate since floating is not very different from a number of overseas exchange rates. Certainly, exchange rates of developed economies were displaying movements in excess of the movement of relative price levels, rendering the purchasing power parity theorem in either its absolute or relative version[3] an

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[2] The explanatory models of exchange rate determination were essentially either a price-based analysis such as the elasticities approach where price changes and income is considered constant, or income-based analysis such as the absorption approach developed by Alexander (1952) where in its simplest form income changes and price is considered constant.

[3] The absolute version of purchasing power parity holds that the exchange rate between domestic and foreign currencies in equilibrium equals the ratio between domestic and foreign price levels. The relative version of purchasing power parity states that changes in the ratio of domestic and foreign prices would indicate the necessary adjustment in the exchange rate between any pair of currencies.

inadequate explanation of exchange rate behaviour (Branson, 1977 and Trevor and Donald, 1986). As a consequence, theories of exchange rate determination focussed increasingly on the exchange rate as an asset price. The flexible exchange rate value became a tool of monetary policy where relative rates of return on foreign and domestic assets were important determinants, and it was the capital account of a country's balance of payments rather than the current account which determined the short run values of the currency. Short run refers to periods of less than one year. The purpose here is to extend these analyses to a particular data set in a systematic fashion.

1.2 Methods and motives

What factors influence a floating exchange rate? This question represents the substance of the first issue addressed in the thesis and it is answered by reference to the portfolio balance model of exchange rate determination. This view of exchange rate determination is modelled on investors' profit maximisation preferences for these financial assets: domestic money, domestic bonds and foreign bonds. In making this choice, rational investors make a trade-off between risk and return. In doing so they influence the demand and supply of the currency which subsequently influences the exchange rate value. Thus the portfolio balance model is an asset market model of exchange rate determination which includes the market fundamentals of asset stocks - both foreign and domestic, and returns on those assets, and wealth. Essentially, the model under scrutiny is a short term explanation of exchange rate behaviour where the exchange rate is an asset price influenced by changes in the demand and supply of the three assets mentioned. Monetary policy has a direct bearing on the exchange

rate value by influencing the price of both monetary and financial assets in the model, *viz.* the interest rate. Parenthetically however, the portfolio balance model does account for changes in the government's fiscal policy through changes in bond financing and current account imbalances through changes in the supply of foreign assets. Although the model represents a short term view of exchange rate movements, it has reference to the long run through a feedback loop running from the exchange rate to commodity prices and trade flows in the current account which in turn influence the changes in supply of foreign assets.

Although there are alternative views of exchange rate determination - and these are discussed in more detail in section 2.2 - the appeal of the portfolio balance model lies in its intuitive and plausible explanation of economic events without the requirement of restrictive assumptions on investor behaviour in international capital markets. An interesting example of these restrictive assumptions is the various studies concerning the relationship between expected spot and forward exchange rates[4] in which case the objective is to determine first, if investors behave rationally in the sense of acquiring and using all available market information and second, if they are risk neutral. The validity of this approach is not questioned, rather the difference in motivation between this study and the studies that examine the relationship between the expected spot and forward rate is acknowledged[5]. The approach taken by many of the latter studies focuses less on the systematic relationships between economic variables and more on the time series statistical relationships. The contribution, here is to

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[4]There is a comprehensive survey of these studies in Chapter seven.

[5]The literature on the efficiency of forward foreign exchange markets is discussed in section 7.2.

determine if the exchange rate and the variables which relate to it, such as the risk premia, are systematically determined by well-known economic arguments.

The second issue addressed in the thesis flows naturally from the first. Although nominally the Australian dollar and similarly other major currencies are floating in currency markets, actual experience over the period since the early 1970's reveals considerable central bank intervention behaviour in the foreign exchange market[6]. There are a number of channels open to the central bank if it wishes to influence the currency value. The most common technique and possibly the easiest to quantify is direct intervention which involves buying and selling currency in an attempt to sterilise the cash base of the economy from the effects of foreign exchange adjustment[7].

The importance of central bank behaviour and its influence on the market place is important for several reasons. First and foremost, government intervention impacts on the exchange rate value independently of the market determinants of that exchange rate. There is a direct link in other words between intervention behaviour and the exchange rate. There is in addition a less direct link from central bank intervention activity to the behaviour of the market participants - the investors who buy and sell both domestic and foreign denominated financial assets. If the central bank

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[6]The behaviour of the Reserve Bank of Australia in this context is discussed in Chapter four.

[7]The government may influence the exchange rate value in other ways: from monetary policy to achieve a given exchange rate value objective to "jawboning" - the process of talking the currency value either up or down. The role of the government in maintaining a stable domestic economy as a means of achieving an exchange rate value - political signalling - cannot be discounted. Such a technique is obviously considerably more difficult to quantify.

intervention in the market affects decision-making by these investors, then intervention activity has an indirect impact on the exchange rate in addition to the direct impact of policy. Specifically, the indirect influence of central bank intervention activity can influence the risk premium and compensates domestic investors for the additional risk of holding foreign denominated rather than domestic denominated financial assets[8]. In so doing, intervention activity affects the profit-maximising decisions of investors affecting the value of the exchange rate.

1.3. Contributions and major findings

In order to focus on the desired emphasis of the key economic interactions between variables, the portfolio balance model is chosen as the framework for exchange rate determination. Therefore the first issue considered in the thesis is an examination of the validity of the portfolio balance model of exchange rate determination through the application of the simplest form of that model to the Australian/United States data set. The novelty at this stage, in addition to the application of the model to the chosen bilateral data set, is provided by the utilisation of an error correction framework to the basic model. Although such an innovation yields satisfactory results, particularly if the variables are expressed in real terms, the overall outcome highlights some deficiencies of a reduced form single equation explanation of exchange rate determination.

The next step in the development of a portfolio balance model is the extension of the model to a structural, systematic explanation of exchange rate determination

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[8]This notion is discussed in considerable detail in section 2.1.

incorporating rational expectations, central bank intervention behaviour in the foreign exchange market and an analysis of the relationship between wage determination in the domestic economy and changes in the exchange rate and/or prices of imported good. An important contribution of this research is the emphasis given to the role of the central bank in influencing the exchange rate value not only through direct intervention activity, but also through the money market. The structural equation form of the model yields considerably better results than the single equation form. Support for the portfolio balance model is strengthened further by the forecastability of the predetermined and endogenous variables in the structural model.

Finally, there is consideration of the relationship between central bank intervention and the perceived riskiness of the domestic currency. The important contribution in the examination of the risk premium on the domestic currency is not so much that there is one[9], but rather the identification of the key economic factors which influence it including central bank intervention behaviour. The results of an empirical analysis indicate that the risk premium does not respond to central bank intervention activity *per se*, but that it does respond to the changes in the management of the exchange rate.

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[9]There is considerable Australian evidence on the existence of a risk premium on the domestic currency. Details are provided in section 7.1.

1.4 Structure of thesis

The theoretical background to the portfolio balance model is presented in the second chapter of the thesis where the development of the portfolio balance model to exchange rate determination is an extension of Tobin's (1969) work on the portfolio demand for money in the closed economy to the open economy. A number of economists have contributed to the development of the open economy portfolio balance model. Pioneering theoretical development was undertaken by Branson (1977) and Dornbusch and Fischer (1980). Subsequent extensions to the model have been numerous. The literature in this area is large and as a consequence, the discussions in Chapter two is confined to relevant issues alone.

In Chapter three, Branson's portfolio balance model is investigated using the Australian/United States dollar exchange rate. Initial analysis undertaken in this chapter is a replication of the analysis by Branson and Halttunen (1979). There is also discussion of the time series characteristics of the data in this chapter. In particular, an error correction model is applied to the portfolio balance model to furnish a longer term dynamic framework to the relationships of the model.

The analysis of the relevance of the portfolio balance model in chapter three is extended into Chapter four where apparent weaknesses are considered. Three weaknesses are considered, *viz.* the first is the assumption of static expectations formation; the second is the omission of the role of the government through the central bank in the foreign exchange market and the third involves the imposition of exogeneity on the explanatory variables in a single equation model of exchange rate

determination.

Chapters five and six gather up these apparent limitations and incorporate them into a more complex but seemingly more realistic view of exchange rate determination: a view whilst still firmly embedded in the portfolio balance explanation of exchange rate determination is based on a small structural model of an open economy. Chapters five and six track the theoretical development and the empirical analysis of this model. There is at times considerable speculation as to whether the central bank intervenes or not, and if so how it intervenes and how effective is its intervention. The first two of these issues is addressed in Chapters five and six.

The complex issue of the effect of government intervention in the foreign exchange market is left to Chapters seven and eight. Not only may central bank intervention actively influence the exchange rate value directly by changing the supply and demand conditions in the market but it may also affect the exchange rate value indirectly by influencing the willingness of private investors to hold a given currency or bonds denominated in a given currency. A secondary issue of the analysis in these chapters is the role of a risk premium in an exchange rate model in general and whether a risk premium actually exists for the currency in question, that is the Australian/United States dollar exchange rate.

Finally, Chapter nine provides a synthesis and discussion of the results of the study and the avenues for further research.

Chapter 2: THEORETICAL BACKGROUND

This chapter presents the theoretical background to the portfolio balance model. The application of the portfolio balance model to determination of the spot exchange rate represents an extension of the portfolio demand for money to the open economy. A number of economists have contributed to this development. The pioneering theoretical developments reviewed here were undertaken by Branson (1972, 1976), and following the discussion of the extension of the model to the open economy, the empirical analyses on more variations of the portfolio balance approach are reviewed.

2.1 The development of the portfolio balance approach to exchange rate determination

The portfolio balance approach to macroeconomic modelling in closed economies was developed by Metzler (1951) and Tobin (1969). According to this approach, equilibrium in financial markets occurs when the available stocks of national monies and other financial assets are equal to the demands for these assets; demands which are determined by the agents in the asset market who are subject to a budget constraint.

The process of adjustment of a portfolio of assets continues as long as desired wealth is not equal to actual wealth. In developing these arguments, the builders of portfolio balance models postulate asset demand functions in preference to deriving them from explicit utility maximising behaviour. The latter implies that the demand equations for assets denominated in different currencies are based on the solution to a maximisation problem faced by an individual investor. The investor consumes a

bundle of goods each of which is produced in a different country and priced in the currency of the country in which it is produced. In each currency denomination, there is an asset with a fixed nominal value and a certain nominal return - the rate of interest. The investor derives income from the asset and from labour income. The investor's objective is to maximise the expected value of discounted lifetime utility. Postulated asset demand functions although not derived from utility maximising behaviour nonetheless refer to microeconomic theory by their relationship to the theory of portfolio selection in the case of non-monetary assets and to the theory of money demand in the case of monetary assets (Branson and Henderson, 1985). The main drawback of using postulated asset demands rather than those derived from utility maximising behaviour is that the results of any analysis are subject to the Lucas critique where changes in policy regimes change the utility maximising behaviour and therefore the asset demands (Lucas, 1976).

A number of economists have contributed to the integration of international macroeconomics with financial portfolio balance analysis. The Mundell-Fleming model[1], although not a portfolio balance model is nevertheless considered to be the intellectual antecedent to the portfolio approach to the open economy (Krueger, 1983). The origins of the open economy portfolio balance approach are attributable to McKinnon (1969) and McKinnon and Oates (1966). They recognised several weaknesses in the Mundell-Fleming model: in particular the implicit assumption in

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[1] Mundell (1963) and Fleming (1962) developed a Keynesian-type model in which the net current account balance is a function of real income and the exchange rate, whereas the net capital account balance is a function of the differential in interest rates between the home country and the rest of the world. The major shortcoming of the Mundell-Fleming model for which compensation was forthcoming in the portfolio balance models, was neglect of the central role of wealth variables. (Isard, 1978)

the model that differential interest rates between the domestic economy and the rest of the world lead to a continuous capital inflow, and new equilibrium positions in the current account in response to monetary and fiscal policy were attained without regard to the influence of the policy on wealth variables. Model development by McKinnon (1969) and McKinnon and Oates (1966) subsequently, recognised the central role of wealth variables.

Branson (1972, 1976) further developed the portfolio balance model by drawing on Tobin's closed economy models. Central to all portfolio models is the notion that individuals allocate their wealth, which is fixed at a given point in time among alternative assets of domestic money and domestic and foreign denominated financial assets. Branson in his open economy portfolio balance model hypothesises that the exchange rate is determined in the short run by changes in the supplies of these assets held by investors in response to changes in relative rates of return on those assets. The rates of return are the domestic and foreign rate of interest. In the long run, it is hypothesised that the exchange rate is determined by the real factors of international trade flows, long term investment decisions and purchasing power parity. The exchange rate is thus the focus for bringing about international portfolio balance. Expectations are considered static in this preliminary development of the portfolio balance model.

2.2 Theoretical models of exchange rate determination

Theoretical models of exchange rate determination are built around two views of foreign and domestic financial asset substitutability. In monetary models[2] of exchange rate determination, domestic and foreign financial assets are considered to be perfectly substitutable. The classical version of the monetary model is associated with the strict quantity theory of money, where money is neutral implying that all variables in the real economy are constant and relative prices are unaffected by monetary changes. Two assumptions enable derivation of an expression for the exchange rate under this view of exchange rate determination. The first of these is an assumption of absolute purchasing power parity: prices are the same in both economies when converted at the market-determined spot exchange rate. The law of one price assumes that arbitrage - the profit maximising behaviour of investors in buying an asset when the price is low and selling when the price is high - ensures the equality between countries of the exchange rate adjusted prices of identical tradeable goods. The absolute purchasing power parity assumption can be expressed as:

$$P = SP^* \qquad (2.1)$$

where P is the domestic price level, and S is the exchange rate measured as domestic currency price of foreign currency, and an asterisk denotes a foreign variable. All variables are expressed in levels.

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[2] Monetary models of exchange rate determination represent an application of the monetary approach to the balance of payments to an economy with a flexible exchange rate. The development of the monetary approach to the balance of payments is in part attributable to Harry G. Johnson (1977) In the monetary approach to the exchange rate determination, the exchange rate is the relative price of two monies.

The second assumption underlying the monetary model of exchange rate determination is that each country has a stable demand for money[3] where the demand for real balances is a proportion of income:

$$\frac{M}{P} = KY, \qquad \frac{M^*}{P^*} = K^*Y^* \tag{2.2}$$

where M is the money stock, Y is income, and K, the proportion of income demanded is the inverse of the velocity of circulation of money[4].

Rearranging the money demand equations and substituting them into equation (2.1) yields:

$$S = \frac{M}{M^*} \cdot \frac{K^*}{K} \cdot \frac{Y^*}{Y} \tag{2.3}$$

where the exchange rate, S is determined by relative money stocks, relative velocities of circulation and relative income. In order for equation (2.3) to hold there must be continuous equilibrium in the goods markets, purchasing power parity must hold and, money is neutral[5].

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[3]The assumption of a stable demand for money function holds that the determinants of the demand for money - largely and conventionally income and the interest rate - are time invariant.

[4]From the classical quantity theory of money, $Mv = pY$, K is equal to the inverse of v, where v is the velocity of circulation of money.

[5]Subsequent analysis of this monetary model - or the flexible price monetary model as it became known - of exchange rate determination revealed a flaw in one of its major assumptions. Dornbusch (1976) found that the exchange rate tended in the short run to overshoot its long run equilibrium.

The underlying assumption of this model is that money is the only financial asset instrumental in the determination of the exchange rate. In this case domestic and foreign assets can be treated as a single asset and are therefore perfectly substitutable. The assumption of perfect substitutability implies that investors are risk neutral, and therefore the stronger form of the interest rate parity theorem - uncovered interest rate parity - holds. Equation (2.4) describes the uncovered interest parity condition:

$$(s_{t+1}^{e} - s_t) = (r_t - r_t^*) \qquad (2.4)$$

where s is the spot exchange rate, s_{t+1}^{e} is the expected spot rate of the currency in the time period $t+1$, r is the interest rate, and an asterisk denotes a foreign variable. Both exchange rate terms are expressed in natural logarithms[6]. The expectation of the movement of the exchange rate between period t and $t+1$ is conditional on the set of

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[6]Expression of the uncovered interest rate parity theorem (and covered interest rate parity theorem below) in natural logarithms overcomes the difficulty of what is termed Siegel's paradox. Siegel (1972) shows that the proposition that the level of the forward rate is equal to the level of the future spot rate implies a contradiction. If the proposition were true for the Australian/United States dollar exchange rate, it could not also be true for the United States/Australian dollar exchange rate. This is because Jensen's inequality requires that $E(1/x) > 1/E(x)$, when x has positive variance. The paradox was resolved by Roper (1975) and Boyer (1977) who found that it is legitimate to express the uncovered interest rate parity theorem in logarithmic form.

Expressed in levels rather than natural logarithms, the uncovered interest parity condition states that:

$$\frac{E_t(S_{t+1})}{S_t} = \frac{(1 + r_t)}{(1 + r_t^*)}$$

This condition arises because one dollar invested in the domestic economy yields:

$$\$1(1 + r_t)$$

or, it yields a return of:

$$\frac{\$1(1 + r_t^*)}{S_t} E_t(S_{t+1})$$

if it is invested in a foreign denominated interest bearing assets, and no forward cover is purchased to protect the investor against exchange rate risk.

all relevant and available information at time t. Thus instead of purchasing forward cover for protection against exchange rate risk, the investor under the assumption of uncovered interest rate parity is holding an open position in the spot market which is dependent on his/her expectations of the future exchange rate. Assuming that investors form their expectations rationally[7], that is they take into account all available information in their information set and do not make systematic errors and assuming that they are risk neutral, the activities of profit maximising investors bid up or down the spot exchange rate or interest rates to the point where the market's expected rate of depreciation or appreciation of the spot rate is equal to the interest rate differential. The joint hypothesis of rationality and risk neutrality is discussed in considerably more detail in section 7.1.

A distinguishing feature of portfolio balance models is the assumption of imperfect substitutability of foreign and domestic financial assets. Apart from the risk factor of exchange rate variability, there are a number of factors such as differential tax risk, political risk and default risk which suggest that financial assets issued in different currencies are unlikely to be viewed as perfect substitutes. Thus international investors hold a portfolio of assets in an attempt to optimise the risk/return trade-off. The portfolio balance model however, follows the monetary models by assuming perfect capital mobility. This assumption allows instantaneous adjustment in asset stocks held by investors in response to the return on assets in the portfolio. Furthermore, this assumption restricts the source of risk in the model to exchange rate variability.

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[7]The hypothesis of rational expectations is discussed in more detail in section 4.3.

There are two ways in which perfect capital mobility has been viewed in the literature. On the one hand, perfect capital mobility is the joint hypothesis summarised by the uncovered interest parity condition in equation (2.4) where domestic and foreign assets are perfect substitutes and adjustment is instantaneous. MacDonald (1988) notes that Fleming (1962) and Dornbusch (1976) use this definition of perfect capital mobility. On the other hand, in a portfolio balance model, uncovered interest rate parity no longer holds as there is a risk premium over and above the expected change in the exchange rate. Perfect capital mobility in this context refers to the instantaneous adjustment of portfolios only. MacDonald (1988) states that Dornbusch and Krugman (1978) and Frankel (1979) use this latter definition of perfect capital mobility.

The introduction of imperfect substitutability of domestic and foreign assets implies that uncovered interest parity does not hold as investors are no longer risk neutral but risk averse. Investors however eliminate the risk originating from exchange rate variability by purchasing a forward contract. Equation (2.4) is thereby replaced with the covered interest parity condition. Thus investors' portfolios are in equilibrium when:

$$(f_{t,1} - s_t) = r_t - r_t^*$$
(2.5)

where f is a forward rate at time t due for delivery at time $t+1$. The forward contract protects the investor against unanticipated movements in the exchange rate over the time period $t+1$. Once again the exchange rate terms - both the forward and spot rate

- are expressed as natural logarithms[8]. The equilibrium condition of equation (2.5) states that assuming no transaction costs, a difference in domestic and foreign interest rates for financial assets of similar risk and maturity should be equal but opposite in sign to the forward exchange rate premium or discount for the foreign currency.

2.3 The portfolio balance model

In the portfolio balance model developed by Branson, investors in both the domestic and foreign countries hold three assets: domestic money, domestic financial bonds and foreign financial bonds. It is assumed that investors hold all three assets[9].

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[8]Expressed in levels rather than natural logarithms, the covered interest parity theorem states that:

$$\frac{F_{t,1}}{S_t} = \frac{(1 + r_t)}{(1 + r_t^*)}$$

This equality arises because one dollar invested in a domestic currency denominated interest bearing asset yields:

$$\$1(1 + r_t)$$

or, it yields a return of:

$$\frac{\$1(1 + r_t^*)}{S_t} F_{t,1}$$

if it is invested in a foreign currency denominated interest bearing asset, and a forward contract is purchased to protect the investor against exchange rate risk.

[9] The portfolio balance model developed here assumes that investors do not hold foreign money. Models in which investors' hold a portfolio of monies in different denominations are termed currency substitution models. There are two types of currency substitution models. Monetary currency substitution models are similar to models of the monetary approach to the balance of payments in that any current account imbalance reflects a disequilibrium between the demand or supply of domestic money relative to foreign money. Initial development of the monetary currency substitution models is by Barro (1978) and Calvo and Rodriguez (1977). The second type of model attributable to the work of Bilson (1979) and Girton and Roper (1981) is the global currency substitution model. The emphasis here is on a global money supply achieved by a highly integrated capital market. There are considerable similarities between the global currency substitution model and the portfolio balance model that is developed here. In particular, an investor in the currency substitution money holds a portfolio of money assets: the investor in the portfolio balance model holds a portfolio largely consisting of non-monetary assets. The portfolio balance model, can be extended to include the three assets mentioned here plus foreign money.

Furthermore, the small country assumption holds for the domestic economy: that is domestic investors are price takers with respect to the interest rate on world traded assets, and changes in the rates of return on domestic currency denominated assets do not impact on rates of return overseas. At any point in time in the asset market, equilibrium conditions are given by the requirement that the supply of assets be equal to the demand for assets. The market equilibrium conditions are defined by the three equations below:

$$M = m(r,r^*)W \qquad (2.6)$$

$$B = b(r,r^*)W \qquad (2.7)$$

$$SFa = fa(r,r^*)W \qquad (2.8)$$

where *M, B and SFa* are domestically issued money, domestic currency denominated assets and foreign currency denominated assets held by domestic residents, respectively. All variables are expressed as levels. These assets are predetermined stock supplies. Both the exchange rate and the domestic interest rate are endogenous variables. The foreign interest rate is exogenously determined according to the small country assumptions of the model.

Equations (2.6) to (2.8) are bound by a wealth constraint:

$$W = SFa + B + M \qquad\qquad (2.9)$$

which is consistent with the assumption that investors at any point in time hold their wealth in all three assets[10]. Equation (2.9) is also a balance sheet constraint which ensures that the sum of the proportions of total wealth held in the three different type of assets - m, b, and fa from equations (2.6) to (2.8) - are equal to one. The balance sheet constraint (2.9) plus an assumption of gross substitutability among assets in the portfolio distribution function implies:

$$m_r + fa_r = -b_r < 0 \; ; \quad m_{\bar{r}} + b_{\bar{r}} = -fa_{\bar{r}} < 0 \qquad\qquad (2.10)$$

where a subscript refers to a partial derivative, and the bar over a variable refers to

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[10]The inclusion of bonds issued by the domestic government, B in the specification of wealth is controversial. Ricardian equivalence assumes that government bonds are not part of the net wealth of an individual and therefore do not affect private decisions, otherwise influenced by the value of wealth. The exclusion of bonds from wealth follows from a rational evaluation by investors that with the issuance of bonds, there is in future time periods both an explicit obligation on the government's behalf to pay interest and an implicit obligation for the government to collect tax revenue to finance the payment of that interest. Barro (1974) discusses a number of different circumstances under which bonds are not net wealth. Feldstein (1982) on the other hand presents evidence supporting the view that households value government debt as net wealth. Liederman and Blejer (1988) in a survey paper on Ricardian equivalence, note arguments for the possible inclusion of some or all of bonds in the wealth function. One possibility is that the obligation of an individual to pay taxes is finite: it lasts - assuming the tax collection is based on an income tax and not consumption tax - to the end of the working life of the individual. The stream of government bond interest payments, on the other hand may accrue over a considerably longer time period, approaching infinity. The second reason for the inclusion of bonds as net wealth centres on the assumption of Ricardian equivalence that no individual is constrained by liquidity. In particular, individuals whose only form of collateral is their human capital tend to face a higher borrowing rate than a lending rate, and therefore such individuals tend to be liquidity constrained. The market failure implied by differential interest rates is mitigated by the role of a government as a financial intermediary in the issuance of interest bearing assets, for the issuance of the bonds decreases the tax obligation of a liquidity strained individual and therefore increases her disposable income.

A portfolio balance model views money as a direct portfolio substitute for interest bearing assets, including bonds, where wealth is a scaling variable. With due acknowledgment to the controversy surrounding Ricardian equivalence, bonds are considered to form part of the wealth function in the use of the portfolio balance model of exchange rate determination.

its long run value.

The three market equilibrium conditions (equations 2.6 to 2.8) contain two endogenous variables - the exchange rate and the domestic interest rate. Thus any pair of these three market equilibrium equations with wealth, W substituted from equation (2.6) can be used to determine the short run equilibrium values for the endogenous variables.

Equations (2.11) and (2.12) describe equations (2.6) and (2.7) in implicit function form, with W substituted from equation (2.9):

$$m(r,r^*)(SFa + B + M) - M = 0 \qquad (2.11)$$

$$b(r,r^*)(SFa + B + M) - B = 0 \qquad (2.12)$$

Total differentiation of these two implicit functions yields:

$$dM = Wm_r dr + Wm_{r^*} dr^* + m[dM + dB + SdFa + FadS] \qquad (2.13)$$

and,

$$dB = Wb_r dr + Wb_r dr^* + b[dM + dB + SdFa + FadS] \qquad (2.14)$$

In matrix form, equations (2.11) and (2.12) can be written as:

$$
\begin{bmatrix} Wm_r & mFa \\ Wb_r & bFa \end{bmatrix} \begin{pmatrix} dr \\ dS \end{pmatrix} = \begin{bmatrix} 1-m & -m & -mS & -Wm_{r^*} \\ -b & 1-b & -bS & -Wb_{r^*} \end{bmatrix} \begin{pmatrix} dM \\ dB \\ dFa \\ dr^* \end{pmatrix}
$$

(2.15)

Denoting the matrix immediately to the left of the equality as A, then the determinant of (A) can be defined as:

$$
Det.(A) = WFa(m_r b - b_r m) \qquad (2.16)
$$

then the sign on the determinant is negative, as the sign of the first term inside the brackets of equation (2.16) is negative and the sign on the second term is positive.

Therefore the solution for changes in the domestic interest rate and the spot exchange rate is given by:

$$
\begin{pmatrix} dr \\ dS \end{pmatrix} = \frac{1}{DET.(A)} \begin{bmatrix} bFa & -mFa \\ -Wb_r & Wm_r \end{bmatrix} [Bij] \begin{pmatrix} dM \\ dB \\ dFa \\ dr^* \end{pmatrix} \qquad (2.17)
$$

From equation (2.17), the direction of change of the interest rate and the exchange rate can be derived in response to an increase in any one of three assets stocks. These

signs are summarised in Table 2.1 and an explanation for the signs follows the table.

Table 2.1: Effects of increases in asset stocks on the short run equilibrium exchange rate and interest rate

| | Accumulation of stocks | | |
	ΔM	ΔB	ΔFa
r	-	+	0
S	+	+/-	-

The sign on the interest rate term in Table 2.1 reflects the expected relationship between a change in the stock of money and its rate of return. There is no nominal return for holding money, M^{11} and assuming no inflation or deflation, there is no real return to individuals for holding money. It does however, yield a return to individuals as an asset since it is perfectly liquid and can be used as a medium of exchange. An increase in the stock of money in the domestic economy, relative to the money stock in the foreign economy decreases the rate of interest in the domestic market. With the supply of money greater than the demand for money at the given interest rate and wealth levels, individuals' demand for goods and financial assets increases. The increase in the demand for financial assets increases the price of bonds and decreases

---

[11]This assumes that the money stock is defined as M1.

their yield[12]. Consequently, there is a capital outflow and a rise in the price of foreign currency. For a home economy, an increase in the stock of money depreciates its currency relative to the foreign currency and conversely increase the value of the exchange rate, S.

Domestic financial assets, B, or more generally bonds, are interest-bearing domestically-issued short term assets held by domestic residents and denominated in domestic currency. Branson assumes that domestic financial assets are short-term and therefore, the difficulty of incorporating capital gains into the analysis can be ignored. Domestic bonds, like domestic money are a liability of the government. As the supply of domestic bonds falls - due to a change in bond financing associated with a change in fiscal policy - the demand for bonds is greater than the supply of bonds. The price of bonds rises and the return on bonds falls. Thus the interest rate falls in response to a fall in the supply of bonds.

The effect on the exchange rate, however is uncertain. This is reflected in Table 2.1 by the sign for the impact on a change in bond supply on the exchange rate. The fall

---

[12]When there is a change in the demand for bonds, the market price of bonds responds accordingly. The change in the market price in turn leads to a change in the effective rate of return. Jüttner (1987) describes the relationship between the fixed-in-dollar value coupon payment (C), the effective rate as a decimal (r), the principal at maturity in dollars (F), and the present value or market value in dollars (P) as:

$$P = \frac{(C + F)}{(1 + r)}$$

where the coupon rate in decimal form equals C/F. The effective rate is used in this relationship to discount a stream of future cash flows and is therefore otherwise known as the discount rate. The equality above shows the one-to-one inverse relationship between the market price (P) and the effective rate (r). That is an increase in the market price of bonds decreases the effective rate of return and *vice versa*.

in the return on domestic bonds makes foreign bonds relatively more attractive. The increase in the demand for foreign bonds increases the demand for foreign currency and the foreign currency would appreciate. That is, the domestic currency depreciates; S rises.

However, there may be a wealth effect. The increase in the value of domestically held debt may increase the demand for money for transactions purposes, assuming that the demand for money for everyday transactions purposes is dependent on wealth. The domestic interest rate must rise. This produces a capital inflow and the domestic currency appreciates; S falls. A portfolio effect may be important here. If foreign bonds and domestic bonds are considered by investors to be good (but not perfect) substitutes and better substitutes than other portfolio combinations - say money and domestic bonds (they are usually considered to be complements) - then the fall in the interest rate in response to a fall in the supply of domestic bonds tends to increase the demand for domestic bonds. Demand for domestic currency increases; it appreciates and S falls.

Foreign financial assets or bonds, Fa are interest-bearing short-term foreign assets held by residents of the domestic economy and recorded in domestic currency. Similar to the assumption about domestic bonds, a proportion of foreign bonds is held privately by the rest of the world; the remainder is held privately in the domestic economy. Foreign bonds are a liability to the foreign government.

Domestic holdings of foreign bonds increase as a result of a current account surplus

in the domestic balance of payments. If for example there is a current account surplus, domestic investors are holding excess supplies of foreign bonds, given the rate of interest current in their portfolios. The process of selling off the assets causes the domestic currency to appreciate as the assets are exchanged for domestic currency and the demand for that currency increases. The foreign currency depreciates as the supply of foreign currency increases. Thus the value of S falls.

An important issue concerns the short-run stability of the equilibrium position at which the demand for money, domestic bonds and foreign bonds are equal to their respective supplies at a given rate of interest and exchange rate. From Branson (1979), the short-run dynamic adjustment system for the exchange rate, S and the rate of interest, r is assumed to be given by:

$$\dot{r} = \gamma[B - b(r,\bar{r})W] \tag{2.18}$$

$$\dot{S} = \lambda[fa(r,\bar{r})W - SFa] \tag{2.19}$$

where the dot over the variable refers to a change in the variable in continuous time, and the bar over the variable refers to its long-run value. Here γ *and* λ are adjustment coefficients, where $0 < \lambda, \gamma < \infty$. Equations (2.18) and (2.19) state that if the market for domestic bonds, B is in disequilibrium, then the adjustment mechanism is through changes in the interest rate; whereas if the market for foreign bonds, Fa is in disequilibrium, then the adjustment mechanism is through changes in the exchange rate.

Linearising equations (2.18) and (2.19) by Taylor's expansion around the equilibrium with the wealth definition, equation (2.9) substituted for W, yields the adjustment equation:

$$\begin{pmatrix} \dot{r} \\ \dot{S} \end{pmatrix} = \begin{bmatrix} -\gamma \bar{W} b_r & -\gamma \bar{b} Fa \\ \lambda \bar{W} fa_r & -\lambda \bar{F}(1-fa) \end{bmatrix} \begin{bmatrix} r_z - r \\ S_z - S \end{bmatrix}$$

$$(2.20)$$

where r_z and S_z are the rate of interest and the spot exchange rate at equilibrium. The stability matrix - to the immediate right of the equal sign - has the signs as indicated. Necessary and sufficient conditions for stability of r_z and S_z are that the trace of the stability matrix < 0 which is clearly true in this case, and that the determinant of the stability matrix > 0. The determinant is:

$$Det = \gamma \lambda WFa[b_r(1-fa) + fa_r b] > 0 \qquad (2.21)$$

since we know from equation (2.10) that $b_r > -fa_r$, and $1 - fa > b$. Thus the short run equilibrium is stable.

Finally, the primary emphasis in the simple portfolio balance model is an explanation of the short run determinants of the exchange rate. In turn, those determinants are asset stocks whose bases are in the capital account of the balance of payments rather than in the current account. The longer run dynamics of the portfolio balance approach, however do not ignore the influence and importance of the current account

in determining the exchange rate value.

The discussion of the portfolio balance model above describes a process whereby the adjustment of the stocks of assets to changes in the demand for these assets determines the exchange rate value. The exchange rate in turn however, influences the level of net exports through the terms of trade and the initial stock of foreign bonds held by domestic residents influences the amount of investment income. Together these two factors determine the current account and the rate of accumulation of net foreign assets. In turn the accumulation (or decumulation) of foreign assets influences the exchange rate value by the portfolio selection process.

2.4 Empirical analysis of the portfolio balance model

Initial testing of the model was conducted not surprisingly by Branson often in partnership with other researchers.

Branson and Halttunen (1979) use the short-run comparative statics of equations (2.6) through to (2.8), and the solution for changes in the domestic rate of interest and the exchange rate in equation (2.22) to derive an implied reduced form equation for the exchange rate:

$$S = S(M,B,Fa,r*) \qquad (2.22)$$

The argument in equation (2.22) focuses on one small country facing a world market. Branson and Halttunen translate equation (2.22) into a relationship for the determination of a bilateral exchange rate which is dependent on the stocks of assets

of both domestic and foreign origin. The equilibrium value of the exchange rate is the value at which the two private sectors together are willing to hold the existing stocks of the two national monies.

The empirical equation used by Branson and Halttunen is a version of (2.22) expressed bilaterally in order to consider the movement of one national currency against another:

$$s = \alpha_0 + \alpha_1 m + \alpha_2 m^* + \alpha_3 fa + \alpha_4 fa^* + \mu \qquad (2.23)$$

where the lower case notations indicates the natural logarithms of the variable in question, μ is an error term and foreign variables are indicated by an asterisk.

Branson and Halttunen proxied the money supplies by M1 and the foreign assets by cumulated current accounts. The authors used M1 because generally speaking the relationship between the monetary base of the economy and the money stock tends to be looser than the relationship between M1 and the money stock. In the economies considered by Branson and Halttunen - West Germany and the United States - M1 is frequently used as an independent target variable for monetary policy.

Their decision to exclude domestic financial bonds was based on two arguments. The first factor reflects an ongoing difficulty with portfolio balance models, namely the unavailability of good data for non-monetary assets. Second, they do not include domestic assets in empirical tests because of the ambiguity about the sign of the effects of changes in these asset stocks. We know from the development of the theory

by Branson and from the discussion in section 2.2 that the coefficients α_1 and α_4 are positive, and α_2 and α_3 are negative.

Branson and Halttunen estimated equation (2.23) for a number of currencies[13] from July 1971 to June 1976. Overall the results of testing the simple portfolio balance model were considered by Branson and Halttunen to be encouraging. In most of the equations across a number of currencies, the coefficients are significant and they have the expected signs. They found however that the residuals in almost all the ordinary least squares estimates were highly autocorrelated.

Development of the portfolio balance model subsequent to the contribution of Branson (1972, 1976) consists largely of an extension of the theory through the incorporation of additional explanatory variables into the model of exchange rate determination.

For example, Branson, Halttunen and Masson (1977) apply the portfolio balance model developed by Branson (1976) to the United States dollar/Deutschemark exchange rate. They extend the theory to include government reaction functions for both monetary policy and exchange market intervention by the central bank. Branson and Halttunen (1979) consider the same asset market model as developed earlier by Branson (1972, 1976) as the explanation for exchange rate determination in the short run and consider the role of relative prices - representing purchasing power parity -

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[13]These currencies were the Japanese yen and the Deutschemark against the United States dollar, and the French franc, the Swiss franc, the United Kingdom pound and the Italian lira against the Deutschemark.

for the long run. Some authors (Dornbusch 1975 and Artus 1976) formulate their models so that the relative price term is incorporated in the short run explanation of exchange rate determination in addition to the asset market explanation. Branson and Halttunen conclude given that as the relative price variable contributes to the explanation of movements in exchange rates, the assets demand functions need to be respecified in real terms.

Artus (1976) developed a structural version of the portfolio balance model for Germany where all variables were expressed as first differences. His model includes a specification for investors' expectations (which assumes that expectations are adaptive, not rational) and includes policy reaction functions for both monetary and intervention policy. Therefore, it differs considerably from Branson's reduced form, levels (or stock) version of the portfolio balance model. Branson and Halttunen, however consider that Artus' results are qualitatively similar to their own.

Dornbusch (1975) assumes a role for relative prices in addition to the changes in asset supplies in the model of short run exchange rate determination. Dornbusch and Fischer (1980) develop the exchange rate determination model further by the integration of relative prices, asset supplies and expectations as well as emphasising the importance of the current account through its effect on net asset markets. An important point of departure exemplifying the difference between their model and the asset market models of exchange rate determination developed by Branson concerns the issue of overshooting; where the greater flexibility of prices in the asset as opposed to the goods markets leads to a more than proportionate adjustment in the

exchange rate in the short run.

Bisignano and Hoover (1982) suggest that the data deficiencies in many of the analyses of the portfolio balance model may account for the presence of autocorrelation in many cases. First they suggest that the omission of domestic assets - both domestic and foreign - would result in biased regression coefficients. Second, the use of accumulated current accounts as the proxy for foreign assets may also lead to spurious results. Such an approximation includes accumulation of foreign assets due to trade surpluses with third countries as well as the foreign economy of interest. A consistent implementation of the portfolio balance model using a bilateral exchange rate therefore, requires that all data is bilateral. Bisignano and Hoover incorporated these two modifications into their estimates of equation (2.23). Using monthly data for the Canadian/United States dollar exchange rate for the period March 1973 to December 1978, they present results that provide a better fit than those results presented by Branson and Halttunen (1979).

Numerous other authors have tested forms - some simple, others more complex - of the portfolio balance approach. Frankel (1983) for example, used a form of equation (2.23):

$$s = -\alpha + \beta(r-r*) + \gamma b - \lambda f + \mu \qquad (2.24)$$

where the exchange rate is determined by relative bond supplies - domestic and foreign - and the interest rate differential. Here as in other simple specifications of the portfolio balance model, expectations are considered to be static; that is the

expected value of the exchange rate in future time periods is the same as the exchange rate value now.

The key difference between the Frankel approach and that of the simple portfolio balance model in the Branson format is the abandonment of the small country assumption. This assumption holds that domestic residents are the only ones who wish to hold domestically denominated assets as the domestic country is assumed to be too small for its assets to be of interest to foreign residents (Frankel, 1983). Frankel considers the outcome for the portfolio balance model under four alternative assumptions of the ownership of foreign and domestic currency denominated assets. He uses the United States dollar/Deutschemark rate from January 1974 to October 1978. The empirical analysis yielded poor results as the coefficients are always of the incorrect sign and usually significantly so.

The small country assumption appears particularly restrictive when the domestic country under consideration is the United States or West Germany. One alternative is to assume that the foreign country is the small country so that domestic residents do not hold foreign bonds. Another alternative is the preferred local habitat model which recognises that residents of both countries hold assets issued by both countries[14]. But an assumption is made in each case that domestic residents prefer to hold more of the domestically denominated assets than the foreign ones. This approach although seemingly more appropriate for large countries has not been

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[14] Kouri and de Macedo (1978) have examined empirically the proposition of preferred local habitat.

popular and few empirical analyses adopt this approach.

2.5 Empirical analysis of the portfolio balance model with Australian data

M. G. Porter (1974) considered financial equilibrium adjustment in a small open economy with portfolio substitutions which generate both capital flows and changes in the domestic interest rate. Of course, this analysis considered a fixed rather than a flexible exchange rate and is not a model of exchange rate determination, but is nonetheless a forerunner to such models. Kouri and Porter (1974) derive a model of international capital flows from a portfolio equilibrium model of an open economy under fixed exchange rates. Their model is a synthesis of the portfolio approach developed by Branson (1968) and the monetary approach to the balance payments developed *inter alia* by Johnson (1977).

The Kouri and Porter model is extended by Murray (1978) to include a disaggregation of GNP into investment and non-investment spending. Murray concludes that only part of the capital inflow into a country can be interpreted in the monetary model as a response to the excess demand for money. The remainder of a country's capital inflow is tied to a particular sector by institutional factors, and therefore does not response to monetary variables.

Kearney and MacDonald (1988a) consider the validity of the portfolio balance model using Australian/United States data for the period since the floating of the Australia dollar in late 1983. They regress the spot rate on relative money, income, the interest rate and a wealth variable. They use the share price index as a proxy for wealth and

find that the variable is consistently wrongly signed across the estimating equations. Their analysis although not comprehensive in the sense that the main interest of the paper is in testing monetary models of exchange rate determination is not supportive of the portfolio balance model. The conclusion suggested by them is that such lack of support for the model may imply a data difficulty rather than necessarily a rejection of the model.

2.6 Conclusions

In this chapter, I have outlined the theoretical foundations of the simple portfolio balance model and discussed some of the initial empirical analysis of it using both Australian and foreign data. The task of the next chapter is to examine the portfolio balance relationship of equation (2.23) using Australian and the United States bilateral data. Equation (2.23) is chosen as a starting point for the empirical analysis as it represents the simplest form of the portfolio balance model. Subsequent analysis in Chapter three builds on the basic relationship of equation (2.23).

Chapter 3: EMPIRICAL RESULTS FROM TESTING THE SIMPLE PORTFOLIO BALANCE MODEL

The task of this chapter is to present and analyse the results from testing the simple portfolio balance model in the Branson format as presented in Chapter two for the Australian dollar against the United States dollar. The objective here is to indicate whether the model is suited to the Australian economy or not. The significance of this analysis is that there has not been an extensive application of the portfolio balance model of exchange rate determination to Australian data. A discussion of the limited use of the model with Australian data is presented in section 2.5.

The discussion in section 3.1 outlines the changes in the management of the Australian currency during the period under review. Changes in policy contribute to changes in the important variables of determination of the exchange rate value and therefore add to the discussion of the applicability of the theory to the data.

3.1 The management of the Australian dollar from 1977 to present

From November 1976 until the floating of the Australian dollar on international currency markets on 9 December 1983, the Australian currency was a crawling-peg trade-weighted exchange rate regime. The trade-weighted index is an effective exchange rate or an weighted average mix of foreign currencies where the weights reflect bilateral trade shares. Prior to November 1976, the trade-weighted exchange rate system was fixed and the authorities had to manage the United States/Australian dollar exchange rate so as to always offset the effects of overseas currency movements on the constant trade-weighted index (Polasek and Lewis,1985). After the

1976 modifications, a committee of representatives from several government departments was given the discretionary power of varying the value of the trade-weighted index on a daily basis in accordance with their perceptions of the effective rate for the Australian dollar given changing circumstances (Polasek and Lewis, 1985). Intervention was minimal and was used to smooth out and follow prevalent market forces; given that however, there was still no guarantee that on any particular day the demand for foreign currency would be equal to the supply. Indeed, the deliberate intention at times was to set a rate which aimed not at clearing the market but at providing support to domestic economic management (Polasek and Lewis, 1985). Thus any imbalance in the private sector between demand and supply had to be absorbed by the Reserve Bank of Australia through changes in the level of official reserves. The Bank's role as the foreign exchange buyer or seller of last resort in a regulated market led to the downfall of the crawling-peg trade-weighted system. When a speculative run out of the Australian currency developed and demand for foreign currency was greater than the supply, the Reserve Bank was forced to supply speculators with foreign exchange from official reserves. In the opposite case when there was a speculative run into the Australian currency and the supply of foreign currency was greater than demand, the Reserve Bank was forced to pay for the excess foreign exchange with Australian dollars. As the burden of adjustment to any disequilibrium in the market place fell upon official reserves and thus affected the monetary base of the economy, the regime of management of the exchange rate was undermining the independence of domestic monetary policy[1].

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[1]Of course, if the change in the monetary base was counteracted by an opposite but equal change in the base, then the net change is equal to zero. This action is usually described as sterilisation.

On 28 October 1983, the Reserve Bank withdrew as the residual buyer or seller in the official forward market and ceased selling forward margins. Six weeks later on 12 December 1983, after a protracted period of speculative inflow, the government announced that the value of the Australian dollar would in future be determined by the forces of supply and demand in the foreign currency market, with only light intervention to smooth out a disorderly market. Accompanying the move to allow market conditions to determine the exchange rate value was the abolition of foreign exchange regulations. This was a step toward greater capital mobility between Australia and the rest of the world. Moreover, such action complemented the deregulation of the financial sector recommended by the Australian Financial System Inquiry (1981) under the chairmanship of Sir Keith Campbell[2] of which a floating exchange rate was but a part.

At the inception of the float, the Reserve Bank made it known that it would generally not intervene but it retained the discretion to do so. The intervention behaviour of the Bank at this time was known as "testing and smoothing". It would enter the market periodically to test market trends or smooth the path of large currency transactions through the market (Reserve Bank of Australia, Report and Financial Statements, 30 June 1984). In February and again in April 1985, the Australian currency fell

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[2] This report is more commonly known as the Campbell Committee Report and was established in 1979 by the then Treasurer of the Liberal-National Party Coalition Government. When the Labor Party was elected to office in 1983, a committee under the chairmanship of Mr. V. Martin reviewed the Campbell Committee Report's in light of the new government's social and economic philosophy. The main thrust of both reports was the removal of existing government and Reserve Bank controls on the financial system. Other major deregulatory initiatives to flow from these reports apart from the floating of the exchange rate and the removal of currency controls, were the granting of additional licences to deal in foreign exchange and the approval of domestic banking licences to new banks which had considerable foreign ownership.

abruptly; the depreciation against the trade-weighted index was 13.5% in February

and 11% in April, bringing the net depreciation since late 1984 to over 25%. During

these months of February and April, the Bank was a net seller of foreign currency

in the market and intervention activity was considerably heavier than usual. The

stated aim of intervention during this period was to test the strength of market forces

as before, and also to seek the moderation of the volatility of the exchange rate

(Reserve Bank of Australia, Report and Financial Statements, 30 June 1985). The

action of the Bank in entering the market to sell foreign exchange when the exchange

rate was depreciating - that is leaning against the wind - is in accordance with an

empirical investigation undertaken by the author in an earlier paper which found

evidence of leaning against the wind intervention behaviour by the Reserve Bank

over the period 1977 to 1986 (Hopkins, 1987[3]). Parenthetically, it is important to add

here that the Reserve Bank does not explicitly or officially acknowledge the use of

such an intervention strategy.

In early November 1985, a number of factors including poor balance of payments

figures, the outcome from the National Wage Case and a sizeable increase in the rate

of growth of broad money led to a 13.5% fall in the trade-weighted index since July

1985. Against the United States dollar, the exchange rate depreciated to a low point

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[3]The model used in the 1987 paper postulates simple leaning against the wind behaviour with lagged response variables similar to that used by Hutchison (1984):

$$i_t = \alpha_0 + \alpha_1 i_{t-1} - \alpha_2 \Delta s_t + \mu_t$$

where i_t is an intervention variable representing the change in gold and foreign exchange held by the Australian Reserve Bank from the end of the preceding month expressed in United States dollars, and Δs_t is the change in the spot exchange rate. The hypothesis of "leaning against the wind" intervention activity would yield a negative sign on the change in the exchange rate term. For the floating exchange rate period using Australian and United States bilateral data, the hypothesis is supported by significant and correctly signed coefficients.

of 65.5 U.S. cents for each Australian dollar. The Bank was active in the foreign

exchange market during this period to attempt to smooth some of the more extreme

instability (Reserve Bank of Australia, Report and Financial Statements, 30 June

1986). To some economic commentators (Indecs Economics, 1988 p.110), a switch

to a more active style of exchange rate management relying on both intervention and

monetary policy occurred in November 1985. Certainly monetary policy, which had

been tight over the first half of 1985, was tightened further in November 1985.

Consequently, the interest rate on 90-day bank bills approached 20% in late 1985.

The wide differential with overseas rates created by the tight domestic monetary

policy led to strong demand for the domestic currency. Moreover, with the abolition

of monetary targeting in January 1985, the Bank was then relying on a checklist of

indicators for its monetary policy stance. The main indicators used in the checklist

were money and credit aggregates, interest rates, the exchange rate, the external

account and inflation. The Bank's policy with respect to the importance of the

exchange rate in the checklist was that it is an important indicator but that there was

no attempt by the Bank to establish any particular exchange rate or to go past its

usual practice of testing and smoothing transactions in the market (Reserve Bank of

Australia, Report and Financial Statements, 30 June 1986). Indeed the Bank is

persistent with its denial of a practice of targeting the exchange rate[4] in spite of many

contrary views. For example, a Syntec paper in 1986 suggested that at the end of

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[4] A target zone is a range of permissible deviations of the exchange rate around a defined long run
equilibrium real exchange rate. This policy option differs from a system of managed floating in that
it is expected that the authorities will intervene in the exchange rate market in order to maintain the
exchange rate within the zone. The instruments of policy in a system of target zones are both exchange
rate intervention and monetary policy. The advantage of this form of management is that an anchor
is provided for expectations of future exchange rate values and thus instability and its associated
problem of misalignment should diminish. (Frenkel and Goldstein 1986, Williamson 1986)

1985, the Bank had put a floor of around 70 United States cents under the Australian dollar. In mid-1986, the Macquarie Bank (1986) believed that the Reserve Bank had established an exchange rate target zone with both a floor and a ceiling. Hogan and Nguyen (1987) stated that the Reserve Bank's intervention action in mid-1986 had effectively established a floor of 60 United States cents under the Australian dollar. Both Shields (1988) and Marsden and Jones (1988) maintain that beginning in January 1986, the Reserve Bank policy became one of smoothing the exchange rate. Both sets of authors cite evidence to support their claim of a reduction in exchange rate volatility since 1986. Later in 1987, Michael Stutchbury in the Australian Financial Review commented that in 1986 the Reserve Bank put a floor under the Australian dollar at about 60 United States cents and in 1987 rising commodity prices have seen the Bank put a ceiling on the Australian dollar value at 70 United States cents. Regardless of what the practice is called, November 1985 does appear to represent a change in the management style of the Australian dollar. The debate as to the type and effect of Reserve Bank intervention in the foreign exchange market is concluded in subsequent chapters (Chapter six in particular and Chapter eight to a lesser extent) by an extensive empirical analysis of the intervention relationships.

Financial conditions were very disorderly in July and August 1986 due to expectations surrounding the 1986/87 budget and adverse trade conditions caused by low world prices for commodities and declining terms of trade. Over these two months, the Bank sold $1.2 United States billion in an attempt to arrest the depreciation of the Australian currency. Another period of substantial depreciation of the Australian dollar occurred in January 1987 at the time of the realignment of the

German deutschemark in the European Monetary System and the consequent

adjustment against the United States dollar. Though exogenous to the Australian

economy, this event had a considerable impact on the Australian dollar. Once again,

the Bank sold $1.2 United States billion. A key objective of the operation of external

policy by the Bank during the financial year 1986/87 was the maintenance of

stability in the exchange rate market. The burden of adjustment in order to achieve

this objective fell on monetary policy through the use of rationing by setting high

interest rates, and open market sales and purchases of foreign exchange (Reserve

Bank of Australia, Report and Financial Statements, 30 June 1987). In spite of the

heavy sales of foreign currency during the two periods in 1986/87, by the end of the

year the Bank's holdings of foreign currency had increased by $2.5 United States

billion. The Bank had to intervene frequently throughout the year to prevent the rapid

appreciation of the currency in response to the capital inflow. The Bank's net

purchases of the foreign exchange market in 1986/87 were $3.9 United States billion

compared with net sales of $0.7 United States billion in 1985/86 (Reserve Bank of

Australia, Report and Financial Statements, 30 June 1987).

The international fall in share market values in late October 1987 led to a sharp

depreciation of the Australian currency and the Bank was forced to enter the market

to sell foreign currency. For most of the 1987/88 financial year however, the demand

for the Australian dollar was strong due to rising commodity prices, relatively high

interest rates and overall confidence in the direction of policy, and so, on the whole

the Bank was a buyer of foreign currency and not a seller. Once again as in 1986/87,

the Bank added to its foreign reserves (Reserve Bank of Australia, Report and

Financial Statements, 30 June 1988). Over the financial year, the main difficulty the Bank faced was the dilemma of maintaining interest rates at a level appropriate to dampen domestic demand and at the same time deter an excessive capital inflow which could lead to an exchange rate overvalued with respect to the fundamentals of trade flows and long term investment.

From a low point of 59 United States cents for the Australian dollar in late 1986, the currency trended upwards and reached a high point of just under 88 United States cents per Australian dollar in February 1989. The trade-weighted index went from a low point of 51 points to over 66 points in the same period. The steady appreciation in the currency reflected, as before relatively higher interest rates in Australia and improving commodity prices. The Bank tested the strength of demand for the currency without vigorously resisting the appreciation (Reserve Bank of Australia, Report and Financial Statements, 30 June 1989). Disappointing news about inflation and the current account deficit in early 1989 led to a sharp depreciation of the domestic dollar in February. Over the course of 1988/89, the Bank's transactions in the foreign exchange market resulted in net purchases of foreign currency equivalent to $5.5 United States billion (Reserve Bank of Australia, Report and Financial Statements, 30 June 1989). The net purchases in 1988/89 were high when compared to net purchases of $3.9 United States billion in 1986/87 in what was considered to be a period of considerable interference in the market place. The banking industry conjecture however, about what the Reserve Bank was doing had died down either because it was now accepted that the Bank did intervene or that the Bank intervened with a great deal more subtlety.

3.2 Division of the data sample

In the empirical analysis in the remainder of this chapter and in the following chapters, the full data set is divided into a number of subsamples for better examination of the properties of the data. The deciding factor in determining subsamples is the history of the data over the sample period. The discussion above has an important role in that regard, for the division of the sample has been based on substantive changes in the management of the Australian currency. Specifically in section 3.3 below, the first subsample extends from the beginning of the sample - January 1977 - to the beginning of the floating exchange rate - November 1983. The second subsample extends from December 1983 to October 1985. November 1985 is considered to be a watershed in the management of the floating exchange rate as there is evidence of a more active management of the floating currency at that point. The final subsample thus is from November 1985 to July 1988. Empirical analysis in the following chapters conforms to this division.

Further, the subdivision of time periods coincides with other events in the Australian economy in addition to changes in the management of the Australian currency. The period from late 1983 to late 1985, referred to throughout as the second subsample saw extensive institutional reforms in the financial system of which the changes in the management of the currency were a part. In addition, it is a period in which the terms of trade declined[5]. The terms of trade actually continued to fall until September 1986. Nevertheless, the terms of trade indicates a declining trend path in the second

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[5]The terms of trade here refers to the ratio between the prices we receive on average for our exports and those we pay for our imports.

subsample and an increasing trend path over the third subsample of post-1985 (Tease, 1990). During the second subsample, there was also a substantial fall in the nominal Australian dollar/United States dollar exchange rate: fall of approximately 20% in the period November 1984 to February 1985 (Felmingham, 1991).

Institutional changes in the labour market also coincide with the division of the sample. The Fraser Liberal Government introduced wage fixing guidelines in the third quarter of 1976. This period corresponds with the move to a crawling peg trade-weighted exchange rate regime. These two events coincide not by chance, but as a result of policy adjustments by a newly elected government. The same comment applies to the close timing of two major policy changes in 1983. Following the election of the Hawke Labor Government to their first term of office, the exchange rate was floated in late 1983 and the Prices and Incomes Accord was introduced in April of the same year.

3.3 Empirical analysis of the simple portfolio balance model

The empirical analysis presented in this section represents the first application of the portfolio balance model in the Branson format (Branson, 1972 and 1976, and Branson and Halttunen, 1979) to Australian/United States data. The choice of the Branson version represents a desire to start from a simple form of the model, to examine its ability to explain exchange rate movements with a particular data set and then to move onto a integrated explanation of exchange rate behaviour.

Equation (2.23) from Chapter two is used as a starting point for empirical analysis:

$$s = \alpha_0 + \alpha_1 m + \alpha_2 m^* + \alpha_3 fa + \alpha_4 fa^* + \mu$$

$$(2.23)$$

where the lower case variables represent natural logarithms. Thus, equation (2.23) is a log linear version of the implied reduced form equation derived from the portfolio demand equilibrium conditions. Recall from Chapter two that in their empirical analysis, Branson and Halttunen omitted domestic assets due to the ambiguity of the sign pattern for the effects of changes in this asset stock and the lack of availability of suitable domestic asset data. From the development of the theory in Chapter 2, however we know that the coefficients $\alpha 1$ *and* $\alpha 4$ are positive and $\alpha 2$ *and* $\alpha 3$ are negative.

A series of data for debt held by the Australian public was developed and incorporated into equation (2.23)[6]. The foreign holding of domestic debt is not incorporated due to the lack of suitable data. Inclusion of a domestic debt variable in equation (2.23) and expression in discrete rather than continuous time yields:

$$s_t = \alpha_0 + \alpha_1 m_t + \alpha_2 m_t^* + \alpha_3 fa_t + \alpha_4 fa_t^* + \alpha_5 b_t + \mu_t$$

$$(3.1)$$

where the sign on α_5 is ambiguous due to the competing wealth and substitution effects.

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[6]The formation of the debt series is detailed in Appendix A.1.

The results from testing equation (3.1) are presented in Table 3.1. The analysis here replicates the initial work done by Branson and Halttunen (1979) with Australian/United States data. The model is specified and tested in terms of the levels of variables. The period used for data analysis is January 1977 to July 1988.

One of the drawbacks of using the portfolio balance model is the deficiency of good disaggregated data. This difficulty has been highlighted by a number of authors, for example Sarantis (1987), MacDonald (1988) and Kearney and MacDonald (1988b). A series of monthly bilateral data for foreign assets, that is United States assets owned by Australians and Australian assets owned by United States residents is available until July 1988 only[7]. The availability of these data determined the end point of the sample for testing of the simple portfolio balance model using monthly data. The starting point is set at January 1977, when the management of the Australian dollar was that of a crawling-peg trade-weighted exchange rate regime. Thus the period for empirical analysis represents 139 observations.

The full sample is used to examine the performance of the portfolio balance model across several changes of exchange rate regime. The results are reported according to these differing exchange rate regimes. The division of the full sample period into subsamples is discussed above in section 3.2.

The portfolio balance model in the original formulation used by Branson and Halttunen (1979) - equation (2.18) from Chapter two - was modelled for the

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[7] Data descriptions and sources are in Appendix A.1.

determinants of a freely floating exchange rate. The authors considered a number of currencies over the period July 1971 to June 1976[8]. The analysis in this chapter is based on a considerably larger sample than the analysis of Branson and Halttunen (1979). For consistency with the Branson and Halttunen analysis, M1 is used to represent the money stock.

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[8]The United States dollar, the Japanese yen and major European currencies were included in their empirical analysis. Each of these currencies was floated in foreign exchange markets in the early 1970's. The deutschemark was floated on international currency markets in May 1971. In August 1971, the United States formally suspended dollar convertibility into gold. With expectations of a dollar devaluation threatening inflows of speculative capital into their relatively strong currencies, other major currencies - including the currencies used by Branson and Halttunen (1979) for analysis, namely the Japanese yen, the Italian lira and the United Kingdom pound - were forced to follow the West German example and float their currencies on international currency markets (Argy, 1981). These events culminated in the Smithsonian Agreement in December 1971. The Swiss franc was not floated until January 1973.

Table 3.1: Portfolio balance model, equation (3.1)

	1977:01 to 1988:07			1977:01 to 1983:11		
	OLS	AUTO 1st order	AUTO 2nd order	OLS	AUTO 1st order	AUTO 2nd order
m	-0.854 (-9.47)	0.261 (1.871)	0.3131 (2.609)	-0.721 (-8.53)	-0.140 (-0.69)	-0.0117 (-0.06)
m*	1.064 (6.462)	0.078 (0.351)	0.0948 (0.483)	1.202 (7.745)	0.381 (1.455)	0.1758 (0.679)
fa	-0.006 (-0.44)	-0.019 (-1.58)	-0.0197 (-1.99)	0.047 (4.607)	-0.002 (-0.24)	-0.0087 (-1.04)
fa*	0.108 (3.44)	0.030 (1.256)	0.024 (1.209)	-0.017 (-0.76)	0.008 (0.373)	0.0131 (0.739)
b	0.474 (3.251)	-0.022 (-0.21)	0.0289 (0.293)	0.041 (0.313)	-0.068 (-0.68)	-0.0434 (-0.44)
ρ_{-1}	-	0.986 (69.83)	1.4015 (18.28)	-	0.986 (54.29)	1.3716 (13.58)
ρ_{-2}	-	-	-0.4274 (-5.57)	-	-	-0.3911 (-3.87)
$\bar{R}^2$	0.919	0.988	0.991	0.871	0.965	0.9699
s(%)	84.27	30.76	27.89	-39.73	-20.65	19.17
d	0.258	1.189	1.889	0.403	1.298	1.8165
CH	-	-	-	47.63*	-	-
BG	104.1*	36.64*	19.2*	54.31*	23.03*	16.215*

Table 3.1 contd.: Portfolio balance model, equation (3.1)

	1983:12 to 1985:10			1985:11 to 1988:07		
	OLS	AUTO 1st order	AUTO 2nd order	OLS	AUTO 1st order	AUTO 2nd order
m	1.788 (4.36)	1.0311 (2.30)	0.8593 (2.47)	-0.508 (-2.94)	0.030 (0.11)	-0.1684 (-0.07)
m*	0.862 (0.929)	0.939 (1.11)	0.9616 (1.731)	1.062 (3.225)	-0.263 (-0.54)	-0.2998 (-0.76)
fa	0.107 (0.474)	0.047 (0.238)	0.0751 (0.65)	-0.146 (-2.84)	-0.066 (-1.93)	-0.0432 (-1.69)
fa*	0.070 (0.471)	0.107 (0.96)	0.1729 (2.624)	0.087 (0.855)	0.017 (0.237)	-0.0317 (-0.53)
b	-0.262 (-0.91)	0.025 (0.074)	0.4975 (1.91)	-0.063 (-0.17)	0.269 (0.924)	0.1837 (0.739)
ρ_{-1}	-	0.739 (5.256)	1.3281 (9.397)	-	0.923 (13.74)	1.4038 (9.878)
ρ_{-2}	-	-	-0.7352 (-5.20)	-	-	-0.5775 (-4.06)
$\bar{R}^2$	0.904	0.937	0.9641	0.563	0.822	0.8691
s(%)	17.26	13.98	10.55	11.90	7.60	6.51
d	1.023	1.1709	2.2091	0.626	1.1869	1.8053
CH	7.710*	-	-	35.02*	-	-
BG	14.25	14.25	14.835	23.15*	18.95*	16.403*

Notes: figures in round brackets are asymptotic t-ratios. The *rho* value refers to the application of a first or second order autocorrelation of the error equation to the data. BG is the Breusch-Godfrey Lagrange Multiplier Statistic testing for first to eighth order autocorrelation. The d refers to the Durbin-Watson Statistic and s(%) is the standard error of the regression expressed as a percentage of the sample mean of the dependent variable. CH refers to the Chow test for parameter stability across time periods corresponding to changes in the management of the Australian currency. The asterisk indicates rejection of the null hypothesis at the 5% level of confidence.

The results are poor. Across the sample and the three subsamples for the ordinary least squares equation (OLS), the adjusted R^2 value is high, but the Durbin-Watson statistic, d is low indicating that the null hypothesis of no first order autocorrelation is rejected at the 95% level of confidence. The indication that the error terms are correlated can arise for a number of reasons. However, in this case the most likely reason is misspecification of the equation and in particular the omission of a relevant independent variable or variables.

The Breusch-Godfrey test (BG) is a Lagrange Multiplier test for n-th order autocorrelation when the autocorrelated errors are either generated by a n-th order autoregressive or n-th order moving average process[9]. In Table 3.1, the error terms from the OLS equation are tested for 1st to 8th order autocorrelation. The appropriate reference statistic for the test is the Chi-square statistic where the degrees of freedom are equal to 8 - the number of lags in the error variable. In all cases except the second subsample where there is a borderline statistic, the null hypothesis that first to eighth order autocorrelation coefficients of the OLS residuals are not significantly different from zero is rejected. This rejection indicates that there is autocorrelation past first order.

Low Durbin-Watson statistics - that is values significantly different from two - indicate first order residual autocorrelation. For that reason a corrective technique is applied. The results after the application of that corrective technique - the Cochrane-

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[9]Breusch (1978) and Godfrey (1978) developed the test independently. The analysis here has followed the test procedure suggested by Johnston (1984).

Orcutt equation - are presented in Table 3.1. The results indicate that although the coefficient of determination of the equation or the adjusted R^2 value is high, there is still significant residual autocorrelation: indicating either omission of important variables or dynamic misspecification. Moreover, large differences are observed - for example, sign reversals - between coefficients estimated using ordinary least squares and Cochrane-Orcutt techniques. This is an additional indicator of model misspecification (Boothe and Glassman, 1987).

The second order autocorrelation equation on the basis of both the Durbin-Watson and the Breusch-Godfrey statistics - in most cases at the 10% level of confidence - indicates an absence of autocorrelation in the residuals. Moreover, the adjusted R^2 value displays good explanatory power. The second subsample has a number of significant coefficients. The domestic money variable is of the expected sign - this variable is also significant and of the correct sign in the full sample. The domestic bond demand variable is positive in the second subsample indicating that the wealth effect from the impact of a change in the price of bonds outweighs the substitution effect[10]. The United States held Australian dollar assets variable, fa^* is of the correct sign and significant.

The Chow test[11] is used to test whether or not a parameter or parameters are

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[10]Refer to section 2.3 for a comprehensive discussion on the wealth and substitution effects as a consequence of a change in the price of domestically denominated bonds.

[11]The Chow test is named for G. C. Chow (1960). Maddala (1977) comments that although the test is referred to as the Chow test by econometricians after Chow's 1960 paper, it was derived much earlier by C. R. Rao (1952) and O. Kempthorne (1952). The test procedure used here follows Maddala (1977) and Johnston (1984).

unchanged from one data set to another. Within the data set used in this chapter, there is evidence of shifts in regime. It is possible that those shifts in regime or management are accompanied by shifts in parameter values and thus some of the inability of the OLS equation for the entire sample to explain adequately the relationship between the independent and dependent variables may be due to a structural change rather than some other error. In Table 3.1, three results are presented for the Chow test. In each case, the null hypothesis that the parameters of the equation are unchanged across the sample period is rejected. This result indicates that the determination of the exchange rate across the three subsamples is sufficiently different to render invalid the equation of explanation for the entire period - 1977:1 to 1988:7. In spite of this finding, the results from the subsamples do not appear to furnish better explanations of exchange rate determination than do the results from the sample.

The following conclusions can be drawn from the analysis presented in Table 3.1. First, the simple portfolio balance model specified and tested in terms of levels of variables does not adequately explain the determinants of the Australian dollar over the time period considered. Furthermore, the only variable able to explain exchange rate behaviour over a number of time periods is domestic money. In both the Branson, Halttunen and Masson (1977) and the Branson and Halttunen (1979) papers where the simple portfolio balance model is also specified and tested in terms of levels of variables, there are problems with persistent autocorrelation throughout, and insignificant and/or incorrectly signed parameter estimates.

3.4 Further empirical analysis of the simple portfolio balance model

The analysis and discussion presented in this section concentrates solely on the empirical and econometric issues in testing reduced form exchange rate equations. More fundamental issues addressing theoretical misspecification of the exchange rate relationship will be addressed in the following chapter.

High coefficients of determination and indications of first order residual autocorrelation are familiar symptoms of estimated exchange rate models. One reason promoted to explain the observed statistical values is that the dependent and independent variables are not stationary[12]. Nelson and Plosser (1982) show that many macroeconomic series are nonstationary (or have unit roots) including the money supply. Granger and Newbold (1974) observe the tendency for exchange rate equations to have high coefficients of determination and first order autocorrelation and suggest the first differencing of all the variables in a model in order to a produce a stationary series.

Stationarity tests on the variables in equation (3.1) are presented in Table 3.2. The method used for testing follows that proposed by Dickey and Fuller (1981). The augmented Dickey-Fuller regression equation used for analysis is the following:

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[12]A series is stationary when the stochastic properties of a variable are invariant with respect to time, i.e. for a given variable Z_t, the mean of Z_t, its variance and its covariance with other values do not depend on time. Most economic time series are such that their stochastic properties do vary over time. Gross domestic product for example, is non-stationary because of its growth trend, i.e. the mean of GDP varies over time.

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 t + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \epsilon_t \qquad (3.2)$$

where Y_t refers to the variable in natural logarithms and ϵ_t is a white noise error term. The number of lagged terms, p is chosen to ensure the errors are uncorrelated. Equation (3.2) has both a constant and a trend variable and is consequently testing for a unit root in a variable with non-zero trend path. The null hypothesis is:

$$\alpha_1 = \alpha_2 = 0$$

The test statistic for the null hypothesis is an F test.

Table 3.2 Stationarity tests with variables expressed in levels

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:11 to 1988:07
s	1.4860 (5.49)	2.3972 (5.53)	1.9916 (5.91)	3.4731 (5.84)
m	2.1990 (5.48)	3.6524 (5.52)	5.0876 (5.91)	5.1980 (5.83)
m*	1.9980 (5.48)	3.7324 (5.52)	1.5121 (5.91)	2.1066 (5.84)
fa	3.7621 (5.48)	3.636 (5.52)	2.0685 (5.91)	4.5736 (5.83)
fa*	2.1337 (5.49)	2.0314 (5.52)	2.6223 (5.91)	1.1270 (5.89)
b	0.9766 (5.49)	1.7799 (5.54)	1.2717 (5.91)	2.8990 (5.83)

Notes: the figure in brackets is the critical value at the 90% point of the distribution[13].

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[13]The source for the critical value is Table VI, Dickey and Fuller (1981).

The results in Table 3.2 indicate that the null hypothesis proposing a unit root is accepted in all cases. Thus, there is evidence of nonstationarity in all variables expressed in levels across all time periods. This is consistent with the findings of Boothe and Glassman (1987) of evidence of nonstationarity in all but one variable[14] in the real-interest-differential monetary model of Frankel (1983) using United States and West German data. The United States money stock represented by M1 is nonstationary for a similar time period in both the results presented in Table 3.2 and in the Boothe and Glassman results.

Table 3.3 presents the results for testing for a unit root when the variables are expressed in first differences. The null hypothesis is unchanged from above.

Table 3.3: Stationarity tests with variables expressed in first differences

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:11 to 1988:07
Δs	5.5300 (5.49)	5.884 (5.54)	5.7138 (5.91)	4.9636 (5.85)
Δm	5.1834 (5.49)	4.5775 (5.55)	5.3643 (5.91)	6.3327 (5.84)
Δm*	8.9532 (5.48)	6.3429 (5.54)	7.4356 (5.91)	4.9955 (5.85)
Δfa	6.5985 (5.49)	7.7686 (5.53)	22.637 (5.91)	6.0284 (5.85)
Δfa*	5.1964 (5.49)	6.535 (5.53)	19.270 (5.91)	7.6950 (5.89)
Δb	7.8845 (5.49)	12.404 (5.55)	5.7196 (5.91)	5.5535 (5.84)

Notes: the figure in brackets is the critical value at the 90% point of the distribution[15].

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[14]They found evidence of stationarity in the West German money stock.

[15]The source for the critical value is Table VI, Dickey and Fuller (1981).

The results in Table 3.3 show that the null hypotheses of a unit root and time stationarity are rejected in most cases. Where there is not rejection of the null hypothesis, the test statistic is nonetheless borderline. Stationarity in the first difference but not in levels of the estimating equation indicates that all the series of variables are integrated of order one (Engle and Granger, 1987).

Multicollinearity in the independent variables of an exchange rate relationship provides a reason in addition to stationarity for the expression of an estimating equation in first difference rather than levels. Granger and Newbold (1974) state that high serial correlation between adjacent values, particularly if the sampling interval is small such as a week or a month is typical and to some extent expected. This is because many economic series are smooth and changes over a short time period are small in magnitude. A matrix of correlation coefficients between all pairs of independent variables in equation (3.1) reveals high correlation - coefficients over 0.75 in most cases - for all pairs of variables in the matrix. There are many causes of multicollinearity, and thus many solutions. One solution that is suggested by Maddala (1977) is to take the first difference of the dependent and independent variables and estimate the equation using ordinary least squares.

Table 3.4: Portfolio balance model with variables expressed in first differences

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10		1985:11 to 1988:07	
	OLS	OLS	OLS	AUTO	OLS	AUTO
Δm_t	0.335 (2.421)	-0.185 (-0.870)	0.756 (1.730)	0.693 (1.925)	0.453 (1.129)	0.345 (0.895)
Δm^*_t	0.291 (0.952)	0.168 (0.542)	2.560 (1.630)	2.672 (1.615)	0.469 (0.763)	0.403 (0.639)
Δfa_t	-0.021 (-1.943)	-0.009 (-1.005)	-0.160 (-0.767)	-0.181 (-0.987)	-0.047 (-1.498)	-0.045 (1.754)
Δfa^*_t	0.033 (1.493)	0.0176 (0.884)	0.2341 (2.015)	0.244 (2.054)	-0.055 (-0.763)	-0.066 (-0.724)
Δb_t	0.031 (0.308)	-0.041 (-0.431)	0.576 (0.576)	0.563 (1.350)	0.336 (1.184)	0.319 (1.187)
Δs_{t-1}	0.417 (5.291)	0.381 (3.392)	0.660 (2.535)	0.709 (1.875)	0.422 (2.387)	0.326 (0.536)
Q_{t-1}	-	-	-	-0.096 (-0.23)	-	0.245 (0.379)
$\bar{R}^2$	0.1877	0.0952	0.2921	0.2942	0.2113	0.240
h	1.106	3.219˙	4.369˙	-	3.256	-
CHOW	-	3.544*	1.634	-	5.240*	-
BG	4.425	11.242	11.002	-	18.451*	-

Notes: figures in round brackets are asymptotic t-ratios. The *rho* value refers to the application of a first order autocorrelation error equation to the data. BG is the Breusch-Godfrey Lagrange Multiplier Statistic testing for first to eighth order autocorrelation. The h refers to the Durbin test for a regression containing lagged values of the dependent variable. The prime refers to the situation where Durbin's h cannot be computed: the value in that case refers to the BG test for first order autocorrelation. CHOW refers to the Chow test for parameter stability across time periods corresponding to changes in the management of the Australian currency. The asterisk indicates rejection of the null hypothesis at the 5% level of confidence.

The results from testing equation (3.1) with the variables specified in terms of first differences are presented in Table 3.4. In addition to the variables included in equation (3.1) and reported in Table 3.1, the results here include a lagged dependent variable as one of the independent variables, following the advice of Granger and

Newbold (1974) who argue that a lagged dependent variable may correct problems of misspecification which is due to the influence of an excluded variable and/or autocorrelation. Their argument is that theory, whilst being precise about variables to be included in an economic model, provides no information about the lag structure which should be used in the empirical investigation. This view is supported by Bisignano and Hoover (1982) and Sarantis (1987) who include a lagged dependent variable in their analysis of the portfolio balance model.

The results are unsubstantial. The coefficient of determination in all cases is low. Interestingly, the coefficient is considerably better for the last two subsamples - when the Australian dollar was floating - than in either the entire sample or the first subsample. This confirms an expectation that the portfolio balance model is a better explanation of the determinants of a floating exchange rate than of the crawling peg exchange rate regime pre-1983. There are two significant results for the entire sample: the coefficients of both the domestic money stock and domestic holdings of foreign assets are significant and of the expected sign. The coefficient of the foreign demand for domestic assets variable is significant and of the correct sign for both estimation equations in the second subsample.

The Breusch-Godfrey statistic with a null hypothesis of no first to eighth order autocorrelation in the lagged residuals is accepted in the sample and the first and the second subsample. The Chow test for parameter stability indicates that there is evidence of parameter stability between the sample and the second subsample only.

3.5 An error correction formulation of the portfolio balance model

The results presented above are disappointing but before abandoning the simple portfolio balance model as an explanation of the performance of the Australian dollar in international currency markets, a further analysis is applied. Indeed, the analysis of the data and model that follows recognises a problem alluded to previously. Specifically, the given static theory of the portfolio balance model is limited in the sense that the single relationship between the independent variables and dependent variable is at best only part of the data generation process. What is required here is a dynamic specification of the relationship between the variables over time. However, there is no dynamic theory-based specification that can indicate what form the lagged variables should take. Error correction models do, however, indicate an empirical specification of the lagged variables in a model.

A number of authors have contributed to the literature on error correction models and for that reason there are alternative formulations of error correction systems. In particular there are two prominent formulations of the error correction model. Hendry, Pagan and Sargan (1984) suggest a framework for structuring the more detailed analysis of infinite distributed lag models, and describe that analysis as a reparameterisation of the dynamic linear regression model in terms of differences and levels. Engle and Granger (1987) use a formulation which is based on a particular representation of a vector autoregression appropriate for cointegrated vectors. The formulation of the error correction model used here is based on the representation of Engle and Granger (1987) as this more closely matches the requirements of the present analysis.

The first step in the application of the Engle and Granger technique is to test for cointegration in the dependent and independent variables. Engle and Granger noted that most economic time series are highly trended with stationary growth rates, or they are integrated of order one, I(1). All variables used in the econometric analysis in this chapter are integrated of order one as they are stationary after first differencing. They also noted that linear combinations of I(1) variables for example:

$$y_t = \alpha_0 + \alpha_1 x_t + \alpha_2 x_{t-1} + \alpha_3 y_{t-1} + \mu_t \qquad (3.3)$$

where y_t and x_t are both I(1) variables may result in a residual term which is either I(1) or I(0). If the residual term as a result of the linear combination of nonstationary variables is stationary, then the series is said to be cointegrated. If a series is cointegrated, there exists an error correction representation of that relationship.

Cointegration implies that deviations from equilibrium are stationary with finite variance, even though the series themselves are nonstationary and have infinite variance. Cointegration techniques enable us to test for the existence of long run relationships between variables. The resulting error correction model combines the long run equilibrium relationship between variables as well as the short run dynamic structure.

Tables 3.2 and 3.3 establish that all variables in the simple portfolio balance model of equation (3.1) are integrated of order one. Cointegrating regressions of the exchange rate on the variables in the simple portfolio balance model equation and a constant was run for four different time periods. Three different tests for the existence

of cointegration are then applied to those results of the cointegrating regression: these are all reported in Table 3.5.

Table 3.5: Cointegration tests

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:11 to 1988:07
CRDW	0.2581	0.4028*	0.3911*	0.4833*
DF	-3.0730**	-2.9617	-2.0455	-2.5851
ADF	-4.1811*	-2.4031	-3.0844**	-3.2055*

Notes: critical values for CRDW, DF and ADF statistics are from Table II, Engle and Granger (1987). The asterisk refers to a significant value at the 5% confidence interval: the double asterisk corresponds to 10%.

The first of these tests is the Cointegrating Regression Durbin-Watson statistic (CRDW). If the residuals in the cointegrating regression are nonstationary, the Durbin-Watson statistic will approach zero. Thus the test rejects the null hypothesis of noncointegration if the Durbin-Watson value is greater than the 5% critical value of 0.386 (Table 2, Engle and Granger, 1987). In Table 3.5, the null hypothesis is rejected in three out of four cointegrating regressions.

The second and third tests for cointegration are obtained from regressions using the residuals from the cointegrating regression. The Dickey Fuller regression test (DF) - equation (3.4) below - uses the t ratio on the lagged dependent variable coefficient. Using the residuals from equation (3.3):

$$\Delta \mu_t = -\rho \mu_{t-1} + \xi_t \qquad (3.4)$$

the DF statistic is the t ratio for ρ. The critical value for the DF statistic at the 5%
level of confidence is 3.37. From Table 3.5, in all cases the null hypothesis of
noncointegration is accepted at the 5% confidence level. In one case the null
hypothesis is rejected at the 10% confidence level.

The Augmented Dickey Fuller (ADF) statistic is obtained from the equation:

$$\Delta\mu = \rho\mu_{-1} + \sum_{i=1}^{k} \tau_i \Delta\mu_{-i} + \xi \qquad (3.5)$$

where the ADF statistic is the t ratio for ρ. The critical value for the ADF statistic
at the 5% level of confidence is 3.17. From Table 3.5, the null hypothesis of
noncointegrating is rejected at the 5% level of confidence in two out of three samples
and at the 10% level of confidence in one time period.

The evidence of cointegration is patchy. The Dickey Fuller statistic is considered by
Engle and Granger to be a more powerful test than the ADF statistic as that latter test
is over-parameterised for the first order case. Generally speaking, published results
of cointegration tests (Choi, 1990) have used the CRDW and the ADF (where the
variables in the regression are I(1)) only.

The next step is to develop the error correction formulation of the portfolio balance
model. The objective of an error correction mechanism is to accommodate
disequilibrium from one period into the explanation of the determination of the
dependent variable in the next period. In this manner, the equation of estimation is

capturing some of the dynamics in the adjustment process from the long run to the short run. Thus a typical error correction model in the Engle and Granger formulation would relate the change in the dependent variable this period to past equilibrium errors and to past and present changes in the independent variables.

The error correction variable in the model is derived from the cointegrating regression. For example for the full sample period from 1977:01 to 1988:07, the error correction variable is constructed as follows:

$$EC = s - (-4.025 - 0.854m + 1.064m^* - 0.006fa + 0.108fa^* + 0.4744b)$$

(3.6)

For the period 1977:01 to 1983:11, the error correction variable is constructed as:

$$EC_1 = s - (-1.034 - 0.721m + 1.202m^* + 0.047fa - 0.017fa^* + 0.041b)$$

(3.7)

For the second subsample - 1983:12 to 1985:10 - the error correction variable is constructed as:

$$EC_2 = s - (-8.895 + 1.788m + 0.862m^* + 0.107fa + 0.07fa^* - 0.262b)$$

(3.8)

Finally, for the third subsample, the error correction variable is constructed as:

$$EC_3 = s - (-0.412 - 0.508m + 1.062m^* - 0.146fa + 0.087fa^* - 0.063b)$$

$$(3.9)$$

The results of the error correction formulation of the portfolio balance approach are presented in Table 3.6. The lag structure and the variables included in the equation were determined on a general to specific basis. Generally, insignificant lags and variables were omitted. Some variables with insignificant t ratios however were maintained as they add to the overall flavour of the portfolio balance approach. The results overall are good. The adjusted R^2 values whilst not high are an improvement on the coefficients of determination when using first differences alone. Moreover, these values are similar to those obtained by Boothe and Glassman (1987) in their error correction formulation of the-real-interest-differential monetary model of Frankel (1979)[16]. Furthermore, the explanatory power of the error correction model improves considerably in the two subsamples where the exchange rate is floating, confirming the appropriateness of the model to a floating rather than a more fixed exchange rate regime.

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[16]The adjusted R^2 value in their error correction model was 0.3828.

Table 3.6: Error correction model

Dependent variable = Δs_t

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:11 to 1988:07
Δs_{t-1}	0.3239 (3.7038)	0.3818 (3.4534)	-	0.1657 (0.9595)
Δs_{t-2}	-	-0.2441 (-2.0797)	-0.6356 (-2.7291)	-0.4584 (-2.9351)
ec_t	0.5472 (1.9841)	-	0.6355 (3.8503)	0.2772 (2.1983)
ec_{t-1}	-	-0.1605 (-2.8594)	-	-
Δm_t	0.3293 (2.3708)	-	1.5409 (3.882)	0.0847 (0.3426)
m_{t-1}	-	-0.0137 (-2.289)	-	-
m^*_{t-1}	-0.0001 (-2.0578)	0.0001 (1.2781)	0.0006 (0.8261)	0.0001 (0.5242)
Δfa_t	-0.0191 (-1.767)	-	-	-0.0699 (-2.9727)
fa_{t-1}	-	-0.0084 (-1.8705	0.2074	-
Δfa^*_t	0.0355 (1.549)	0.0258 (1.3643)	-	-
fa^*_{t-1}	-	0.0265 (2.4093)	0.1894 (1.4976)	-
Δb_t	0.0059 (0.0578)	-0.1013 (-1.1534)	-	-
b_{t-1}	-	-	0.1125 (0.6010)	-0.5242 (-2.9778)
$\bar{R}^2$	0.2014	0.2824	0.6063	0.5707
h	0.1632*	-0.1163	3.1912*	0.0829
CHOW	-	1.7271	2.1123	1.1081
BG	15.854	3.6573	14.6865*	3.877

Notes: figures in round brackets are asymptotic t-ratios. BG is the Breusch-Godfrey Lagrange Multiplier Statistic testing for first to eighth order autocorrelation. The h refers to the Durbin test for a regression containing lagged values of the dependent variable. The prime indicates that Durbin's h cannot be estimated and the Breusch-Godfrey statistic with a lag of one is used in its place. Chow refers to the Chow test for parameter stability across time periods corresponding to changes in the management of the Australian currency. The asterisk indicates rejection of the null hypothesis at the 5% level of significance. The use of the lagged variables is justified by the existence of a cointegrating vector among these variables. That is, there is more than one cointergrating vector among the variables m, m^*, fa, fa^* and b.

The Durbin's h statistic indicates that there is no first order autocorrelation in any of the three equations. Moreover, in the sample and two subsamples, the Breusch-Godfrey statistic indicates that there is no first to eighth order autocorrelation. In the middle subsample - where the test is for fifth order rather than eighth order autocorrelation due to the small sample size - the null hypothesis is rejected at the five percent level of significance.

The error correction terms, ec_t and ec_{t-1} are significant in all samples. The error correction term represents the disequilibrium errors in the long run relationship between the dependent variable and the explanatory variables. The positively signed and significant error correction term in three of the four specifications is intuitively implausible, as it indicates that the exchange rate is being pushed away from its long run equilibrium position by the error correction term. The lagged negatively signed error correction term is thus, intuitively plausible as it indicates that the exchange rate is being pushed towards its long run equilibrium position. The lagged term was significant in one sample only.

The lagged dependent variable is positively signed and significant in the full sample and the first subsample only. The twice lagged dependent variable is significant and negative in three of the four samples. These are expected result given the tendency for time series of a given variable to display considerable autocorrelation. The first difference of the domestic money supply is of the sign expected by the theory and significant in two of four samples. In the full sample, the foreign money stock is of the expected sign in levels. A number of the foreign assets variables are of the

expected sign and significant. The coefficient for the domestic asset variables in the third subsample is significant and of negative sign when the variable is lagged in levels. This conforms as in the discussion accompanying Table 3.1 to a substitution effect rather than an wealth effect determining the impact that a change in domestic bond supply has on the exchange rate.

3.6 The portfolio balance model expressed in real variables

Original specification of the portfolio balance model undertaken by Branson (1972, 1977) and Branson and Halttunen (1979) expressed the explanatory variables in nominal terms. The alternative view, however is that investors respond to real rather nominal movements in variables. Branson and Henderson (1985) explain this response in terms of two types of uncertainty in the portfolio decision: exchange rate and price index risk. For that reason more recent specifications of the portfolio balance model using foreign data sets by for example, Danker *et al.* (1987) and Kearney and McDonald (1988b) have used real variables. The results presented in Table 3.7 accordingly use real variables.

Equation (3.1) is rewritten as:

$$s_t = \beta_0 + \beta_1 \frac{m_t}{p_t} + \beta_2 \frac{m_t^*}{p_t^*} + \beta_3 \frac{fa_t}{p_t} + \beta_4 \frac{fa_t^*}{p_t^*} + \beta_5 \frac{b_t}{p_t} + \mu_t$$

(3.10)

Table 3.7: Simple portfolio balance model with real variables

	1977:01 to 1988:07			1977:01 to 1983:11		
	OLS	AUTO 1st order	AUTO 2nd order	OLS	AUTO 1st order	AUTO n order
m/p	-0.241 (-1.57)	0.145 (0.986)	0.2521 (2.025)	-1.113 (-5.13)	-0.513 (-2.33)	-0.2548 (-1.24)
m^*/p^*	1.281 (11.51)	0.248 (0.986)	0.2188 (0.828)	0.619 (4.211)	0.242 (1.031)	0.1708 (0.670)
fa/p	-0.055 (-3.42)	-0.021 (-1.74)	-0.0207 (-2.05)	0.028 (2.743)	-0.005 (-0.51)	-0.0086 (-1.04)
fa^*/p^*	0.391 (13.4)	0.037 (1.541)	0.028 (1.389)	0.004 (0.151)	0.006 (0.298)	0.0117 (0.654)
b/p	-0.707 (-7.54)	-0.116 (-1.07)	-0.040 (-0.39)	-0.505 (-6.04)	-0.139 (-1.46)	-0.1064 (-1.11)
ϱ_{-1}	-	0.992 (94.19)	1.4074 (18.27)	-	0.989 (60.86)	1.3213 (12.78)
ϱ_{-2}	-	-	-0.4185 (-5.43)	-	-	-0.3365 (-3.25)
$\bar{R}^2$	0.896	0.988	0.9899	0.8732	0.968	0.9707
$s(\%)$	90.87	31.03	28.29	-39.33	-19.81	-18.91
d	0.328	1.140	1.6779	0.428	1.423	1.7811
CH	-	-	-	35.843*	-	-
BG	89.39*	23.59*	5.135	45.08*	4.912	2.775

Table 3.7 contd.: Simple portfolio balance model with real variables

	1983:12 to 1985:10			1985:11 to 1988:07		
	OLS	AUTO 1st order	AUTO 2nd order	OLS	AUTO 1st order	AUTO 2nd order
m/p	2.000 (3.959)	0.6637 (1.357)	0.3636 (1.037)	-0.335 (-0.97)	-0.03 (-0.10)	-0.0860 (-0.39)
m˙/p˙	1.004 (1.011)	0.882 (0.847)	1.9241 (2.648)	0.951 (3.336)	0.091 (0.20)	-0.033 (-0.08)
fa/p	-0.209 (-1.46)	-0.184 (-1.29)	-0.155 (-1.72)	-0.142 (-2.81)	-0.066 (-1.91)	-0.0444 (-1.68)
fa˙/p˙	0.015 (0.092)	0.121 (1.020)	0.2169 (2.857)	0.129 (1.422)	0.031 (0.428)	-0.017 (-0.28)
b/p	-0.401 (-1.36)	-0.135 (-0.38)	0.6206 (1.979)	0.139 (0.26)	0.353 (1.059)	0.2853 (1.121)
ϱ_{-1}	-	0.835 (7.276)	1.3286 (10.34)	-	0.881 (10.70)	1.3663 (9.537)
ϱ_{-2}	-	-	-0.7655 (-5.70)	-	-	-0.568 (-3.96)
$\bar{R}^2$	0.8864	0.9259	0.9532	0.6018	0.822	0.8679
s(%)	18.77	15.15	12.05	11.36	7.60	6.54
d	1.2363	1.3106	2.4275	0.633	1.2407	1.8926
CH	33.541˙	-	-	16.730˙	-	-
BG	7.825	10.579	6.309	19.246˙	5.705	3.446

Notes: figures in round brackets are asymptotic t-ratios. The *rho* value refers to the application of a first order or second order autocorrelation of the error equation to the data. The BG is the Breusch-Godfrey Lagrange Multiplier Statistic testing for first to eighth order autocorrelation. The d refers to the Durbin-Watson Statistic and s(%) is the standard error of the regression expressed as a percentage of the sample mean of the dependent variable. CH refers to the Chow test for parameter stability across time periods corresponding to changes in the management of the Australian currency. The asterisk indicates rejection of the null hypothesis at the 5% level of significance.

There are considerable similarities between the empirical analysis of the portfolio balance equation where the variables are expressed in nominal terms - reported in Table 3.1 - and that same equation where the variables are expressed in real terms as reported above. For example, in the second subsample in both tables, there are a number of significant coefficients in the second order autocorrelation equation. In

both cases the foreign money variable is significant but of the incorrect sign, the domestic asset variable is significant and positive, and the foreign demand for domestic assets variable is significant and of the correct sign. In Table 3.7, however for the same estimation equation, the domestic demand for foreign assets variable is also significant - at about the 10% level of confidence - and of the correct sign. A distinguishing feature of the results in Table 3.7 is the evidence from the Breusch-Godfrey Lagrange multiplier statistics of an absence of autocorrelation from first to eighth order (first to fifth order in the second subsample) in all second order autocorrelation equations. The critical Chi-square value is 15.5 for eighth order and 11.1 for fifth order autocorrelation at the 5% level of confidence. On balance, there is sufficient difference evident in the results in Table 3.7 to warrant further investigation.

The next stage of the investigation is an examination of the real variables data set for evidence of stationarity or otherwise and these results are presented Tables 3.8 and 3.9. The same testing procedure as that used in section 3.4 reveals that all F statistics in Table 3.8 are insignificant indicating the presence of a unit root in all variables across all time periods. There are a number of insignificant but borderline statistics in Table 3.9.

Table 3.8: Stationarity tests with real variables expressed in levels

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:10 to 1988:07
m/p	1.3090 (5.48)	0.8855 (5.52)	4.1618 (5.92)	2.4269 (5.86)
m*/p*	2.9841 (5.49)	0.9526 (5.52)	2.1290 (5.91)	3.5330 (5.84)
fa/p	4.1039 (5.48)	3.5115 (5.52)	2.3865 (5.91)	4.5780 (5.83)
fa*/p*	2.1904 (5.48)	1.7508 (5.52)	2.6608 (5.91)	1.2042 (5.89)
b/p	2.1673 (5.49)	0.7774 (5.54)	1.1300 (5.91)	3.9374 (5.83)

Notes: the figure in brackets is the critical value at the 90% point of the distribution.

Table 3.9: Stationarity test with real variables expressed in first differences

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:10 to 1988:07
Δ(m/p)	5.7288 (5.49)	6.9366 (5.53)	5.8452 (5.92)	6.2434 (5.84)
Δ(m*/p*)	6.4300 (5.49)	5.8406 (5.54)	10.540 (5.91)	4.8952 (5.85)
Δ(fa/p)	6.5061 (5.49)	7.7622 (5.53)	22.200 (5.91)	6.1314 (5.85)
Δ(fa*/p*)	8.6727 (5.49)	7.8104 (5.53)	19.355 (5.91)	8.1829 (5.89)
Δ(b/p)	7.3744 (5.49)	6.6756 (5.54)	4.8906 (5.91)	5.7633 (5.84)

Notes: the figure in brackets is the critical value at the 90% point of the distribution.

The results of empirical analysis with all variables in first differences is presented below in Table 3.10.

Table 3.10: Portfolio balance model with real variables expressed in first differences

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:11 to 1988:07	
	OLS	OLS	OLS	OLS	AUTO
$\Delta(m_t/p_t)$	0.2399 (5.1747)	-0.3709 (-1.7516)	0.6535 (1.502)	0.3765 (1.327)	0.303 (0.809)
$\Delta m^*_t/p^*_t)$	0.2660 (1.1143)	0.2549 (1.1515)	2.0214 (1.448)	0.3102 (0.547)	0.242 (0.445)
$\Delta(fa_t/p_t)$	-0.0222 (-2.0478)	-0.0009 (-1.0792)	-0.1598 (-0.769)	-0.047 (-1.516)	-0.045 (-1.778)
$\Delta(fa^*_{it}/p^*_t)$	0.0361 (1.6341)	0.0153 (0.8072)	0.2014 (1.758)	-0.055 (-0.822)	-0.069 (-0.602)
$\Delta(b_t/p_t)$	-0.0282 (-0.283)	-0.0787 (-0.848)	0.3217 (0.845)	0.252 (0.857)	0.207 (0.791)
Δs_{t-1}	0.4143 (5.1747)	0.3351 (3.0211)	0.6717 (2.395)	0.4327 (2.486)	0.322 (0.426)
ϱ_{t-1}	-	-	-	-	0.256 (0.325)
$\bar{R}^2$	0.1734	0.1374	0.2484	0.1747	0.2061
h	1.2684	0.8424*	0.899*	4.8471*	1.863*
CHOW	-	1.7376	1.643	1.3279	-
BG	4.472	1.554	3.630	9.8463	-

Notes: figures in round brackets are asymptotic t-ratios. The *rho* value refers to the application of a first order autocorrelation of the error equation to the data. BG is the Breusch-Godfrey Lagrange Multiplier Statistic testing for first to eighth order autocorrelation. The h refers to the Durbin test for a regression containing lagged values of the dependent variable. The prime refers to the situation where Durbin's h cannot be computed: the value in this case refers to the BG test for first order autocorrelation. CHOW refers to the Chow test for parameter stability across time periods corresponding to changes in the management of the Australian currency. The asterisk indicates rejection of the null hypothesis at the 5% level of confidence.

A comparison of Table 3.10 with Table 3.4 for the nominal case reveals similar results. And on the strength of this there appears to be very little difference between testing the portfolio balance model with real as opposed to nominal variables. This can be gauged by an examination of the adjusted R^2 values which are consistently low and the coefficient values which are generally of the same sign and significance. However, the real version of the model performs better in terms of the significance tests. This is particularly so for the full sample. From Table 3.10, the Breusch-Godfrey Lagrange Multiplier statistic reveals no first to eighth order autocorrelation. The Chow test indicates an absence of coefficient instability across the time period. This contrasts with the results in Table 3.9 where there is an indication of coefficient instability across the same sample period.

Table 3.11 presents the results from applying an error correction model to the portfolio balance model with all explanatory variables in real terms. The error correction terms are calculated in the same manner as in the previous section, and therefore the description of the method is not repeated here.

Table 3.11: Error correction model with real variables

Dependent variable = Δs_t

	1977:01 to 1988:07	1977:01 to 1983:11	1983:12 to 1985:10	1985:11 to 1988:07
Δs_{t-1}	0.3624 (4.4063)	0.3348 (2.9885)	0.2746 (1.1707)	0.6487 (4.0517)
Δs_{t-2}	-	-0.3161 (-2.7394)	0.6422 (1.5290)	-
ec_{t-1}	-0.0757 (-2.7311)	-0.1556 (-2.6562)	-0.5995 (-1.9908)	-0.3926 (-3.1812)
Δm_t	0.2831 (2.1304)	-0.3837 (-1.0842)	0.4776 (0.8437)	-
Δm^*_t	-	-	-	1.0354 (1.8451)
m^*_{t-1}	-0.0526 (-2.5275)	0.0692 (1.0475)	1.2554 (1.4300)	-
Δfa_t	-0.0244 (-2.3354)	-	-	-0.0743 (-2.7923)
fa_{t-1}	-	-0.0106 (-1.8104)	0.1819 (1.4931)	-
Δfa^*_t	0.0483 (2.1777)	0.0323 (1.7134)	0.1215 (0.9333)	-
fa^*_{t-1}	0.0147 (2.2868)	0.0295 (2.3253)	-	-
Δb_t	-0.0710 (-0.7318)	-0.1961 (-2.0794)	-	-
b_{t-1}	-	-0.0682 (-1.6925)	0.3531 (1.4691)	-0.1922 (-1.5726)
$\bar{R}^2$	0.2461	0.2911	0.3175	0.4101
h	1.4834	1.2877	1.1172	1.0185
CHOW	-	1.4573	1.1882	1.3733
BG	5.2503	4.2924	4.7565	13.0152

Notes: figures in round brackets are asymptotic t-ratios. BG is the Breusch-Godfrey Lagrange Multiplier Statistic testing for first to eighth order autocorrelation. The h refers to the Durbin test for a regression containing lagged values of the dependent variable. The prime refers to the situation where Durbin's h cannot be computed: the value in that case is the BG test for first order autocorrelation. Chow refers to the Chow test for parameter stability across time periods corresponding to changes in the management of the Australian currency. The use of the lagged variables is justified by the existence of a cointegrating vector among these variables. That is, there is more than one cointergrating vector among the variables m, m^*, fa, fa^* and b.

If the results in Table 3.10 and Table 3.11 are compared, the error correction model for all four periods presented in Table 3.11 improves the overall explanatory power of the equation. The adjusted R^2 values however are still low, and lower in the latter two subsamples in comparison with the same statistic in Table 3.6 where the error correction model has nominally expressed variables. In both cases - nominal or real variables - the adjusted R^2 value is higher in the periods corresponding to a floating exchange rate regime. This result is repeated a number of times in the analysis of this chapter and is consistent with the expectation that the portfolio balance model explains the determinants of a floating exchange rate.

In all periods, the error correction variable - ec_{t-1} - is negative and significant. This is a better result for the error correction term than that found in the results in Table 3.6. The sign and significance on the lagged error correction term is intuitively plausible as it indicates that the term is pushing the dependent variable back towards its long run equilibrium value which is determined within the model. In all periods, there is evidence of neither first order autocorrelation - as indicated by the acceptance of the null hypothesis in all cases for the Durbin's h test - nor eighth order autocorrelation as indicated by the values for the Breusch-Godfrey test. The null hypothesis for the Chow test is accepted in all cases. There is no evidence on the basis of this test of coefficient instability across the time periods under scrutiny.

The results for the full sample are particularly pleasing. The signs on all the coefficients - apart from the domestic bond demand where the sign is unclear *a priori* - are those predicted by theory and they are significant. The sign on the domestic

bond demand looking back through the results in previous tables seems to be on the whole negative. The obvious exception to this pattern is for the second subsample - 1983:12 to 1985:10 - where the sign has tended to be positive throughout testing. Given that domestic bond demand tends not to be significant in terms of its explanatory power, much interpretative weight need not be put on its sign. Further, there are both correctly and incorrectly signed significant coefficients across the subsamples. The third subsample is an interesting one, for in this case, there are very few significant variables. Thus for the period from late 1985 to mid-1988, the explanatory variables for the exchange rate are its lagged value, the error correction term, the change in the United States money stock, the change in the real domestic demand for foreign assets and the lagged level of real domestic bond demand. All variables apart from the foreign money stock are of the expected sign.

Both error correction specifications presented in Tables 3.6 and 3.11 support the portfolio balance model of exchange rate determination. In both cases there are significant and correctly signed coefficients on not only monetary variables but also the portfolio adjustment variables of foreign and domestic assets. However, the real representation of the model performs better than the nominal value specification. This is evident in the comparison of results from Tables 3.6 and 3.11.

3.7 Forecasting and policy simulations of the preferred model

The error correction model with real variables (Table 3.11) is selected as the preferred model for forecasting and policy simulation. The reason for such a choice is based on the performance of the model under a number of different model

specifications. These are presented and discussed in the previous section.

The first step is an *ex-post* forecast of the model. According to Pindyck and Rubinfeld (1991), this refers to a forecast where the model is simulated forward starting at the end of the estimation period and continuing as long as historical data are available. The time period forecast is from April, 1988 to July 1989, a period of 16 months. The forecast of the change in the exchange rate variable compared to the actual movement of the exchange rate over the same time period is presented in Figure 3.2. (The actual change in the exchange rate over the entire sample period is shown in Figure 3.1.)

Figure 3.1 : Change in the exchange rate, 1977:3 to 1989:7

Figure 3.2: Actual and forecast change in the exchange rate, 1989:5 to 1989:7
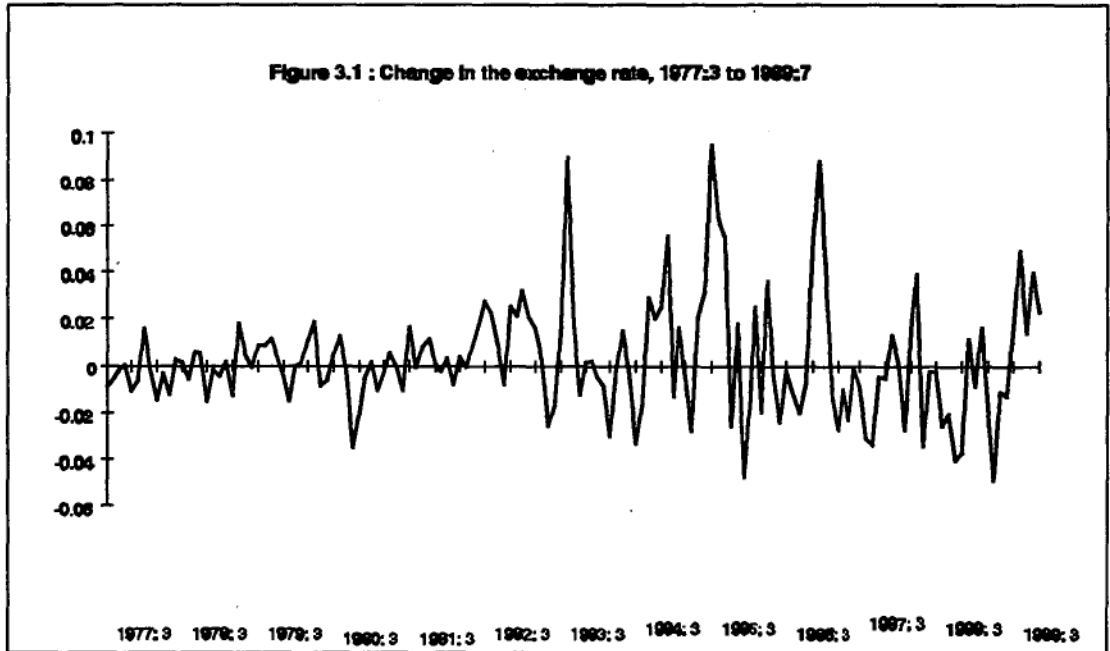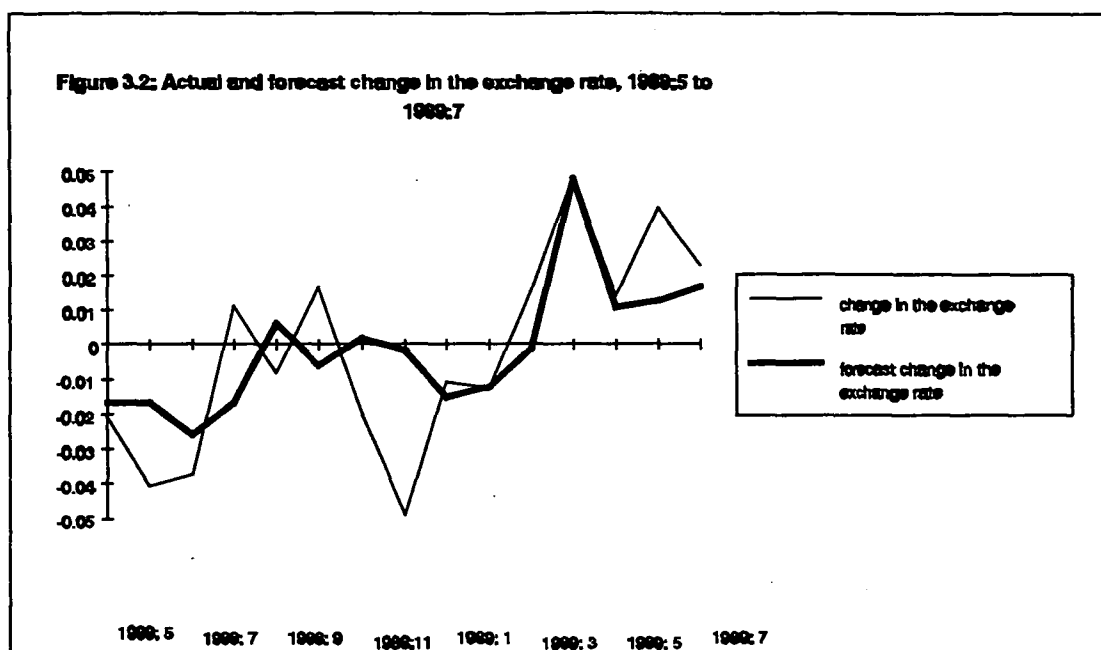
The forecast evaluation statistics are shown in Table 3.12. The RMS (root-mean-square) error is a measure of the deviation of the forecast variable from its actual time path. The magnitude of the error reflects the average size of the variables in question. The second evaluation statistic of Theil's inequality statistic (1958) or Theil's U is related to the RMS forecast error. The value of U always lies between 0 and 1. If U = 0, then the forecast value equals the actual value across all time periods forecast. If U = 1, then the forecast is as bad as it could possibly be (Pindyck and Rubinfeld, 1992).

The Theil inequality coefficient is decomposed into three explanatory statistics. The first of these, U^M, represents the error due to bias, the second, U^S, the error due to difference variation and the third, U^C, the error due to difference covariation. The statistics of $U^M + U^S + U^C$ are equal to one. They decompose the total average squared error into three components. The bias proportion, U^M, is an indication of systematic error, as it measures the extent to which the average values of the forecast and average series deviate from each other. Ideally, therefore, U^M should approach zero. Pindyck and Rubinfeld note that a value of $U^M > 0.2$ is undesirable as it indicates that there is some systematic bias in the forecast. In Table 3.12, the value of U^M is less than 0.2.

The variance proportion, U^S indicates the ability of the model to replicate the degree of variability in the variable. Pindyck and Rubinfeld note that if U^S is large then the actual series has fluctuated more than the forecast series or *vice versa*.

The final statistic is the covariance proportion, U^C which represents the error remaining after deviations from average values have been accounted for. Pindyck and Rubinfeld note that for any value of $U > 0$, the ideal distribution of inequality over the three sources is $U^M = U^S = 0$ and $U^C = 1$.

Table 3.12: Evaluation of forecasts

	RMS error	U	U^M	U^S	U^C
change in the exchange rate	0.020	0.447	0.012	0.298	0.746

Two types of policy simulations are presented in Figures 3.3 and 3.4. The first

represents the impact of a 10 per cent increase in the money supply on the forecasted

exchange rate. The policy adjustment occurs in 1988:8. The movement of the

adjusted forecast in Figure 3.3 shows that the domestic currency depreciates as

expected in response to the policy change. The second policy simulation is a ten per

cent increase in debt levels, representing an expansionary fiscal policy, in the same

period. (Money supply figures are adjusted to their original levels for the fiscal

simulation.) The results presented in Figure 3.4 show that the forecasted domestic

currency appreciates in response to the policy change. This is in accordance with a

wealth effect from changes in debt levels. The wealth effect from higher debt levels

leads to an increase in the demand for money. The subsequent rise in domestic

interest rates causes a domestic currency appreciation.

Figure 3.3: Impact of an expansionary monetary policy on the exchange rate forecast

Figure 3.4: Impact of an expansionary fiscal policy on the exchange rate forecast
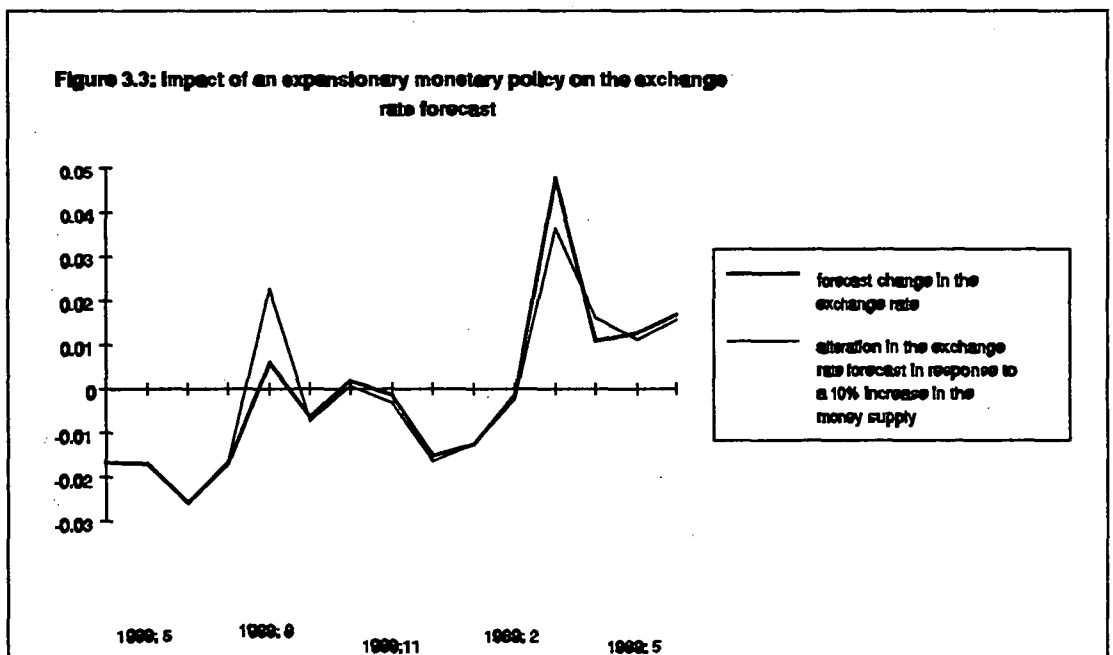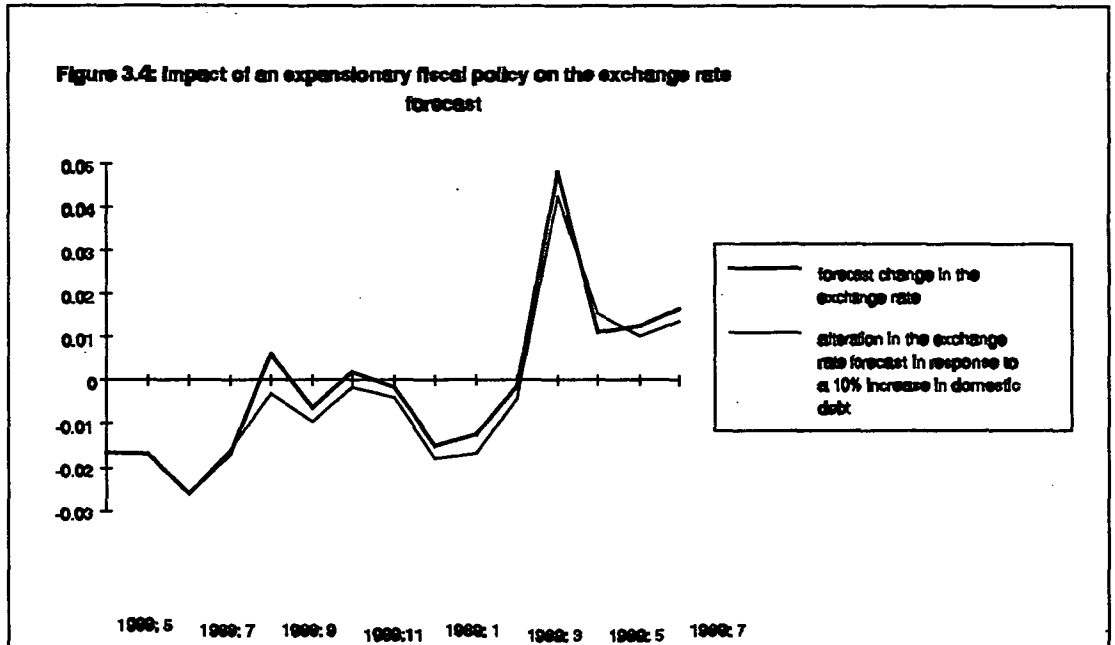
The overall conclusions from the forecasting and policy simulations is that the model performs adequately. The forecasting performance is mixed in that the performance is very good in some time periods and very poor in others. The forecasted exchange rate adjust in the expected direction to the policy simulations.

3.8 Conclusions

On the basis of the results in this chapter, when the portfolio balance model is expressed as an error correction system, it provides a better explanation of the movements of the exchange rate than the alternative specifications of the equations as levels or first differences. This applies to both nominal and real specifications of

the equation. Thus the portfolio balance model is responsive to an error correction explanation. Overall however, the real variables specification appears to provide better results than the nominal variables specification. This conclusion is based on the sign of the real variables which more often conform with the theoretical prediction, and there is more overall significance of those variables.

Although, the error correction models outperform other specifications, they still lack some explanatory power. It could be that single equation explanations of exchange rate determination overlook systematic problems. There may be a number of reasons for this. The first reason relates to the expectations formation: the implied expectations formation in the simple portfolio balance model is static when the appropriate expectations formation may be rational. Furthermore, the reduced form imposes exogeneity on the independent variables when they may not be exogenous. Third, the role of the government in determining the direction of exchange rate changes is omitted from the analysis.

Finally, there is a problem common to all exchange rate modelling, not only within the single equation framework; namely, the problems of developing a sound bilateral data set. These difficulties have been addressed by a number of authors. The next chapter is devoted to an examination of the issues considered in this concluding section.

Chapter 4: THEORETICAL AND EMPIRICAL WEAKNESSES OF THE SIMPLE PORTFOLIO BALANCE MODEL

A difficulty with model building based on any economic theory is that in the compromise between simplicity and complexity, inevitably, some of the storyline disappears. This is apparent in the development of testable models of exchange rate determination. A single equation reduced form model of the exchange rate, such as the model analysed in Chapter three is a simple application, which may sidestep some of the essential determinants of the exchange rate. Although the empirical results of Chapter three generally support the portfolio balance model, there is a contrary view that there is more to the explanation of exchange rate behaviour than explanations based on simple profit maximising decision behaviour. The possible flaws in the simple portfolio balance model are considered in this chapter. The discussion centres on means of improving the explanatory power of the model and yet at the same time maintaining its appealing intuitive power. In the context of this thesis, this chapter serves as a link between the empirical analysis of the simple portfolio balance model presented in the previous chapter, and the development of a more sophisticated version of the exchange rate determination process in later chapters.

4.1 Comments by other researchers on theoretical and empirical weaknesses in the simple portfolio balance model of exchange rate determination

Difficulties in empirical estimation of exchange rate relationships have been well-documented by other researchers. Sarantis (1987), for example, at the conclusion of his paper comments that there are a number of fruitful areas for further research. In particular, he mentions both the specification of government policy reaction functions for exchange market intervention and the specification of alternative schemes for the

formation of exchange rate expectations as useful additions to the current state of knowledge in terms of empirical exchange rate relationships. Davidson (1985) comments that the exchange rate is recognised as a particularly tricky subject for modelling and prediction. The problems of unobservables such as expectations, of simultaneity, and of policy changes in the sample period to which the models must be fitted may account for the disappointing results of recent attempts to test theories of exchange rate determination. Kearney and MacDonald (1988b) suggest that there are three main empirical issues on which simple reduced form asset market models are deficient. First, they comment that there are problems of endogeneity in reduced form equations which arise in part through the intervention behaviour of the authorities. Second, they suggest that not only are the variables in the models potentially endogenous, but they are also potentially interrelated. Finally, they argue that the empirical implementation of asset market models has largely ignored the existence of adjustment lags. Isard (1987) suggests that the analysis of exchange rate behaviour should be conducted within the context of complete macroeconometric models, and that the treatment of expectations plays a critical role in any analysis. Backus (1984) suggests that non-bond, interest-bearing assets such as equity should be included in the wealth constraint. Sarantis (1987) includes equity in his portfolio balance model based on the pound sterling. Typically, however, such data are not readily available.

The discussion below focuses on three weaknesses of the simple portfolio balance model discussed and empirically tested in Chapters two and three. The first of these apparent weaknesses of the model is the issue of implied exogeneity of the

explanatory variables in a reduced form model. Misspecification of the model occurs if the right-hand side variables rather than being exogenous are indeed endogenous, and interrelated with the dependent variable. A further possible difficulty centres on the issue of expectations formation. The simple reduced form model tested in Chapter three assumes that expectations in the foreign exchange market are formed statically. If instead, the expectations are determined by some other process, then there is a further misspecification concerning the relationship among variables. Third and finally, the simple portfolio balance model focuses entirely on private sector behaviour in the foreign exchange market. There has been increasing emphasis in the exchange rate literature on the role of the central bank in that market, not only in terms of their role in affecting the exchange rate value by intervention activity, but also in terms of the impact that their role has on private sector behaviour in the market place.

These potential sources of weakness in the simple portfolio balance model are discussed in turn in the remainder of this chapter. The reason for doing so, is to incorporate possible weaknesses of the model into a structural model of exchange rate determination developed later in the thesis.

4.2 Problems inherent in imposing exogeneity on the independent variables

A reduced form exchange rate equation such as equation (3.1) makes an explicit assumption that the independent variables "cause" the value of the dependent variable. Furthermore, an assumption is made of no feedback from the dependent variable to the independent variables. That is, the use of a reduced form equation for testing may

disguise sources of weakness in the underlying structural relationships, for example in the money demand equation. The investigation of causal relationships between economic variables has conventionally relied upon Granger's definition of causality: Granger-causality[1] refers to temporal precedence rather than causality in a strict methodological sense. That is, Granger-causality implies that Y causes X if the past history of Y can be used to predict X more accurately than does the past history of X (Feige and Pearce, 1979). Sims (1972) shows that Granger-type causality is equivalent to econometric exogeneity. Moreover, he shows that most efficient estimation techniques for distributed lags are invalid unless causality is unidirectional. Thus, reduced form distributed lag models such as the one used in section 3.5 and 3.6, must pass the causality test in order for the estimation and interpretation of the model to be valid.

Feige and Pearce (1979) describe a further implication of Granger-type causality tests. Statistical evidence that a variable X is caused by variable Y also indicates that Y is a leading indicator of X. Thus, this type of test for Granger-type causality is an economical means to assess what information can be employed in forming rational expectations models based on the same set of variables.

A further benefit of Granger-type causality is described by Bisignano and Hoover (1982). The small country assumption implicit in the portfolio balance model implies

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[1]Granger's definition of causality comes from his 1969 Econometrica article. Strictly speaking to be classified as a causative agent, an effect must not occur unless the cause is present (Christensen, 1980). In experimental methodology, there are a set of necessary and sufficient reasons for establishing causality. For that reason when discussing causality in this section, the term "Granger-causality" is used to indicate the difference between causality here and causality in a strict methodological context.

that the domestic economy being modelled cannot affect world interest rates and other price variables. In a bilateral context, this implies that the economic action and policy of the Australian economy cannot affect United States interest rates, but United States interest rates can affect the Australian economy. Therefore, the procedure for establishing the small country assumption used by Bisignano and Hoover (1982) is based on Granger-type causality. On the basis of an Australian/United States data set, for the small country assumption to hold, Australian monetary and financial assets must not "cause" U.S. interest rates, but U.S. interest rates should "cause" Australian monetary and financial assets.

Several interesting pieces of information may be gleaned by applying a causality test to the bilateral data used in Chapter three. First, causality testing provides an answer to the issue of exogeneity or otherwise of the explanatory variables in the equation of exchange rate determination. Evidence of endogeneity of the explanatory variables is an indicator that the particular econometric techniques applied, viz. ordinary least squares and the autocorrelation correction equation, are inappropriate. In this case, a more appropriate econometric form would be instrumental variables, two stage least squares, three stage least squares or a full information maximum likelihood technique. Additionally, the causality test may indicate the appropriateness or otherwise of the small country assumption.

Two different tests of Granger-type causality are employed here. The first is the Sims approach based on the method for testing developed by Sims (1972). Sims stated that if and only if causality runs one way from current and past values of some list of

exogenous variables to a given endogenous variable, then in a regression of the endogenous variable on past, current and future values of the exogenous variable, the future values of the exogenous variables should have zero coefficients. Furthermore in terms of the testing procedure, Sims suggests that in order to ensure that the residuals are white noise[2], variables used in the regressions should be prefiltered by a prescribed method.

Under the Sims approach, an assumption is made that X and Y are jointly covariance stationary and that they are purely indeterministic. Such a system may be specified in the moving average Wold representation as:

$$X_t = \sum_{i=0}^{\infty} a_i \epsilon_{t-i} + \sum_{i=0}^{\infty} b_i \eta_{t-i} \qquad (4.1a)$$

$$Y_t = \sum_{i=0}^{\infty} c_i \epsilon_{t-i} + \sum_{i=0}^{\infty} d_i \eta_{t-i} \qquad (4.1b)$$

where ϵ *and* η are serially uncorrelated and mutually uncorrelated processes with unit variance. Sims showed that Y does not Granger-cause X if and only if either all of the a's or all of the b's in those equations are zero. On the basis of this result, Sims showed that Y could be expressed as a one-sided distributed lag of X, with a disturbance uncorrelated with past, future and current X's if and only if Y does not cause X (Sargent, 1976). Sims' test for exogeneity of X is to regress Y on past,

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[2] A white noise is a serially uncorrelated process.

present and future values of X and then to test the null hypothesis that coefficients on future X's are zero. If X were endogenous, then significant coefficients on the leading values of X would indicate feedback from the left-hand variable, Y to X. That is:

$$Y_t = \sum_{i=-n}^{\infty} \gamma_i X_{t-i} + e_t \tag{4.2}$$

where e_t is a residual. Under the null hypothesis that Y does not cause X, future values of γ are equal to zero.

There are a number of difficulties with the Sims method. First, it requires the use of a formula for prefiltering to reduce or eliminate the serial correlation problem in the regression residuals (Sims, 1972). The values used for the filter are considered to be somewhat arbitrary (Gordon, 1977 and Feige and Pearce, 1979). Furthermore, there is an issue of the appropriate number of leading and lagging terms to be used in the regression. Moreover, the use of both leading and lagged terms rapidly reduces the degrees of freedom in testing.

Table 4.1: F statistics for the Sims causality test, 1977:01 to 1988:07

All variables prefiltered by $1 - 1.5L + 0.5625L^2$

REGRESSION	F STATISTIC
s on m	2.005*
s on m*	0.933
s on f	1.196
s on f*	1.191
s on b	1.252
m on s	0.090
m* on s	1.571
f on s	1.192
f* on s	0.715
b on s	0.122

Notes: the asterisk on the F statistic indicates that it is greater that the critical value at the 90% confidence level.

Table 4.1 presents results from the use of the Sims test for causality. All variables used in the regressions are expressed as natural logarithms and prefiltered by the filter $1 - 1.5L + 0.5625L^2$, so that for example the logarithm of the exchange rate s_t becomes $s_t - 1.5s_{t-1} + 0.5625s_{t-2}$[3]. Four leading and twelve lagging variables were used in the testing procedure. This conforms with the procedure adopted by Sargent (1976). The prefilter removes serial correlation in the ordinary least squares equation. The F statistics in Table 4.1 are testing the null hypothesis that the coefficients on future values of the right-hand side variable are equal to zero: the null hypothesis that the left-hand side variable does not cause the right-hand side variable.

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[3]Geweke (1978) using a given data set shows that the F statistic from the causality test is relatively insensitive to a number of different prefilters.

There is one significant result in Table 4.1. That result however, is significant only at the 90% confidence level. Thus at the 90% confidence interval, the null hypothesis that the Australian/United States dollar exchange rate does not cause Australian money supply as measured by M1 can be rejected. Indeed significant coefficients on the leading variables in the regression indicate that there is feedback from the left-hand variable to the right-hand variable. This is an interesting result considering that in the latter part of the sample period - in particular from late 1985 onwards - there was considerable speculation that the Reserve bank was targeting the exchange rate and using monetary policy to do so[4]. Thus, it could be said that the government's objective for a particular exchange rate value was influencing the money supply. In order to pursue this matter further the sample period was broken into subsamples to investigate whether or not the causality between the exchange rate and the Australian money supply is stronger in some periods than in others. Splitting the sample period into a number of different subsamples however, did not produce results that lead to rejection of the null hypothesis.

The second method of testing for Granger-type causality is the Granger approach. The procedure here is similar to the Sims method, but the leading variable on the independent variable is replaced by lagged values of the dependent variable. Thus, given X and Y as the dependent and independent variables respectively, the Granger causality test considers the relationship between them as:

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[4] Refer to section 3.1 of Chapter 3 for more detail.

$$X_t = \sum_{i=1}^{\infty} \alpha X_{t-i} + \sum_{i=1}^{\infty} \beta Y_{t-i} + \mu \qquad (4.3)$$

where α *and* β are least-squares estimates. Under the null hypothesis that Y does not cause X, the coefficients on the lagged independent variable from i *to* ∞ are equal to zero.

Table 4.2 presents results from the Granger-type causality tests. The regressions include four lagged values of the dependent variable and six lagged values of the independent variable. Once again, this conforms to the testing procedure adopted by Sargent (1976).

Here the null hypothesis is that the coefficients on the lagged values of the independent variable are equal to zero; that is the independent or right-hand side variable does not cause the dependent or left-hand side variable. The Granger test generally does not require prefiltering of the variables as the presence in the equation for estimation of lagged values of the dependent variable removes much of the serial correlation in the residuals. Nevertheless in order to attain the white noise residuals required for the Granger test, the F statistics reported here are calculated after the application of the Cochrane-Orcutt method to provide efficient estimates of an equation whose disturbances display first order serial correlation.

Table 4.2: F statistics for the Granger causality test, 1977:01 to 1988:07

REGRESSION	F STATISTIC
s on m	0.445
s on m*	1.985**
s on f	2.713*
s on f*	0.852
s on b	0.586
m on s	1.182
m* on s	4.232*
f on s	1.492
f* on s	0.687
b on s	2.548*

Notes: the asterisk on the F statistic indicates that it is greater that the critical value at the 95% confidence level. The double asterisk indicates significance at the 90% confidence level.

The results in Table 4.2 indicate at the 95% confidence level, there is evidence that foreign assets held by Australians, Granger-cause the exchange rate value, and that the Australian/United States dollar exchange rate Granger-causes the level of Australian domestic debt. The first result is intuitive and consistent with the predictions of the portfolio balance model. The second result is not as consistent with the predictions of the model, although a depreciation of the domestic currency would make domestic debt more attractive to domestic investors.

At the 95% and 90% confidence levels respectively, the results in Table 4.2 indicate that the United States money stock is Granger-causing the Australian/United States exchange rate and the exchange rate value is determining the United States money stock. The first result is plausible to the extent that actions of the Federal Reserve in the United States in changing the quantity of money (M1) would affect United States

interest rates and United States bilateral exchange rates. The second result which indicates that the exchange rate Granger-causes the United States money stock is not as intuitive but nevertheless may indicate some feedback from the money stock to the exchange rate.

There are two major shortcomings of causality testing that should be considered before further discussion. The first is that the results presented in Table 4.2 are bivariate causality testing and therefore suffer from the potential problems of omitted variables. Geweke (1984) states that one must specify the set of all information assumed in the definition since Y may cause X for some sets but not others. Second, a positive test for causality is a necessary but not sufficient condition for exogeneity. Sargent (1979) and Evans and Wells (1982) show that not all polynomial lag structures in the relationship between X and Y will accord with the requirement in the definition of causality that Y causes X. This can be observed in equation (4.3) where there are a number of configurations of the relationship between the dependent and independent variable and although in some testing it may be that X is found to be exogenous to Y, this may not apply across all configurations.

Overall, the results from the causality testing are disappointing. In particular, there is no compatibility between the results in Table 4.1 and Table 4.2. The Sims test appears on the basis of the results here to reject causality more readily than the Granger test. Sargent (1976) found an apparent general tendency of the Granger test to reject causality more readily than the Sims test. Feige and Pearce (1979) applied

three methods for causality testing[5] to the same data set. Their findings indicate that the Sims procedure yields results substantially different from the results from the application of the Haugh-Pierce or Granger technique. Furthermore, they found that the Sims method is sensitive to the particular prefilter chosen to implement the empirical analysis. This is contrary to the finding of Geweke (1978) reported earlier that the results from causality testing tend to be relatively insensitive to the particular prefilter chosen.

Table 4.3 presents the results of testing for the small country assumption using both the Sims and Granger methods. The small country assumption implies that economic policy in a small domestic economy is unable to influence the return on assets in the foreign economy, whereas such changes in the foreign economy may influence domestic asset returns and prices. In Table 4.3, r is the domestic interest rate and r^* is the United States interest rate.

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[5]In addition to the Granger method and Sims method discussed here, they use the Haugh-Pierce approach. The Haugh-Pierce approach was developed by Larry D. Haugh (1976) and Pierce (1977). Their approach is strictly appropriate only as a test of independence between two variables and is based on the cross-correlation function of the univariate innovations of the two series (Feige and Pearce, 1979).

Table 4.3: Testing the small country assumption using both the Sims and Granger causality tests, 1977:01 to 1988:07

REGRESSION	F STATISTIC	
	SIMS	GRANGER
r on m*	0.221	0.855
r* on m	0.487	1.041
r on f*	0.824	0.407
r* on f	1.157	1.806
r* on b	0.223	0.910
m* on r	0.600	0.871
m on r*	1.710	0.793
f* on r	0.493	0.993
f on r*	0.628	1.894*
b on r*	1.108	0.455

Notes: the asterisk on the F statistic indicates that it is greater that the. critical value at the 90% confidence level.

Interpretation of the statistics here is not straight forward. The null hypothesis for the Sims causality test is that the left-hand side variable does not cause the right-hand side variable. The null hypothesis for the Granger causality test however, is that the right-hand side variable does not cause the left-hand side variable. There are many results in Table 4.3 which support the small country assumption, consider the Sims test: reading down the relevant column of Table 4.3, the first, third, seventh, ninth and tenth results support the small country assumption as in these cases, the acceptance of the null hypothesis is consistent with it. For the Granger causality test, the second, fourth, fifth, sixth, eighth and ninth results support the small country assumption. There is however, only one result in Table 4.3 which supports the small country assumption under both testing procedures: the ninth result which has a significant F statistic. This result indicates that the United States interest rate does

Granger-cause Australian demand for foreign assets. There is evidence of feedback which refutes the small country assumption. The null hypothesis that the Australian demand for foreign assets does not Granger-cause the United States interest rate cannot be categorically accepted. The F statistic for this null hypothesis is equal to 1.806 and the F statistic at the 90% confidence level for rejection of the null hypothesis is equal to 1.82. The results are generally disappointing and the outcome is unclear.

The use of both the Granger and Sims methods is prompted by the concerns expressed about each method by Feige and Pearce (1979). There is a lack of acceptance in most cases of causality between the independent variables in the portfolio balance model and the exchange rate, and consequently of exogeneity of the independent variables, in spite of inconsistencies between the Granger and Sims tests. The reduced form equation, modelled in Chapter three assumes explicitly that causality exists between the explanatory and dependent variable in the relationship and that the explanatory variables are exogenous. Finally the small country assumption of the particular formulation of the portfolio balance model in Chapter three is not strongly supported by these findings.

4.3 The role of expectations in models of exchange rate determination

The simple portfolio balance model of Branson, Halttunen and Masson (1977) is developed with the assumption of static expectations concerning the future exchange rate value as follows:

$$_{t-1}x^e_t = x_{t-1} \qquad (4.4)$$

which indicates that the agent's expectation of x_t held in period $t-1$ is equal to the value of that variable now.

Branson *et al.*(1977) assumed static expectations because there was at that time very little empirical evidence on alternative, more realistic models of expectations formation. Branson and Henderson (1985) add in a footnote that when short-run portfolio balance models are used to analyse a regime of flexible exchange rates, it is usually assumed that exchange rates are static or regressive. Bisignano and Hoover (1982), Backus (1984) Sarantis (1987) all assume that the formation of expectations is static.

Kouri (1976) investigated the dynamic stability of the balance of payments adjustment process under flexible exchange rates using three mechanisms of expectations formation. These are models of static, perfect foresight and adaptive expectations formation. Each of these has drawbacks and limitations. The static case which is discussed above has obvious advantages because it is easy to model empirically. The disadvantage of static expectations is that individuals either do not acquire information on the movement of variables over time, or if they do acquire information then they do not incorporate that information into their decision-making.

The perfect foresight model implies that the expected value of a variable, x in a future time period is equal to the actual value of x in the future time period. That is:

$$_{t-1}x^f_t = x_t \qquad\qquad (4.5)$$

The weakness of the perfect foresight model is obvious: individuals do not have perfect knowledge and there are unforeseen events that impact on the value of x in the future time period[6].

The hypothesis of adaptive expectations was developed by Cagan (1956) and postulates that individuals use information on past forecasting errors to revise current expectations. Adaptive expectations is equivalent to a geometric distributed lag on the past values of x. From Begg (1982), the adaptive expectations hypothesis is described as:

$$_{t-1}x^e_t = \Phi x_{t-1} + \Phi(1-\Phi)x_{t-2} + \Phi(1-\Phi)^2 x_{t-3} + ... + \Phi(1-\Phi)^n x_{t-n-1}$$
$$+ (1-\Phi)^{n+1} {}_{t-n-2}x^e_{t-n-1} \qquad (4.6)$$

where Φ is a positive fraction. Therefore the weight placed on the lag terms closer to n are greater; indicating that the most recent past values of the variable, x have the greatest impact on the formation of the expected future value of that variable. As Begg discusses, the great appeal of adaptive expectations is that it allows us to model unobservable expectations in terms of past observations on the relevant variable, x only. Moreover, it is unnecessary to specify the process by which the initial level of expectations is determined. The weakness of the model of adaptive expectations is that the expectation is based entirely on past information and second, that the weights placed on the lag structure cannot be determined by economic theory and thus tend to be rather arbitrary.

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[6] Indeed, the perfect foresight assumption of expectations formation is a special case of rational expectations with perfect certainty.

The hypothesis of rational expectations overcomes these limitations by asserting that the market expectation of the value of the exchange rate in the next time period is equated with a mathematical expectation conditional upon some information set. Individuals act as if they know the model and form expectations accordingly (Begg, 1982). Unlike the weakness inherent in adaptive expectations formation, individuals learn by their mistakes and do not rely solely on past information to make judgements about the future values of variables.

Equation (4.7) is an example of a rational expectations model. The expected spot rate is the mathematical expectation of the spot rate, given the information available between the past and present time periods which is summarised in the information set, I_{t-1}:

$$s_t^e = E(s_t^e \mid I_{t-1}) \qquad (4.7)$$

where E is the expectations operator. The term on the left-hand side is the agent's expectation of s_t held at time $t-1$. The information set, I_{t-1} includes at least past and present values of the variables that determine the exchange rate value. It may also include other current and future exogenous variables. Thus equation (4.7) defines rational expectations.

In the above model, expectations are assumed rational in the sense of being unbiased relative to a given information set. Davidson (1985) suggests the information set may be either wide or narrow, implying strong and weak forms of rationality. Under the extreme rationality hypothesis where the information set used by agents is wide, it

may not be possible to improve on a random walk model[7] for ex-ante prediction (Davidson, 1985). It is highly improbable that the strong form of rationality holds however, given that costs of collecting and analysing information are not zero.

An implication of market rationality is that participants in the market process should, if acting rationally incorporate all information about past, present and future values of variables in the information set into their decision-making. Therefore a standard test of market rationality is an investigation of the return on assets. Evidence of excess returns thus, implies *ceteris paribus* a lack of rational expectations formation by participants. The issue however, is not a simple one. The difficulty of testing empirically for rational expectations formation in a market is that is encompasses a test of market efficiency and any test of market efficiency is a joint test of several different market hypotheses (Hodrick, 1987). Fama (1970) describes an efficient market as one which fully reflects all available information. Returns on a market asset outside some normal range may indicate the presence of a risk premium, rather than indicating that investors do not incorporate all information in a given information set when making decisions[8].

The notion of market rationality was first investigated extensively in financial markets, for example by Fama, 1970. Since the move to widespread floating of exchange rates in the early 1970's, however, there have been several studies of

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[7]A random walk refers to the situation where the change in the exchange rate today is uncorrelated with all previous changes, and past exchange rate changes give us no economically useful information about future exchange rate changes.

[8]There is a more extensive discussion of market efficiency in section 7.2.

rationality in the exchange rate market. For example, Levich (1978) tested market efficiency in the international money market: his research leads him to the conclusion that although exchange rate forecasts based on market prices are not perfect, they do display many statistical properties consistent with the efficient use of available information.

Australian studies of market rationality are inconclusive. Tease (1990) notes Australian evidence, for example of Tease (1988), and Smith and Gruen (1989) which does not wholly support foreign exchange market efficiency. Smith and Gruen (1989) find that expected returns do not appear to be equalised across countries, and that in the case of Australia the unequal returns have little to do with the risk preferences of market participants. They find that *ex post*, investors are over-compensated for holding Australian dollar denominated assets and that these excess returns are too large to be accounted for by conventional measures of risk. Tease suggests that the excess return is explained by investors not forming expectations of a future value of a variable rationally. An alternative view provided by Frankel and Froot (1987) is that expectations are formed extrapolatively: a market expectation that an appreciation of the currency in one period reveals an appreciating trend. Market participants who behave according to this extrapolative view then tend to push the exchange rate away from the equilibrium implied by the fundamentals of the balance of trade and the long term investment flows of the capital account.

The timing may be important here. Extrapolative behaviour in the foreign exchange market in the short term - a day to a week - may push the exchange rate away from

a short run equilibrium. There is however, an abundance of evidence that in the longer run - a month to a year - that the exchange rate does move in line with the fundamentals of the balance of payments (Blundell-Wignall and Thomas 1987, and Macfarlane and Tease 1989).

Many recent studies of exchange rate determination have used rational expectations rather than static or adaptive expectations. For example, Dornbusch and Fischer (1980), Rodriguez (1980), Dooley and Isard (1982), Branson and Henderson (1985) and Papell (1986) assume rational expectations formation in a general portfolio balance framework. Kearney and MacDonald (1988b) extend the rational expectations approach into a small structural model of the open economy which operates a managed exchange rate; where the exchange rate is determined within a portfolio balance model.

4.4 The role of the central bank in the foreign exchange market

The simple portfolio balance model modelled in Chapter three considers private sector actions only in the foreign exchange market. Many countries with floating exchange rates are subject to varying degrees of central bank intervention in the foreign exchange market. The presence of such intervention needs to be justified by reference to a source of market failure. Although there is no such explicit reference justifying market intervention by the Reserve Bank of Australia, one can assume that the policy makers perceive there to be some divergence between social and private costs and benefits. For example, the Reserve Bank intervenes at times to smooth the path of large transactions through the market. In this case the actions of one

transactor in the foreign exchange market may impose a cost on the wider economy due to the uncertainty created by a large swing in the exchange rate value. Central bank intervention has the potential to minimise the social cost of a private action.

The extent of intervention in the market place varies between economies and between time periods. The discussion below focuses on the type and extent of intervention activity by the Reserve Bank of Australian in the foreign exchange market since 1983.

The Australian Government announced in December 1983 that the Australian dollar would move from a crawling-peg trade-weighted exchange rate regime to a floating regime with only light intervention to smooth out a disorderly market[9]. Intervention activity intensified over the years to the point where there has been, since late 1985 both public acknowledgment and general acceptance that the Australian currency is a managed float[10]. Generally, the objective of central bank intervention under a floating exchange rate is to reduce instability in exchange rate markets by reducing the magnitude of random fluctuations away from the equilibrium rate and by smoothing out swings in exchange rate values. The rhetoric of the Reserve Bank over the period under consideration bears testimony to this observation. A distinction is made here between two intervention strategies. The first involves reducing and

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[9]Section 3.1 discusses the management of the Australian dollar from January 1977 to the end of 1989.

[10]There was some speculation around late 1985 that the exchange rate was being targeted at some predetermined value. In this case, intervention is expected to maintain the exchange rate within the target contrary to the case of a managed float where intervention is discretionary. For the purposes of the discussion in this section, it is sufficient to acknowledge that there is a form of management of the currency or to state the converse, that it is definitely not a freely floating currency.

countering erratic fluctuations away from an equilibrium rate and consequently smoothing the path of the exchange rate through time. At the inception of the float of the Australian dollar,the Reserve Bank engaged in a intervention strategy known as testing and smoothing. For example, it would enter the market periodically to test market trends or smooth the path of large currency transactions through the market (Reserve Bank of Australia, Report and Financial Statements, 30 June 1984). This intervention strategy is more closely identified with intervention on a very short-term basis (that is daily). The method of intervention consists of the Reserve bank buying and selling foreign and domestic currency in order to influence the exchange rate value.

The second strategy involves the moderation of the speed and the smoothing of the path of exchange rate movements towards a new equilibrium. This latter strategy is commonly referred to as leaning against the wind, because it refers to intervention activity aimed at moving against the prevailing market forces. For example, leaning against the wind requires the depreciation of the exchange rate when the interest rate differential leads to a capital inflow and an appreciating exchange rate. It implies intervention on a larger scale and over a longer time period in comparison with the first strategy, and is consequently controversial. Heavier intervention activity was acknowledged by the Bank in the early months of 1985 (refer to section 3.1, again). The Reserve Bank, however has never stated that it was leaning against the wind by buying and selling foreign exchange. Both Quirk (1977) and Hutchison (1984) have empirically tested and analysed the use of this policy by the Japanese central bank. Hopkins (1988) found evidence of leaning against the wind intervention behaviour

by the Reserve Bank of Australia from 1977 to 1986[11]. Intervention by use of a leaning against the wind policy moreover, is in accordance with the International Monetary Fund guidelines for management of members' exchange rates (Hutchison, 1984). In addition, a leaning against the wind intervention strategy may be complementary to an intervention policy where the exchange rate is being targeted. Target zones as a policy option differ from a system of managed floating because there is an expectation that the authorities will intervene in the exchange rate market and that the intervention will maintain the exchange rate within a target zone. This policy has been advocated as a means of improving exchange rate stability and problems of misalignment (Frenkel and Goldstein, 1986 and Williamson, 1986). From section 3.1, there was a sustained belief towards the end of 1985 in the Australian financial community that the Reserve Bank of Australia had adopted exchange rate targeting as a means of managing the currency. It should be emphasised here that the instruments of policy in a system of target zones are both exchange rate intervention (purchase and sales of foreign currencies by the Reserve Bank in order to influence the exchange rate value) and monetary policy (using monetary policy to achieve a desired interest rate and capital inflow/outflow). An empirical exchange rate model, in order to account for the actions of both the private and public sector in influencing the exchange rate value needs to accommodate the role of the central bank.

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[11]Analysis of monthly data from January 1977 to December 1986 indicated that every time that the dollar appreciates (depreciates) by a cent the Reserve Bank authorities buy (sell) $7.6 million of foreign exchange reserves. Dividing the sample into two subsamples - pre and post floating reveals values for foreign exchange reserves of $4.7 and $8.8 million respectively. This indicates that leaning against the wind intervention activity increased rather than decreased in the period after the float of the Australian dollar.

4.5 Conclusions

The chapter considers a number of weaknesses in the simple portfolio balance model of exchange rate determination. The task of the following chapters is to draw on this information to develop a structural model of the open economy which is based on the intuition of the portfolio balance model. Such a model should overcome the many weaknesses of the simple reduced form portfolio balance model. This process of model development is extended over a number of chapters, as the issues raised in this chapter are considered further. Thus Chapter five develops a structural model of the macroeconomy based on the notion of portfolio balance in the exchange rate market. Chapter six examines empirically the relationships developed in Chapter five.

Chapter 5: A SMALL STRUCTURAL EQUATION OPEN ECONOMY MODEL IN THE SPIRIT OF THE PORTFOLIO BALANCE APPROACH

The empirical analysis described in Chapter three and the discussion following in Chapter four demonstrate the limitations of the simple reduced form portfolio balance model in explaining the movements of the Australian/United States dollar exchange rate over the chosen time period. By building on the analysis in these chapters, the aim of this chapter is to develop a model with better explanatory power than the simple portfolio balance model. This small structural equation open economy model remains based on the portfolio balance approach. The notion that the actions of profit maximising investors adjusting their portfolio of assets to changes in rates of return on those assets is still the key to understanding the process of exchange rate determination in the short run. And in the long run, it is the current account or more specifically trade flows which yield a long run equilibrium exchange rate. The model embeds the the portfolio balance approach into a standard open economy model with a budget constraint and endogenous wages.

Chapter five is structured as follows. In section 5.1, a small structural equation open economy model is developed. This development is based on the work of the following: Black and Salemi (1987) and (1988), Murphy (1988b) and Kearney and MacDonald (1988b). In section 5.2, there is a discussion of the way in which the model will be applied. Actual empirical analysis of the model will be left to the next chapter.

5.1. Model development

The overall direction in this model is derived from the work of Black and Salemi (1987) and (1988). Their model addresses many of the questions left unanswered in the portfolio balance model which is developed and tested in Chapters three and four. In particular, the Black and Salemi model incorporates both rational expectations and government policy reaction functions. In addition, their model structure acknowledges that the perceived riskiness of holding assets changes with variations in the management of the exchange rate. Thus, portfolio adjustments are affected by two interrelated factors: changes in relative rates of return and policy effects.

Model development in this chapter also draws on the work of Kearney and MacDonald (1988b), who develop a small structural model of an open economy operating under a managed exchange rate regime. The model consists of an asset sector of the portfolio balance genre accompanied by a real sector which solves for the current account balance together with income and prices. Kearney and MacDonald test their model on British and United States quarterly data. Attempts to apply this model to Australian data are complicated by the profound policy changes occurring in Australia during the early 1980's, not the least of which was the decision to float the dollar in 1983 and the return to greater foreign exchange intervention in the late 1980's.

In addition, the model developed here draws on a well-known Australian macroeconomic model formulated by Murphy (1988b). This is a small, quarterly macroeconomic model of the Australian economy designed for policy analysis and

forecasting. The structure of both the Murphy model and the model developed in this chapter are based on a Keynesian methodology[1] and includes rational expectations in financial markets including foreign exchange markets, but not in other markets[2]. This feature of the Murphy model is in turn based on similar analyses of the United States economy by Fair (1979). The model's long run structure is based on optimising behaviour by agents. Once again this is pertinent to the Black and Salemi approach where it is assumed that a representative agent chooses foreign or domestic assets in order to optimise his or her utility from a particular portfolio.

The following assumptions underpin the model developed in this chapter.

(i)   A representative agent chooses foreign and/or domestic assets in order to optimise his or her expected utility from a particular portfolio which in turn, implies that individuals conform to certain axioms of rational choice[3]. The

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[1]Here the term "Keynesian model" is used to describe a view of the macroeconomy which is based on a two basic tenets. The discussion here draws on the 1988 Australian Economic Congress Paper by Blinder, which was later published in The Economic Record (1988). First, Keynesian economics is demand orientated and aggregate demand is influenced by both private and public decision-making. Secondly, those aggregate demand fluctuations have their greatest short-run impact on real output and employment, not prices. Indeed, prices and wages tend to be sticky in the short-run. Thus in Keynesian models, labour and goods markets tend to perpetuate disequilibrium in the short-run.

[2]Murphy justifies this assumption with two related arguments. First that rational expectations are more plausible in financial markets than in labour and goods markets. In labour and goods markets, the gains or losses associated with making inefficient forecasts are typically smaller, and often may be small in relation to the costs of collecting information to produce forecasts with minimum mean square error, given all the information potentially available at the time. Second, tests of rationality have been more supportive of its evidence in financial markets than elsewhere. For example Tease's (1986a,1986b) studies of the joint hypothesis of risk neutrality and rationality are reasonably supportive of the joint hypothesis.

[3]These axioms of rational behaviour are:
  (i)   individuals are able to rank alternatives, and *ceteris paribus* prefer the larger outcome to a smaller outcome,

  (ii)   individuals preferences are transitive,

  (iii) the expected utility of a combination of alternatives is a linear combination of the

utility function of the individual is assumed to be concave, implying risk averse individual behaviour. Risk aversion implies in turn that the individual gains utility from the minimisation of some risk. A risk premium is the maximum amount that the individual is willing to pay to have the sure return rather than the expected return from some uncertain outcome (Laffont, 1989). Expected utility is determined on the basis of the probability distribution of possible returns; where that distribution can be summarised in terms of two parameters of the distribution; *viz.* the expected return and the standard deviation. Thus, our representative domestic investor chooses a portfolio of foreign and domestic assets in order to maximise expected utility such that the following maximand holds:

$$U = E_t \pi_{t+1} - (\frac{\phi}{2}) V_t \pi_{t+1} \qquad (5.1)$$

utilities of those alternatives.

The utility approach discussed here has its origins in the work of von Neumann and Morgenstern (1944).

here ϕ is a measure of relative risk aversion[4], and the first term is the expected return on the portfolio in the next period, π_{t+1}, and $V_t\pi_{t+1}$ is the expected variance on the portfolio in the next time period, given information available in period, t. The investor's utility function is concave and as ϕ is assumed constant, it exhibits constant relative risk aversion.

(ii)   There are no significant transaction costs, capital controls, or other impediments to the international flow of capital.

(iii)   Domestic and foreign assets are imperfect substitutes. This assumption is fundamental to the portfolio balance model and implies that investors adjust their portfolios in response to changes in the rates of return on financial assets and in response to changes in the riskiness of assets. An implication of imperfect substitutability of assets is that uncovered interest parity[5] does not hold. Uncovered interest parity asserts that arbitrage by investors ensures that

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[4]From Laffont (1989), a relative risk premium is equal to:

$$\hat{\rho}(\bar{x}, \tilde{\varepsilon}) = -\frac{1}{2} \sigma_\varepsilon^2 \frac{\bar{x}u''(\bar{x})}{u'(\bar{x})}$$

where $u(.)$ is a concave, twice differentiable, and strictly increasing utility function, and $\tilde{x} = \bar{x} + \varepsilon$ is a stochastic variable with mean $\bar{x}$ and variance σ_ε^2. It is assumed that ε is small, and that in this example $\bar{x}$ refers to a given level of wealth.

The coefficient of relative risk aversion is equal to:

$$r_r(\bar{x}) = \frac{-\bar{x}u''(\bar{x})}{u'(\bar{x})}$$

The coefficient is twice the relative risk premium per unit of variance for proportional risk. This analysis of a coefficient of relative risk aversion is based on the Pratt Theorem (1964).

[5]Section 2.1 considers the interest rate parity theorem in more detail.

the differential between domestic and foreign interest rates is equal to the

expected depreciation or appreciation of the spot exchange rate:

$$r = r^* + (s_{t+1}^e - s_t) \qquad (5.2)$$

where r and r^* are one-period domestic and foreign interest rates on financial

assets of similar risk and maturity, s is the spot exchange rate in period t

expressed in natural logarithms and the superscript e refers to the expected

spot rate in period $t+1$. Expression of the exchange rate term in natural logs

overcomes the difficulty of Siegel's paradox[6].

Under conditions of uncertainty, however, an investor taking a position in the

foreign exchange market is exposed to exchange risk. Such risk can be

eliminated by purchasing a forward contract. The weaker interest rate parity

theorem refers to this covered relationship such that:

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[6]Siegel (1972) showed that the proposition that the level of the forward rate is equal to the level of the future spot rate implied a contradiction. If the proposition were true for the Australian dollar per United States dollar exchange rate, it could not also be true for the United States dollar per Australian dollar exchange rate. This is because Jensen's inequality requires that $E(1/x) > 1/E(x)$, when x has positive variance. The paradox was resolved by Roper (1975) and Boyer (1977) who found that it is legitimate to express the unbiasedness hypothesis in logarithmic form, so that:

$$E_t(s_{t+1})^{-1} = E_t(\ln S_{t+1})^{-1} = -E_t \ln S_{t+1} = -\ln F_t$$

and thus avoid the problem of Jensen's inequality.

In levels form, the covered interest parity condition is:

$$\frac{F_t}{S_t} = \frac{1 + r_t}{1 + r_t^*}$$

where the upper case variables denotes expression in levels.

$$r = r^* + (f_{t,1} - s_t) \qquad (5.3)$$

where f represents a forward contract purchased at time, t which matures at time $t+1$, and both the forward and spot exchange rate are expressed in natural logarithms.

Assuming that investors form their expectations about future prices rationally and that they are risk neutral, the arbitrage action of profit-maximising individuals should ensure that the forward rate is an unbiased predictor of the expected future spot rate, that is:

$$s_{t+1}^e = f_{t,1} \qquad (5.4)$$

This is the unbiasedness hypothesis.

On the other hand, any deviation between the expected spot rate and the forward rate such that the unbiasedness hypothesis does not hold, implies *inter alia* that there is an exchange rate risk premium. Following Fama (1984), the forward rate can be broken down into two parts:

$$f_{t,1} = s_{t+1}^e \cdot \lambda_t \qquad (5.5)$$

so that the forward rate comprises the expected future spot rate times a risk premium, λ.

The presence of a risk premium indicates that arbitrage is not eliminating the differential between the forward rate and the expected spot rate. Indeed, a risk premium implies that investors rather than being risk neutral as assumed in the interest rate parity theorem, are risk averse and consequently require a risk premium to compensate them for the perceived riskiness of holding a foreign currency denominated asset. Other forms of uncertainty such as default risk and political risk are assumed away by assumption (ii).

(iv)   The domestic country is small relative to the rest of the world, or small relative to another country in a bilateral model. The results of the Sims and Granger causality tests presented in Table 4.3 provide inconclusive support for the small country assumption.

(v)   Rational expectations hold in financial sectors of the economy, including the foreign exchange market for the reasons that are provided above.

The model structure is described below. Notation used in the model is described in Table 5.1. All variables are expressed in natural logarithms except interest rates which are conventionally not expressed in terms of logs. The coefficient signs indicate *a priori* values expected from the theory. The error terms denoted by the Greek symbol, μ are all random disturbance terms intended to represent unsystematic forces impinging on the economy in unpredictable ways. The error terms are assumed to have zero means and constant variances, and to be stochastically independent of

past values of all variables and error terms and of each other.

Equations (5.1) to (5.3) are the asset demand equations expressed in real terms:

$$(m^d - p)_t = \alpha_1 r_t^* - \alpha_2 r_t - \alpha_3 \lambda_t s_{t+1}^e + \alpha_4 s_t + \alpha_5 y_t + \alpha_6 a_{t-1} + \mu_{1_t}$$

$$(5.6)$$

$$(b^d - p)_t = \alpha_7 r_t - \alpha_8 r_t^* - \alpha_9 \lambda_t s_{t+1}^e + \alpha_{10} s_t + \alpha_{11} y_t + \alpha_{12} a_{t-1} + \mu_{2_t}$$

$$(5.7)$$

$$(s + fa^d)_t - p_t = \alpha_{13} r_t^* - \alpha_{14} r_t + \alpha_{15} \lambda_t s_{t+1}^e - \alpha_{16} s_t + \alpha_{17} y_t + \alpha_{18} a_{t-1} + \mu_{3_t}$$

$$(5.8)$$

Investor behaviour is generally considered to be a response to real variables rather than nominal variables because an investor in an open economy must take account of both exchange rate and price index uncertainty. According to Branson and Henderson (1985), uncertainty about real returns arises not only because future values of exchange rates are unknown but also because future values of the price index used to deflate nominal wealth are unknown. Specification of the asset demand functions in real terms imposes the constraint of homogeneity of degree one in nominal values. Danker *et al.* (1987) and Kearney and MacDonald (1988b) posited their asset demands in real terms.

Table 5.1: Notation for equations

Roman alphabet script has the following meanings:

m	=	money
p	=	price level
y	=	real income
a	=	real financial wealth of the private sector
r	=	rate of interest
s	=	spot exchange rate defined as domestic currency in terms of foreign currency
f	=	forward exchange rate
b	=	domestic bonds held by domestic residents denominated in domestic currency
fa	=	foreign assets held by domestic residents denominated in foreign currency
i	=	monetary authorities purchases of foreign exchange for intervention purposes
g	=	total public sector expenditure including transfer payments in real terms
tx	=	total public sector taxation both direct and indirect in real terms
w	=	wages
u	=	rate of unemployment
o	=	overtime index
c	=	current account balance
ff	=	domestic assets held by foreign residents denominated in domestic currency
ff^o	=	net foreign debt defined as (ff - fa.s)

All variables except interest rate terms are expressed in natural logarithms. Additionally, superscripts *d, * and e* refer to the demand for a variable, the foreign magnitude of a variable and the expected value of a variable respectively. Greek alphabet script, α *and* μ are used to denote coefficients and error terms respectively.

All asset demands depend positively on real income and real wealth. The real wealth term is lagged one period to account for Turnovsky's assertion (1977) that the appropriate wealth variable determining household demands at time *t*, for time *t+1* is wealth at time *t*. Turnovsky maintains that it follows that wealth as an explanatory variable in aggregate private expenditure equations should appear with a one period lag. All assets demands are also related to the four variables that constitute the interest parity condition: the domestic and foreign interest rate, the spot rate and the forward rate. The latter term is represented in each equation, from equation (5.5), by the expected rate multiplied by the risk premium.

In equation (5.6), the positive relationship between money demand and real income represents the transactions demand for money. Money demand is negatively related to the domestic rate of interest as a decrease in the rate of interest decreases the opportunity cost of holding money, and money becomes attractive relative to bonds. This substitution effect of money for bonds in response to a decrease in the rate of interest is otherwise known as the speculative demand for money. An increase in the foreign rate of interest relative to the domestic rate of interest increases the demand for domestic money as the opportunity cost of holding domestic money is less than that of holding foreign money. Finally, the demand for money is negatively related to the expected change in the exchange rate. An expected decrease in the exchange rate value, an appreciation, increases the demand for domestic money as its value is expected to increase relative to foreign money in the next period.

In equation (5.7), the demand for bonds is positively related to the domestic interest rate and negatively related to the foreign interest rate. If the domestic rate of return is more attractive than the foreign rate of return, the more attractive are domestic bonds and if the foreign rate of return is more attractive than the domestic rate of return, the less attractive are domestic bonds. The demand for bonds does not depend solely on the relative rate of return, it also depends on real income and real wealth.

The left-hand side of equation (5.8) refers to the domestic currency value of the real demand for foreign assets by domestic residents. That is, foreign assets are denominated in foreign currency and are converted into domestic currency by the application of the rate of exchange. The real demand for foreign assets is positively

related to both real income and real wealth as is the case in (5.6) and (5.7). The demand for foreign assets is negatively related to the domestic rate of return and positively related to the foreign rate of return.

Foreign income and wealth variables are not included in the bond demand equations, as in each case the emphasis is on the domestic demand for money and financial assets. The reason for the domestic orientation of the model is related to the small country assumption (assumption iv) made earlier in this chapter. Furthermore, there is a discussion of this issue in section 2.2. This particular theoretical specification focuses on one small country facing a world market. Translation of the theoretical model into an empirically testable view is based around a bilateral exchange rate. For that reason, the empirical specification which focuses on an explanation of the movements of a bilateral exchange rate, may necessitate the incorporation of other bilateral data.

Equation (5.9) is a wealth constraint:

$$a_t = (m_t^d - p_t) + (b_t^d - p_t) + (s + fa_t^d - p_t) \qquad (5.9)$$

which indicates that total net private sector wealth in a given economy comprises money, and domestic and foreign bonds.

The market clearing conditions for domestic money, domestic assets and foreign assets are described in equation (5.10):

$$m_t^d = m_t$$
$$b_t^d = b_t$$
$$s_t + fa_t^d = s_t + fa_t$$

(5.10)

Here, the money supply is not considered to be exogenous. The money supply is determined by the central bank in the context of appropriate monetary conditions as is described by equation (5.11) below. The supply of domestic assets is determined by the fiscal stance of the government. An expansionary fiscal policy expands the supply of domestic bonds and a contractionary fiscal policy decreases the supply of domestic bonds. Thus the supply of domestic assets is positively related to the public sector deficit, as described in equation (5.13) below. During an expansionary fiscal policy, when there is a public sector deficit, the supply of domestic bonds increases. This relationship between the deficit and the supply of domestic bonds assumes that deficits are bond financed, although not necessarily entirely bond financed. The supply of foreign assets to domestic private residents cannot be considered exogenous as it is determined by the current account less the rate of accumulation of foreign assets by the central bank for intervention purposes. For that reason, the rate of accumulation of total foreign assets is described in equation (5.18) below.

Central bank intervention activity occurs across two markets. In the first market, the money supply is assumed to be determined by the central bank by a process similar to that used by Black and Salemi (1987):

$$m_t = \bar{m} + \alpha_{19} r_t + \alpha_{20} i_t$$ (5.11)

where it follows a targeted money supply path, $\bar{m}$, modified by two components. The first of these is a positive interest elastic supply response where it is assumed that the higher the rate of interest, the greater the money supply. The second of these is related to the external orientation of the money supply, where i_t refers to the purchases by the central bank of foreign exchange for intervention purposes. In summary, equation (5.11) describes the central bank's management of domestic credit in response to its anti-inflationary, countercyclical and sterilisation goals. It is appropriate to review Australia's recent approaches to monetary management.

Over the last twenty years, the conduct of monetary policy in Australia has varied greatly. During the period 1975 to 1985, the growth rate of the M3 monetary aggregate was targeted. Jonson and Rankin (1986) note that the high inflation of the 1970's gave impetus to the introduction of a target for M3. The period of innovation and deregulation subsequent to the Australian Financial System Inquiry in 1981 and the Martin Review Group in 1983[7] altered the relationship between the money stock and money income underlying a stable money demand function (Jonson and Rankin, 1986). Other recent studies (Stevens, Thorp and Anderson 1987, and Blundell-Wignall and Thorp 1987) provide evidence that previously robust money demand relationships tended to break down in the 1980's. This period therefore also saw the demise of monetary targeting and a return to explicit recognition of the role of discretion in policy making. The adoption of a checklist approach[8] to the operation

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[7]Refer to footnote 2 in Chapter three for further detail of the Australian Financial System Inquiry and the Martin Review of the findings of the Inquiry.

[8]The checklist approach was described by the Governor of the Reserve Bank in 1987 as using all major economic and financial factors - present and prospective. These include the state of the economy, the balance of payments, prices, other policies and the monetary factors namely interest

of Australian monetary policy after the abandonment of monetary targets in January 1985 was recognition that the utilisation of additional information was both desirable and necessary. The switch from a monetary rule to discretionary monetary policy forced monetary policy to work via the price of assets in preference to the quantity of them. Milbourne (1990) argues that the switch implies that the interest rate must play a more important role in the conduct of monetary policy.

These important revisions of the approach to monetary policy make the specification of a money supply determination process problematic. Stemp (1991), for example, develops an optimal money supply rule that is based on the checklist approach to monetary policy. He examines the checklist approach in a formal framework by interpreting the checklist as an optimal money supply rule that keeps the economy as close as possible to a pre-planned path. Thus the money supply rule developed by Stemp is a function of deviations from a given exchange rate value, deviations in nominal domestic interest rate from a pre-planned path and the lagged deviation of the price of domestic output.

Jonson and Rankin (1986) suggest that an approach based on the monitoring of a number of indicators, including monetary aggregates, does not represent a radical departure from that of the monetary targeting. They further claim that central banks pay close attention to a wide range of economic indicators and have deviated from the target when the non-monetary indicators have given a reading contrary to the monetary indicators. Indeed, the Australian experience of monetary targeting supports

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rates, the exchange rate and monetary aggregates.

this claim for over the 10 year period subject to targeting, the target was met on only three occasions. Jonson and Rankin thus conclude that the different approaches to monetary policy represented by rules and discretion are more apparent than real. The main change, they suggest is increased uncertainty about economic inter-relationships.

Equation (5.11) presents a view of money supply determination which attempts to combine the two policy regimes of rules and discretion. In doing so, the equation incorporates both the price and the quantity of financial assets, in addition to a variable, i_t which responds to exchange rate changes.

The second path of central bank intervention in the economy is through the foreign exchange market. This approach to intervention is described in equation (5.12) below. The relationship between foreign exchange market intervention and the money supply hinges on the central bank's preference for sterilisation or non-sterilisation of the monetary effects of such intervention. An increase in the central bank's purchases of foreign exchange for intervention purposes, i_t would reduce the asset and therefore the monetary base of the economy as domestic money is issued in place of the purchased foreign exchange. The central bank can then choose to sterilise the intervention in which case they would conduct open market sales of government securities. This would reduce the money supply, thereby counteracting the monetary implications of foreign exchange purchases. Alternatively, unsterilised intervention implies that no monetary reversal action occurs and the money supply does increase with the increase in purchases of foreign exchange. Of the two courses of action, unsterilised intervention is considered to be the more effective means of achieving

exchange rate adjustment (Henderson, 1983 and Dornbusch and Fischer, 1984a[9]) as the consequent decrease in the rate of interest and of the capital outflow complements the market place actions of the central bank. On the contrary, unsterilised intervention is more likely through increased monetary effects to undermine the anti-inflationary policy of the central bank. In equation (5.11), the sign on the last coefficient assumes that intervention activity is unsterilised rather than sterilised. If on the other hand, intervention is sterilised, then there is no change in the monetary base. Consequently, the value of the coefficient on the term i_t in equation (5.11) should be zero.

The central bank's purchases of foreign exchange for intervention purposes are represented by the following:

$$i_t = -\alpha_{21}\Delta s_t - \alpha_{22}(s_t - \bar{s}) \qquad (5.12)$$

Equation (5.12) is similar to that used by both Black and Salemi (1987) and Kearney and MacDonald (1988b) and supported by an extensive discussion of intervention behaviour in Section 4.4 of Chapter four. This discussion is recalled briefly: the first type of intervention activity is called leaning against the wind and involves reducing and countering erratic fluctuations from an equilibrium rate and thus smoothing the path of the exchange rate through time. Intervention in the form of leaning against the wind depreciates the domestic currency to offset the appreciation explained by the

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[9]Dornbusch and Fischer (1984a) refer to the 1978-79 period in the United States when the United States dollar was depreciating in currency markets even though there was intervention on a massive scale. This intervention was carefully sterilised. They also refer to a study conducted in 1982-83 by the main industrialised countries on the effectiveness of sterilised versus unsterilised intervention. The results contained in the Report of the Working party on Foreign Exchange Intervention, U.S. Treasury, Washington D.C., 1983 confirms the view expressed by Dornbusch and Fischer that unsterilised intervention is more effective than sterilised intervention.

presence of an excess demand for the currency. Thus, in equation (5.12), the negative sign on the change in the exchange rate term indicates that the domestic currency is appreciating relative to the foreign currency, and that the central bank must purchase foreign exchange or conversely sell domestic currency to depreciate the domestic currency. Thus i increases. The second method of intervening is concerned with moving the present exchange rate towards a new targeted level. For example, when the spot exchange rate is below the target exchange rate, the spot rate must depreciate to reach the target. An increase in the central bank's purchases of foreign exchange that is i, will bring about a depreciation as the demand for domestic currency decreases. On the contrary, when the spot exchange rate is greater than the target, the spot rate needs to appreciate to approach the target. In this case, the sign on the second coefficient in equation (5.12) is positive. The central bank however, needs to sell not buy foreign exchange for intervention purposes and consequently i must decrease.

Real income is determined as follows:

$$y_t = \alpha_{23} y_{t-1} + \alpha_{24} a_{t-1} + (\alpha_{25} g - \alpha_{26} tx)_t - \alpha_{27} r_t + \alpha_{28}(s + p^* - p)_t + \alpha_{29} y_t^* + \mu_{4_t}$$

$$(5.13)$$

where the main determinants of real income in the economy are public and private sector demand-orientated decision-making. In addition, the real income equation includes a Lucas-type response to lagged supply: real income in the current period is positively related to income last period. The lagged income variable represents a distributed lag to accommodate cyclical behaviour.

On the whole, the real income equation is based around a standard Keynesian specification of goods market equilibrium. First, income is related to the fiscal stance of the government where *(g-tx)* represents the public deficit or surplus. A public surplus decreases the level of demand in the economy and thus decreases real income and a public deficit increases demand and real income. Government spending and taxation activities have different multipliers and therefore different coefficient values. The deficit or surplus will in part be financed by borrowing from the public through bond sales and therefore, the bond supply is equal to some proportion of the public deficit or surplus[10]:

$$b_t - p_t = \theta_t (g - tx)_t \qquad\qquad (5.14)$$

where θ_t represents the unobserved variable proportion financed in this way. Thus the above equation indicates that if there is an increase in the budget deficit, the supply of bonds to the non-bank public increases. If there is on the other hand an increase in the budget surplus then the supply of bonds to the public decreases. This deficit sponsored increase in the supply of bonds to the public, changes the rate of return on bonds and through the subsequent portfolio adjustment influences the exchange rate.

The financing of the deficit or surplus has direct monetary implications for the net accumulated stock of bonds constitutes part of the monetary base. Equation (5.11), is therefore rewritten to take into account the budgetary financing implications:

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[10]Bonds is used here as a generic term to represent all government securities.

$$m_t = \bar{m} + \alpha_{19}r_t + \alpha_{20}i_t - \gamma[\theta_t(g-tx)] \qquad (5.11a)$$

where γ is the proportion of the bonds which are sold in the domestic economy and therefore affect the domestic money supply. An increase in the budget deficit which is financed by bonds sales through the Reserve Bank decreases the monetary base of the economy and therefore the money supply.

Second, income is negatively related to interest rates as *inter alia* investment demand by the business sector and some household consumer durable demand are negatively related to the interest rate. The terms of trade also influences real income: the better are the terms of trade - the quantity of imported goods that can be obtained per unit of goods exported - the higher will be domestic income. The final variable influencing domestic real income is foreign real income. The higher the level of foreign real income, the greater is the demand for domestic goods. These are well-established principles.

Wage movements are determined as follows:

$$\Delta w_t = \alpha_{30}\Delta p_t^e + \alpha_{31}\Delta(s+p^*)_t - \alpha_{32}u_t + \alpha_{33}o_t + \mu_{5_t}$$

$$(5.15)$$

where w represents nominal average earnings in the economy, u is rate of unemployment, and o is the level of overtime in the labour market. The expectations of domestic price changes are adaptive not rational: thus they depend on the past series of price changes. This assumption is consistent with the Friedman-Phelps

accelerationist hypothesis that the Phillips curve is negatively sloped in the short run, implying a trade-off between unemployment and inflation. As the data observations used in Chapter six for empirical analysis - that is quarterly data - focus on the short run relationships between variables, equation (5.15) does not describe the long run relationship between price and wage changes and unemployment.

Import prices affect wage movements in two ways: first, an increase in overseas inflation causes expenditure switching to domestically produced goods and generates demand pull inflation as a consequence. Second, the more likely route for overseas inflation to enter the domestic economy is through an increase in production costs flowing onto wage increases with resulting cost push inflation. Boehm and Martin (1989) found over the period 1954 to 1985 that the link from import prices to wages was of variable strength and continuity. Evidence of causality relationships between import prices and wage movements (in addition to other variables) is presented in Appendix A.2. The Granger-causality test indicates that import price changes precede (or Granger-cause) wage movements in the period from the beginning of 1968 to the end of 1976. Since that time, on the basis of the causality testing, the domestic economy has been reasonably well insulated from import price changes by various institutional arrangements[11].

The labour market pressure variables of the level of unemployment and the level of overtime represent labour market conditions affecting two distinct groups of people -

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[11]Wage fixing guidelines were introduced by the newly elected Fraser government in the third quarter 1976, and the Prices and Incomes Accord was introduced by the newly elected Hawke Labor Government in April 1983.

the unemployed and the employed. Simes and Richardson (1987) suggest that the unemployment rate be used to represent the labour market conditions facing the unemployed and the level of overtime to represent the labour market conditions of those in secure employment. Unemployment is negatively related to wage movements and overtime levels are positively related to wage movements. Their evidence suggests that the effect of overtime levels on wages pressure is asymmetric. That is when overtime levels are high, the pressure on wages is correspondingly high, however, when overtime levels are low, the behaviour of those in secure employment does not change. This suggests an insider-outsider theory of the labour market[12]. Simes and Richardson (1987) find that during loose labour market conditions, it is the level of unemployment[13] that leads to the easing of pressure on wages rather than a moderation of wage claims by those in employment. Gregory (1986) also uses an overtime variable in a wage determination equation for Australia.

The Granger-causality testing reported in Appendix A.2 considers the relationship between price movements, wage movements and unemployment. From these results, there is no evidence that the unemployment level impacts on wage movements. In

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[12]Insider-outsider theories of the labour market are based on the observation that in general a firm finds it costly to exchange its current employees (the insiders) for workers outside the firm (outsiders). A turnover cost related to technological, administrative, skilling and legal costs confers on the insiders an economic rent, in that the firm is a willing to pay a premium to avoid a given level of turnover. The insiders are assumed to have enough bargaining power to capture some of this rent when they make their wage demands, and in this sense can afford to be somewhat indifferent to the economic climate. Lindbeck and Snower have contributed to this view through several seminar papers published by the Institute for International Economic Studies at the University of Stockholm and with a survey paper published in the Oxford Review of Economic Policy (1985).

[13]The unemployment variable in models of aggregate wage determination generally refers to the actual unemployment rate. In the empirical analysis which is presented in the next chapter, there is a consideration of whether it is perhaps more appropriate to consider the cyclical unemployment in the economy as the quantity variable that influences the wage rate; where cyclical unemployment is defined as unemployment in excess of the natural rate of unemployment.

one sample period only, from the beginning of 1968 to the end of 1976, is there any evidence that unemployment impacts temporally on price movements. On the other hand, the Granger-causality test indicates a temporal relationship between prices and unemployment and wages and unemployment. Granger-causality testing does not however, describe the full relationship between variables. Harvey (1990) notes that the full extent of the measured relationship between variables may only be determined by regression analysis.

Finally, a note is required on the absence in the theoretical equation specification of a variable to capture the institutional forces that are important in the wage determination process in Australia. There is considerable wage regulation in Australia. The role and importance of the Australian Conciliation and Arbitration Commission, now known as the Industrial Relations Commission, has varied with changes in government, and attitudes to the wage adjustment process[14]. Following Gregory (1986) and Dornbusch and Fischer (1984b), it is assumed here that the Commission is a shield for market forces and does not affect the rate of growth of nominal or real wages in the macroeconomy. Rather, the Commission influences the rate of growth of award wages only.

The price determination process is closely linked to the wage determination process in the following specification of price changes:

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[14]The actual changes in the role of the Commission over time will be discussed in more depth in the empirical chapter.

$$\Delta p_t = \alpha_{34}\Delta w_{t-1} + \alpha_{35}\Delta(s + p^*)_t - \alpha_{36}u_t + \mu_{6_t} \qquad (5.16)$$

In this theoretical specification, domestic price changes precede changes in wage levels. This sequencing follows from Boehm and Martin's evidence about causality. Moreover, that evidence is supported by the Granger causality test results presented in Appendix A.2, where in all three periods under scrutiny wage movements do Granger-cause price movements. Those same results detect no evidence of bidirectional causality between wages and prices. Domestic price movements are also related to foreign price levels through the demand-pull and cost-push pressures described above. Finally, price movements and wage movements are influenced by the level of unemployment. This follows from the adoption of a Phillips representation of the trade-off between inflation and unemployment.

The combination of equations (5.15) and (5.16) yields the following:

$$\Delta p_t = \alpha_{37}\Delta p_{t-1}^e + \alpha_{38}\Delta(s + p^*)_t + \alpha_{39}\Delta(s + p^*)_{t-1}$$
$$- \alpha_{40}u_t - \alpha_{41}u_{t-1} + \alpha_{42}0_{t-1} + \mu_{7_t}$$

$$(5.17)$$

where $\mu_{7t} = \mu_{5t} + \mu_{6t}$. Note the lag structure in (5.17): domestic price changes are shown as depending on lagged price expectations where these are adaptive rather than rational in relation to both current period and lagged foreign price changes, both current period and lagged unemployment variables and lagged overtime levels.

The current account balance written in the following way:

$$c_t = \alpha_{43}(s+p^*-p)_t - \alpha_{44}(y-y^*)_t + \alpha_{45}(r+ff^n)_t + \mu_{8_t}$$

$$(5.18)$$

is related to three factors: the terms of trade, the relative pressure of demand both at home and abroad and the incomes flows of the current account. The second term in equation (5.18) is a restatement of the conventional Keynesian proposition that if foreign income and thus foreign demand is relatively more robust than domestic income then the consequent demand for imports by foreign residents improves the domestic current account. The last term relates the current account to the level of foreign debt held in the domestic economy. The total of the net foreign debt multiplied by the domestic rate of interest is a income debit in the current account. Net foreign debt is equal to the domestic currency value of nominal domestic assets held by foreign investors less foreign assets held by domestic investors. Domestic assets held by foreign residents are accumulated through the same process as the foreign assets held by domestic residents[15].

The accumulation of private foreign assets is as follows:

$$\Delta(s + fa)_t = c_t - i_t \qquad (5.19)$$

It depends on the current account balance as described in equation (5.18) less the

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[15]The demand for domestic assets by foreign investor in real terms is given by:

$$ff_t - p_t = \omega_1(r_t^* - r_t + \lambda\frac{1}{s_{t+1}^e} - \frac{1}{s_t}) + \omega_2 y_t^* + \omega_3 a_{t-1}^* + \xi_t$$

The demand in nominal terms is related to the nominal value of both assets and income.

central bank's purchases of foreign exchange for intervention purposes, i_r described in equation (5.12).

5.2 Use of the structural model

The model in section 5.1 comprises nine equations and five identities. The bond supply equation (5.14) is an identity rather than a behavioural relationship. For completeness, the structural relationships which make up the model are presented in Table 5.2.

Table 5.2: Structural equation model

$$(m^d - p)_t = \alpha_1 r_t^* - \alpha_2 r_t - \alpha_3 \lambda_t s_{t+1}^e + \alpha_4 s_t + \alpha_5 y_t + \alpha_6 a_{t-1} + \mu_{1_t}$$

$$(5.6)$$

$$(b^d - p)_t = \alpha_7 r_t - \alpha_8 r_t^* - \alpha_9 \lambda_t s_{t+1}^e + \alpha_{10} s_t + \alpha_{11} y_t + \alpha_{12} a_{t-1} + \mu_{2_t}$$

$$(5.7)$$

$$(s + fa^d)_t - p_t = \alpha_{13} r_t^* - \alpha_{14} r_t + \alpha_{15} \lambda_t s_{t+1}^e - \alpha_{16} s_t + \alpha_{17} y_t + \alpha_{18} a_{t-1} + \mu_{3_t}$$

$$(5.8)$$

$$i_t = -\alpha_{21} \Delta s_t - \alpha_{22}(s_t - \bar{s}) \qquad (5.12)$$

$$y_t = \alpha_{23} y_{t-1} + \alpha_{24} a_{t-1} + (\alpha_{25} g - \alpha_{26} tx)_t - \alpha_{27} r_t + \alpha_{28}(s + p^* - p)_t + \alpha_{29} y_t^* + \mu_{4_t}$$

$$(5.13)$$

$$m_t^s = \bar{m} + \alpha_{19} r_t + \alpha_{20} i_t - \gamma[\theta_t(g - tx)] \qquad (5.11a)$$

$$\Delta w_t = \alpha_{30} \Delta p_t^e + \alpha_{31} \Delta(s + p^*)_t - \alpha_{32} u_t + \alpha_{33} o_t + \mu_{5_t}$$

$$(5.15)$$

$$\Delta p_t = \alpha_{34} \Delta w_{t-1} + \alpha_{35} \Delta(s + p^*)_t - \alpha_{36} u_t + \mu_{6_t} \qquad (5.16)$$

$$c_t = \alpha_{43}(s + p^* - p)_t - \alpha_{44}(y - y^*)_t + \alpha_{45}(r + ff^n)_t + \mu_{8_t}$$

$$(5.18)$$

There are ten exogenously determined variables: the unemployment rate, the real financial liabilities of the domestic private sector, the public sector deficit or surplus, the target exchange rate, the target money supply growth variable, the foreign variables of real income, the price level, the interest rate and the foreign demand for domestic assets, and the level of overtime in the domestic economy. Using the terminology of Blanchard and Kahn (1980), the remaining variables are described as either predetermined or non-predetermined[16]. The domestic rate of interest, real wealth and domestic bond supplies are all predetermined variables. All remaining variables, including the exchange rate are non-predetermined.

Interaction between the sectors of the economy is based on a number of important linkages. Wages and prices are determined by the following in equations (5.15) and (5.16): external price levels, domestic employment conditions and adaptively formed expectations of price and wage changes. The evidence of causality between prices and wages allows us to formulate one equation, (5.17) representing the price-wage determination process. The terms of trade in equation (5.18) which is the ratio of the domestic currency value of foreign price levels and the domestic price level forms with the domestic interest rate, the public sector fiscal stance and foreign income, the theoretical specification of income determination. Income in equation (5.13) is also influenced by wealth; while relative income levels along with the terms of trade

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[16] A predetermined variable, X_{t+1} is a function only of variables known at time t, where these variables are given in a certain information set, Ω_t. For example, $X_{t+1} = {}_t X_{t+1}$ whatever the realisation of the variables in Ω_{t+1}. A non-predetermined variable P_t can be a function of any variable in Ω_t, where that information set includes at least past and current values of predetermined and other non-predetermined variable, as well as past, present and future values of exogenous variables. Thus, the distinction between predetermined and non-predetermined variables centres on whether the variables in the information set, Ω_t are known at time t or not.

determine the current account balance. A current account deficit leads to decumulation of foreign assets and a surplus leads to accumulation. In either case, the total change in holdings of foreign assets domestically is tempered by the central bank's intervention behaviour in the foreign exchange market. Official purchases or sales of foreign exchange are related to two types of intervention behaviour in equation (5.12): leaning against the wind and exchange rate targeting. The accumulation of foreign assets in equation (5.19) affects total domestic real wealth and given that foreign exchange held by the central bank affects the monetary base, it also affects the money supply (5.11). The monetary policy preferences of the government affects money supply also. The interaction between demand for and supply of money determine the interest rate. The domestic interest rate in turn influences domestic income and the current account balance. Furthermore, given that the monetary policy may be directed towards inflation, alterations in the interest rate may impact on both domestic prices and wages. Drawing the foreign exchange market and the money market together, *inter alia*, is central bank intervention in both markets described in equations (5.11) and (5.12) and the impact of such intervention on prices in other markets.

Foreign asset supplies alter in response to changes in the current account balance and the central bank's purchase or sale of foreign exchange. Domestic asset supply varies with the fiscal stance of the government while domestic investors preferences for a balanced portfolio of foreign and domestic assets in turn influences the exchange rate.

The theoretical model described in this chapter is translated into an empirically

testable econometric model in Chapter 6. There are a number of basic steps in this process and these are outlined in some detail in the introduction to that chapter.

Chapter 6: EMPIRICAL ANALYSIS OF A SMALL STRUCTURAL EQUATION OPEN ECONOMY MODEL

The task of this chapter is to translate the theoretical model developed in the previous chapter into an econometric model that can be used for empirical purposes. This empirical analysis is centred on the structural model summarised in section 5.2 of Chapter 5. In particular, tests of the model will emphasise the usefulness[1] of the model as an approximation of the relationship among macroeconomic variables in the economy. The chapter concentrates on the testing and analysis of the model following the methodology of Fair (1984).

The first section describes the data set and the choice of variables used to represent the variables of the theoretical model. The second section of the chapter discusses estimation while in a third the results of estimation are presented. The chapter is finalised with a discussion of the model's usefulness.

6.1 Choice of variables both observed and unobserved

One of the potential difficulties with macroeconometric modelling of an entire system[2] concerns the number of degrees of freedom allowed by the model. For example, Sargan (1975) shows that estimation of a linear model by three stage least squares (3SLS) is inconclusive if the number of observations is less than the number

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[1] The terminology used here is attributable to Fair (1984). He suggests that as there is often a loose transition from the theory to the econometric formulation of a macroeconomic model that those models cannot be judged - as perhaps they are more readily so in a discipline such as physics - as either true or false. Thus he suggests that theories should be termed either useful of not useful.

[2] Techniques and explanations of estimation of models as a full system are described in considerable detail later in the chapter. For present purposes, it is sufficient to contribute that the advantage of full system estimation is the treatment of all endogenous or non-predetermined variables as simultaneous.

of endogenous and exogenous variables. For this reason, the sample size chosen is at a maximum subject to data availability. The sample period is third quarter (September) 1966 to third quarter (September) 1990: thus there are 97 observations taken at the end of each quarter. Data for exchange rates, wages, current account balance, unemployment, domestic and foreign income, domestic and current prices, domestic and foreign rates of interest, money stock, and total assets are from the NIF-10s model data set. All other observed data - observations of the capital account, total reserves, liabilities, the public sector borrowing requirement and total domestic debt holdings - are from the variety of sources indicated in Appendix A.1.

Unobserved variables required considerably more effort. The following unobserved variables: the target exchange rate $\bar{s}_t$, the targeted money supply path $\bar{m}_t$, and the expected spot exchange rate in time $t + 1$ are discussed in sequence below.

6.1.1 The target exchange rate

Equation (5.12) describes the relationship between the central bank's purchases of foreign exchange for intervention purposes and two types of intervention behaviour. Specifically, equation (5.12) describes intervention behaviour as leaning against the wind and exchange rate targeting:

$$i_t = -\alpha_{21}\Delta s_t - \alpha_{22}(s_t - \bar{s}) \qquad (5.12)$$

where i_t represents the central bank's purchases of foreign exchange for intervention purposes and $\bar{s}$ represents the target exchange rate in nominal terms.

A target exchange rate[3] is a fundamental equilibrium exchange rate which is expected to generate a current account surplus or deficit equal to the underlying capital flow over the trade cycle, given that the country is pursuing internal balance (Williamson, 1985) and which reflects a judgement about the medium-term norm for competitiveness (Edison *et al.*, 1987). Thus a target exchange rate is the rate justified by the fundamentals of the current account balance and longer run capital flows as distinct from short run speculative flows of capital. There are a number of suggestions in the literature as to the most appropriate means of estimating the target exchange rate. For example, Williamson (1985) employs the traditional approach to estimating fundamental equilibrium exchange rates by identifying a period in which the exchange rate appears to have been at a level appropriate to external balance, and by then making a purchasing power parity adjustment to produce a base period real exchange rate which allows for the intervening rate of inflation. Frenkel and Goldstein (1986) suggest two additional methods of calculating the exchange rate target. The first is to employ an estimated structural model of exchange rate determination, either a monetary or portfolio balance model, for example, each of which relate the nominal exchange rate to the fundamentals of the current account and longer run capital flows. Given estimates for such a structural model of exchange rates, the equilibrium exchange rate is defined as the rate corresponding to the desired path of the explanatory fundamentals in the exchange rate equation. Alternatively, the target is estimated according to one of the definitions provided above. In particular, the equilibrium real exchange rate is defined as the rate that would make the underlying current account, the actual current account adjusted for temporary factors,

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[3]Target exchange rates are also discussed briefly in section 4.4 and section 7.2.

equal to longer term net capital flows during some longer term time period[4] given the following: anticipated macroeconomic policies in the countries under scrutiny, the delayed effect of past exchange rate changes and a number of other expected developments.

All these methods of estimation have obvious weaknesses[5]. A feature common to all methods of estimation is that they are according to Williamson (1985) uncomfortably adhoc. Moreover, he claims with respect to his own technique that it is better to be roughly right than to be precise but irrelevant. The technique chosen here is in the spirit of this latter remark by Williamson.

The unobserved variable that we are seeking to quantify is given by equation (5.12). Following Branson (1986) , the latter term in equation (5.12) can be defined as:

$$s^e_{t+1} - s_t = \theta(\bar{s}_t - s_t) \qquad (6.1)$$

where all variables are expressed in natural logarithms. Branson's formulation used the real exchange rate. It is assumed here that the relationship between the spot rate and the target rate is the same for both the real or nominal exchange rate. Branson (1986) describes equation (6.1) as a proportional adjustment mechanism, where the

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[4]This is generally considered to be two to three years.

[5]The purchasing power parity method assumes all disturbances between the base and current period are monetary in origin. Thus, this method is not suitable in the context of a portfolio balance model to exchange rate determination. A weakness of the second approach to the calculation of the target is that models of exchange rate determination have indicated very poor explanatory ability, including the model used in Chapter three and forecasting ability in extensive analysis over a number of different currencies and time periods. The major difficulty with the final approach to calculating a target is that it is operationally very complex.

change in the exchange rate over some time period greater than or equal to t moves

the actual exchange rate, s_t closer to its long-run or targeted value, $\bar{s}$.

Expressing equation (6.1) in terms of the target exchange rate yields:

$$\bar{s}_t = \frac{1}{\theta}(s_{t+1}^e - s_t) + s_t \qquad (6.1a)$$

Incorporating the right hand side of equation (6.1a) into equation (5.12) gives:

$$i_t = -\alpha_{21}\Delta s_t - \frac{\alpha_{22}}{\theta}(s_t - s_{t+1}^e) \qquad (5.12a)$$

In keeping with the Branson view described by the equation (6.1a) that the target

exchange rate is equal to the spot rate plus some proportion of the deviation between

the spot rate and the expected rate, the proxies used for the target rate are based on

the relationship between the spot rate and its expected value.

6.1.2 The money supply target

Equation (5.11a) specifies the money supply process as follows:

$$m_t = \bar{m} + \alpha_{19}r_t + \alpha_{20}i_t - \gamma[\theta_t(g - tx)] \qquad (5.11a)$$

where the money supply, m follows a targeted money supply growth rate determined

by the central bank, $\bar{m}$, subject to three qualifications. The first of these is a positive

interest elastic supply response where it is assumed that the lower is the rate of

interest, the lower is the money supply. The hypothesised relationship between the two variables of monetary policy reflects a countercyclical policy. The second component is related to the external orientation of the money supply, where i_t refers to the purchases by the central bank of foreign exchange for intervention purposes. The third represents the financing implication of a change in the government budget.

In conformity with McCallum (1980) and Papell (1984), the money supply target is proxied by a lagged endogenous variable in equation (5.11b):

$$m_t = m_{t-1} + \alpha_{19}r_t + \alpha_{20}i_t - \gamma[\theta_t(g-tx)] \qquad (5.11b)$$

and this formulation of the money supply equation is used in the empirical analysis below.

6.1.3 The expected exchange rate

A number of techniques have been applied to the problem of modelling the expected exchange rate subject to rational expectations. Two of the simpler approaches are considered here. The first is to use the forward rate as a proxy for the expected change in the spot rate. Both Obstfeld (1983) and Kearney and MacDonald (1988b) use this proxy. In order to do so, it is assumed that financial assets in the Eurocurrency market differing only in their currency of denomination are perfect substitutes. This enables the premium on forward dollars in an offshore market to be used as a proxy for the expected depreciation of the Australian dollar. In keeping with the spirit of the portfolio balance approach, onshore financial assets are imperfect substitutes.

The second approach is to use the realised value of the spot rate in time period *t+1* as a representation of the expectation now of the spot rate in period *t+1*. Danker *et al.* (1987) use the realised value of the spot rate. Moreover, this is the technique used in the empirical modelling of the risk premium equation in Chapter eight. Such analysis requires a transformation to remove both the autoregressive error in the residual, and the moving average error component which results from using the actual value of the spot rate as a proxy for the expected future spot rate.

Econometrically, there are a number of solutions to linear rational expectations models. One most commonly used in the recent literature - for example in Papell (1984, 1988), Salemi (1986) and Black and Salemi (1988) - is the method of undetermined coefficients. This method is used in time series analysis to convert stochastic difference equations into deterministic difference equations where the variables are represented in general infinite moving average form. These difference equations have exactly the same form as a deterministic version of the original model. Thus, the general form determined from the difference equations can then be substituted into the structural equations and the resulting identities can be solved for the coefficients. Muth (1961) used this technique and it has subsequently been developed by Taylor (1986). The drawback of using econometric approaches to solving rational equations models is that a number of assumptions are required in order to restrict the model to two first-order difference equations. Papell (1984) comments that a complementary modelling strategy is to first specify a model that is too complicated to be solved analytically, gain insight into the workings of the model through simulation, and then estimate it. He adds that this technique is superior

econometrically although the method of undetermined coefficients results in clearer theoretical propositions.

Following Obstfeld(1983) and Kearney and MacDonald (1988b), the forward premium or discount is used as a measure of the expected change in the exchange rate. This technique is used in preference to the econometrically complex route of using the realised value of the spot rate in period $t+1$ as a proxy for the expected spot rate in period $t+1$. The latter technique involves in this case the application of an autoregressive moving average model to the residuals of the estimation of a full system model.

6.2 Model estimation using OLS and 2SLS

Preliminary investigation of the structural model developed in Chapter five is undertaken using ordinary least squares (OLS) estimation except the price and wage determination equations which are estimated by two-stage least squares (2SLS). This latter econometric specification corresponds to the argument which posits that prices and wages are jointly determined. Results from the OLS and 2SLS equations are presented in Tables 6.1 and 6.2. respectively.

Table 6.1: OLS estimation, 1966:03 to 1990:03

	money (m^r_t)	domestic bonds (b^r_t)	foreign bonds (fa$_t$)	intervention (i$_t$)	income (y^r_t)	current account (c$_t$)
constant	4.138 (4.462)	0.073 (0.095)	-42.1 (0.997)	-0.037 (2.446)	3.162 (3.288)	1.627 (1.996)
m$^r_{t-1}$	0.01 (0.780)	-	-	-	-	-
Δm^r_t	0.468 (1.352)	-	-	-	-	-
r$_t$	-	-0.008 (0.605)	-3.022 (4.117)	-	-0.025 (2.364)	-
r$^*_t$	-0.046 (2.562)	0.0260 (1.45)	2.829 (2.7)	-	-	-
i$_t$	0.143 (5.64)	-	-	-	-	-
λ_ts$^e_{t+1}$	0.0147 (0.039)	0.601 (1.808)	16.02 (0.825)	-	-	-
s$_t$	0.113 (0.286)	-0.429 (1.212)	-9.203 (0.447)	-		-
Δs$_t$	-	-	-	-2.052 (6.003)	-	-
(s$_t$ - s$^e_{t+1}$)	-	-	-	0.287 (0.391)	-	-
y^r_t	0.189 (1.743)	0.104 (1.335)	5.01 (1.105)	-	-	3.386 (2.336)
y$^r_{t-1}$	-	-	-	-	0.087 (0.786)	-
a$^r_{t-1}$	0.002 (0.025)	0.175 (3.163)	3.029 (1.016)		-0.032 (0.343)	-
debt^r_t	-0.048 (1.789)	-	-	-	-	-
b$^r_{t-1}$	-	0.696 (9.33)	-	-	-	-
g$_t$	-	-	-	-	0.142 (1.046)	-
tx$_t$	-	-	-	-	-0.047 (0.858)	-
(s+p*-p)$_t$	-	-	-	-	0.0737 (0.919)	-
y$^{r*}_t$	-	-	-	-	1.100 (4.898)	-6.204 (1.727)
c$_{t-1}$	-	-	-	-	-	0.701 (11.9)
x$_t$	-	-	-	-	-	-1.666 (0.297)

m_t	-	-	-	-	-	-1.811 (2.519)
$ydebit_t$	-	-	-	-	-	-0.098 (3.825)
$\bar{R}^2$	0.886	0.724	0.5411	0.2873	0.917	0.942
h	2.196	0.646	-	-	0.254*	-0.360
DW	-	-	2.029	1.9025	-	-

Notes: T-statistics are in parentheses. The asterisk denotes the use of the Breusch-Godfrey statistic where $\rho=1$.

Table 6.2: **OLS and 2SLS estimation of price and wage equations, 1966:03 to 1990:03**

	wages Δw_t	prices Δp_t	inflation Δp_t
constant	0.001 (0.042)	0.001 (0.445)	-0.004 (0.669)
Δp^e_t	-	0.674 (3.910)	0.776 (1.966)
Δp^e_{t-1}	0.907 (1.059)	-	-
Δp^e_{t-2}	0.709 (1.945)	-	-
Δp^*_t	-	-0.058 (1.793)	0.067 (1.879)
$\Delta(s+p^*)_t$	-	-	0.018 (0.444)
$\Delta(s+p^*)_{t-2}$	0.082 (0.987)	-	-
$\Delta(s+p^*)_{t-3}$	0.112 (1.872)	-	-
Δu_t	-0.029 (0.528)	-	0.003 (0.245)
Δu_{t-1}	-0.019 (1.651)	-0.013 (1.052)	-0.014 (1.074)
Δw_t	-	0.161 (1.487)	-
m^r_t	-	-	0.001 (0.553)
m^r_{t-1}	0.002 (1.618)	-	-
o_t	-	-	0.011 (1.217)
dacc	-0.012 (2.180)	-	-0.003 (1.218)
hys	-0.004 (1.459)	-	-
dsr	-	0.001 (0.996)	-
d1	0.004 (1.251)	-	-
d3	-	0.006 (2.768)	0.006 (3.309)
d4	-	-0.004 (1.931)	-0.003 (0.003)
$\bar{R}^2$	0.464	0.508	0.498
DW	2.1076	2.302	2.396

Table 6.3: Variables used in Tables 6.1 and 6.2

m^r_t	=	real money proxied by M3 deflated by GDP implicit price deflator
r_t	=	domestic rate of interest
r^*_t	=	foreign rate of interest
y^r_t	=	real income proxied by nominal GDP deflated by GDP implicit price deflator
y^{r*}_t	=	real foreign income proxied by US nominal GNP deflated by GNP implicit price deflator
i_t	=	central bank's purchases of foreign exchange for intervention purposes expressed in domestic currency
s_t	=	spot exchange rate expressed as Australian dollars per United States dollars
b^r_t	=	real demand for domestic assets
a^r_t	=	real wealth
fa_t	=	real demand for foreign assets
λs^e_{t+1}	=	expected exchange rate in period t+1 proxied by the forward exchange rate, where λ represents the risk premium
g_t	=	government expenditure in real terms
tx_t	=	taxation in real terms
$(s+p^*-p)_t=$		terms of trade where s is the exchange rate, p^* foreign price level and p the domestic price level
$debt_t$	=	a proxy representing the proportion of the government deficit which is debt financed
c_t	=	current account
x_t	=	value of exports in domestic currency
m_t	=	value of service imports in Australian dollars
$ydebit_t$	=	a proxy representing the net income flows in the current account
d_1, d_3, d_4	=	seasonal dummies
w_t	=	nominal wages
p_t	=	domestic price level
$(s+p^*)_t$	=	import prices in domestic currency
u_t	=	unemployment
o_t	=	overtime
dacc	=	dummy for the Prices and Incomes Accord
hys	=	current unemployment rate less the average of the unemployment rate over the last eight quarters
dsr	=	a dummy variable representing significant exchange rate adjustment

Data sources are indicated in Appendix A.1.

6.2.1 Money equation (5.6) and (5.11b)

The money equation combines both the demand and supply characteristics in one equation and therefore imposes the equilibrium condition that money demand is equal to money supply. Expressing equation (5.11b) in terms of the domestic interest rate and combining the equations yields:

$$(m-p)_t = \alpha_1 r_t^* - [\frac{1}{\alpha_{19}}(\Delta m - \alpha_{20}i + \gamma(b-p))]_t - \alpha_3\lambda s_{t-1}^e + \alpha_4 s_t + \alpha_5 y_t + \alpha_6 a_{t-1} + \mu_{1_t}$$

(5.6a)

where the term representing the debt financing of the government deficit is replaced by $\gamma(b-p)_t$ from the identity (5.14). The proportion of the deficit which is debt financed and held domestically is proxied by the net domestic sale of all Commonwealth Government Securities.

Money is proxied by M3[6]. The foreign interest rate coefficient is significant and of the incorrect sign. Real domestic income, the variable representing the monetary implications of debt financing (debt$_t$) and the monetary impact of foreign exchange market intervention variables are all of the correct sign and significant (at, at least the 10 percent level of confidence). Neither of the exchange rate terms is significant.

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[6]Unlike the previous analysis in Chapter three, a wider definition of money, namely M3 is considered more appropriate in the present investigation. There is an entirely pragmatic reason for the choice of M3 rather than M1: reporting of M1 figures by the Reserve Bank of Australia ceased in 1985 as a result of the deregulation of the Australian financial system. Such changes combined with the amendment to the Banking Act in late 1989 effectively removed the distinctions between Trading Banks and Savings Banks. This not only renders the M1 definition redundant, but also means that the time series of M1 reflects such institutional changes as well as expected monetary changes in the aggregate.

The money equation has very good explanatory power. The test for autocorrelation in the residuals, Durbin's h test is rejected at the 5 percent level of significance but accepted at the one percent level.

6.2.2 Domestic bonds equation (5.7)

The domestic bonds equation is not presented as a semi-reduced form as the bond supply equation (5.14) is an identity rather than a behavioural relationship. In the results presented for equation (5.7) in Table 6.1, real income, real assets and the lagged dependent variable are all significant at the one percent level of significance and of the correct sign. The expected spot rate is significant and of the incorrect sign. The relationships between both the wealth and income assets and the demand for domestic assets are consistent with a portfolio effect.

6.2.3 Foreign bonds equation (5.8)

Although some are only weakly significant, all the explanatory variables of the demand for foreign assets are of the correct sign. Both interest rate terms are significant at the 5 percent level. The coefficient of determination is good and there is no evidence of first order autocorrelation in the residuals.

6.2.4 Intervention equation (5.12a)

The dependent variable in the intervention equation (5.12a) is the change in gold and foreign exchange held by the Australian Reserve Bank from the end of the preceding quarter converted into foreign currency at the average of that quarter's exchange rate. This variable conforms to that used in other analyses of intervention, for example

Quirk (1977), Hutchison (1984) and Hopkins (1988). For the entire sample, the best fit for the intervention equation is that intervention is related to changes in the exchange rate in the current period and the current period levels of the forward and spot rate. The negative sign and the significance of the change in the exchange rate variable supports leaning against the wind exchange rate intervention.

The coefficient on the targeting variable, proxied by the difference between the spot rate and the expected rate, is insignificant. Therefore, there is no evidence of targeting for the entire period. Given that for the most of the sample, the exchange rate was fixed rather than floating, this is an expected outcome. Appendix A.3 presents results of the intervention equation where the sample has been split into three separate subsamples that correspond to the changes in the management of the Australian currency.

It is important to acknowledge at this point the possible inconsistency of targeting and leaning against the wind intervention behaviour. That is, if the exchange rate is presently depreciating, then the appropriate leaning against the wind intervention behaviour is to decumulate foreign reserves by purchasing the domestic currency and the exchange rate appreciates as a result. If at the same time, the exchange rate is less than the target rate, the appropriate intervention strategy is to depreciate the domestic currency by accumulating foreign reserves. Thus these two intervention strategies may work against one another, even more so since leaning is aimed towards minimising short-term fluctuations in the currency value and targeting is aimed toward achieving a longer-term equilibrium goal.

6.2.5. Income equation (5.13)

A number of coefficients are correctly signed in the income equation results presented
in Table 6.1. Only the variables of the domestic interest rate and foreign income are
both correctly signed and significant.

6.2.6 Current account equation (5.18)

The current account equation (5.18) is tested linearly rather than in logs due to the
negative value of the dependent variable through most of the time period under
scrutiny. The empirical examination of this equation draws on the analysis of Meer
and Heijdra (1987) and the Economic Planning Agency (1981). The terms of trade
variable in the theoretical specification is replaced by export and import values. This
alternative specification is necessary given the somewhat indirect link between the
explanatory variables and the dependent variable in equation (5.18). It is important
to note however, that in essence it is equivalent to replacing the terms of trade
variable and the relative income variables with export and import values.

There are a number of significant and correctly signed coefficients in the estimation
of the current account equation (5.18) which is reported in Table 6.1. Domestic and
foreign income, the interest repayments of the foreign debt variable ($ydebit_t$) and
imported services are all significant and correctly signed.

6.2.7 Wage equation (5.15)

The results of time series analysis of the wage and price equations presented in Table

6.2, are modelled on data for the period 1966(3) to 1990(3). This period crosses a

number of changes in management of the wage determination process in Australia

which are discussed earlier. These changes are accommodated through the use of the

dummy variables described below. In addition, Appendix A.3 presents results for

three distinct time periods within the sample. The lag structure for explanatory

variables was determined initially by incorporating a long lag structure and then

dropping sequentially insignificant lags.

After considerable preliminary data investigation using an ordinary least squares

estimator, both the wage and price determination equations have been calculated

using a two-stage least squares estimator. The theoretical specification of the wage

and price equations (5.15 and 5.16) indicates that the price variable is an endogenous

variable in the wage determination equation, and the wage variable is an endogenous

variable in the price determination equation. When an equation contains endogenous

variables, one of the critical assumptions of the classical regression model is violated,

as these variables will in general be correlated with the disturbance term

(Harvey,1990). In this case, OLS is not consistent. For this reason a 2SLS estimator

is used for both the wage and price determination equations. All exogenous variables

from both the estimated wage and price determination equations are used as

instrumental variables.

The price expectations variables are adapted from Simes and Richardson (1987). A

simple distributed lag on price changes is used to proxy expected prices[7]. Thus price

expectations are formed adaptively. Moreover, given the institutional constraints on

wage movements in the Australian economy, adaptive rather than rational

expectations is an entirely reasonable assumption. The two price expectations

equations included are built around three factors: an important wage decision, namely

the June 1974 Metal Trades decision which was outside the wage indexation decision,

periods when indexation was the criteria of wage adjustment and the flow-through

of these institutional arrangements to the domestic economy. The first price

expectation variable accounts for the effect of lagged price changes on wages outside

the indexation period and outside of the Metal Trades decision. Thus:

$$\Delta p_1^e = \alpha(1 - \text{DINX})(1 - \text{DMT})\Delta p^e$$

where the price variables are in logs, *DINX* is a dummy variable representing time

periods where indexation applied to wage movements, and *DMT* is a dummy variable

representing both the quarter when the wages decision was made as well as the two

previous quarters when the domestic economy was subject to demand pressure. The

first price variable in equation (5.15) is insignificant at the 5% level of confidence

but of the correct sign. Although using a different data set from this study and also

importantly not incorporating the foreign variables included in this equation, Simes

and Richardson's analysis found considerable significance of this particular price

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[7]The price expectations variable is generated from the price data as follows:

$$\Delta p^e = 0.4\Delta p_t + 0.3\Delta p_{t-1} + 0.2\Delta p_{t-2} + 0.1\Delta p_{t-3}$$

where the price variables are in logs.

variable. The causality testing presented in Appendix A.2 however, indicates that there is no significant causality running from prices to wages and the result in Table 6.2 is in accordance with the causality tests.

The second price expectations variable accounts for the ripple effect of the Metal Trades decision through the economy in the immediate time period but outside the indexation period:

$$\Delta p_2^e = \beta(1-DINX)(DMT)[\gamma\Delta p^e+\delta DMTA(\Delta p^e+\Delta p^e_{-1}+\Delta p^e_{-2})]$$

where *DMTA* represents a dummy variable for the Metal Trades decision of the third quarter 1974. The reason for this formulation is the demand-pull pressure that was present in the Australian economy in the period leading up to the Metal Trades Decision. This price variable in equation (5.15) shows significance at the 10% level of confidence and is of the correct sign. Not surprisingly, the results in Appendix A.3 show that the greatest significance for this price variable occurs in the data period to which the Metal Trades decision directly corresponds, namely the smallest sample period. The result here indicates the significance of the demand pressure variable for this particular time period flowing from price changes to wage movements.

The import price variable lagged two periods is significant at the 10% level of confidence in equation (5.15). The change in the unemployment variable is of the correct sign for current and lagged values of the variable. Similarly, the current money supply variable expressed in levels is of the correct sign but only weakly

significant.

The hysteresis variable is calculated as the current unemployment rate less the average unemployment rate over the last eight quarters. This variable effectively introduces a time trend into the explanation to reflect the fact that over the entire sample period the relationship between the actual rate of unemployment and the full employment rate[8] has changed. The full employment rate of unemployment is generally considered to be around 4% in the 1960's; 6% in the 1970's; and 8% in the 1980's (Indecs Economics, 1990). This variable is weakly significant in equation (5.15) presented in Table 6.2. More current unemployment rates, such as the change in the unemployment rate term lagged one quarter have more impact on wage movements than the time trend of unemployment modelled by the hysteresis variable.

The *dacc* variable is a dummy for the Prices and Income Accord in place since 1983. Not surprisingly, it is significant here.

Overall, the specification of the wage equation (5.15) is good based on either the adjusted R^2 or the R^2 between observed and predicted values. Moreover, the explanatory power of (5.15) is comparable with wage equation specifications by other researchers, for example, Simes and Richardson (1987), and the NIF 88 model and the Murphy model presented in Chapman and Gruen (1990). The explanatory power

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[8] The concept of the full employment rate used here is equivalent to the Friedman-Phelps' concept of the natural rate of unemployment or the non-accelerating inflation rate of unemployment (or NAIRU). As the term implies, where the actual rate of unemployment is equal to the natural rate or the NAIRU, then inflation will be constant over time.

of equation (5.15) is better for the full sample presented here than for either of the two subsample results presented in Appendix A.3.

6.2.8 Price equation (5.16)

In the price determination equation, the price expectations variable, Δp^e is adapted from Simes and Richardson (1987) and is in formulation the same as that used in the wage determination equation. A simple distributed lag on price changes is used to proxy expected prices. Thus expectations formation is considered to be adaptive. The price expectations variable is significant. Indeed with the exception of one of the dummy variables d_3, the price expectations variable is the only coefficient significant at the 5% level of confidence in the estimation. This indicates that the main explanatory force behind price changes is past price changes.

Furthermore, the lack of significance, at least at the 10% level of confidence, of wage changes in the price determination process refutes the evidence of causality running from wages to prices both presented in Appendix A.2 and in Boehm and Martin (1989). The impact of wages expressed in levels on price movements were included in the econometric analysis. This variable was found to be insignificant.

Import prices are weakly significant. Interestingly, there was more significance in the current period's change in import prices than in lagged values. Import prices lagged two and three quarters were significant independent coefficients in the wage equation. Thus, there is overall evidence, albeit weak that import prices impact on price changes before they impact on wage changes. This confirms the anecdotal evidence

mentioned earlier that *ex ante* import price changes would effect changes in prices before changes in wages.

The change in the unemployment variable is of the correct sign, but insignificant at both the 5% and 10% level of confidence. Greater significance is found where the change in unemployment is lagged one quarter. This is also the case for the wage equation (5.15).

There are three dummy variables in the estimation of equation (5.16). Seasonal dummies are represented by d_3 and d_4; the first dummy is significant, the second seasonal dummy is weakly significant. The third dummy, *dsr*, represents periods of substantial change in the exchange rate, where a positive coefficient indicates a depreciation of the exchange rate. The inclusion of both this dummy and import prices allows for the possibility that some exchange rate movements are not reflected in changes in import prices and *vice versa*.

6.2.9 Inflation (5.17)

Table 6.2 also presents the estimation results for equation (5.17). This equation combines the wage and price determination process assuming the causality evidence that wage changes lead price changes. *Ceteris paribus*, the lagged determinants of the wage equation (5.15) can be incorporated into the price determination process as explanatory variables representing the lagged change in wages[9]. Thus equation (5.17)

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[9]If the inflation equation (5.17) is a good representation of combined wage and price determination, its use simplifies considerably the estimation of a full system method of estimation, as there is one less equation to model.

presents results for this combination even though lagged wage changes are only weakly significant in the estimation results of equation (5.16). The price determination equation is estimated using a two stage least squares estimator for the same reasons as before.

The explanatory power of the estimation equation for the wage and price determination process combined (5.17) is approximately the same as that for the price equation (5.16). The overtime variable which was omitted from previous analyses due to low significance and/or incorrect sign is of reasonable significance and the correct sign here. Most of the explanatory power is in the price expectation variable as was the case in the price equation (5.16).

The results here indicate that the combination of the wage and price determination processes is acceptable and that import prices do play an important role in both wage and price determination, but doubts about the claim that wage changes lead price changes remain.

6.3 Full system model estimation

The model analysed by OLS and 2SLS in the first section of this chapter is now fitted to the same data set by a full system estimation. There are a number of advantages of a full system estimation over a reduced form single equation method such as that used in Chapter three. The first is that economic theory is framed in terms of structural relationships. Theoretical restrictions on the structural form are of interest in themselves, in addition to being important in providing meaningful

estimates of the structural parameters. Moreover, estimation of the parameters of a model through a reduced form equation leads to inefficient estimators if there are restrictions on the structural model which are by implication placed on the reduced form model. As a consequence, the reduced form leads to a considerable loss of efficiency. Furthermore, OLS estimation is not consistent when an equation contains an endogenous variable as an explanatory variable (Harvey, 1990).

The full system estimation technique adopted here is a three stage least squares (3SLS) estimator[10]. The system comprises the seven equations of money (5.6a), bond and foreign asset demand (5.7 and 5.8), foreign exchange market intervention (5.12a), income (5.13), prices and wage determination (5.17) and the current account (5.18) plus the two identities of the wealth constraint (5.9) and the supply of domestic bonds (5.14). The results of the full system estimation are presented in Table 6.4.

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[10] 3SLS was used in preference to a full information maximum likelihood (FIML) estimator largely because the next stage of model analysis - forecasting - was computationally easier tacked onto the 3SLS results. Harvey (1990) notes that under fairly general conditions, 3SLS estimators have the same large sample properties as the FIML estimators.

Table 6.4: 3SLS estimation, 1966:03 to 1990:03

	money $(m^r t)$	domestic bonds (b^r_t)	foreign bonds (fa_t)	inter-vention (i_t)	income (y^r_t)	inflation (Δp_t)	current account (c_t)
constant	3.171 (2.396)	0.570 (0.909)	-14.9 (2.323)	0.087 (2.552)	-3.051 (1.655)	-0.003 (1.216)	1.627 (1.996)
m^r_{t-1}	0.009 (0.680)	-	-	-	-	-	-
Δm^r_t	-0.048 (0.055)	-	-	-	-	-	-
r_t	-	-0.001 (0.071)	-1.902 (1.866)	-	-0.035 (3.153)		
r^*_t	-0.054 (2.221)	0.006 (0.428)	4.151 (3.271)	-	-	-	-
i_t	0.193 (3.982)	-	-	-	-	-	-
$\lambda_r s^e_{t+1}$	-0.273 (0.248)	0.473 (0.763)	16.16 (3.012)	-	-	-	-
s_t	0.393 (0.349)	-0.471 (0.725)	-14.16 (2.485)	-	-	-	-
s_{t-1}	-	-	-	5.289 (3.856)	-	-	-
Δs_t	-	-	-	1.989 (1.268)	-	-	-
$(s_t - s^e_{t+1})$	-	-	-	-3.316 (1.129)	-	-	-
y^r_t	0.172 (1.052)	-0.071 (1.162)	16.44 (2.367)	-	-	-	9.286 (0.480)
y^r_{t-1}	-	-	-	-	-0.472 (2.411)	-	-
a^r_{t-1}	-0.022 (0.203)	-0.014 (0.293)	9.655 (2.207)	-	0.579 (5.528)	-	-
$debt^r_t$	0.111 (1.610)	-	-	-	-	-	-
b^r_{t-1}	-	-0.014 (0.293)	-	-	-	-	-
g_t	-	-	-	-	2.993 (4.221)	-	-
tx_t	-	-	-	-	-0.124 (1.813)	-	-
$(s+p^*-p)_t$	-	-	-	-	-0.087 (0.922)	-	-
y^{r*}_t	-	-	-	-	1.412 (5.527)	-	-29.58 (2.522)
c_{t-1}	-	-	-	-	-	-	0.703 (7.774)

x_t	-	-	-	-	-	-	10.63 (1.628)
m_t	-	-	-	-	-	-	-6.675 (0.726)
$ydebit_t$	-	-	-	-	-	-	-0.098 (4.177)
Δp_{t-1}	-	-	-	-	-	-0.005 (0.021)	-
Δp^e	-	-	-	-	-	0.720 (3.080)	-
$\Delta(s+p^*)_t$	-	-	-	-	-	0.126 (2.009)	-
Δu_t	-	-	-	-	-	-0.001 (0.109)	-
Δu_{t-1}	-	-	-	-	-	-0.013 (1.520)	-
o_t	-	-	-	-	-	0.009 (1.893)	-
d1	0.005 (0.198)	-0.115 (9.725)	-	-	-0.052 (2.624)	-	-
d3	-	-	-2.969 (2.291)	-	-	0.006 (3.877)	2.07 (2.432)
SER	0.087	0.044	0.443	0.268	0.063	0.003	0.362

Note: SER refers to the standard error of the regression.

The significant feature of the results of the money equation reported in Table 6.4 is the sign of the central bank's purchases of foreign exchange variables. The significance of the intervention variable is again supportive of unsterilised intervention activity.

The foreign bonds, income, inflation and current account equations reported in Table 6.4 have some interesting results which generally support the theoretical specification. All coefficients in the foreign bonds equation (5.8), including both exchange rate terms, are significant and of the correct sign. All explanatory variables in the income equation, except for the terms of trade term are significant and of the correct sign. Similarly, in the current account equation (5.18), a number of coefficients have both

the expected sign *a priori* and are significant. These are the explanatory variables of foreign income, exports, imports and the net income on the foreign debt.

The intervention equation (5.12a) does not support leaning against the wind. Indeed, most of the explanatory power of intervention behaviour in equation (5.12a) is derived from the lagged exchange rate term.

The outcome of the analysis of a small equation model of the portfolio balance model is good. The signs on the income coefficients in the domestic bond demand and the money equations and on the both the income and wealth coefficients in the foreign bond demand equation support a portfolio balance effect. There are two significant and consistent results from the estimation of the intervention equation. The first is the lack of evidence of leaning against the wind intervention activity by the central bank. This result is not entirely unexpected given that there are many changes in the management of the exchange rate over the period under review and that for much of this time period the exchange rate was fixed rather than floating. The second is that the intervention activity of the central bank over the sample period is unsterilised rather than sterilised.

6.4 The usefulness of the model

An important means of assessing the usefulness of an economic model is to consider its applicability to the functions of forecasting and policy evaluation (Harvey, 1990). The discussion here concentrates on the forecastability of the endogenous variables and the forecasting performance of the model under policy analysis.

The forecasts of the endogenous variable undertaken are dynamic and *ex-post*. Dynamic means that forecasts of the endogenous variables in earlier periods are fed through into later periods. *Ex-post* forecasts are within sample forecasts of the end of the estimation period where the values of the exogenous variables are taken from the actual data. The advantage of *ex-post* as compared to *ex-ante* forecasting (which is forecasting beyond the sample period) is that the forecasts of the endogenous variables generated may be compared with the actual data and an evaluation of the accuracy of the forecasts undertaken. Moreover, *ex-ante* forecasting necessitates time series for all the exogenous variables in the model covering the entire forecast period. In this particular model, there are ten exogenous variables.

The *ex-post* forecasting period is from the first quarter, 1987 to the third quarter 1990. Below are a set of figures (Figures 6.1 to 6.7) showing the ex-post forecasts and actual values for the endogenous variables. The analysis, evaluation and discussion of the model follows that of Pindyck and Rubinfeld (1991).

An important evaluation criterion of the model is how well it forecasts the turning points in the data. The exchange rate forecast (Figure 6.1) tracks the actual data well
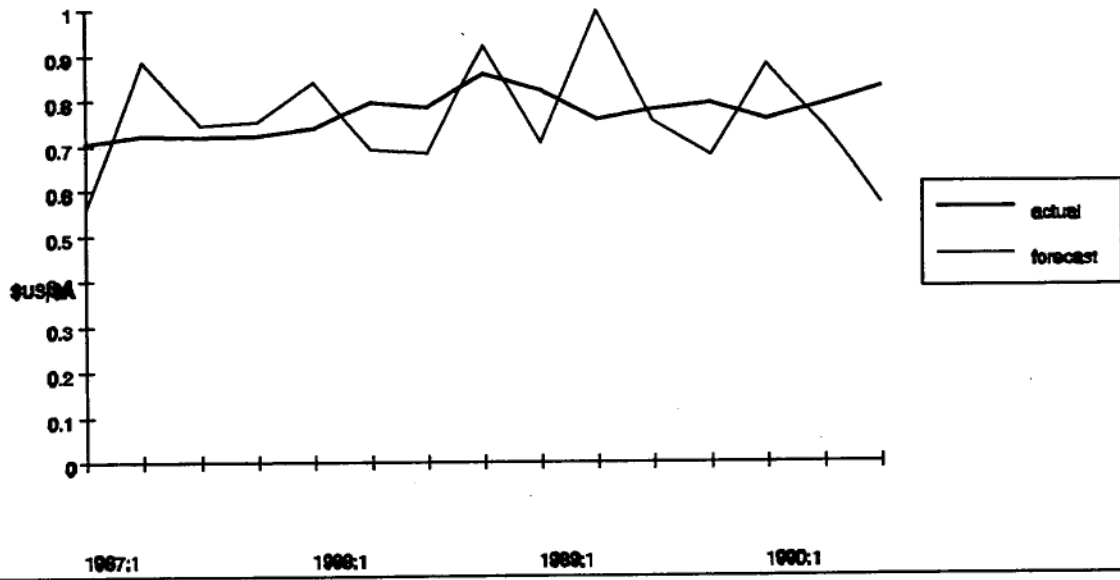
Figure 6.1: Actual and forecast exchange rates

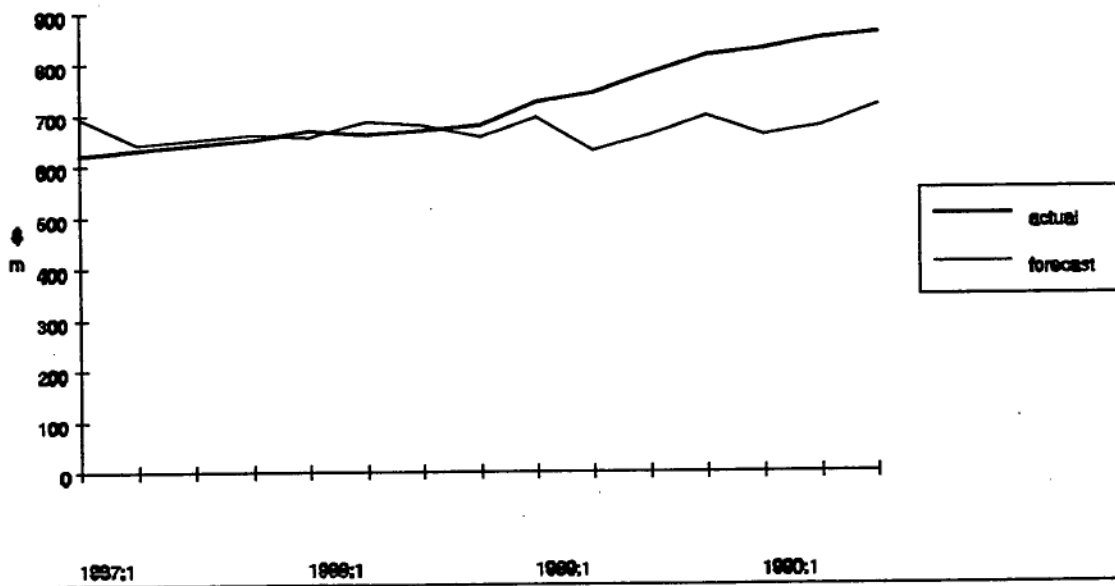Figure 6.2: Actual and forecast real money
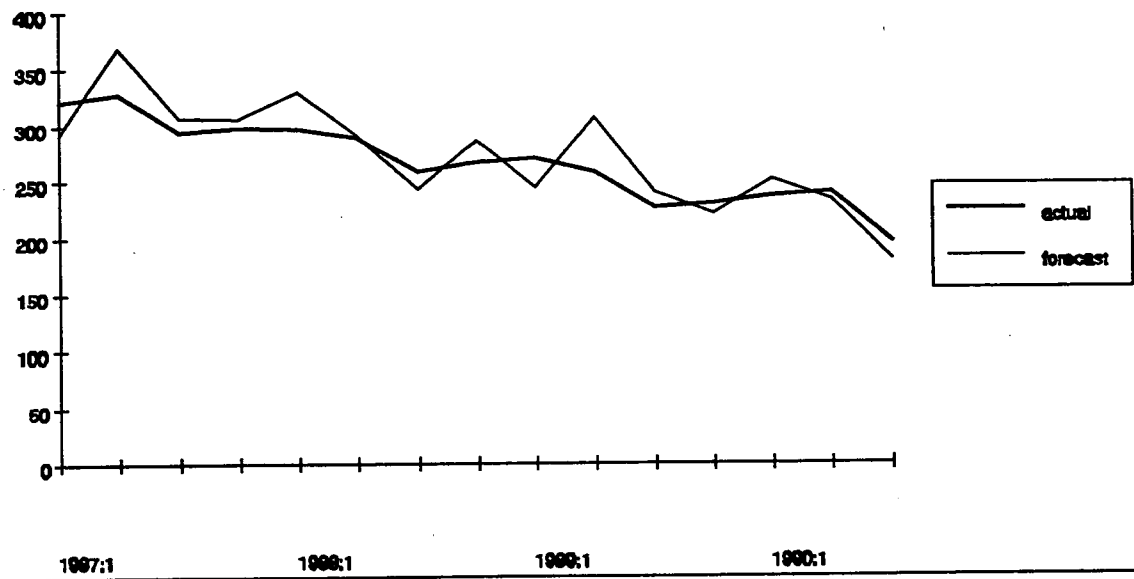
Figure 6.3: Actual and forecast real bonds

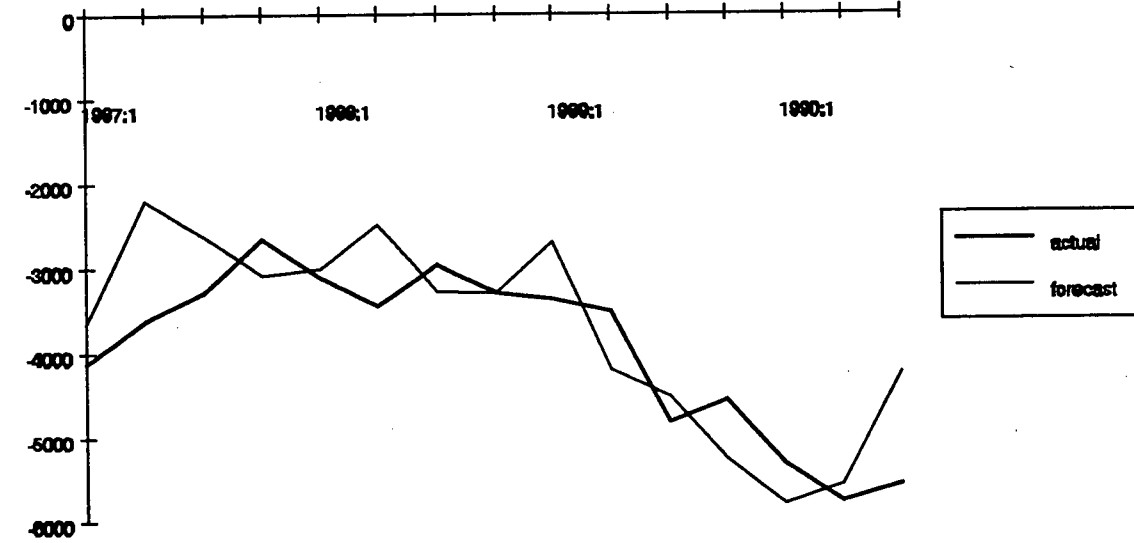Figure 6.4: Actual and forecast foreign bonds

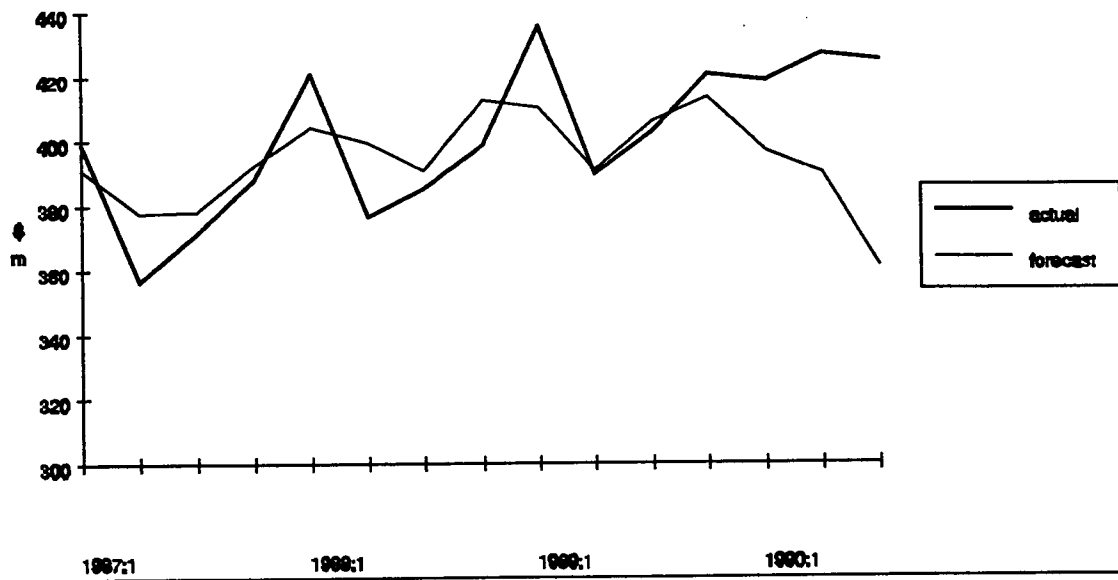**Figure 6.5: Actual and forecast real income**

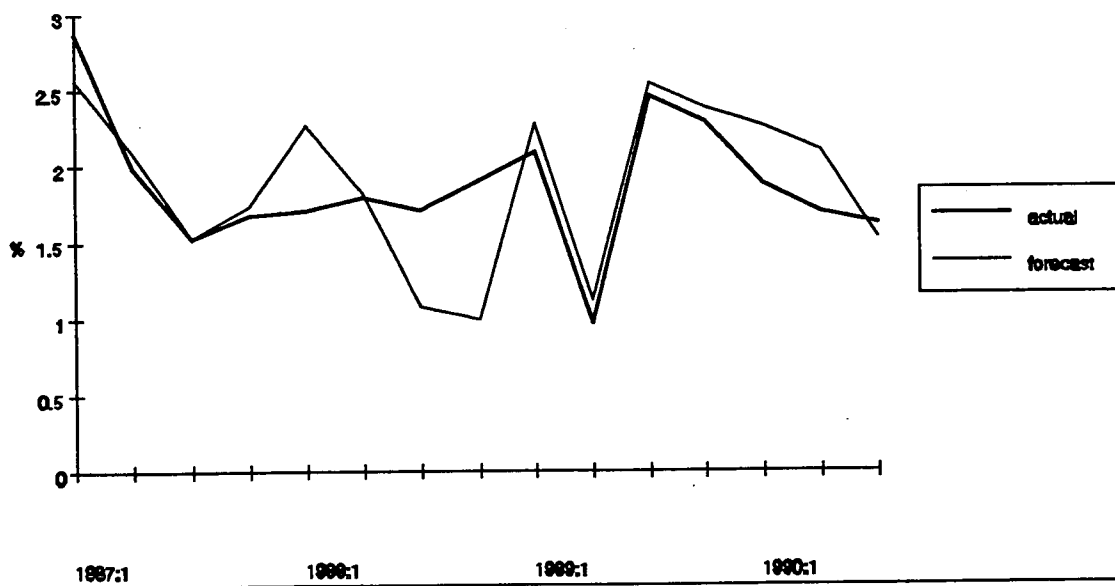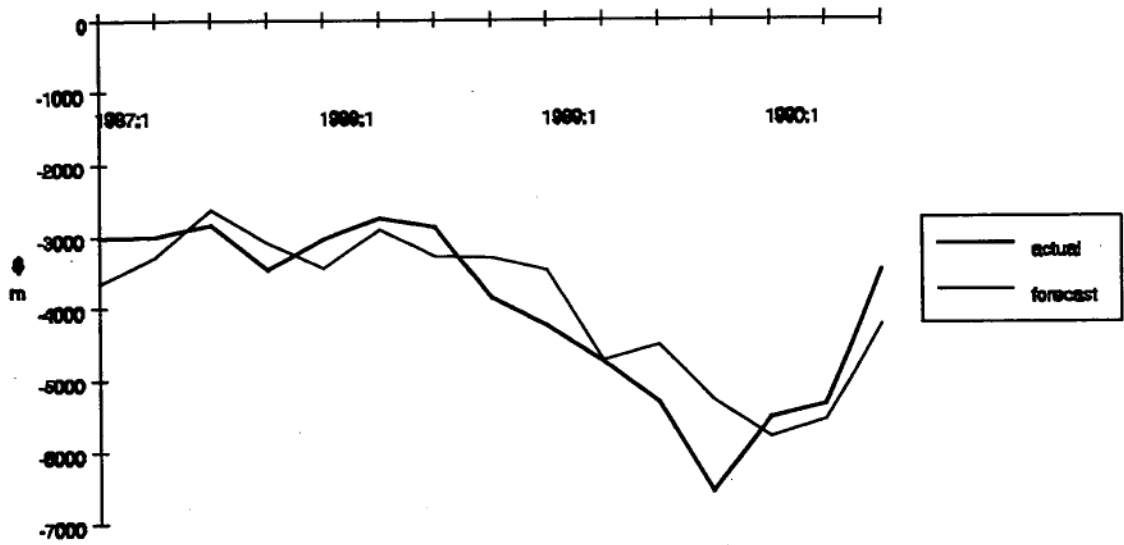**Figure 6.6: Actual and forecast change in prices**

Figure 6.7: Actual and forecast current account balance

during mid -1987 and from the second quarter to the fourth quarter 1988. In other time periods, however the forecast runs against the actual exchange rate movement. A notable feature is the greater variability of the exchange rate forecast compared to the actual rates.

The real money forecast (Figure 6.2)tracks the data well during the 1987 and 1988 but deviates from the actual path from mid-1989. This period corresponded to a easing of monetary policy after a period of tight policy during the 1980's. The real bond forecast (Figure 6.3) tracks the actual data well and, in particular, predicts the turning points in the data in a number of time periods. The forecast series shows greater variability, as it does for the exchange rate forecast, than the actual series. The forecasts for foreign bonds (Figure 6.4) does not show increased variability, but the forecast series fails in a number of cases to predict the important turning points in the data.

The real income forecast (Figure 6.5) differs somewhat from the actual data because the latter series is not seasonally adjusted whereas the forecast has seasonal dummies to reduce the amplitude. The forecast, thus shows less variability and importantly predicts the turning points in the data well.

The change in the prices forecast (Figure 6.6) shows more variability than the actual series. The forecast, however, does predict well the important turning point in the data.

The actual and forecast current account balance (Figure 6.7) move together well over the entire period under scrutiny. Moreover, the forecast predicts the turning points in the data well.

Table 6.5: Evaluation of forecasts

	RMS error	U	U^M	U^S	U^C
s	0.154	0.233	0.005	0.395	0.671
m^r	0.118	0.009	0.175	0.140	0.744
b^r	0.077	0.007	0.050	0.224	0.794
f^r	702.4	0.088	0.111	0.046	0.794
y^r	0.058	0.005	0.058	0.117	0.897
Δp	0.419	0.478	0.110	0.034	0.856
c	544.6	0.059	0.005	0.153	0.914

Evaluation of a multiequation model is based on an evaluation of each of the single equations which comprise the model. Table 6.5 summarises the results from the firgures. The RMS (root-mean-square) error is a measure of the deviation of the forecast variable from its actual time path. The magnitude of the error reflects the average size of the variables in question. The second evaluation statistic of Theil's inequality statistic (1958) or Theil's U is related to the RMS forecast error. The value of U always lies between 0 and 1. If U = 0, then the forecast value equals the actual value across all time periods forecast. If U = 1, then the forecast is as bad as it could possibly be (Pindyck and Rubinfeld, 1992). For all the forecasted variables the Theil's U is less than 0.5. Based on that statistic, however, the forecast is

considerably better for the money, bond, foreign assets, income and current account variables than it is for the exchange rate and the change in prices.

The Theil inequality coefficient is decomposed into three explanatory statistics. The first of these, U^M, represents the error due to bias, the second, U^S, the error due to difference variation and the third, U^C, the error due to difference covariation. The statistics of $U^M + U^S + U^C$ are equal to one. They decompose the total average squared error into three components. The bias proportion, U^M, is an indication of systematic error, as it measures the extent to which the average values of the forecast and average series deviate from each other. Ideally, therefore, U^M should approach zero. Pindyck and Rubinfeld note that a value of $U^M > 0.2$ is undesirable as it indicates that there is some systematic bias in the forecast. In all cases, presented in Table 6.5, the value of U^M is less than 0.2. Although it should be noted that the value for the money supply is close to 0.2.

The variance proportion, U^S indicates the ability of the model to replicate the degree of variability in the variable. Pindyck and Rubinfeld note that if U^S is large then the actual series has fluctuated more than the forecast series or *vice versa*. In all cases, the value of U^S is less than 0.4. The U^S value for the exchange rate is equal to 0.395 which is consistent with the evidence in Figure 6.1 where the forecast exchange rate fluctuates more than the actual rate.

The final statistic is the covariance proportion, U^C which represents the error remaining after deviations from average values have been accounted for. Pindyck and

Rubinfeld note that for any value of U > 0, the ideal distribution of inequality over the three sources is $U^M = U^S = 0$ and $U^C = 1$. In all variables reported in Table 6.5, the value of U^C, is greater than 0.65. On the basis of the reported statistics, the exchange rate forecasts are the poorest.

Overall, the forecast evaluation results are good. Pindyck and Rubinfeld suggest that the response of the model to large changes in exogenous variables or policy variables should be investigated as another means of model evaluation or usefulness. Two separate domestic policy changes were considered; a 15 percent increase in government expenditure and a 15 percent increase in the money supply in the first quarter 1988. The response of the model to the stimuli is shown in Figures 6.8 through 6.12.

Figures 6.8 to 6.10 show the response of real income, real money and the exchange rate respectively to a 15 percent increase in government expenditure. From equation (5.13) - the real income equation - an increase in government expenditure has a direct and positive impact on real income. This *a priori* relationship is confirmed by both the results in Table 6.4 and in Figure 6.8 where the increase in government expenditure in the first quarter 1988 leads to an increase in the forecast value of income in both that period and subsequent periods. The financing of an increase in government expenditure may have, depending on the means of financing the deficit, monetary implications. Another link between the deficit and the financial sector is through the increase in income. The relationship in equation (5.11b) indicates that increases in real income lead to an increase in the demand for money. The evidence

Figure 6.6: Real income - actual, forecast and forecast with a 15% increase in government expenditure
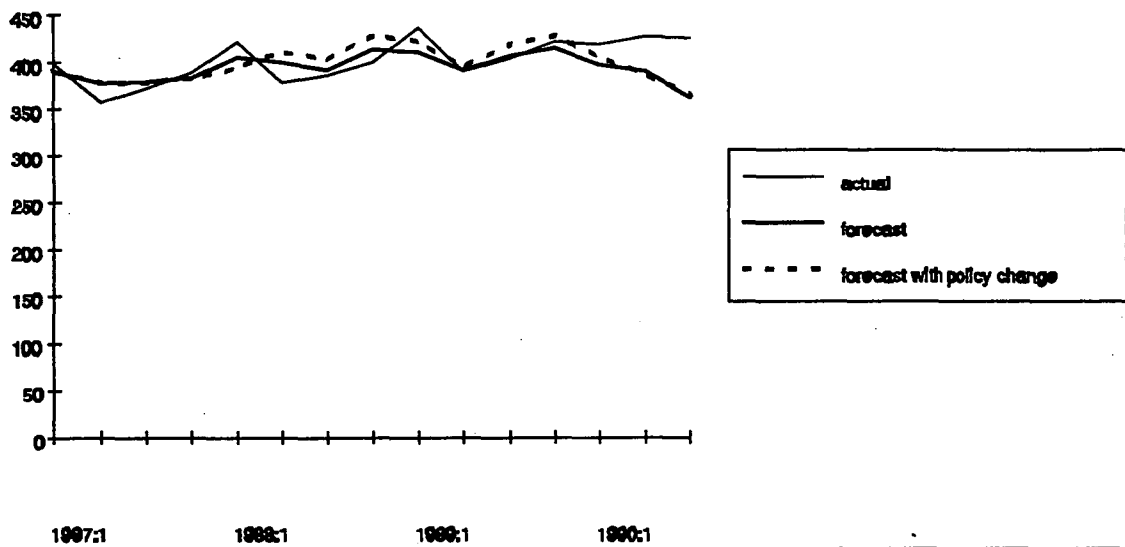

Figure 6.9: Real money - actual, forecast and forecast with a 15% increase in government expenditure
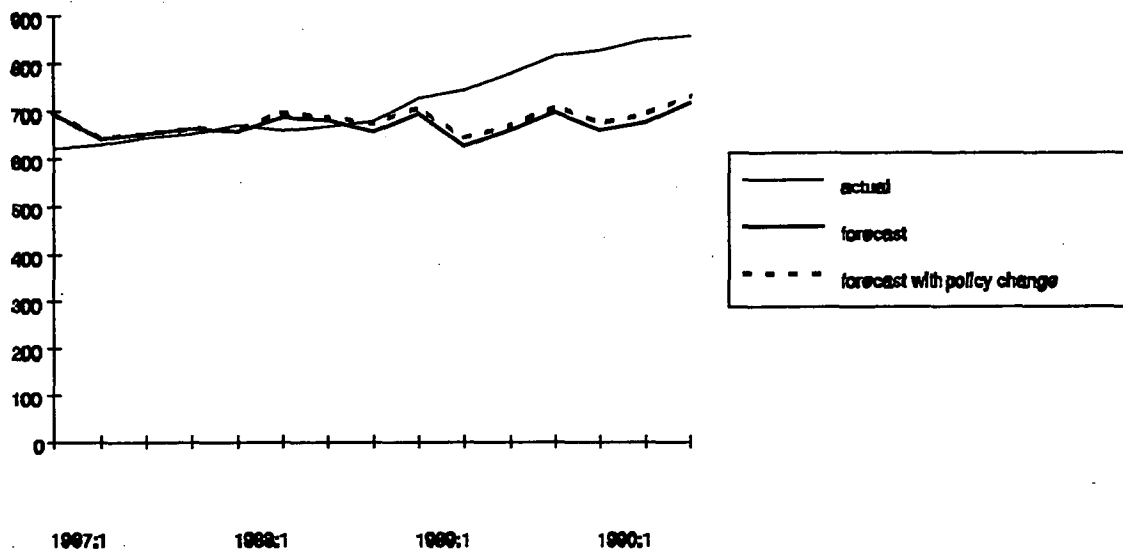
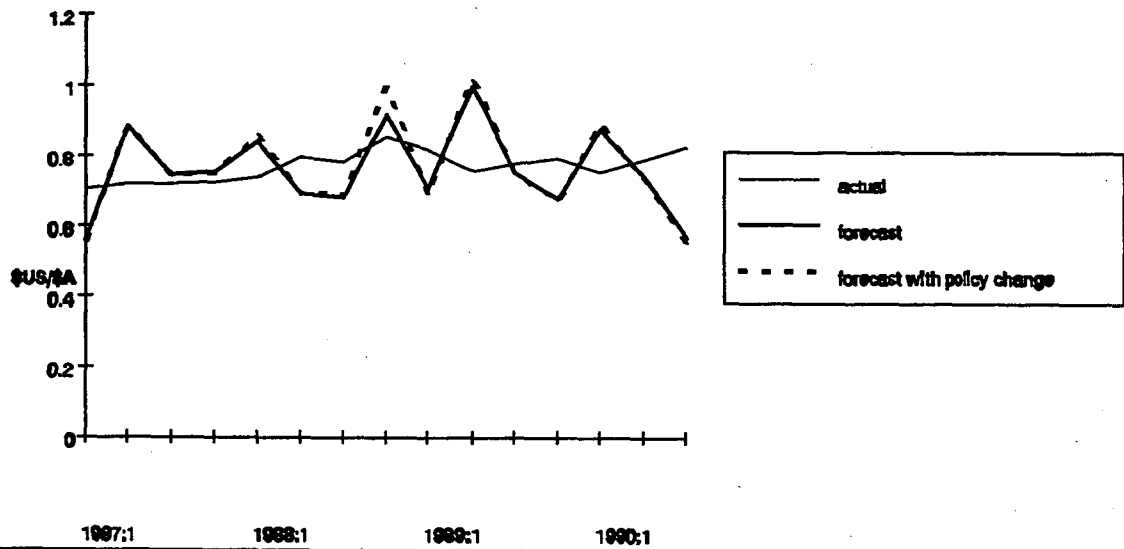Figure 8.10: Exchange rate - actual, forecast and forecast with a 15% increase in government expenditure

Figure 8.11: Exchange rate - actual, forecast and forecast with a 15% increase in money supply
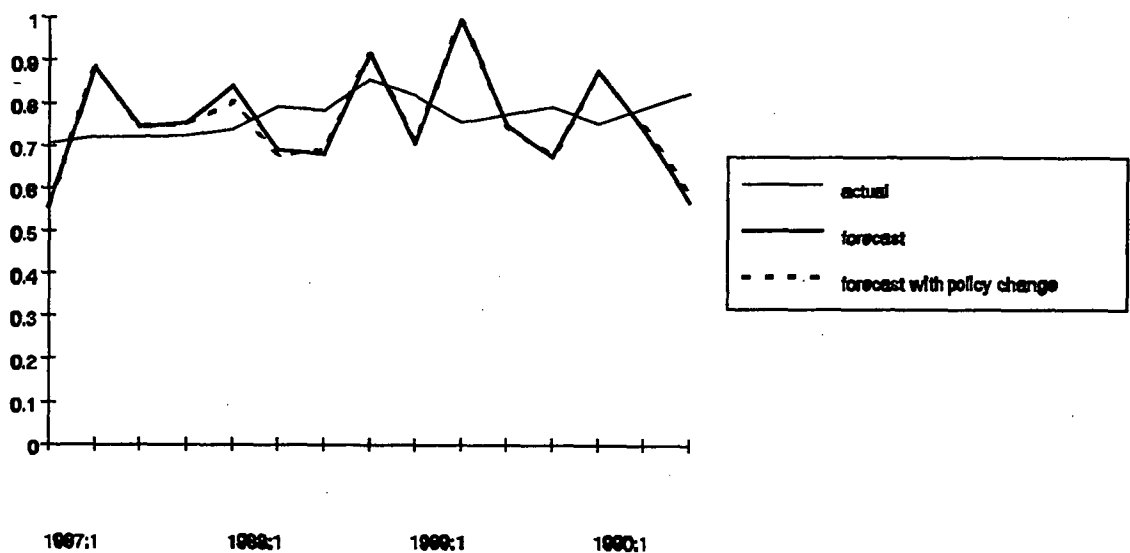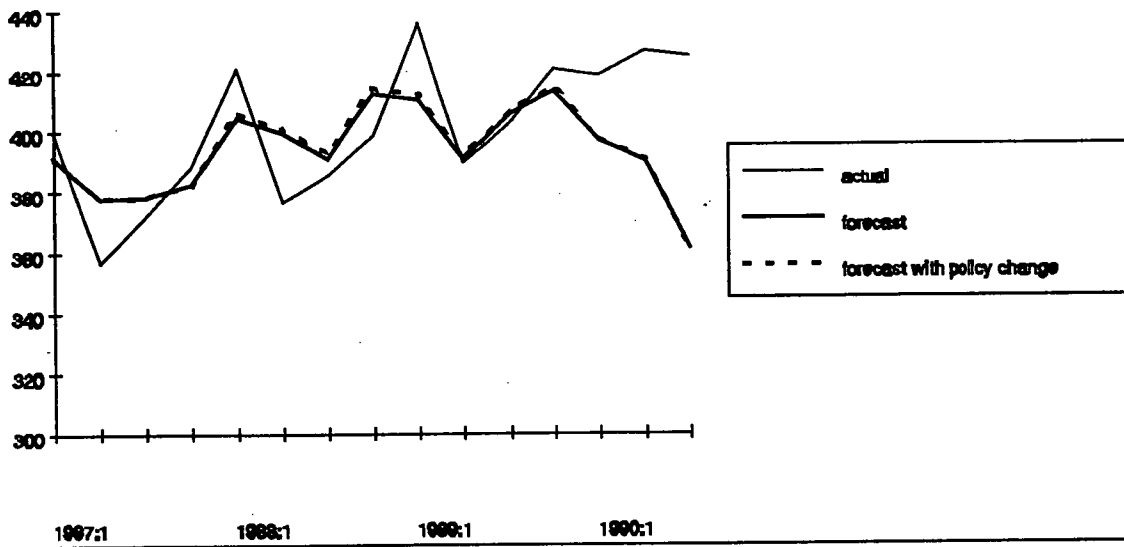
Figure 8.12: Real income - actual, forecast and forecast with a 15% increase in money supply

in Figure 6.9 shows that the forecast value of money increases with an increases in government expenditure. With a constant money supply, the increase in demand for money leads to an increase in the interest rate. An increase in the interest rate in turn, leads to an appreciation of the domestic currency. The impact of the change in the exogenous government expenditure variable on the forecast value of the exchange rate is shown in Figure 6.10.

The impact of a 15 percent increase in the money supply on the forecast values of the exchange rate and real income is shown in Figures 6.11 and 6.12 respectively. The theoretical relationship between changes in the money supply and exchange rate and income changes is somewhat ambiguous. An increase in the money supply leads to an decrease in the domestic rate of interest relative to the foreign rate and a domestic currency depreciation. An increase in the domestic money supply and decrease in the interest rate also, however, increases domestic income through increasing investment expenditure. The increase in domestic income, in turn, increases the demand for money and the interest rate increases. The initial stimulatory impact of the investment spending is therefore "crowded out" to some extent.

In Figure 6.11, the exchange rate falls (or the domestic currency depreciates) in response to the increase in the domestic money supply. The impact of the policy change on the exchange rate forecast is, however, weak and not sustained. The forecast value of real income increases in response to an increase in the domestic money supply as anticipated *a priori*. The change in income is, however, sustained over most of the remaining time period.

Figure 8.13: Exchange rate - actual, forecast and forecast with a 15% increase in foreign interest rate

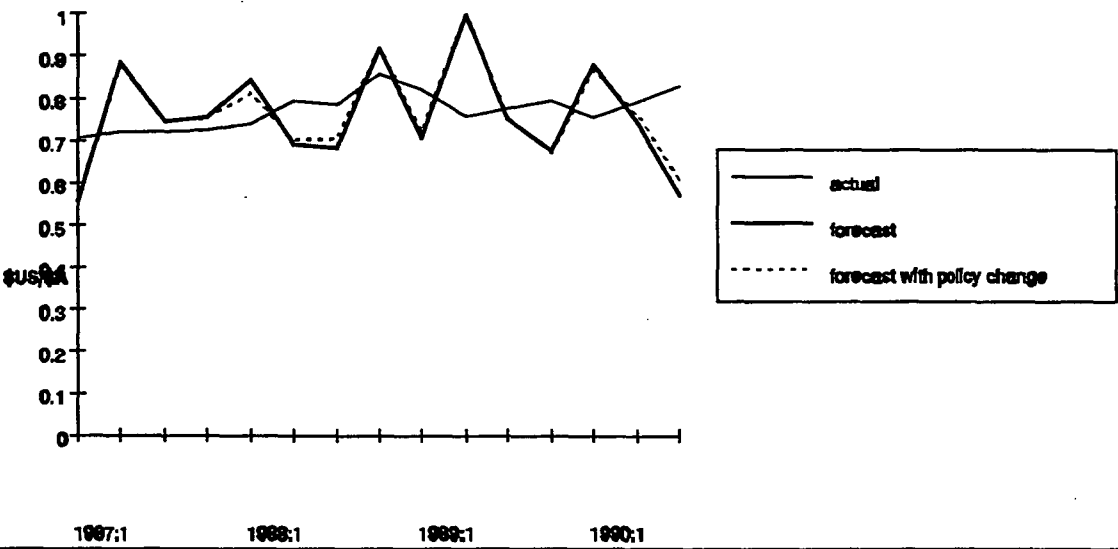Figure 8.14: Foreign bonds - actual, forecast and forecast with a 15% increase in foreign interest rate
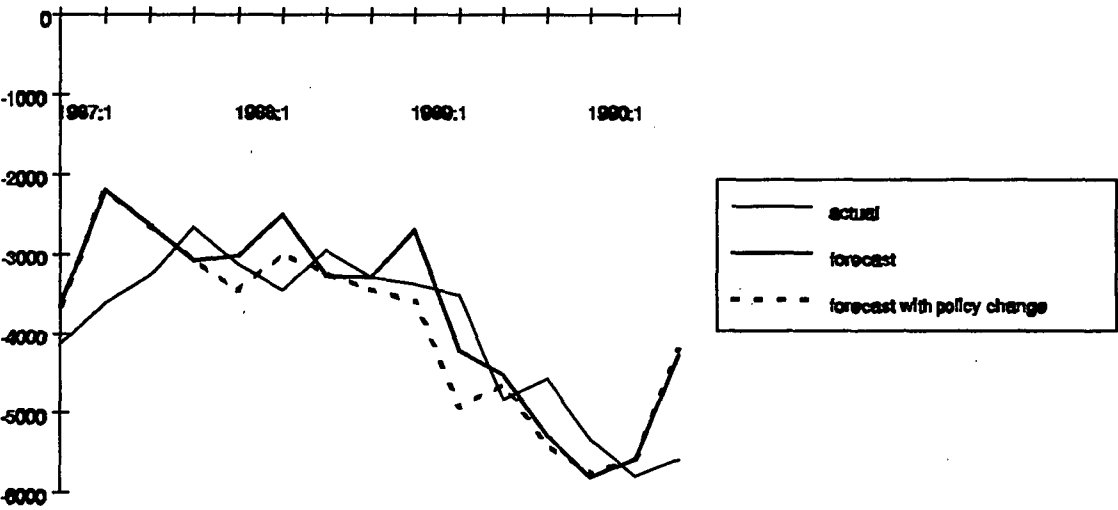
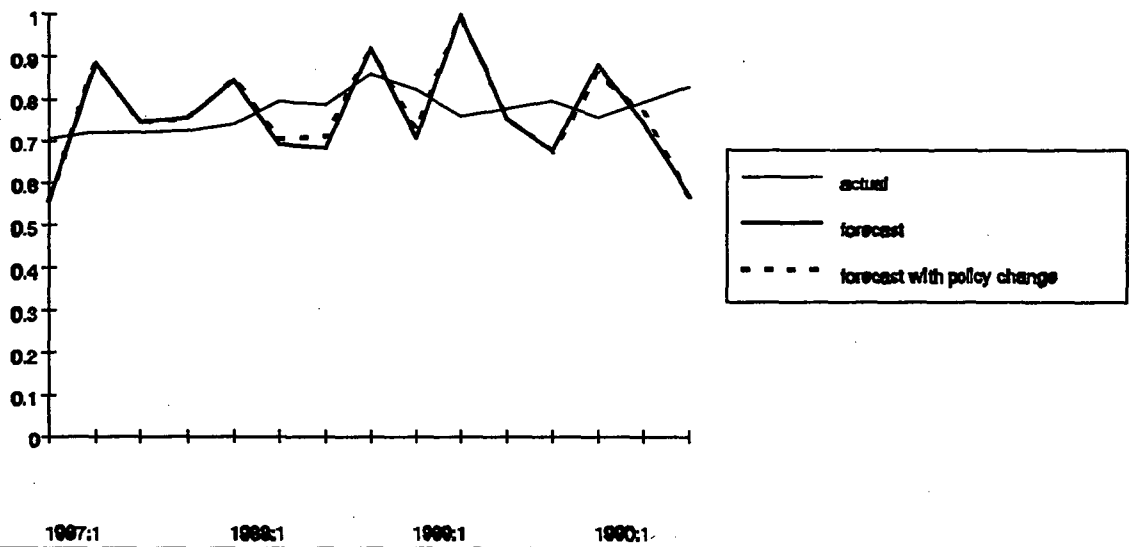Figure 8.15: Exchange rate - actual, forecast and forecast with a 15% increase in foreign income

Figure 8.16: Real income - actual, forecast and forecast with a 15% increase in foreign income
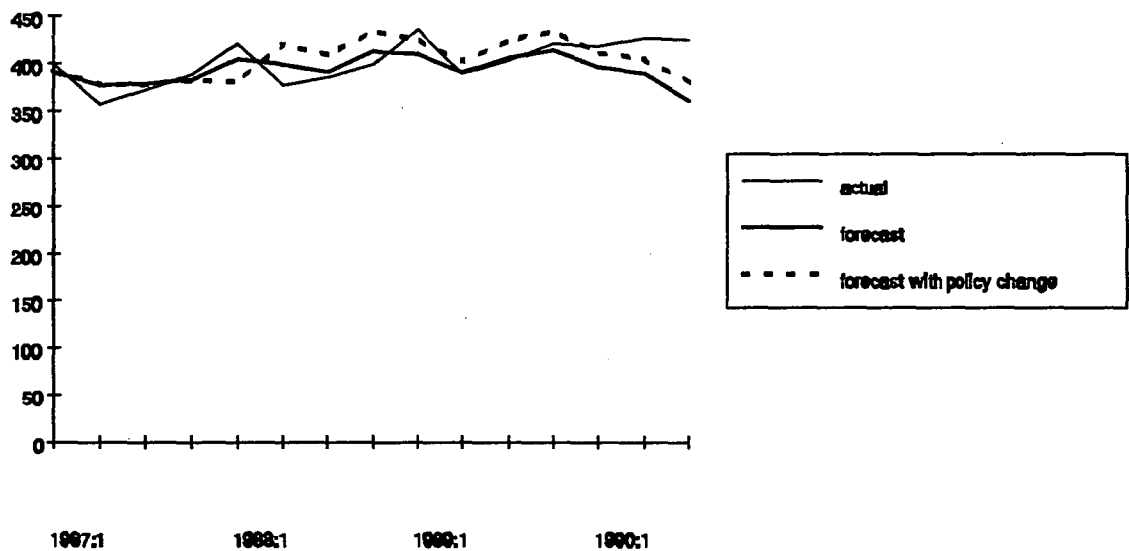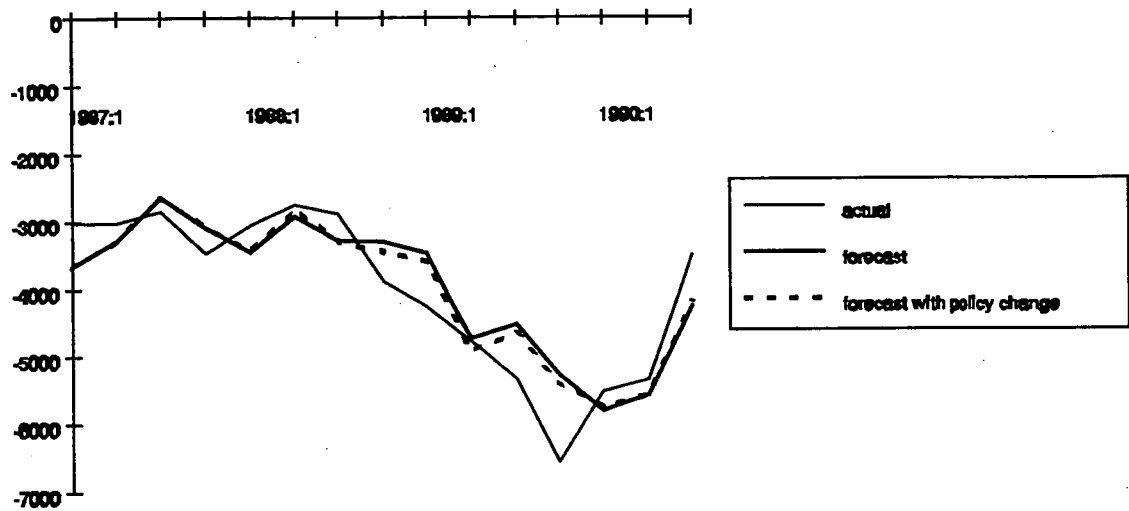
Figure 6.17: Current account - actual, forecast and forecast with a 15% increase in foreign income

The next step in the policy evaluation is to consider the model response to changes in foreign exogenous variables of the interest rate and income. Figures 6.13 and 6.14 consider the response of two of the endogenous variables to a 15 percent increase in the foreign interest rate. In Figure 6.13, the domestic currency depreciates in the same period that the foreign interest rate increases. This is an expected response, and provides some albeit weak support for interest rate parity. In Figure 6.14, the demand for foreign bonds increases in response to the increase in the foreign interest rate. Again, this is an expected response.

Figures 6.15, 6.16 and 6.17 show the response of the forecasts of three endogenous variables to a 15 percent increase in foreign income. In the first case, in Figure 15, the exchange rate movement is insignificant in response to an increase in foreign income. Theoretically, the domestic currency would depreciate if the increase in foreign income leads to an increase in domestic money demand and in domestic interest rates. On the other hand, the domestic currency would appreciate, with a lag, if the increase in foreign income leads to an increase in demand for domestically produced goods and a current account improvement. The domestic real income forecast shows a more immediate as well as a prolonged response to a change in foreign income.

6.5 Conclusions

The empirical analysis of the structural model presented here indicates a competent fitting of the model to the data set. The 3SLS estimation of the model suggests general acceptance of the relationship between those macroeconomic variables

modelled in the preceding chapter. It is of some concern, however that the model

forecasts the endogenous variables other then the exchange rate better than it

forecasts the exchange rate. Moreover, a comparison of Figure 6.1 of this chapter

with Figure 3.1 of Chapter three reveals that the error correction model forecasts the

exchange rate better than the structural model. Pentecost (1991) surveys econometric

approaches to empirical exchange rate models and states that model results are better

when simultaneous equation methods are used. This view is seemingly at odds with

the outcome here. Two points of qualification are necessary, however. The first is,

as Pentecost, notes that a better means of modelling exchange rate expectations is

desirable. An examination of Figure 6.1 where the forecast exchange rate value shows

more variability than the actual exchange rate bears witness to this view. The second

issue is the importance of the long run relationships between the macroeconomic

variables. The error correction model accommodates these dynamic, long term

relationships whereas the structural equation model does not.

In the next chapter, we develop a model of the relationship between exchange rate

changes and intervention behaviour in the context of the risk premium on the

domestic currency.

Chapter 7: AN ECONOMIC MODEL OF THE RISK PREMIUM

The analysis to this point has focussed on a systematic economic explanation of exchange rate determination. It is time to look further into a particular aspect: the factors which determine the risk premium on the Australian dollar. This particular issue is singled out from other factors influencing the exchange rate for three reasons. First, the available evidence suggests that the existence of a risk premium on the Australian currency is a relatively recent phenomenon, and the variability of the premium is a significant aspect of forward market efficiency and the volatility of currency values. The second reason follows from the first: changes in the risk premium represent a further dimension to the policy task from the central banks's viewpoint, and the argument about the risk premium cannot be divorced from exchange rate intervention policy. Finally, existing studies of the risk premium on the Australian dollar, while having an intricate statistical foundation, do not on all occasions provide the required policy emphasis. These may emerge if a structural economic interpretation of the risk premium is developed and applied to Australian data.

7.1 Relationship between government activity and the risk premium

Chapter six analysed the determinants of the exchange rate within a small macroeconomic model based on an asset market model of exchange rate determination. A feature highlighted by the results of the analysis in that chapter (although they appear in Appendix A.3) is the difference in intervention behaviour between the regimes of management of the Australian currency. The intervention behaviour of the central bank has up to this point largely been explained as a desire

to influence the level of the exchange rate[1] in order to achieve some wider macroeconomic policy goal such as a given capital inflow. It has an important impact on private investment decision-making, regardless of the type or means of government intervention behaviour[2]. According to Lucas (1976), changes in the policy of the monetary authorities can be expected to lead to changes in private behaviour because private agents optimise their actions subject to a different set of environmental conditions. Studies analysing the risk premium on Australian dollar denominated assets advanced a number of explanations of variability. Penm and Wright (1990) suggest that the risk premium may be related to the level of net foreign debt. Kendall and McDonald (1990) find that higher risk premia are associated with the period leading up to the float in 1983, the period of rapid depreciation in 1984/85 and the period of appreciation in 1988/89: all periods in their model of greatest volatility in the Australian foreign exchange market. Buchanan and Felmingham (1990) found significant evidence that the risk premium required for holding Australian dollars rather than U.S. dollars does change follow substantive government decisions such as floating the currency in December 1983 and massive depreciation in February 1985.

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[1]Intervention in the exchange rate market may be either with the aim of minimising volatility in the short run by moving the exchange rate toward a current equilibrium - leaning against the wind - or moving the exchange rate toward a new equilibrium - targeting the exchange rate. There is an extensive discussion of the goals of intervention behaviour in section 4.3.

[2]It should also be emphasised at this point that the presence of a risk premium is considered essential in order for sterilised intervention to be effective, although this view has been recently challenged by Henderson (1983). Sterilised intervention leaves the monetary base unchanged and therefore influences the exchange rate value solely by altering the currency composition of the supply of bonds available to investors. On the other hand, the effectiveness of unsterilised intervention is not dependent on the presence or otherwise of a risk premium. The empirical analysis in both sections 6.2 and 6.3 using OLS and 3SLS estimators respectively is supportive of unsterilised intervention activity by the Reserve Bank of Australia.

A common feature running through these studies is the relationship between a risk

premium and changes in government policy. This issue is pursued in the discussion

below and in the subsequent chapter. In particular, consideration is given here to the

relationship between the risk premium and alterations in intervention behaviour.

Danker *et al.* (1987), Osterberg (1989) and Humpage and Osterberg (1990) all

consider the importance of the relationship between the exchange rate, the risk

premium and central bank intervention. If such a relationship is in place, then the

coefficients of the chosen model may alter in response to a change in government

policy, indicating that there is a variable risk premium in the demand for assets in the

portfolio, in contrast to the simple portfolio balance model which implies a constant

risk premium. In terms of the analysis of Chapter six, a time-varying risk premium

implies that empirically, there are a number of different models for exchange rate

behaviour over the sample period rather than just one explanation.

Black (1985) and Black and Salemi (1987) demonstrate the existence of the "Harrod

effect" to explain the variable risk premium. Harrod (1965) hypothesises that the

adoption of a floating exchange rate regime would deter speculators from taking

foreign currency positions because of the increased uncertainty about the future value

of the exchange rate[3]. Thus the Harrod effect refers to the response of investors'

willingness-to-bear-risk to changes in the variability of exchange rates. This

variability of exchange rates will respond to both shocks in the system which are

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[3]On page 50 of <u>Reforming the world's money</u>, Harrod states that there are two options facing a
country under flexible exchange rates. If there is no official intervention, vast fluctuations are
accompanied by damaging undervaluations; if there is appropriate official intervention,it will result in
moderate fluctuations only and no marked damage to decisions to undertake trade.

exogenous and changes in government policies which are endogenous. Thus changes

in government policies have the ability to either increase or decrease the willingness

of investors to hold foreign exchange by changing the perceived riskiness of holding

foreign exchange. Black and Salemi (1987) make the point that an increase in the

strength of government intervention directed towards an appropriate target will reduce

the riskiness of the exchange rate and increase the responsiveness of the demand to

hold assets. Thus stabilising government intervention policy stabilises private activity.

Before proceeding to look more closely at the relationship between intervention

activity and the risk premium, it is first appropriate to consider whether there is a risk

premium or not. That process entails the development of an economic model of the

risk premium.

7.2 The role of a risk premium in the portfolio balance model

Chapter two provides a discussion of the relationship between imperfectly

substitutable domestic and foreign assets and the interest rate parity theorem. For the

sake of continuity that analysis is briefly repeated here.

The interest rate parity theorem asserts that bilateral exchange rates are determined

by differential rates of interest on financial assets of similar risk and maturity. The

process of arbitrage as investors rearrange their portfolios to accommodate those

assets with the higher rates of return brings about compensating adjustments in

flexible exchange rates. The assumptions underlying this view of exchange rate

determination are that investors use all currently available market information in

forming their expectations of future rates of return, and are risk neutral. Moreover, zero transaction costs, and the absence of capital controls and taxes ensures perfect capital mobility so that portfolio adjustment occurs instantaneously.

The stronger relationship of uncovered interest rate parity asserts that arbitrage by investors ensures that the differential between domestic and foreign interest rates is equal to the expected depreciation or appreciation of the spot exchange rate:

$$r = r^* + (s^e_{t+1} - s_t) \qquad (7.1)$$

where r *and* r^* are one period domestic and foreign interest rates on financial assets of similar risk and maturity, s is the spot exchange rate in period t expressed in natural logarithms, and the superscript e refers to the expected spot rate in period $t+1$. Expression of the exchange rate terms in natural logs overcomes the difficulty of Siegel's paradox[4].

Under conditions of uncertainty, however an investor taking a position in the foreign exchange market, in this particular case because he or she holds foreign denominated assets, is exposed to exchange risk. Such risk can be eliminated by purchasing a forward contract. The weaker interest rate parity theorem refers to this covered relationship such that:

$$r = r^* + (f_{t,1} - s_t) \qquad (7.2)$$

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[4]Siegel's paradox is discussed in footnote 6 in Chapter 5.

where f represents a forward contract purchased at time, t which matures in the next period, and both the forward and spot exchange rate are expressed in natural logarithms.

Assuming that investors form their expectations about future prices rationally and that they are risk neutral, the arbitrage action of profit-maximising individuals should ensure that the forward rate is an unbiased predictor of the expected future spot rate, that is:

$$s_{t+1}^{e} = f_{t,1} \qquad (7.3)$$

Equation (7.3) is known as the unbiasedness hypothesis. Empirical analysis of the unbiasedness hypothesis entails a market efficiency test of the joint hypothesis of rationality and risk neutrality.

On the other hand, any deviation between the expected spot rate and the forward rate such that equation (7.3) does not hold, implies *inter alia*[5] that there is an exchange rate risk premium. Following Fama (1984), the forward rate can be broken down into two parts:

$$f_{t,1} = s_{t+1}^{e} \cdot \lambda_{t} \qquad (7.4)$$

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[5]The failure of any of the assumptions of the interest rate parity theorem may lead to the breakdown of the unbiasedness hypothesis. Examples of such failure which have been considered empirically include the presence of significant transactions costs, and the imposition of withholding taxes.

so that the forward rate comprises the expected future spot rate plus a risk premium, λ.

The presence of a risk premium indicates that arbitrage is not eliminating the differential between the forward rate and the expected spot rate. Indeed, a risk premium implies that investors rather than being risk neutral as assumed in the interest rate parity theorem, are risk averse and consequently require a risk premium to compensate them for the perceived riskiness of holding a foreign currency denominated asset.

The difficulty of testing empirically for a risk premium is that it encompasses a test of market efficiency and any test of market efficiency is a joint test of several different market hypotheses (Hodrick, 1987). Fama (1970) describes an efficient market as one which fully reflects all available information. Thus evidence of abnormal returns indicates market inefficiency. This comment however implies some view in a statistical sense of market excess returns. Following Levich (1979), the excess market return, Z on asset, i is defined as:

$$Z_{i,t} = x_{i,t} - E(\bar{x}_{i,t} \mid I_{t-1}) \qquad (7.5)$$

where $x_{i,t}$ is the one-period percentage return, E is the expectations operator, I_{t-1} is the information set last period and $\bar{x}_{i,t}$ represents the equilibrium value. In an efficient market, the actual return should approach the expected return given information last period, and the excess return should therefore approach zero. Note, that only in the

case of perfect foresight will the excess return always be equal to zero. The definition of an excess return implies two conditions for an efficient market: first that investors are able to form a view of an equilibrium model of expected returns upon which to base their investment decisions and second, that they use the information available in the market place rationally and thus do not make systematic errors.

Conventional analyses of the existence of an efficient market for foreign exchange have been based around time series analysis of the properties of exchange rates[6]. The approach taken in many of these papers is based around the following econometric specification of the unbiasedness hypothesis. Assuming the efficient market condition as before in equation (7.3) but in period t rather than period $t+1$:

$$s_t^e = f_{t-1,t} \qquad (7.6)$$

where the forward exchange rate, f is purchased last period, $t-1$ and is set for maturity in the current period, t. As long as investors are rational then:

$$s_t = s_t^e + u_t \qquad (7.7)$$

where s_t^e is equal to $E(s_t/I_{t-1})$, E is the mathematical expectation operator, I_{t-1} is the information set last period, and u_t is the white noise error term. Equation (7.7) proposes that the actual spot rate this period and the expected spot rate this period diverge in the presence of some unsystematic error only.

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[6]It is not intended in this chapter to survey comprehensively the research on the relationship between the forward and expected spot exchange rate. More detail is given of the general thrust of some studies below. There are many good surveys of this literature, for example Hodrick (1987), MacDonald (1988) and Baillie and McMahon (1989).

Substituting (7.7) into (7.6), gives:

$$s_t = f_{t-1,t} + u_t \qquad (7.8)$$

which is the unbiasedness hypothesis given that u_t is white noise only.

Suppose that investors still form their expectations rationally, but they are now risk averse as opposed to being risk neutral:

$$s_t^e = f_{t-1,t} + \lambda_{t-1} \qquad (7.9)$$

which is a period $t-1$ representation of equation (7.4). Following Frenkel (1981), the risk premium, λ may be represented by:

$$\lambda_{t-1} = \eta + \epsilon_{t-1} \qquad (7.10)$$

where η represents the mean of the risk premium and ϵ represents a white noise error term. Substituting (7.10) into (7.8) gives:

$$s_t = \eta + f_{t-1,t} + u_t + \epsilon_{t-1} \qquad (7.11)$$

where both u_t and ϵ_{t-1} represent white error terms. Redefining these error terms as being equal to θ gives:

$$s_t = \eta + f_{t-1,t} + \theta_t \qquad (7.12)$$

which can be re-expressed in a form more amenable for time series analysis as:

$$s_t = \alpha_o + \alpha_1 f_{t-1,t} + \theta_t \qquad (7.12a)$$

where if investors are risk neutral the mean of the risk premium is equal to zero, and if investors are rational, the coefficient on the forward rate is equal to one, and the error should be serially uncorrelated and orthogonal to the information set as defined earlier.

The findings of many researchers of non-stationarity in the variables led to the expression of equation (7.12a) in first differences:

$$s_t - s_{t-1} = \alpha_0 + \alpha_1(f_{t-1,t} - s_{t-1}) + u_t \qquad (7.13)$$

The majority of tests of the unbiasedness hypothesis for example those of Geweke and Feige (1979), Hansen and Hodrick (1980), Meese and Singleton (1982), Meese and Rogoff (1983), Cumby and Obstfeld (1984), Fama (1984) and Hodrick and Srivastava (1984) have concentrated on the econometric testing of either equation (7.12) or (7.13). Of course, an econometric analysis is by no means as simple as the derivation of the econometric equation for testing presented here. Analysis by different researchers has grappled with difficulties such as non-overlapping versus overlapping time periods and strategies for the estimation of parameters such as Hansen's (1982) Generalised Method of Moments. Importantly, the overall thrust of all this research activity is a rejection of the null hypothesis of unbiasedness.

More recently, Kearney and MacDonald (1991) tested the unbiasedness hypothesis using the Australian/United States dollar exchange rate over the period January 1984 to March 1987. They use an overlapping data base rather than a non-overlapping data base. The results suggest that there is a significant risk premium on the Australian currency, and that the risk premium does vary over time.

Hodrick (1987) suggests that there are three alternative interpretations of the rejection of the unbiasedness hypothesis. The first is related to the statistical characteristics of the data. This line of argument suggests that the market is efficient but the tests of unbiasedness fail due to statistical difficulties. These difficulties are associated with the limitations of asymptotic distribution theory. There is always the possibility that the sample moments of the data are poor reflections of their asymptotic counterparts. In particular, he suggests that government policies and other exogenous processes determining exchange rates make this a problem in many studies.

The second interpretation suggests that the market is inefficient as indicated by the profitability on trading in excess of any explanation based on risk aversion (Bilson, 1981 and Dooley and Schafer, 1983). The latter authors conclude that the rejection of the unbiasedness hypothesis is due to inefficient assimilation of market information into price setting in the foreign exchange market.

Finally, Hodrick suggests that the rejection of the unbiasedness hypothesis is related to a time-varying risk premium. That is, the risk premium, λ in equations (7.4) and (7.9) is not constant but varies over time. A risk premium in itself implies rejection

of the unbiasedness hypothesis: a time-varying risk premium compounds the rejection. There are two means of approaching the issue of a time-varying risk premium. Many papers utilising financial data of returns on assets have approached the risk premium as a statistical issue where the econometric analysis is centred around a null hypothesis in two parts: first, that expectations are rational and second, risk neutrality. On the whole, however the analysis reported above in equations (7.6) to (7.13) is not of sufficient sophistication to capture a time-varying risk premium. More recently, an autoregressive conditional heteroscedasticity framework is used for much of this statistical analysis[7].

Alternatively, the time-varying risk premium is accommodated in econometric models of market fundamentals including assets stocks. This latter approach places the analysis much more within an economic - as opposed to a statistical - interpretation of events, and within a portfolio balance interpretation. Such a model has been developed by Frankel (1982) using an asset market equilibrium model incorporating asset supplies based on asset demands derived from a two-period mean-variance maximisation problem. His model assumes that the conditional variance matrix of the relative rates of currency depreciation is constant over time. Frankel's analysis,

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[7]The autoregressive conditional heteroscedasticity model, otherwise known as ARCH is an alternative model of the risk premium developed from the work of Engle (1982). Domowitz and Hakkio (1985) use the ARCH model to model a time-varying risk premium, where the risk premium depends on the difference between the conditional variances of the two money supplies that relate to the bivariate exchange rate. As with models of the risk premium discussed earlier the analysis relies on little additional information apart from the exchange rates themselves. Importantly, Domowitz and Hakkio conclude that their results are generally consistent with the rejection of the unbiasedness hypothesis, and find that there is little support for the conditional variances of the exchange rate forecast error being an important sole determinant of the risk premium.

however, suffers the limitations of related studies: in testing a composite hypothesis[8],

the interpretation that one can then put on the rejection or acceptance of the null

hypothesis is not clear. Both Rogoff (1984) and Danker *et al.* (1987) assume a

portfolio balance framework, but allow for an error term in the relationship. Whilst

all of these models are addressing the issue of the risk premium in exchange rate

models, none address the more difficult issue - both conceptually and econometrically

- of the time-varying risk premium. Hodrick (1987) discusses these models in some

detail.

The procedure followed here is to take the latter approach, estimation within a model

of market fundamentals, to consideration of first, the existence of a risk premium on

the demand for foreign assets by Australian investors. Furthermore, consideration is

taken of the relationship between the risk premium and government intervention

activity that may impact on investors' perceived riskiness of the holding of foreign

assets rather than domestic assets. The government's activity in the market may help

in explaining the rejection of the unbiasedness hypothesis. That is if the government's

activity is unstable in the sense of being of either uncertain timing or direction, then

investors may not have sufficient time to learn from period to period the

government's foreign exchange intervention rules which may induce investors to

make serially correlated errors.

The reason for the choosing a markets fundamentals approach to the risk premium

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[8]The composite hypothesis in this case has a number of simplifying assumptions. In the case of rejection of the null hypothesis, it is not clear which of the assumptions, for example same consumption shares across countries, and conditional homoscedasticity, lead to the rejection.

is that the overall emphasis of this thesis is on the explanation of exchange rate movements within a portfolio balance approach. Moreover, the alternative technique using an ARCH framework necessitates data frequency of less than monthly, preferably weekly or even daily and does not allow any endogenous variables other than the exchange rate and returns on assets to be included.

7.3 A model of the risk premium

In light of the above discussion, this section develops a model of the risk premium using a portfolio balance model framework. This allows the risk premium to be explained by the market fundamentals rather than by the statistical pattern of the prices and rates of return. The development of this model draws on the model of Danker *et al.* (1987). Their model however is enlarged in order to incorporate a more explicit role for central bank intervention behaviour, and the relationship of that intervention behaviour to the risk premium.

Danker *et al.* construct a two-country, portfolio-balance model of the risk premium. The significant difference between their analysis and other studies, for example Frankel (1982), is the careful construction of asset demands corresponding to different sectors of the economy. The model they develop is similar to a conventional portfolio balance model - such as that used for data analysis in Chapter three - but it incorporates the portfolio behaviour with respect to the demand for financial assets of the nonbank private sector (as in the conventional portfolio balance model), the banking sector and the central bank. This model is used as a starting point here to develop a theoretical model showing the relationship between the risk premium and

intervention activity.

7.3.1 The balance sheet constraint of the non-bank private sector

The balance sheet constraint of the non-bank private sector of the domestic economy is described in the following relationship. Private sector wealth is held in various forms[9]:

$$W_p = [C_p(X_p) + D_p(X_p) + T_p(X_p) + B_p(X_p) + (SF_p)(X_p)] - L_p(X_p)$$
$$(7.14)$$

where nominal net wealth, W is held as currency, C, demand deposits, D, fixed deposits, T, domestic bonds, B and foreign bonds expressed in domestic currency, SF, where S is the spot price of foreign currency in domestic currency units. Loans of the private sector are represented by L, and it is assumed here that all loans of the domestic banking system are to the domestic non-bank private sector and that the domestic private sector does not borrow from overseas, or in other words:

$$L_p = L_b$$

where the subscript b represents the domestic banking sector.

Households divide their wealth between two types of deposits in the banking system, interest bearing bonds of both domestic and foreign origin, and currency. This representation differs from the simple portfolio balance model of Chapter three where

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[9]Equity is excluded from this analysis.

the deposits of the retail banking sector are omitted.

The demand for each of these assets is a function of a vector, X_p, of the rates of return on interest bearing assets in the wealth function as well as the domestic price level, p, nominal income, y, and nominal private net wealth, W_p:

$$X_p = (r^H, r^T, r, r^{**}, r^L, p, y, W_p) \qquad (7.15)$$

Here r^H is the rate of return on both currency and demand deposits which is assumed to be zero[10], r^T is the rate of interest on fixed deposits, r^L is the rate of interest on loans, r is the domestic bond rate and r^{**} is the return on foreign bonds where:

$$r_t^{**} = r_t^* + s_{t+1}^e - s_t \qquad (7.16)$$

and all rates are return are nominal.

Equation (7.16) is an interpretation of the interest rate parity theorem where the total expected return on holding foreign bonds, r^{**} is a function of the rate of return on foreign bonds, r^* and the expected depreciation or appreciation of the foreign currency, where lower case s is the logarithm of the spot exchange rate, and s_{t+1}^e is the expected value of the logarithm of the future spot exchange rate[11].

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[10]The rate of return on currency whilst being zero in nominal terms, is not zero in real terms during an inflationary period.

[11]In the covered interest parity condition, the spot exchange rate is expressed in logarithms for two reasons. One is an issue of simplicity in the algebraic expressions used in the analysis. The second reason for using a logarithm form is connected to Siegel's paradox which has been mentioned earlier in this chapter.

7.3.2 The balance sheet constraint of the domestic banking sector

For the banking sector, the balance sheet constraint is that the financial liabilities - deposits from the non-bank private sector[12] - are equal to its financial assets:

$$TD_b = C_b(X_b) + B_b(X_b) + (SF_b)(X_b) + RR_b(X_b) + L_b(X_b)$$
$$(7.17)$$

The domestic banking sector accepts two types of deposits from the non-bank sector, that is demand deposits and time deposits (TD), and holds these liabilities in the form of currency (C), and domestic and foreign denominated bonds, required reserves (RR) at the central bank and loans to the non-bank domestic sector (L).

The required reserves are determined by the reserve ratio requirements of the central bank[13]. Assuming that the reserve ratios apply to both demand and time deposits, that the same reserve requirement applies to both forms of deposits and that no excess reserves are held, then the total reserves held at the central bank are:

$$RR_b = k_{DT}[D_p(X_p) + T_p(X_p)]$$
$$(7.18)$$

where k_{DT} is the reserve requirement on demand and time deposits.

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[12]It is assumed here that banks do not borrow: their debt/equity ratio is equal to zero.

[13]In Australia, the Banking Act requires that banks hold a given percentage of their domestic assets in high quality liquid assets such as cash, Commonwealth Government Securities and Reserve Bank deposits. This requirement called the Prime Assets Ratio (PAR) affects the amount of domestic currency and government bonds held by banks. The inclusion of this requirement would considerably complicate the analysis without necessarily improving the empirical explanatory power of the model. For this reason the impact of the prime assets ratio is ignored in this model development.

Thus the net demand and time deposits, (NTD_b) held by the banking sector are equal to the total deposits net of the reserve requirements of the central bank:

$$NTD_b = (1 - k_{TD})[D_p(X_p) + T_p(X_p)] \qquad (7.19)$$

The discretionary items in the banking sectors' balance sheet - currency (C_b), domestic bonds (B_b), foreign bonds (SF_b) and loans to the non-bank domestic sector (L_b) are functions of the vector X_b:

$$X_b = (r, r^{**}, r^H, r^L, p, NTD_b) \qquad (7.20)$$

where r^L is the rate of return to the banking sector on loans to the non-bank private sector, and r^H is assumed to be zero as before.

7.3.3 Balance sheet constraint of the central bank

The domestic central bank controls the money supply through its control over the issue of the domestic currency and the imposition of the reserve requirements on the domestic banking sector. Together the two liabilities - currency in the hands of the non-bank and bank private sector and reserve deposits at the central bank - represent the monetary base, H:

$$H = C_p + C_b + RR_b \qquad (7.21)$$

The central bank then disperses these liabilities amongst a number of key assets:

$$H = B_{cb}(X_{cb}) + SF_{cb}(X_{cb}) + C_{cb}(X_{cb}) + C^{*}_{cb}(X_{cb}) \qquad (7.22)$$

where C_{cb} represents domestic currency held by the central bank, C^{*}_{cb} represents foreign currency held by the central bank[14]. The currency assets have a nominal zero rate of return. Any valuation effects due to capital appreciation or depreciation are excluded. It is further assumed here that the central bank does not lend to the domestic banking sector[15].

The central bank's choice of one type of financial asset as opposed to another is a discretionary decision based in part on the rate of return on those assets. That choice however may also be tied to the role that the central bank has in the foreign exchange market. Intervention activity of the central bank entails purchasing or selling foreign exchange, and therefore altering the portfolio of foreign assets and currency, and domestic assets and currency in the balance sheet. The driving motivation for exchange rate intervention assumed here is leaning against the wind, or central bank activity that appreciates a depreciating exchange rate or depreciates an appreciating exchange rate. Thus exchange rate intervention is motivated by a desire to reduce the volatility of the exchange rate. Evidence of leaning against the wind intervention

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[14]Central bank holdings of gold are considered to be irrelevant to the central bank demand for domestic bonds function and are therefore excluded from the analysis

[15]The only situation in which the central bank would lend to the domestic banking sector is as a lender of last resort when the reserve deposits of the banking sector falls below the minimum requirement. It is assumed here - once again for the sake of simplicity - that there is strict adherence to the central bank's reserve deposits requirements.

behaviour is well-documented both in this thesis[16] and in the exchange rate literature
(Quirk, 1977, Hopkins, 1987).

Footnote two in this chapter notes that the presence of a risk premium is generally
considered to be essential in order for sterilised intervention to be effective. Sterilised
intervention leaves the monetary base unchanged and therefore influences the
exchange rate value solely by altering the currency composition of the supply of
bonds available to investors. There is really a two-way effect that needs to be
considered in both model development and more particularly in terms of its empirical
interpretation. That is, although a risk premium is essential for sterilised intervention
to be effective, that intervention in turn may affect the size of the risk premium.

The assets comprising the portfolio of the central bank are functions of a vector X_{cb}
of rates of return, the change in the exchange rate, the price level and the monetary
base:

$$X_{cb} = (r, r^{**}, r^H, \Delta S_p, p, H) \qquad (7.23)$$

The exchange rate term, ΔSt is equal to the difference between this period and last
period's nominal exchange rates, $S_t - S_{t-1}$, and indicates that in part, the central bank's
demand for foreign bonds or currency is tied to the bank's intervention activity.
Additionally however, the demand for these assets may be tied to relative rates of

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[16]Intervention behaviour is discussed in section 4.3, and there is a comprehensive analysis of
empirical results from an examination of intervention behaviour by the Australian Reserve Bank in
Appendix A.3.

return on foreign and domestic assets. The rate of return on domestic money, r^H is assumed to be equal to zero.

There are four market clearing conditions: domestic and foreign monetary bases and domestic and foreign bonds. The market clearing condition for the domestic monetary base has been presented above in equation (7.21), but is repeated here for the sake of completeness:

$$H = C_p + C_b + RR_b \qquad (7.21)$$

where the domestic monetary base comprises the reserve deposits of the domestic banking sector with the central bank and the currency held by the private sector.

The total demand for domestic bonds is represented by the equality:

$$B = B_p + B_b + B_{cb} + B_p^* + B_b^* + B_{cb}^* \qquad (7.24)$$

which is the summation of domestic and foreign demand across three sectors.

Finally, the total demand for foreign bonds is defined in an analogous way:

$$F = F_p + F_b + F_{cb} + F_p^* + F_b^* + F_{cb}^* \qquad (7.25)$$

which represents the total demand for foreign bonds from the domestic and foreign economy.

7.4 Bond demand equations

A number of assumptions are made in aggregating the demand for domestic bonds across the three sectors of the economy. The first is that the demand for bonds is a function of the interest rate differentials in preference to interest rates levels. The second assumption is that the real value of bonds matters in the decision-making process of investors and not their nominal value. This latter assumption is made and supported by the earlier analysis: in Chapter three, the exchange rate value as the dependent variable in the portfolio balance model responds with more significance to real variables, and in Chapter six asset demand, income and wealth variables are all expressed in real terms. Furthermore the real demand for bonds is a function of other real variables in the economy including real income and real wealth.

Considering first the sector by sector determinants of bond demand before aggregating the net domestic demand for bonds, the real demand for bonds in the non-bank private sector is determined as follows:

$$\frac{B_p}{p} = \rho_0 + \rho_1(r-r^{**}) + \rho_2(r-r^{H}) + \rho_3(r-r^{T}) + \rho_4\frac{Y}{p} + \rho_5\frac{W}{p} + \epsilon_1$$

$$(7.26)$$

where the total return on holding foreign rather than domestic bonds, r^{**} is described in equation (7.16) as a function of the rate of return on foreign bonds, r^{*} and the expected depreciation of the foreign currency, $s^{e}_{t+1} - s_t$. Alternatively (7.16) can be written as:

$$r - r^{**} = -r^* + r - s^e_{t+1} + s_t \qquad (7.27)$$

Thus the demand for bonds by the non-bank private sector in (7.26) is influenced by the rate of return differential between domestic and foreign bonds, $r - r^{**}$, the interest rate differential between domestic bonds and currency and demand deposits[17], $r - r^H$, the interest rate differential between domestic bonds and time deposits, $r - r^T$, and real income, Y/p, and real net wealth, W/p. The interest rate differentials in (7.26) follow the same principle, in all cases the higher is the domestic bond rate, the higher is the real demand for bonds. An increase in real wealth, increases the demand for bonds; an increase in real income, however, increases the transactions demand for money from a fixed supply and the demand for bonds decreases and the rate of interest increases.

The real demand for bonds in the bank sector is determined as follows:

$$\frac{B_b}{p} = \pi_o + \pi_1(r-r^{**}) + \pi_2(r-r^H) + \pi_3(r-r^L) + \pi_4\frac{NTD_b}{p} + \epsilon_2$$
$$(7.28)$$

where the real net demand and time deposits, NDP_b/p of the bank sector are a measure of wealth or well-being, analogous to the real net wealth of the private sector. Thus an increase in real net demand and time deposits, NDP_b/p, increases the

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[17]The interest rate differential reduces to the bond rate expressed as a level as the return on currency and demand deposits is assumed to be equal to zero.

demand for bonds. The third interest rate differential term in (7.28) represents the difference between the rate of return on bonds and the rate of return on loans to the private non-bank sector, $r - r^L$. The higher is the rate of return on bonds, r, the higher is the demand for bonds by the bank sector.

The real demand for bonds by the central bank is defined in (7.29) as:

$$\frac{B_{cb}}{p} = \sigma_0 + \sigma_1(r-r^{**}) + \sigma_2(r-r^B) + \sigma_3\Delta S + \sigma_4\frac{H}{p} + \epsilon_3$$
$$(7.29)$$

where the level of monetary base, H, represents the real financial liabilities of the central bank. The higher the monetary base, the higher is the real demand for bonds by the central bank. The change in exchange rate term, ΔS, is positive if the domestic currency is depreciating relative to the foreign currency and negative if the domestic currency is appreciating. Given that the central bank undertakes a leaning against the wind exchange rate intervention policy, an appreciating currency will lead the central bank to decrease the demand for domestic currency and therefore bonds. Thus the sign on the exchange rate term in the above equation is positive.

In the derivation of equation (7.30) below, it is assumed that the return on currency and demand deposits, r^H is assumed to be zero, and therefore omitted from the analysis. The omission of r^H leads to the expression of the domestic bond rate as a level rather than a differential. Combining the three sector real demand for bonds equations, namely (7.26), (7.28) and (7.29) and expressing the relationship in a form suitable for empirical analysis:

$$\frac{B}{p} = \alpha_0 + \alpha_1(r-r^{**}) + \alpha_2 r + \alpha_3(r-r^T) + \alpha_4(r-r^L) + \alpha_5\Delta S + \alpha_6\frac{Y}{p}$$
$$+ \alpha_7\frac{W}{p} + \alpha_8\frac{NTD}{p} + \alpha_9\frac{H}{p} + \mu_1 \qquad (7.30)$$

where $\alpha_0 = \rho_0 + \pi_0 + \sigma_0, \quad \alpha_1 = \rho_1 + \pi_1 + \sigma_1,$

$\alpha_2 = \rho_2 + \pi_2 + \sigma_2, \alpha_3 = \rho_3, \quad \alpha_4 = \pi_3, \quad \alpha_5 = \sigma_3,$

$\alpha_6 = \rho_4, \alpha_7 = \rho_5, \alpha_8 = \pi_4, \alpha_9 = \sigma_4,$ and

$B = B_p + B_b + B_{cb};$

$\mu_1 = \varepsilon_1 + \varepsilon_2 + \varepsilon_3$ (a normal error term).

As the objective here is to test for the presence of a risk premium in the demand for domestic bonds, the bond demand equation (7.30) is inverted so that the risk premium, $(r-r^{**})$ becomes the dependent variable in the equation. Inversion of equation (7.30) yields:

$$(r - r^{**}) = \gamma_0 + \gamma_1 r + \gamma_2(r-r^T) + \gamma_3(r-r^L) + \gamma_4\Delta S$$
$$+ \gamma_5\frac{Y}{p} + \gamma_6\frac{W}{p} + \gamma_7\frac{NTD}{p} + \gamma_8\frac{H}{p} + \gamma_9\frac{B}{p} + \mu_3$$
$$(7.31)$$

where:

$$\gamma_0 = -\frac{\alpha_0}{\alpha_1}, \quad \gamma_1 = -\frac{\alpha_2}{\alpha_1}, \quad \gamma_2 = -\frac{\alpha_3}{\alpha_1}, \quad \gamma_3 = -\frac{\alpha_4}{\alpha_1}, \quad \gamma_4 = -\frac{\alpha_5}{\alpha_1},$$

$$\gamma_5 = -\frac{\alpha_6}{\alpha_1}, \quad \gamma_6 = -\frac{\alpha_7}{\alpha_1}, \quad \gamma_7 = -\frac{\alpha_8}{\alpha_1}, \quad \gamma_8 = -\frac{\alpha_9}{\alpha_1}, \quad \gamma_9 = \alpha_1, \quad \mu_3 = \frac{\mu_1}{\alpha_1}$$

The risk premium equation in terms of domestic demand for domestic bonds is now in an empirical form amenable for econometric analysis. The task of the next chapter is to undertake this empirical analysis. In doing so two questions are addressed. The first is as follows: is there a risk premium on the Australian dollar with respect to the United States currency? And the second question is: what influence does the intervention activity of the central bank have on that risk premium?

Chapter 8: EMPIRICAL ANALYSIS OF A RISK PREMIUM MODEL AND ITS RELATIONSHIP TO INTERVENTION

There are two fundamental questions addressed in this chapter. These are noted at the end of the previous chapter however in the interests of emphasis and simplicity, they are repeated here. The first issue is to determine if there is a risk premium on the holding of Australian dollar denominated bonds rather than foreign dollar denominated bonds. The second issue concerns the relationship of an observed risk premium to central bank intervention behaviour. Consideration of the second issue involves an explanation of how the risk premium has changed along with the management of the domestic currency. Thus this second issue involves some prior knowledge of the timing of alterations of central bank intervention behaviour. The model used to consider these issues is that developed in the previous chapter. In particular, equation (7.31) is used to test for a risk premium on the domestic demand for domestic denominated bonds.

8.1 Empirical specification of a risk premium equation

The risk premium equation based on the Australian demand for Australian bonds equation (7.31) is reproduced here from Chapter 7 with the expected signs:

$$(r - r^{**}) = \gamma_0 - \gamma_1 r - \gamma_2(r - r^T) - \gamma_3(r - r^L) - \gamma_4 \Delta S$$
$$+ \gamma_5 \frac{Y}{P} - \gamma_6 \frac{W}{P} - \gamma_7 \frac{NTD}{P} - \gamma_8 \frac{H}{P} + \gamma_9 \frac{B}{P} + \mu_3$$

$$(8.1)$$

The coefficients on all the interest rate terms are expected to be negative, implying

that an increase in the bond rate relative to other rates of return increases the demand

for bonds. An increase in the demand for bonds increases the market price and the

effective rate of return decreases[1].

An increase in the spot exchange rate indicates a depreciation: thus the central bank

leans against the wind by increasing the demand for Australian dollar denominated

bonds. The increase in the demand for bonds increases their market price and the rate

of interest decreases. The interest rate decrease produces an appreciation to offset the

initial depreciation. Thus the depreciating exchange rate leads to a decrease in the

risk premium: the sign on the exchange rate term is negative. A complicating factor

here is whether the central bank chooses to sterilise the intervention activity or not[2].

To some extent the relationship between sterilised or unsterilised intervention and the

risk premium is the crux of the risk premium issue. Sterilised intervention aims to

alter the currency composition of bonds held in the domestic economy. A central

bank increase in the demand for domestic bonds appreciates the spot exchange rate

by increasing the demand for domestic currency required to purchase those bonds.

The money supply decreases as the central bank draws in domestic currency in order

to effect these purchases. If the central bank chooses to sterilise or counteract the

impact of its intervention activity on the domestic money supply, then they may

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[1]Refer to footnote 12, Chapter two for a discussion of the relationship between a bond price and its effective rate of return.

[2]Sterilisation is discussed in section 5.1 and 7.1. A conclusion of the empirical analysis presented in section 6.2 and 6.3 is that intervention activity of the Reserve Bank of Australia has been unsterilised over the time period under consideration.

conduct open market purchases of government bonds. This produces the money supply sterilisation which leaves both the monetary base and the money supply unchanged. What the central bank action has done however, is to change the supply of domestic bonds available for domestic investors altering their portfolio choices.

If on the other hand the central bank does not sterilise its intervention activity, then the decrease in the money supply leads to an increase in the domestic rate of interest and a capital inflow. The marketplace actions of the private sector in causing an appreciation of the currency thus complement the initial action of the central bank. For this reason, unsterilised intervention is considered to be a more effective means of achieving exchange rate adjustment. An outcome of this discussion is that the determination of the sign on the monetary base variable in the equation is not straightforward. The simple relationship between the risk premium and the monetary base is discussed below.

Central bank intervention activity provides a link between the initial change in the exchange rate and the change in the demand for the domestic currency necessary to effect a desired outcome in the exchange rate. Not all changes in the exchange rate, however generate intervention action by the central bank. For this reason, in the empirical analysis below, an intervention variable is used as a proxy for a change in the exchange rate.

Section 5.1 presents a theoretical specification of intervention behaviour which is repeated here:

$$i_t = -\alpha_{38}\Delta s_t - \alpha_{39}(s_t - \bar{s}) \qquad\qquad (5.7)$$

where i refers to purchases by the central bank of foreign exchange for intervention purposes and $\bar{s}$ is a target exchange rate. Thus intervention behaviour is of two types. The first variable represents leaning against the wind intervention activity where the central bank intervenes to partially resist market forces and stabilise the exchange rate. The second variable represents exchange rate targeting: intervention aimed at moving the exchange rate toward a predetermined target. The empirical testing of equation (5.7) in Chapter six found poor support for the hypothesis of exchange rate targeting by the Reserve Bank of Australia. Therefore, the targeting variable is omitted from the analysis here. There was strong support for leaning against the wind intervention activity in the empirical analysis of equation (5.7) using OLS estimators. These results are presented in section 6.2.

Given the negative relationship between a change in the exchange rate term and the intervention variable, the intervention variable enters equation (8.1) with a positive sign. Thus a depreciation of the exchange rate leads to a decrease in intervention assets held by the central bank as it leans against the wind by swapping foreign assets for domestic assets. The resulting increase in the demand for domestic bonds increases the price of bonds and decreases the rate of return on them. The risk premium in (8.1) decreases as a consequence.

The sign on real income is positive, as an increase in real income increases the transactions demand for money from a given fixed money supply while the demand

for bonds decreases and the rate of interest increases.

An increase in any one of the wealth variables in equation (8.1), namely net private real wealth, W/p, net time and demand deposits of the banking sector, NTD/p, and the monetary base controlled by the central bank, H/p, increases the demand for domestic bonds. An increase in the demand for bonds, increases the price of bonds increase and the interest rate decreases. Thus the sign on all the wealth variables is negative.

The sign on the real bond demand is positive as from an initial position of equilibrium between bond demand and bond supply, an increase in bond supply at a given rate of interest as a result of a change in the government's financing requirements implies that the supply of bonds is greater than the demand for bonds. The price of bonds therefore decreases and the interest rate increases.

In equation (8.1), the size of the coefficients on the interest rate differentials reflect the degree of substitutability between domestic and foreign financial assets. Therefore the null hypothesis of perfect substitution is tested against the alternative hypothesis that bonds denominated in different currencies are imperfect substitutes. Acceptance of the null hypothesis is based on coefficients on the right-hand side of equation (8.1) being equal to zero. Acceptance of the alternative hypothesis of imperfect substitutability implies that coefficients on the right-hand side variables are finite and preferably significant[3].

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[3]Caution is required in interpretation of results in this analysis. Frankel (1982) notes with respect to his analysis of a risk premium, that failure to reject the null hypothesis does not nonetheless mean that the null is true. It may be that our tests are simply not powerful enough.

8.2 Assumptions about expectations formation in the risk premium equation

In the actual empirical analysis of the risk premium equations, two assumptions are made about expectations formation following Danker *et al.* These assumptions about expectations formation are necessary given that in the theoretical specification of the risk premium equation in the previous chapter, the risk premium is defined as follows:

$$r_t - r_t^{**} = -r_t^* + r_t - s_{t+1}^e + s_t \qquad (7.28)$$

The first assumption requires expectations to be formed statically in which case the expected future spot rate is equal to the current rate:

$$s_{t+1}^e = s_t \qquad (8.2)$$

which indicates that the expected exchange rate value in the next time period is equal to the exchange rate this period.

The second assumption is that expectations are formed rationally where the expected future spot rate is the mathematical expectation of the future spot rate, given a current information set, I_t:

$$s_{t+1}^e = E(s_{t+1}^e \mid I_t) \qquad (8.3)$$

where E is the expectations operator. The proxy used for the future spot rate under this assumption is the realised value of the spot rate in the next time period.

Testing for a risk premium under the assumption of rational expectations imposes a similar difficulty to that encountered by other researchers, namely, in the empirical analysis of equation (8.1), there is a joint hypothesis of rationality and perfect substitutability. This problem is mentioned in section 7.2. Thus rejection (or acceptance) of the null hypothesis imposes the potential difficulty of which part of a composite hypothesis is subject to rejection (or acceptance).

In order to model rational expectations and avoid the difficulty of interpretation of results where there are composite hypotheses, Danker et $al.$, transform the data to remove both the autoregressive error in the residual, and the moving average error component which results from using the actual future value of the spot rate as a proxy for the expected future spot rate in constructing the series for r^{**}. This transformation into a model without autocorrelation allows the instruments in the instrumental variables technique to remain predetermined. This procedure which follows the work of McCallum (1976), Cumby, Huizinga and Obstfeld (1983), and Hayashi and Sims (1983) is applicable to models assuming rational expectations.

Following Danker et $al.$, the procedure to remove the autoregressive and moving average error from the bond demand equations assuming rational expectations is outlined in Appendix A.4. This procedure yields an equation for bond demand where the forward lag operator $(1 + \gamma F)$ ensures that both the autoregressive and moving average error is removed. The equation for estimation from Appendix A.4 is:

$$(1 - \rho L)\hat{b}_t = \alpha_0(1 - \rho L)\mathring{R}_t + \alpha_1(1 - \rho L)\mathring{X}_t + \psi_t$$

$$(A.4.16)$$

where

$$\hat{b}_t = \frac{b_t}{1 + \lambda F}, \quad \mathring{R}_t = \frac{R_t}{1 + \lambda F}, \quad \mathring{X}_t = \frac{X_t}{1 + \lambda F}$$

A two step procedure is applied in estimation. The first step is to estimate equation (8.1) as either a bond demand equation or in inverted form with the risk premium as the dependent variable, using non-linear two stage least squares assuming no moving average error but accommodating possible first order autoregressive error. Next, the coefficient on the forward lag operator in equation (A.4.16), γ is estimated by applying an autoregressive, integrated moving average (ARIMA) model to the residuals from the first step. The second step requires re-estimation of the two stage least squares equation with the same instrumental variables as before but with the data transformed by the estimated value of γ. This procedure yields an estimated equation of the risk premium on the assumption of rational expectations with white noise error.

8.3 Estimated risk premium equations assuming central bank involvement

This section and Tables 8.1 and 8.2 present the results from the empirical estimation of equation (8.1) under the two different assumptions about expectations formation. Table 8.1 presents the results from the estimation of a variation of equation (8.1) as follows:

$$(r - r^{**}) = \gamma_0 - \gamma_1 r - \gamma_2 (r - r^T) + \gamma_3 \Delta I + \gamma_4 \frac{Y}{p}$$
$$- \gamma_5 \frac{W}{p} - \gamma_6 \frac{NTD}{p} - \gamma_7 \frac{H}{p} + \gamma_8 \frac{B}{p} + \mu$$

(8.4)

where expectations formation is static, as described in equation (8.2), the interest rate on loans, r^L, is omitted due to the unavailability of a full data set and an intervention variable, ΔI is used as a proxy for movements in the spot rate, as described in section 8.1.

The data are monthly and the total time period extends from July 1970 to November 1989. The actual data set analysed is smaller than that due to lags in the estimation process. The chosen time period reflects both data availability and the coverage of a number of substantial changes in the management of the Australian currency. All data sources are indicated in the data appendix.

The time periods for division of the major sample correspond to chosen dates of significant changes in management of the Australian currency. The first subsample extends from the beginning of the sample until the end of the fixed trade-weighted exchange rate regime in December 1976. The second subsample corresponds to the era of the crawling peg trade-weighted exchange rate regime from January 1977 to November 1983. The third subsample extends from the beginning of the floating exchange rate until the end of the sample. The data were examined for major changes in risk premia prior to October 1985 and post October 1985 as there is evidence of

heavier intervention activity by the Reserve Bank of Australia[4] in this latter time period. Subsamples four and five thus represent a split of subsample three.

A non-linear instrumental variables estimation technique is used for all equations. The reasons for the choice of the two stage least squares technique is outlined above and in Appendix A.4. The non-linear specification is considered appropriate in this situation where the variables are real and all variables except the rates of return are expressed as natural logarithms. Alternative estimations using linear techniques were trialled and did not produce significantly different results. All variable series were examined for stationarity using the Dickey Fuller tests outlined in section 3.3. On the basis of that test, those variables nonstationary in levels but stationary in first differences (that is integrated of order one) are thus expressed in the estimation equations as first differences[5]. Instrumental variables are all the exogenous variables in the analysis.

The only significant and correctly signed coefficient in Table 8.1 is for real bond demand in the first subsample. This result is pleasing as it supports the portfolio balance model. The last subsample from - the end 1985 to the end of the sample - has a number of correctly signed but insignificant coefficients.

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[4]Refer to section 3.2 for more detail.

[5]The expression of the dependant and some right-hand side variables in levels and the remaining right-hand side variables in differences means that the estimating equation differs from the theoretical specification of the relationship. Given, however that the theory is not specific as to whether the variables are in levels or differences, the applied specification is considered valid. The alternative approach to this problem is to estimate the equation in its theoretical specification with all variables expressed in levels. In this case, there would be a mixture of stationary and nonstationary variables in the estimating equation and the interpretation of the results is problematic.

The Wald[a] statistic is used to test the null hypothesis that the coefficient values are equal to zero rather than the more commonly used F statistic due to the nonlinearity in the estimation equation (8.4). The rejection of the null hypothesis indicates that the movement of the risk premium is being explained by the right-hand side variables in the estimating equation (8.4). The Wald[a] statistic was calculated twice for each of the estimation equations in the chapter: first with all variables including the interest rate level term and second with all variables but excluding the interest rate level term. The Wald[a] statistic results in each table in this chapter represent the first method of calculation. The reason for the two different methods of calculation is to consider whether the interest rate term alone is explaining the changes in the risk premium. In Table 8.1, the null hypothesis that the coefficient values are equal to zero is rejected across all time periods, it is similarly rejected when the interest rate level term is omitted from the calculation..

The Wald[b] statistic tests the null hypothesis of parameter stability between a full sample and subsamples in the presence of heteroscedasticity[6]. In Table 8.1, all the Wald[b] statistics for parameter stability are insignificant indicating that the null hypothesis is accepted.

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[6]A number of tests, namely the Breusch-Pagan-Godfrey test, the Harvey test, the ARCH test and the Glejser test from the SHAZAM Econometrics Computer Program (White *et al.* 1990) were applied to the residuals of the equations of estimation. These revealed considerable heteroscedasticity. The Wald test for parameter stability of equations with unequal variances used here was developed by Watt(1979).

Table 8.1: Risk premium equation (8.4) assuming static expectations

	1971:02 to 1989:11	1971:02 to 1976:12	1977:01 to 1983:11	1983:12 to 1989:11	1983:12 to 1985:10	1985:11 to 1989:11
const.	-14.027 (-2.4269)	-15.101 (-1.6366)	-15.027 (-1.2928)	-25.408 (-2.5403)	-20.148 (-0.8178)	-22.825 (-2.1233)
r	0.9399 (16.506)	1.1315 (13.461)	0.9187 (7.790)	0.9937 (10.922)	0.6928 (3.8343)	1.0284 (9.4805)
$(r - r^T)$	-0.0169 (-0.4832)	0.0068 (0.1525)	0.0439 (0.5743)	-0.0823 (-1.3708)	-0.1742 (-1.7589)	-0.1066 (-1.3381)
Y/p	0.7668 (0.8531)	-0.6965 (-0.6158)	1.6819 (0.7591)	1.4444 (1.084)	3.3262 (0.8122)	1.1796 (0.8319)
ΔW/p	-0.0186 (-0.2561)	-0.0704 (1.3416)	3.3757 (3.2840)	-0.4242 (-0.8498)	-0.8452 (-0.6334)	-0.8199 (-1.4939)
Δ(NTD/p)	0.4924 (0.6322)	2.0623 (1.3927)	-0.3942 (-0.3204)	1.8931 (1.1865)	-0.4105 (-0.1132)	1.7060 (0.9511)
Δ(B/p)	0.0001 (0.1639)	0.0001 (2.1459)	-0.0001 (-0.2136)	-0.0001 (-0.1118)	-0.0001 (-2.0345)	0.0001 (0.1142)
Δ(I)	0.2415 (0.1538)	2.4126 (1.0196)	-2.3270 (-0.8194)	-1.0913 (-0.3693)	-6.3108 (-1.1255)	1.1956 (0.3363)
(H/p)	0.4385 (0.4283)	-0.8074 (-0.5834)	3.3941 (1.5439)	-0.6994 (-0.3859)	1.5001 (0.4544)	-1.0454 (-0.4844)
ρ_{-1}	1.335 (21.8)	1.3221 (12.599)	1.3234 (12.879)	1.4329 (13.737)	1.7124 (13.174)	1.3678 (10.8057)
ρ_{-2}	-0.361 (-5.897)	-0.3899 (-3.716)	-0.3662 (-3.564)	-0.4770 (-4.5735)	-0.7926 (-6.0979)	-0.4805 (-3.7959)
$\bar{R}^2$	0.9689	0.9450	0.8636	0.9822	0.9735	0.9628
SER	0.1936	0.3004	0.5634	0.3475	0.3327	0.3287
WALD[a]	316.9**	195.58**	69.453**	209.846**	42.722**	176.58*
WALD[b]	-	11.776*	12.998	3.1962	10.273	4.6114

Notes: the figures in brackets are T statistics. The *rho* value in the table refers to a situation where a first order or second order autocorrelation of the error equation is applied to the data. The Wald[a] statistic is an asymptotic χ^2 test statistic appropriate for testing the null hypothesis that the coefficient values in all equations are insignificantly different to zero where the restrictions are nonlinear. The double asterisk indicates that χ^2 for the Wald statistic exceeds its 99% critical value. The Wald[b] statistic is testing the null hypothesis of coefficient stability across subsamples in the presence of heteroscedasticity. The asterisk indicates that χ^2 for the Wald statistic exceeds its 95% critical value. SER refers to the standard error of the regression.

The intervention variable used to proxy the change in the exchange rate term is represented by a change in the foreign assets and gold held by the central bank. The expected sign on the intervention variable is positive for reasons described above. In Table 8.1, the intervention variable is positive but not significant in three sample periods, including the full sample.

Table 8.2 presents the same estimation equation as in Table 8.1 but under the assumption of rational expectations as described in equation (8.3). The fourth subsample representing the period from the floating exchange rate regime to late 1985 offers the best results for this particular estimation equation. Every coefficient, apart from the interest rate level term, is correctly signed; although none are significant at the 95% critical level. Incorrectly signed interest rate terms have been a reasonably consistent feature of the empirical results. The interpretation of the incorrectly signed coefficients may be that there is a multicollinearity problem.

All time periods are support the existence of a risk premium, as the Wald[a] test is significant at least the 95% critical level both when the domestic interest rate term is included and excluded from the calculation. The null hypothesis of parameter stability is rejected in the first subsample only. This is the period corresponding to the crawling peg trade-weighted exchange rate regime and one in which market forces were the least predominant of all subsamples.

Table 8.2: Risk premium equation (8.4) assuming rational expectations

	1971:02 to 1989:11	1971:02 to 1976:12	1977:01 to 1983:11	1983:12 to 1989:11	1983:12 to 1985:10	1985:11 to 1989:11
const.	1.4734 (0.5860)	0.5222 (0.4974)	-0.9973 (-0.2807)	-0.0452 (-0.5271)	-0.4866 (-0.7730)	-0.5054 (-0.3812)
r	0.5407 (0.89035)	0.6128 (3.2204)	-1.0849 (-0.1515)	1.5197 (0.4971)	1.4264 (2.0487)	1.1275 (1.5271)
$(r - r^T)$	-1.2415 (-0.7823)	-0.0893 (-0.1287)	2.6671 (0.3393)	-0.8133 (-0.2614)	-0.0412 (-0.0703)	-0.5079 (-0.3250)
Y/p	-6.2270 (-0.2773)	-3.1635 (-0.3516)	0.0539 (0.0009)	18.153 (0.6293)	9.0743 (0.6599)	-4.2407 (-0.2725)
ΔW/p	12.063 (1.0218)	-0.1963 (-1.0376)	-35.122 (-0.4221)	-31.575 (-0.7029)	-5.8698 (-0.5907)	13.451 (0.7801)
Δ(NTD/p)	4.572(0.2336)	1.9992 (0.2590)	3.1346 (0.0825)	-20.104 (-0.9677)	-11.664 (-0.9515)	1.8496 (0.1308)
Δ(B/p)	0.0002 (0.1717)	-0.0001 (-0.1284)	0.0005 (0.2740)	-0.0006 (-0.8885)	0.0002 (0.7357)	-0.0004 (-0.7168)
Δ(I)	-12.67(-0.1549)	9.9663 (0.6429)	125.5(0.8506)	-51.752 (-0.5367)	8.7201 (0.1870)	-17.985 (-0.2687)
(H/p)	3.0640 (0.0438)	-4.7871 (-0.8174)	-39.624 (-0.2438)	59.575 (0.3439)	-26.86 (-1.4848)	-19.255 (-0.2331)
$\bar{R}^2$	0.9318	0.9532	0.8470	0.9923	0.8195	0.9976
SER	25.455	6.1193	6.9349	0.3526	1.8638	4.1946
WALD^a	78.923**	630.95**	57.155**	602.06**	92.40**	3725.5**
WALD^b	-	4.6673**	1.4698	5.309	34.97	0.9020

Notes: the figures in brackets are T statistics. The Wald^a statistic is an asymptotic χ^2 test statistic appropriate for testing the null hypothesis that the coefficient values in all equations are insignificantly different to zero where the restrictions are nonlinear. The Wald^b statistic is testing the null hypothesis of coefficient stability across subsamples in the presence of heteroscedasticity. The double asterisk indicates that the χ^2 value for the Wald statistic exceeds its 99% critical value. SER refers to the standard error of the regression.

Only in the fourth subsample is there evidence of support for the portfolio balance model explanation of the risk premium: that is where the coefficient on the real bond demand variable is of the correct sign and significant at the 75% level of confidence. There is on the basis of the empirical results presented here both in the last table and

the previous one, no statistically significant evidence of a relationship between the intervention activity of the central bank and the risk premium.

8.4 Estimated risk premium equations assuming no central bank involvement

The empirical analysis in this section omits the central bank variables from equation (8.4). Such an omission enables a better comparison of the results presented in Table 8.3 with those of Danker *et al.* which use different data sets. The estimation equation in this section is as follows:

$$
(r - r^{**}) = \gamma_0 - \gamma_1 r - \gamma_2 (r - r^T) + \gamma_3 \frac{Y}{p}
$$
$$
- \gamma_4 \frac{W}{p} - \gamma_5 \frac{NTD}{p} + \gamma_6 \frac{B}{p} + \mu
$$

$$(8.5)$$

where the central bank variables are omitted due to the reasons mentioned above and r^L is omitted due to data unavailability.

Table 8.3 presents results for the risk premium equation (8.5) for domestic demand for domestic bonds assuming static expectations and excluding the central bank activity that may impact on that risk premium. The overall results are mixed. A consistent feature across subsamples however, is the lack of significance of variables, and a tendency for those variables to be on the whole of the unexpected sign.

The absence of the interest rate level term in the calculation of the Wald[a] statistic renders the statistic insignificant at the 95% critical level across the full sample and all subsamples. The appropriate interpretation here is that movements in the domestic

interest rate influence the risk premium. The other explanatory variables in the equation (8.2) have a combined explanatory power approaching zero. Importantly, this result does not support the portfolio balance model.

Table 8.3: Risk premium equation (8.5) assuming static expectations

	1970:08 to 1989:11	1970:08 to 1976:12	1977:01 to 1983:11	1983:12 to 1989:11	1983:12 to 1985:10	1985:11 to 1989:11
const.	-15.02 (-2.801)	-13.810 (-1.572)	-17.688 (-1.5635)	-22.992 (-2.798)	-15.023 (-0.7908)	-19.846 (-2.2171)
r	0.9396 (16.800)	1.1212 (13.565)	0.9227 (7.9719)	0.9926 (11.176)	0.7214 (4.0963)	1.0165 (9.7782)
$r - r^T$	-0.0177 (-0.5090)	-0.0041 (-0.0953)	0.0125 (0.1673)	-0.0892 (-1.4484)	-0.16028 (-1.7057)	-0.0938 (-1.2746)
Y/p	0.7893 (0.8851)	-0.6888 (-0.6220)	1.3003 (0.5928)	1.2966 (1.0210)	0.7538 (0.2249)	1.3158 (0.9594)
ΔW/p	-0.0178 (-0.2446)	-0.0691 (-0.13281)	2.8754 (2.9061)	-0.4545 (-0.9409)	-0.7796 (-0.616)	-0.7701 (-1.4471)
Δ(NTD/p)	0.6690 (0.9910)	1.8177 (1.3769)	0.4682 (0.4278)	1.5544 (1.3372)	0.8138 (0.3190)	1.0329 (0.7748)
Δ(B/p)	0.0001 (0.1696)	0.0001 (2.10929)	-0.0001(-0.2592)	-0.0001 (-0.1420)	-0.0001 (-2.0558)	0.0001 (0.7495)
ρ_{-1}	1.3351 (21.80)	1.3266 (12.665)	1.318 (12.812)	1.4353 (13.77)	1.7062 (13.019)	1.3454 (10.5332)
ρ_{-2}	-0.3613 (-5.90)	-0.3938 (-3.7597)	-0.3633 (-3.5318)	-0.479 (-4.597)	-0.7888 (-6.0186)	-0.4656 (-3.6455)
$\bar{R}^2$	0.9691	0.9457	0.8621	0.9826	0.9745	0.9643
SER	0.4381	0.2985	0.5663	0.3429	0.3266	0.3218
WALD[a]	319.22**	200.15**	69.185**	215.55**	55.68**	189.43**
WALD[b]	-	11.179	10.5314	2.7866	9.1837	4.1555

Notes: the figures in brackets are T statistics. The *rho* values in the table refers to a situation where an autocorrelation of the error equation is applied to the data. The Wald[a] statistic is an asymptotic χ^2 test statistic appropriate for testing the null hypothesis that the coefficient values are insignificantly different to zero where the restrictions are nonlinear. The Wald[b] is testing the null hypothesis of parameter stability across subsamples in the presence of heteroscedasticity. The asterisk indicates that the χ^2 value for the Wald statistic exceeds its 95% critical value. The double asterisk indicates that the statistic exceeds it 99% critical value. SER refers to the standard error of the regression.

Table 8.4 presents the results from the estimation of equation (8.5) assuming that expectations are formed rationally rather than statically. The proxy for the expected spot rate this period is the realised spot rate next period as described in equation (8.3).

Table 8.4: Risk premium equation (8.5) assuming rational expectations

	1970:08 to 1989:10	1970:08 to 1976:12	1977:01 to 1983:11	1983:12 to 1989:10	1983:12 to 1985:10	1985:11 to 1989:10
const.	-5.5433 (-0.4811)	3.5442 (1.0017)	0.1018 (0.4262)	-0.1331 (-0.3110)	-0.2318 (-0.1692)	-0.1276 (-0.1534)
r	0.3420 (0.2438)	0.8762 (3.6623)	-0.7557 (-1.0922)	1.9611 (0.4422)	3.3740 (1.9171)	0.4783 (0.2974)
$(r - r^T)$	-0.8559 (-0.0527)	0.2434 (0.5155)	0.9961 (0.3033)	-1.8501 (-0.6495)	-0.1247 (-0.1370)	-0.4409 (-0.1404)
Y/p	-0.398 (-0.0024)	1.049 (0.2572)	-0.1823 (-0.0048	-36.226 (-0.4532)	-9.3226 (-0.5582)	6.1308 (1.4449)
ΔW/p	-16.528 (-0.4736)	0.6287 (0.2811)	-15.057 (-0.202)	6.1298 (0.0735)	22.376 (1.2241)	-9.9191 (-0.2379)
Δ(NTD/p)	-0.1260 (-0.0008)	-2.1132 (-0.6023)	2.008 (0.0595)	28.309 (0.4643)	0.1789 (0.0125)	-5.827802 (-1.1458)
Δ(B/p)	0.0024 (0.0749)	-0.0001 (-0.3407)	0.0002 (0.1481)	0.0005 (0.0851)	-0.0004 (-0.4916)	-0.0001 (-0.0831)
$\bar{R}^2$	0.9776	0.8322	0.5533	0.9672	0.9996	0.9992
SER	65.818	15.9666	1.0671	1.7337	4.2386	3.1718
WALD[a]	113.706**	128.57**	11.358**	359.832**	384.16**	353.67**
WALD[b]	-	4.4253**	5.6295**	3.5631	11.588**	5.4933**

Notes: the figures in brackets are T statistics. The Wald[a] statistic is an asymptotic Chi-square test statistic appropriate for testing the null hypothesis that the coefficient values in all equations are insignificantly different to zero against the alternative where the restrictions are nonlinear. The Wald[b] statistic is testing the null hypothesis of coefficient stability across subsamples in the presence of heteroscedasticity. The double asterisk indicates that χ^2 value for the Wald statistic exceeds its 99% critical value. SER refers to the standard error of the regression.

The rational expectations assumption produces rather different results in Table 8.4 compared with static expectations. The standard error of the regression, *SER*, is invariably higher in Table 8.4 in comparison with the results in Table 8.2. Moreover, there is, in general, less significance of the estimated coefficient values. The Wald[a] statistic reported in Table 8.4 indicates the rejection in all periods of the null hypothesis that the sum of the coefficient values are equal to zero. Furthermore, where the Wald[a] statistic has been calculated with the omission of the interest rate level term, the null hypothesis is rejected in all except one time period. Thus, the results in Table 8.4 support of a risk premium on the equation modelling the Australian demand for domestic assets.

The Wald[b] statistic indicates that on the whole, there is not coefficient stability between the subsamples and the full sample set of data.

The results presented in Tables 8.3 and 8.4 represent a replication of the Danker *et al* analysis using a different data set. That study used bilateral data for the West Germany, Japan and Canada with respect to the United States economy. Their results varied slightly across the different economies. On the whole however, they were similar to those here in that F statistic (or Wald statistic) for the null hypothesis that the value of the independent variables is insignificantly different to zero was rejected in most cases, yet the coefficients on the independent variables tended to be insignificant. Thus for all countries in the Danker *et al* paper, there is strong support for the rejection of perfect substitutability. But given the largely insignificant coefficients, however there is not such strong support for the alternative of the

portfolio balance model. This outcome may indicate strong collinearity between the explanatory variables.

8.5 Conclusions

The overall thrust of the results here is that there is strong support for a risk premium on the Australian dollar since the float of the Australian dollar across all subsamples. The results of the Wald[b] test in Tables 8.1 and 8.2 indicate that the factors determining the risk premium differ in the period before the floating of the Australian currency in late 1983. This is confirmation that the risk premium does change overtime and moreover that it alters in response to changes in the management of the currency. Given, however, that the empirical results presented here find no support for a relationship between the intervention activity of the central bank and a risk premium, then the changes in the risk premium over time cannot be attributed to explicit central bank behaviour in the foreign exchange market, but may be attributed to changes in the management of the currency by the central bank.

Support for the portfolio balance model is indicated by the relationship between the risk premium and the real bond demand variable. This support is particularly strong in Table 8.2 for the fourth sample period where the coefficient on the real bond demand variable is both of the correct sign and significant at the 75% level of confidence. Across other sample periods and other tables, the sign on the real bond demand variable is generally positive and in most cases, the t statistic indicates that the estimate is statistically greater than zero at the 5% level of confidence.

Furthermore, there is support in this analysis of rational expectations formation in the foreign exchange market. Where the equation of estimation has been corrected for the moving average error expected in a rational expectations model, the results are still supportive of the risk premium equation.

Overall, the results indicate that there is a risk premium on the Australian currency. Furthermore that risk premium changes overtime. The answer to the second question posed at the beginning of this chapter is unclear. It is not clear that the risk premium is affected by intervention and there is no evidence of any sustained relationship between the risk premium and intervention. It is important to add, however, that management of the currency, not intervention behaviour *per se* has impacted on the risk premium. Thus it appears that central bank management of the currency does affect the risk premium on that currency. Importantly, changes in the risk premium may not be reacting to changes in management *per se* but rather to the uncertainty that inevitably attends a change in management. Furthermore, if one adds a third question: do participants in the foreign exchange market form their expectations rationally?: the answer is yes.

Chapter 9: CONCLUSIONS

In concluding, it is necessary first to reiterate the questions posed at the beginning of the thesis: what factors influence the exchange rate, and what can or should the policy makers do to influence the exchange rate? To answer these questions, we attempt to develop a model of the foreign exchange market which accommodates policy intervention. For ease of application, the analysis is focussed on the foreign exchange relationships between two countries, Australia and the United States.

The analysis is conducted in three parts. The first, presented in Chapters three and four considers a reduced form portfolio balance model of the exchange rate. This model provides an explanation of exchange rate determination. The fifth and sixth chapters then expand on the model developed earlier in order to take in the broader issue of central bank participation in the foreign exchange market. Thus the analysis in Chapters five and six considers both issues of exchange rate determination and the impact of central bank intervention behaviour on the marketplace. Finally, Chapters seven and eight address more directly the issue of the impact of intervention in the foreign exchange market, in the context of the relationship between the risk premium and intervention activity.

9.1 What factors influence the exchange rate?

The model chosen to consider the determinants of the exchange rate is based on a portfolio balance explanation of exchange rate determination. This view of exchange rate determination is built around investors' profit maximisation preferences for domestic money, domestic assets and foreign assets. The appeal of the portfolio

balance model lies in its intuitive and plausible explanation of economic events without requiring restrictive assumptions, such as uncovered interest rate parity[1], on the structure and performance of international capital markets. Moreover, the incorporation of domestic currency denominated and foreign currency denominated assets as explanatory variables accounts for government behaviour through changes in the supply of domestic assets and current account balances through changes in the supply of foreign assets.

The initial results in Chapter three relating to the portfolio balance model reveal for a particular data set - monthly bilateral exchange rate data for the Australia and the United States, and time period - January 1977 to July 1988, the same difficulties that have affected other researchers testing single equation exchange rate relationships; namely considerable autocorrelation in the error terms and coefficient values which are frequently insignificant and incorrectly signed when compared with the theoretical explanations. The model responds well to an error correction specification; more so when the explanatory variables are expressed in real terms rather than in nominal terms. The results in Table 3.8 for example have a number of correctly signed and significant coefficients that are consistent with the portfolio balance model explanation of exchange rate determination.

In Chapter four, a number of weaknesses of the simple portfolio balance model analysed in Chapter three are discussed. These inadequacies of the model are

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[1]This assumption is not only restrictive but also implausible given the results of Chapter 8 of the evidence of a risk premium on the Australian currency.

generally supported by the analysis of other researchers. The key objection to the simple portfolio balance model is that there is more to the explanation of exchange rate behaviour than simply private sector profit maximising behaviour. Whilst private sector behaviour is still integral to the process of adjustment, it needs to be balanced by inclusion of the role of public sector intervention in the foreign exchange market. Other objections to the simple model are based on the role of expectations formation, and the possible exogeneity of the explanatory variables in the reduced form equation model under analysis in Chapter three.

These weaknesses are then incorporated into a more dynamic, and less simplistic explanation of exchange rate behaviour in Chapter five. That chapter develops a small structural equation open economy model in the spirit of the portfolio balance approach which incorporates intervention behaviour. The value or usefulness of the model is determined by its capacity to forecast. The change in the exchange rate variable is a predetermined variable in the model. Its forecast capacity is deemed to be substantial. For example, the correlation coefficient value between the actual and predicted series is very high.

The model developed in Chapters five and six addresses a number of weaknesses which are suggested by various researchers (refer to section 4.1) and improves as a consequence. The analysis in those chapters reassures the viability of the portfolio balance model as an explanation of exchange rate behaviour. Further support is found for portfolio balance model in the modelling of the risk premium in Chapters seven and eight. The empirical analysis of the risk premium equation in Chapter eight

clearly indicates that there is a risk premium on holding domestic as opposed to foreign assets under alternative assumptions about expectations formation.

9.2 What can or should the government do to influence the exchange rate?

A first step in considering the role of the government in the foreign exchange market is to incorporate a central bank intervention function into a small structural equation model of the Australian economy. The analysis of equation (5.7) using an OLS estimator reveals a consistent relationship between the intervention action of the central bank and the change in the exchange rate variable. The results in Table 6.1 and the breakdown of those results in Appendix A.3 indicate clear evidence of the Reserve Bank of Australia leaning against the wind, but no evidence of targeting the exchange rate. Moreover, the intervention equation (5.7) results for different time periods indicate that intervention behaviour has altered overtime in response to changes in management of the Australian currency.

The impact of the changes in the management of the Australian currency are developed further in Chapters seven and eight. In addition to the simpler issue of whether there is a risk premium or not (which is discussed above in section 9.1), the model developed and tested over these two chapters addresses the more complex issue of the relationship between intervention behaviour of the policy maker and the risk premium. The results presented in Tables 8.4 and 8.5 afford only very weak evidence of a relationship between the intervention variable and the risk premium. There is however, strong support for the hypothesis that the risk premium alters in response to changes in the management of the currency. Further, the results in Chapter eight indicate that the risk premium changes over time. The time periods

over which the risk premium is observed to alter is based on an historical selection of subsamples which correspond to substantial changes in the management of the Australian currency. There is no statistically significant connection between intervention activity and the risk premium. However, this does not disprove the Harrod effect[2] completely. Intervention activity designed to influence the exchange rate value stands out in the results drawn form Chapters seven and eight. Other government action which is considerably more difficult to model but which may still affect the exchange rate value includes political signalling, jawboning and the use of discretionary monetary policy to determine a desired exchange rate outcome[3].

Finally, in the economic model of the risk premium presented in Chapters seven and eight, there is strong evidence supporting the view that the risk premium changes over time, and that its alteration is in response to changes in the management of the Australian currency. However, the evidence that the risk premium alters in response to the intervention behaviour of the central bank is however weak.

9.3 Future directions

There are a number of clear directions for future research stemming from this thesis. These are addressed below.

In terms of the issue of what factors influence the exchange rate value, the structural

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[2]From section (7.1), the Harrod effect refers to increased instability in the market possible due to destabilising government activity in the foreign exchange market.

[3]These issues are discussed in footnote 5 in Chapter one.

model developed in Chapter five could be used for prediction and policy evaluation. This step is essentially a natural progression after the construction of an econometric model and forecasting the endogenous variables of that model. Prediction differs from forecasting in that the predictions are made conditional on future values of the exogenous variables (Harvey,1990). In this way the model can be manipulated to evaluate the impact of a policy on the endogenous and predetermined variables. An example in terms of the model here is the assessment of the impact of a change in the tax rate on the exchange rate value. Further given that the model includes an intervention reaction function, we may evaluate the effects of a change in a variable such as unemployment on the direction of intervention.

At a simpler level, the structural model developed in Chapter five may be applied to bilateral data other than Australian/United States data. Obvious alternative data sets include Australian/British and Australian/Japanese exchange rate data. This represents a relatively simple replication of the model - possibly taking into account institutional differences - which may nonetheless provide some interesting comparisons.

There are a number of directions in which the economic model of the risk premium may be taken. The results from the risk premium model are good; the model however is obviously simplified and in that respect shares a defect with the model analysed in Chapter three. In particular, the explanatory variables are treated as exogenous variables whereas in some circumstances, they are clearly endogenous. This suggests a small structural model of the risk premium to analyse further the question: what can or should a government do to influence the exchange rate?

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Appendix A.1: DATA SOURCES AND DESCRIPTIONS

Sources and descriptions of data used in the thesis are presented on a chapter-by-chapter basis below.

A.1.1 Chapters three and four

All observations are monthly.

s monthly average observations of the Australian/United States dollar exchange rate. Source: International Monetary Fund (IMF) International Financial Statistics, various issues.

m Australian money stock M1, seasonally adjusted. Source: IMF International Financial Statistics, various issues.

m^* United States money stock M1, seasonally adjusted. Source: IMF International Financial Statistics, various issues.

fa Australian held United States assets in millions of United States dollars. Source: IMF International Financial Statistics, various issues.

fa^* United States held Australian assets in millions of United States dollars. Source: IMF International Financial Statistics, various issues.

b Domestically held government securities in millions of Australian dollars. Source: Reserve Bank of Australia index of changes in the holding of government debt domestically and the National Debt Commission annual report, various issues.

r Treasury bond interest rate of two years maturity. Source: Financial aggregates, Time Series Data Manager.

r^* United States government security yields of five years maturity. Source: Financial markets, Time Series Data Manager.

p Domestic price index - articles produced by manufacturers, 1984/85 = 100. Source: Economic activity and prices, Time Series Data Manager.

p^* Foreign price index - United States consumer price index, 1985 = 100. Source: IMF International Financial Statistics, various issues.

A.1.2 Chapter six

All observations are quarterly. Unless otherwise indicated, all data are taken from the indicated file of the Time Series Data Manager (DX) computer-based data set.

s exchange rate expressed as Australian/United States dollar exchange rate, quarterly average values. Source: Balance of Payments.

p GDP implicit price deflator. Source: NIF 10s model data set.

p^* United States implicit price index, GNP deflator. Source: OECD Main Economic Indicators Historical Statistics, various issues.

m M3 monetary aggregate. Source: Financial aggregates.

r Treasury bond interest rate of two years maturity. Source: Financial aggregates.

r^* United States government security yields of five years maturity. Source: Financial markets.

y Australian nominal GDP. Source: NIF 10s model data set.

y^* United States GNP. Source: OECD Main Economic Indicators Historical Statistics, various issues.

i Change in the official reserve assets including foreign exchange, reserve position at the International Monetary Fund, gold and Special Drawing Rights (SDR's) at the International Monetary Fund held by the Reserve Bank of Australia at the end of the quarter. An adjustment is made to the change in total reserve for changes due to revaluations. Source: Balance of Payments.

b Total holdings of government securities including public authorities, government financial institutions, Reserve Bank of Australia, trading banks, major Commonwealth trusts, savings banks, authorised money market dealers and life assurance offices. Source: Government Finance.

a Stocks of physical and financial assets in private non-farm inventories. Source: NIF 10s model data set.

fa Non-official total Australian investment abroad. Source: Balance of Payments.

s^e_{t+1} Expected exchange rate in period t+1 proxied by the forward exchange rate. Source: Syntec Economic Services Newsletter, Melbourne, various issues.

g   Final consumption expenditure of the Commonwealth government. Source: NIF 10s model data set and National Accounts data.

tx   Total taxes including taxes on income collected from individuals, enterprises and non-residents and indirect tax. Source: NIF 10s model data set and National Accounts data.

debt   The proportion of the government deficit which is debt financed. Source: Government Finance.

w   Average weekly earnings of non-farm wage and salary earners. Source: NIF 10s data set.

u   Total labour market unemployment rate, end of period. Source: NIF 10s model data set.

dacc   Dummy for the Prices and Income Accord; where observations from 1983:2 onwards are equal to one, all other observations are equal to zero.

c   Current account balance, seasonally adjusted. Source: NIF 10s model data set.

x   Total exports of goods and services, seasonally adjusted. Source: NIF 10s model data set.

ms   Imports of total services, seasonally adjusted. Source: NIF 10s model data set.

ydebit   The net income flows in the current account. Source: Balance of Payments.

A.1.3 Chapter eight

All observations are monthly. All data are taken from the indicated file of the Time Series Data Manager (DX) computer-based data set.

r   Treasury bond interest rate of two years maturity. Source: Financial aggregates.

r^* United States government security yields of five years maturity. Source: Financial markets.

r^T Bank rate on certificates of deposits; weighted average issue yield. Source: Financial aggregates.

y   Melbourne Institute Production Index, all groups. Source: Economic activity and prices.

w   Australian share price indices, all ordinaries. Source: NIF 10s model data set.

NTD   All trading banks' liabilities: total current deposits including non-interest bearing and fixed deposits less reserves held at RBA. Source: Trading Banks.

p   Price index of all articles produced by manufacturers. Source: Economic activity and prices.

B   Commonwealth Government debt: change in non-official holdings. Source: Government finance.

I   RBA official reserve assets. Source: Balance of Payments.

H   Money base. Source: Financial aggregates.

Appendix A.2: THE RELATIONSHIP BETWEEN WAGE DETERMINATION AND IMPORTED INFLATION IN AUSTRALIA

Chapter 5 outlines a small structural equation open economy model in the spirit of the portfolio balance approach. The development of that model raises interesting questions as to first, the role between wages and prices determination in the Australian economy, and second the relationship between the wage determination process, import prices and the exchange rate.

Generally speaking there are two ways in which higher import prices feed through to the domestic price and wage levels. First, higher prices of imported final goods feed through to the consumer price index via either a direct or indirect route. The direct route occurs when due to a relatively low import price elasticity of demand, there is continued consumption of the higher priced import: the indirect route involves expenditure switching from the import to a domestically produced good and probable excess demand pressure in the domestic economy. Alternatively, higher import prices of inputs lead to higher costs of production and then indirectly to increases in the consumer price index. On the surface either of these channels of transmission of higher import prices into the domestic economy indicates that increases in the import price index lead to changes in the price level domestically which then lead onto changes in wage levels domestically. Indeed, this surmised temporal relationship between import prices, the domestic price level and the domestic wage rate is supported by causality testing performed by Boehm and Martin (1989). Using the Granger causality test, they found over the period 1956(2) to 1985(2) that changes in import prices lead changes in domestic prices. At the same time, the link from import prices to wage levels was weak. Their overall conclusions

indicated strong evidence that wage movements lead price changes; that is causality

runs from wage movements to the inflation rate.

Reversing the direction of transmission, increases in domestic prices and wages can

impact through the exchange rate onto import prices. On the usual assumption that

Australia is a small open economy and therefore domestic price changes would not

affect foreign price levels, then this channel of transmission would not be significant.

In an attempt to unravel this seemingly conflicting information, this appendix

undertakes causality testing on the variables of interest. The Granger causality test

has been used in Chapter 4 of this thesis and there is some discussion there on the

meaning, formulation and weaknesses of that test. Suffice to say here that the

Granger causality test allows us to consider predictability in econometric models

which have been estimated from non-experimental time series data[1]. Extensive

Granger causality testing on a similar set of time series data has been undertaken by

Boehm and Martin (1989)[2]. For the sake of completeness and in order to

accommodate a slightly different data set used in this paper, the Granger causality

tests are re-estimated.

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[1]The Granger causality test is one of many test that have been developed to analyse causality. Other causality tests, for example the Sims and the Haugh-Pierce causality tests have inherent theoretical and empirical weaknesses. The difficulties with the application of the Sims causality test are discussed in section 4.2. There is a discussion on the Haugh-Pierce approach in section 4.2, footnote 5.

[2]Boehm and Martin conducted tests of causality patterns using the Granger causality test from 1956(2) to 1985(2). The variables they used were prices (represented by the CPI), wages (represented by average weekly earnings), the unemployment rate, money supply, current government expenditure and import prices.

The results of the Granger causality testing are presented in Table A.2.1. The results

are presented for three time periods. The first period corresponds to the full data set

running from third quarter 1966 to third quarter 1989. As the data are lagged six

periods, the actual starting point of the data is first quarter 1968. The second period

is from the same starting date through to the first quarter 1983. This period

corresponds, albeit not perfectly, to two regime changes. The first is the introduction

of the Prices and Incomes Accord[3] in April 1983; the second is the floating of the

Australian dollar in international currency markets in December of the same year.

The final period extends from the same starting date as before through to the final

quarter in 1976. Once again this corresponds, albeit imperfectly to two regime

changes. The first is the introduction of wage fixing guidelines introduced by the

newly elected Fraser Liberal Government in the third quarter 1976; the second is the

movement away from a fixed trade-weighted exchange rate system in November 1976

to a crawling peg trade weighted exchange rate system.

The sources of the data set used here are detailed in Appendix A.1. In addition to

prices, wages and unemployment, import prices and the exchange rate are included

as dependent variables. This decision reflects both the international flavour of this

study as well as an assertion that import prices do not perfectly reflect exchange rate

movements and *vice versa*. This is particularly important with regard to the various

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[3]The Prices and Incomes Accord is a centralised wage fixing system built around prices and productivity. It does not incorporate full indexation of award wages, rather wage decisions take the national interest into account in particular with respect to the impact of domestic wage rises on the exchange rate and overseas markets. Prior to the Accord, and between 1975 and 1981 wages were indexed to movements in the Consumer Price Index. Toward the end of 1981, the Liberal government leaned toward a decentralised wage fixing system. There is some dispute about the flexibility of such a system given that within a year, 90% of employees covered by major Federal and State awards had received almost identical rises (Indecs, 1990).

exchange rate management regimes covered by the data set. During the earlier periods - up to 1977 - there was considerably more inflexibility in exchange rate movements than in later periods. After some initial data investigation, money supply was omitted as a dependent variable. This decision reflects insignificant results in addition to difficulties in deriving a form for testing with only white noise errors. In the discussion below, the simpler term "causality" is used to indicate Granger causality.

The Granger causality test is testing the null hypothesis that the right-hand side or independent variable does not cause the left-hand side or dependent variable. The results in table A.2.1 indicate that causality runs from wages to prices in all three periods under analysis. This accords with the results of Boehm and Martin. Again in accordance with the Boehm and Martin results, Table A.2.1 indicates that such causality is not bidirectional. That is, causality does not run from prices to wages. There is evidence of strong causality from both wages and prices to unemployment. In only one period is there causality from unemployment to prices; in none of the sample periods is there evidence of causality from unemployment to wages. This finding indicates that wage and price movements in the Australian economy do not respond sequentially to demand pressure from the labour market, but rather that unemployment responds to price and wage pressure. This accords with Classical view of the labour market that unemployment is a result of wage/price movements away from labour market equilibrium. The evidence of causality from unemployment to prices in the smallest data set may reflect more labour market orientated wage determination procedures as opposed to centralised wage determination during that

period. However, if that were the case then the unemployment should impact on wages as well as prices for that sample.

Table A.2.1: F statistics for the Granger causality test

dependent variable	indep. variables	1968:01 to 1989:03	1968:01 to 1983:01	1968:01 to 1976:04
p	w	3.2272*	3.5047*	2.9792*
	u	1.5122	1.1944	2.0007*
	imp	0.4004	0.0222	1.1321
	e	1.7137	1.8650**	2.4100*
w	p	1.5504	1.6539	1.7713
	u	1.0151	1.3184	1.2957
	imp	0.9064	0.8357	3.0455*
	e	1.4462	1.9745**	1.1478
u	p	2.5720*	4.8234*	7.9188*
	w	3.2942*	4.1151*	3.8209*
	imp	3.7696*	4.0821*	4.8176*
	e	1.8843*	0.4076	1.5949
imp	p	1.9295**	4.4047*	4.7275*
	w	3.3217*	2.9406*	3.0219*
	u	2.7392*	2.4827*	1.1523
	e	1.3589	1.0331	0.6561
e	p	2.8053*	3.2374*	2.4352**
	w	3.6706*	4.0055*	2.3735**
	imp	2.9227*	2.3772*	2.1323**
	u	0.7931	1.2467	1.3246

Notes: a single asterisk refer to significance at the 5% level of confidence, and double asterisks refer to the 10% level of confidence.

Interestingly, strong causality also runs from import prices to unemployment, in spite of the evidence here that import prices cause neither prices nor wages. The exception is the sample period truncated in 1976 where there is evidence of strong causality from import prices to wages. On the contrary, Boehm and Martin found evidence of causality from import prices to wages and prices in all samples except their largest sample period which runs from 1956(2) to 1985(2). This period encompasses a larger portion of the data set used here than the other two samples used by these authors.

Prices, wages and unemployment do, however, cause import prices. Thus, there is bidirectional causality from import prices to unemployment and from unemployment to import prices (with the exception of the smallest data set). The notion of wages and prices causing import prices runs contrary to the assumption of Australia as a small country and a price taker in international markets. Moreover, it is partially supported and partially refuted by the conclusions of Boehm and Martin that changes in domestic prices contributed to movements in import prices in the base period but were not a significant factor in the first half of the 1980's. Further support is found for the results here with respect to import prices with the evidence that both prices and wages cause the exchange rate across all three samples. Combined with the evidence that import prices also cause the exchange rate, there is strong support for the role of purchasing power parity in exchange rate determination. Importantly, the support for purchasing power parity is weakest - in all cases with significance at the 10% level of confidence - in the smallest sample period which corresponds to the most inflexibility of exchange

rate adjustment. There is some evidence for the two earlier samples that the exchange rate causes both prices and wages. There may be institutional significance in this result. The Labor Government under the Accord agreement which lies within the largest and latest sample - that is post-1983 - instituted after large currency depreciations from February 1985 onwards, a wage movement discount to minimise the deleterious inflationary impact of exchange rate depreciation on the domestic economy. This discounting, in effect, has prevented the full impact of exchange rate movements from reverberating on the domestic economy, and thus eliminating any competitive advantage gained through the depreciation. Thus it is consistent with the wage setting structure in place in the Australian economy after 1983 for exchange rate movements not to impact on wages and prices. This would also explain the lack of significant causality from import prices to wages and prices.

The tests of causality or precedence in this appendix have set out to address a number issues in terms of causation in the Australian labour market. The first is: what is the direction of causation between wages and prices? A number of research papers using Australian data have found evidence of unidirectional causality running from wages to prices, for example Boehm and Martin (1989) and Boehm (1982, 1984 and 1986). This evidence has been supported by the results. The strengthened evidence of unidirectional causality from wages to prices should allow us to combine the wage and price determination processes as wage movements flow onto price movements.

The second issue of interest here is: what is the relationship between the wage determination process, import prices and the exchange rate? The results here are mixed. Both domestic and foreign prices and domestic wages impact on the exchange rate; and domestic prices and wages cause import prices. This is contrary to the small country assumption applied to the Australian economy. In the smallest sample period, there is evidence that import prices cause domestic wage levels and the exchange rate causes domestic price levels.

Evidence of causality in itself may not be sufficient to indicate the full relationship between variables. Granger-causality indicates predictability (Harvey, 1990), and the full extent of the measured relationship between variables can be gauged only from regression analysis.

Appendix A.3:   FURTHER RESULTS OF THE ANALYSIS OF THE INTERVENTION EQUATION AND THE WAGE AND PRICE DETERMINATION EQUATIONS .

In Table 6.1 of Chapter six, I present the ordinary least squares (and in some cases the two stage least squares) estimation equations for the structural small macroeconomy model of Chapter five. The discussion below provides more detail on some of those empirical relationships. In particular, the wage and price determination process and the intervention equation are analysed in greater detail by dividing the sample period into smaller periods that correspond to institutional changes in the Australian economy.

A.3.1 Analysis of the intervention equation (5.12a) in distinct time periods

The intervention equation for estimation is given by:

$$i_t = -\alpha_{21} - \frac{\alpha_{22}}{\theta}(s_t - s_{t+1}^e) \qquad (5.12a)$$

where i_t represents the central bank's purchases of foreign exchange for intervention purposes, s_t is the spot rate and s_{t+1}^e is the expected spot rate in the next period.

Table 6.1 in Chapter 6 presents the empirical intervention equation for the full sample. Table A.3.1 presents the empirical intervention equation (5.12a) for the full sample as well as the three subsamples corresponding to significant changes in the management of the Australian dollar. The first two subsamples correspond to a period over which the Australian dollar was managed as a trade-weighted exchange rate regime. Over the period considered in the first subsample, the trade-weighted

exchange rate system was fixed and the authorities had to manage the United States/Australian dollar exchange rate so as to always offset the effects of overseas currency movements on the constant trade-weighted index. After November 1976, the Australian currency was a crawling-peg trade-weighted exchange rate regime. A committee of representatives from several government departments was given the discretionary power to vary the value of the trade-weighted index on a daily basis in accordance with their perceptions of the effective rate for the Australian dollar given changing circumstances. The third subsample corresponds to the period after December 1983 of flexibility of the Australian currency with an official Reserve Bank policy of only light intervention to smooth out a disorderly market. More detail on the management of the Australian currency over this period is given in section 3.1.

Table A.3.1: Intervention equation across the full sample and three subsamples

dependent variable = i_t

	1966:03 to 1990:03	1966:03 to 1976:03	1976:04 to 1983:03	1983:04 to 1990:03
Δs_t	-2.052 (6.003)*	-2.261 (3.233)*	-1.745 (1.646)*	-2.082 (6.269)*
$(s_t - s^{et+1})$	0.287 (0.391)	2.10 (3.233)*	-0.235 (0.083)	0.138 (0.238)
constant	-0.037 (2.446)*	0.025 (0.969)	0.092 (1.838)*	0.029 (0.524)
$\bar{R}^2$	0.287	0.218	0.101	0.617
DW	1.903	1.561	1.777	2.184
CHOW	-	77.6*	89.5*	24.8*

Notes: the figures in brackets are asymptotic t ratios where the single asterisk indicates the 5% level of significance. The $\bar{R}^2$ indicates the value for the adjusted R^2. The CHOW statistic test the null hypothesis of coefficient stability between subsamples.

A glance at the empirical equations for the entire sample and the three subsamples reveals substantial differences in both the explanatory power and the explanatory variables. Whilst a reasonable fit for the full sample, the equation (5.12a) explains intervention behaviour better in the period during the float of the Australian currency. The second subsample has a low adjusted R^2 value of 0.101. This may reflect the lender of last resort role of the Reserve Bank during that time period to make up any short-fall between supply and the demand for foreign currency. Thus the Reserve Bank accumulation or decumulation of foreign reserves was not necessarily a reflection of intervention behaviour in order to maintain a given exchange rate value, but was rather directed toward foreign exchange market disequilibrium caused by private speculative activity[1]. On the other hand in the third subsample, the intervention behaviour has good explanatory power, indicating that the activity of the Reserve Bank in the market place was better aimed toward the achievement of a given exchange rate value. In particular, there is strong evidence within this third subsample, as indicated by the significant and correctly signed coefficient on the change in the exchange rate term of leaning against the wind. Indeed across all samples, the change in the exchange rate term is correctly signed and significant indicating that leaning against the wind intervention behaviour has been an important and consistent intervention strategy of the Reserve Bank.

The F statistic for the Chow test indicates that we can reject the hypothesis that the relationship is stable. This is the expected result given substantial changes in the management of the currency between the subsamples.

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[1]Refer to section 3.1 for more detail.

Overall the results in Table A.3.1 indicate that the Reserve Bank has consistently followed a leaning against the wind intervention strategy. The importance of this strategy has however, differed with changes in the management of the Australian currency.

A.3.2 Analysis of the wage and price determination process in distinct time periods

The results of time series analysis of the wage and price equations as presented in Table 6.2, are modelled on data for the period 1966(3) to 1990(3). This period crosses a number of changes in management of the wage determination process in Australia. There is some discussion on the changes in the institutionalised wage determination process in Australia in section 3.1 and in Appendix A.2. Some of these changes, for example the Metal Trades Decision of late 1974 and the introduction of the Prices and Incomes Accord are incorporated by the use of dummy variables of which details are given below. Additionally, results are presented for distinct time periods which correspond to the division of the sample used in the Granger causality testing in Appendix A.2[2]. These results for subsamples within the entire sample period are presented in Tables A.3.2 and A.3.3 below. The first data column of all the tables in this section are a reproduction of the appropriate information in Table 6.2.

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[2]The sample is made up of three distinct periods. The first is the full sample from late 1967 to the third quarter 1990. The second is from the beginning of the sample to the introduction of the Prices and Incomes Accord by the newly elected Hawke Labor Government in April 1983. The third and smallest sample runs from the late 1967 to the introduction of wage fixing guidelines by the newly elected Fraser Liberal Government in the third quarter 1976. As much as possible these subsamples correspond to other studies of wage and price determination in the Australian economy, for example Simes and Richardson (1987) and Boehm and Martin (1989) for ease of comparability.

After considerable preliminary data investigation using an ordinary least squares estimator, both the wage and price determination equations and the inflation equation have been calculated using a two-stage least squares estimator. All exogenous variables from both the estimated wage and price determination equations are used as instrumental variables. The lag structure for explanatory variables was determined initially by incorporating a long lag structure and then dropping sequentially, insignificant lags. Wrongly signed and insignificant variables, where the level of insignificance was greater than 10 percent, were generally omitted from the analysis.

The price expectations variables, $\Delta p1^e$ and $\Delta p2^e$, have the same formulation as that described in section 6.2.6. The second price expectation variable is strongly significant across all time periods.

A.3.2.1 Empirical wage determination, equation (5.15)

The results for the wage determination equation in three distinct time periods are presented in Table A.3.2.

The import price variable lagged two periods is significant at the 5% level of confidence for the smallest sample set. This corresponds with the causality results for the same time period which indicate that import prices do cause wage movements. For the second sample, the import price variable indicates some significance lagged both two and three quarters. For the first and largest sample, the import price variable is significant when lagged three quarters only. The results for the first and second sample are not in accordance with the causality testing results.

The impact of import prices on wages in different periods is interesting to consider with respect to policy changes. The first sample corresponds to the period when for a considerable part of the time the Australian dollar was flexible with minimal intervention from the Reserve Bank and there was centralised wage fixing. Superficially at least one would anticipate that under a floating exchange rate as opposed to a more managed, controlled crawling peg regime, there would be more rapid pass-through from import price changes to the price and wage structure in the domestic economy. The impact of centralised wage fixing continuously since April 1983 and in particularly the discounting of price movements due to substantial depreciation in the wage determination process during that time are the likely cause of the greater lagged response of wages to import price changes in the larger sample set.

In all sample periods, the change in the unemployment variables are of the correct sign both where the variable is current and lagged one quarter. The significance of the coefficient is greater, although not at the 5% level of confidence where the change in unemployment is lagged one quarter. Likewise, the current money supply variable expressed in levels is of the correct sign in all samples but only weakly significant. The overtime variables were insignificant and incorrectly signed in the wage equation and were thus omitted.

The hysteresis variable is calculated as the current unemployment rate less the average unemployment rate over the last eight quarters. Real wages increased for a considerable part of the third sample period, for example in 1974, money wages

growth peaked at over 30%. This is an indicator according to the Friedman-Phelp's hypothesis, that the full employment rate was in excess of the natural rate of unemployment. For the latter part of the sample period that is included in the first and second sample, however the natural unemployment rate was less that the actual unemployment rate. This relationship between the actual and natural rate, although not perfect, would in part explain the change in sign on the hysteresis variable. Moreover, the hysteresis variable is significant at the 10% level of confidence in the second sample set.

Overall the equation specification is good based on either the adjusted R^2 or the R^2 between observed and predicted. Moreover, the power of explanation is comparable with other wage equation specifications by other researchers, for example Simes and Richardson (1987), and both the NIF 88 model and the Murphy model presented in Chapman and Gruen (1990). The explanatory power of the equation is better in the third sample than in either of the other two sample periods.

Table A.3.2: Empirical wage determination equation (5.15) across three samples using a 2SLS estimator

	1967:04 to 1990:03	1967:04 to 1983:01	1967:04 to 1976:04
Δp_1^e	0.9067 (1.0587)	1.0752 (1.3226)	0.6706 (0.9316)
Δp_2^e	0.7087 (1.9450)	0.7046 (1.8359)**	0.8322 (2.4237)*
$\Delta(s + p^*)_{t-2}$	0.0816 (0.9865)	0.2184 (1.7280)**	0.1831 (2.2125)*
$\Delta(s + p^*)_{t-3}$	0.1327 (1.8718)**	0.1739 (1.8502)**	-
Δu_t	-0.0294 (-0.5279)	-0.0436 (-0.6605)	-0.0483 (-0.7157)
Δu_{t-1}	-0.0674 (-1.5612)	-0.0822 (-1.6102)	-0.0725 (-1.5813)
m_t	0.0017 (1.6177)	0.0018 (0.9873)	0.0013 (1.1962)
m_{t-1}	-	-0.0011 (-0.7515)	-
dacc	-0.0119 (-2.1797)*	-	-
hys	-0.0040 (-1.4592)	-0.0049 (-1.7700)**	0.0066 (0.8020)
d1	0.0042 (1.2504)	0.0041 (0.9906)	0.0072 (1.7555)**
constant	0.0004 (0.0417)	0.0048 (0.4958)	0.0015 (0.1792)
$\bar{R}^2$	0.4638	0.4177	0.6575
R^2	0.5316	0.5069	0.7172
h	2.1076	1.9411	2.5558

Notes: the figures in brackets are asymptotic t ratios where the single asterisk indicates the 5% level of significance and the double asterisks the 10% level of significance. The $\bar{R}^2$ indicates the value for the adjusted R^2; the R^2 indicates the coefficient of determination for the R^2 between observed and predicted dependent variable. White et al (1988) suggest this statistic as a preferred indicator of the fit of the equation where the method of estimation is two stage least squares.

A.3.2.2 Empirical price determination, equation (5.16)

The results from testing the price determination equation (5.16) across a number of sample periods are presented in Table A.3.3. Similarly to the wage equation, the price equation is estimated using a two stage least square estimator.

The price expectations variable, Δp^e is adapted from Simes and Richardson (1987) and is in formulation the same as that used in the wage determination equation. A simple distributed lag on price changes is used to proxy expected prices. Thus expectations formation is considered to be adaptive. Price expectations variables across the three time periods are significant. Indeed with the exception of one of the dummy variables d_3, the price expectation variable is the only coefficient significant at the 5% level of confidence in the estimation. This indicates that the main explanatory force behind price changes is past price changes.

The change in wages variable is insignificant across all three time periods, although it displays considerably more significance in the first time period than in the others. This may be related to the role of the Prices and Incomes Accord in the wage determination process, and in particular may imply that a more structured and centralised wage fixing system contributes to the inflationary process rather than as in its stated aim reduces the inflationary impact of wages movements. Moreover, the lack of significance, at at least the 10% level of confidence, of wage changes in the price determination process refutes the evidence of causality running from wages to prices both presented in Appendix A.2 and in Boehm and Martin. Wages expressed in levels are also insignificant.

Table A.3.3: Empirical price determination equation (5.16) across three samples using a 2SLS estimator

	1967:04 to 1990:03	1967:04 to 1983:01	1967:04 to 1976:04
Δp^e	0.6741 (3.9100)*	0.6800 (3.7827)*	0.7790 (3.2351)*
Δw_t	0.1611 (1.4870)	0.1171 (0.7254)	0.0267 (0.1394)
$\Delta(s + p^*)_t$	0.0581 (1.7929)**	0.0741 (1.7960)**	0.0489 (0.8369)
Δu_{t-1}	-0.0134 (-1.0524)	-0.0174 (-1.2357)	-0.0267 (-1.6308)
d3	0.0059 (2.7675)*	0.0086 (3.7210)*	0.0086 (2.7368)
d4	-0.0041 (-1.9305)**	-	-
dsr	0.0003 (0.9959)	0.0003 (1.1012)	0.0006 (1.1758)
constant	0.0014 (0.4452)	0.0001 (0.0250)	0.0017 (0.3914)
$\bar{R}^2$	0.5085	0.5244	0.5244
R^2	0.5514	0.5652	0.6044
h	2.3018	2.2782	2.2587

Notes: the figures in brackets are asymptotic t ratios where the single asterisk indicates the 5% level of significance. The $\bar{R}^2$ indicates the value for the adjusted R^2; the R^2 indicates the coefficient of determination for the R^2 between observed and predicted dependent variable. White et al (1988) suggest this statistic as a preferred indicator of the fit of the equation where the method of estimation is two stage least squares.

Import prices are weakly significant. Import prices lagged sometimes two and sometimes three quarters are significant independent coefficients in the wage equation. Thus, there is overall evidence, albeit weak that import prices impact on price changes before they impact on wage changes. This confirms the anecdotal evidence mentioned in Appendix A.2 that *ex ante* import price changes would effect

changes in prices before changes in wages. The change in unemployment variable is of the correct sign, but insignificant at both the 5% and 10% level of confidence. More significance is found where the change in unemployment is lagged one quarter.

There are three dummy variables in the estimation of equation (5.16). Seasonal dummies are represented by d_3 and d_4; as was mentioned earlier the first seasonal dummy is significant across all samples. The second seasonal dummy is weakly significant for the first sample period only. It was omitted from the estimation equation in the other samples. The fourth dummy, *dsr*, represents periods of substantial changes in the exchange rate, where a positive coefficient indicates a depreciation in the exchange rate. The inclusion of both this dummy and import prices allows for the possibility that some exchange rate movements are not reflected in changes in import prices and *vice versa*.

A.3.2.3 Empirical inflation equation (5.17)

Table A.3.4 presents the estimation results for equation (5.17). That equation combines the wage and price determination process on the basis that given that wage changes lead price changes then *ceteris paribus* the lagged determinants of the wage equation (5.15) can be incorporated into the price determination process as explanatory variables representing the lagged change in wages. Thus Table A.3.4 presents results for this combination even though the wage changes variable is only weakly significant in the estimation results of Table A.3.3. The price determination equation in Table A.3.4 is estimated using a two stage least squares estimator as before.

Table A.3.4: Empirical inflation equation (5.17) across three samples using a 2SLS estimator

	1967:04 to 1990:03	1967:04 to 1983:01	1967:04 to 1976:04
Δp^e	0.7662 (1.9665)**	0.7775 (2.3808)*	0.4241 (0.7832)
$\Delta(s + p^*)_t$	0.0667 (1.8790)**	0.0635 (1.3300)	0.1236 (1.2291)
$\Delta(s + p^*)_{t-1}$	0.0180 (0.4439)	0.02449 (0.4822)	0.0783 (0.7910)
Δu_t	0.0031 (0.2452)	0.0038 (0.2774)	0.0146 (0.7671)
Δu_{t-1}	-0.0136 (-1.0744)	-0.0136 (-1.0021)	-0.0310 (-1.9081)**
o_t	0.0112 (1.2169)	0.0113 (1.1067)	0.0279 (1.7366)**
m_t	0.0006 (0.5530)	0.0004 (0.4851)	0.0007 (0.7328)
hys_{t-1}	-	-	0.0099 (1.5923)
$d3$	0.0064 (3.0391)*	0.0076 (2.9101)*	0.0088 (2.6499)*
$d4$	-0.0030 (1.3031)	-0.0029 (-1.0377)	-
$dacc$	-0.0029 (-1.2183)	-	-
constant	-0.0039 (-0.6693)	-0.0031 (-0.4813)	-0.0081 (-1.0718)
$\bar{R}^2$	0.4980	0.4964	0.5146
R^2	0.5562	0.5603	0.6100
h	2.3696	2.3034	2.2716

Notes: the figures in brackets are asymptotic t ratios where the single asterisk indicates the 5% level of significance. The $\bar{R}^2$ indicates the value for the adjusted R^2; the R^2 indicates the coefficient of determination for the R^2 between observed and predicted dependent variable. White et al (1988) suggest this statistic as a preferred indicator of the fit of the equation where the method of estimation is two stage least squares.

The explanatory power of the estimation equation for the inflation determination

process combined is approximately the same as that for the price equation results presented in Table A.3.3. Moreover, the overtime variable which was omitted from previous analyses due to low significance and/or incorrect sign is of reasonable significance and the correct sign here. As in the Table A.3.3 results, most of the explanatory power is in the price expectation variable. Import prices show more significance when the sample period includes the years of the floating exchange rate; lagged unemployment shows more significance as before in the smaller sample when wage determination tended to be more market orientated.

Overall, the results here indicate that the wage and price determination process in the Australian economy has varied with institutional changes in the wage determination process. The impact has been one of degree however rather than substance.

Appendix A.4: TRANSFORMATION OF THE BOND DEMAND EQUATION

Based on Danker *et al* (1987), the bond demand equation (7.30)[1] from Chapter seven, can be rewritten as:

$$b_t = \alpha_0 \overline{R}_t + \alpha_1 X_t + \mu_t \qquad (A.4.1)$$

where $b_t = B/P$, is the domestic real demand for domestic bonds in period t, $\overline{R} = (r - r^{**})$, is the risk premium, X_t is a vector of other variables in equation (7.31), and μt is the residual. The risk premium is defined in equation (7.27) as:

$$\overline{R}_t = r_t - r_t^* - (s_{t+k}^e - s_t) \qquad (A.4.2)$$

where both exchange rate variables are expressed in natural logarithms. Assuming that the residual term in equation (A.4.1) exhibits first order autocorrelation, then μ_t may be represented as:

$$\mu_t = \rho \mu_{t-k} + \epsilon_t \qquad (A.4.3)$$

where ϵ_t is a white noise residual.

The assumption of rational expectations holds that investors do not make systematic

---

[1]Equation 7.30, the real demand for bonds equation is:

$$\frac{B}{p} = \alpha_0 + \alpha_1(r - r^{**}) + \alpha_2 r + \alpha_3(r - r^T) + \alpha_4(r - r^L) + \alpha_5 \Delta S + \alpha_6 \frac{Y}{p}$$
$$+ \alpha_7 \frac{W}{p} + \alpha_8 \frac{NTD}{p} + \alpha_9 \frac{H}{p} + \mu_1$$

errors. Therefore:

$$s_{t+k} = s_{t+k}^e - \Theta_{t+k} \qquad (A.4.4)$$

where Θ_{t+k} represents the unsystematic or white noise forecast error.

The ex-post risk premium is defined as:

$$R_t = r_t - r_t^* - (s_{t+k} - s_t) \qquad (A.4.5)$$

which implies that from equation (A.4.4):

$$R_t = \overline{R}_t + \Theta_{t+k} \qquad (A.4.6)$$

Substituting (A.4.6) into (A.4.1) yields:

$$b_t = \alpha_0 R_t + \alpha_1 X_t + \Phi_{t+k} + \mu_t \qquad (A.4.7)$$

where:

$$\Phi_t = -\alpha_0 \Theta_t$$

The residual term in equation (A.4.7), $\Phi_{t+k} + \mu_t$ contains both autoregressive and moving average components. The autoregressive part derives from μ_t, assuming that it is autocorrelated. The moving average part derives from the transformation in equation (A.4.5), where s_{t+k} is used as a proxy for s_{t+k}^e. The autoregressive component

can be removed by multiplying equation (A.4.7) by *(1 - ρL)*, where L is the lag operator. Thus equation (A.4.7) becomes:

$$(1 - \rho L)b_t = \alpha_0(1 - \rho L)R_t + \alpha_1(1 - \rho L)X_t + w_t \qquad (A.4.8)$$

where w_t is defined as a first order moving average error process:

$$w_t = (1 - \rho L)\Phi_{t+k} + (1 - \rho L)\mu_t = \Phi_{t+k} - \rho\Phi_t + \epsilon_t \qquad (A.4.9)$$

where ϵ_t is a white noise error term.

The residual, w_t, follows a first order moving average error process. This can be seen by evaluating its autocovariance function:

$$
\begin{aligned}
cov(w_t, w_{t-j}) &= E[(\Phi_{t+k} - \rho\Phi_t + \epsilon_t)(\Phi_{t+k-j} - \rho\Phi t{-}j{+}\epsilon_{t-j})], \\
&= E(-\rho\Phi_t^2 + \epsilon_t\Phi_t) \neq 0, \qquad |j = 1| \\
&= 0, \qquad\qquad\qquad |j > 1|
\end{aligned}
$$

$$(A.4.10)$$

The term w_t has a first order autoregressive representation:

$$w_t = \mu_t + \zeta\mu_{t-k} = (1 + \zeta L)\mu_t \qquad (A.4.11)$$

and if:

$$|\zeta| < 1, \qquad \mu_t = \frac{w_t}{1 + \zeta L}$$

where μ_t is white noise error.

Therefore, a means of removing the moving average error from equation (A.4.8) is to divide by $(1 + \zeta L)$:

$$(1 - \rho L)\tilde{b}_t = \alpha_0(1 - \rho L)\tilde{R}_t + \alpha_1(1 - \rho L)\tilde{X}_t + \mu_t \qquad (A.4.12)$$

where:

$$\tilde{b}_t = \frac{b_t}{1 + \zeta L}, \quad \tilde{R}_t = \frac{R_t}{1 + \zeta L}, \quad \tilde{X}_t = \frac{X_t}{1 + \zeta L} \qquad (A.4.13)$$

Equation (A.4.13) is an appropriate form for estimation of the bond demand functions with the moving average error removed. Estimation by a conventional instrumental variables technique with an autocorrelation correction is not valid as the error term is correlated with past values of the instruments. Therefore, Danker et al. (1987), and Cumby, Huizinga and Obstfeld (1983) use a two-step two stage least squares estimator to address this particular problem. The process corrects for serial correlation while delivering parameter estimates that are consistent and asymptotically efficient in a class of instrumental variables estimates.

Danker et al. further suggest that the residual term, w_t from equation (A.4.8) has an alternative forward looking representation:

$$w_t = \lambda \psi_{t+k} + \psi_t = (1 + \lambda F)\psi_t \qquad (A.4.14)$$

where F is a forward operator. If $|\gamma| < 1$, this process can be inverted to obtain:

$$\psi_t = \frac{w_t}{1 + \lambda F} \qquad (A.4.15)$$

Dividing equation (A.4.8) by $(1 + \gamma F)$, yields:

$$(1 - \rho L)\mathring{b}_t = \alpha_0 (1 - \rho L)\mathring{R}_t + \alpha_1 (1 - \rho L)\mathring{X}_t + \psi_t \qquad (A.4.16)$$

where:

$$\mathring{b}_t = \frac{b_t}{1 + \lambda F}, \quad \mathring{R}_t = \frac{R_t}{1 + \lambda F}, \quad \mathring{X}_t = \frac{X_t}{1 + \lambda F}$$

Equation (A.4.16) represents a formulation of the bond demand equation with both autoregressive and moving average error removed. This formulation is adapted for estimation of the risk premium equation assuming rational expectations formation in Chapter eight.