# New Challenges for Monetary Policy in the Twenty–First Century

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*For my father, John Andrew Greenwood–Nimmo*

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# Abstract

Developments in information and communications technologies, the increasing sophistication and deepening of financial markets and the ineluctable process of globalisation have profound implications for the conduct of monetary policy. This thesis identifies three areas in which the impact of such developments may be felt most acutely by modern central banks: the electronification of retail payments systems, the increasing frequency and severity of asset market cycles and the continuing integration of the global economy.

The high profile debate concerning the threat of e–money to the efficacy of monetary policy has been largely resolved. It has, nevertheless, diverted attention away from other important concerns, including the potential for runs on service providers and systemic risks arising from unregulated offshore issuers. The importance of these issues can only be evaluated with reference to the importance of e–money as a payment instrument. However, e–money usage remains marginal at present and forecasts of its development indicate limited growth potential. This raises a number of regulatory issues. Firstly, regulators must ensure systemic security. Secondly, is existing regulation stifling innovation? Finally, can regulation be designed to promote innovation, and would this be desirable? This thesis argues that regulation must balance systemic security with the incentives for innovation, and proposes a general regulatory framework to this end.

Since the onset of global financial crisis in mid 2007, it has become clear that central banks underestimate the macroeconomic influence of financial markets at their peril. The Minskyan financial fragility hypothesis asserts that inflation targeting monetary policy may contribute to financial fragility. The estimation of a small macroeconomic model lends substantial support to this view, suggesting that central banks should manipulate the interest rate with great care. However, it is within the power of the central bank to set differential reserve requirements by asset class, providing an additional policy instrument. This thesis proposes a simple approach in which interest rates and reserve requirements are used in a complementary manner.

The majority of monetary policy research is conducted assuming either a closed, or small open economy. However, the exclusion of feedback effects renders these approaches inappropriate in many economically interesting cases. This thesis develops a simple stock–flow consistent model comprised of two mutually dependent economies with financial and real linkages. The performance of various stabilisation policies is analysed using this framework. The results call into question the ability of simple inflation–targeting rules to achieve price stability in an open economy and stress that a combined monetary and fiscal regime is necessary for effective stabilisation.

The conclusion of this thesis is threefold. Firstly, regulators are rightly concerned with financial innovation but they must leave room for innovation and technological progress. Secondly, central banks must pursue interest rate policy with great care to avoid exacerbating financial fragility. Thirdly, the interest rate is not the sole instrument of monetary policy and, indeed, the central bank is not the sole institution capable of undertaking stabilisation policy.

**Keywords:** Monetary policy, electronic money, regulation of financial institutions, financial fragility, asset–based reserve requirements, stock–flow consistency, monetary and fiscal policy interaction.

**JEL Codes:** C51, E27, E52, E63, F41, F47.

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# Chapter 1

# Introduction

The design and implementation of active policies aimed at smoothing macroeconomic fluctuations across the cycle is a relatively new phenomenon, attributable to Keynes and his revolution in economic thought. Prior to this Keynesian revolution, the principle role of most central banks was to act as the banker to their government and to ensure the stability of the financial system (c.f. Tymoigne, 2006). While few modern economists would advocate Hellerian fine–tuning (Heller, 1966), most in the New Keynesian school would agree that monetary policy can, and should, be used to target inflation through aggregate demand management.

The emergence of a 'new consensus' in macroeconomics has resulted in a degree of convergence of the operating procedures of central banks around the world, in both developed and developing economies. The adoption of inflation targeting (IT) regimes, whether formal or informal, in which the central bank manipulates the short–term interest rate in order to achieve a desired level of inflation, has been one of the defining characteristics of the last decade and a half. Chapter 2 critically reviews the role and nature of monetary policy in this currently dominant school of thought and provides the backdrop against which the remaining chapters are set.

The purpose of this thesis is to assess the suitability of this dominant position in the twenty–first century. The increasing integration of information and communications technologies (ICT) into our everyday lives and the relentless process of globalisation have fundamentally altered the economic landscape. The world is now smaller than it has ever been and the pace of life faster. This process of change presents many challenges to policymakers, three of which are discussed here: the electronification of the payments system, the increasing frequency and amplitude of asset market cycles, and the increasing openness of the global economy.

## 1.1 Electronification of the Payments System

The increasing electronification of retail payments systems and the development of electronic money received a great deal of attention at the turn of the millennium. A number of authors, most notably Benjamin Friedman and Mervyn King, suggested that the substitution away from central bank issued money toward privately issued e–money would undermine the ability of the monetary authority to stabilise the macroeconomy (Friedman, 1999, 2000; King, 1999). However, this remained a minority position and was largely defeated in the literature by a number of papers which argued that the operation of monetary policy *per se* does not require that households and commercial banks hold large quantities of high powered money (c.f. Freedman, 2000; Palley, 2001b; Woodford, 2000, 2001a). The general consensus which emerged was that central banks could simply impose reserve requirements on e–money issuers or that they could adopt Lombard systems, such as that used in Canada, which would be almost totally unaffected by the introduction of e–money.

It is the contention of Chapter 3 that the high profile debate over the monetary policy ramifications of e–money issuance diverted attention from a number of important, and less fanciful, issues with which its adoption is associated. Concerns that have been raised in the literature include the possibility of runs on e–money providers (Meyer, 2001b; Palley, 2001a), the appearance of loopholes that may be exploited through circumventive innovation (Friedman, 1999), the inaccuracy of monetary statistics (EMI, 1994), risks arising from offshore issuers (Krueger, 2002b), social exclusion (Van Hove, 2003) and the invasion of privacy coupled with a relative increase in the criminal demand for the anonymity associated with traditional currency (Goodhart, 2000). These issues have received relatively little attention from regulators and policymakers. This chapter aims to bring attention back to these concerns, and is rather timely given the current heightened state of awareness of regulatory issues in the financial sector.

Much of the theoretical work on e–money is based on the assumption that it will come to achieve a significant market share, or even total dominance of the retail payments sector. Chapter 3 challenges this assumption in three ways. Firstly, by careful consideration of the nature of money, it is possible to identify a number of conditions necessary for the complete substitution of private e–money for central bank money. These include perfect interoperability of e–money schemes, full transferability of e–monetary value, the acceptance of e–money in the payment of tax obligations, and the payment of wages in e–money in an environment in which e–money is not redeemable for currency. When presented in this way, it is clear that the widespread substitution of e–money for more conventional forms of money is highly unlikely to arise in practice, at least in the foreseeable future.

Secondly, detailed analysis of the historical performance of e–money services at the macroeconomic level in the Euro Area and Singapore reveals that the degree of market penetration has been relatively modest, certainly when one considers the entire retail payments industry as opposed to the market for cashless instruments. Furthermore, the fact that each individual in Singapore holds an average of three e–money cards can be interpreted as evidence of a failure to coordinate between e–money service providers, merchants and consumers. The lack of interoperability of existing schemes coupled with a shortage of installed e–money loading terminals is clearly evident in the data, and represents a significant obstacle to the continuing growth of the new technology. It must be noted, however, that e–money products account for a substantial majority of cashless payments in Singapore and that the Monetary Authority of Singapore's announcement that it intends to issue electronic legal tender in the near future has provided a substantial impetus to the industry. This suggests that the regulatory stance of the Government is likely to be a significant determinant of the commercial success of e–money schemes.

Finally, a range of forecasting exercises are carried out on a hitherto unused European dataset. The dataset is unique within the field in the sense that it spans ten years at monthly frequency while most countries report data annually at most. The richness of the data provides scope for the development of sophisticated forecasting models. Three such models are employed here: a simple geometric random walk model to act as a benchmark; a Bayesian average model employing a non-informative prior in which equal weight is attached to each of twenty–eight candidate models; and a nonlinear Gompertz function. The adoption of innovative products (particularly those where network effects are likely to be strong) is widely believed to follow a sigmoid process. The Gompertz curve is among the class of sigmoid functions and is used to investigate this sigmoid adoption hypothesis.

Pseudo out–of–sample forecast testing reveals that the benchmark model and the Gompertz specifications yield similar results while the Bayesian forecast significantly outperforms both. In general, the results indicate that the medium–term growth prospects of the e–money industry in Europe are relatively modest over a five year horizon. Moreover, forecast intervals derived from non–parametric bootstrapping reveal that the degree of uncertainty surrounding the forecasts is relatively limited, indicating that a drastic surge in e–money usage in very unlikely[1]. Indeed, if e–money adoption can be accurately

[1] Note that the computation of intervals for the average model is not undertaken in this thesis due to the uncertainty surrounding the choice of computational approach. This is discussed in more detail in Section 3.6.

described by the sigmoid hypothesis, the results suggest that it is approaching its upper asymptote, indicating limited potential for existing e–money technologies to achieve significant increases in their market share.

Once one accepts that the probability of e–money gaining significant market share in the medium–term is low, the foundation on which much of the existing theoretical work rests becomes rather weak. The most pressing issue is the question of how regulators should handle the development of e–money[2]. This issue is addressed by Chapter 4.

A comparison of the regulatory frameworks in place in the USA, Europe and Singapore reveals substantial differences in their respective approaches to e–money. Regulators in the USA have taken a market–oriented, *laissez–faire* stance which has resulted in substantial heterogeneity between states. European regulation, by contrast, is extensive and has a thorough legal basis, while the Singaporean system occupies the middle ground. Each of these approaches has its associated advantages and disadvantages and, by identifying these and drawing on the positives, Chapter 4 attempts to outline the general characteristics of an optimal (or at least preferable) regulatory scheme. The more fundamental of these characteristics may be crudely summarised as follows:

i. regulators must carefully weigh the benefits of making e–money legal tender against the potential loss of competitive forces in the market;

ii. the deployment of a unified technological architecture is essential, both for systemic security and to promote interoperability (the latter reflecting liquidity);

iii. similarly, unified regulation is of fundamental importance;

iv. regulators must strictly enforce robust asset–backing, net worth and ongoing capital requirements to protect systemic security;

v. regulation should explicitly prevent e–money issuers from engaging in deposit–taking activities and credit extension to avoid the blurring of boundaries between banks and other financial institutions;

vi. various waivers could be used to promote innovation;

vii. e–money must be redeemable at par for central bank money in order to protect issuers from what may be thought of as exchange rate risk; and

[2]E–money regulation is the responsibility of the Financial Services Authority (FSA) in the UK but in most countries it remains closely linked to the central bank. The desirability of divesting this role from the central bank is unclear, particularly to the extent that it may result in serious coordination failures and may introduce an element of moral hazard between the two organs of state. However, such issues are beyond the scope of this thesis.

viii. the payment of interest on small e–money balances may be desirable as long as e–money schemes do not offer depository services.

One feature is particularly evident from simple analysis of the raw data: the Singaporean Government's decision to issue electronic legal tender and its development of common technological standards for e–money systems have driven progress in the industry. While the desirability of the state–issuance of e–money remains unclear, the adoption of common standards is surely a positive development. The world should closely monitor the Singaporean e–money experiment and should not hesitate to move in a similar direction if it proves successful.

## 1.2 Monetary Policy and Financial Fragility

In the last three decades, both the frequency and amplitude of asset market cycles have increased markedly. This effect has been attributed to a number of phenomena, perhaps the most credible of which is the proliferation of 'managed money', where fund managers invest vast quantities of money in a foot–loose manner, potentially driving or contributing to the observed cyclicality (Wray, 2008a; 2008b).

Mainstream modelling during this period has been dominated by the tenets of the efficient market hypothesis (EMH), albeit with some insights gleaned from behavioural models (see Ritter, 2003, for a concise survey of the latter). An important implication of the EMH is that the price of an asset is closely related to its fundamental value, defined as the discounted present value of the dividend stream, optimally forecast. This implies that speculative bubbles are not possible *per se* but that market fluctuations are caused by movements in underlying fundamentals. In this setting, booms and busts seemingly unrelated to fundamental values indicate that the market is not efficient: prices either fail to reflect all relevant information, or do so with a significant lag.

By weakening various assumptions of the EMH, two types of bubbles can be envisaged: deterministic and stochastic[3]. The first is largely an academic curiosity and can only arise rationally if prices rise *ad infinitum*. By contrast, stochastic rational bubbles of the type described by Blanchard and Watson (1982) may be propagated by the actions of rational arbitrageurs (c.f. Abreu and Brunnermeier, 2002; 2003)[4]. Consider a situation in which

[3]A further broad category of bubbles is associated with the behavioural finance literature. Considerable research effort has been dedicated to the development of models in which a proportion of investors act according to the EMH while the remainder operate other strategies. A notable example of this approach is Shiller (1989).

[4]Intuitively, bubbles cannot be propagated in a setting of perfect arbitrage in which rational arbitrageurs act in a coordinated fashion. In this way, Abreu and Brunnermeier's work is reminiscent of the 'limits to arbitrage' approach of Shleifer and Vishny (1997).

investors estimate the probability of the continuation of a stochastic bubble into the next period and will invest if the expected excess return is sufficient to compensate for the inherent riskiness of the investment. In layman's terms, it may be preferable to 'ride the wave' in order to realise risky excess returns rather than to exit the market. Such trading of risk against return in the setting of a nascent bubble may be particularly prevalent in the case of managed money, where funds attract investors on the strength of their prior returns.

Drawing on the Keynesian tradition, one can raise a fundamental objection to the EMH. In an uncertain world in which time is an irreversible continuum, the principal of invariance central to mainstream notions of rationality is rendered largely unworkable. Mainstream rationality is dependent on the existence of an invariant ordering of preferences such that if $A$ is preferred to $B$ ($A > B$) and $B > C$ then $A > C$. However, in an uncertain world, the fact that $A > B$ at time $t$ and $B > C$ at time $t+1$ does not necessarily imply that $A > C$ either in period $t$ or $t+1$, nor even that $A > B$ at time $t+1$ or $B > C$ at time $t$. Once future uncertainty is introduced, the principal of invariance cannot be generalised across time periods. In such a setting, an optimally forecast return cannot be defined without reference to an individual's expectations and, therefore, cannot be generalised. The implication is that different investors are likely to attach different values to the same asset. The concept of a fundamental value which exists based on factors which are strictly independent of investors' expectations would require exact knowledge of the discount rate and income stream into the future. This simple process of *reductio ad absurdum* convincingly discredits the EMH[5].

Mark Hayes (2006) presents a simple framework based on Keynes' argument that, in practice, the ability of economic agents to assess the future value of a good in an unpredictable market situation is limited if not negligible over anything but a short timeframe (Keynes, 1936, ch. 12; 1937, pp. 214-215; Erturk, 2006, §3). Hence, it is rational for investors to pay more attention to the expected price of an asset in the near future than to relatively more weakly held beliefs about its price in distant periods. Thus, Hayes proposes a relation of the form:

$$(q_{t+1} \geq q_t (1 + r_{t+1})) |\Omega_t = (q_{t+1} \leq q_t (1 + r_{t+1})) |\Omega_t$$

which states that the Keynesian probabilities of an asset price appreciating and depreciating are equal. The implication is that in a world characterised by Keynesian uncertainty,

[5] While criticism of the EMH was once the preserve of a marginalised group of non–conformist economists, there is evidence that such views are slowly permeating into policymaking circles (e.g. Buiter, 2007).

a rational arbitrageur should be concerned not with the basis of a particular pricing convention but rather with its expected duration.

This simple framework bears a striking similarity to the financial Keynesianism of Hyman Minsky (1976, 1977, 1980, 1982, 1986a, 1986b). In stylised fashion, the critical elements of the Financial Fragility Hypothesis (FFH) may be summarised as follows: (i.) debt–funded asset acquisition is widespread; (ii.) investment behaviour is significantly affected by conventional valuation and so asset booms tend to gain momentum; (iii.) price level inflation is met by rising interest rates which may cause safe hedge financing units to become either potentially unstable speculative units or demonstrably fragile Ponzi units[6]; (iv.) thinly capitalised financial institutions are vulnerable to bankruptcies among their clients; and (v.) failures of individual financial institutions are unlikely to remain isolated due to the inter–relationships typifying financial contracting (financial contagion).

Two general points characterise the Minskyan scheme. Firstly, no exogenous spur is required to start this chain of events. Minsky views financial fragility as arising endogenously as the natural product of a capitalist economy under passive governance. Secondly, inflation–targeting interest rate policy may be destabilising in a Minskyan model as it alters the cash commitments of firms after they have made their borrowing decisions in an *ex ante* unforeseeable manner. This last point is highly controversial as it cautions against the current practice of manipulating the interest rate in an attempt to achieve price stability. Given the earlier observation that asset market cycles are becoming both more frequent and more severe, the importance of developing a proper understanding of the relationship between monetary policy and financial fragility is apparent. Indeed, in the present economic climate, this must be considered the single most important challenge facing central banks around the World. Motivated by these concerns, Chapter 5 attempts to contribute to the analysis of the proposed linkage between interest rates and financial fragility.

Despite the recent surge of interest in Minskyan economics, very little formal modelling has been undertaken in the Minskyan tradition. Notable examples of model–based simulations include Taylor and O'Connell, 1985; Delli Gatti, Gallegati, and Gardini, 1993; and Fazzari, Ferri, and Greenberg, 2008. However, at present there is a distinct lack of empirical evidence in direct support of Minsky's core propositions[7]. This lack of empirical

[6]Minsky (1986b, pp. 335-341) rigorously defines these three financial structures. For an example of his view of the transition between financial structures see Minsky (1982, p. 66-8).

[7]Fazzari (1999) argues that recent micro–founded modelling at the interface between finance and economics complements Minsky's work and that the associated empirical research provides indirect support for the FFH. However, these models are not inherently Minskyan and financial fragility does not generally arise endogenously. Moreover, Fazzari notes that Minsky's advocacy of a 'Big Government' and a 'Big (Central) Bank' remains largely unknown to mainstream academics and practitioners alike.

support is one of the principle reasons that the FFH, and particularly the link between interest rates and financial fragility, remains so controversial.

Chapter 5 attempts to address this lacuna by developing a small macroeconomic model which displays many of the key features of a Minskyan economy. The model is comprised of four equations: an aggregate demand curve, a central bank reaction function, an investment function, and a price inflation equation. The equations will be mostly familiar to students of monetary economics with the exception of the investment function, which draws inspiration from Fazzari and Mott (1986-7), Ndikumana (1999) and Godley and Lavoie (2001-2). Real investment is modelled as a function of real internal funds, the real cost of servicing existing debt, the valuation ratio and the output gap, which proxies the rate of capacity utilisation. The cash–flow and debt–service terms reflect the ability of the firm to finance new investments through retained earnings and borrowing, while the inclusion of Tobin's $q$ allows stock market sentiment to enter the investment decision.

The system of equations is imposed as the over–identified long–run structure in a cointegrating VAR model estimated on US data covering 1967Q1 to 2007Q4. The use of CVAR methodology provides for a thorough analysis of the dynamic relationships between the variables in the model, while the imposition of a theory–based over–identifying structure provides a means by which various core principles of the FFH can be incorporated as long–run relationships. It is for these reasons that CVAR models are so popular in the analysis of monetary and fiscal policies. Furthermore, in order to account for the profound volatility of the price of oil during the sample period, and the effect that this has exerted on the US business cycle, an oil price index is included as an I(1) forcing variable in the sense of Granger and Lin (1995). The resulting CVARX model is estimated following the long–run structural method of Garratt, Lee, Pesaran, and Shin (2006).

The results derived from the model suggest that inflation–targeting monetary policy may be destabilising to the extent that interest rate rises impair the ability of firms to meet their debt–servicing obligations. An interest rate hike results in a substantial increase in the real cost of debt–service accompanied by a real fall in internal funds. There is, thus, substantial support for Minsky's proposition that interest rate innovations may be destabilising.

The model is also used to analyse the effect of a shock to the valuation ratio, which may be interpreted as an episode of 'irrational exuberance'. It is typically assumed by proponents of the New Consensus approach to monetary policy that the inflation and output gaps are sufficient summary statistics for the state of the economy. If this proposition holds, one would expect that a positive shock to the valuation ratio would be reflected in increased inflationary pressure. The results reveal that the shock has no significant effect on inflation, indicating that monetary policy formulated using a Taylor–type rule will not react to such pressure. With this in mind, one could argue that monetary policy decisions should be made with regard to a wider range of indicators (see Svensson, 2000, for a similar view).

There is a general (although by no means universal) consensus that monetary policy should neither target nor respond to asset price misalignments. Four reasons are typically advanced in support of this position: (i.) a belief that price level stability cultivates financial stability (Schwartz, 1988; 1998); (ii.) the contention that bubbles cannot be reliably identified (Bernanke, 2002; 2003); (iii.) policy cannot operate meaningfully with more targets than instruments (Tinbergen, 1952); and (iv.) the interest rate implement is too unwieldy to target specific markets (Bernanke, 2006).

Recent economic events have convincingly demonstrated that the first of these propositions is profoundly flawed. Similarly, with regard to the second point, monetary policy already relies on tentative estimates of unobservable concepts including potential output and the equilibrium real interest rate: it is not clear why identifying bubbles should be any more difficult (Cecchetti, Genberg, Lipsky, and Wadhwani, 2000)[8].

Points (iii.) and (iv.) are of more interest, although their validity rests fundamentally on the assumption that the central bank has just one instrument of policy: the short–term interest rate. Following Schwartz (2002) and Palley (2004; 2006), the chapter argues that the central bank has the power to manipulate the reserve requirement by asset class. In an economy with $n$ asset classes, the exploitation of these heterogeneous reserve requirements would grant the monetary authority an additional $n-1$ policy instruments. In this way, monetary policy can be meaningfully conducted with respect to multiple targets or goals. Similarly, the interest rate need not be changed in order to cool (or indeed stimulate) a specific market. Hence, the chapter concludes in favour of the use of asset–based reserve requirements (ABRR) in conjunction with traditional interest rate policy as appropriate but with a distinct emphasis on minimising interest rate volatility.

## 1.3 Monetary Policymaking in an Open Economy

The vast majority of economic modelling is conducted in the setting of a closed economy, with external shocks either altogether absent or otherwise introduced in an *ad hoc*

[8]Much of the existing bubble–testing literature is flawed to the extent that it identifies bubbles with deviations from fundamental value (see Gurkaynak, 2005, for a thorough survey). A more pragmatic approach may be required, an interesting and simple example of which is proposed by Holz (2008).

fashion, with little attempt to model their transmission (see also Svensson, 2000). With the widespread liberalisation of financial flows and the deepening of international financial markets, the degree of simplification introduced in this manner is rapidly becoming untenable and the results thus achieved increasingly unreliable. Simply put, there is a pressing need for further research into open economy modelling. Chapter 6 attempts to illuminate the conduct of monetary policy in an open economy setting and demonstrate the important interaction between monetary and fiscal approaches to economic stabilisation.

Closed economy models are especially poorly suited to the analysis of monetary policy for at least two reasons. Firstly, they omit the exchange rate channel of monetary transmission which, the House of Lords (1999) estimates, accounts for more than 60% of the anti–inflationary influence in the first year of a 100 basis point interest rate hike maintained for 12 months. Secondly, closed economy models cannot illuminate the interaction between the interest rate, the current and capital accounts and the budget deficit. The importance of such linkages is apparent in the UK, which currently operates its largest recorded budget deficit and is experiencing unprecedented growth of government debt (c.f. Prince and Swaine, 2008). This observation underscores the fundamental linkage between monetary and fiscal policy decisions.

It is possible to identify two main strands of literature attempting open economy monetary policy analyses: empirical models, and simulations employing the Dynamic Stochastic General Equilibrium (DSGE) framework[9]. Many studies in both traditions have employed the ubiquitous Taylor rule, defined as follows:

$$i_t = r^* + \pi_t + \gamma_1 (\pi_t - \pi^*) + \gamma_2 (Y_t - Y^*)$$

where $i_t$ is the short–term nominal interest rate, $r^*$ is the Wicksellian natural rate of interest, $\pi_t$ is the rate of price level inflation[10], $\pi^*$ is the targeted rate of inflation, $Y_t$ denotes the level of economic activity and $Y^*$ is potential output. For internal consistency, and to ensure that the number of targets does not exceed the number of implements (c.f. Tinbergen, 1952), it is usually assumed that $Y^*$ is the level of output obtained when unemployment is at the NAIRU and when inflation is at the targeted level. Furthermore, the so–called Taylor principle states that $\gamma_1 > 1$ is required for the active stabilisation

[9] An increasing amount of research covers both areas, a recent example being Ratto, Roeger, and in't Veld (2008).

[10] The appropriate inflation measure is not entirely clear. Pragmatism tends to favour the use of consumer price inflation as this (or some variant thereof) is the most commonly targeted metric in practice. This approach has also found a good deal of support in the theoretical and empirical literature (see Clarida, Galí, and Gertler, 1998, and Svensson, 2000, for example). However, Leith and Wren–Lewis (2002) argue that the use of CPI inflation may be chronically destabilising in open economy models, favouring the use of an output price index.

of inflation, while it is typically assumed that $0 \leq \gamma_2 < 1$. A number of authors have suggested that the weight attached to the output gap should in fact be precisely zero (Christiano and Gust, 1999) or otherwise that uncertainty over the measurement of the output gap may result in a smaller optimal value of the parameter $\gamma_2$ than would otherwise be the case (Smets, 1998)[11].

The estimation of empirical exchange rate models has proved remarkably challenging, providing results which are often contradictory, seemingly counter–intuitive or statistically weak (see Cheung, Chinn, and Pascual, 2005, and Engel, 2006). Given this foundation, it is not surprising that the scope of empirical open economy macroeconomic policy models is typically relatively limited.

Vector autoregression (VAR) is undoubtedly the most popular econometric method for use in counterfactual policy analysis, largely due to the ease with which dynamic analysis may be undertaken. While simple VAR models are very much data–driven, it is well established that an identifying structure must be imposed on the matrix of contemporaneous coefficients in order to identify economically meaningful shocks to the system (including monetary and fiscal policy shocks). Unfortunately, the resulting structural VAR (SVAR) models are often highly dependent on the nature of these restrictions.

Two papers which have informed a great deal of the SVAR literature on monetary policy are Bernanke and Mihov (1998) and Galí and Monacelli (2005). The first deploys a semi–structural VAR in the measurement of monetary policy innovations and develops a measure of the policy stance of the central bank based on an exactly–identified model of the reserve market. The second develops a New Keynesian small open economy model which has been widely used to define identifying restrictions in SVAR models. A particularly common practice in the SVAR literature is the imposition of the Ricardian Equivalence proposition, which renders fiscal policy ineffective (Fontana, 2008, provides a critical discussion). The prevalence of fiscal stimulus packages aimed at reducing the severity of the contemporary credit crisis underscore the fact that policymakers evidently do not share this view. For this reason, the majority of the SVAR literature may be considered flawed, certainly in a recessionary environment. In a recent contribution, Galí, López–Salido, and Vallés (2007) deploy an SVAR model in which a proportion of consumers are non–Ricardian. They find substantial support for the idea that increased government spending is expansionary. Similarly, Dungey and Fry (2007) develop a sophisticated SVAR model for New Zealand in which the effects of monetary and fiscal policy are

[11] A growing body of authors including Kara and Nelson (2002) and Bask and Selander (2007) have argued in favour of including the exchange rate or other open economy series in the central bank reaction function, with Corsetti and Pesenti (2005) arguing explicitly that monetary policy conducted with regard to the inflation and output gaps alone may induce unnecessary exchange rate volatility.

jointly identified. Their analysis reveals that the economic consequences of fiscal shocks have been more pronounced than those of monetary shocks between 1983q2-2006q4. There is evidently considerable scope for further work in this area.

DSGE models have become commonplace in the analysis of optimal monetary (and, to a lesser degree, fiscal) policy rules. Proponents of the approach stress its rigorously micro–founded nature and its emphasis on rational, optimising, representative agents (c.f. Kremer, Lombardo, von Thadden, and Werner, 2006). However, the extent to which complex real world economies can be meaningfully modelled using the representative agent framework is unclear. Moreover, the strong assumptions underlying many DSGE models including rational expectations equilibria and linear or logarithmic separability of the utility function, as well as the implications of the transversality conditions, are open to criticism[12].

The DSGE literature does, however, have a considerably broader scope than the SVAR literature, an effect largely attributable to the freedom from dimensionality constraints derived from the paucity of data. Indeed, there is a modest but growing literature deploying DSGE models in the simultaneous analysis of monetary and fiscal policy in an encompassing manner. Recent examples of this approach in a closed economy setting include Chadha and Nolan (2004; 2007), which stress the fundamental interdependence of monetary and fiscal policy decisions. Similarly, Leith and Wren-Lewis (2000; 2006) discuss the interaction of monetary and fiscal policies in the EMU, demonstrating that there is an important role for a combined approach to economic stabilisation. In a subsequent paper (Leith and Wren-Lewis, 2008), the authors conclude that such interactions are similarly important in a two–country system with flexible exchange rates.

Much of the modelling of monetary and fiscal stabilisation regimes relies on the concept of a 'small open economy' as one which is too small to influence global events but which is affected by them. This construct has a number of appealing features, not least of which is the theoretical support that it provides for the assumed weak exogeneity of many variables in empirical analyses. However, in many cases, the assumption that an economy is too small to affect world markets may be unreasonable and the modelling of a system of interdependent economies may provide superior economic insights[13]. This is one of the key advantages of the model developed in Chapter 6, which revolves around a stock–flow consistent (SFC) system of accounts describing a world consisting of two mutually

[12] Note that, like the SVAR literature, many DSGE models also assume Ricardian households.

[13] Recent developments in Global VAR and Panel VAR modelling have the potential to open new frontiers in multi–country macroeconomic modelling (c.f. Ballabriga, Sebastian, and Valles, 1999; Dees, di Mauro, Pesaran, and Smith, 2007; and Greenwood–Nimmo, Hoang, and Shin, 2008). However, such approaches are yet to achieve widespread utilisation due to their computational intensity.

dependent economies. This represents the first serious attempt at developing an SFC model with which to analyse open economy stabilisation policy.

The SFC approach to macroeconomic modelling does not depend on strong assumptions to the same degree as either the SVAR or DSGE paradigms. Rather, SFC models are built upon a foundation of rigorous double entry accountancy. This simple structure ensures that the balance sheet constraints of all sectors are simultaneously satisfied, while also providing a simple means of tracking economic transactions, thereby ensuring the logical coherence of the model. A simple system of behavioural relations is then constructed upon this inviolable basis. For example, the consumption function and the determinants of export prices and quantities must be specified and parameterised.

The model employed in Chapter 6 is a modified and extended version of the advanced open economy model presented by Godley and Lavoie (2006, ch. 12). The model consists of two economies which are identical in most respects and which are linked by financial transactions and trade relations. US bills act as the international asset and households invest their wealth in the form of domestic and foreign bills and in domestic cash. Their portfolio choices are modelled according to the vertical adding up constraints advanced by Brainard and Tobin (1968) and the symmetry restrictions associated with Friedman (1978).

This basic framework is extended in three ways. Firstly, a cost–push inflationary mechanism is added to the model to introduce nominal growth into the model and provide the inflationary forces targeted by the central bank. Secondly, the marginal propensities to consume out of disposable income and wealth are determined endogenously as decreasing functions of the real interest rate. This modification introduces a simple interest rate channel into the model and also results in endogenous cyclical fluctuations following a disturbance, motivating the use of stabilisation policy. Finally, the model is closed with the following stabilisation policies:

i. Procyclical inflation–targeting interest rate policy (IT);

ii. US interest rate leadership (LF);

iii. Anti–inflationary countercyclical fiscal policy combined with IT (CFPIT); and

iv. Anti–inflationary countercyclical fiscal policy and US leadership (CFPLF).

The performance of each of these stabilisation policies is evaluated in light of three economic shocks: a step decrease in UK real exports; an increase the autonomous component of the UK target real wage; and an expansionary US income tax cut. The first shock is explicitly an open economy shock and could not be meaningfully simulated in a closed economy model. The other experiments represent a cost (supply) shock and a demand shock, respectively. In contrast to models of small open economies, it is in the nature of the model developed in Chapter 6 that a country–specific shock will typically pass through to the other country through a series of financial and real linkages. Each of the three shocks works its way through the model in a different way, providing a thorough test of the various policy regimes.

The simulation exercises reveal a number of interesting effects. Firstly, monetary policy in isolation is incapable of stabilising the economy and results in an explosive trajectory in all cases. Similarly, inflation–targeting fiscal policy fails to stabilise the cyclicality of output and inflation following a shock. The combination of inflation targeting monetary and fiscal policies (i.e. CFPIT and CFPLF) results in good stabilisation in most cases, with the combination of fiscal policy and US leadership yielding the best performance in general.

The inability of procyclical monetary policy to stabilise the model is certainly controversial and may seem counter–intuitive. However, this result is potentially consistent the work of Ball and Sheridan (2003) and Angeriz and Arestis (2006) on the ineffectiveness of IT policies. Alternatively, this result may be viewed as evidence of a fundamental interdependence of monetary and fiscal policies of the type discussed by Chadha and Nolan (2004) and Leith and Wren-Lewis (2000; 2006; 2008), among others. This result may be reconciled with the existing empirical literature supporting the efficacy of IT policies if one believes that much of this research has failed to adequately control for the influence of automatic stabilisers and discretionary fiscal interventions. In order to properly account for these influences, empirical analyses would, at a minimum, have to include terms capturing changes in the average and marginal tax rates faced by economic agents, the composition of the tax and benefit systems, the level and composition of net government transfers, and public expectations of future fiscal policy interventions. I am not aware of any studies that have attempted such an analysis.

In addition to lending support to a combined fiscal and monetary approach to economic stabilisation, the results adduced in Chapter 6 suggest that the exchange rate channel of monetary policy may be rather complex. In the current version of the model, in which the government is assumed to fund its budget deficit through the issuance of bills, an increase in the domestic interest rate can induce depreciation in the medium- to long–term. This result is consistent with the observation of Arestis and Sawyer (2004) that the interaction of monetary policy with the exchange rate may be more complex than is often assumed.

Finally, the results also demonstrate an effect that is often overlooked: by increasing the interest rate to combat inflation, the central bank increases the interest income of those agents holding financial assets (c.f. Lavoie, 1995). In the current model, this channel is rather strong and is only reinforced by the government's choice to fund its deficit through increased bill issuance. In fact, when considered together, these effects tend to dominate the interest rate channel of monetary policy operating through the endogeneity of the savings propensities (given the choice of model parameters).

When considered as a whole, the model presents a strong case for a combined fiscal and monetary approach to stabilisation policy. This result stands in stark contrast to the New Consensus in macroeconomics which affords monetary policy an elevated position. The chapter concludes that this currently dominant position is unhelpful and, by invoking the famous 'cat theory' of Deng Xiaoping, argues in favour of a combined policy regime.

## 1.4 Policy Implications

Three general conclusions arise from this thesis. Firstly, if one considers that the central bank's stewardship of the financial system extends beyond systemic stability to the maintenance of a well–functioning system, then it follows that it should consider efficiency and convenience as well as security issues. Hence, the central bank should engage in active regulation of innovations in the payments system in order both to protect the financial system and its consumers from potentially dangerous practices and also to foster those developments that have the potential to improve systemic performance in a variety of ways.

Secondly, the central bank must acknowledge that it possesses a range of tools with which to conduct stabilisation policy, of which the short–term interest rate is just one. In particular, central banks should be ready to manipulate the reserve requirements associated with different asset classes in order to cool or stimulate specific markets as necessary. In this way, the volatility of the short–term interest rate may be minimised and the often undesirable distributional consequences of interest rate policy reduced.

Thirdly, there is strong evidence that closed economy models are of limited use for policy analysis as they fail to properly account for the interaction of the interest rate, the exchange rate, and the current and capital accounts. Furthermore, the interaction of monetary and fiscal policy highlights the need for a mutually consistent approach to economic stabilisation, and stresses the need for the development of an encompassing economic framework capable of simultaneously addressing monetary and fiscal policy issues.

Finally, it should be noted that the work undertaken in this thesis is not intended as an attack on the New Consensus in macroeconomics. Rather, it should be interpreted as a call for reform of a theory which has served the profession well during the "non–inflationary consistently expansionary decade" (King 2003, ¶6) but which is struggling in the current turbulent climate.

# Chapter 2

# Monetary Theory and Policy

## 2.1 Introduction

Recent years have seen a remarkable convergence of the theory and practice of central banking around the notion of inflation–targeting interest rate policy. In such a system, the short–term interest rate is used to manipulate the level of aggregate demand in relation to a given level of aggregate supply in order to achieve a desirable rate of inflation. This inflation target is usually associated with an unemployment rate equal to the NAIRU and output at its potential level.

The policy prescriptions of the New Keynesian model that has developed around this framework may be crudely summarised as the belief that low and stable inflation is a prerequisite condition for a healthy economy and that the most appropriate means of achieving this goal is by way of inflation–targeting interest rate policy. The purpose of this chapter is to review this New Keynesian literature and demonstrate that it presents an excessively narrow view of stabilisation policy. Insodoing, this chapter provides a backdrop to the four chapters forming the body of the thesis, each of which addresses various contemporary issues facing policymakers and the dominant academic model.

The chapter proceeds in six sections. Section 2.2 introduces the simple New Keynesian monetary policy model and elaborates on a number of its basic features. Among these features is a fundamental linkage between the interest rate and output (via aggregate demand) which underlies the modern view of monetary policy. Six channels of monetary transmission are regularly identified in the literature and these are discussed in Section 2.3. Particular attention is paid to the credit channels and the exchange rate channel as these will be especially relevant in Chapters 5 and 6. Section 2.4 identifies a number of lacunae in the standard New Keynesian model, including the strong assumptions underlying the transmission mechanism at a general level, the assumed long–run neutrality of money and the neglect of supply side influences on the time path of inflation and economic growth. Perhaps one of the more significant features of the New Keynesian model is the assumption that agents act in a Ricardian fashion and, therefore, that fiscal policy is largely impotent. This is the focus of Section 2.5. Finally, Section 2.6 summarises the key points of this chapter and discusses their relevance to the work undertaken in the remainder of the thesis.

## 2.2 The New Consensus Macroeconomic Model

Neoclassical theories of the transmission mechanism of monetary policy stress that the central bank sets the amount of money in circulation and that the effects on the macroeconomy derive from either a relative shortage or excess of money in the economy. The gradual realisation that monetary policy can no longer be conducted by the targeting and manipulation of the level, or rate of growth, of various monetary aggregates has led to the general acceptance that money is endogenous and that the interest rate is determined exogenously as the policy implement of the central bank. This observation is embodied in the so–called *New Consensus in Macroeconomics* (NCM) or *New Neo–Classical Synthesis* (see Meyer, 2001a, for example)[1].

In its simplest form, the NCM is typically described by a system of three equations (examples include Meyer, 2001a, p. 2; Monvoisin and Rochon, 2006, p. 65; and Arestis and Sawyer, 2006, p. 848). Monvoison and Rochon present the system as follows:

$$(Y - Y^*) = \alpha_0 - \alpha_1 (r - r^*) + \varepsilon_1 \tag{2.1}$$

$$(\pi - \pi^*) = \beta_1 (Y - Y^*) + \varepsilon_2 \tag{2.2}$$

$$(r - r^*) = \gamma_1 (\pi - \pi^*) + \gamma_2 (Y - Y^*) \tag{2.3}$$

where $(Y - Y^*)$ represents the output gap (defined as the difference between the realised level of output and the maximum achievable level given existing quantities of capital and labour and without creating sustained inflationary pressure), $r$ is the real interest rate, $r^*$ is the Wicksellian natural rate of interest, $(\pi - \pi^*)$ is the deviation between the realised rate of inflation and its target level and Greek letters are coefficients, with the exception

[1]The degree to which the endogeneity of the money supply is viewed as systematic is a point of divergence between Post Keynesian and New Keynesian scholars. Post Keynesians stress that money is brought into existence in the process of credit creation and that the money thus created is extinguished when loans are repaid (Kaldor, 1970; 1982; Moore, 1988). By contrast, New Keynesian theory holds that the money supply is endogenous because the central bank chooses to make it so following Poole's (1970) work on the relative volatility of the IS and LM curves. See Monvoisin and Rochon (2006) and Fontana and Palacio-Vera (2002; 2006) for a more detailed analysis.

of the $\epsilon_i$ which represent stochastic shocks.

Equation 2.1 is a simple IS curve, which is typically augmented with expected future output to represent the forward–looking decision making stressed by the NCM. Equation 2.2 is a Phillips curve and equation 2.3 is a monetary policy reaction function. The specification of equation 2.3 results from a simple re–arrangement of the Taylor rule but it should be clear that the policy instrument of the central bank is the short–term nominal interest rate (Borio, 1997) and that monetary policy only exerts an indirect influence over the real interest rate. It is generally believed that $\gamma_1 > 1$ and $0 \leq \gamma_2 < 1$.

Of course, monetary policy interventions are typically not conducted in a one–off manner and so it is common practice to augment the system of equations in a manner intended to account for various feedback effects, policy inertia and for the forward–looking nature of the policy decisions (a good example of the latter is Clarida et al., 1998; 1999; 2000). Indeed, the role of expectations in linking nominal and real interest rates is fundamental to the NCM approach (see Woodford, 2003, for example). If monetary policy is to succeed in stabilising macroeconomic fluctuations, it must first guide public expectations in the desired manner, a task in which the credibility of the central bank is of paramount importance. It is for this reason that New Keynesian economists typically advocate central bank independence, the transparency of operating procedures and the use of policy rules or constrained discretion.

The omission of monetary aggregates from the system reflects the endogeneity of the money supply, leaving it as a residual quantity (McCallum, 2001, p. 146). Indeed, Woodford (2003, pp. 9-10) argues that the replacement of the LM with a Taylor–type interest rate rule demonstrates that the New Consensus is not concerned with "the consequences of monetary targeting"[2]. Similarly, the deterministic specification of equation 2.3 (there is no stochastic error term) reflects the assumption that the operation of monetary policy is not subject to random errors and that the central bank can exert fine and accurate control over its administered interest rate (Arestis and Sawyer, 2004). However this statement does not by any means imply that monetary policy and the actions of the monetary authority are not subject to uncertainty. The estimation of the natural rate of interest, the model parameters, potential output and even the rate of inflation and GDP

[2]McCallum (2001) specifies a four equation model which incorporates money supply terms which, he stresses, reflect the notion that the power of the central bank to influence short–term nominal interest rates derives from its ability to manipulate the supply of base money (see also Meyer, 2001a). However the underlying structure of the model is similar to that outlined in equations 2.1 to 2.3. In an interesting contribution, Laidler (2002) interprets the observation that the money stock leads output and inflation as evidence that a monetary aggregate may enter the IS curve. Hence, he argues that there may be a 'money channel' whereby agents use excess liquidity to purchase goods rather than to extinguish debt, thereby propagating the disequilibrium and providing a role for the money stock in monetary policy.

growth are all subject to varying degrees of uncertainty (see Dow, 2004, on monetary policymaking under model uncertainty).

Mishkin (2001) identifies a generic desirable range of inflation of between zero and three percent. Setterfield (2006) and Pollin and Zhu (2006) argue that this range is considerably lower than the level consistent with maximum growth, although the results of their cross–country analyses must be interpreted with care. In practice, the institutional arrangements vary by country and the targeted rate of inflation is often considerably higher in developing countries (South Africa is a good example). It is an interesting feature of the NCM that there is little formal basis for the choice of inflation target[3]. The use of various targets in practice leads Lavoie (2004) to the conclusion that there is a hidden equation linking the targeted rate of inflation to the perceived maximum rate of economic growth. The fact remains, however, that the choice is essentially arbitrary. The principle constraint governing this choice is the necessity that the output and inflation gaps provide mutually consistent signals such that there is no conflict between the two goals when the interest rate is set (Tinbergen, 1952).

### 2.2.1 The Open Economy Extension of the NCM

The New Consensus model has been extended to the setting of an open economy with flexible exchange rates by Agénor (2002) and Angeriz and Arestis (2007). The latter present an extended system of equations as follows[4]:

$$
\begin{aligned}
(Y_t - Y_t^*) &= \alpha_0 + \alpha_1\left(Y_{t-1} - Y_{t-1}^*\right) + \alpha_2\left(Y_{t+1}^e - Y_{t+1}^{*e}\right) + \alpha_3\left(i_t - \pi_{t+1}^e\right) && (2.4)\\
&+ \alpha_4 rx_t + \epsilon_1 \\
\pi_t &= \beta_1\left(Y_t - Y_t^*\right) + \beta_2\pi_{t-1} + \beta_3\pi_{t+1}^e + \beta_4\left(\pi_{t+1}^{W,e} - \Delta x_t^e\right) + \epsilon_2 && (2.5)\\
i_t &= (1-\gamma_0)\left\{r^* + \pi_{t+1}^e + \gamma_1\left(Y_{t-1} - Y_{t-1}^*\right) + \gamma_2\left(\pi_{t-1} - \pi^*\right)\right\} && (2.6)\\
&+ \gamma_0 i_{t-1} + \epsilon_3 \\
rx_t &= \delta_0 + \delta_1\left\{\left(i_t - \pi_{t+1}^e\right) - \left(i_t^W - \pi_{t+1}^{W,e}\right)\right\} + \delta_2 c_t + \delta_3 rx_{t+1}^e + \epsilon_4 && (2.7)
\end{aligned}
$$

[3]The choice of two percent CPI inflation instead of zero inflation as a target for UK monetary policy is rooted in the inadequacy of common inflation measures (liquidity trap arguments are also to be found in the literature - an example is Fontana, 2006, p. 442). The figure takes account of both the persistent over–estimation of true inflation by the CPI measure (the Bank of England, 2006, finds over–estimation of 1% while the 1996 US Boskin Commission identifies a range of 0.8-1.6%) and also of improvements in quality which are not reflected by the CPI, estimated as a further 1% (Bank of England, 2006).

[4]Note that, in contrast to the simple model outlined above, the authors include an error term in the monetary policy reaction function.

$$
\begin{aligned}
c_t &= \eta_0 + \eta_1 rx_t + \eta_2 \left(Y_t - Y_t^*\right) + \eta_3 \left(Y_t^W - Y_t^{W*}\right) + \epsilon_5 && (2.8) \\
x_t &= rx_t + p_t^W - p_t && (2.9)
\end{aligned}
$$

where $Y$, $Y^*$, $r^*$, $\pi$ and $\pi^*$ are defined as before, $i$ denotes the short–term nominal interest rate, $rx$ the real exchange rate, $x$ the nominal exchange rate (both defined as the number of units of foreign currency per unit of domestic currency), $c$ the current account and $p$ the natural logarithm of the price level. The superscripts '$e$' and '$W$' indicate expected and World values, respectively.

In this generalised form of the model, the IS curve represented by equation 2.4 is explicitly forward–looking, accounting appropriately for the expectations of economic agents. Furthermore, the real exchange rate enters the IS curve, reflecting its influence over net export activity and, thereby, aggregate demand. The inclusion of expected future inflation in the Phillips curve (equation 2.5) reflects the aforementioned emphasis on expectations in forward–looking New Keynesian models. Angeriz and Arestis note that the inclusion of lagged terms in equations 2.4 and 2.5 allows for short–run price stickiness while maintaining the assumption of long–run price flexibility. Equation 2.6 is a Taylor rule augmented to include policy inertia, where the degree of smoothing is determined by the parameter $\gamma_0$. Equation 2.7 embodies the received wisdom that the real exchange rate is determined by international interest rate differentials, the current account balance and the expectations of market participants. Equation 2.8 notes that the current account position is determined by the real exchange rate and the levels of domestic and global output. Finally, equation 2.9 defines the nominal exchange rate in the usual manner.

The earlier discussion of the three equation system remains valid in this more general case. The main purpose of introducing the open economy framework here is to illuminate the role of the exchange rate in the New Consensus model. A policy–induced nominal interest rate innovation will feed through to the real interest rate due to the stickiness of prices in the short–run. By changing the differential between domestic and foreign real interest rates, the initial monetary policy decision will affect the real exchange rate. This, in turn, will affect aggregate demand through its influence on the current account balance. Furthermore, exchange rate fluctuations are associated with fluctuations in the price of imported goods, thereby exerting a direct influence over inflation.

Based on the New Keynesian models outlined above, it follows that inflation results from the excess of aggregate demand over aggregate supply. Given that supply shocks are assumed to be limited to the short–run and to follow a random walk with zero mean and finite variance, aggregate supply is simply equal to the natural level of output in the long–run. Hence inflation is viewed strictly as a demand phenomenon in the New Consensus (Arestis and Sawyer, 2003a; Blanchard, 2005). In this setting, monetary policy essentially reduces to an exercise in demand–management. Manipulation of the short–term rate of interest on reserves (or settlement balances), is undertaken by the central bank in order to exert an influence over aggregate demand and thereby inflation. The mechanism by which these effects come about is, however, highly complex.

## 2.3 The Channels of Monetary Transmission

The transmission mechanism of monetary policy consists of a number of channels, each of which isolates one particular route by which the effects of a central bank induced shock become manifest. Due to the complexity of the transmission process, there is little agreement over the interaction of these channels, their relative strength or the timescale over which they are likely operate. Any consensus in the field is limited to the general recognition of six major channels: the cost–of–capital channel, the two credit channels, the wealth channel, the asset (monetarist) channel and the exchange rate channel (see, for example, Mishkin, 1995). These are identified in schematic form in Figure 2.1, which is a slightly modified version of that presented by Arestis and Sawyer (2004)[5]. The theory underlying each channel and the degree to which it is supported by empirical evidence is now reviewed, with an emphasis on the credit and exchange rate channels, as these will be of particular relevance to the remainder of this thesis.

### 2.3.1 The Cost–of–Capital Channel

The cost–of–capital channel is common to both the endogenous and exogenous money approaches and is in the spirit of the traditional Keynesian mechanisms found in macroeconomics textbooks (Mankiw, 2003, is a typical example). The mechanism may be summarised as follows: an exogenous increase in the central bank's base rate causes an increase in short–term nominal interest rates due to the commercial banks' practice of setting their lending rate as a mark up over the base rate. This change in short–term interest rates is transmitted to longer–term rates by investors who act to close out the arbitrage position. The New Keynesian proposition of sticky prices causes real interest rates to rise. The implication of an increase in the real interest rate across all time horizons is that the real

[5]Further examples are provided by Kuttner and Mosser (2002, p. 434) and the Monetary Policy Committee (1999, p. 3).

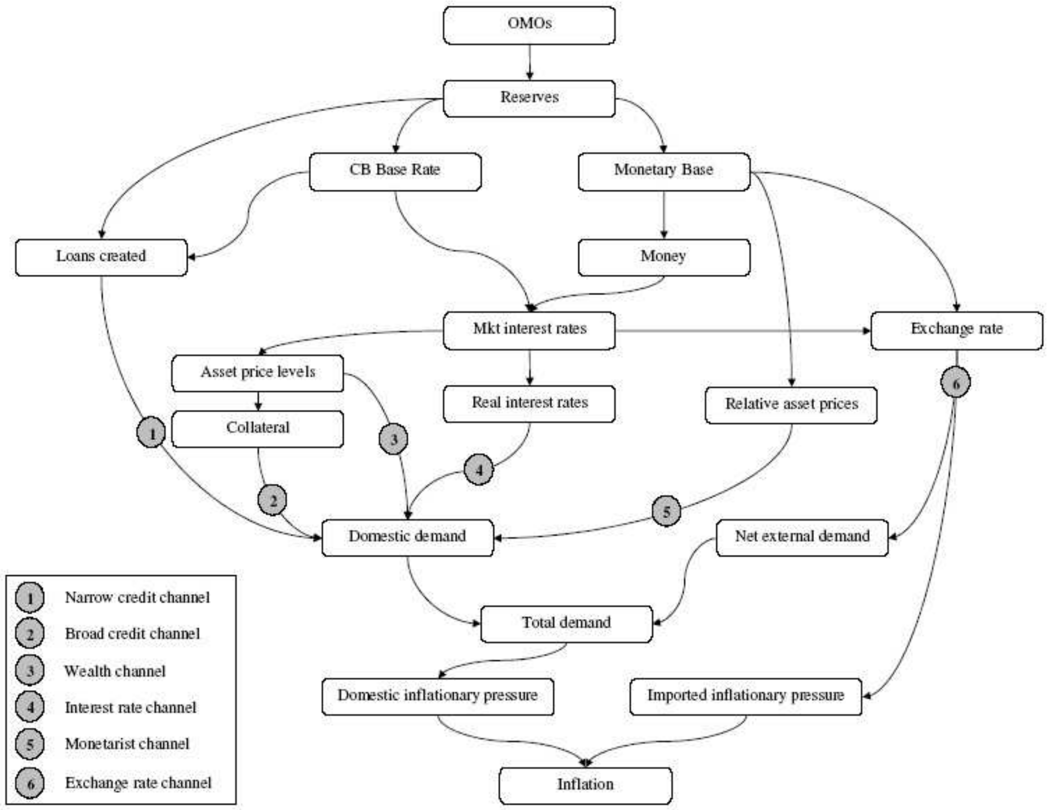


Figure 2.1: The Transmission Mechanism of Monetary Policy

required rate of return on investment rises. This leads households to cut back on their consumption of durable goods and firms to reduce their investment expenditure, as those projects which were marginally worthwhile prior to the change are no longer financially viable. This decline in investment is associated with a concomitant decline in aggregate demand, output and employment[6]. This may be summarised schematically as:

$$i \uparrow \longrightarrow r \uparrow \longrightarrow I \ \& \ C \downarrow \longrightarrow Y \downarrow$$

where $i$ represents the short–term nominal interest rate, $r$ the required real rate of return on investment, $I$ investment, $C$ spending on consumer durables and $Y$ output. It is noteworthy that this channel provides scope for quantity effects in the sense that commercial banks may decide to institute credit rationing in response to a change in the central bank rate rather than (or in addition to) changing their lending rate (Stiglitz and Weiss, 1981; Arestis and Sawyer, 2004).

[6]Cecchetti (1995, p. 85) asserts that such a result is necessarily socially efficient but its simplicity may be criticised for its abstraction from the distributional issues associated with any decline in equilibrium investment.

**Empirical Evidence**

In order for monetary policy to significantly affect investment, the user–cost elasticity of the capital stock (UCE) must be non–zero, with larger values associated with a stronger cost–of–capital channel[7]. However, neoclassical cost–of–capital variables are often found to be statistically insignificant in explaining the investment behaviour of firms (see especially Chirinko and Eisner, 1983, and Chirinko, 1993).

Many studies have attempted to overcome the empirical weakness of the UCE. Until recently, most resorted to the use of specifications which exogenously fixed the UCE at a given level, typically unity under a Cobb–Douglas framework (Blanchard, 1986). The use of such techniques led to the belief in the early 1990's that the true value of the UCE was approximately unity. This assumption has subsequently informed a great deal of fiscal and monetary policymaking. However, the imposition of a unit elasticity lacks a proper rigorous basis, and once it is relaxed many of the familiar results no longer hold (Rowthorn, 1999). Moreover, the cost–of–capital may not be a particularly major determinant of investment as many projects are funded largely by retained earnings (c.f. Chatelain and Tiomo, 2001, and Hannsgen, 2006)[8].

In recent years, the notion that $0 \leq UCE \leq 1$ has gained traction and the Cobb–Douglas function is often replaced with a constant elasticity of substitution (CES) production function which typically generates lower and more plausible figures for the interest rate elasticity of investment (Harrison et al., 2005, p. 34). Major studies in the last decade include Chirinko, Fazzari, and Meyer (1999, 2004), Chatelain, Generale, Hernando, Vermeulen and von Kalckreuth (2001), Chatelain and Tiomo (2001), Mojon, Smets and Vermeulen (2001), Harhoff and Ramb (2001), the Deutsche Bundesbank (2002) and Ellis and Price (2004). The resulting estimates are mostly in the range -0.2 to -0.5, suggesting that a policy–induced increase of 1% in the user–cost–of–capital will lead to a reduction of approximately 0.2% to 0.5% in the demand for capital as opposed to the one–to–one ratio associated with the neoclassical literature[9]. Furthermore, there is evidence of considerable cross–country heterogeneity and that the UCE may be larger in the long–run than in the short–run, indicating that the cost–of–capital channel may operate with a significant lag.

[7] Much of the empirical literature is concerned with the estimation not of the UCE directly but rather of the capital–labour substitution elasticity in a constant elasticities framework (see Ellis and Price, 2004, for example).

[8] There is, of course, an opportunity cost associated with the investment of retained earnings and, to the extent that the rental cost–of–capital is related systematically to this opportunity cost, a cost–of–capital channel will still operate even when investment is not debt–financed.

[9] Chirinko et al. (1999) stress that the popular contention that a sub–unit UCE invalidates the neoclassical theory of the firm is misled on the grounds that a lower elasticity may derive from a production function which constrains in some way the firm's ability to substitute between factors of production.

### 2.3.2 The Broad Credit Channel

The broad credit (balance sheet) channel stresses the importance of a firm's balance sheet in determining its access to, and terms of, credit and the potential for monetary policy to affect the balance sheet and, thus, the relative cost of different sources of capital.

Gertler (1988b) presents an exhaustive, if now dated, review of the literature concerning the role of the credit market in the macroeconomy and discusses the sequence of events which led to the revival of credit–based approaches to monetary policy transmission. In their search for an explanation of the excess variation in business fixed investment and consumer spending following monetary policy innovations, Bernanke and Gertler (1989, 1990) provided the basis of the broad lending approach[10]. At the core of this theory is the proposition that uncollateralised external borrowing is more expensive than internal sources of finance due to the joint problems of agency and monitoring costs arising from informational asymmetries, resulting in an *external financing premium* (see Walsh, 2003, pp. 326-40, for a summary of various informational imperfections characterising credit markets). Such costs are mitigated as the borrower's stake in the proposed project increases and, therefore, the external financing premium varies inversely with the borrower's capitalisable net worth.

Changes in borrowers' net worth arising endogenously are expected *a priori* to be procyclical. This procyclicality implies that movements in borrowers' balance sheets act to reinforce monetary policy actions, an effect known as the *financial accelerator* (Bernanke, Gertler, and Gilchrist, 1996). Thus, an interest rate change engineered by the monetary authority will change the external financing premium in the same direction, thereby reinforcing the effect of the initial policy decision.

Contractionary monetary policy not only raises the repayments on existing debt (thus weakening a firm's balance sheet) but is also generally associated with reduced asset prices and, thereby, a reduction in potential collateral. The second round effect of the tight policy on consumer expenditure further reduces cash flows and net revenues, thereby further weakening the firm's financial position[11]. The resulting reduction in liquidity and collateralisable net worth decreases the borrowers stake in any given investment project, thereby increasing losses associated with adverse selection and moral hazard. In response,

[10]Bernanke and Gertler (1989) invoked costly state verification in the spirit of Townsend (1979) to overcome the inevitability of the Modigliani-Miller (1958, 1963) theorem under Marshallian perfect competition. However, it should be clear that more broadly defined market imperfections also invalidate the Modigliani-Miller result without the restriction that investment projects are observationally identical *ex ante*. Examples of more general models include Gertler (1988a) and Bernanke and Gertler (1990).

[11]Bernanke and Gertler (1995) argue that the mechanism of the broad credit channel is equally applicable to households as to firms. An extension of the balance sheet approach to the household sector is provided by Mishkin (1977, 1978) and Zeldes (1989) and, more recently, Li (2000) has developed a general equilibrium model of the liquidity effect acting through the household sector.

bank lending declines, reducing investment and output. Drawing on Mishkin (1995, p. 8), these effects may be summarised as follows:

$$i \uparrow \longrightarrow P_e \;\&\; CF \;\downarrow \longrightarrow AS \;\&\; MH \;\uparrow \longrightarrow L \downarrow \longrightarrow I \downarrow \longrightarrow Y \downarrow$$

where $P_e$ denotes equity prices, $CF$ represents cash flows, $AS$ & $MH$ the losses associated with adverse selection and moral hazard, and $L$ is bank loans. This mechanism is closely related to the Minskyan model of endogenous financial fragility at the heart of Chapter 5, which can be discussed in terms of a strongly countercyclical external financing premium.

**Empirical Evidence**

The existence of a broad credit channel is relatively widely accepted and has received a good deal of empirical support. In particular, Gertler and Gilchrist (1993, 1994) use firm size to proxy for access to credit and identify significant differences between the behaviour of small and large firms. In the wake of an unanticipated decline in their cash flows, large firms engage in short–term borrowing to smooth production and employment, resulting in the accumulation of inventories (i.e. investment increases). By contrast, small firms are apparently unable to borrow short–term and respond with inventory divestment and reduced production. Similarly, using flow–of–funds data, Christiano, Eichenbaum, and Evans (1996) find that the borrowing of firms' as a whole increases following a monetary tightening, suggesting that they are unable to reduce their nominal expenditure in the short–term. Moreover the authors find that households do not change their borrowing behaviour for a significant period after a monetary tightening.

The use of aggregate credit data cannot resolve the question of whether or not a credit channel is at work. Gertler and Gilchrist propose the use of firm–level data to resolve this indeterminacy, citing the earlier work of Gertler and Hubbard (1988) and Whited (1992) on investment spending and inventory investment, both of which are suggestive of broad credit effects. However, such studies do not specify a unique role for monetary policy in explaining the observed investment behaviour. Oliner and Rudebusch (1996a) address this issue and find a strong association between internal funds and investment spending for small firms following a monetary tightening which does not hold for large firms. Furthermore, in another paper (1996b) the authors find evidence that contractionary monetary policy diverts credit from small to large firms. Given the relatively high frequency of the dataset used and its sample length, these results provide strong support for the existence of a broad credit channel.

Bernanke, Gertler, and Gilchrist (1999) demonstrate the importance of the financial accelerator in monetary policy transmission. In their model, entrepreneurial investment varies inversely with net worth due to the assumption of costly state verification and, while wholesale prices are fully flexible, retail prices are sticky in the sense of Calvo (1983). The authors show that under such a framework, the financial accelerator amplifies the real effect of a monetary policy shock.

### 2.3.3 The Narrow Credit Channel

Oliner and Rudebusch (1996a) emphasise that, beyond the distinction between internal and external finance, the source of finance is unimportant in the broad lending view. However, the narrow credit or bank–lending channel has at its core the proposition that some borrowers are bank–dependent, in that they cannot readily secure finance from alternate sources. In a departure from his famous 1980 paper in which he stresses that financial intermediaries are merely a veil, Fama (1985) argues that they may have a comparative advantage in gathering information about and assessing the risks associated with borrowers, which could explain why the interest rate on bank loans is typically significantly higher than that on directly issued securities. If monetary policy can affect the supply of bank loans, then any policy which reduces lending activity will lead to a concomitant reduction in investment and durable consumption by this class of constrained borrowers and, thereby, a reduction in aggregate demand.

In the textbook exposition of monetary policy, the central bank manipulates the stock of high–powered money which, through the base–multiplier relationship, affects the money supply and causes banks to adjust their interest rates and balance sheets. While traditional accounts of monetary policy transmission focus on the effect of such interest rate manipulations on the economic activity of households and firms, proponents of the bank–lending channel stress the importance of the asset side of bank balance sheets in the absence of perfect and costless substitutes for reserves and loans. Thus any reduction in the stock of base money is reflected in reduced lending, lower investment and lower output.

However, central banks are increasingly acknowledging that they cannot exercise fine control over the money supply and that the relationship between the nominal money supply and nominal GDP may be unstable. For the narrow credit channel to be effective, it must be the case that changes in the base rate affect the lending activity of banks. Such a result follows from the fact that a tightening of monetary policy increases the costs associated with short overnight positions, reducing interbank lending. Moreover, while some banks may secure alternate funds with which to maintain their lending activity, to the extent that the informational imperfections characterising financial markets hinder the valuation of the loan portfolios of banks dealing predominantly with bank–dependent borrowers, some of these banks will be unable to insulate their loan portfolios from the monetary tightening and will have to reduce their lending activity (c.f. Alfara, Garcia, Jara, and Franken, 2005). The mechanism can be summarised as follows:

$$i \uparrow \longrightarrow L^{IB} \downarrow \xrightarrow{*} L \downarrow \longrightarrow I \downarrow \longrightarrow Y \downarrow$$

where * denotes imperfect substitutability of alternate sources of finance in the aftermath of a monetary tightening and $L^{IB}$ represents lending in the interbank market.

Gertler and Gilchrist (1993), Kashyap and Stein (1994) and Oliner and Rudebusch (1995) summarise the conditions necessary for the existence of a distinct bank lending channel as[12]:

i. bank credit is 'special' in that borrowers cannot freely substitute away from bank loans to an alternate source of finance in the aftermath of a decrease in the extension of loans (c.f. James, 1987);

ii. an increase in the central bank base rate is associated with decreased interbank lending in a situation where at least some banks cannot costlessly find alternative sources of funds with which to insulate their loan portfolios; and

iii. price–stickiness is required for the policy shock to have real effects.

Note that the second assumption has been modified for consistency with the endogenous money view. The first and third assumptions are relatively uncontroversial although it is not clear that bank credit will remain 'special' as equity and other financial markets grow deeper and falling transactions costs widen participation in these markets. Indeed, future developments in e–money technologies may further undermine the privileged position of bank credit.

Romer and Romer (1990) argue that the second condition as originally defined (with regard to exogenous money) is violated when banks can fund lending at the margin by increasing their holdings of time deposits (e.g. certificates of deposit, CDs) which are not subject to reserve requirements. However, in an endogenous money model, the second condition is only invalidated if all banks can costlessly substitute between reserves and

[12]Walsh (2003) stresses that credit rationing (in the sense of Jaffee and Russell, 1976; Keeton, 1979; Stiglitz and Weiss, 1981; Jaffee and Stiglitz, 1990) is a sufficient but not a necessary condition for the existence of a credit channel of monetary policy, a contention supported by Gertler and Gilchrist (1993) among others. For a Post Keynesian perspective on credit rationing which stresses the role of asymmetric expectations and endogenous financial fragility in addition to the traditional asymmetric information assumption, see Wolfson (1996).

alternative sources of funds (Hubbard, 1995). Such a situation is not plausible, particularly because large–denomination CDs are not eligible for Federal Deposit Insurance. Hence, potential lenders would have to incur investigative and monitoring costs in order to limit their exposure to default risk (Moore, 1988, pp. 32-37). Thus, the supply schedule of such liabilities may be imperfectly elastic, with the implication that a tightening of monetary policy associated with reduced interbank lending would increase banks' reliance on non–deposit sources of funds, thereby increasing the marginal cost of funds and shifting the loan supply inward (Kashyap and Stein, 1994).

The Post Keynesian literature can make a valuable contribution here. The bank–lending channel stresses the role of the supply of bank lending as a constraint to the level of investment (Rochon, 1999, p. 248). By contrast, the horizontalist position (Moore, 1988) holds that the supply of bank loans passively accommodates demand at any particular rate of interest. Under such a framework, money is credit–driven and demand–determined and the supply of loans is never a constraint to creditworthy investors. However, this is not to deny the existence of an 'unsatisfied fringe' (in the words of Keynes) of insufficiently creditworthy agents. This represents a form of credit constraint which emanates strictly from the demand–side (Rochon, 1999, p. 269). A policy–induced interest rate impulse may cause the definition of creditworthiness to change in line with the severity of the problems of moral hazard and adverse selection. Hence, monetary policy may change the size and membership of the unsatisfied fringe[13].

**Empirical Evidence**

The existence of a distinct bank–lending channel is highly controversial. Empirical attempts to positively identify narrow credit effects have been largely inconclusive. Early attempts can be divided into two categories: those employing time series methodology to show that monetary policy causes changes in lending activity and those using cross–sectional techniques to identify the effects of monetary policy on liquidity–constrained borrowers. More recently, some innovative contributions have been made using panel data.

Bernanke (1983) provides one of the earliest time series studies into bank lending in his analysis of the Great Depression. He finds that the supply of bank loans is important in explaining the severity and persistence of the depression, an effect which he attributes to the reduction in lending brought about by the fear of bank runs.

[13] A second school of thought, referred to by Rochon as 'neo–post–Keynesian', assumes imperfect accommodation of reserve demand by the central bank, with the implication of non–accommodation of private loan demand by commercial banks. This amounts to an explicit recognition of the role of supply–side constraints on investment in the Post Keynesian tradition (Rochon, 1999, p. 263).

King (1986) estimates an unrestricted VAR and finds that changes in monetary aggregates lead changes in GDP, while changes in lending occur contemporaneously. He interprets this as evidence that loans cannot be important in transmitting the effect of monetary policy to GDP. King's finding that monetary aggregates have more predictive power for future output than bank lending in the US is supported by the work of Romer and Romer (1990) and Ramey (1993). However, Bernanke and Blinder (1992) criticise King for drawing structural inferences from a reduced–form model. Using a semi–structural VAR, they find that bank lending responds strongly but in lagged fashion to monetary policy. Moreover, they find that the response of loans coincides with that of unemployment in a manner "strikingly consistent with the credit view" (p. 903).

These early approaches using aggregate data suffer from an identification problem: it is unclear whether a change in the aggregate data derives from the supply–side in a manner consistent with a credit channel, or from the demand–side reflecting a cost–of–capital effect. To overcome this indeterminacy, much of the modern literature follows the approach of Kashyap, Stein, and Wilcox (1993), which considers the impact of monetary policy on the composition of borrowing and lending. The authors assess the impact of monetary policy[14] on the mix of bank lending and commercial paper on firms' balance sheets. A demand–side response should reduce demand for all types of borrowing while a supply–side effect will manifest itself as a reduction in the proportion of bank lending in the mix. Their results indicate that an increase in the base rate raises the proportion of commercial paper in the mix. Furthermore, the debt mix is found to have explanatory power for investment, indicating that some borrowers may be bank–dependent. Finally, they find that the prime lending rate increases more than the rate on commercial paper during periods of contractionary monetary policy. Taken together, these results provide strong support for the operation of a bank–lending channel[15].

Using similar intuition, Gertler and Gilchrist (1994) find evidence of a bank–lending channel while Nilsen (2002) focuses on trade credit rather than commercial paper and finds that both small and large firms increasingly rely on this means of finance following a monetary tightening. Nilsen speculates that the critical issue is whether or not a firm

[14]In this case, tight policy episodes are identified firstly by the Romer dates (Romer and Romer, 1989) and also by the statistical method of Bernanke and Blinder (1992).

[15]Oliner and Rudebusch (1995, 1996b) contest the results adduced by Kashyap et al., arguing that once trade credit is included in the analysis and firm size effects are appropriately controlled for, then the mix remains unaffected by interest rate innovations. However, in a damning response to this criticism, Kashyap, Stein, and Wilcox (1996) argue that these results derive from the introduction of a new mix variable. Moreover they argue that Oliner and Rudebusch's empirical results are not necessarily inconsistent with the existence of a credit channel because the observed increase in the issuance of commercial paper by large firms is consistent with an increased level of trade credit brought about by the reduced availability of bank loans to smaller firms.

has a bond rating rather than its size as traditionally defined, implying that the group of credit–constrained firms may be larger than previously thought.

If the existence of a bank–lending channel in the US alone is contentious, the international picture is equally varied. Alfara et al. (2005) obtain results strongly suggestive of the operation of a bank lending channel in Chile, while Hernando and Martínez-Pagés (2001) find little evidence of such effects in Spain. Similarly, Huang (2003) finds evidence of a bank lending channel operating in the UK while Ludi and Ground (2006) find no evidence of its operation in South Africa.

The general conclusion arising from the empirical work is that the bank–lending channel is considerably more controversial than its broad credit counterpart. In addition to this, it seems likely to become gradually less important as innovation changes the financial landscape and reduces the transaction and informational costs associated with financial markets, diminishing the role of conventional banks (Thornton, 1994; Edwards and Mishkin, 1995).

### 2.3.4 The Wealth Channel

The wealth effect on consumption, associated particularly with Ando and Modigliani (1963), has become a cornerstone of modern macroeconomic theory. In a subsequent paper, Modigliani (1971) estimates that a dollar increase in household wealth causes an increase in consumption of five cents, an estimate which has subsequently received a good deal of empirical support (as discussed in the next section).

Starr–McCluer (1998, pp. 2-3) presents an excellent discussion of the wealth effect using a life–cycle model. She represents the household's lifetime budget constraint as:

$$\sum_{t=0}^{T} \frac{1}{(1+r^S)^t} C_t = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r^S)^t} Y_t^L \tag{2.10}$$

where $r^S$ is the rate of return on saving, $C_t$ is consumption, $A_0$ is the initial asset endowment and $Y_t^L$ denotes wage income. It is assumed that the household dies at time $T$ with no wealth. Starr–McCluer assumes a logarithmic utility function and shows that the sum of utility, discounted at the rate $\delta$, is equal to $\sum_{t=0}^{T} \delta^t log(C_t)$. By simple maximisation of this expression with respect to (2.10) it follows that:

$$C_t^* = \frac{\delta^t(1+r^S)^t}{\sum_{t=0}^{T} \delta^t(1+r^S)^t} \left\{ A_0 + \sum_{t=0}^{T} \frac{1}{(1+r^S)^t} Y_t^L \right\} = m_t V \tag{2.11}$$

where $m_t$ is the marginal propensity to consume and $V$ is the sum of the initial wealth endowment and the discounted value of future labour income. An unexpected exogenous increase in the value of assets leads to an increase in consumption at time $t$ of $m_t \Delta A_0$.

The wealth channel relies on the joint propositions that consumer wealth enters the consumption function and that at least some of the elements comprising consumer wealth are interest sensitive (e.g. financial assets and real estate). If these conditions are met, then an exogenous change in the interest rate will affect consumption and aggregate demand directly:

$$i \uparrow \longrightarrow P_I\ ,\ P_h \downarrow \longrightarrow W \downarrow \longrightarrow C \downarrow \longrightarrow Y \downarrow$$

where $P_I$ denotes the price of investment assets, $P_h$ the price of real estate, $W$ wealth and $C$ consumption.

**Empirical Evidence**

There is some debate concerning the impact that exogenous changes in the various components of consumer wealth will have on consumption spending. Case, Quigley, and Shiller (2005, p. 5), for example, demonstrate that there is no reason to think that the effect of changes in real estate wealth are of comparable magnitude (or even direction) to those associated with changes in stock prices. Furthermore, in the case of real estate, the effects of higher prices on owner–occupiers, tenants and those who derive an income from property will differ. Given these difficulties in modelling broadly defined wealth effects, the literature focuses almost exclusively on stock market wealth effects.

The existence of a wealth effect is generally accepted but its strength, its timing and the role of monetary policy are unclear. Loosely following Poterba (2000), the key points raised in the literature may be summarised as follows:

i. the empirical evidence generally supports the existence of a direct stock–market wealth effect (Poterba, 2000; Dynan and Maki, 2001);

ii. estimates of the marginal propensity to consume out of stock market wealth generally lie between 0.01-0.05 (c.f. Brayton and Tinsley, 1996) although some studies suggest higher figures (examples include Parker, 1999 and Dynan and Maki, 2001);

iii. stock ownership is concentrated among high net–worth households, which explains the modest impact of equity shocks on aggregate consumption (c.f. Mankiw and Zeldes, 1991; Starr–McCluer, 1998; Parker, 1999; Dynan and Maki, 2001);

iv. there is little reason to believe that the wealth effect acts symmetrically, although the direction of asymmetry is unclear. Zandi (1999) finds a more pronounced effect of negative stock market shocks while Apergis and Miller (2005) find the opposite.

Two recent papers which deserve special attention are those of Ludvigson, Steindel, and Lettau (2002) and Lettau and Ludvigson (2004). Ludvigson et al. (pp. 118-120) demonstrate that the consumption–wealth effect is important in the transmission of monetary policy in some major American macroeconometric models, although estimation of their own SVAR indicates only a weak wealth effect and, moreover, suggests that asset prices may react more strongly to price signals than to interest rates. More recently Lettau and Ludvigson (2004) separate the permanent and transitory elements of household wealth and show that while there is a relationship between consumption and permanent wealth shocks, transitory wealth shocks exert no influence over consumption. Their result has intuitive appeal, although their approach has been criticised on the grounds of model uncertainty by Koop, Potter, and Strachan (2005).

The focus of the empirical work on wealth effects arising from the stock market has been to the detriment of research into real–estate wealth effects. The impact of the housing market on consumption and thereby aggregate demand is particularly relevant at the present time given the spectacular real estate bubbles that have recently started to burst in many Western economies. However, the theoretical literature does not offer any strong, unambiguous insights into the real–estate wealth effect. Case et al. (2005) find little consensus in the literature and, while their own modelling supports the real–estate wealth channel, their results are sensitive to the choice of specification.

### 2.3.5 The Asset (Monetarist) Channel

The wealth and broad credit channels provide an avenue whereby the level of asset prices can influence aggregate demand. The asset channel, by contrast, stresses the role of relative prices. An asset channel operates when money and a range of real assets are readily substitutable. This view critically underpins the Monetarist approach to monetary policy, which emphasises a range of relative prices (Meltzer, 1995). This, in effect, downgrades the interest rate as this represents just one price among many.

Due to the increasingly wide rejection of the assumption of money supply exogeneity (c.f. Woodford, 2003), no discussion of the formalities of Monetarist modelling is offered here[16]. Instead, the main points of the Monetarist theory of monetary transmission are highlighted from an endogenous money perspective. Furthermore, the empirical work testing the Monetarist hypothesis is framed in terms of an exogenous money supply and, as

[16]See Meltzer (1995) for a thorough discussion of the Monetarist view of the monetary transmission mechanism.

such, it is not discussed here. The emphasis of this section is on discussing the observation that a range of relative prices is important in monetary transmission and on briefly summarising the key asset price effects identified in the Monetarist literature.

Meltzer (1995, pp. 53-59) stresses that Monetarist models include at least three asset classes: (i) money; (ii) bonds and securities and (iii) real capital assets. The inclusion of the real capital stock allows for the consideration of complex optimising behaviour: rational economic agents now have the choice to hold their wealth (in various proportions) not just in money and bonds but also in real assets. The three asset classes are typically treated as imperfect substitutes, at least in the short–run.

The wealth channels outlined in the previous section represent integral components of the Monetarist view of monetary transmission. It is typically also argued that the effect of stock market fluctuations on firms are an important determinant of the effect of monetary policy in the Monetarist tradition. This may be most clearly expressed in relation to Tobin's (1969) $q$ theory. Tobin's $q$ is defined as the ratio of the market value of a firm to the replacement cost of its capital. A firm will invest in new capital as long as it is cheaper to do so than to acquire the assets through takeover activity. This is the case when $q > 1$[17]. If $q < 1$ then it is preferable for firms to engage in takeover activity in order to expand, while firms are indifferent between either course of action when $q = 1$.

To the extent that stock prices are sensitive to monetary policy changes, then $q$ is also sensitive to such changes. It is widely accepted that monetary policy can affect stock prices by changing the risk–free rate of interest and also various risk–premia. It is generally the case that an unexpected change in the central bank base rate results in a stock price movement in the opposite direction subject to a multiplier of between three and six (Bernanke, 2003). Thus the mechanism associated with $q$–theory may be summarised as:

$$i \uparrow \longrightarrow P_e \downarrow \longrightarrow q \downarrow \longrightarrow I \downarrow \longrightarrow Y \downarrow$$

where $P_e$ is the price of equity. While the simplicity and observability of $q$ is appealing, it is not without its flaws. The most fundamental problem with $q$ is that it is not the absolute level of $q$ which should be used for investment decisions but the marginal value, which can-

[17] Hannsgen (2006, p. 210) shows that this condition is analogous to $NPV > 0$, highlighting the similarities between this approach and the cost–of–capital channel. The principal difference arises due to the emphasis on the value of the firm in Monetarist theory as opposed to the role of the interest rate in directly affecting the cost–of–capital in the Keynesian model. However, the Monetarist approach based on $q$–theory may have some advantages over standard cost–of–capital explanations, especially with regard to Hannsgen's observation that changes in the estimated profits of firms may override the effect on investment of a change in the rate of interest arising through the cost–of–capital channel. It is precisely such effects that the $q$–theory captures.

not be satisfactorily measured. Moreover, the theory is reliant on the strong assumptions of perfect and symmetrical information in a world without agency problems (see Crotty, 1990, 1992, Palley, 2001b, and Hannsgen, 2006, for a more thorough discussion).

### 2.3.6 The Exchange Rate Channel

The exchange rate channel is often discussed last among the group of monetary transmission channels, if it is mentioned at all. Indeed, a substantial majority of the research effort devoted to the analysis of monetary policy is conducted in a closed economy setting where the exchange rate channel is explicitly omitted.

Arestis and Sawyer (2004) identify two independent routes by which the effects of monetary policy arise through the exchange rate channel. The first may be summarised as follows:

$$i \uparrow \longrightarrow e \uparrow \longrightarrow NX \downarrow \longrightarrow Y \downarrow$$

where $e$ represents the exchange rate (in terms of units of foreign currency per unit of domestic currency) and $NX$ represents net exports. Arestis and Sawyer argue that a policy–induced increase in the interest rate makes financial assets denominated in the domestic currency more attractive, leading to a relative appreciation of the currency. This, in turn, reduces the competitiveness of exported goods, lowering net exports and thereby aggregate demand, output and inflation.

The second route works through the change in import prices arising due to a change in the exchange rate, which directly affects aggregate demand and price level inflation:

$$i \uparrow \longrightarrow e \uparrow \longrightarrow P_M \downarrow \longrightarrow Y \uparrow$$

where $P_M$ denotes import prices. The divergence of the two mechanisms reflects the differential effect of an exchange rate change on the domestic and foreign components of aggregate demand. There is little firm basis upon which to form an informed expectation about which effect will dominate *ex ante*, leaving the direction and magnitude of the economic response to monetary policy arising through the exchange rate channel ambiguous. Moreover, to the extent that banks and non–financial firms and even households hold assets denominated in foreign currencies, a change in the exchange rate may affect their balance sheets, causing additional effects through the broad credit, wealth and Monetarist channels (and potentially the bank–lending channel in the event of a significant effect on banks' balance sheets).

Arestis and Sawyer (2006) use the term ‘spillover effects’ to identify the effect of interest rate policy on exchange rates. Such a term invokes visions of a system in which monetary policy is set without consideration for the exchange rate and its impact on the latter is accidental. While this may be an unreasonably harsh characterisation of some monetary regimes (e.g. those of the European countries during the Exchange Rate Mechanism - Smets, 1997), it is in keeping with the majority of the literature on interest rate rules, which seldom mentions a role for the exchange rate in the formulation of monetary policy.

**Empirical Evidence**

In their conclusions, Kuttner and Mosser (2002, p. 441) contend that:

> the absence of attention to an open economy channel running through the exchange rate is an important lacuna. There are two reasons for this. The first is that despite the growth of trade in recent years, the external sector has remained a relatively small part of the US economy...[a]nd the second is that a firm connection between economic fundamentals and short–run exchange rate movements continues to elude researchers, frustrating efforts to pin down the exchange rate channel empirically.

The first point is somewhat specific to the US economy and is not relevant in the case of smaller open economies. However, their second point highlights the critical reason for the absence of a rigorous empirical literature assessing the exchange rate channel. In the simplest case, the exchange rate channel may be represented as follows:

$$\Delta i \xrightarrow{(1)} \Delta e \xrightarrow{(2)} \Delta \pi$$

here $\Delta i$ represents a change in the rate of interest brought about by the central bank and $\Delta \pi$ the resulting change in the rate of inflation. In the diagram, (1) represents the linkage between interest rates and exchange rates which, the theoretical literature informs us, depends critically on the UIP relationship. However, it has been found repeatedly that this is not robust to empirical testing (see Froot and Thaler, 1990, for example). Secondly, as discussed above, the linkage between the exchange rate and inflation denoted (2) is not as trivial as the simple ‘exchange rates up *ergo* prices down’ relationship found in many textbooks.

A great deal of research effort has focused on either (1) or (2) but, due to the general finding that the UIP does not hold and the complexity of the pass–through effects, little progress has been made on the nature of the entire mechanism. These difficulties underlie Kuttner and Mosser's observation that much of the empirical literature on monetary transmission focuses on the US and assumes that it is a closed economy. Even where an exchange rate channel is modelled, it is typically the case that the UIP (or a similar condition) is imposed rather than estimated. The Bank of England Macroeconomic Model is a good example of this: the equation listing provides a model of the effective exchange rate based on the UIP but augmented with a risk adjustment and a measure of the rate of change of inflation of GDP and exports (Bank of England, 1999, pp. 28-29 and 41-42).

Arestis and Sawyer (2006, pp. 852) stress that regardless of whether the UIP holds in practice, it is likely that unexpected monetary policy innovations will exert some influence over the exchange rate and that, therefore, there is a case for the consideration of the impact of monetary policy on the exchange rate in its formulation and implementation. In support of this they cite the comparative approach of Church, Mitchel, Sault, and Wallis (1997) which reveals a potentially highly significant, if somewhat model–dependent, role for an exchange rate channel in the UK. Moreover, the importance of the exchange rate channel is highlighted by the Report of the House of Lords Select Committee on the Monetary Policy Committee at the Bank of England, which estimates that more than 60% of the anti–inflationary effect in the first year after a 1% rate hike maintained for twelve months is attributable to the exchange rate channel (House of Lords, 1999, ¶4.34 and Table A). The need for further research in this area is clear and forms the motivation for Chapter 6.

## 2.4 Lacunae in the New Consensus Model

In the simplest case, the impulse resulting from a monetary tightening can be traced through the system in the following three stages:

(i.) excessive aggregate demand reflected in positive inflation and/or output gaps leads the central bank to raise the interest rate according to equation 2.3;

(ii.) the increase in the interest rate relative to the natural rate reduces investment and consumption spending, reigning in aggregate demand (equation 2.1); and

(iii.) with the excess demand neutralised, equation 2.2 shows that inflation will fall back toward the targeted level.

Each stage in this process relies on a number of assumptions. In the case that $\gamma_2 \neq 0$, the logical consistency of the policy rule requires that the inflation and output gaps are mutually consistent (Tinbergen, 1952). This rests critically on the notion that inflation is predominantly a demand–pull phenomenon, an assumption that is clearly evident in equation 2.2. However, this assumption has been powerfully challenged by Setterfield (2004), who emphasises the contribution of factor costs and institutional factors in the determination of the rate of inflation. Where cost–push factors and conflicting claims are important sources of inflationary pressure, it is not clear that monetary policy conducted in this way can succeed in slowing the rate of price level inflation. Indeed, to the extent that the interest rate affects the debt–servicing costs of firms, rate hikes may actually prove inflationary, certainly in the short–run before firms can economise on their use of credit (c.f. Fontana and Palacio-Vera, 2002; Monvoisin and Rochon, 2006; Palley, 2006; Arestis and Sawyer, 2006).

Implicit in the transition from stage (i.) to stage (ii.) is the notion that the short–term nominal interest rate controlled by the central bank is related systematically to the longer–term real rates which are thought to influence investment and consumption decisions. As mentioned in Section 2.2, the role of expectations in tying nominal and real interest rates together is fundamental to the NCM approach. While this may explain how the central bank can affect short–term real rates, it does not explain how it can manipulate the yield curve at longer horizons. There is little reason to believe that the influence of short–term interbank rates over longer–term market rates is particularly strong, direct, immediate or predictable. Furthermore, it is highly probable that the degree to which longer–term rates track the central bank rate varies with time (due to financial innovation, changes in economic sentiment etc.) and may be discontinuous and/or state–contingent. Monetary policymaking is far from an exact science.

Stage (ii.) of the process relies on the idea that investment and consumption are dependent on the interest rate in a simple, systematic manner. The discussion of the interest rate and credit channels revealed that the empirical evidence is inconclusive with regard to this assertion. In general, the empirical evidence lends no more support to a simple relationship than to one characterised by pronounced non–linearities.

Finally, stage (iii.) relies on the validity of the Phillips curve specified by equation 2.2. This has been fundamentally questioned by Freedman, Harcourt and Kriesler (2004), in which the authors hypothesise the existence of a flat region in which the familiar trade–off is non–existent. Should one accept the existence of a flat section in the short–run Phillips curve, it follows that a similar feature will be present in the long–run Phillips curve. This raises the possibility of a long–run trade–off between capacity utilisation and inflation, and suggests that monetary policy may be non–neutral in the long–run (see Kriesler and Lavoie, 2007)[18]. In such a setting, there may be substantial scope for opportunistic monetary policy of the type discussed by Orphanides and Wilcox (2002) and Palacio-Vera (2005).

A number of more general concerns can also be raised against the NCM view of monetary policy. Firstly, and most importantly, it is not clear that inflation–targeting is necessarily consistent with the maximisation of the level and rate of growth of output (at a sustainable level) and the maintenance of full employment which, most economists would agree, are to be held as the ultimate goals of monetary policy (c.f. Monvoisin and Rochon, 2006). To the extent that price stability facilitates the attainment of these goals it may be useful but it is rather restrictive and distinctly non–Keynesian to consider it an end in itself.

Similarly, the adoption of a Wicksellian equilibrium rate of interest may be questioned. Once one acknowledges the fundamental endogeneity of the money supply, it is clear that the interest rate is simply a quantity administered by the central bank to affect its policy goals. In this context, any equilibrium interest rate depends on the prevailing economic conditions (i.e. the parameterisation of the model) including the budget position, the state of expectations and the 'animal spirits' influencing investment decisions. When viewed in this way, there is little reason to believe that the rate of interest compatible with zero inflation and output gaps will remain constant between periods (see, for example, Fontana and Palacio-Vera, 2002; Monvoisin and Rochon, 2006).

Lastly, the narrow focus of the New Consensus on interest rate operating procedures to the exclusion of all other forms of stabilisation policy is excessively restrictive. Even if one accepts the proposition that the interest rate should be used to target demand–pull inflation, it does not follow that there is no role for other policy instruments. This argument is developed in Chapters 5 and 6.

## 2.5 The Role of Fiscal Policy

The assumption of Ricardian agents embodied in much of the New Consensus literature renders fiscal policy largely irrelevant. It is clear that the New Keynesian school has strayed considerably from its apparent Keynesian roots. The assumption that agents act in a manner consistent with the Ricardian Equivalence even in the long–run is rather tenuous (Fontana, 2008). Recent empirical work by Galí et al. (2007) supports the efficacy of expansionary government spending by introducing a proportion of non–Ricardian households into an otherwise standard SVAR model. Similarly, using a simple reformulated

[18]See also Arestis and Sawyer, 2004, and Setterfield, 2006, on the non–neutrality of money.

NCM model, Setterfield (2007) finds that the combination of active fiscal policy and passive monetary policy is at least as effective at combating inflation as the NCM approach of active monetary policy and passive fiscal policy.

Influenced by Arestis and Sawyer (especially 2003b), Fontana and Palacio-Vera (2006) stress the need for a combined monetary and fiscal approach to stabilisation policy for at least four reasons. First, they note the ambiguity of the interest rate channel of monetary policy (see Section 2.3.1). Second, they dispute the long–run neutrality of monetary policy due to potential labour market hysteresis (Blanchard and Summers, 1989) and the possibility that the natural rate of growth may be endogenous (Cornwall and Cornwall, 1997; León-Ledesma and Thirlwall, 2002). Third, they stress the potentially undesirable distributional effects of interest rate changes (c.f. Argitis and Pitelis, 2001; Rochon and Rossi, 2006) and, finally, they note that higher interest rates may contribute to cost–push inflation by raising the debt–servicing expenditures of firms.

At the core of these issues is the untargeted nature of interest rate policy. References to the 'blunt tool' (Bernanke, 2006) or 'blunderbuss' (Palley, 2006) of the interest rate are not uncommon. The advocacy of inflation targeting interest rate policy in the NCM is fundamentally based on a value judgment that the costs of high and volatile inflation exceed those associated with the indiscriminate 'collateral damage' associated with the manipulation of the interest rate. There is little evidence on which to base this assertion. Fontana and Palacio-Vera hold that the careful use of discretionary fiscal policy in an IT regime could reduce these difficulties[19].

In the extreme case, Arestis and Sawyer (2006) argue that, due to the real effects of interest rate innovations on the exchange rate and fixed capital formation, and in light of their earlier research indicating that monetary policy is of limited use in managing aggregate demand (Arestis and Sawyer, 2004), monetary policy should be concerned with the exchange rate and fiscal policy with inflation. Of course, the fundamental difficulty associated with using fiscal policy to target inflation is that it is not clear which of the many types of tax or government spending should be manipulated to achieve the desired end. It is hoped that the work undertaken in Chapter 6 of this thesis may help to shed some light on these issues.

[19] Of course, a raft of additional stabilisation policies can be identified, including incomes policy, for example. The interested reader is referred to Pollin and Zhu (2006) and Setterfield (2006) for recent examples.

## 2.6 Concluding Remarks

This chapter has provided a thorough survey and critique of the New Consensus in macroeconomics, and has discussed in some detail the theoretical and empirical literature on the transmission mechanism of monetary policy. This discussion forms the basis of the four principle chapters of the thesis, which discuss the adoption of e–money and its regulation, the implications of the increased frequency and severity of asset market cycles and the nature of stabilisation policy in an open economy.

Chapter 3 revisits the literature on the implications of the electronification of the payments system for monetary policy. The argument that the widespread adoption of e–money could break the linkage between reserves and aggregate demand (c.f. Friedman, 1999; 2000) essentially revolves around the contention that e–money poses a threat to the links between reserves, lending and market interest rates in Figure 2.1. Should these links fail, the central bank would be unable to influence the time path of aggregate demand and inflation. However, based on the structure presented above, Chapter 3 argues that this could not happen. This does not, however, imply that e–money is not an important innovation with potentially serious consequences for systemic stability. Hence, the key issue is one of regulation and the maintenance of systemic stability. This is the focus of Chapter 4.

Chapter 5 investigates the proposition that endogenous financial fragility in the sense of Minsky (1982) may impose limits on the degree to which the interest rate may be used to pursue macroeconomic stabilisation. The Minskyan proposition that an anti–inflationary interest rate hike may hinder the ability of firms to service their debts and increase their financial fragility effectively represents very strong interest rate, credit and, potentially, wealth channels (Hannsgen, 2005, identifies an additional 'Minskyan Accelerator Channel'). In a Minskyan model, monetary policy may be non–neutral in the long–run, carrying the implication that inflation targeting interest rate policies may be ill–advised. Indeed, Minskyan endogenous asset cycles may necessitate direct intervention in the activities of financial intermediaries. Hence, there may be a role for alternative policy instruments including prudential credit controls (Fontana and Palacio-Vera, 2002; Arestis and Sawyer, 2006), asset–based reserve requirements (Palley, 2006) and a range of fiscal measures.

Finally, the core contentions underlying the Chapter 6 model are neatly captured in Arestis and Sawyer's (2002) analysis of the Bank of England's (1999, 2000) Macroeconometric Model. The authors show that it shares many of the features of Meyer's (2001a) NCM model but that it differs in three crucial respects: (i) the UK is an open economy and thus the Bank's discretion in setting the repo rate is constrained; (ii) the repo rate has long–run real effects; and (iii) fiscal policy enters the aggregate demand equation. The model developed in Chapter 6 stresses these points, and finds evidence supporting the adoption of a combined monetary and fiscal stabilisation regime.

# Chapter 3

# E–Payments: Adoption, Dispersal and Market Share

## 3.1 Introduction

The acceleration of the process of electronification of financial markets and payments systems has generated considerable interest among both academics and practitioners. Electronification has taken many forms, from the introduction of automated telling machines and internet banking to the deployment of EFTPOS (electronic funds transfer at the point of sale) terminals and, most recently, to the development of various forms of electronic money (e–money). E–money involves the use of encrypted digital images stored either on a hardware device (e.g. a card) or on a computer network. These images may then be used in lieu of traditional means of payment at vendors equipped with the appropriate technology. In many countries, e–money usage has flourished in certain markets, including mass transport systems, parking meters and other high frequency low value transactions (e.g. newsstand purchases).

While the substitution away from physical cash toward electronic alternatives provides scope for potentially substantial efficiency gains and increased convenience, much of the early academic work in the field viewed the development of e–money as a threat to the efficacy of monetary policy. This threat, it was argued, derived from the diminution of the central bank balance sheet and the potential for economic activity to take place in isolation from the central bank (i.e. without recourse to its liabilities for payment purposes). Moreover, it was suggested that e–money schemes may evolve to offer settlement services in competition with those of the central bank. It was argued that, in such a situation, the central bank would lose it's influence over the economy, becoming unable to engage in stabilising monetary policy and leaving the financial system vulnerable.

This chapter argues that this extreme position relies on a flawed model of monetary policy. Furthermore, its alarmist nature has generated more heat than light in the sense that it has distracted attention from the potential efficiency gains associated with electronic payment media and has generated a general sense of mistrust. Furthermore, a number of genuine concerns about the security of e–money schemes and privacy issues have been obscured. The extent to which these concerns may be judged to be significant depends on the degree of usage of the new technology, a subject which has received relatively little attention to date.

The chapter proceeds in eight sections. Section 3.2 attempts to address the lack of a consistent definition of e–money within the existing literature by updating Freedman's (2000) three–way typology. Section 3.3 discusses e–money in terms of the Mengerian and Chartalist views of money, and attempts to ascertain the extent to which e–money possesses the six properties of money. Section 3.4 discusses the provocative writings of Friedman (1999; 2000) and King (1999) in which e–money is treated as a threat to the efficacy of monetary policy. Having concluded that this threat is largely illusory, various more immediate regulatory issues arising from the activities of e–money issuers are discussed. However, the importance of these issues can only be judged in relation to the importance of e–money in general. Section 3.5 provides an overview of the degree of adoption of e–money technologies to date in the Euro Area and in Singapore. The Singaporean system is considerably more developed than those of the European countries which may be attributable to the announcement by the Singaporean government in 2001 that e–money will be granted the status of legal tender. A range of forecasting exercises are carried out in Section 3.6, the results of which suggest that the growth of e–money in the medium–term will be no more than moderate. Section 3.7 discusses the longer–term prospects for e–money systems in terms of three key issues: the incentives for all parties concerned, the security of the system and the development and deployment of new services. Section 3.8 offers some concluding remarks.

## 3.2 What is 'E–Money'?

While the literature on electronic payment media is relatively recent, it has been fast growing. An unfortunate consequence of this rapid expansion has been the lack of a unified vision of the phenomena under scrutiny: simply put, the literature lacks a clear consensus about what actually constitutes electronic payment media (c.f. Fullenkamp and Nsouli, 2004). For this reason, it seems prudent to start with some rigorous definitions.

Probably the broadest term covering a wide spectrum of recent innovations in payment systems that utilise electronic devices is 'electronic payments', or 'e–payments'. The term e–money has come to be used interchangeably with e–payments although, as Allen, 2003, notes, this is somewhat misleading. Freedman (2000, p. 218) provides the following simple typology of e–payments technologies:

i. **access devices** provide access to traditional banking services through electronic means but do not represent any conceptual departure from traditional banking arrangements. A good example is internet banking.

ii. **stored value cards (SVCs)**, also known as hardware e–money, involve prepaid 'smart–cards' that employ a microchip upon which funds are stored. Freedman cites Mondex, Visa Cash and Proton as examples of contemporary international schemes. National examples include Moneo in France, Geldkarte in Germany and Edy in Japan.

iii. **network money**, also referred to as software e–money, involves the use of electronic communication networks in facilitating the transfer of funds between economic agents where the funds are stored electronically, possibly on the hard-disk of one's PC. An example of a network money system is Netcash.

Such is the speed with which e–payments technology is developing that since Freedman wrote his piece, a further category has emerged:

iv. **mobile payments, or 'm–payments',** involve the use of mobile phone technology in the transference of funds, either to facilitate access to traditional transaction facilities or, increasingly, by the addition of supplemental charges to the cost of calls, SMS or WAP/GPRS services or by spending prepaid value (Allen, 2003, pp. 430-431). Collaboration between phone manufacturers and card issuers has already resulted in the addition of credit card functionality to mobile phone handsets in many countries (examples include PayPass in the US and NTT DoCoMo's DCMX and DCMX mini platforms in Japan).

The majority of the existing literature is concerned with the impact of SVCs and network money systems on the efficacy of monetary policy and not with the use of access devices which, as noted above, do not differ conceptually from traditional bank activities[1].

[1] While such innovations may reduce shoeleather costs in a Baumol–Tobin framework (Baumol, 1952; Tobin, 1956), and this may, in turn, increase both the velocity of circulation and the interest elasticity of the demand for money, such effects are not the focus of the present chapter as they pose no significant threat to the efficacy of monetary policy. For a discussion including access products, the reader is referred to Fullenkamp and Nsouli (2004) in particular and also Bernkopf (1996).

Moreover, recent innovations in m–payments are yet to receive much attention in the literature because the use of the mobile phone in contemporary schemes does not represent any significant departure from the three–way typology devised by Freedman (2000). In general, the mobile phone acts either as an 'e–money access device' or as an the hardware on which e–monetary value is stored (i.e. it acts as an SVC). This would no longer be the case if contract phones were to provide non–prepaid e–money functionality. However, such developments are not currently permitted, as this would amount to the extension of a credit line by the service provider which is prohibited by law (see Sections 4.2.1 and 4.2.2 below).

Allen (2003, p. 431) highlights the evolution of the term 'e–money' which originally referred to "pre–paid cards aimed at low–value transactions" but now identifies a much broader range of electronic payments services. In light of this observation, and to avoid confusion, the following terminological conventions are adopted here:

i. **e–banking** will refer to access devices;

ii. **e–purse** and **SVC** will refer interchangeably to hardware–based schemes;

iii. **network money** will refer to software–based schemes;

iv. **e–payment** will refer to all of the above; and

v. **e–money** will refer to e–purses and network money systems.

## 3.3 E–Money and the Theory of Money

### 3.3.1 Mengerian and Chartalist Theories of Money

Two dominant theories propose alternative reasons for the development of money. The Mengerian view stresses that the evolution of monetary systems of exchange has, historically, been motivated by the desire for increased convenience and efficiency, and for reduced costs in transacting. An example is the removal of the famous 'double coincidence of wants' when a barter economy evolves into a monetary system. Recent innovations in ICT have the potential to provide the vehicle for great efficiency gains in the payments system. To the extent that much of the resulting increase in efficiency is a public good, there are social welfare gains to be reaped through the development and implementation of the new technology. Moreover, there are substantial private costs involved in operating the current payments system[2]: new technologies have the potential to dramatically re-

[2] For example, the cost of operating the cheque clearing system in the US is estimated at 0.25-1% of GDP (Meyer, 2001b).

duce these costs, which represent a substantial economic rent that the participants in the new technology could hope to appropriate. Hence there are also strong private incentives to develop new and ever more efficient payment systems. Thus, the Mengerian position provides clear scope for the widespread development of e–money.

By contrast, the state–driven chartalist view of money emphasises the role of the state in the development of money, arising particularly due to its position at the head of the social relations involved in monetary transactions. Chartalist theory stresses the unit of account feature of money above its role as a means of payment and medium of exchange (Tcherneva, 2006). Moreover, the neo–chartalist revival considers that the role of the state in deciding what constitutes money is defined by its ability to unilaterally determine those assets which will be accepted to extinguish debts to the government (typically due to taxation). Once a government has imposed a tax obligation upon every resident that can only be discharged using a particular means of payment, then this becomes intrinsically useful to every inhabitant. Hence, it will be accepted as a means of payment in any transaction.

The state–driven view of money proposes a hierarchy of monies where a net imbalance in any tier may be settled by using only monies from higher tiers. The standing of central bank money at the top of the hierarchy is defined by government ordinance to the extent that it is the only means of payment that is accepted in the payment of taxes (Bell, 2001). Hence, by refusing to accept any other form of payment, the government creates demand for its own liabilities in a manner which cannot be diminished by substitution. A simple diagrammatical representation is presented in Figure 3.1[3]:

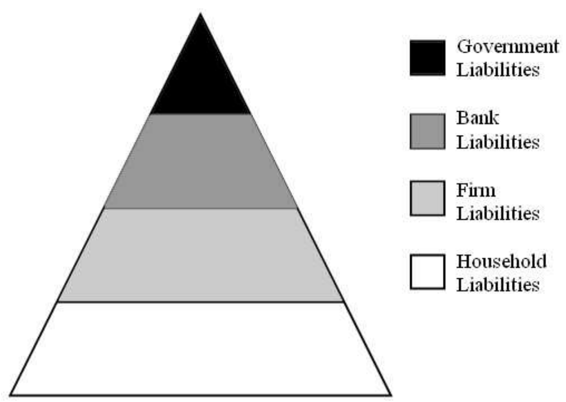


Figure 3.1: The Hierarchy of Money

Bell (2001) stresses that the position of each liability within the pyramid is determined

[3]Note that the relative areas of the various tiers of the pyramid are not meant to denote quantities of money in use; the shape is merely intended to reflect the position of government liabilities at the top of the hierarchy.

by its liquidity (i.e. the ease with which it can be converted into that form which can extinguish tax liabilities). She notes that bank money (i.e. deposit accounts) occupy a special role in modern economies and that firms' liabilities are more liquid than those of households due to the existence of superior (or at least deeper) secondary markets. So where does e–money fit into the hierarchy? Government issued electronic legal tender (as in Singapore - more on this below) would presumably be part of the top tier alongside cash. However, most e–money schemes are privately operated and would not enjoy the benefits of perfect liquidity and unimpeachable risklessness derived from government issuance. The classification of such schemes depends critically on the costs associated with redemption in terms of central bank money. The law in most countries states that banks and e–money issuers cannot impose disproportionate redemption costs on the consumer. In this sense, the liquidity of bank liabilities and those of e–money issuers are similar.

The position of various types of liability or 'promise' within the hierarchy is also determined by the degree to which that promise is accepted. To the extent that private e–money schemes are typically limited to single–use or small multiple–use systems and that the geographical area in which they can be used is typically very limited, it is clear that e–money should not be considered alongside bank deposits. However, it seems logical to separate e–money firms from other firms whose primary business is not the provision of payment services. The liabilities of this latter class of firms are likely to be comprised of bonds and debt instruments which are considerably less liquid than e–money. Hence e–money should be placed between tiers two and three.

The chartalist position provides an unambiguously continuing role for central bank money in a world otherwise dominated by private electronic substitutes as long as the government continues to limit the range of assets acceptable in the extinguishing of tax debts to the liabilities of the central bank. However, it should be clear that these central bank liabilities occupying the top tier of the hierarchy need not take the form of notes and coins. In the case of Singapore, in which state–issued e–money is due to become legal tender in the near future, e–money will become an ultimately liquid and riskless government liability, serving the same role as cash.

This discussion of electronic legal tender leads naturally to an important point raised by Bell (2001), citing Wray (1998, p. 32). The authors stress that legal tender laws in themselves are insufficient to keep the monetary system functioning. Rather, it is the ability of the government to impose legally binding tax obligations and to specify the acceptable means of payment that is of fundamental importance. This is not to suggest that legal tender laws are unimportant; government recognition of this type is likely to lend credibility to a payment instrument, increasing public trust in its viability and promoting investment by issuing firms. However, the same results would be achieved if the government announced that it would accept e–money in the payment of taxes.

### 3.3.2 The Attributes of Money

A question of fundamental importance in any analysis of e–money is to what extent it possesses the attributes of money. The following characteristics are typically identified: (i.) store of value or wealth; (ii.) unit of account; (iii.) medium of exchange; (iv.) longevity; (v.) divisibility; and (vi.) fungibility.

**Store of value or wealth**

To the extent that e–monetary value loaded at time $t$ may subsequently be spent at time $t + \tau$ where $\tau \in \mathbb{R}_+$ and $\mathbb{R}_+ = [0, \infty)$, it is clear that e–money allows the bearer to transfer purchasing power into the future and, therefore, that e–money represents a store of value. However, e–money in Europe and the US (although not in Singapore) is forbidden from paying interest *per se*, rendering it a poor store of wealth due to the erosion of purchasing power resulting from price level inflation. In these countries, e–money schemes are comparable to cash. However, circumventive innovation is likely to occur where e–money issuers are restricted from paying interest. Indeed, the Financial Services Authority (FSA) in the UK recognises the validity of various alternatives to the direct payment of interest (see Section 4.2.1). Depending on the success of such innovations, hardware based e–money may surpass cash as a store of wealth, and the gap between non interest bearing software e–money accounts and bank deposit accounts may narrow[4].

**Unit of account**

The unit of account property of money refers to its use in the assessment of the value of goods and services and in financial reporting. Krueger (2002b) notes that there is no legal impediment to e–money developing into a unit of account. It is likely that e–money would need to achieve a significant market share in order to be a viable unit of account, although its dominance in some sectors may be sufficient for it to take on the role of numeraire in these sectors. The commonly cited areas of strength of e–money schemes are

[4]Given that the activities of e–money issuing institutions are not typically covered by deposit insurance schemes, there is a degree of default risk associated with e–money which exceeds the risks associated with bank instruments where the customer benefits from a governmental guarantee. Hence, in order for an individual to be indifferent between holding their wealth in relatively riskless bank instruments and e–money, the latter must offer either a higher risk–adjusted rate of return, or a significant benefit in terms of increased convenience.

unmanned point–of–sale (POS) stations such as public transport and vending machines. The coexistence of multiple units of account is not unusual. Krueger uses the example of the Swiss WIR–Wirtschaftsring bank to demonstrate that a national and a private unit of account can coexist in the same country. Moreover, similar systems operate in many African, Caribbean, Latin and South American countries, where the US Dollar or the Euro circulate alongside a national currency. A further example is provided historically by bi–metallism.

While it is theoretically possible for e–money to serve as a unit of account, practical considerations make it highly unlikely. Taking the EU as an example, the requirement to redeem e–monetary value for currency at par, combined with its statutorily prepaid nature, render e–money products little more than a convenient way of transporting and transmitting central bank money. In such systems, e–money clearly does not serve as a unit of account, rather it is explicitly pegged to the national currency which performs this role. Similarly, e–money will be granted the status of legal tender in Singapore in the near future but the unit of denomination will be the Singaporean Dollar. In order for e–money to act as a unit of account distinct from the national currency, it would have to be decoupled from it in the sense that the requirements for redeemability at par and pre–payment in full would need to be relaxed. However, these requirements are typically enshrined at the heart of the regulatory framework (see Sections 4.2.1 - 4.2.3) and are very unlikely to be eased, certainly in the foreseeable future.

**Medium of exchange or means of payment**

The precise wording has proven contentious in this case and has been contested on the grounds that credit, for instance, undeniably facilitates exchange but does not represent final settlement and, for this reason, is not typically considered as money. In a seminal contribution, Shackle (1971) refined the terminology, distinguishing between a medium of exchange and a means of final payment or settlement. Goodhart (1989) finds the root of this distinction in the uncertainty surrounding the 'personal information' and creditworthiness of the purchaser in an economic transaction.

A medium of exchange is simply something which facilitates the exchange of goods and services and may function merely as an intermediate step in the interactions between buyer and seller. By contrast, a means of payment refers to some instrument which settles such obligations with demonstrable finality. Under such a framework, trade credit, credit cards etc. represent media of exchange but not means of final payment. In the present legislative environment, e–money cannot provide finality and, in this regard, is similar to these various forms of credit[5].

The words 'widely' ore even 'universally accepted' are often included. It seems likely that e–money will fail to satisfy this point for some time for at least three reasons. Firstly, most contemporary e–money systems are for single or limited use only and are, therefore, by definition not widely accepted. Secondly, interoperability is a prerequisite for widespread use (otherwise e–money cannot be considered to be a single payment instrument) and this is seemingly a distant prospect. Finally, the hardware requirements necessary for the use of e–money are far from widely operable at present. The costs that must be borne by merchants in adopting e–money technology will be of fundamental importance in the future development of this infrastructure.

### Longevity, Divisibility and Fungibility

The longevity of money is the property of durability, that it must not degrade substantially with the passage of time. E–money obviously meets this criterion (in fact it is infinitely durable in a way that no other form of money has ever been).

The property of divisibility was originally defined in terms of commodity money such that a given weight of gold, for example, could be divided without any loss in value. In fiat money systems it is typically taken to refer to the idea that exact change can always be provided for a purchase no matter what denomination of currency was used for payment. Strictly speaking, this property only holds up to a limit defined by the smallest unit of currency.

Fungibility is the property of perfect substitutability. Cash is perfectly fungible in the sense that one dollar bill may be substituted for another in a perfect zero–sum game. The same is clearly true of e–monetary value issued by the same firm. However, this condition often does not hold across service providers.

This exercise has demonstrated that e–money does not possess many of the attributes of central bank fiat money and, in this sense, it is not a proper substitute for currency. Without doubt, the most significant issue preventing the widespread use of e–money is the lack of interoperability. This is fundamental to any payment system in the sense that it is related to the liquidity of the asset in question. Central bank money sits at the top of the chartalist pyramid (Figure 3.1) because it is accepted in the discharge of any debt and this, in turn, leads to near universal acceptability in transactions. Seen from the viewpoint of the French and Italian circuitists, cash is acceptable in all circuits and

[5]The potential for e–money systems to develop to the extent that they could operate real–time gross settlement (RTGS) facilities presents some (limited) scope for them to offer final settlement in the future, at least in theory. However, the prospect of such developments is so distant as to be largely irrelevant to the present discussion.

therefore is perfectly liquid. By contrast, debit cards are not acceptable forms of payment in many situations and so they are less liquid. In this sense, e–money which can be used on public transport infrastructure is less liquid than e–money which is also valid in a range of shops. The more that e–money schemes become interoperable, the more liquid their liabilities will become.

## 3.4 The 'Threat' to Monetary Policy and Financial Stability

Developments in electronic payment systems have been discussed in the literature in terms of their potential to substitute for central bank money and the 'threat' that this may pose to the efficacy of monetary policy and to the stability of the financial system. This threat, it is argued, derives from the reduction in demand for central bank liabilities that would result from the widespread adoption of e–money. Two extreme scenarios rooted in the work of Friedman (1999) and King (1999) have dominated discussion in the field while other, more mundane effects can be identified but have yet to receive much attention.

### 3.4.1 The Extreme Position

The early and provocative contributions of Friedman (1999) and King (1999) discuss the threat of e–money in terms of the potential of SVCs and network e–money systems to compete with central bank money. Where the central bank relies on manipulating the quantities of borrowed and non–borrowed reserves in order to achieve an operating target for its short–term interest rate, the existence of such substitutes is potentially significant. Under such systems, the central bank's position as the monopolistic supplier of base money allows it to determine the price of issuance/rate of return. Thus, it is argued that the adoption of such forms of e–money may weaken the position of a central bank operating in this way: indeed, if various forms of e–money were to eliminate the demand for central bank money entirely, such monetary policy arrangements may be rendered powerless (Woodford, 2000)[6]. In terms of Figure 2.1, the proposed threat of e–money relates to the potential weakening, or even breakage, of the links between reserves and market interest rates (especially the linkage between high powered money and broad money).

The monetary base is comprised of two elements: currency and reserves. Currency refers to notes and coins in circulation and represents the bulk of money. Reserves refer to the balances maintained by commercial banks in order to facilitate their day–to–day

[6]Fullenkamp and Nsouli (2004) make the obvious point that if the central bank were the issuer of e–money then its monopoly would remain intact. Hence, it should be clear that the extreme position is concerned with the private issuance of e–money.

operations. Commercial banks may be legally bound to hold a certain amount of required reserves (as in the US) although even in the absence of such requirements, or in the case that they do not bind[7], they will voluntarily hold reserves with the central bank for use in end–of–day settlement[8].

SVCs, which are often subject to purse limits and cannot take deposits or pay interest, are envisaged as a substitute for currency in small–value transactions. Network money systems, by contrast, provide an alternative vehicle for medium- and large–value transactions and, therefore, have the potential to substitute for services typically provided by depository institutions (although such schemes are forbidden from paying interest and cannot extend credit so the degree of substitution is likely to be minimal - see Chapter 4). Friedman (1999) investigates the situation in which electronic payment media come to dominate the marketplace to such an extent that the demand for currency and/or reserves at the central bank falls to negligible levels and even disappears altogether. Two distinct scenarios can be identified: firstly, that SVCs wholly displace currency for use in transactions (c.f. Costa Storti and De Grauwe, 2001) and, secondly, that network money systems develop to the extent that they offer settlement systems in competition with those of the central bank (c.f. King, 1999).

#### Scenario 1: SVCs wholly displace currency

If SVCs were to eliminate the demand for currency then, as currency comprises the vast majority of central bank liabilities, the central bank balance sheet would shrink substantially and its seigniorage revenue would largely disappear. In the case where final settlement still occurs on the books of the central bank, then it is immediately apparent that channel or corridor systems of monetary policy[9] remain effective, as changes in short–term interest rates are not expressly linked to balance sheet operations. Freedman (2000) and Woodford (2000, 2001a) argue that, in the case of more traditional monetary policy arrangements, where the deposits are non interest–bearing and the central bank manipulates the quantities of borrowed and non–borrowed reserves in achieving its inter-

[7] There is some debate concerning the nature of US reserve requirements and whether or not they are binding - see for example Bennett and Peristiani (2002).

[8] This is the case in Canada and New Zealand for example - see Borio (1997) for a survey of the monetary policy operating procedures in industrial countries.

[9] Also known as a Lombard facility, this refers to a system in which the central bank maintains short–term nominal interest rates within a band defined by its standing facilities: it will provide unlimited settlement balances at a fixed mark–up over its target for the overnight rate and it will pay interest on deposits at a rate set symmetrically below its target. Thus, if the rates available in the interbank market are inferior to those offered by the central bank, commercial banks will make use of the standing facilities thereby providing strong incentives to ensure that market rates remain within the 'corridor'. Such systems are in operation in Canada, New Zealand and the UK, among others. The reader is referred to Woodford (2001a, pp. 31-46) for a thorough discussion of the technical aspects of the channel system and a comparison with the US system of monetary policy.

est rate target, the monetary authority could continue operating in the same way that it does at present. This can be most clearly seen by reference to Figure 3.2, taken from Palley (2001a, p. 227, fig. 1):

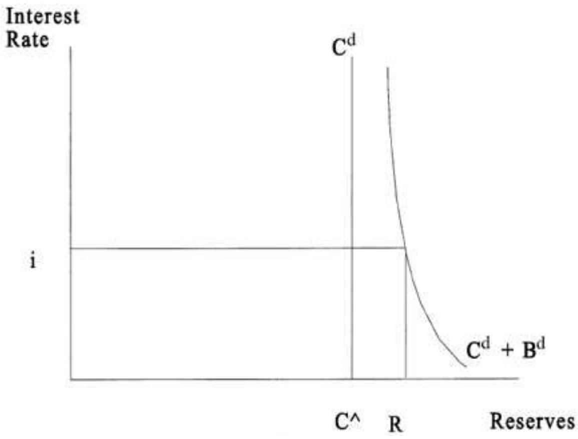


Figure 3.2: The Composition of Reserve Demand

where $R$ represents the supply of reserves (which adjusts passively to equate to the demand for reserves), $C^d$ currency held by the non–bank public (which is assumed to be perfectly interest inelastic and fixed in the short–run), $B^d$ the demand for reserves arising from commercial banks and $i$ the central bank's policy rate. The curve $C^d + B^d$ is steeply downward sloping, indicating the short–run interest inelasticity of commercial banks' demand for reserves. Note that the mechanism underlying the diagram is consistent with the horizontalist position (Moore, 1988) as the central bank controls the interest rate and the quantity of reserves, $R$, responds endogenously due to the actions of commercial banks.

Should privately issued e–money eliminate the demand for currency, $\hat{C} = C^d = 0$ and the demand for reserves would decline dramatically. This would, in turn, reduce the seigniorage revenue of the central bank. However, as long as there remains a continued demand for central bank balances to facilitate gross settlement between commercial banks, a small highly inelastic demand remains. In this case, the linkage between reserves and market interest rates in Figure 2.1 remains intact, and its manipulation by the central bank through open market operations remains effective. Hence, Palley (2001a, p. 221) dismisses the threat to the efficacy of monetary policy arising from developments in what he calls 'e–tail money' (e–money used in retail transactions). Indeed, Woodford (2000, p. 237; 2001a, pp. 23-24) argues that the elimination of currency demand would make the task of central bankers *easier* on the grounds that it would remove the feedback which currently results from the interest–sensitivity of households and firms[10].

[10]In response to an increase in the funds rate (associated with an open market sale of securities), economic agents reduce their currency holdings and increase their deposits with banks, thereby increasing the amount of non–borrowed reserves available to banks and partly offsetting the effect of the initial OMO.

The only major effects of a substitution by the non–bank public away from currency in favour of e–money would be the shrinkage of the central balance sheet and the reduction in its seigniorage revenue[11]. Various measures to recoup the lost seigniorage revenues have been proposed, including charging banks for services that are currently free or increasing the cost of chargeable services (Hawkins, 2001, p. 100), the issuance of interest bearing bonds by the central bank, the imposition of reserve requirements on e–money issuers and the state issuance of e–money, either competitively or monopolistically (c.f. Freedman, 2000). It is, however, difficult to imagine how private e–money could compete with riskless central bank e–money under the present legal framework where issuers are forbidden from paying interest. Presumably an appropriate risk premium would be required to induce end–users to adopt private e–money in the presence of a riskless alternative. Moreover, when one considers that central banks are not bound by the constraints of profitability or the demands of shareholders, it seems likely that they would rapidly come to dominate the SVC market should they enter it. Such an outcome is clearly incompatible with the desire to promote competition and innovation in free market economies. However, the EMI (1994) states that no European NCB has any intention of entering the e–money market in the foreseeable future, although the Monetary Authority of Singapore (MAS) will shortly begin issuing electronic legal tender (Low, 2002).

While such actions may prove effective in preventing the erosion of central bank revenues, one must question to what extent any action would be necessary at all. The central bank is under no obligation to operate with a net surplus and so a shrinkage of its balance sheet is not a cause for undue concern, beyond the extent to which its independence may suffer if it were indebted to the government.

#### Scenario 2: e–money provides alternative final settlement mechanisms

Friedman (1999) proposes two ways in which the settlement services offered by the central bank may become obsolete. Firstly, he argues that commercial banks could agree to settle net payments imbalances with a nominated commercial bank (i.e. a private bank that takes on the settlement role of the central bank). Secondly, he contends that an evolution of existing private interbank clearing arrangements such as CHIPS[12] could create a situation whereby commercial banks could settle bilaterally with no element of mediation provided

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This effect is not captured by Figure 3.2, in which the public demand for currency is assumed to be perfectly interest–inelastic for simplicity.

[11] In the US in particular and, to a lesser degree, in Europe and the UK, concerns about the reduction of domestic demand for currency are not excessively pressing due to the vast overseas holdings of these currencies as a store of value (Meyer, 2001b, p. 10).

[12] Clearing House Interbank Payments System. At present, such mechanisms merely allow intra–day netting of claims and still require final settlement on the books of the central bank at the end of the day.

by a central bank or any other third party[13]. Friedman notes the similarities between such a system of bilateral settlement and that of the European Union, in which NCBs settle payments imbalances directly and do not hold settlement balances with the ECB.

Referring to Figure 3.2, assuming that electronic substitutes eliminate the demand for settlement balances at the central bank, the overall demand for base money would not diminish greatly assuming continued demand from the non–bank public. However, it is the highly interest inelastic demand arising from the banking sector that allows relatively small open market sales and purchases of securities to affect the interest rate. If the settlement services of the central bank become redundant, then traditional US–style monetary policy arrangements will become impotent (Woodford, 2000, 2001a; Palley, 2001a)[14]. This would be associated with the breakage of the links between open market operations, reserves and market interest rates in Figure 2.1.

Goodhart (2000) suggests that the obvious course of action for a central bank faced with such a situation would be to increase the scale of its open market operations to the extent that they become significant relative to the size of the financial markets[15]. However, in order for a central bank to counterveil market sentiment in order to achieve its stabilisation goals, it seems likely that it may be forced to engage in loss–making open market operations on a potentially vast scale. While this is theoretically consistent with the objectives of a central bank, the associated costs are likely to be politically unpalatable.

Woodford (2000, 2001a) provides an alternative approach. He demonstrates that the performance of monetary policy in itself is not dependent on the special role of reserves in the financial system and the inherent monopoly of the central bank in this regard. He discusses the channel system, in which the quantity of reserves plays no special role in interest rate setting (i.e. it is a residual)[16]. He shows that, in the case where the central bank provides settlement services in a (pseudo) competitive market and its settlement facilities have no specific competitive advantage, then the payment of interest on reserves

[13]See also King, 1999, who envisages an extreme evolution of network money systems in which a centralised super–computer provides real–time gross settlement between individuals with no role for a central bank. The conceptual similarity to contemporary Local Economy Trading Systems (LETS) which are detached from the central bank is clear. Closely related to this is the work of Capie, Tsomocos, and Wood (2003) on ‘e–barter’.

[14]It should be noted that, in response to the ongoing financial crisis, the Federal Reserve started paying interest on deposits on October $9^{th}$, 2008. This is an important change in the policy regime, as will be made clear below. However, the operational details of the new system still seem to be subject to revision and its continuation after the resolution of the current crisis is not guaranteed. See Anderson (2008) for further details.

[15]This is a response to Friedman’s (1999) observation that the scale of open market operations relative to the aggregate value of financial market transactions is very small. Such small operations are effective in steering the economy (however crudely) due to the highly inelastic reserve demand arising from banks, a point made clear in Figure 3.2 above and discussed by Palley (2001a, p. 227).

[16]See also Sellon and Weiner (1996, 1997); Borio (1997); Henckel, Ize, and Kovanen (1999); Meyer (2001b, p. 11) and Palley (2001a, p. 229, fn13).

would serve as a reference level for the providers of alternative settlement mechanisms. The profit–maximising motives of private entities would lead them to use whichever settlement system provided the highest return (or imposed the smallest cost). Therefore, if the central bank were to pay a positive rate of interest on reserves, then other settlement institutions would be forced to follow suit in order for their settlement services to be used. Moreover, private institutions would not pay a higher risk–adjusted rate than the central bank, as this would conflict with their own profit–maximisation objectives. Thus, the central bank may operate monetary policy using the rate of interest paid on reserves, rather than the spread, as its policy instrument. Such a system is conceptually similar to the channel system, except that the lending facility is redundant and the deposit rate is exactly equal to the overnight rate target. In relation to Figure 2.1, it follows that such a system replaces the role of OMOs and reserves with a direct linkage between market interest rates and the standing facilities of the central bank.

The above discussion relies on the bold assumption that e–money systems evolve to the point that they can offer interbank settlement services in competition with those offered by the central bank. It seems likely that improvements in ICT will permit better forecasting of the net end–of–day positions of banks *vis–à–vis* their competitors, thereby reducing the demand for settlement balances. However, it is unlikely that this demand will be eliminated altogether, certainly in the foreseeable future.

Goodhart (2000) and Hawkins (2001) agree that there is no technological impediment to direct (bilateral) interbank gross settlement. However, this does not occur because central banks "have evolved to meet a combination of both governmental and structural needs" (Goodhart, 2000, p. 206, fn27). Among the advantages possessed by central banks, Freedman (2000) lists their risk free nature, their ability to act as lender of last resort and their historical position as the provider of settlement services. Moreover, the incentives of the central bank are, by statute, uniquely compatible with the maximisation of a measure of economic welfare. This contrasts markedly with private banks, the actions of which are constrained by their responsibilities to their shareholders (Meyer, 2001b).

Hawkins (2001, p. 101) elaborates on this discussion and provides the following reasons why settlement will continue to occur on the books of the central bank:

i. it is often compulsory;

ii. central banks are unique in being the only riskless counterparty;

iii. commercial banks are likely to feel uneasy about divulging detailed information to a competitor;

iv. the adoption of a new system involves commercial banks incurring migration costs;

v. the central bank offers credit to those banks with net deficits in the overnight market;

vi. the central bank acts as lender of last resort to ensure the solvency of the financial system as a whole - thus it acts as guarantor of the settlement obligations of banks; and

vii. it is within the power of governments to require that taxes and other transfers are conducted using central bank liabilities (the chartalist position).

**A Rebuttal of the Extreme Position**

An issue which fundamentally underlies the extreme position is the nature of the e–money value chain. In the current regulatory environment (outlined in Chapter 4), the value chain of private e–money schemes starts with the purchase of e–monetary value using conventional financial instruments (e.g. cash, debit and credit cards, direct debits etc.). This 'charging-up' of the e–money account is necessitated by the prepaid nature of e–money products enshrined in the regulatory frameworks of most countries. Moreover, e–money issuers in the EU are required by law to redeem e–monetary value for central bank money at the request of the bearer without imposing disproportionate costs. In most other countries, such unconditional redeemability is demanded by the end–users of e–money products and is granted by service providers in order to increase both their credibility and the degree of public trust in the new technology. Finally, e–monetary value is redeemed by those merchants that have accepted it in payment for goods and services. This redemption extinguishes the e–monetary value and results in a bank transfer from the issuer to the merchant in satisfaction of the transaction. This is neatly summarised by Lanskoy (2000, p. 21) as follows:

> [Hardware based e–money] refers to the electronic units issued by the issuer and recorded in the electronic purse micro–chip. To make a payment using an electronic purse, holders transfer electronic units from their card to the sellers card. This transaction does not generate any debit/credit movement on the buyers or sellers bank account. Electronic units are converted into currency units at a later stage and the funds are transferred to the seller's account by bank transfer. Purseholders' accounts are debited when they buy the electronic units, if the transaction is carried out using bank money.

This is only technically correct in the case of non–transferable e–money and those schemes with limited transferability prior to spending. This simplification is fairly innocent because, although the technology exists to develop systems capable of multiple payments in which electronic coins may be transferred *ad infinitum*, such schemes are not widely available due to the 'double spending' problem[17], and the necessity to maintain large and costly databases tracking the usage of transferable e–money (Baddeley, 2004, pp. 242-3).

The implication of the prepayment requirement and the demand for redeemability is that e–money issuers must hold sufficient reserves of highly liquid assets to ensure that they can meet this demand. Assuming that there is no compulsion to redeem e–money for cash (i.e. it may be redeemed by bank transfer or some alternative means) then it is possible, in theory at least, for e–money to wholly displace currency. However, to the extent that e–money issuers will hold a fraction of their outstanding float in the form of bank deposits for the purposes of redemption, the demand for reserves arising from commercial banks may actually *increase* with the increasing substitution away from currency. In this way, an ongoing demand for the liabilities of the central bank arises indirectly from the activities of e–money issuers themselves.

An interesting thought experiment is to consider the attributes that private e–money schemes would need to possess in order to eliminate reserve holding at the central bank altogether. It seems likely that the following would be necessary:

i. faith in the soundness of e–money issuers must be complete so that redeemability is no longer demanded;

ii. the liabilities of e–money issuers must be universally accepted as a means of payment and e–money systems must be fully interoperable;

iii. e–money must be fully transferable so that it is not extinguished in the process of being spent;

iv. wages must be paid in e–money so that the e–monetary value chain can exist independently of central bank money (in conjunction with point iii, the prepaid nature of e–money is effectively circumvented);

v. e–money schemes must be granted the ability to pay interest on deposits so that e–money may compete with traditional savings instruments;

[17]It is theoretically possible to create identical copies of units of e–money and so it is feared that counterfeiting could be a major issue. Given the speed of development of the ICT industry and the increasing sophistication of personal computers, there are concerns about the security of the encryption algorithms in use. The recent announcement that the Mifare RFID microchip at the heart of the Oyster Card in London can be easily and cheaply hacked made headlines around the World (c.f. Richards, 2008).

vi. e–money schemes must be granted the ability to extend credit such that they can compete with depository institutions in loans markets;

vii. e–money schemes must develop settlement systems offering all of the desirable characteristics of settlement schemes managed by the central bank; and

viii. e–money must be accepted in the payment of tax debts and must be used by governments to the exclusion of central bank money.

Even if these conditions were met, e–money programmes would still have to out–compete the incumbent instruments/technologies mentioned in points v. - vii. to the extent that they would come to dominate the market. Moreover, as point viii. makes clear, e–money could only wholly displace the liabilities of the central bank with governmental support. Once these conditions have been spelled out clearly, it is understandable why many economists have dismissed the concerns of Friedman and King merely as an exercise in futurology of some theoretical interest but of little practical relevance[18].

### 3.4.2 More Mundane Effects of E–Money

The preceding section demonstrated that the two extreme outcomes envisaged by Friedman (1999; 2000) and King (1999) are not plausible threats to the efficacy of monetary policy. The interest in these two theories has diverted attention from the more mundane, but also more serious issues associated with e–money, some of which are now discussed.

#### Bank Runs

Palley (2001a) and, to a lesser degree, Meyer (2001b) suggest that the emergence of privately issued e–money which coexists with, and is redeemable in terms of, government money may revive the spectre of old–fashioned bank runs. Palley reasons that the ‘herd instincts’ of investors may lead them to react *en masse* to real or perceived signals from the market. Such signals may lead investors to believe either that they can make a profit through arbitraging between private e–money and government money or that their e–monetary funds are in some way unsafe: in either case the likely outcome is a massive

[18] In a subsequent paper with a decidedly defensive tone, Friedman (2000) argues that it is not the complete substitution of e–money for currency or the elimination of settlement balances which poses the problem (although this would suffice), it is merely the possibility that monetary policy actions may become decoupled from real macroeconomic activity at the margin. The basis of his argument is that if some proportion of economic activity occurs through a medium of exchange which is independent of the central bank, then monetary policy is powerless to influence this section of the economy. If this proportion becomes sufficiently great, then the economic influence of the central bank may diminish. However, it is difficult to see how this argument would change the conclusions reached above. It seems unlikely that such decoupling could occur in a world where e–money is redeemable for central bank money, which will remain the case as long as there is some degree of (perceived) default risk on the part of e–money issuers.

liquidity shortage. Meyer usefully highlights the fact that if e–money issuers were depository institutions then, under US law, the discount window and Federal Deposit Insurance Corporation (FDIC) would protect the integrity of the financial system in the case of a run on a provider. However, as issuers are not required to be depository institutions under present legal arrangements (see Chapter 4), the danger of runs exists, at least in the event that e–money schemes achieve a significant market share.

A related concern frequently raised in the formal literature (especially that of the monetary authorities) is that the potential mismanagement of e–money schemes may lead to financial distress or even insolvency on the part of the issuer which could damage confidence in e–money systems and the payment system more generally. Such concerns provide the rationale for the security and soundness provisions and the prudential regulatory regimes in effect in the EU and US regulatory frameworks (among others) outlined in Sections 4.2.1 and 4.2.2 respectively. As long as e–money issuance is 100% backed by low risk, liquid investments, then there is no cause for concern. Presumably, such strict working capital requirements will not be lowered until regulators are satisfied that the risks associated with e–money issuance are suitably small.

#### Circumventive Innovation

Friedman (1999) notes another frequently overlooked aspect of the development of ICT. He asserts that the diminution of the credit market share of depository institutions is a cause for concern of central banks. He argues that recent technological advances have reduced the advantage of banks in assessing the creditworthiness of potential borrowers and that the securitisation of loans has served to further reduce the proportion of credit which is backed by deposits at the central bank (these issues have recently come to the fore in the aftermath of the subprime crisis). Although Friedman's point is that the proportion of credit backed by central bank deposits is falling and therefore that the demand for these deposits may decrease, he does not suggest that there is a particular role for e–money in this process. If, however, innovation on the part of e–money issuers were to provide a means by which they could circumvent current regulations which forbid them from extending credit, this could cause serious problems for the operation of monetary policy. Moreover, when one considers the cost advantage that non–depository institutions would derive from avoiding the requirement to hold non–interest–bearing reserve assets in proportion to their credit extension, the scope of the potential problem becomes clear. Although existing regulation limits credit provision to depository institutions, profitable opportunities provide strong incentive for circumventive innovation.

### Inaccuracy of Monetary Aggregates

Another issue raised notably by central bankers and bodies related to the conduct of monetary policy is the inaccuracy of the narrow monetary aggregates which may result from the misreporting of e–money balances (see, for example, EMI, 1994). It is argued that in the absence of clear guidelines concerning the definition of e–money and its place within the payment system, it is likely to be either omitted from the relevant monetary aggregate, included in the wrong aggregate or not reported at all. To the extent that the monetary aggregates are used for modelling and as indicators in monetary policy decisions (at the ECB at least), such an outcome is undesirable. However, is should be clear that such concerns are easily allayed by the introduction of suitable regulation. Indeed, this has been achieved in the EU where Directive 2000/46/EC clearly outlines the reporting obligations of e–money issuers.

### Systemic Risks Arising from Offshore Issuers

As is commonly noted in the literature (see, for example, Krueger, 2002b) it is possible for a company to largely or even entirely circumvent national e–monetary regulation by basing its operations overseas. Given that many countries are yet to regulate the business of e–money issuance, it may be possible for an overseas issuer to act in a largely unregulated manner. While it is conceivable that, in the absence of effective regulation, private agencies will act in a self–policing manner in order to instill confidence in their customers, this is by no means a guarantee of the safety of such schemes. In light of such concerns, national governments may wish to explicitly extend their regulation to cover any e–money issuer operating within their borders where this is not already the case (as in the EU - see Section 4.2.1). Lee and Longe-Akindemowo (1999) call for a harmonised global regulatory framework in order to address such issues of international regulation. If offshore issuance is seen to pose a significant threat to systemic security, then there may be a role for an international agency in deploying an integrated global regulatory framework. The obvious candidate is the Bank for International Settlements (this is discussed in more detail in Chapter 4).

### Systemic Risks Arising from the Insolvency of Issuers

Government issued currency has the fundamental advantage that it is backed by an institution whose solvency is unimpeachable. Therefore, the default risk associated with central bank liabilities is zero (to a first approximation). In the case of any privately issued money not covered by deposit insurance (or similar arrangements), there is a risk associated with the possibility that the issuer may either refuse to honour its liabilities or, more likely, that it will be unable to do so. Given the interconnections characterising financial contracting, it is possible that the default of one issuer could have serious ramifications for the financial system as a whole. Such risks are, however, mitigated by the institutional framework. E–money schemes are targeted at low value transactions, e–money accounts are subject to relatively strict purse limits and issuers are subject to stringent asset–backing requirements. Moreover, if the default of an e–money issuer was considered likely to have substantial repercussions, it seems likely that the central bank would intervene in its role as lender of last resort even if it was not obliged to do so. Hence, the threat posed to systemic security by e–money is relatively minimal.

### Social Exclusion

Van Hove (2003) raises the issue of social exclusion, reasoning that those members of society without a bank account will be unable to use the new technology. He identifies low–income consumers and the poor as those groups which are likely to become excluded from the new technology. However, this argument is not particularly persuasive as it is possible to load SVCs using cash without recourse to a bank account. Van Hove does, however, identify another reason why groups may become socially excluded. He argues that some groups within society may be unable (or unwilling) to master the new technology. The European Union e–Inclusion policy identifies five groups that may be excluded from technological innovations: those without the required skills and education, the elderly, the disabled, ethnic minorities and residents of remote areas (European Commission, 2006). Among the recommendations of the e–Inclusion policy that are likely to prove relevant in the case of e–money are the promotion of affordable solutions and the necessity to close geographical disparities.

### Anonymity and the Underground Economy

Individuals and groups that wish to maintain a degree of anonymity and privacy may voluntarily exclude themselves from e–money technology. In particular, agents involved in the underground economy find the anonymity of cash particularly useful (Goodhart, 2000). This suggests that as e–money usage proliferates through the legal economy, the usage pattern of cash will shift increasingly toward the underground economy. This raises the question of whether the central bank should continue to provide a convenient and anonymous means of transacting when the demand for these properties originates largely from illicit sources (Rogoff, 1998).

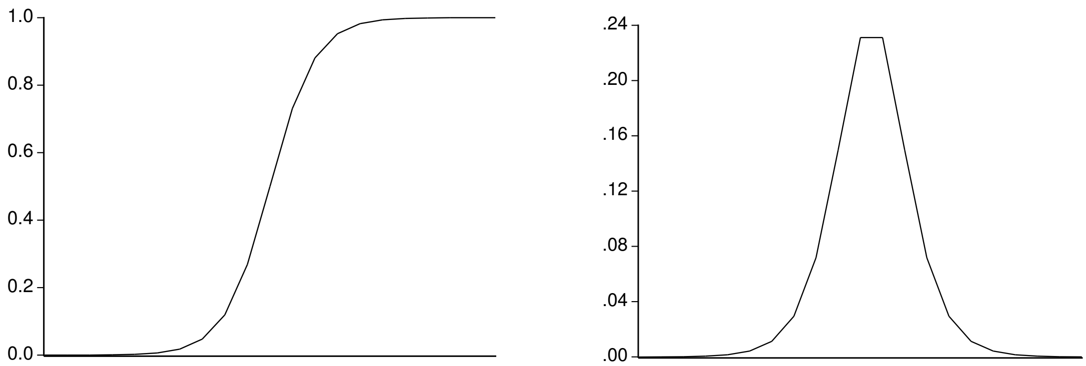
The other side of the debate is the question of whether it is desirable for money to be traceable. While it is theoretically possible to provide anonymous e–money, this is not typically done in practice. Contemporary e–money leaves an electronic trail which can be tracked in a similar way to a credit or debit card transaction. The degree to which this would impinge on civil liberties in a world in which cash is wholly displaced by e–money (i.e. one in which anonymous payment is no longer possible) is unclear, but it is an important and interesting issue.

The extent to which the consequences of e–money issuance discussed above may be considered important depends on the degree to which the technology is used and its future growth prospects. These issues are addressed below.

## 3.5 The Adoption of E–Money To Date

The uptake of e–money schemes to date has been slow. They have mainly developed only where competing payment technologies are unavailable (Furche and Wrightson, 2000; Meyer, 2001b; Stefanadis, 2002). Two main theories attempt to explain this limited adoption. Firstly, it is often argued that there is no convincing business case for e–money on an economy–wide scale at the present time (Furche and Wrightson, 2000, p. 41). Meyer (2001b) and Krueger (2002b) argue that e–money typically succeeds in limited purpose applications because it possesses attributes which make it uniquely compatible with the particular use to which it is being applied. Such attributes may include purse limits in the case of company–issued SVCs, or the ability to limit the items that may be purchased with an e–money product (Krueger, 2002b, p. 20, suggests that parents could give their children allowances in such a form). By contrast, e–money fails in open systems where alternative means of payment exist because it does not possess a sufficient comparative advantage in a general setting relative to the incumbent payment systems. Indeed it may even suffer from a comparative disadvantage due to concerns over its safety (mentioned above), the first–mover advantage of the established system and the regulatory uncertainty surrounding the new technology (Furche and Wrightson, 2000, pp. 42-45). Furthermore, migration to e–money systems is costly for at least two of the three actors in the market (c.f. Van Hove, 2003, pp. 13-14). The service provider must invest in infrastructure and the merchant must invest in the appropriate terminals with which to process payments. To the extent that e–money schemes may charge a subscription fee, some cost may also be borne by the customer. In order for the three actors in the market to be willing to bear these migration costs, the new technology must offer some benefit relative to the old. It is not clear that this is the case at present.

The second explanation is rooted in the work on the diffusion and adoption of innovations. Following Rogers (2003), it is commonly argued that the uptake of innovative solutions follows a sigmoid pattern similar to that depicted in Figure 3.3(a) which plots the simple logistic function, $y = (1 + e^{-x})^{-1}$ for $x \in [-10, 10]$. Figure 3.3(b) plots the first difference of the logistic function, demonstrating the implication of the sigmoid hypothesis that the per–period rate of adoption of an innovative product will increase until some point at which the pool of non–users shrinks to a critical level. An example of the application of this approach to e–money can be found in Krueger (2002b, pp. 5-6).




(a) Cumulative Adoption

(b) Per–period Adoption

Figure 3.3: Sigmoid Adoption of Innovation

The proposed sigmoid pattern reflects the notion that the probability that an individual will adopt the new technology depends positively on the number (or proportion) of their friends and colleagues that already use it. Such a scenario naturally leads to nonlinearly increasing market penetration until the pool of non–users shrinks to such a point that the market becomes saturated and the adoption rate declines. Once this stage is reached, firms can no longer hope to simply attract new users and must attempt to actively win customers from their competitors if they wish to increase their market share.

The sigmoid adoption hypothesis has intuitive appeal in markets with significant network effects. Payments technology is an extreme example of a network industry which gravitates toward either a single monopoly network or an interoperable system of sub–networks (Van Hove, 1999a, 1999b). A critical feature of network technologies is that the number of potential bilateral interactions between users (or more accurately the number of nodes in the network as each user may possess multiple devices) increases quadratically with the number of terminals/cards in use. This may be most clearly seen with reference to Table 3.1[19].

[19]Hardware–based e–money schemes may not conform to this model as users often cannot transfer

| Nodes | Possible Interactions |
|---|---|
| A | AA |
| A, B | AA, AB, BA, BB |
| A, B, C | AA, AB, AC, BA, BB, BC, CA, CB, CC |
| A, B, C, D | AA, AB, AC, AD, BA, BB, BC, BD, CA, CB, CC, CD, DA, DB, DC, DD |

Table 3.1: Quadratic Growth of Interactions in Network Industries

The quadratic increase in the number of potential bilateral interactions resulting from the addition of each new node provides strong incentives for e–money service providers to strive for greater interoperability. Each service provider that subscribes to a common standard gains access to a larger network than would be the case otherwise, increasing the liquidity of their liabilities and providing stronger incentives for merchants to accept payment in this manner (i.e. the number of different transactions/uses to which the e–money device can be put increases). With this said, product differentiation becomes more difficult, making the market more competitive and squeezing profit margins.

The uptake of e–money may be interpreted within the sigmoid adoption framework. The slow initial growth of the new technology reflects the relatively high costs of adoption and the strength of the network effect in this case. The logistic curve plotted above is a highly simplistic representation of the sigmoid adoption hypothesis. In general, the shape of the curve will depend on a range of factors including cost and the importance of the network effect. Where the cost of adoption is relatively high, as is the case with e–money, the initial low adoption phase may be considerably extended. Moreover, for products with significant network effects, the rate of growth is likely to become very rapid once a critical mass of users is achieved. These issues are addressed in Section 3.6, in which a Gompertz curve is fitted to the data in order to test Rogers' model.

### 3.5.1 The Historical Performance of E–money at the Macro Level

Discussions of the historical performance of e–money are typically undertaken at the firm- or product–level (e.g. Van Hove, 2000; Giannopoulou, 2004) and rarely in the macro context, largely due to the lack of reliable data and the relatively short span of data where it is available. The most authoritative source of data on e–money schemes at the macro level (certainly in a global context) is the Committee on Payments and Settlements Systems (CPSS) at the Bank for International Settlements (BIS). Using figures from their annual publication *Statistics on Payment and Settlement Systems in Selected Countries* it is possible to build a picture of the nature of, and developments in, the payments infras-

value from one card to another directly (Mondex, among others, is an exception to this rule). However, software–based schemes may be reasonably accurately described in such a manner.

tructure in these countries[20]. This data not only provides an interesting insight into the adoption and diffusion of innovative payment platforms, but also illuminates the nature of substitution between competing technologies.

The CPSS data on e–money is most complete for the Euro Area (EA), its member states and Singapore, with most other countries either reporting negligible activity in e–money schemes or, more often, failing to report data altogether. However, the availability of data for these two regions permits interesting comparisons, especially in light of their differing degrees of e–money adoption, their respective approaches to the regulation of the newly created innovative markets and the social attitudes prevailing toward such innovations.

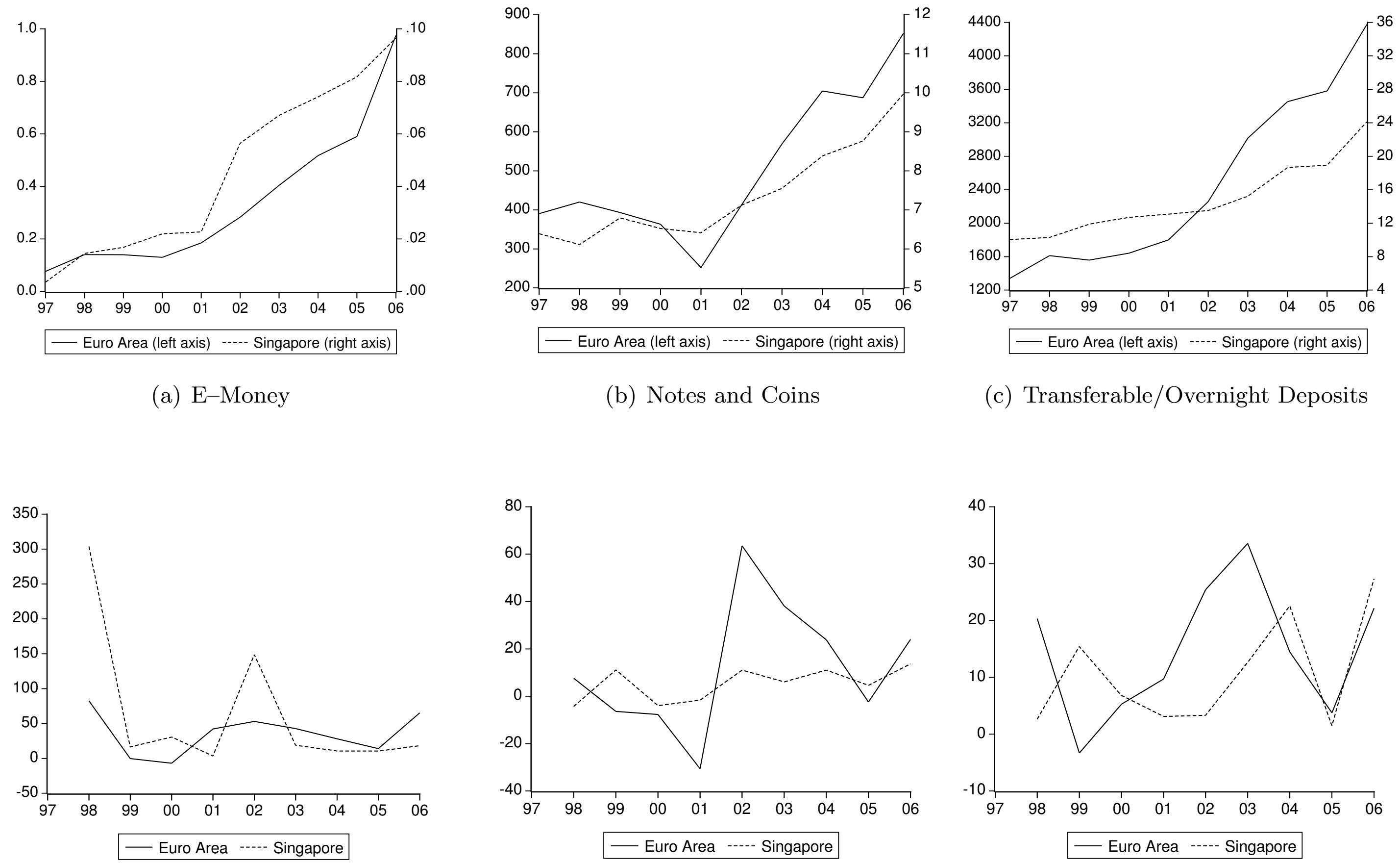
### Payments Systems in The Euro Area and Singapore Compared

Figure 3.4 plots the volume of e–money, cash and bank deposits in the EA and Singaporean economies, and their respective rates of growth[21]. Panels (a)-(c) reveal that the volume of e–money outstanding is very small relative to cash and overnight deposits (in 2006 e–money outstanding accounted for just 0.1% of cash and 0.02% of overnight deposits in the EA while the equivalent figures for Singapore were 1% and 0.4%). However, panels (d)-(f) show that e–monetary value outstanding is growing at a considerably faster rate than either currency or bank deposits, averaging 35.6% p.a. in the EA and 62.3% p.a. in Singapore. These figures are somewhat exaggerated by the exceptionally rapid growth over the period 1997-8, and fall to 29.7% and 32.1% respectively if this initial period is discounted. This compares to average growth in currency of 12.2% and 5.3% and in deposit accounts of 14.6% and 10.6% in the EA and Singapore, respectively. This vibrant growth suggests that interest in e–money schemes is healthy and indicates clear scope for further development and commercialisation of e–money products.

The quantity and rate of growth of e–monetary value outstanding suggests that e–money schemes are somewhat more developed in Singapore than in the EA. This is perhaps not surprising given Singapore's reputation as a technological leader in a number of fields. Furthermore, as a small city state with a remarkably high population density (approximately 6,500 residents per square kilometre), the infrastructural costs associated with the roll–out of new technologies is very low in comparative terms. Hence, the average cost of e–money transactions is likely to be lower in Singapore than in the EA, resulting in increased demand if these costs are borne by the end–user, or in increased revenue accruing to the issuer if they are not passed on in this manner.

[20] A comprehensive description of the data used in this section may be found in the Appendix.

[21] The adoption of the Euro as a physical currency is responsible for the spike in 2001 in panels (b) and (e), reflecting households' desire to exchange national currencies that they had accumulated before the official transition on January 1st, 2002.




(a) E–Money

(b) Notes and Coins

(c) Transferable/Overnight Deposits

(d) E–Money

(e) Notes and Coins

(f) Transferable/Overnight Deposits

Figure 3.4: Outstanding Balances (panels a-c, billions US$) and Growth Rates (panels d-e, % p.a.)

The greater relative importance of e–money in Singapore is underscored by Figure 3.5 which plots the outstanding value of each of the three payment media both as a fraction of GDP and on a per capita basis. Panels (a) and (d) reveal that not only is e–money considerably more widely used in Singapore than in the EA but that the rate of adoption is more rapid. This observation is distinctly consistent with Rogers' sigmoid adoption theory and suggests that e–money usage is gaining momentum in Singapore (i.e. that Singapore is further along the curve than the EA). This process will surely accelerate when e–money is formally granted the status of legal tender under the SELT initiative.

In the analysis of Figures 3.4 and 3.5, e–monetary value outstanding is assumed to be a crude proxy for the usage of e–money schemes, but it must be acknowledged that it does not capture the level of activity in e–money schemes *per se*, as e–money is typically destroyed in the process of being spent, unlike cash and bank deposits which are simply transferred. Hence, the data contained in the figures are likely to understate the importance of e–money in both the Euro Area and in Singapore. This may be overcome by the analysis of the relative importance of various payment media according to various criteria, including their share of total transactions. However, this data is not available at the EA level so the five member states covered by the CPSS surveys (Belgium, France, Germany, Italy and the Netherlands) are considered separately in the following analysis[22].

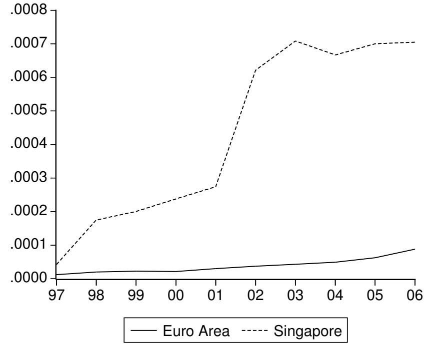
### Relative Importance by Transactions Volume and Value

Figure 3.6 plots the transaction shares of five classes of cashless payment instrument (credit and debit cards[23], cheques, credit transfers, direct debits and e–money) by volume. A number of general trends are common to each country. Firstly, the share of cheques is falling across the period considered in all cases. Secondly, the share of credit and debit cards is growing in all cases except Germany and Singapore, although at a decreasing rate (this could be seen as evidence that these technologies are in the late stages of sigmoid adoption). Thirdly, credit transfers and direct debits account for a large proportion of transactions by volume, and that proportion has remained relatively constant over the sample period in most countries, with the notable exception of Singapore.

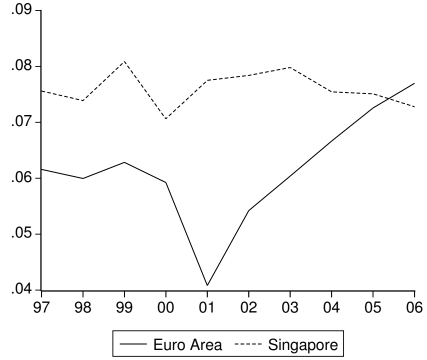
The plots differ most significantly with regard to the role of e–money. In the largest of the three EA countries, e–money usage is negligible, while it is gradually growing in both

[22] In the data analyses based on the CPSS comparative tables, 'neg' (negligible) entries are replaced with zero. Furthermore, 'nap' (not applicable) and 'nav' (not available) entries are computed by extrapolation based on the 5 year growth rate where applicable. A detailed discussion of the data cleansing process may be found in the Appendix.

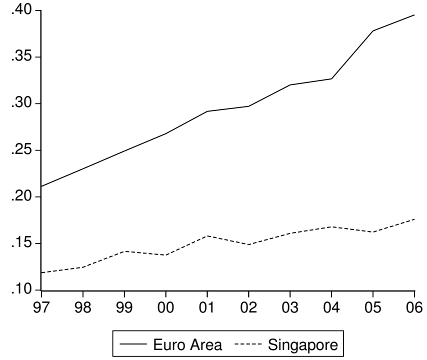
[23] Further subdivision of this category is possible in the more recent CPSS surveys but the required data is unavailable in the earlier surveys.



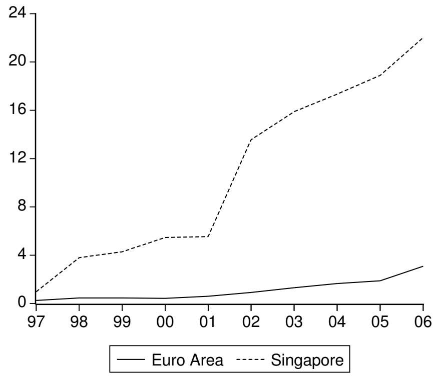

(a) E–Money



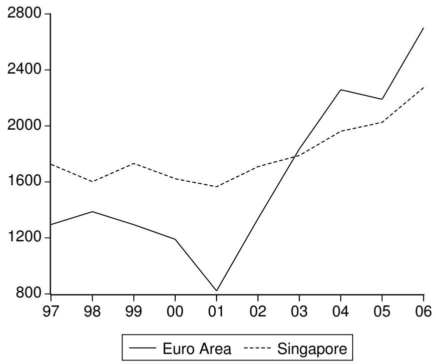

(b) Notes and Coins in Circulation



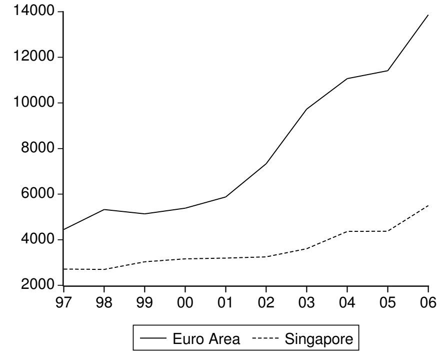

(c) Transferable/Overnight Deposits




(d) E–Money




(e) Notes and Coins




(f) Transferable/Overnight Deposits

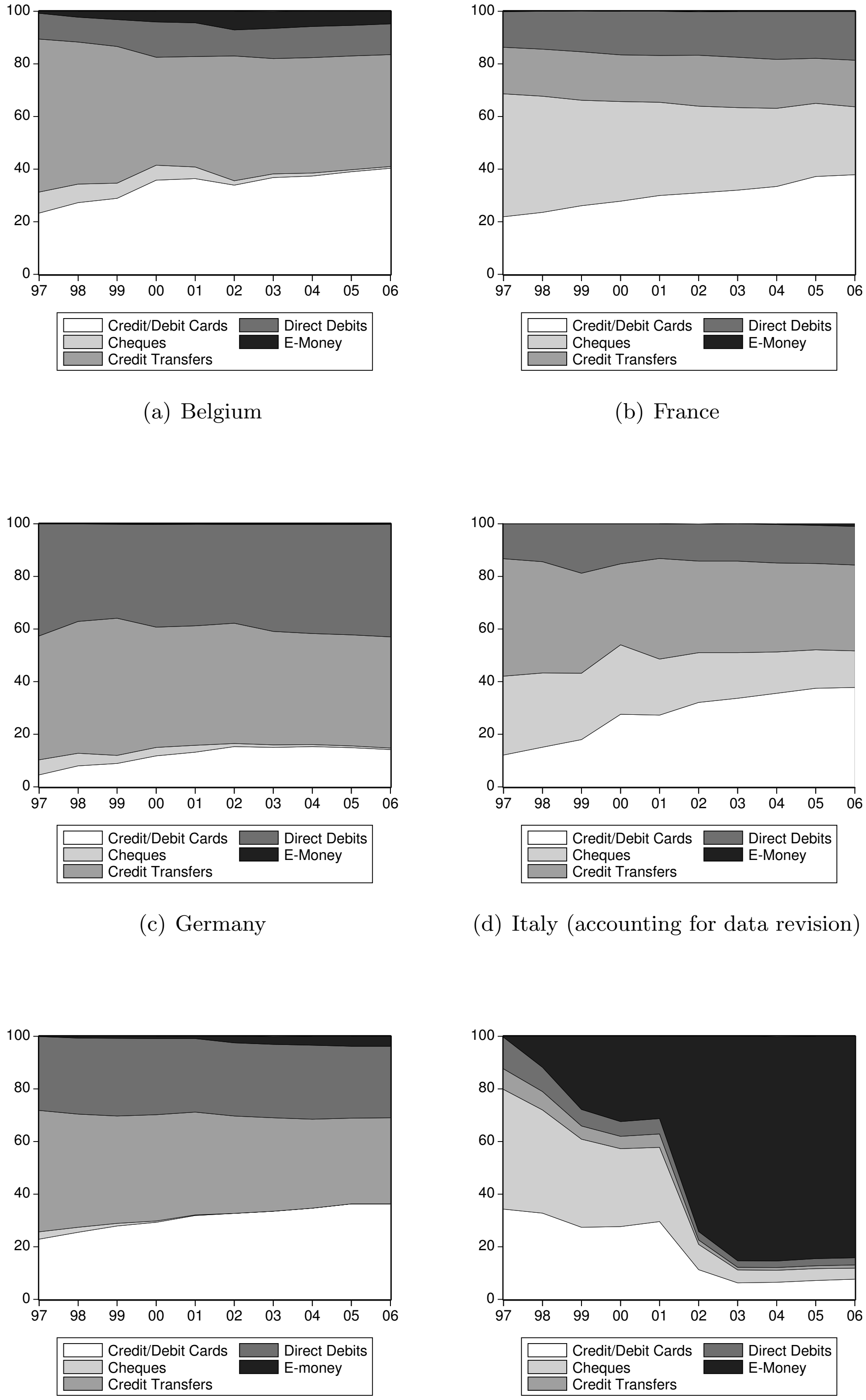
Figure 3.5: Outstanding Balances Relative to GDP (panels a-c) and per Capita (panels d-e, US$)

Belgium and the Netherlands, accounting for 4.9% and 3.9% of all cashless payments in 2006 in each country, respectively. However, the most striking feature of Figure 3.6 is the remarkably rapid expansion of e–money schemes in Singapore, the market share of which has grown from 0.4% in 1997 to 84.2% in just nine years. This growth has come largely at the expense of cheques, debit and credit cards.

The most rapid growth of the market share of e–money occurred in the year 2001-2, coinciding with the government's announcement of the SELT initiative. This episode provides an example of the power of state–backing. Two of the greatest hurdles facing e–money schemes are overcoming the lack of trust and achieving widespread acceptance and interoperability. By announcing its plans for an electronic legal tender system, the Singaporean government has increased the credibility of electronic payment media with its end–users (the Congressional Budget Office, 1996, p. 45, makes a similar point concerning the public issuance of e–money), and has provided an institutional framework around which providers can rally, achieving greater integration and providing a unified service environment. For its part, the government has propelled Singapore into the international spotlight as a leading technological innovator and hopes to steal a march on its international competitors in the provision of integrated electronic payment systems, a market with massive growth potential. Furthermore, by moving toward an increasingly electronic payments environment, the government may hope to reduce the costs associated with the existing payments infrastructure and increase its efficiency (Low, 2002).

Figure 3.7 presents the share of each of the cashless payment media in terms of total transaction value. Interestingly, credit transfers dominate in all countries with the exception of Germany, where direct debits account for a share of approximately 10%. The share of credit transfers in Singapore is more than 95% on average across the sample[24], with e–money accounting for just 0.2%. The dominance of credit transfers results from their use in large value transactions and also reflects the nature of the large value transfer systems, in which all transactions above a threshold value are settled electronically in this way.

[24]The Singaporean data on transactions values is adjusted to account for an apparent revision error or anomaly that saw the value–share of cheques in 2002 revised from 3.8% to 78.1%. The data for 2003-2006 was constructed by extrapolation of the original (unrevised) series using the growth rates of the revised series under the assumption that the pattern should be similar despite the apparent rescaling of the series. The value–shares of the four other payment mechanisms were then recalculated to be consistent with the new series.




(a) Belgium

(b) France

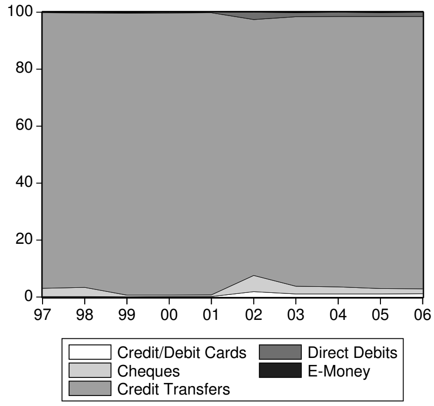
(c) Germany

(d) Italy (accounting for data revision)

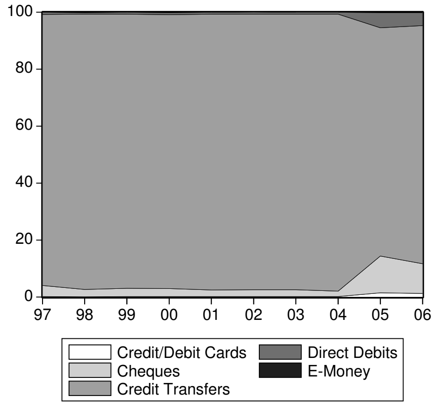
(e) Netherlands

(f) Singapore

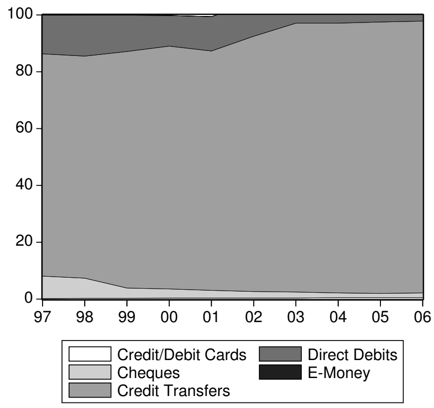
Figure 3.6: Relative Importance of Cashless Payment Instruments by Transaction Volume (percentage of total)



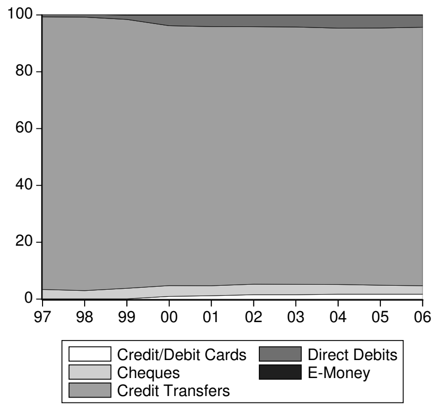

(a) Belgium



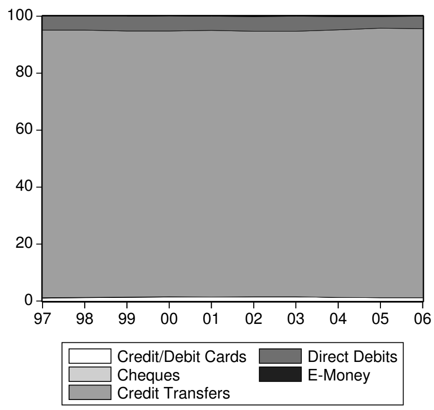

(b) France



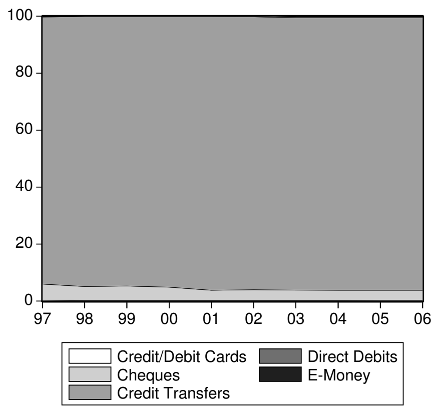

(c) Germany




(d) Italy (accounting for data revision)




(e) Netherlands




(f) Singapore (accounting for data revision)

Figure 3.7: Relative Importance of Cashless Instruments by Transaction Value Measured in USD (%)

### Number of Cards by Category

Figure 3.8 compares the number of cards issued in terms of their functionality. The data covers three classes of cards: cash cards, debit cards and e–money cards (i.e. hardware–based e–money schemes). The number of cards in circulation provides an indication of the degree of access to each payment instrument, as well as a measure of public awareness of, and interest in, each product[25].

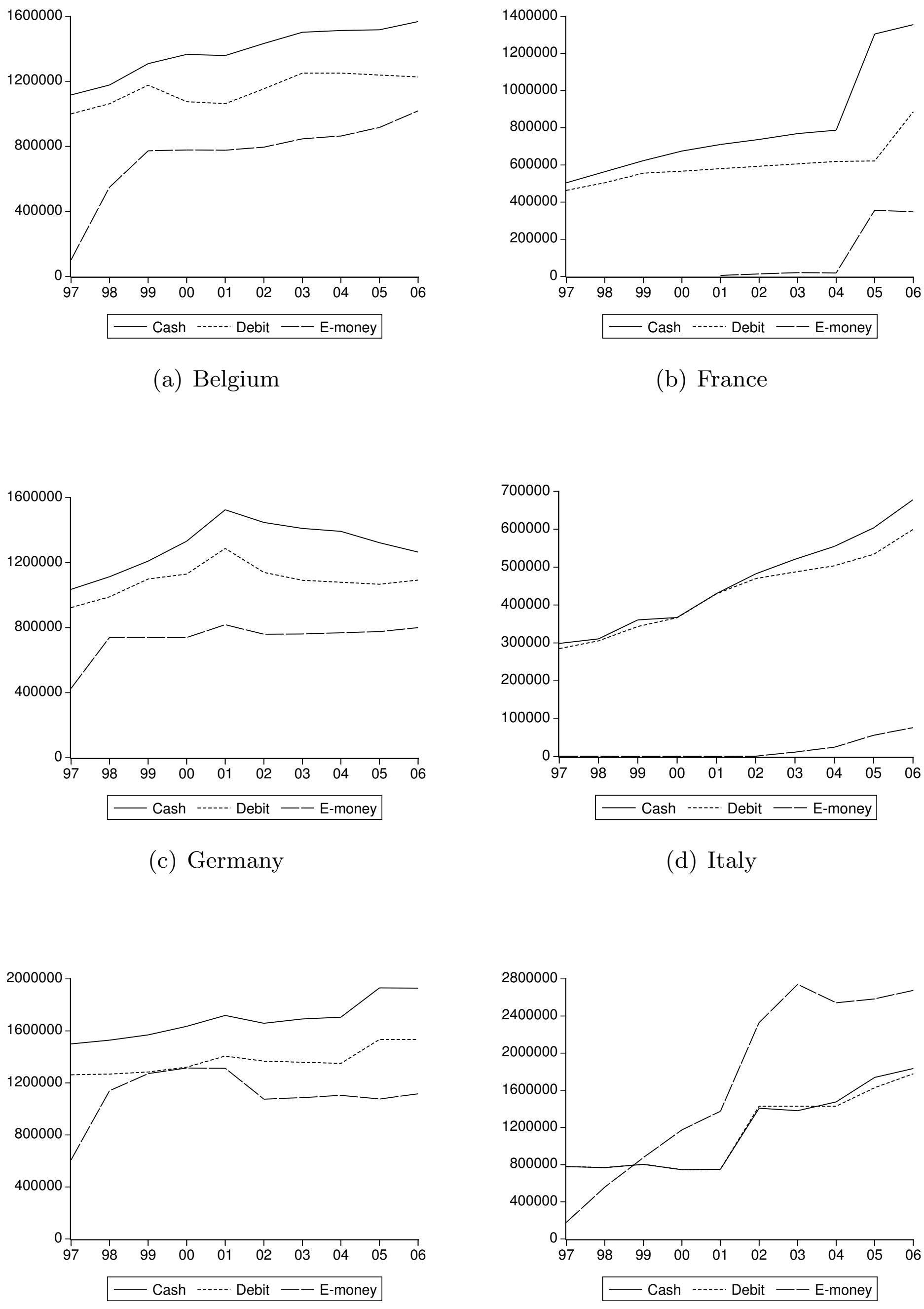
Firstly, it is apparent that the proliferation of e–money cards has been very uneven between countries, with France and Italy displaying delayed adoption and the remaining four countries experiencing different patterns of growth. Among the remaining European countries, there has been a tendency toward stagnation after rapid growth in the late nineties, whereas Singaporean growth accelerated markedly with the announcement of the SELT initiative in 2001.

Around the turn of the millennium, the number of e–money cards in circulation in the Netherlands briefly equalled the number of debit cards, a feat not since repeated in any European country. By contrast, the number of e–money cards in Singapore exceeded the number of debit cards in 1999, *before* the major acceleration of e–money growth, and has now reached a relatively stable level at approximately one and a half times the number of debit cards.

The Singaporean data suggests that there are approximately three e–money cards per head of population in Singapore. However, if one accounts appropriately for the demographics of the population, there are probably at least five e–money cards per adult in Singapore, indicating that these cards perform different functions. In light of this, the recent cessation of growth in the issuance of e–money cards may be interpreted as evidence that the degree of interoperability of Singaporean e–money schemes is increasing (i.e. that fewer cards are required to perform the same number of functions).

Belgium and Italy are the only EA countries in the sample where the gap between the number of debit cards and the number of e–money cards in circulation is closing. Indeed, these are the only EA countries in which the number of e–money cards seems to be growing significantly.

[25]Unfortunately, the coverage of the CPSS surveys in terms of credit card usage statistics is relatively limited and so this category is omitted. The same is true for delayed debit/charge cards. Note that there is likely to be a considerable degree of double counting between cash cards and debit cards. The spread reflects credit cards with a cash function as well as cash cards without a debit function.




(a) Belgium (b) France

(c) Germany (d) Italy

(e) Netherlands (f) Singapore

Figure 3.8: Number of Cards per Million Inhabitants by Function

### ATMs and E–Money Loading Terminals

Figure 3.9 plots the number of automated telling machines (ATMs) and e–money loading terminals (ELTs) per million head of population. The purpose of ATMs and ELTs is essentially similar. ATMs are used to increase an agent's stock of cash (notes and, indirectly, coins) for use largely in purchase transactions[26]. Similarly, ELTs are used to increase the stock of e–monetary value held on an e–money device for use primarily in purchase transactions. In this sense, the relative number of ATMs and ELTs provides an indication of the shoeleather costs associated with each means of payment.

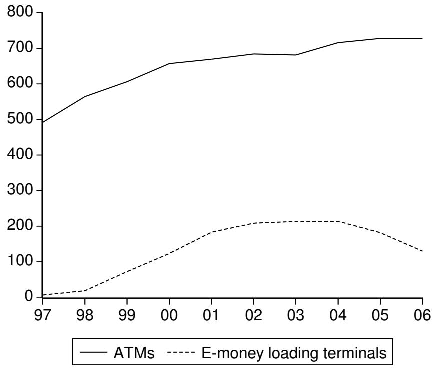
Among the EA countries, the proportion of ELTs relative to ATMs is small and even negligible in some cases (especially Italy). The only exception is Belgium, where the ratio briefly exceeded 30% in 2003 and has been non–negligible throughout the sample. Unfortunately, ELT data is not available for Singapore, although the number of ATMs has been gradually declining (panel (f)) which may reflect a degree of substitution away from cash in favour of e–money.

Given the shortage of ELTs relative to ATMs, certainly in the EA countries, it may be reasonably inferred from the simple Baumol–Tobin framework that agents must hold larger e–money balances than cash balances in order to carry out their day–to–day transactions without incurring higher shoeleather costs. Given that neither e–money nor cash balances are interest bearing, the necessity to hold a larger average balance of e–money implies that its user–cost is higher than that of cash. If one assumes that the attributes of the two payment systems are essentially similar, then this observation provides an unambiguously continuing role for cash and suggests that there is no business case for e–money. However, as e–money is currently in relatively widespread use in a number of countries, it follows that it possesses unique attributes that induce a willingness to pay on the part of the consumer. These attributes include the removal of the 'exact change' problem, the increased efficiency associated with contactless card technology (i.e. time savings through reduced queueing), increased security relative to cash and the potential for remote use (e.g. for internet purchases).

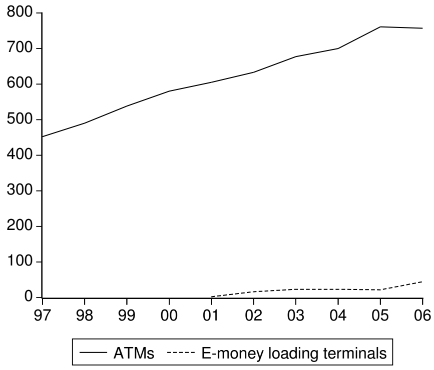
### Point–of–Sale and E–Money Purchase Terminals

Unlike the situation regarding the e–money loading infrastructure discussed above, e–money purchase terminals (EPTs) are gradually gaining ground relative to the established POS infrastructure in the larger European economies, with the possible exception of France

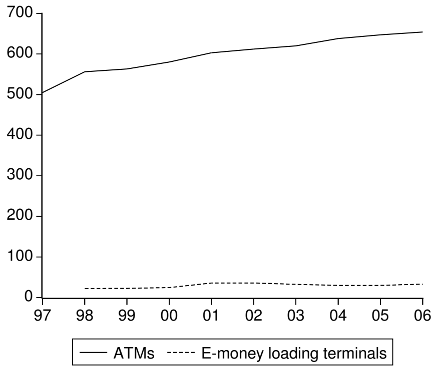
[26] Of course, cash may also be held as a store of wealth (although it performs this role badly in an inflationary environment) and for speculative reasons, although the assumption that its dominant role is in exchange seems relatively innocuous.



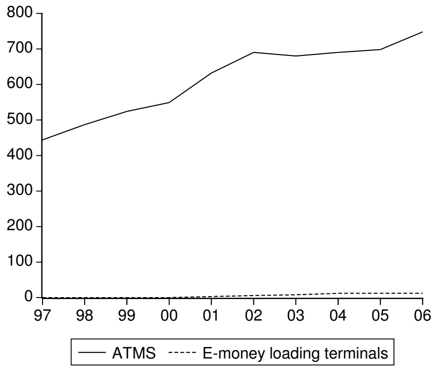

(a) Belgium (accounting for data revision)



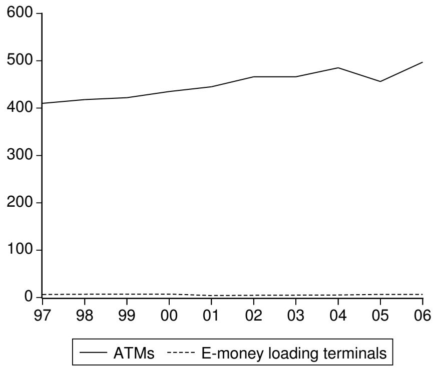

(b) France



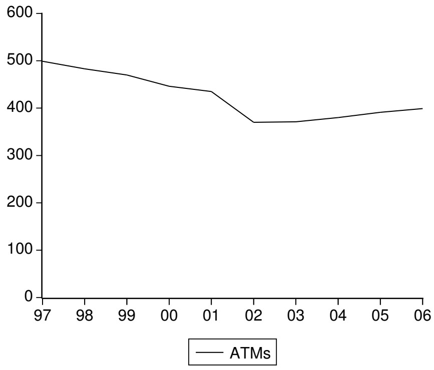

(c) Germany




(d) Italy




(e) Netherlands




(f) Singapore

Figure 3.9: Number of ATMs and E–Money Loading Terminals per Million Inhabitants

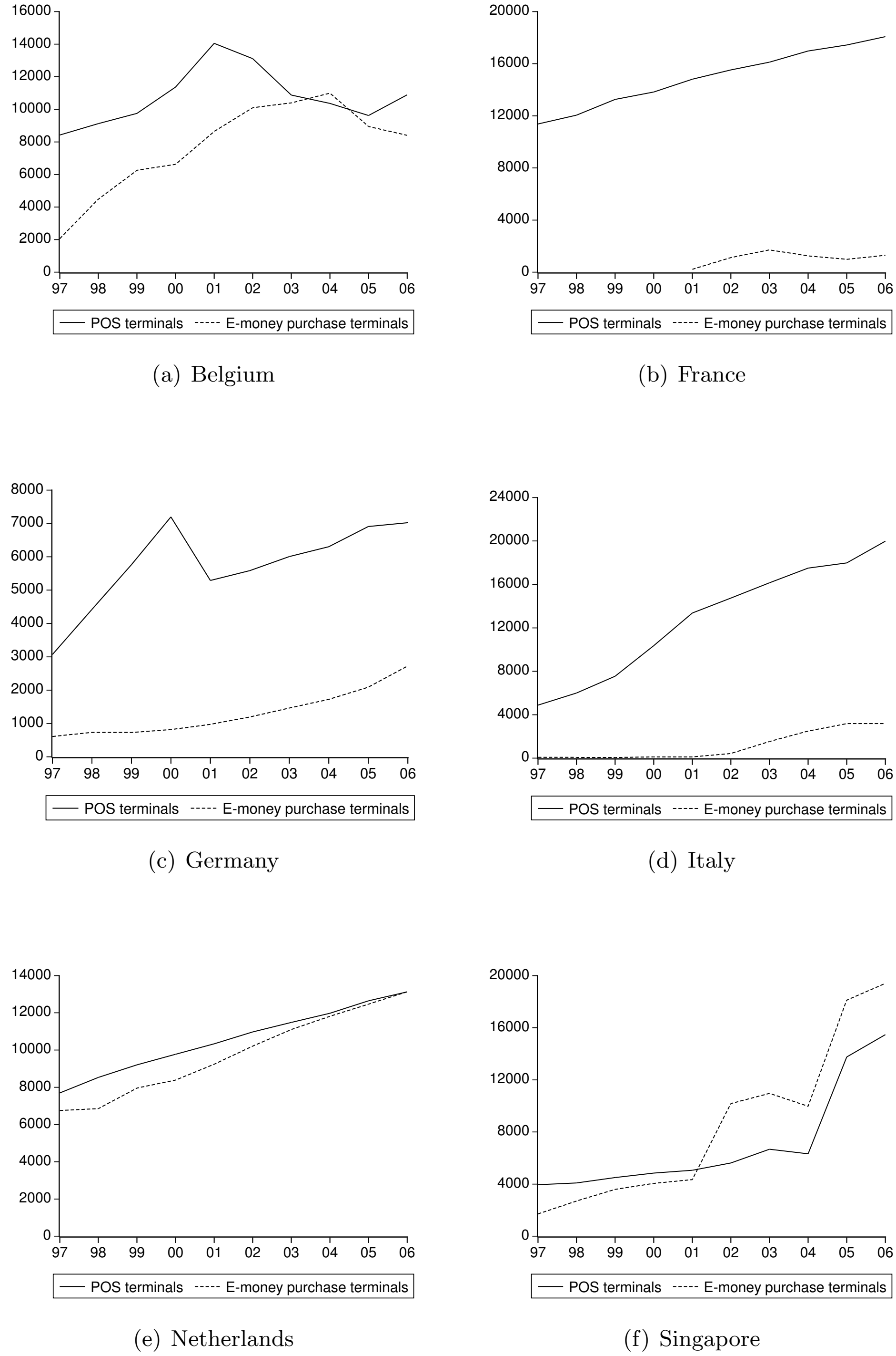
(see Figure 3.10). The installed POS and EPT capacity in Belgium and the Netherlands is comparable, while in Singapore there have been more EPTs than POS terminals since 2001. An interesting trend which seems to be emerging in Singapore and, to a lesser degree, in the Netherlands and Belgium, is that the number of EPTs and POS terminals have come to track one another increasingly closely. This may be due to the adoption of multi–purpose purchase terminals that can accept payment from debit, credit and e–money cards.

In general, by comparing Figures 3.9 and 3.10, it is clear that access to e–money loading and unloading facilities seems to be in greater relative shortage than access to e–money purchase facilities, in the EA at least. The observation that, in some cases, EPTs outnumber POS terminals is, perhaps, not surprising given that many e–money schemes often provide either single–purpose or simple multi–purpose products where the range of uses is limited. Considered in this way, the apparent wealth of e–money purchase terminals may simply reflect a lack of interoperability. As has already been discussed, payments technology exhibits extreme network effects and the concept of interoperability is inextricably linked to that of liquidity. Hence, the apparent lack of coordination is both a serious impediment to the further development of electronic payment media, as well as a potentially profitable opportunity for existing firms and new entrants alike.

The effects of the announcement of the SELT initiative by the Singaporean government in 2001 can be discussed in either of two ways. Firstly, it could be argued that SELT was a response to the growing market share of e–money in Singapore prior to 2001 and that the government may have wished both to promote this growth and to regulate it for reasons of systemic security. If one subscribes to this reactionist view, there is little need for electronic legal tender laws in the EA because e–money usage in the EA countries is not even approaching the levels observed in Singapore in 2001.

The SELT initiative may also have been motivated by a desire to promote the growth and development of the new technology by increasing the credibility of the new payment instruments and providing a common framework around which service providers could coordinate, increasing interoperability. Given the relatively early stage of development of e–money systems in Europe, the European Commission faces a trade–off. One may argue that the deployment of a comprehensive regulatory framework risks stifling innovation[27]. Alternatively, it could be argued that a carefully crafted policy outlining common standards for the industry could provide a nexus for coordination that could act as a catalyst to growth.

[27]There are some signs that the current legislation may already be having this effect - this is discussed in detail in the next chapter.




(a) Belgium

(b) France

(c) Germany

(d) Italy

(e) Netherlands

(f) Singapore

Figure 3.10: Number of POS and E–Money Purchase Terminals per Million Inhabitants

## 3.6 Forecasting the Future Growth of E–Money

The only serious attempts at forecasting the degree of uptake of e–money to date have taken the form of simple substitution models in which e–money is assumed to compete with cash for use in transactions below a certain threshold value (c.f. Boeschoten and Hebbink, 1996; Bounie and Soriano, 2003). The usefulness of such models is limited due to the strength of the assumptions upon which they rely. For example, it is typically assumed that the only payment instruments available for small transactions are cash and e–money. While this may be a relatively innocuous simplification for genuinely small transactions, the thresholds that are commonly discussed in the literature are €10 and €30 which provide scope for other forms of payment including credit cards, debit cards and cheques. In light of the data presented above which clearly demonstrates that e–money competes with other forms of cashless payment instrument as well as cash, this assumption becomes untenable. Moreover, the assumption that the probability of carrying out a transaction with cash as opposed to e–money is time–invariant is inconsistent with Rogers's sigmoid adoption hypothesis.

To date, no data–driven forecasts of e–money adoption and usage have been made publicly available for the Euro Area. However, the ECB has provided an e–monetary aggregate at a monthly frequency since 1997m9. Using this data, it is possible to forecast the growth of outstanding e–money balances. The Baumol–Tobin framework discussed above suggests that these outstanding balances are likely to be small on average because e–money bears a zero nominal interest rate (and therefore a negative real interest rate of $-\pi/\left(1+\pi\right)$, where $\pi$ is the rate of inflation). However, if the stock of e–monetary value outstanding is closely related to the volume of transactions carried out using e–money, then one can draw inferences about the degree of usage of e–money. This assumption seems relatively innocuous in the short–term. Moreover, the empirical evidence shows that, between 2002 and 2006, the ratio of e–money/M2 to billions of e–money purchase transactions has been approximately constant at $2.14\text{x}10^{-4}$ and that the two series are strongly positively correlated ($\rho = 0.937$)[28]. This approach has the advantage that high frequency data on e–money balances outstanding may be used to compute sophisticated forecasts which may then be used to draw inferences about series for which no such data is available (data on transaction volumes is only available annually since 2000 for the Euro Area, for example). Moreover, these inferences do not rely on strong assumptions about the nature of the substitution of e–money for other forms of payment.

[28] Data on the volume of e–money purchase transactions in Europe comes from the Eurostat series PSS.A.U2.F000.IEM.Z00Z.NT.X0.20.Z0Z.Z.

Three different forecast models are considered. Firstly, a simple geometric random walk model is estimated as a benchmark against which the performance of the other models may be evaluated. Secondly, a simple model–averaging exercise is undertaken in order to account for model uncertainty and to sharpen the resulting forecasts. Finally, the sigmoid adoption hypothesis is tested by fitting a Gompertz curve to the data.

### 3.6.1 The Dataset

The following variables are considered for use in the multivariate forecasting models:

| Symbol | Variable definition |
|---|---|
| $m_{hp}$ | Log of e–money balances outstanding relative to M2 |
| $c$ | Log of currency in circulation relative to M2 |
| $d$ | Log of demand deposits relative to M2 |
| $y$ | Log of real industrial production |
| $r$ | Log of the 1 month Euribor |
| $z$ | Log of the technology index |
| $q$ | Log of the deflated NASDAQ adjusted closing price |

Table 3.2: Variable Definitions

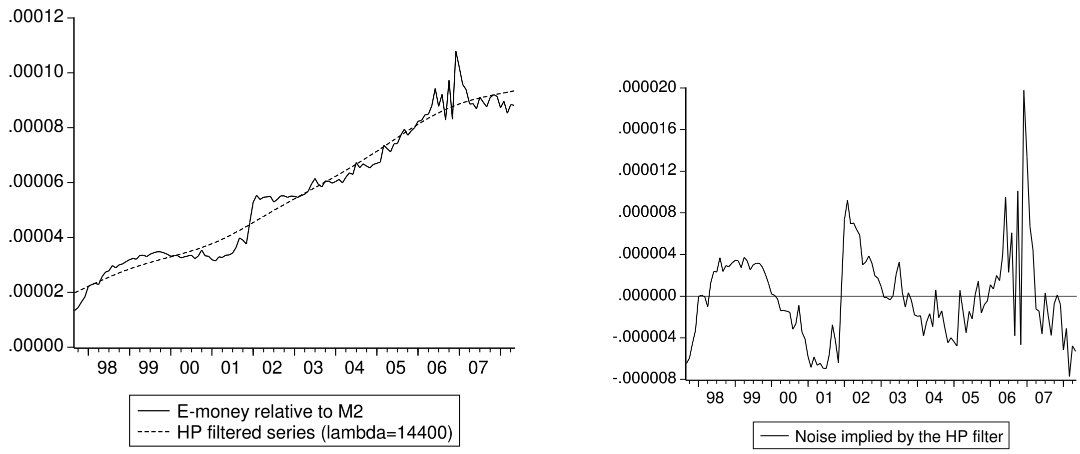
All series are seasonally–adjusted with the exception of the technology index which is interpolated from annual data (see the Appendix for details). E–monetary value outstanding, currency in circulation and demand deposits are expressed as a fraction of M2 so that the development of e–money schemes may be discussed in terms of market penetration rather than simply aggregate value outstanding. The ECB reports the stock of e–money as an overnight deposit, a category conventionally included in the M1 aggregate. However, given that e–money is theoretically a multiple of currency and deposits (the multiplier is currently set at 1 but this need not remain the case in the long–term) it seems more appropriate to consider the stock of e–money relative to M2. Table 3.3 provides descriptive statistics. Unit root testing (the results of which are presented in the Appendix) reveals that all series are I(1).

The series $m_{hp}$ is smoothed using the method of Hodrick and Prescott (1997) in order to remove the high frequency noise characterising the raw data. This noise does not reflect pure seasonal variation as both component series (e–money and M2) are seasonally adjusted. Rather, it is a result of trial schemes and promotional activities which are not strictly relevant for forecasting the trend growth of the e–money stock. Minimal smoothing is employed so that the noise is attenuated while retaining as much of the informational content of the raw data as possible. Hence, the smoothing parameter $\lambda$ is set to 14,400, the figure typically associated with quarterly data. This is considerably lower than the value of 126,400 recommended for monthly data by the frequency rule of Ravn and Uhlig

| | $m_{hp}$ | $c$ | $d$ | $y$ | $r$ | $z$ | $q$ |
|---|---|---|---|---|---|---|---|
| Mean | -9.886 | -2.449 | -0.904 | 4.562 | 1.156 | 4.881 | 3.999 |
| Median | -9.826 | -2.412 | -0.889 | 4.559 | 1.208 | 5.029 | 3.945 |
| Maximum | -9.278 | -2.352 | -0.764 | 4.623 | 1.598 | 5.560 | 4.849 |
| Minimum | -10.828 | -2.817 | -1.136 | 4.524 | 0.714 | 3.551 | 3.403 |
| Std. Dev. | 0.457 | 0.099 | 0.100 | 0.022 | 0.289 | 0.562 | 0.280 |
| Skewness | -0.293 | -1.399 | -0.578 | 0.799 | -0.218 | -0.878 | 0.917 |
| Kurtosis | 1.833 | 4.155 | 2.458 | 3.290 | 1.656 | 2.642 | 4.190 |
| Jarque–Bera | 9.171 | 49.272 | 8.772 | 14.171 | 10.725 | 17.248 | 25.688 |
| Probability | 0.010 | 0.000 | 0.012 | 0.001 | 0.005 | 0.000 | 0.000 |
| Sum | -1275.350 | -315.882 | -116.662 | 588.467 | 149.075 | 629.633 | 515.855 |
| Sum Dev.$^2$ | 26.711 | 1.261 | 1.269 | 0.063 | 10.671 | 40.371 | 10.039 |

Table 3.3: Descriptive Statistics

(2002), and results in considerably reduced smoothing. The smoothed and raw series are compared in Figure 3.11.




(a) Raw and filtered series (b) Implied noise

Figure 3.11: Hodrick–Prescott Filtering of E–Money Relative to M2 ($\lambda = 14,400$)

### 3.6.2 The Benchmark Case: A Geometric Random Walk Model

The geometric random walk model is appropriate for series exhibiting exponential growth. The model is defined as follows:

$$lnY_t = \beta_0 + \beta_1 lnY_{t-1} + \epsilon_t \tag{3.1}$$

Due to its simplicity and relatively robust forecasting performance, the random walk model is used as a benchmark against which to evaluate the alternative specifications.

### 3.6.3 Model Averaging

In recent years, much applied forecasting work has employed various model averaging techniques in the Bayesian tradition in order to reduce the problems associated with model uncertainty and to sharpen the resulting forecasts. The principle difference between Bayesian econometrics and the frequentist approach is that the matrix of model parameters, $\theta$, is treated as a random variable. Given a number of models, $M_i$, $i = 1, 2, ..., m$, which span the model space, one may calculate the posterior model probability which permits optimal weighting of these $m$ models in the averaging process.

Here, a simplified version of the general Bayesian framework is employed in which models are averaged using the simple arithmetic mean with equal weights. This case is often used as a benchmark against which more sophisticated Bayesian systems may be judged and has the advantage that it is valid even when the 'true' model is not among the candidate set. The $m$ component models will be:

**AR Models** AR($p$) including the benchmark geometric random walk model;

**ARIMA Models** integrated ARIMA($p$,$d$,$q$) models;

**VAR Models** $p$-th order VAR–in–differences models using the regressors in Table 3.2;

**VEC Models** $p$-th order cointegrating VAR models using Johansen's (1991) exactly identifying restrictions.

Every combination of the models containing up to four lags is considered, resulting in $m = 28$[29]. The computation of forecast intervals in the case of model averaging is non–trivial. The most obvious method is to generate bootstrap samples from the residuals of each model independently and use these to compute intervals for each of the candidate models. The resulting 28 pairs of intervals could then be averaged to yield the forecast interval for the model as a whole. An alternative method is to generate bootstrap samples from the residuals of the average model, and then re–estimate every component model for these samples which are common for all candidate models. In this way, the average model could be generated for each bootstrap replication, thereby generating an empirical distribution of forecasts from which the relevant intervals could be easily computed. However, these approaches are unlikely to yield the same result, and it is not clear which is preferable. Given this uncertainty, the computation of forecast intervals for the average model is left for future work.

[29] The cointegrating VAR models are estimated with five cointegrating vectors based on the Johansen trace statistic.

### 3.6.4 Forecasting from a Simple Sigmoid Specification

The model averaging exercise undertaken above accounts for model uncertainty in a simple but effective manner. However, it does not provide any obvious means by which the sigmoid adoption hypothesis may be examined. Among the class of sigmoid functions, the Gompertz function stands out for its simplicity and ease in estimation. The Gompertz curve is defined as:

$$y_t = \alpha e^{-\beta e^{\gamma t}} \tag{3.2}$$

where $\alpha$ denotes the saturation level, $\gamma$ the rate of growth, $\beta$ is a positive parameter determining the lateral position of the curve and $t$ is a deterministic trend.

Franses (1994) provides a method for fitting a Gompertz curve based on simple estimation of a single equation using non–linear least squares (NLS), and where the coefficients and standard errors can be computed in the normal manner. By a process of log–linearisation, first differencing, further log–linearisation, and the addition of an idiosyncratic error term, Franses transforms equation 3.2 into the following form:

$$ln\left(\Delta ln y_t\right) = -\gamma t + ln\left(\beta e^{\gamma} - \beta\right) + \epsilon_t \tag{3.3}$$

The upper asymptote, $\alpha$, is then estimated by substituting the parameter estimates obtained from NLS regression of equation 3.3 into the following[30]:

$$\hat{a}_t = e^{ln y_t + \hat{\beta} e^{-\hat{\gamma} t}} \tag{3.4}$$

Forecast errors and confidence intervals may then be computed by non–parametric bootstrapping. The boostrapping procedure involves the construction of $B$ error series $\epsilon^{*(b)}$ by resampling with replacement from the residuals from initial estimation of equation 3.3. Using the parameter estimates $\hat{\beta}$ and $\hat{\gamma}$, one may then compute the series $y^{*(b)}$ associated with each of these error series using:

$$y_t^{*(b)} = -\hat{\gamma} t + log\left(\hat{\beta} e^{\hat{\gamma}} - \hat{\beta}\right) + \epsilon_t^{*(b)} \tag{3.5}$$

Equation 3.3 is then re–estimated on each of the $B$ simulated datasets. For each of the models estimated in this way, forecasts $\widehat{y^{(b)}}_{t+h}$ may be generated over the horizon

[30] Franses (1994) assumes that $\alpha$ is constant so that it may be removed in the process of first–differencing. Estimates of $\alpha$ derived from equations 3.3 and 3.4 tend to support this assumed constancy. Note also that the Newey–West procedure is employed to adjust for the apparent serial correlation of the error process in equation 3.3.

$h$ by forecasting $\widehat{y^{*(b)}}_{t+h}$ and noting that $\widehat{y^{*(b)}}_{t+h} = ln\left(\Delta ln\widehat{y^{(b)}}_{t+h}\right)$ may be rearranged to yield $\widehat{y^{(b)}}_{t+h} = e^{ln\widehat{y^{(b)}}_{t+h-1}+e^{\widehat{y^{*(b)}}_t}}$ which is easily solved using the value $y_T$ for initialisation. Forecast intervals are then retrieved as the relevant percentiles of the empirical distribution. Once again, more detail is provided in the Appendix.

In his original application, Franses fits the model to smoothed data. In the present application, such smoothing has the appealing feature that it renders the first difference strictly positive, avoiding the indeterminacy of the left–hand–side of equation 3.3 that would result from attempting to take the log of a negative number.

### 3.6.5 Pseudo Out–of–Sample Forecasting

The forecasting performance of each of the models may be evaluated in the usual manner by pseudo out–of–sample testing. The sample period used in estimation is restricted to 1997m9-2007m5 while the remaining 12 observations are reserved for comparison against the forecasts. Figure 3.12 plots the pseudo out–of–sample forecasts derived from each model. It is immediately apparent that all models have a tendency to over predict to some degree but that the average model performs considerably better than either the benchmark or the Gompertz specifications. Furthermore, the similarity of the Gompertz and random walk forecasts is quite striking.

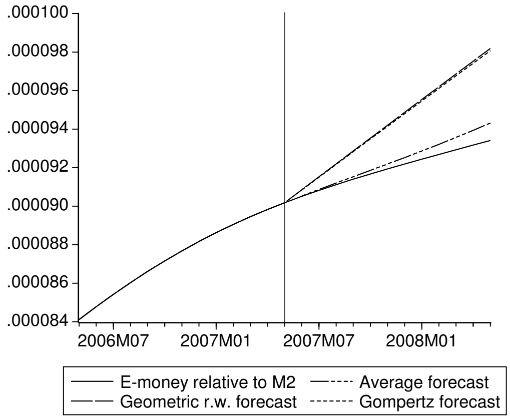



Figure 3.12: Pseudo Out–of–Sample Forecasts

Table 3.4 provides analytical statistics for each of the three models. The root–mean–squared forecast error (RMSFE) and mean absolute forecast error (MAFE) are of comparable magnitude for the benchmark and Gompertz models but considerably smaller in the case of the average model. Furthermore, the mean absolute forecast percentage error (MAFPE) of the average model is less than one seventh that of the random walk model, indicating considerably superior forecasting performance.

| | Benchmark | Average | Gompertz |
|---|---|---|---|
| RMSFE | $2.87\text{x}10^{-6}$ | $4.56\text{x}10^{-7}$ | $2.80\text{x}10^{-6}$ |
| MAFE | $2.51\text{x}10^{-6}$ | $3.58\text{x}10^{-7}$ | $2.44\text{x}10^{-6}$ |
| MAFPE | 2.710 | 0.387 | 2.640 |
| Theil Inequality Coef. | 0.015 | $2.38\text{x}10^{-5}$ | 0.015 |
| Bias proportion | 0.762 | 0.617 | 0.762 |
| Variance proportion | 0.237 | 0.365 | 0.238 |
| Covariance proportion | $3.65\text{x}10^{-4}$ | 0.018 | $3.79\text{x}10^{-4}$ |

Table 3.4: Pseudo Out–of–Sample Forecast Analysis

The Theil Inequality Coefficient of the average model is considerably smaller than those of the other models, again indicating a superior forecast (a value of zero indicates a perfect fit). In all cases, however, the bias and variance proportions are substantial, reflecting the persistent over–prediction of the forecasts. Ideally, the covariance proportion should be dominant as it reflects the unsystematic errors in forecasting.

### 3.6.6 Dynamic Out–of–Sample Forecasting

Simple $h$–step ahead dynamic interval forecasts are computed for both the average model and the Gompertz specification over the 60 months between 2008m6 and 2013m5. These may be compared to those derived from the benchmark geometric random walk model.

#### Benchmark Random Walk Forecast

The forecast from the geometric random walk model is plotted in Figure 3.13(a) with analytical standard errors. The logarithmic approximation to the annualised rate of growth is presented in Figure 3.13(b). This simple benchmark case suggests a slowly decreasing growth path of the ratio of e–money to M2 over a five year horizon. Indeed, the rate of growth is forecast to fall below 4% in 2013m5. The model achieves an adjusted $R^2$ of 1.000 to 3d.p. and has a near–unit AR coefficient of 0.990.

#### Average Forecast

The average forecast is plotted in Figure 3.14. The model indicates that the rate of growth of e–money as a fraction of M2 is likely to increase over a five year horizon, exceeding 7% per annum by 2013. These figures are considerably more optimistic than the benchmark case. It is interesting to note that the forecast rate of growth is considerably smoother than either the benchmark or the Gompertz forecasts (i.e. there is no spike at 2008m6).

**Gompertz Forecast**

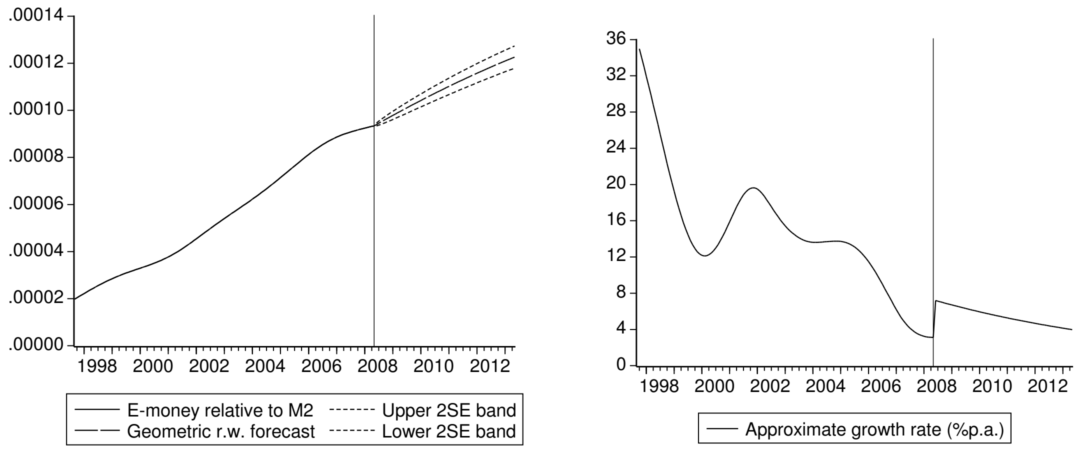
The forecasts from the Gompertz curve are presented in Figure 3.15, including standard errors derived from non–parametric bootstrapping with 500 iterations. The model achieves an adjusted $R^2$ value of 0.670. The $h$–step ahead levels forecasts suggest that the rate of growth of e–money relative to M2 will decelerate over the five year horizon, falling below 3% by 2013m1. This is the most pessimistic of the forecasts, suggesting that the adoption of e–money technology may be in the latter stages of the sigmoid process.

The parameters $\beta$ and $\gamma$ are estimated as 1.909 and 0.012 respectively and both are highly statistically significant. $\beta$ measures the lateral position of the curve and reflects the duration of the initial low adoption phase. $\gamma$ measures the rate of growth of the curve. The mean saturation level $\widehat{\alpha}$ across the sample is 0.013% of M2. While this seems rather low at first sight, it must be remembered that e–money is destroyed in the process of being spent and so the outstanding balance is simply that which has been pre–loaded but not yet spent. The estimated saturation level does not greatly exceed the present level, indicating a rather limited scope for the development of e–money in the future (at least to the extent that the relationship between e–monetary value outstanding and transactions volume remains constant in the short–run).

The forecasts derived from the various models provide support for a range of scenarios concerning the growth of e–money. As the model which performed best in pseudo out–of–sample testing, it seems logical to place somewhat more faith in the average forecast than in either the random walk or Gompertz forecasts. Even though this is the most optimistic of the forecasts, indicating growth reaching 7% per annum by 2013m5, the figure remains relatively modest. With growth occuring at this rate it seems unlikely that the EC will be forced to reconsider its regulatory framework by sweeping change in the payments system, certainly in the foreseeable future (i.e. if one subscribes to the reactionist view then there is no case for regulatory change at this time). However, the EC may choose to change its regulatory framework precisely because of these uninspiring growth prospects, in an effort to foster growth and innovation.

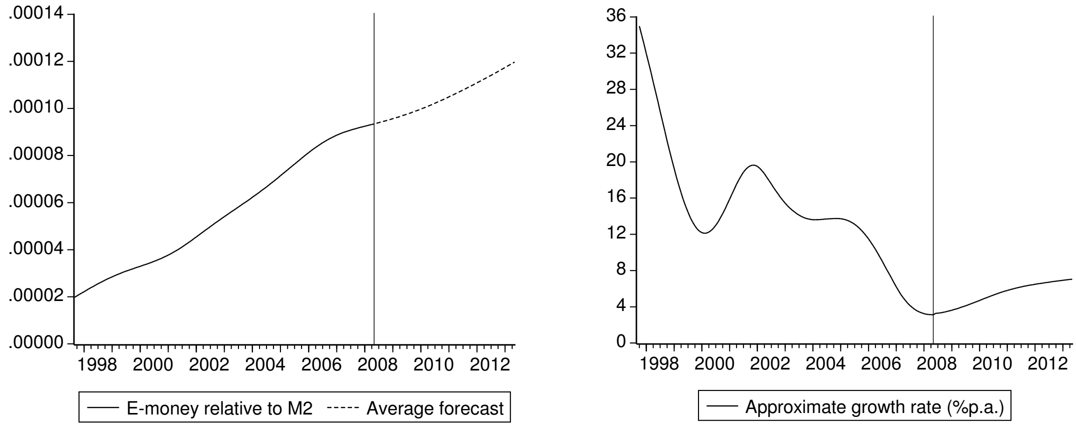
## 3.7 Longer–Term Prospects of E–Money Systems

The forecasting exercises undertaken above indicate that the degree of adoption and usage of e–money technologies will grow moderately but uninspiringly in the medium–term. In the longer–term, the prospects of these innovative payments technologies depend critically on three issues: (i.) the incentives for end–users and issuers; (ii.) security issues and the



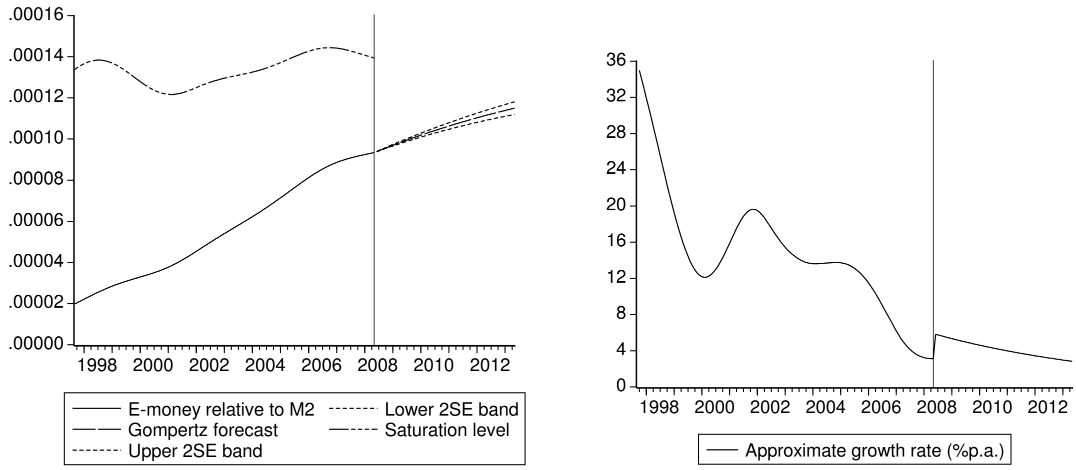

(a) Level (b) Growth Rate

Figure 3.13: $h$–step Ahead Geometric Random Walk Forecast




(a) Level (b) Growth Rate

Figure 3.14: $h$–step Ahead Average Forecast




(a) Level (b) Growth Rate

Figure 3.15: $h$–step Ahead Gompertz Forecast

potential for identity theft; and (iii.) developments in the capabilities of e–money systems.

### i. Incentives

Three key groups may be identified in the e–money market: the issuers and the end–users, comprising both merchants and their customers (Wenninger and Laster, 1995). In order for e–money to succeed, the incentives for each group must be sufficiently strong. In an early contribution, Friedman (1999, p. 329) recognises the importance of these incentives:

> [a]s long as taking deposits and providing payment services is a source of profit for banks, bank customers - like telephone companies, New York's MTA [Metropolitan Transport Authority] or the merchants whom the MTA would like to induce to use its cards - have an incentive to recoup some of their costs by undertaking a form of this activity themselves. And to the extent that they can pass on some of what they recoup to their own customers, individuals will have an incentive to use these alternative payment vehicles just as non–bank firms will have an incentive to provide them[31]

The incentives for the issuers of e–money are relatively clear. As Friedman notes, to the extent that banks charge fees for their services, non–banks will attempt to avoid paying them or, better still, to appropriate some of the rent that would otherwise accrue to the bank. Similar logic can be applied to the central bank. If e–money were to substitute entirely for currency, the private sector would capture the seigniorage revenue $OC^d$ from the central bank in Figure 3.2. Given such incentives, it is likely that both banks and non–bank financial institutions will continue developing innovative payment systems.

While the incentives for service providers are clear, the incentives for merchants and consumers are less so. Friedman's optimistic view outlined above suggests that those merchants that engage in e–money issuance may make cost savings and may choose to pass some of their savings on to their customers. However, in the first instance, it is unclear whether they would actually pass them on. Secondly, and more fundamentally, only a limited proportion of merchants are likely to enter the e–money market as issuers; the majority are likely to remain simple merchants. In order to accept electronic payments, merchants will have to invest in the relevant infrastructure, an outlay which represents a fixed cost which may be relatively high[32]. Furthermore, the costs associated with training

[31]The implication that deposit–taking is a source of profit for depository institutions is somewhat misleading, as it actually represents a cost. The profit accrues indirectly through the lending operations of banks which maintain a spread between their deposit and lending rates.

[32]Low (2002, p. 154) provides a breakdown of the costs associated with an e–money trial in Singapore in which each terminal cost S$200.

staff to use the technology may be non–negligible. In order for merchants to be willing to bear these costs, they must expect to derive quantifiable benefits. In businesses that rely on providing a quick, efficient and convenient service, these benefits may derive from increased trade resulting from the increased efficiency of e–money (particularly contactless card technology) relative to payment with cash. Furthermore, given that e–money schemes eliminate the costs associated with handling and securing cash, the marginal cost to the merchant may be lower.

Finally, the incentives for the consumer must be considered. The cost of e–money to the consumer is typically positive. Many contemporary e–money schemes charge administrative fees and sometimes a commission on purchases (for example Giannopoulou, 2004, reports a 0.9% commission on Moneo transactions in France). Although it is true that there are costs associated with all payment systems, the customer is often unaware of them, as they are typically borne by the service provider. Hence, the user costs of e–money may actually prove higher than those of many other payment vehicles. The critical issue is the willingness of consumers to pay for the benefits afforded to them by e–money. Wenninger and Laster (1995, p. 2) note a willingness to pay among US consumers of between 2 and 5 cents per transaction, or an equivalent annual fee. Provided that the value attached to the benefits derived from e–money exceeds the costs imposed by the issuers, consumers will adopt the new technology.

Irrespective of the willingness to pay, in some situations individuals may be obliged to use a specific means of payment. Examples include the requirement to use stored value cards to pay for parking in Paris (Giannopoulou, 2004) and in a number of cities in the Netherlands (De Nederlandsche Bank, 2002, p. 24) and for toll roads in Singapore (Van Hove, 2003). In such situations, the consumer has a simple choice between using the new technology and bearing the associated costs or excluding themselves from these services. Such initiatives exploit a little–known feature of legal tender laws in these countries whereby legal tender need not necessarily be accepted in exchange, merely in extinguishing existing debts (Van Hove, 2003, pp. 5-6). Of course, one may question whether it is ethical to impose e–money usage in this manner, but the fact remains that such policies will have significant impacts on public attitudes toward the new technology.

A common theme that pervades the preceding discussion is that of cost. A key factor in determining the extent to which a new product will displace an existing competitor is its relative cost (in the case of e–money, this is composed of two parts, namely the cost of its implementation and of its subsequent use). Meyer (2001b, p. 7) and Stefanadis (2002) show that while the costs of operating an e–money system are very low, the initial fixed costs incurred in development and implementation are substantial. This suggests that while the marginal cost of e–money usage is presumably lower than that of cash (which is positive due to the expenses incurred in its transport, storage, counting etc.), its average cost is likely to be higher until it becomes sufficiently widely used. Overcoming this average cost barrier poses a problem: e–money schemes must achieve a critical mass before retailers will accept payment in e–money, and consumers demand for e–money will remain low until a sufficiently large number of retailers accept the new technology. Thus, there is a 'chicken–and–egg' problem (Van Hove, 1999a; Stefanadis, 2002; Krueger, 2002b).

**ii. Security Issues and Identity Theft**

E–money is, in principle, more secure than cash for the end–user. If one loses an SVC, for instance, it is possible to cancel the card and recover any unspent e–monetary value. However, as already mentioned, counterfeiting could be a serious problem for e–money schemes as it is possible to produce a perfect, indistinguishable copy of an electronic image. Moreover, to the extent that online systems are vulnerable to hacking, remote theft is possible, adding to the complex task of securing the new payments technology. Finally, the fact that e–money schemes rely on computer networks suggests that viruses may be a further significant threat to security, whether deliberately targeted or otherwise. These security issues are likely to significantly shape the future development of e–money schemes (particularly network money) not simply because of concerns over monetary losses, but also due to the potential for identity theft. The issue of identity theft is likely to be exacerbated by the use of multi–purpose cards which incorporate a range of non–money functions. A prime example of this is the Malaysian Government Multi–purpose Card which combines stored–value functionality with an ID card, drivers license, passport and health records (Van Hove, 2003, pp. 15-16).

None of these security threats are insurmountable, they simply suggest that e–money issuers are likely to have to invest heavily in advanced encryption technologies and security software. Given public scepticism about the security of online systems in many countries, it is likely that firms will compete to some degree to offer the most secure service, or may use security to achieve product differentiation once the market becomes more developed.

**iii. Developments in the Capabilities of E–Money Schemes**

As mentioned above, the payments system is an extreme example of a network industry. The largest obstacle to the success of e–money schemes at the present time is their lack of interoperability. Until e–money systems are fully interoperable, e–money will not become widely accepted as a medium of exchange. The expectation of increased interoperability in Singapore following the announcement of SELT in 2001 provided a substantial impetus to the industry. While it is possible that e–money issuers will develop interoperable systems of their own accord without government intervention, it seems likely that there is a role for government in providing a basic framework around which issuers can coordinate.

The market for electronic payments is becoming increasingly competitive and dynamic. The growing interest of mobile telecommunications providers in e–payments solutions has led to rapid developments in m–payments technologies. Furthermore, the development of contactless smart–card technology has greatly increased the convenience of e–money relative to traditional means of payment. Continuing investment in such areas is likely to increase public interest in the new technology.

Finally, although e–money schemes are prevented from paying interest in many countries (although significantly not in Singapore) and from the extension of credit in most (if not all) countries, the record of private firms circumventing such regulations where a profitable opportunity presents itself is well established. Many e–money schemes are already paying *de facto* interest in a form of lottery, a practice acknowledged by the FSA (see Section 4.2.1). Such circumventive innovations provide fresh challenges for policy–makers on the one hand, and on the other they provide fresh opportunities for both firms and consumers.

## 3.8 Concluding Remarks

E–money became a high profile topic at the turn of the millennium due to the proposed threat that it posed to the efficacy of monetary policy and the stability of the payments system. Once the debate concerning this threat had been largely settled, research interest in e–money dwindled. However, with the imminent launch of electronic legal tender in Singapore and the proliferation of prepaid smart–cards in many countries around the world, the subject is once again becoming topical. Furthermore, the ongoing development of the Single European Payments Area (SEPA) is providing a largely unprecedented forum for the discussion of issues relating to the design and regulation of (cross–border) electronic payments systems.

A number of regulatory challenges present themselves as a result of the development of e–money systems. Among the most serious are the possibility of bank runs, circumventive innovation, misreporting of macroeconomic statistics, systemic risks, social exclusion and the erosion of privacy. The extent to which these issues may be judged to be important depends on the degree to which the new technology is used and is likely to be adopted in the future. Comparison of the retail payments systems in the Euro Area and Singapore reveals that e–money usage in Europe is significantly less pronounced than in Singapore. Moreover, it is clear that there are significant regional disparities between EU member states. The forecasting exercises carried out in Section 3.6 suggest that e–money usage will continue to grow at a moderate rate in the Euro Area as a whole but that the probability of a significant shift toward increased electronification of the payments system is unlikely in the medium–term. In light of this, the EC may consider that e–money is not a threat at present and that its existing regulatory framework is sufficient. Alternatively, it may take a more proactive position and engage in regulatory reform to promote the development of electronic payments technology in a manner similar to the Singaporean government.

In the longer–term, regulatory reform is inevitable. Given the strong incentives for innovative firms to enter the market and attempt to circumvent the regulation, there is likely to be a regulatory 'arms–race' between the regulator on the one hand, and issuing firms on the other. In particular, the nature of the implicit multiplier between reserve assets and e–monetary value outstanding is likely to change substantially as both parties learn about the nature of the market. It seems likely that the reserve asset portfolios of issuers will come to contain less cash as estimates of the demand for redemption become increasingly precise. This will result in portfolios skewed toward less liquid assets with a higher rate of return. It is likely that such evolutions will lead to the establishment of a fractional–reserve system similar to those currently operated by banks. These and other regulatory issues are the focus of the next chapter.

# Chapter 4

# The Regulation of E–Money

## 4.1 Introduction

Given the fundamental importance of a well–functioning and secure payments system, both at the national and international level, the issue of the regulation of e–money schemes has received a great deal of attention. The nature of the legislative environment varies from country to country and reflects both the relative importance of the e–money in the broader economy and the attitude of the regulators towards such innovative enterprises.

The previous chapter presented statistics which demonstrate that e–money usage is considerably more deeply embedded in the Singaporean economy than in that of the European Union. The regulatory stance of the respective governments of these regions was identified among a number of factors that may explain this difference. This chapter will demonstrate that the proposed regulatory framework in Singapore is more conducive to innovation that those of either the EU or the US. Hence, the European and American authorities will be well advised to closely monitor the progress of the Singaporean legal tender experiment and must remain open to the adoption of similar policies should the need arise.

In the longer–term, the need for a unified international regulatory framework accompanied by a set of common technological standards is clear if e–money usage is to expand across national boundaries. The BIS already monitors the state of payments systems in a number of countries and has published guidance on a variety of important issues for electronic payments systems. Considered alongside its central position in the regulation of banking activities, the BIS is the natural candidate for the role of coordinator of such an international accord.

This chapter progresses in five sections. Firstly, Section 4.2 offers a detailed discussion of the regulatory frameworks in place the EU and the US and of the Singaporean proposals.

Furthermore, a crude comparison of the three is provided. Section 4.3 discusses some of the characteristics of an optimal regulatory approach to e–money and attempts to balance the need for systemic security against the reduction in innovation with which stringent regulation may be associated. Section 4.4 discusses two important considerations for the future; the benefits associated with extension of the lender of last resort facility to e–money issuers and the impact of potential evolutions in the nature of the asset portfolios backing e–monetary value. Section 4.5 offers some concluding remarks and advocates an active role for the BIS in promoting international interoperability.

## 4.2 The Current Regulatory Framework

The regulation of e–money is being approached from a number of angles in different parts of the world. One of the most liberal, *laissez–faire* regimes is that of the US. This contrasts markedly with the early regulation approach of the EU (Krueger, 2002a). The most extreme case is undoubtedly that of Singapore where the MAS intends to issue e–monetary value with the status of legal tender in the near future, and where the government is actively engaged in the provision of common technical standards for e–money systems. These three frameworks are now briefly reviewed.

### 4.2.1 E–Money Regulation in Europe

In 1994, the European Monetary Institute (EMI, the predecessor of the ECB) raised three concerns about the development of electronic purses: firstly, the potential for e–money to damage consumer confidence in the payment mechanism; secondly, that the development of e–money may hamper the implementation of monetary policy by conventional means; and, lastly, that the substitution of e–money for cash may affect the ‘activities and revenues’ of member central banks. Paragraphs 41-2 in the report develop rather unconvincingly on this last point, concluding merely that central banks may need to evaluate their banknote ‘printing and handling activities’ as the new technology develops, and that the reduction in the use of banknotes resulting from the adoption of the new technology would lead to a reduction in central bank revenues. This last point would have little effect on the actions of central banks given that they are not bound by constraints of profitability.

It was the opinion of the EMI that “the money received by the issuer of an electronic purse is a bank deposit” (EMI, 1994, ¶31) and, therefore, that the issuance of electronic purses should be limited to credit institutions. Given their concerns, the Institute advocated early regulation of the new technology. Despite the emphasis on gentle regulation in the 1998 draft of the directive on e–money[1], the final version published on October 27, 2000 (European Commission, 2000c) after extensive consultation with the ECB and industry figures represents a rigorous regulatory framework[2].

Article 1(3)(b) of Directive 2000/46/EC offers the following definition of e–money (European Commission, 2000c, p. 40):

> 'electronic money' shall mean monetary value as represented by a claim on the issuer which is:
>
> (i) stored on an electronic device;
>
> (ii) issued on receipt of funds of an amount not less in value than the monetary value issued;
>
> (iii) accepted as means of payment by undertakings other than the issuer.

An additional feature of e–money not mentioned above but embodied in Article 3 of the Directive is that it should be redeemable for government currency at par in order to maintain the link between central bank money and commercial bank money. Koenraad de Geest (Deputy Director General of the Payment Systems Directorate General at the ECB) explains this point as follows:

> For us it is essential that e–money is redeemable. That means that it can be easily exchanged, at par, in central bank money. Without this redeemability you risk to lose [*sic*] the link between central bank money and commercial bank money. The functioning of the economy is based on the implicit...perfect substitutability of commercial bank money and central bank money (de Geest, 2001, p. 8).

Krueger (2002a) argues that this redeemability criterion represents a concession to the ECB. It is, however, noteworthy that the Commission rejected the recommendation of the 1994 EMI report that only credit institutions should be licensed to issue e–money and, instead, created a new type of institution which may perform this role:

> 'electronic money institution' [ELMI] shall mean an undertaking or any other legal person, other than a credit institution as defined in Article 1, point 1,

[1]This was due, in large part, to the view of the Commission that Europe may be able to steal a march on the rest of the world in developing electronic payments and more broadly defined e–commerce and then may be able to leverage these gains in promoting integration between the member states (Krueger, 2002a).

[2]E–money–related activities in the EU are actually governed by two directives, 2000/46/EC (hereafter 'the Directive') and also 2000/28/EC (European Commission, 2000b) which amends the definition of a credit institution in Directive 2000/12/EC (European Commission, 2000a).

> first subparagraph (a) of Directive 2000/12/EC which issues means of payment in the form of electronic money (Article 1(3)(a)).

In order to facilitate entry by non–banks into the e–money market and thereby promote competition and innovation, ELMIs are not subject to the same strict regulations as traditional credit institutions. The counterpart of this regulation is that ELMIs may not engage in the extension of credit (Article 1(5)(a)).

Article 4 of the Directive requires that ELMIs have an initial capital of at least €1,000,000 and ongoing capital of at least the same amount or 2% of either the average or current level of their e–money liabilities over the preceding six months (whichever is greater). Article 5 stresses that the liabilities of ELMIs must be 100% backed by investments in financial assets, and states that these "investments...shall be subject to limitations which are at least as stringent as those applying to credit institutions" (Article 5(2)).

Articles 6 and 7 of the Directive require that ELMIs report financial statistics twice yearly and that they must exercise 'prudence' in their operation. Lastly, and significantly, Article 8 introduces a waiver clause whereby national authorities can waive some or all of the clauses of the Directive under certain circumstances (notably when the total liabilities of the ELMI or their acceptability are limited).

To address the inherent transnationality of the institutional arrangements, the Commission makes provision for 'passporting' whereby an ELMI licensed in one member state may operate in the other member states as well. However, the responsibility for implementing the Directive lies with the relevant authorities in the member states, each of which has exercised some discretion, resulting in a degree of heterogeneity across countries (c.f. The Evaluation Partnership, 2006).

In the UK, for instance, the issuance of e–money is regulated under the Financial Services and Markets Act 2000 (FSMA) by the Financial Services Authority (FSA). The definition of e–money under UK law omits item (ii) of the EC definition concerning issuance of e–money at a discount (Her Majesty's Treasury, 2001, p. 4). The FSA and the Treasury felt that this provided a loophole whereby e–monetary value issued at a discount would not constitute e–money (see also Lelieveldt, 2001 and Krueger, 2002b). In response, the FSA banned the issuance of e–money at a discount *per se*[3]. Furthermore, the FSA (2002) imposed a purse limit of £1000 in order to limit the exposure of the bearer of e–money to losses due to damage, loss or theft of their e–purse. Finally, ELMIs are

[3]ELMIs may sell e–monetary value to their customers at a discounted value in order to act as an incentive on the condition that a third party makes up the value of the e–money float to 100% prior to the issuance of the discounted value (Financial Services Authority, 2002, pp. 9-11; 2006, ELM4.4).

again restricted from "granting any form of credit" and also from paying interest on their liabilities (ELM4.3.2R and 4.3.7R).

### 4.2.2 E–Money Regulation in the US

The general approach to e–money regulation in the US may be well summarised as *laissez–faire*; the authorities have proved reluctant to regulate the market early for fear that this may stifle future development and innovation. There is, therefore, no specific legislation at the Federal level (although there is a discretionary framework in place, as discussed below) and e–money issuers are subject to state–level financial regulation (Ramasastry, 2001). This cautious approach to regulation has resulted in a degree of heterogeneity between states, and is likely to hinder issuers wishing to operate on a nationwide level. This is likely to lead to a high level of undesirable market segmentation, reduced interoperability and depressed investment in the new technology. Furthermore, the resulting concentration of firms at the state level may act as a barrier to the entry of new firms, leading to the proliferation of uncompetitive practices detrimental to social welfare.

Krueger (2002a) identifies the following six inputs into e–money regulation in the US:

i. the general concern of the Federal Reserve for the security of the payment system and confidence therein;

ii. Federal Regulation E concerning electronic funds transfers;

iii. state money transmitter laws;

iv. state banking laws;

v. the Federal Deposit Insurance Corporation; and

vi. anti–money–laundering laws.

The National Conference of Commissioners of Uniform State Laws (NCCUSL) ratified the Uniform Money Services Act (UMSA) in August 2000. Pichler (2001, pp. 16-17) summarises the priorities of the UMSA as "(i) [p]roviding a harmonised and uniform legal framework with respect to MSBs [money services businesses, a type of non–bank financial institution]; (ii) ensuring the safety and soundness of MSBs; and (iii) reducing barriers to competition and growth in new sectors such as emerging Internet and electronic payment mechanisms".

Unlike the Directive, the UMSA is concerned not just with e–money and its issuers but with 'monetary value' and with any entity engaged in the provision of 'money services'.

The UMSA defines monetary value as "a medium of exchange, whether or not redeemable in money" (§102(11))[4] where the term 'medium of exchange' implies that the monetary value is accepted in transactions by a community consisting of more than two parties (§102, comment no. 10)[5]. Similarly, 'money services' identifies a "group of entities that engage in any of the following activities: money transmission, sale of payment instruments (i.e. money orders, travellers' cheques or stored value), check cashing and currency exchange" (§102, comment no. 8). 'Stored value' refers to "monetary value that is evidenced by an electronic record" (§102(21)). The UMSA views the flexibility of these definitions as a positive attribute of the Act, although such vagaries in its drafting combined with its discretionary nature are unlikely to yield a level playing field across the US.

The UMSA distinguishes between banks and MSBs in a manner similar to that of the EC Directive, and does not impose banking regulations on MSBs (Pichler, 2001). MSBs are not permitted to engage in deposit taking activities or the extension of commercial loans. The UMSA requires that MSBs adhere to the following requirements at a minimum:

**Licensing:** MSBs must be licensed with the relevant authority in every state in which they operate (§201). There is no passporting principle whereby a license granted in any state is effective in all states.

**Surety Bond:** A 'surety bond' must be posted with the application for a license of \$50,000 plus \$10,000 per additional location up to a maximum of \$250,000 (§203(a)). The purpose of this bond is to ensure that the MSB can continue to honour its obligations to its customers in the event of insolvency or financial distress.

**Net Worth:** An MSB must maintain a net worth of at least \$25,000 (§206). This amount seems rather trivial although it must be considered alongside the surety bond and prudential regime included in the UMSA.

**Examination and Reporting:** Sections 601 and 602 make provisions for the superintendent and any other relevant authorities to examine the MSB. Sections 603, 605 and 606 outline the reporting and record–keeping requirements of MSBs.

**Permissible Investments:** A licensee must maintain a portfolio of permissible investments not less in value than the aggregate amount of their liabilities outstanding (§701(a)). Permissible investments are defined in Article 7, Section 702 of the Act.

[4]Monetary value includes both stored value products and 'internet scrip' which represents non–redeemable monetary value including bonus points and coupons. The implication of this is that it would be infeasible to impose a redeemability requirement similar to Article 3 of the Directive.

[5]This provision excludes barter systems such as LETS and allows state–level regulatory bodies to exercise discretion with regard to the inclusion of schemes with limited participation or geographical dispersion.

Even before the UMSA, some states had brought electronic payment systems under their regulations governing money transmitters. Thus the UMSA was not enacted to create a legal framework for the regulation of e–money where previously there was none. The goal of the UMSA was to provide a degree of uniformity across states in order to create a level playing field for the various types of MSB at a national level. To the extent that the content and adoption of the UMSA is discretionary, it seems unlikely to succeed in this endeavour. Moreover, the omission of a passporting principle is significant, as it will impose costs on those firms wishing to operate on a national scale, leading to a highly segmented market and preventing firms from realising the scale economies that could be reaped by a national operation. Hence, the light–touch regulation undertaken in the US may prove counter–productive and, far from promoting innovation and competition, may actually hinder both.

### 4.2.3 The Singaporean Proposals

The case of Singapore is interesting not because of its current regulatory environment but because of its proposed reforms. For this reason, I will offer only a brief discussion of the core principles of the current framework and will concentrate instead on the forthcoming changes.

E–money in Singapore is regulated by the Payments Systems (Oversight) Act 2006 (PSOA). The PSOA distinguishes between single- and multi–purpose Stored Value Facilities (SVFs), and between those which are widely accepted (WASVF) and those which are not. In an effort to promote innovation among small providers and to reduce unnecessary bureaucracy, only multi–purpose WASVF are subject to regulation by the MAS.

A WASVF is defined as a multi–purpose scheme (meaning its liabilities are accepted by businesses unrelated to the issuer) with outstanding stored value of at least S$30,000,000. Furthermore, an approved bank must assume full liability for all monies collected by a WASVF scheme. At the present time there are just two registered WASVFs in Singapore: the *Network for Electronic Transfers Singapore* (NETS) whose cashcard is used to pay for parking and road tolls, and *ez–link*, whose cards are used on the mass–transit system. The distinction between WASVFs and other SVFs revolves around the value of the outstanding float, and reflects a belief by the Singaporean authorities that small issuers pose no threat to systemic security.

Purse limits are not explicitly mentioned in the PSOA, a provision which allows issuers discretion in this regard. The government information portal *Moneysense* notes that limits vary by provider but do not typically exceed S$1,000 (MAS, 2007).

WASVFs must register with the MAS and are subject to an annual license fee, the magnitude of which is determined on a discretionary basis by the MAS (§9). Rather than insisting on net–worth and ongoing capital requirements, the PSOA states that an approved bank must accept full liability for the outstanding stored value of a WASVF. This regulation may be supplemented by the MAS which "intends to issue guidelines to encourage the adoption of sound practices in the SVF market" (Shanmugaratnam, 2006, ¶34). Furthermore, the PSOA defines a supervisory role for the MAS and grants it the power to issue directives to an e–money business, even to the extent of appointing an officer to advise the firm on its actions (§20(2)(b)).

The PSOA grants the MAS the authority to exempt schemes from the regulations outlined in the PSOA as it sees fit (§53). This last point, in consort with a number of those made earlier, reflects the substantial discretionary powers afforded to the MAS. The legal framework governing e–money businesses in Singapore is generally less transparent than those of either the EU or the USA. While Shanmugaratnam portrays this as an attempt at promoting innovation in the market, it is likely to lead to a undesirable degree of regulatory uncertainty.

The theme of efficiency pervades the Singaporean approach to e–money. Section 5 of the PSOA states that the MAS must consider the efficiency of the payments system in its capacity as overseer. Indeed, Shanmugaratnam (2006, ¶13) stresses that "[e]fficiency and innovation for retail payment systems are essential if we are to keep our economy vibrant and meet consumer needs". In many respects, the existing regulation may be viewed as an interim measure before the adoption of a number of widely–publicised reform proposals which are expected to increase efficiency and bolster Singapore's reputation as a technological leader.

### The Proposed Reforms

Under the proposals, two institutions would govern the issuance of e–monetary value and the technological framework underpinning the new technologies. The Monetary Authority of Singapore (MAS) would be responsible for the introduction and commission of SELT. The Infocomm Development Authority (IDA) would lead a multi–agency task–force responsible for the oversight and development of a common standard for interoperable e–money transactions (a project known as the Contactless e–Purse Application, CEPAS 2.0) as part of the Intelligent Nation 2015 initiative.

The Monetary Authority of Singapore Act charges the Authority with a responsibility to "develop Singapore as an international financial centre" (§4(2)(d))[6]. The MAS apparently feels that this goal may be served by its active participation in the e–money market. More specifically, the MAS proposes to issue e–monetary value with the status of legal tender in the near future.

The earliest comprehensive announcement relating to SELT appeared in the OECD publication *The Future of Money* (Low, 2002). Low stresses that the principle motivations of the SELT proposals are to exploit the lower handling and transaction costs of e–money relative to physical currency and to improve the efficiency of the retail payments system (pp. 148-149). While this statement reflects a Mengerian view of money, the fact that e–money will be granted the status of legal tender would suggest a concern with the chartalist position as well.

The concept of legal tender outlined by Low (p. 147) is not universal in the sense that it permits firms to refuse to accept legal tender as payment for goods and services (Van Hove, 2003). While it is not uncommon for legal tender laws to be selective, it is nevertheless significant in this case. As long as firms are not obliged to accept payment in e–money there will be a continued demand for currency, at least in the short- to medium–term. For this reason, although SELT, unlike physical currency, is seen as consistent with the Singaporean government's goal of achieving a cashless society (Low, 2002, p. 149), the MAS will continue issuing currency until there is widespread public support for full electronification (Van Hove, 2003, p. 4).

The proposed SELT arrangements are outlined in Figure 4.1 which is taken from Low (2002, p. 151, fig. 1). SELT is electronic value issued by the MAS in a similar manner to currency (notes and coins). In this way, the MAS will monopolise the issuance of e–monetary value. However, the MAS has expressed no interest in monopolising the provision of e–money services. As can be seen in Figure 4.1, banks[7] would draw e–monetary value from the MAS (referred to in the diagram by its old name, the Board of Commissioners of Currency Singapore, BCCS) which would be held on a suitably secure computer system. Account holding customers of these banks could then withdraw SELT from their accounts onto any appropriately enabled device such as a smart–card or mobile phone. Furthermore, Low suggests that idle balances may accrue interest.

The existing infrastructure referred to in the diagram is that of the NETS payments system which is currently owned and operated by a number of large Singaporean banks. By leveraging on this infrastructure, the MAS may deliver SELT in a rapid and cost–effective

[6] It also provides for a "Financial Sector Development Fund" which may be employed to this end (§30A-D).

[7] Although Low does not mention non–bank financial institutions engaged in the issuance of e–money, one must assume that they would act in a similar manner.

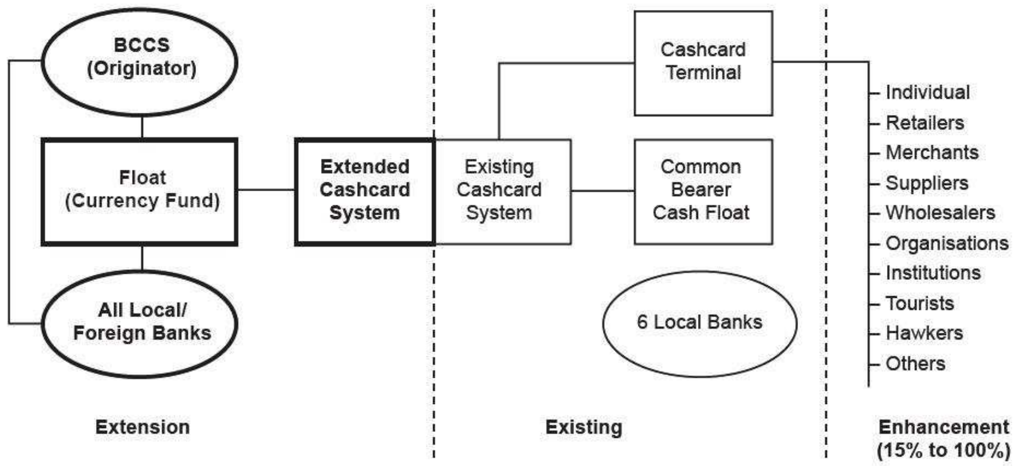



Figure 4.1: Proposed SELT Arrangements

manner. Of course, as a small and densely populated island state, Singapore already enjoys a considerable infrastructural advantage when compared to many other developed countries, which makes it uniquely suitable for the roll–out of such technologies.

The 'enhancement' of between 15% and 100% identified in the diagram is rather ambiguous. Low does not elaborate on the figure in his text and so it is difficult to comment on its validity. Presumably it is supposed to reflect the gains in efficiency and the reduction in costs associated with the migration from physical currency to SELT, although the range seems rather implausible.

Low advances three reasons that government issuance of e–monetary value is preferable to private issuance of stored value: (i) the risk of bank runs under a system of free–banking (c.f. Palley, 2001a); (ii) the risk of bank failures, a sensitive subject in the aftermath of the Asian financial crisis and the subprime debacle; and (iii) to retain seigniorage revenues in the public domain (p. 150).

While it may be the case that restricting the right to issue e–monetary value to the state will mitigate the risks associated with the use of e–money, it is not clear that it is the best way to do so. Extending deposit insurance provisions to e–money schemes would provide a simple means of ensuring the soundness of the payments system. However, such a system would fail to retain seigniorage revenues in the public domain. The concern with seigniorage is a common theme among regulators (see, for example, the EMI's 1994 report on e–money) who fail to realise that seigniorage is not of fundamental importance to the central bank, which can easily fund itself by other means if necessary, including the issuance of bonds, the levying of charges for services and the imposition of additional reserve requirements (see Section 3.4). Indeed, the potential to appropriate seigniorage revenues provides strong incentives for private firms to enter the market. Hence, by extending its monopoly to incorporate the issuance of e–money, a central bank may reduce the incentives for innovation in the payments system. It is not clear that a public monopoly is preferable to a private oligopoly and certainly not to a reasonably competitive market.

The SELT proposals do not seem to preclude the issuance of non–widely–accepted SVF (i.e. those schemes with outstanding e–money liabilities of less than S$30,000,000). The effect on such schemes would presumably be rather modest, with the only notable change being that their prepayment and redemption requirements could be met with SELT as opposed to physical currency. Indeed, the introduction of SELT may lead to a proliferation of smaller schemes in an attempt to circumvent the new regulatory framework.

The initial timescale for the introduction of SELT indicated that the system should be operational by 2008. However, this timeframe seems to have been informally relaxed. It seems unlikely that SELT will become a reality until 2010 at the earliest, when the common technological standards contained in CEPAS 2.0 are scheduled for adoption.

### 4.2.4 A Brief Comparison

The key attributes of the proposed Singaporean arrangements and the European and American regulatory frameworks are summarised in Table 4.1. The degree of stringency of the regulation may be considered to decrease as one moves leftward through the table (certainly in terms of the degree of governmental involvement). The Singaporean decision to engage in state issuance of e–money represents the most significant regulatory step taken by any of the world's governments regarding e–money to date. However, contrary to the generally accepted wisdom, it is not clear that less stringent regulation will encourage innovation, as the comparison between the Singaporean and European experience of e–money in the previous chapter has demonstrated[8]. Indeed, the reticence of the authorities to engage in active regulation seems likely to be one of the causes of the slow adoption of e–money in the US, as it has created regulatory uncertainty and has failed to create a level 'playing field' across states.

A great deal of uncertainty surrounds the Singaporean proposals because there has been no official discussion of the legal aspects of SELT. The most authoritative source of information at present is the brief conceptual outline provided by Low. For this reason, a number of entries in the table are taken from the existing regulatory framework and may change with the adoption of electronic legal tender. In particular, the asset backing and capital arrangements will need to be redrafted following the migration to SELT. In

[8]It should be noted that the most stringent of the Singaporean regulations are yet to be implemented, although their announcement even at the conceptual stage had a profound positive impact on the uptake of e–money.

| | Singaporean Proposals | EU | US |
|---|---|---|---|
| **Scope of Regulation** | | | |
| Includes single–use products? | No | No | Yes |
| Includes internet scrip? | No | No | Yes |
| **Role of Government** | | | |
| Government issuance? | Yes | No | No |
| Legal tender status? | Yes | No | No |
| Unified architecture? | CEPAS 2.0 | No | No |
| Unified regulatory framework? | Yes | Yes | No |
| **Licensing** | | | |
| Surety bond? | *Bank–backing* | No | $50,000-250,000 |
| Asset backing requirements? | *Bank–backing* | 100% | 100% |
| Net worth? | *Bank–backing* | No | $25,000 |
| Initial Capital? | *Bank–backing* | €1m | No |
| Own Funds? | *Bank–backing* | €1m / 2% liab | No |
| Issuance restricted to banks? | *No* | No | No |
| Passporting provision? | n/a | Yes | No |
| Waiver clause? | *Yes* | Yes | Not explicitly |
| **Characteristics of e–money** | | | |
| Prepaid? | Yes | Yes | Yes |
| Legally imposed purse limit? | No | Varies by state | No |
| Exchange rate parity? | Yes | Yes | Yes |
| Redeemable for CB money? | Yes | Yes | No |
| Extension of credit? | No | No | No |
| Balances are interest bearing? | Yes | No | No |

**Note:** Italicised text indicates that existing regulation has been inserted where the Singaporean proposals are unclear. References to 'bank–backing' in the Singaporean column indicate that the PSOA currently requires a registered bank to accept liability for the outstanding stored value of a WASVF. Hence, one might consider that the requirements pertaining to banks regarding net worth etc. are applicable.

Table 4.1: Regulatory Frameworks Compared

some other cases, the properties of the system have not been made explicit but can be inferred with a reasonable degree of certainty. For example, SELT will be denominated in Singaporean Dollars, so the exchange rate parity between SELT and tangible currency will be absolute. Furthermore, Low's SELT proposals suggest that most economic activity would continue in much the same way as it does at present. Wages would continue to be paid electronically into one's bank account in most cases and in order to retrieve monetary value one would simply transfer money from one's account onto a suitable SELT enabled device. In this sense, SELT remains prepaid and, to the extent that unwanted SELT value could presumably be credited back into one's account, SELT remains redeemable.

A great deal of variation exists between the licensing requirements embodied in each system. The Singaporean system transfers the risk of default of a WASVF to an approved bank. Both the EU and US systems insist on 100% asset backing of outstanding e–monetary value but this is where the similarities end. The US system stresses the need for positive net worth (i.e. the balance sheet must remain in the black) while the European approach relies on initial capital and own–funds requirements.

The characteristics of e–money in each system are generally comparable with the interesting exception of SELT, which provides for the payment of interest on idle balances. This will fundamentally change the relationship between e–money and other payment instruments, positioning it between cash and demand deposits in terms of its attributes and functions. If it transpires that e–money systems can be operated at a lower cost than traditional payment systems, e–money issuers may find themselves in a position to pay higher rates of interest than banks which are subject to more stringent regulation. Left unchecked, such developments could lead to a potentially destabilising restructuring of the market for deposit accounts and savings instruments.

## 4.3 Towards An Optimal Regulatory Strategy

All of the regulatory frameworks outlined above possess a number of significant shortcomings. This section draws on these three cases to address a number of these issues.

### 4.3.1 Scope of Regulation

#### Single- and Multi–Purpose Products, Internet Scrip etc.

The issue of whether single and limited multi–purposes schemes, internet scrip etc. should be regulated in the same way as e–money must be considered in terms of their systemic importance. In general, such schemes present no threat to systemic security and so should not be subject to the same degree of regulation[9]. Indeed, it seems likely that liberalising these markets in the US and Europe may promote innovation. Furthermore, the authorities should consider issuing waivers to innovative firms that drive progress in the market for retail payments and to those that serve the public interest in order to provide the appropriate incentives for the continuation of such activities (this is discussed in more detail in Section 4.3.3 below).

A threshold system similar to that currently operating in Singapore is an appropriate means of ensuring that a small scheme which grows into a significant player in the market would fall under the scope of the e–money regulations passively, without any need for intervention from the authorities. Whereas the Singaporean system currently concentrates solely on the value of outstanding stored value, it seems desirable to consider a broader range of factors including, for example, the number of active users and the range and

[9]Clearly some regulation in these markets is important to prevent blatant abuses, including fraudulent activities and money–laundering.

nature of uses to which the system is put. In this way, if the outstanding float exceeds \$$A$ and/or the number of users exceeds $B$ and/or the system is used for various purposes that are considered important in their own right, then the system would need to meet the full set of regulatory requirements. In this way, a mass transit or prepaid household utility scheme which does not exceed the float or circulation thresholds might be considered important due to the fact that it provides access to a public utility.

### 4.3.2 The Role of Government

#### Government Issuance of E–Money

The government may be involved in the issuance of e–money in at least two ways. Firstly, and most simply, the central bank may simply provide stored–value and network products directly, either monopolistically or in competition with the private sector. As discussed in Section 3.4, it seems unlikely that private sector firms could compete with the central bank for a number of reasons including its riskless nature, its freedom from profit–maximisation constraints and its legally enshrined status at the heart of the financial system. Hence, it seems likely that the central bank would rapidly come to dominate the market should it enter it, stifling innovation and removing market discipline.

The alternative is that the central bank issues e–monetary value in the same way that it currently issues currency (in the manner envisaged in Singapore). As discussed above, this approach may reduce the risks associated with bank runs and bank failures, although it is not clear that it is the best way to do so. By retaining seigniorage revenues for itself, the central bank removes a major incentive driving the innovation required to maintain the dynamism of the retail payments system. Furthermore, it is not clear that a public monopoly is preferable to a private oligopoly which is likely to be considerably more efficient.

Rather than issuing e–monetary value itself, the central bank could extend existing deposit insurance schemes to include e–money balances outstanding. This would increase public confidence in e–money issuers and would greatly reduce the risk of ‘bank runs’. In order to limit the risks associated with the failure of e–money issuers, a system of prudential regulation and oversight would be required. Some of the salient points of such a system are described in Section 4.3.3 below.

#### Legal Tender Status

The Collins Essential English Dictionary defines legal tender as “currency that a creditor must by law accept to pay a debt”. This definition is broadly consistent with both the selective and absolute concepts of legal tender identified by Van Hove (2003). It seems clear that the extension of legal tender laws to include electronic payments will have an important signalling role. By backing e–money in this way, the government would lend credibility to the system and increase public perceptions about its longevity. In this sense, electronic legal tender is likely to promote the development of electronic retail payments systems. However, it is not clear that the role of government extends to promoting one payment system over another (except to the extent that some may be unsound or insecure). With this said, to the extent that the government and central bank are concerned with the maintenance of a well–functioning payments system, as opposed to just a secure system, then the promotion of efficient and convenient technologies may be justified.

Even if one sets aside doubts about the role of government in an electronic legal tender system, a fundamental hurdle to the concept of electronic legal tender in most countries is the lack of complete and unconditional interoperability. It is inconceivable that the government would consider affording non–interoperable, isolated e–money systems the status of legal tender. The only country which has shown any significant development in the direction of an interoperable system is Singapore but this system revolves around government issuance of e–monetary value which, as noted above, may be criticised from a number of angles. Even if market participants were to develop a system of interoperable networks independently of government, the willingness of regulators to extend legal tender status to private, non–governmental monies would, in all likelihood, be limited. Indeed, in many countries, such a move would require a fundamental redrafting of the constitution of the monetary authority, which currently exercises monopoly power over the issuance of legal tender. It seems likely, therefore, that there may be a trade–off between the benefits to be derived from making e–money legal tender on the one hand, and the losses associated with its monopolistic issuance by central government on the other. Given such a trade–off, one must favour the competitive outcome.

### Unified Technological Architecture

A unified technological architecture is essential for the development of the type of interoperable systems which many commentators see as a prerequisite condition for e–money usage to become widespread (see Van Hove, 1999b, for a discussion of the importance of interoperability for e–money usage over the internet)[10]. Furthermore, the adoption of a unified architecture could simplify the tasks of regulation and oversight, particularly with

[10]Issues of cross–border interoperability are particularly prevalent in the case of online transactions. The involvement of a supra–national body would be required to coordinate the development of an international standard, the obvious candidate for this role being the BIS.

regard to the security of the systems in use. Given that payment systems are extreme examples of network industries, there are strong incentives for market participants to develop the required technology without Government intervention (as discussed in Section 3.5).

An early attempt at such a scheme was the Common Electronic Purse Specifications (CEPS) developed collaboratively by Visa, it's Spanish subsidiary SERMEPA and ZKA, the firm responsible for German e–purse *Geldkarte*. However, despite considerable interest from market participants (Van Hove, 1999b), CEPS has yet to be put into practice and seems to have been largely abandoned.

The failure of CEPS reflects the conflicting incentives of firms in network industries. On the one hand, subscribers to a common standard benefit from an increase in the effective size of the network. On the other hand, interoperability implies substitutability and hampers the efforts of firms to differentiate their product. As Van Hove notes, the relative strength of the expected network and substitution effects faced by each firm in the market will determine their attitudes toward interoperability. New entrants to a market gain substantially from achieving interoperability with established firms as there is no possibility of substitution away from their, as yet, non–existent product. By contrast, the substitution effect is likely to substantially outweigh the beneficial network effects achieved by a large incumbent entering into an interoperable system with a much smaller firm, let alone a new entrant with no existing network. When viewed in this way, it is easy to see how technological cooperation between firms may break down or may even be hijacked in an attempt to erect barriers to the entry of new firms. Hence, the potential for coordination failures and antitrust issues in a highly concentrated market environment[11] provides an *a priori* case for government intervention of the type being undertaken in Singapore in the form of CEPAS 2.0.

A potential drawback of interoperable systems is the increased risk posed by hackers and fraudsters. Firstly, the adoption of a unified architecture is likely to encourage hackers to focus their efforts on one system rather than targeting a number of different systems. This increases the probability of a successful attack on the system. Secondly, while thieves have traditionally been limited by the quantity of money stored in any given location and the amount that they can physically transport, these constraints are no longer binding in an electronic world. Of course, existing LVTS and clearing systems also face these issues. However, the public has no direct contact with these systems, rendering the study of their security features more difficult and reducing the opportunity for remote access.

[11] The Singaporean e–money market is essentially a duopoly. Even in the EU, the market structure is oligopolistic with a small number of dominant firms.

**Unified Regulatory Framework**

Current US policy regarding e–money is not unified in at least two respects. Firstly, there are at least six inputs into the regulation of e–money in the US. The lack of clear regulation increases the likelihood of exploitable loopholes and creates a situation of regulatory uncertainty inconducive to a well–functioning system. Such opaque regulation is likely to undermine public confidence in e–money systems. Secondly, the fact that the implementation of the UMSA is discretionary has led to an unacceptable degree of regulatory heterogeneity between states. Hence, a well defined, unambiguous legal framework is clearly essential both to maintain confidence in the system and to ensure a level playing field for system operators.

Lee and Longe-Akindemowo (1999) stress the need for a harmonised regulatory framework across countries to avoid what they refer to as 'regulatory arbitrage'. It has already been suggested that the allegedly restrictive regulatory stance of the EC may lead to the proliferation of offshore ELMIs not subject to the same rigorous regulation (Krueger, 2002b). Similarly, it may be in the interests of some governments to relax their e–money regulation in order to attract investment from foreign issuers. In this way, regulatory arbitrage may be practised by both firms and regulators.

While the risks posed by loosely regulated offshore issuers could be mitigated to some degree by public education schemes, disclosure requirements (discussed below) and domestic regulation, the desirability of international regulatory coherence is obvious. The BIS (2001) already publishes 'core principles for systemically important payment systems' which reflect good practice. It would be relatively straightforward to elaborate on this framework to lessen the scope for regulatory arbitrage. The core principles could be revised and extended to provide a set of basic standards for regulators. Countries could then ratify this framework and ensure that their existing regulation is consistent with it. It would then be a simple matter for members of this community to insist that any firm willing to issue e–money within their borders must be licensed in a country that has also ratified the BIS guidelines.

### 4.3.3 Licensing Requirements

**Surety Bond/Licensee Deposit**

The insistence of the US authorities that would–be e–money firms post a surety bond adds unnecessary complexity to the regulatory system. Furthermore, the fact that the size of the bond does not depend on the size of the operation (except to the extent that it increases in proportion to the number of locations) discriminates against small innovative entrants to the marketplace and fails in its goal of ensuring that the obligations of the issuer to its customers will be met in the event of the insolvency of a large firm. In a system in which the asset backing and ongoing capital requirements are well developed, a surety bond is unnecessary.

### Asset Backing, Net Worth and Own Funds Requirements

The third of the BIS core principles holds that "[t]he system should have clearly defined procedures for the management of credit risks and liquidity risks, which specify the respective responsibilities of the system operator and the participants and which provide appropriate incentives to manage and contain those risks" (2001, p. 3).

The Singaporean system of regulation transfers the risk associated with the failure of a WASVF to the underwriting bank. While this system places an emphasis on a market solution to the governance of risk which may yield efficient outcomes, it seems likely that the WASVF market will be dominated by banks or bank subsidiaries, quite probably to the exclusion of all other types of organisation. This is likely to limit the degree of competition in the market for widely accepted retail payment systems.

Security of US MSBs is achieved using a combination of a surety bond, 100% backing of outstanding liabilities by a portfolio of permissible investments, and a net worth requirement of $25,000. The purpose of the rather meagre net worth requirement is ostensibly to screen prospective entrants to the marketplace to ensure that they have "sufficient resources to honor [their] obligations to customers" (p. 30, §206, comment no. 1). There is, however, no provision to vary the net worth requirement in accordance with the scale of the operation which casts doubt over the validity of this signalling role. If net worth requirements are to be employed, they must reflect the scale of the undertaking.

The EC requirement that ELMIs possess initial capital of €1,000,000 and maintain own funds of the greater of this value or 2% of their outstanding e–money liabilities[12] imposes an effective liquidity ratio. This ensures that issuers have, at their disposal, liquid assets in proportion to their activities for instant use in the event of financial difficulties. The EC regulation is not, however, subject to the criticism that it's capital requirements are scale invariant as there are provisions to waive the initial capital requirements (or rather to reduce its value appropriately) in the case of small firms.

The critical difference between the US and EU systems revolves around the use of own funds. While the US system does, of course, involve the own funds of issuers, the UMSA

[12] The Directive stresses that the value of the float should be considered both instantaneously and on average across a moving six month window, and that the larger figure should be used.

is silent on their proportion in the asset portfolio. It is essential that the portfolio should be sufficiently liquid to meet the demands of the customer base and so the imposition of minimum standards in this regard is equally essential.

### Permissible Investments

There is no doubt that the e–monetary liabilities of issuers should be backed on a one–for–one basis by low risk, liquid investments at the present time. What is less clear is which classes of investment should be permitted and what proportion they should contribute to the portfolio as a whole. In most countries, permissible investments include currency, certificates of deposit, government bonds, sight deposits at regulated banks, equities and high grade non–governmental paper. In many cases, limits are placed on the proportion of the portfolio for which each class of assets may account. These regulations are generally similar in spirit (and often in substance) to the asset backing requirements facing commercial banks as outlined in the Basel II agreement. However, the recent experience of asset bubbles and the controversy surrounding computational errors made by the rating house Moody's (c.f. Jones, Tett, and Davies, 2008) call into question the prudence of these regulations.

The difficulty in defining the range of permissible investments lies in achieving an acceptable balance between liquidity, risk and return. In light of recent events, regulators have an obligation to the public to err on the side of caution until the shortcomings that allowed bond ratings to be so drastically misleading have been addressed.

### Should Issuance be Restricted to Banks?

Opening the provision of e–money services to non–bank financial institutions introduces a wide range of inputs from firms with different specialisms. The benefits of existing laws permitting non–bank institutions to enter the market are already apparent with firms such as Google offering innovative payment systems enhanced by their unique capabilities[13].

While there are advantages to allowing non–banks to issue e–money, the regulation must be carefully constructed to avoid any loopholes whereby non–banks may engage in activities that the spirit of the law intends should be restricted to registered banks. Two such activities include the taking of deposits and the extension of credit.

[13] Google Payment Limited (GPL) is a registered ELMI in the UK and provides an innovative online payment system which builds on Google's existing internet presence.

#### Passporting Provision

Passporting provisions that permit e–money issuers to operate in all the states within a union, wherever they are domiciled and licensed, are essential for the European Union and the USA as they remove unnecessary bureaucracy from the system and reduce the costs faced by firms intending to operate across state boundaries. An interesting question is whether a similar principle could be adopted by the members of a free–trade area, for example. Such a scheme would require a significant degree of cross–border legislative cooperation which, while possible in a bilateral setting, is unlikely to be forthcoming in a multilateral setting. Should demand for such systems become non–negligible, the BIS should engage in discourse with the relevant countries. In the long–term, this may lead to the type of harmonised global regulation mentioned above.

#### Exemptions and Waiver Clauses

The central bank should be able to exercise a degree of discretion in its oversight of e–money systems. In particular, where it feels that the benefits associated with a particular scheme outweigh any potential risks, it should be permitted to waive some (or perhaps even all) of the provisions of the regulatory framework[14].

Consider, for example, the introduction of an electronic purse version of the UK Government's Education Maintenance Allowance whereby students undertaking post–GCSE qualifications are paid up to £30 per week. The central bank could argue that this would yield quantifiable reductions in the the operating cost of the system and that it could be designed in such a way as to limit the basket of goods that could be purchased with the money, thereby combating under–age alcohol and substance abuse, smoking etc. Given the small amounts of money involved, the central bank may consider that the asset backing or net worth requirements could be relaxed to some extent in order to provide an incentive for firms to undertake such schemes in the public interest.

In order to avoid the opacity of the Singaporean regulations regarding exemptions, the central bank should be required to undertake a thorough analysis of the potential costs and benefits associated with the scheme. The results of this consultation should then be made publicly available, so that the central bank could be held accountable for its decision.

[14]Note that such a waiver provision would add a further degree of flexibility to a regulatory framework employing a threshold system of the type discussed in Section 4.3.1. Indeed, it seems unlikely that waivers would be granted particularly often. This contrasts markedly with the current EU system in which waivered institutions outnumber licensed ELMIs (c.f. TEP, 2006) owing to the lack of such a threshold provision.

#### Disclosure Requirements

The second of the BIS core principles is that "[t]he system's rules and procedures should enable participants to have a clear understanding of the system's impact on each of the financial risks they incur through participation in it" (2001, p. 3). An economic agent cannot make a well–informed decision if the information is not publicly available. Regulators should stress that all e–money schemes must clearly indicate whether they are subject to full domestic regulation, whether they have been granted a waiver by the central bank (and which clauses have been waived) or whether they are domiciled and regulated overseas. Furthermore, issuers must be obliged to state unambiguously the risks that their clients are exposed to and their privacy policy regarding client information. Such disclosure requirements would be conceptually similar to the guidelines currently in place in the UK which oblige financial institutions to indicate whether they are FSA regulated and to clearly state the conditions of their various products.

### 4.3.4 Characteristics of E–Money Products

#### Prepayment

Prepayment is essential in any stored value scheme in which the issuer is restricted from extending credit. If the e–monetary value is not prepaid, then the issuer is effectively entering into a loan agreement with the consumer in the intervening period between the loading of the value and it's repayment. While this may seem relatively innocuous in small value, limited purpose schemes, it would set a dangerous precedent if it were legalised. It cannot be stressed enough that granting credit in any form must remain the preserve of licensed credit institutions.

#### Purse Limits

At present, purse limits are imposed under some regulatory regimes (for example in the UK) as a safety feature. However, it seems likely that the market participants would arrive at suitable purse limits without any government intervention. In the first instance, the issuer will presumably impose some form of limit which it considers balances the risks of fraudulent use against convenience. Should this limit prove too low, market participants will migrate to providers with more liberal policies, providing an incentive for the issuer to increase their limit. Should they prove too high, the issuer will notice that very few individuals are constrained by the purse limit and that they could potentially reduce their losses through fraud by reducing the limit appropriately. To borrow a term from Léon

Walras, a process of *tâtonnement* would result in the installation of appropriate purse limits in a reasonably competitive market. An exception to this general principle may arise in the case of interest–bearing e–money, as discussed below.

### Exchange Rate Parity and Redeemability *vis–à–vis* Central Bank Money

Currently, e–monetary value is typically denominated in the national currency of the country in which the scheme operates. From a regulatory viewpoint, there is no particular issue with a non–par exchange rate as long as it is irrevocably fixed. However, it is difficult to see what benefit either the issuer or the end–user would derive from such a system, while a number of drawbacks are immediately apparent. Any situation in which the effective exchange rate could fluctuate would expose both the issuer and the customer to exchange rate risk. Moreover, it would open issuers to the possibility of speculative attack which is clearly inconsistent with the central bank's responsibility for the stability and security of the payments system. Hence, the development of any form of floating exchange rate system cannot be permitted.

The redeemability of e–money is viewed as essential in the EU (de Geest, 2001) and yet neither the UMSA nor the Singaporean framework enforce a redeemability requirement. In general, firms will continue to offer to redeem unused e–monetary value as a guarantee to their customers. De Geest stresses that redeemability is necessary to maintain a link between e–money and central bank money, although there is little reason to think that this is the case. In a regulatory framework in which the exchange rate between e–money and central bank money is irrevocably fixed, no further link is necessary. However, redemption regulations may be important if they improve public confidence in the payments system.

### Extension of Credit and Issuance of Discounted E–Monetary Value

The extension of credit by e–money providers is universally prohibited on the grounds that it may prove deleterious to systemic security. Such restrictions are entirely appropriate as long as e–money issuers are not subject to the same degree of regulation as credit institutions.

The EC Directive also prohibits the issuance of e–money at a discount in order to maintain the solvency of ELMIs. In the UK, however, while FSA guidelines ban the issuance of e–money not backed 100% by float investments, there is no restriction on the sale of e–monetary value at a discounted price to the end–user (FSA, 2006, ELM4.4). This regulation permits ELMIs to issue discounted e–money (presumably for promotional purposes) on the condition that a third party makes up the deficit arising from the discounted value. While such provisions are likely to prove popular with issuing firms as they provide an obvious means of generating interest in the product, they open a number of potential loopholes. For instance, the third party provision opens an obvious channel for money laundering and even in the case where the investment is ostensibly legitimate, it is not clear exactly what the money would be exchanged for. It is not inconceivable that the third party firm could agree to make up the balance of the float in exchange for various commitments from the issuer. Such antitrust issues will be very difficult to detect, let alone combat, in this type of regulatory framework.

A point that seems to have been largely overlooked by the literature concerns the granting of credit in the form of e–money by registered credit institutions. Providing that all of the requirements of existing banking regulation are met, e–money cards issued by such institutions could act in much the same way as credit cards. Such a system could significantly expand the range of goods and services which could be purchased on credit. It is questionable whether this is desirable in an era of record household debt but there is likely to be considerable interest in such schemes nevertheless. An incidental benefit that may obtain as a result of legalising ‘e–credit’ in this way is that it may reduce the incentives for circumventive innovation on the part of non–bank e–money issuers.

#### Payment of Interest on Balances

The payment of interest on outstanding stored value is generally prohibited (the SELT proposals are a notable exception). This is presumably based on a desire to avoid e–money expanding beyond its current domain of frequent low–value transactions. In particular, it would seem to be motivated by a desire to prevent e–money acting as a depository savings instrument, the provision of which is strictly the domain of deposit–taking institutions.

With clear parallels to the discussion of discounted e–monetary value above, the payment of bonus points on outstanding e–money balances, or the use of lottery schemes whereby accounts are randomly credited with additional value, represent the payment of *de facto* interest. As mentioned above, the validity of such schemes is recognised by the FSA. One must question whether anything is achieved by encouraging issuers to engage in farcical lotteries in this manner.

If the restrictions on interest–bearing e–money were relaxed, the regulator would have to ensure that issuers were adequately prepared to meet the additional flows generated by their interest payments. This may be achieved by a combination of prudential measures combined with appropriately enhanced asset backing and working capital requirements. Furthermore, where e–monetary balances are interest–bearing, it may be necessary to impose purse limits to ensure that e–money issuers do not offer savings services in competition with those of depository institutions. A simple way of doing this would be to specify that an e–money issuer wishing to extend it's purse limit beyond a threshold considered consistent with usage as a low–value retail payment instrument must register as a depository institution. This would prevent allegations of unfair competition arising from the well–known reserve–requirement 'tax' faced by banks and would provide for enhanced competition in the provision of savings instruments.

**Privacy/Anonymity**

As discussed in Chapter 3, the electronification of the payments system has important implications for its anonymity and for the privacy of participants. Electronic transactions are typically recorded and concerns centre around the uses to which these records may be put. Of course, to the extent that anonymity facilitates criminal and otherwise reprehensible economic activities, a number of ethical concerns may be raised about the role of the central bank in providing anonymous payment vehicles. However, individuals have an inalienable right to conduct their business dealings with a degree of privacy.

Recent developments in ICT have made anonymous e–money possible[15]. However, the issue is not whether e–money is technically anonymous but rather whether the public perceives that this anonymity is credible. Credible anonymity would require more than contractual non–disclosure agreements: the issuer itself would have to be incapable of viewing a customer's transaction history such that no amount of pressure from the authorities could secure the release of private information (Goodhart, 2000, p. 199).

In many respects, the anonymity of e–money is not an issue as long as individuals have the option of paying for goods and services using cash which is, to a first approximation at least, anonymous. For this reason, there seems to be little to be gained at the present time in insisting that firms provide anonymous e–money. Furthermore, given the double–spending problem discussed in Chapter 3, such regulation may render e–money systems increasingly prone to attack. Should there exist a strong demand for anonymity, the market is likely to provide the appropriate signals and incentives to e–money service providers to respond appropriately[16]. Of course, should the MAS stop issuing currency altogether and migrate wholly to e–money, end–users will no longer have the option to use an anonymous payment instrument, and the right to privacy will become a very important issue.

[15] See Schneier (1996) for a discussion of the use of blind signatures in anonymously securing computer systems.

[16] Blind signature systems are likely to be required for the development of transferable e–money, which Baddeley (2004) sees as a means of unlocking great efficiency gains in the realm of micropayments. Hence the market may again provide anonymity of its own accord.

## 4.4 Considerations for the Future

Like many hi–tech markets, the market for electronic retail payments systems has proven itself to be very dynamic and evolutionary. Within the last ten years, e–money has been transformed from an exciting prospect to a reality far broader than many could have imagined: it is now possible to pay for a wide range of goods and services by simply passing your mobile phone before a contactless reader or by sending an SMS text message. This rapid development in the nature and capabilities of e–money systems raises at least two considerations for the future.

#### Extension of the Lender of Last Resort Function

Currently, there is no provision to extend lender of last resort provisions to the issuers of e–money, presumably because none are viewed as systemically important at this stage. However, should an e–money system develop to the extent that its failure could have significant repercussions for systemic stability, it is absolutely inconceivable that the central bank would fail to intervene in the market. Similarly, the central bank could not allow an e–money system providing access to essential public utilities (e.g. public transport) in a monopolistic manner to fail. This begs the question of whether the scope of the lender of last resort facility should be extended to include e–money issuers. In the event of an informal intervention in the e–money market, the credibility of the central bank would suffer, it's reputation would be tarnished and the transparency of regulation blemished.

Viewed in this way, the benefits of extending the facility seem rather substantial. However, the moral hazard introduced by an assurance from the central bank that an e–money issuer will be rescued from insolvency may lead firms to act imprudently and engage in riskier activities than they would otherwise undertake. Such problems already arise in the case of institutions covered by the lending facility. This effect has come to be known ironically as the 'Greenspan put'.

Recalling the striking transactions importance by volume statistics reported in Section 3.5.1, Singapore may be rapidly approaching a point at which e–money must be considered systemically significant. It will be interesting to see how the Singaporean government approaches the issue of contingency planning for the event of a WASVF failure.

#### Toward a Fractional Reserve System

The historical record of firms circumventing regulations that prevent them from exploiting profitable opportunities is well known. Such circumventive innovation is likely to be particularly prevalent in the hi–tech market for electronic retail payments systems. Friedman (1999, p. 329) envisages the development of a 'regulatory race' which the central bank is likely to lose. One such area where the likelihood of such a race developing is relatively high concerns the nature and composition of e–money issuers' reserve asset portfolios.

A commercial bank accepts deposits of high powered money, a fraction $(1-\tau)$ of which it lends out. The complement of this fraction, $\tau$, is the proportion that the bank holds in reserve to ensure that it can meet its obligation to redeem deposits on demand. It follows that an initial deposit of £1000 with a reserve ratio, $\tau = 10\%$, will lead to the creation of a loan of £900. This loan, in turn, will create a further deposit of £900. The iteration of this process will result in a situation in which the total amount of money in circulation will tend toward a multiple $1/\tau$ of the supply of high powered money. This is the essence of fractional reserve banking.

An e–money issuer is in a slightly different position, however, as it cannot take deposits or extend loans. When an e–money issuer receives funds, they must be exchanged for e–monetary value in a timely fashion. To differentiate such activity from deposit–taking, let us adopt the term 'loading'. This e–monetary value is transferred to the vendor when it is used to purchase goods and services. The vendor will then redeem the e–monetary value thus received with the issuer, which clears its debt by bank transfer. Hence, the issuer must at all times maintain sufficient liquidity to meet these requirements.

It is likely that both the income generated from loading and the redemption of spent e–monetary value will assume an approximately uniform distribution over a given timeframe. Such an outcome simply reflects the plausible outcome that agents will use e–money for frequent transactions and replenish their e–monetary stocks in an uncoordinated fashion. This suggests that, in any given period, the income generated from loading operations will be approximately equal to the redemption of spent value. On average, therefore, the net movement of an issuer's balance sheet should be relatively small, indicating that the asset backing requirement is rather more onerous than is necessary.

The discussion so far has, however, omitted the fact that e–money account holders typically have the right to withdraw value from their accounts. Such withdrawals could lead to large imbalances between loading income and redemption demands, particularly if confidence in the integrity of the issuer were to fail. However, once an e–money issuer has achieved a reputation for prudence, the likelihood of such a dramatic swing in consumer confidence will decline. Furthermore, as issuers learn about the markets in which they operate, they will be able to forecast their net end–of–day closing position with greater accuracy. Against this backdrop of reduced risk, e–money issuers are likely to seek ways of trading return against liquidity in their investment portfolios.

Current regulations already provide a degree of latitude in terms of permissible investments, as discussed above. However, issuers managing a large portfolio will be faced with strong incentives to circumvent existing regulations and will undoubtedly find innovative ways of doing so. An obvious approach would be to create an inter–issuer market for liquidity modelled on existing interbank markets. Similarly, issuers may move toward a practice of averaging their holdings of reserve assets across a window in order to economise on their liquid asset holdings. Such innovations must not necessarily be treated as undesirable by the regulators as they may improve on the efficiency of established systems.

A cursory glance at the history of banking suggests that, in the long–term, it is entirely possible, and even likely, that fully–fledged fractional reserve systems will come to operate in which e–money issuers engage in both deposit–taking and the extension of credit. Of course, such a system would require substantial revision to existing laws which, at the present time, may seem at best a distant prospect and at worst impossible. However, the process of regulatory drift should not be underestimated: a seventeenth century goldsmith would undoubtedly greet current practices with equal incredulity.

## 4.5 Concluding Remarks

This chapter has surveyed the regulatory frameworks in place in three of the key players in the global market for e–money. The US is arguably the most important market in the world and yet it has enacted deeply inadequate regulation that fails to provide appropriate incentives for innovative firms and introduces unnecessary obstacles into the path of those attempting to operate schemes across state borders. The European system of regulation is extensive and well–founded but has been criticised from some quarters for stifling innovation. Finally, the currently under–developed Singaporean system has an air of anticipation about it in the run–up to the introduction of government–issued electronic legal tender and the national roll–out of common technological standards for e–purse systems.

What is clear is that each of these systems has a number of shortcomings. In the US case, there is an urgent need for unified regulation across states, the introduction of passporting provisions to remove unnecessary bureaucracy and the revision of the security provisions to reflect the scale of the operation. The European system could benefit from liberalisation of the regulation surrounding small ELMIs, and from the relaxation of laws restricting the payment of interest on outstanding stored value. The Singaporean system is currently rather *ad hoc* but it is undergoing comprehensive revisions which should align it more closely with the recommendations outlined above.

Based on the preceding discussion, this chapter has discussed the characteristics of an optimal regulatory structure. In particular, there is a need to achieve the greatest possible transparency in order both to engender confidence and trust within the private sector and to minimise regulatory uncertainty. Similarly, one must attempt to balance the need for unambiguous regulation concerning the restriction of lending activities and the nature and content of asset portfolios, for example, against the need for flexibility and support for innovative new systems. Undoubtedly the most controversial of the proposals are those advocating the payment of interest on balances and the extension of credit in the form of e–money by licensed credit institutions. However, the risks from such activities may be mitigated by the installation of appropriate regulatory systems and the benefits in terms of increased efficiency may be substantial. Furthermore, if substantial demand for such facilities were to develop, firms would find ways of evading the regulations in order to provide them. It seems preferable to formalise such activities rather than to encourage firms to act outside the spirit of the law.

The need for harmonised global regulation has been stressed by Lee and Longe–Akindemowo (1999) in terms of combating regulatory arbitrage. A range of additional benefits may be identified, including increased competition and enhanced convenience for the end–user. It seems likely that such a system of global cooperation would require the adoption of common technological standards across national boundaries. Payments systems clearly represent network industries and, therefore, standard economic theory suggests that market participants will naturally endeavour to extend their networks and seek interoperability with their competitors. A good example of a market in which development has followed this pattern is that for mobile telecommunications. However, stored value schemes have shown little sign of such progression and there are reasons to believe that various market failures will prevent the development of viable market–led solutions. Hence, the Singaporean experiments with electronic legal tender and government–led common technological standards will be monitored closely by national and international bodies alike.

# Chapter 5

# Monetary Policy and Financial Fragility

## 5.1 Introduction

Economic history has been characterised by booms and busts in the asset markets which seem neither predictable nor avoidable *ex ante*. The seemingly universal rule is that bust follows boom as extravagant speculative profits, evidenced by ever more conspicuous consumption, fuel an increasingly bullish economic outlook. This, in turn, drives investors to progressively more risky undertakings. For various reasons, confidence in the sustainability of prices eventually fails, with insiders typically leading the exodus. Subsequently, many commentators are left wondering how so many investors, seasoned and novice alike, were swept up in an *ex–post* obviously unsustainable clamour to realise vast unearned profits based on unconsolidated gains.

In the wake of the 1929 crash, *The Atlantic* magazine printed the following statement from an anonymous Wall Street trader which captures the point eloquently:

> In these latter days, since the downfall, I know that there will be much talk of corruption and dishonesty. But I can testify that our trouble was not that. Rather, we were undone by our own extravagant folly, and our delusions of grandeur. The gods were waiting to destroy us, and first they infected us with a peculiar and virulent sort of madness.

(Anonymous, 1933, ¶27)

Examples of such admissions are rare; investors are typically loath to acknowledge culpability in the aftermath of a bubble, favouring instead the farcical explanation *calix meus inebrians*. The elegant prose of American poet and philosopher George Santayana comes to mind: ‘those who cannot remember the past are condemned to repeat it’. And repeat it they do: in recent years, bubbles have become a part of the economic landscape: the 1987 ‘one–day’ crash; the 1990’s real–estate–collateral crash in Japan; the ‘dot–com’ bubble, the 2002 stock market slump and the current subprime crisis, to name but a few.

The historical inability of investors to prevent the growth and subsequent collapse of bubbles has been well documented. The obvious socio–political and economic costs associated with severe asset market distortions furnish an *a priori* case for state intervention. However, this in turn raises the question of whether the state is any better equipped to preemptively identify and harmlessly discharge bubbles than market participants themselves.

This chapter investigates the proposition that the central bank could formulate its monetary policies in a manner designed to alleviate market distortions. Such a contention depends critically on the notion that the central bank enjoys various advantages which place it in a privileged position in terms of preempting bubbles (or at a minimum recognising them at an early stage of development). Moreover, the linked assumptions that the central bank possesses the requisite tools with which to manipulate individual overheated markets and sectors, and that such manipulation is within its aegis, are implicit. Finally, a pragmatic point may be made: does the remit of the central bank extend to concern for particular markets beyond the extent to which they affect aggregate economic activity?

The chapter progresses in six sections. Section 5.2 develops a small macroeconomic model embodying many of the salient features of Hyman Minsky’s Financial Fragility Hypothesis (FFH). In particular, investment is modelled as a function of the internal funds of firms and their debt–servicing obligations, a specification which allows one to investigate the ability of firms to meet their obligations to their creditors. Section 5.3 introduces the dataset and provides details of the calculation of potential output. Estimation results are then presented and discussed in detail in Section 5.4. In general, the empirical evidence suggests that the use of the interest rate as the principle implement of monetary policy is potentially destabilising and that core inflation may be an insufficient summary statistic of the state of the economy. In this sense, monetary policy may be improved by considering a broader range of indicators. In light of these results, Section 5.5 discusses the controversy over the role of asset prices in the formulation of monetary policy, and proposes a rule by which the central bank can attempt to moderate asset market cycles by setting heterogeneous reserve requirements on the asset side of bank balance sheets (c.f. Palley, 2004). Section 5.6 concludes. Detailed data analysis and a review of the empirical methodology are contained in the Appendix.

## 5.2 Hyman Minsky and the Financial Fragility Hypothesis

Hyman Minsky (1976, 1977, 1980, 1982, 1986a, 1986b) develops an alternative theory of financial fragility rooted in the work of Keynes. Erturk (2006, p. 3) captures the essence of the Minskyan scheme elegantly as follows:

> [t]he essential insight Minsky drew from Keynes was that optimistic expectations about the future create a margin, reflected in higher asset prices, which makes it possible for borrowers to access finance in the present. In other words, the capitalized expected future earnings work as the collateral against which firms can borrow in financial markets or from banks. But, the value of long-lived assets cannot be assessed on any firm basis as they are highly sensitive to the degree of confidence markets have about certain states of the world coming to pass in the future. This means that any sustained shortfall in economic performance in relation to the level of expectations that are already capitalized in asset prices is susceptible to engendering the view that asset prices are excessive. Once the view that asset prices are excessive takes hold in financial markets, higher asset prices cease to be a stimulant and turn into a drag on the economy. Initially debt–led, the economy becomes debt–burdened.

Minsky takes the view that a capitalist economy left to its own devices will become increasingly financially fragile and subject to crises. Market participants are incapable in themselves of averting such crises; momentum- and noise–trading strategies may even contribute to the problem. Hence, financial fragility develops endogenously and is an outcome of the normal working of a capitalist economy under *laissez–faire* governance.

Minsky emphasises the destabilising effects of the interest rate implement of monetary policy and the conditions under which credit may be obtained. To Minsky, any change in the rate of interest is akin to 'moving the goalposts' once the economic game is underway and can only have undesirable consequences[1]. In a system characterised by Keynesian uncertainty, economic agents faced with long–lived and irreversible investment decisions engage in forward planning based on an optimal forecast of future conditions which, owing to this very uncertainty, must be heavily conditioned on recent historic experience. Manipulation of the interest rate after such plans have been enacted in an *ex ante* unforeseeable manner represents a significant perturbation to the system.

[1]Minsky focuses on the destabilising influence of rate rises, as these may result in a situation where firms can no longer meet their debt–servicing obligations. Unexpected interest rate cuts will not lead to instability, as firms will have planned for higher interest expenditure. However, they may lead to the suboptimal allocation of economic resources.

A simple Minskyan boom–bust cycle is presented in Figure 5.1. In the initial recovery phase, the rate of capital accumulation is determined by firms based on their tentative forecasts of the path of key variables (including the interest rate). As expectations grow increasingly optimistic and the previous bust is forgotten, an investment boom ensues. Minsky assumes that the investment boom is largely debt–funded and that it is associated with a rising share of profits in national income. The rising profit–share leads workers to bargain for nominal wage increases to maintain the wage–share. The resulting wage inflation is passed through to the general price level as a result of mark–up pricing. The central bank responds to the inflationary pressure by raising the short–term nominal interest rate. This change is passed through to the lending rate, rendering the debt–servicing obligations of firms more onerous and causing a general shift toward increasingly fragile financing arrangements[2]. This is particularly important given the earlier assumption that the investment boom was debt–funded. In the euphoria of the boom phase, financial institutions loosened their credit criteria and reduced their safety margins, leaving them particularly vulnerable to defaults in their loan portfolios[3]. Beyond some threshold, the increasing incidence of default, coupled with the financial difficulties of lenders, causes confidence in the boom to fail, precipitating the bust. If one assumes that memories are short and/or selective, then the cycle is free to start over.

It is important to note that no exogenous spur is required to start this sequence of events: the cyclical behaviour emerges endogenously. Furthermore, unlike most theories of financial bubbles, the financial fragility hypothesis does not rely on informational asymmetries. Rather, it relies on the observation that in a world characterised by Keynesian uncertainty, a rational arbitrageur should be concerned not with the basis of a particular pricing convention but rather with its expected duration (c.f. Hayes, 2006).

The Minskyan explanation of the business cycle can be related to the theories of monetary transmission discussed in Chapter 2 in a number of ways. Firstly, Minsky's emphasis on the conditions under which credit may be obtained implies the existence of strong credit channels. In particular, a powerful financial accelerator mechanism underlies Minsky's ap-

[2]Sufficiently large interest rate hikes may cause safe hedge financing units to become either potentially unstable speculative units or demonstrably fragile Ponzi units. This will be reflected in increasing rightward skewness of the distribution of firms along the spectrum hedge–speculative–Ponzi. Minsky (1986b, pp. 335-341) rigorously defines these three financial structures. For an example of his view of the transition between financial structures see Minsky (1982, p. 66-8).

[3]A corollary to this derives from Minsky's view of the lender of last resort facility which, he argues, will erode the safety margins of the financial sector still further by increasing the losses associated with moral hazard. Hence, the LoLR facility may increase the riskiness of the loan portfolio and may reduce prudential reserve holdings, thereby rendering the economy increasingly susceptible to financial distress. Essentially, Minsky's argument is that the extension of insurance to the financial sector increases the risk–appetite of lenders beyond that which would prevail in its absence, increasing the likelihood that such insurance will be required.

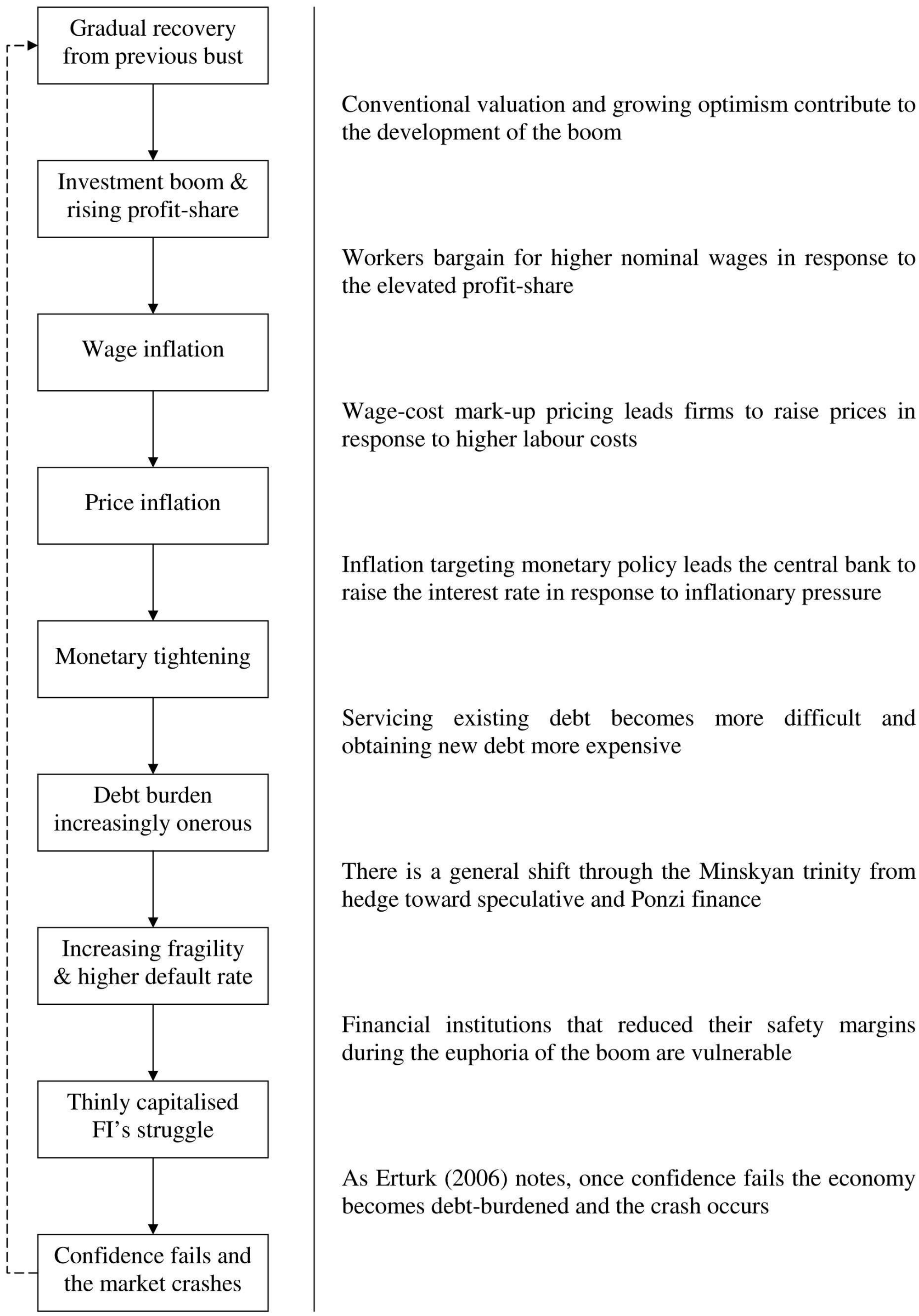



Figure 5.1: A Schematic Representation of the Minksyan Boom–Bust Cycle

proach, resulting in strong countercyclicality of the external financing premium. Similarly, the FFH can be related to the narrow credit channel, and this would suggest that exposure to financial fragility may be borne disproportionately by smaller, bank–constrained firms without access to the commercial paper market. Secondly, there is a clear role for the asset channel in the Minskyan model, as reflected by the specification of the investment function in Section 5.2.1. Indeed, an important implication of the inclusion of Tobin's $q$ in the investment function is that it opens the possibility that monetary policy may have long–run real effects through its impact on the rate of fixed capital formation. Finally, the FFH can be readily related to the cost–of–capital channel given the role of the discount rate in determining the net present value of an investment project[4].

Minsky stresses the role of active stabilisation policies in preventing financial crises. In his 1986 book *Stabilizing an Unstable Economy*, Minsky discusses the 1974-5 and 1982 episodes of instability in the US and credits 'Big Government' with averting crisis. In particular, the increasing importance of transfer payments since World War II has helped to steer the economy away from crises by acting as an automatic stabiliser: "[w]ith Big Government, a fall in income automatically leads to a massive government deficit" (Minsky, 1986b, p. 21). When confidence starts to fail, the scale of any contraction is reduced as increased government spending supports the profitability of businesses, helping them to meet their debt–servicing obligations. Of course, automatic stabilisers act symmetrically and so it could equally be argued that Big Government reduces the scale of booms through taxation, thereby smoothing the upside movement as well as the downside.

The Minskyan view may be summarised crudely as a belief in the destabilising nature of the phenomenon of interest rates and an advocacy of stabilisation policies on the part of the government, enacting automatic stabilisers in order to avert financial crises which would occur under passive governance. A similar summary may be found in Fardmanesh and Siddiqui (1994). In this framework, fiscal policy is effectively elevated above monetary policy in stark contrast to the New Consensus model.

### 5.2.1 A Minskyan Model of the Long–Run

While various authors have developed highly sophisticated chaotic systems in the Minskyan tradition (a succinct survey is to be found in Nasica, 2000, ch. 4) and a good deal of research effort has been devoted to model–based simulation (e.g. Hannsgen, 2005), relatively little empirical testing has been carried out to date. This has, no doubt, contributed to the relatively contentious nature of Minsky's two key propositions (that financial fragility

[4]The wealth channel may also be important in the FFH. Indeed, it provides an obvious means by which Minsky's model, which focuses on firms, could be extended to the household sector.

increases throughout the expansion and that interest rates eventually rise, triggering a contraction). This has led to criticism from some areas and to the neglect of the theory within much of the literature (although the FFH has received renewed interest since the onset of the subprime crisis). This chapter attempts to contribute to this limited literature by developing and estimating a simple macroeconomic model with many of the salient features of a Minskyan economy. The model owes an intellectual debt to Lavoie's (1986-87) early contribution, and extends his modelling in a number of directions.

The long–run structure of the model may be represented by a system of five equations: an aggregate demand function, an interest rate rule, an investment function and a pair of price- and wage–inflation equations[5].

### Aggregate Demand

Aggregate demand is modelled following equation 5.1 where $y_t$ denotes real output, $r_t$ the central bank policy rate, $\Delta p_t$ is the logarithmic approximation to the rate of inflation (and hence $r_t - \Delta p_t$ is the real interest rate), $i_t$ real gross investment, $y_t^*$ real potential output and $t = 0, 1, 2, \ldots, T-1$ is a deterministic time trend.

$$y_t = b_{10} + b_{11}t + \phi_{11}\left(r_t - \Delta p_t\right) + \phi_{12} i_t + \phi_{13} y_t^* + \xi_{1,t} \tag{5.1}$$

Restricting the value of $\phi_{13}$ to unity allows one to interpret equation 5.1 in terms of the output gap rather than aggregate demand *per se* and this is the form that is to be preferred subject to its non–rejection by the likelihood ratio test of the over–identifying structure. In this form, it resembles a New Keynesian IS curve of the form presented in Section 2.2.

### The Monetary Policy Reaction Function

Turning now to the modelling of monetary policy, the central bank is assumed to follow the a Taylor–type interest rate rule represented by equation 5.2, where $\Delta p^*$ denotes the desired rate of inflation. In New Keynesian macroeconomics, $r^*$ is referred to as the natural rate of interest although here it is interpreted as the liquidity premium that prevails when the price level is constant (c.f. Lavoie, 1986-87).

$$r_t = \widetilde{b}_{20} + \widetilde{b}_{21}t + \varphi_{21}r^* + \varphi_{22}\Delta p_t + \varphi_{23}\left(\Delta p_t - \Delta p^*\right) + \varphi_{24}\left(y_t - y^*\right) + \xi_{2,t} \tag{5.2}$$

[5] Note that all variables are expressed as natural logarithms in the following equations.

For simplicity, $r^*$ and $\Delta p^*$ are assumed to be constant over the period under study. Laubuch and Williams (2003) provide empirical support for the notion of a time–invariant natural rate of interest in the US. However, the constancy of both the natural rate of interest and that of the inflation target has been strongly challenged by Woodford (2001b) in which the author argues that, in a coherent system, the inflation target should track the (time–varying) natural rate of interest. Support for the approach adopted here may be derived from practical experience; the systems operated by inflation–targeting central banks have typically involved time–invariant finite positive targets of the order of 1-4% CPI inflation, albeit with occasional breaks.

The constancy of $r^*$ and $\Delta p^*$ allows one to re–write equation 5.2 as follows, making the substitutions $b_{20} = \widetilde{b}_{20} + \varphi_{21} r^* - \varphi_{23} \Delta p^*$, $b_{21} = \widetilde{b}_{21}$, $\phi_{21} = \varphi_{22} + \varphi_{23}$ and $\phi_{22} = \varphi_{24}$:

$$r_t = b_{20} + b_{21} t + \phi_{21} \Delta p_t + \phi_{22} \left( y_t - y^* \right) + \xi_{2,t} \tag{5.3}$$

The empirical tractability derived from these substitutions comes at the expense of the ability to uniquely identify the constituents of the composite parameters $b_{20}$ and $\phi_{21}$ without the imposition of further identifying restrictions. The magnitudes of these quantities are not, however, of interest in themselves. Finally, it should be clear that equation 5.3 reduces to a simple inflation targeting rule when $\phi_{22} = 0$.

**The Investment Function**

At the core of the model is a theory of investment behaviour inspired by that of Godley and Lavoie (2001-2) which, in turn, draws on Ndikumana (1999) and Fazzari and Mott (1986-7). Ndikumana proposes an investment function of the form of equation 5.4, where $L$ is the lag–operator, $e_t/k_t$ represents the ratio of cash-flow to capital, $r_{l,t}$ the rate of interest on bank–lending, $l_t/k_t$ the leverage ratio[6], $\Delta s_t$ sales growth, $\Delta c_t^k$ the change in the cost–of–capital, $q_t$ Tobin's (1969) average $q$[7] and $\epsilon_t$ is an idiosyncratic error term.

$$\frac{i_t}{k_t} = \alpha_1 L \left( \frac{e_t}{k_t} \right) + \alpha_2 r_{l,t} L \left( \frac{l_t}{k_t} \right) + \alpha_3 L \left( \Delta s_t \right) + \alpha_4 L \left( \Delta c_t^k \right) + \alpha_5 L \left( q_t \right) + \epsilon_t \tag{5.4}$$

Godley and Lavoie modify Ndikumana's specification in a number of ways. They model the rate of capital accumulation as follows, where $u_t$ is the rate of utilisation of

[6] Hence the product $r_{l,t} L \left( l_t / k_t \right)$ is interpreted as the minimum cost of servicing existing debt.

[7] Typically it is not average $q$ which is of interest but marginal $q$, which is unobservable. However, Hayashi (1982) demonstrates that the two quantities are equal when certain strict conditions relating to the installation function, the nature of competition and the constancy of returns–to–scale are met (see Ndikumana, 1999, pp. 460-1 for a technical summary).

productive capacity, defined as the ratio of current output to potential output at full capacity and represents the output gap in logarithmic form:

$$\frac{\Delta k_t}{L\left(k_t\right)} = \beta_0 + \beta_1 L\left(\frac{e_t}{k_{t-1}}\right) - \beta_2 r_{l,t} L\left(\frac{l_t}{k_t}\right) + \beta_3 L\left(q_t\right) + \beta_4 L\left(u_t\right) \tag{5.5}$$

This links the investment function presented here to the standard accelerator theory of investment. Noting that the change in the capital stock, $\Delta k_t$, is equal by definition to fixed capital formation less depreciation, one may substitute $\Delta k_t / L\left(k_t\right) = \left(i_t - \delta_t\right) / L\left(k_t\right)$. The similarities between the Godley–Lavoie and Ndikumana specifications are particularly clear if one assumes zero depreciation.

Godley and Lavoie argue that the inclusion of a constant allows for animal instincts in the investment decision. The removal of the cost–of–capital and the replacement of sales growth with capacity utilisation reflects the move from the micro- to the macro–level. The cost–of–capital faced by each firm depends on the characteristics of that firm. Given the essentially microeconomic nature of this concept, it is difficult to arrive at a meaningful macro–level equivalent. This is not to deny the importance of the cost–of–capital in the aggregate, however, which is captured by the term, $r_{l,t} \cdot L\left(l_t/k_t\right)$. The rate of growth of sales is proxied at the macro–level by capacity utilisation. Such an approach is valid if one assumes that changes in the rate of growth of sales are closely related to changes in aggregate demand which, if they are not immediately offset by changes in potential output (presumably associated with changes in the levels of investment, unemployment or productivity), will be reflected in any measure of capacity utilisation. Hence the Godley–Lavoie specification is an aggregate approximation of Ndikumana's micro model.

The Godley–Lavoie model exhibits some particularly interesting features. For instance, if one assumes that the loans rate is a (potentially time–varying or regime–dependent) mark–up over the base rate, $r_{l,t} = \left(1 + m_t\right) r_t$, then monetary policy innovations affect investment in at least two ways. A direct effect arises through the change in the cost of borrowing associated with a change in the base rate. A further, indirect effect operates through the impact of a change in the base rate on the balance sheets of firms brought about by the associated change in the opportunity cost of retained earnings.

The rate of capacity utilisation is a standard feature of Kaleckian investment functions but the inclusion of the Tobin's $q$ is rather unusual. This provides a mechanism whereby market sentiment can affect investment decisions. During a financial boom, the market value of the equity of the representative firm increases relative to its capital replacement cost. In such a situation, the firm finds the acquisition of second–hand capital assets on the financial markets (takeovers) relatively less attractive than the purchase of new capital, which may be expected to stimulate non–financial investment. Perhaps more importantly, if one assumes that changes in Tobin's $q$ are driven predominantly by asset prices, then it may be viewed as a proxy for market sentiment. Increasing optimism among participants in the financial markets is likely to drive stock prices up, increasing $q$. Such bull markets typically reflect favourable conditions in the broader economy and also provide listed companies easier access to investment funds. As mentioned earlier, this suggests a prominent role for both the broad and narrow credit channels in the transmission of monetary shocks.

Godley and Lavoie make an important point about the implications of the inclusion of $q$ noting that, when household preferences shift away from saving in the form of equity, the rate of investment may decrease accordingly. The reverse would be true of an increased demand for equity, *mutatis mutandis*. They cite Basil Moore, noting that the operation of such a mechanism "leads back to the neoclassical conclusions of the control of the rate of accumulation by saver preferences, albeit through a quite different mechanism. A reward to property must be paid…to induce wealth owners to hold voluntarily, and not to spend on current consumption, the wealth accumulation that results from business investment"(Moore, 1973, p. 543).

Godley and Lavoie acknowledge the controversial nature of their omission of expectations from the investment function. However, they contend that expectational effects are incorporated implicitly in the term $r_{l,t}L\,(l_t/k_t)$. They argue that any increase in the indebtedness of firms reflected in the leverage ratio will lower the level of investment on the grounds that higher debt in the present period reduces expected profits in future periods. They also suggest that changes to the constant term could reflect changing expectations about future demand and/or profitability.

For the purposes of this chapter, the investment function is specified as follows:

$$i_t = \phi_{30} + \phi_{31} f_t + \phi_{32}\left(r_{l,t} - \Delta p_t\right) l_t + \phi_{33} q_t + \phi_{34}\left(y_t - y^*\right) + \xi_{3,t} \tag{5.6}$$

where $f_t$ denotes real internal funds (which proxies real cash–flow) and $\left(r_{l,t} - \Delta p_t\right) l_t$ denotes the inflation–adjusted cost of servicing real debt. Equation 5.6 relates the level of real investment to the level of internal funds, the burden of existing debt, the valuation ratio and capacity utilisation (proxied by the output gap).

This formulation exhibits two principle differences to that of Godley and Lavoie. Firstly, investment, internal funds and the debt–servicing cost are considered in levels form and are not normalised by $k$. This results in $I(1)$ series which may exhibit long–run cointegrating behaviour. Secondly, all lagged variables are considered contemporaneously so that they can be treated as endogenous in the proposed CVAR modelling framework. If one were to treat the lagged terms as endogenous, the implication would be that observed historical data may be effected by changes in contemporaneous values. Such a situation is clearly impossible given the irreversible continuum of time. Alternatively, one could treat all of the lagged terms as exogenous, although this would result in rather limited contemporaneous interaction among the variables.

The use of deflated cash flow and debt–service cost is rejected by many scholars of Minsky, who would argue that firms make loan repayments in nominal terms out of their nominal cash–flow and, therefore, that real magnitudes are irrelevant to the investment decision[8]. The statement that nominal cash inflows must at least equal nominal outflows is basically a non–Ponzi condition; in the limit, a firm becomes insolvent when expected cash inflows fall below expected cash commitments.

It is clear that if one deflates both cash–flow and the interest cost by the same price index, the relationship between them remains unchanged. It follows obviously that if $e_t - l_t = \eta_t$ then $e_t/p_t - l_t/p_t = \eta_t/p_t \ \forall t$. Hence, the fundamental issue is the use of the real rate of interest on loans, $r_{l,t} - \Delta p_t$ as opposed to the nominal rate. While it is true that firms must meet their nominal debt–servicing obligation irrespective of the rate of inflation, it does not follow that they are not concerned with the erosion of the purchasing power of the loan principle. One can decompose the term $(r_{l,t} - \Delta p_t)\, l_t$ into two separate effects, $+r_{l,t}l_t$ and $-\Delta p_t l_t$ which capture the nominal interest cost of existing real debt and the inflationary erosion of the real loan principle, respectively. In principle, one could include these terms independently in the investment equation and then Wald test the equality of the coefficients in order to assess the use of the real rate of interest. This approach is not followed here in the interests of keeping the dimensionality of the model sufficiently small given the size of the data set[9].

### Price and Wage Inflation

The model is completed by two equations characterising the inflationary processes in the price- and wage–levels. Minsky and Ferri (1984, pp. 491-2) propose a relationship of the form of equations 5.7 and 5.8, where $w_t$ is the nominal wage, $\bar{z}$ is average labour productivity, $p_t^e$ is the expected price level, $\boldsymbol{x}_t$ is a vector of real factors influencing the

[8] I would like to thank Eric Tymoigne for bringing this to my attention and for a number interesting discussions on the matter.

[9] Four combinations of nominal/real interest rate and nominal/real cash–flow and debt–service cost were entertained in the early stages of model construction. The combination of the real interest rate and real values for the two series was found to yield the most theory–consistent patterns of dynamic adjustment and also did not suffer from convergence problems unlike some of the other combinations.

wage–setting process (including, for example, taxes, technological progress and trade union power) and Greek letters are positive parameters:

$$p_t = \gamma_1 \left(\frac{w_t}{\bar{z}_t}\right) + \gamma_2 p_t^e \tag{5.7}$$

$$w_t = \delta_1 \left(\boldsymbol{x}_t, p_t\right) + \delta_2 p_t^e \tag{5.8}$$

Following this approach, the current model employs price and wage inflation equations of the following form:

$$\Delta p_t = \widetilde{b}_{40} + \widetilde{b}_{41} t + \varphi_{41} \left(\Delta w_t - \Delta z_t\right) + \varphi_{42} \left(y_t - y^*\right) + \varphi_{43} \Delta p_t^e + \widetilde{\xi}_{4,t} \tag{5.9}$$

$$\Delta w_t - \Delta z_t = \widetilde{b}_{50} + \widetilde{b}_{51} t + \varphi_{51} \Delta p_t + \varphi_{52} \left(y_t - y^*\right) + \varphi_{53} \Delta p_t^e + \widetilde{\xi}_{5,t} \tag{5.10}$$

Equation 5.9 follows Gordon (1985) in including the output gap as a measure of demand pressure in order to account for generalised demand pulls in the inflationary process. The inflationary process is a pure cost–push when $\varphi_{42} = 0$, with the coefficient $\varphi_{41}$ representing the markup of prices over productivity–adjusted wages. Equation 5.10 represents the process of wage bargaining in which the labour force demands that the productivity–adjusted wage increases by no less than the price level such that the real wage does not fall[10]. $\widetilde{\xi}_{4,t}$ and $\widetilde{\xi}_{5,t}$ are stationary mean–zero error processes.

Equations 5.9 and 5.10 jointly capture price- and wage–setting behaviour. Taken together, they imply bi–directional causality between the rates of price and wage inflation. Inflation expectations are, however, not readily observable (certainly for most classes of goods not traded on an organised exchange) and an uncontroversial proxy remains elusive. In order to overcome this problem without simply removing expectations from the model, equations 5.9 and 5.10 may be combined in order to substitute out the expectations terms, yielding:

$$\Delta p_t = b_{40} + b_{41} t + \phi_{41} \left(\Delta w_t - \Delta z_t\right) + \phi_{42} \left(y_t - y^*\right) + \xi_{4,t} \tag{5.11}$$

[10]The model was initially estimated following Lavoie (1986-87) including the gap between the share of profits in national income, $\pi_t$, and its 'fair' level, $\pi^*$, which was assumed constant. The rationale for inclusion of the profit–share terms reflects the underlying assumption that output is divided solely between corporate rents and wages. In such a system, any increase in the rate of profits beyond its fair level will prompt demands from the workforce for a compensatory increase in wages. However, empirical testing of this model yielded unsatisfactory results. In particular, the theory–motivated over–identifying structure was rejected by the likelihood ratio test, estimates often failed to converge and the impulse responses failed to asymptote in some cases. Inspection of the Johansen reduced–rank regression results suggested that the share of profits term was the root of the problems.

where:

$$b_{40} = \frac{\varphi_{53}}{\varphi_{53} + \varphi_{43}\varphi_{51}} \left[ \widetilde{b}_{40} - \frac{\varphi_{43}\widetilde{b}_{50}}{\varphi_{53}} \right] \;;\; b_{41} = \frac{\varphi_{53}}{\varphi_{53} + \varphi_{43}\varphi_{51}} \left[ \widetilde{b}_{41} - \frac{\varphi_{43}\widetilde{b}_{51}}{\varphi_{53}} \right] \;;$$

$$\phi_{41} = \frac{\varphi_{53}}{\varphi_{53} + \varphi_{43}\varphi_{51}} \left[ \varphi_{41} + \frac{\varphi_{43}}{\varphi_{53}} \right] \;;\; \phi_{42} = \frac{\varphi_{53}}{\varphi_{53} + \varphi_{43}\varphi_{51}} \left[ \varphi_{42} - \frac{\varphi_{43}\varphi_{52}}{\varphi_{53}} \right] \;;$$

$$\xi_{4,t} = \frac{\varphi_{53}}{\varphi_{53} + \varphi_{43}\varphi_{51}} \left[ \widetilde{\xi}_{4,t} - \frac{\varphi_{43}}{\varphi_{53}} \widetilde{\xi}_{5,t} \right]$$

**The Long–Run Structure**

Economic theory suggests the existence of the four long–run relationships represented by equations 5.1, 5.3, 5.6 and 5.11. This long–run structure may be used to describe the cointegrating relationships embodied in a vector error correction model. Garratt, Lee, Pesaran and Shin (2006, GLPS) advance a long–run structural modelling approach which provides for the inclusion of weakly exogenous $I(1)$ variables. The system is composed of a conditional VECM for the endogenous variables, $\boldsymbol{y}_t$, and a marginal VAR for the weakly exogenous variables, $\boldsymbol{x}_t$. GLPS write the resulting structural CVARX model as follows:

$$\boldsymbol{A}_{yy}\Delta\boldsymbol{y}_t + \boldsymbol{A}^*_{yx}\Delta\boldsymbol{x}_t = \widetilde{\boldsymbol{a}}^*_y + \widetilde{\boldsymbol{b}}^*_y t - \widetilde{\boldsymbol{\Pi}}_y \boldsymbol{z}_{t-1} + \sum_{i=1}^{p-1} \widetilde{\boldsymbol{\Gamma}}^*_{yi}\Delta\boldsymbol{z}_{t-i} + \boldsymbol{\eta}_{yt} \tag{5.12}$$

$$\boldsymbol{A}_{xx}\Delta\boldsymbol{x}_t = \widetilde{\boldsymbol{a}}_x + \widetilde{\boldsymbol{b}}_x t - \widetilde{\boldsymbol{\Pi}}_{xx} \boldsymbol{x}_{t-1} + \sum_{i=1}^{p-1} \widetilde{\boldsymbol{\Gamma}}_{xi}\Delta\boldsymbol{z}_{t-i} + \boldsymbol{\epsilon}_{xt} \tag{5.13}$$

A detailed derivation of this result may be found in the Appendix, including a discussion of the restrictions that the weak exogeneity of the variables in $\boldsymbol{x}_t$ imposes on the coefficient vectors and matrices.

Formal structural modelling is not considered in this chapter due to the dependency of the results on a number of strong modelling assumptions and on a limited number of deep parameters (GLPS make a similar point). However, the pseudo–structural orthogonalisation associated with Sims (1980) is considered. This imposes a Wold–causal ordering on the variables and requires that the contemporaneous matrix $\boldsymbol{A}_0$ is lower triangular and that the covariance matrix $\boldsymbol{\Omega}$ is diagonal. The variables in $\boldsymbol{z}_t = (\boldsymbol{x}_t|\boldsymbol{y}_t)'$ are ordered as follows:

$$\boldsymbol{z}_t = (p^o_t, y^*_t, q_t, \Delta w_t - \Delta z_t, \Delta p_t, r_t, d_t, f_t, i_t, y_t)'$$

where $p_t^o$ is the price of crude oil and $d_t = (r_{l,t} - \Delta p_t)\, l_t$. The oil price is included in the model to account for exogenous business cycle fluctuations. Given that the model is to be estimated over a timescale which includes the oil price shocks of the 1970's, the Gulf wars and the recent turbulence in global oil markets, the rationale for its inclusion is obvious.

The proposed ordering reflects the sequencing of economic decisions. The variables $p_t^o$ and $y_t^*$ are placed first as they are treated as weakly exogenous $I(1)$ forcing for the system in the sense of Granger and Lin (1995). Given that no contemporaneous effect of the endogenous variables on the exogenous variables can exist, it seems reasonable to assume that their values are known prior to the decision process. $q_t$ is the first of the endogenous variables, followed by $\Delta w_t$ and $\Delta p_t$. This ordering reflects the Minskyan view of the inflationary process. The inflationary pressure leads the central bank to raise the interest rate, $r_t$. The ordering of $d_t$ and $f_t$ reflects the belief that firms are likely to notice increased interest costs before they notice the reduction in their cash–flow associated with reduced demand. The relationship between cash–flow and the cost of debt–servicing will influence the investment decision and this, in turn, will impact demand.

Based on this recursive structure, the matrix of contemporaneous coefficients, $\boldsymbol{A}_0$ is defined as follows, paying particular attention to the weak exogeneity of the variables in $\boldsymbol{x}$:

$$\underset{10\times 10}{\boldsymbol{A}_0} = \begin{pmatrix} \underset{2\times 2}{\boldsymbol{A}_{xx}} & \underset{2\times 8}{\boldsymbol{A}_{xy}} \\ \underset{8\times 2}{\boldsymbol{A}_{yx}^*} & \underset{8\times 8}{\boldsymbol{A}_{yy}} \end{pmatrix}$$

where $\boldsymbol{A}_{xy}$ is a $2 \times 8$ null matrix (see the Appendix for further details).

Using the long–run structural modelling approach, the four relationships may be re–written in terms of the long–run deviations from equilibrium as follows:

$$\boldsymbol{\xi} = \boldsymbol{\beta}' \boldsymbol{z}_{t-1} - \boldsymbol{b}_0 - \boldsymbol{b}_1 t \tag{5.14}$$

where:

$$\boldsymbol{b}_0 = (b_{10}, b_{20}, b_{30}, b_{40})' \quad \text{and} \quad \boldsymbol{b}_1 = (b_{11}, b_{21}, b_{31}, b_{41})'$$

and $\boldsymbol{\beta}$ is the $4 \times 10$ cointegrating matrix defined either as the exactly–identified Johansen long–run matrix, $\beta_{ex}$, or the theory–based over–identified matrix, $\beta_{ov}$, where:

$$\boldsymbol{\beta}'_{ov} = \begin{pmatrix} 0 & 1 & 0 & 0 & -\phi_{11} & \phi_{11} & 0 & 0 & \phi_{12} & -1 \\ 0 & -\phi_{22} & 0 & 0 & \phi_{21} & -1 & 0 & 0 & 0 & \phi_{22} \\ 0 & -\phi_{34} & \phi_{33} & 0 & 0 & 0 & \phi_{32} & \phi_{31} & -1 & \phi_{34} \\ 0 & -\phi_{42} & 0 & \phi_{41} & -1 & 0 & 0 & 0 & 0 & \phi_{42} \end{pmatrix}$$

Note also that $\widetilde{\boldsymbol{\Pi}} = \widetilde{\boldsymbol{\alpha}}\boldsymbol{\beta}'$ where $\underset{10\times 4}{\widetilde{\boldsymbol{\alpha}}} = \begin{pmatrix} \underset{2\times 4}{\mathbf{0}} \\ \underset{8\times 4}{\widetilde{\boldsymbol{\alpha}}_y} \end{pmatrix}$ and $\underset{10\times 10}{\widetilde{\boldsymbol{\Pi}}} = \begin{pmatrix} \underset{2\times 2}{\widetilde{\boldsymbol{\Pi}}_{xx}} & \underset{2\times 8}{\mathbf{0}} \\ \underset{8\times 2}{\widetilde{\boldsymbol{\Pi}}_{yx}} & \underset{8\times 8}{\widetilde{\boldsymbol{\Pi}}_{yy}} \end{pmatrix}$.

To this point, very little has been said about the nature of the deterministic time trends included in the long–run relationships and captured by the vector $\boldsymbol{b}_1$. In general, one may be reasonably certain that the demand and investment equations should contain such trend terms owing to the process of economic growth. However, it is not clear that either the reaction function or the inflation equation should incorporate deterministic trends. It is possible that the series co–trend, a hypothesis that will be investigated empirically.

## 5.3 The Dataset

### 5.3.1 Data Used in Estimation

The dataset consists of 164 quarterly observations for the US economy between 1967Q1 and 2007Q4 on the variables listed in Table 5.1. Details of the data sources and manipulations, as well as detailed descriptive statistics and graphical analysis, are recorded in the Appendix.

| Symbol | Variable Definition |
|---|---|
| $p_t^o$ | Natural log of the real price of crude oil† |
| $y_t^*$ | Natural log of potential output (computation discussed below)†† |
| $q_t$ | Natural log of Tobin's $q$ |
| $\Delta w_t - \Delta z_t$ | Natural log of productivity–adjusted wage inflation |
| $\Delta p_t$ | Natural log of consumer price inflation |
| $r_t$ | Natural log of the Federal funds rate |
| $d_t$ | Natural log of the real debt–service cost (i.e. $ln\left(\left(r_t - \Delta p_t\right) l_t\right)$) |
| $f_t$ | Natural log of corporate non–financial internal funds |
| $i_t$ | Natural log of real gross corporate non–financial investment |
| $y_t$ | Natural log of real GDP |

† Note that all variables except $y_t^*$ are indexed at 100 in the year 2000 prior to logging.

†† Potential output is indexed relative to realised output in the year 2000 - see Appendix.

Table 5.1: Variables used in Estimation

### 5.3.2 The Estimation of Potential Output

The output gap is typically defined as $100\left(y_t - y^*\right)/y^*$, which expresses the gap between actual and potential output as a percentage of potential output. Potential output, in turn, typically refers to the highest sustainable level of output given installed capacity which is consistent with stable inflation. Hence, a zero output gap is often set to coincide with the NAIRU, although such normalisation is essentially arbitrary.

Recent controversies surrounding the NAIRU, ranging from both observationally and empirically motivated doubts over its constancy to empirical difficulties in terms of satisfactory estimation, have serious implications for such applications (see in particular Gordon, 1997, and Staiger, Stock, and Watson, 1997). In light of this, and influenced by the Bank of Japan's (2003) 'benchmark output gap', potential output is defined here as the level of output that would be achieved if all factors of production were utilised to the fullest possible extent, regardless of the inflationary consequences. Potential output estimated in this way is always higher than the realised level and, therefore, always results in a negative value of the output gap. This notion of the output gap may be considered as a measure of aggregate economic slack.

Two main methods exist for the estimation of potential output. The first, and most popular, is statistical detrending using, for example, the Hodrick and Prescott (1997) filter. Such procedures attempt to distinguish between permanent and transitory components in the series of interest, thereby separating trend from cycle. However, such statistical filtering is atheoretic and results in an estimate of potential output which may be more accurately termed *trend* output. The second approach involves the construction of an aggregate production function, which is initially estimated using realised quantities and then used to impute the level of output that could be achieved if all productive inputs were fully utilised. The definition of full employment is typically that which is consistent with stable inflation (i.e. unemployment is at the NAIRU).

The Cobb–Douglas production function has gained some popularity in the estimation of potential output. It is used by the OECD (Giorno, Richardson, Roseveare and van den Noord, 1995), the European Commission (Roeger, 2006) and the Bank of Japan (2003), among others. However, concerns over the empirical performance of the Cobb–Douglas function and the apparently flawed assumption of a time–invariant labour share have led many to question its usefulness, certainly at an aggregate level. To address these concerns, a transcendental logarithmic (translog) specification is employed here, of the form:

$$\begin{aligned} ln\left(Y_t\right) &= ln\left(A_0\right) + \alpha_L ln\left(L_t\right) + \alpha_K ln\left(K_t\right) + \frac{1}{2}\beta_{LL}\left\{ln\left(L_t\right)\right\}^2 + \frac{1}{2}\beta_{KK}\left\{ln\left(K_t\right)\right\}^2 \\ &+ \beta_{LK} ln\left(L_t\right) ln\left(K_t\right) + \beta_{tL} ln\left(L_t\right) t + \beta_{tK} ln\left(K_t\right) t + \alpha_t t + \beta_{tt} t^2 + \epsilon_t \end{aligned} \tag{5.15}$$

where $Y_t$, $L_t$ and $K_t$ denote output, labour input and capital input in non–logged form. In order to achieve a tractable specification, linear homogeneity is imposed by setting $\alpha_L + \alpha_K = 1$, $\beta_{LK} = \beta_{KL}$, $\beta_{LL} = \beta_{KK}$, $2\beta_{LL} = -\beta_{LK}$ and $\beta_{tL} = -\beta_{tK}$. Substituting these restrictions into equation 5.15 yields:

$$\begin{aligned} ln\left(Y_t\right) &= ln\left(A_0\right) + \alpha_L ln\left(L_t\right) + \left(1-\alpha_L\right) ln\left(K_t\right) + \frac{1}{2}\beta_{LL}\left\{ln\left(L_t\right)\right\}^2 + \frac{1}{2}\beta_{LL}\left\{ln\left(K_t\right)\right\}^2 \\ &- 2\beta_{LL} ln\left(L_t\right) ln\left(K_t\right) + \beta_{tL} ln\left(L_t\right) t - \beta_{tL} ln\left(K_t\right) t + \alpha_t t + \beta_{tt} t^2 + \epsilon_t \end{aligned} \tag{5.16}$$

It is well established that simple OLS estimation of equation 5.16 will yield biased results (see, for example, Kim, 1992). To achieve unbiased estimation, equation 5.16 is estimated simultaneously with the associated cost–share equations which are defined following Kim as:

$$\begin{aligned} S_L &= \frac{\delta ln\left(Y\right)/\delta ln\left(L\right)}{\delta ln\left(Y\right)/\delta ln\left(L\right) + \delta ln\left(Y\right)/\delta ln\left(K\right)} \\ S_K &= \frac{\delta ln\left(Y\right)/\delta ln\left(K\right)}{\delta ln\left(Y\right)/\delta ln\left(L\right) + \delta ln\left(Y\right)/\delta ln\left(K\right)} = 1 - S_L \end{aligned}$$

where $S_L$ and $S_K$ denote the cost shares of labour and capital, respectively, and sum to unity by construction. Under the assumption that $S_L$ and $S_K$ are logistic–normally distributed, one may log–linearise as follows:

$$ln\left(S_L\right) = \frac{\delta ln\left(Y\right)}{\delta ln\left(L\right)} - \left[\frac{\delta ln\left(Y\right)}{\delta ln\left(L\right)} + \frac{\delta ln\left(Y\right)}{\delta ln\left(K\right)}\right]$$

$$ln\left(S_K\right) = \frac{\delta ln\left(Y\right)}{\delta ln\left(K\right)} - \left[\frac{\delta ln\left(Y\right)}{\delta ln\left(L\right)} + \frac{\delta ln\left(Y\right)}{\delta ln\left(K\right)}\right]$$

from which it follows that:

$$ln\left[\frac{S_L}{S_K}\right] = ln\left[\frac{\alpha_L + \beta_{LL} ln\left(L\right) - 2\beta_{LL} ln\left(K\right) + \beta_{tL} t}{\alpha_K + \beta_{LL} ln\left(K\right) - 2\beta_{LL} ln\left(L\right) - \beta_{tL} t}\right] + e_t \tag{5.17}$$

where $e_t \sim N\left(0, \sigma_e^2\right)$ is an idiosyncratic error process.

In order to estimate potential output from equations 5.16 and 5.17, parameter estimates are first obtained using data on realised output and capital and labour inputs, and these are then used in conjunction with estimates of potential capital and labour inputs to impute the level of potential output consistent with full factor utilisation. Details of the data used in estimation and the computational process may be found in the Appendix.

Table 5.2 presents the coefficient estimates resulting from full information maximum likelihood (FIML) estimation of equations 5.16 and 5.17 using the Marquardt optimisation algorithm. While the specification suffers from serial correlation which invalidates the inferential statistics, the coefficient estimates are unbiased. These coefficient values are imposed in the estimation of potential output under the assumption that the error process is Gaussian. In this way, three potential output series are computed:

i. $Y_1^*$ uses the estimated constant NAIRU in defining the potential labour input;

ii. $Y_2^*$ uses the estimated time–varying NAIRU; and

iii. $Y_3^*$ assumes zero unemployment (this series is used in estimation of the CVAR model).

| | Coefficient | Std. Error | z–Statistic | Prob. |
|---|---|---|---|---|
| Const. | 1.575 | 0.154 | 10.230 | 0.000 |
| $\alpha_L$ | 0.525 | 0.007 | 71.499 | 0.000 |
| $\beta_{LL}$ | 0.027 | 0.002 | 12.602 | 0.000 |
| $\beta_{tL}$ | 0.000 | 0.000 | 5.419 | 0.000 |
| $\alpha_t$ | 0.005 | 0.000 | 20.762 | 0.000 |
| $\beta_{tt}$ | 0.000 | 0.000 | 3.196 | 0.001 |
| Log Likelihood | | | 422.822 | |
| Determinant residual covariance | | | 1.98E-05 | |
| Statistics for equation 5.16: | | | | |
| R–squared | | 0.998 | Mean dependent var | 8.764 |
| Adjusted R–squared | | 0.998 | S.D. dependent var | 0.360 |
| S.E. of regression | | 0.017 | Sum squared resid | 0.045 |
| Durbin–Watson statistic | | 0.113 | | |
| Statistics for equation 5.17: | | | | |
| R–squared | | 0.107 | Mean dependent var | 1.053 |
| Adjusted R–squared | | 0.096 | S.D. dependent var | 0.360 |
| S.E. of regression | | 0.342 | Sum squared resid | 18.858 |
| Durbin–Watson statistic | | 0.087 | | |

Table 5.2: FIML Estimation of Equations 5.16 and 5.17

For comparative purposes, potential output is also estimated using a log–linearised constant returns–to–scale Cobb–Douglas function of the form:

$$ln\left(Y_t\right) = \alpha ln\left(L_t\right) + \left(1-\alpha\right) ln\left(K_t\right) + \epsilon_t \tag{5.18}$$

In order to estimate potential output, the production function is first re–written in terms of $\epsilon_t$, the Solow residual (the change in output not explained by measurable changes in productive inputs), which is composed of total factor productivity (TFP) and an idiosyncratic Gaussian error, $u_t$. Hence:

$$ln\left(TFP_t + u_t\right) = ln\left(Y_t\right) - \alpha ln\left(L_t\right) - \left(1-\alpha\right) ln\left(K_t\right) \tag{5.19}$$

Estimation of equation 5.19 requires knowledge of the output elasticity of labour demand, $\alpha$. It is well established that, under perfect competition, $\alpha$ is equal to the labour–share. The arithmetic mean of the US adjusted labour share (based on data from Table 9 of the European AMECO database over the range 1967-2007) is 0.686. It is possible to remove the noise from the residual series $\epsilon$ using the HP filter ($\lambda = 1600$), thereby estimating TFP. The resulting series is then used in conjunction with the potential capital and labour inputs to estimate the level of potential output. The three estimates corresponding to the various potential labour series are both qualitatively and quantitatively similar to those computed from the translog function.

## 5.4 Estimation of the Model

### 5.4.1 Order of the VAR model

The order of the underlying VAR model is determined in the normal manner using the AIC, SIC and the likelihood ratio (LR) statistic. The results are summarised in Table 5.3. The figures reported result from the estimation of an unrestricted VAR model comprising $y_t$, $r_t$, $\Delta p_t$, $\Delta w_t - \Delta z_t$, $i_t$, $f_t$, $d_t$ and $q_t$ as well as the exogenous variables $y^*_{3,t}$ and $p^o_t$. AIC favours the inclusion of two lags while SIC selects just one. Given the ambiguity of the tests, a parsimonious VAR(2) specification is selected. This represents the best balance between achieving a sufficiently rich lag structure to account for any serial correlation on the one hand, and keeping the dimensionality of the model sufficiently low given the range of the dataset on the other.

| Order | LL | AIC | SIC | LR test | Adjusted LR test |
|---|---|---|---|---|---|
| 4 | 3575.1 | 3303.1 | 2884.9 | | |
| 3 | 3515.3 | 3307.3 | 2987.5 | $\chi^2_{64} = 119.683[.000]$ | 94.250[.008] |
| 2 | 3454.1 | 3310.1 | 3088.7 | $\chi^2_{128} = 242.069[.000]$ | 190.629[.000] |
| 1 | 3387.9 | 3307.9 | 3184.9 | $\chi^2_{192} = 374.502[.000]$ | 294.920[.000] |
| 0 | 2505.6 | 2489.6 | 2465.0 | $\chi^2_{256} = 2139.000[.000]$ | 1684.400[.000] |

Table 5.3: Selection of the Order of the Underlying VAR

### 5.4.2 Estimation of the Long–Run Relationships

The Johansen cointegration test results for the VAR(2) are presented in Table 5.4. Based on the simulated critical values tabulated by Pesaran, Shin, and Smith (2000), the trace statistic indicates three cointegrating relationships while the maximum eigenvalue statistic indicates four. Given the theoretical model described above, the modelling proceeds on the assumption that $r$=4.

| | | VAR(2) | | CV of Trace | | CV of Max | |
|---|---|---|---|---|---|---|---|
| $H_0$ | $H_1$ | Trace | Max | 95% | 90% | 95% | 90% |
| $r=0$ | $r=1$ | 331.59 | 90.60 | 215.79 | 209.11 | 61.22 | 58.18 |
| $r\leq 1$ | $r=2$ | 240.98 | 78.59 | 177.79 | 171.62 | 55.83 | 52.69 |
| $r\leq 2$ | $r=3$ | 162.40 | 59.20 | 141.73 | 136.21 | 50.10 | 47.08 |
| $r\leq 3$ | $r=4$ | 103.20 | 43.87 | 108.90 | 103.71 | 43.72 | 40.94 |
| $r\leq 4$ | $r=5$ | 59.33 | 20.02 | 81.20 | 76.68 | 37.85 | 35.04 |
| $r\leq 5$ | $r=6$ | 39.31 | 19.66 | 56.43 | 52.71 | 31.68 | 29.00 |
| $r\leq 6$ | $r=7$ | 19.65 | 14.34 | 35.37 | 32.51 | 24.88 | 22.53 |
| $r\leq 7$ | $r=8$ | 5.31 | 5.31 | 18.08 | 15.82 | 18.08 | 15.82 |

Table 5.4: Johansen Cointegration Test Results

Estimation of the system subject to the full theory–based over–identifying restrictions outlined in Section 5.2.1 results in convergence failure. Through a process of trial and improvement, the following over–identified structure was developed:

$$y_t = b_{10} + b_{11}t + \phi_{11}(r_t - \Delta p_t) + \phi_{12}i_t + \phi_{13}y_t^* + \xi_{1,t}\ ,\quad \phi_{13}=1 \tag{5.20}$$

$$r_t = b_{20} + \phi_{21}\Delta p_t + \xi_{2,t} \tag{5.21}$$

$$i_t = b_{30} + b_{31}t + \phi_{31}f_t + \phi_{32}d_t + \phi_{33}q_t + \phi_{34}y_t + \phi_{35}y^* + \xi_{3,t} \tag{5.22}$$

$$\Delta p_t = b_{40} + \phi_{41}(\Delta w_t - \Delta z_t) + \phi_{42}r_t + \xi_{4,t}\ ,\quad \phi_{41}=1 \tag{5.23}$$

Based on this system of equations, the long–run matrix $\boldsymbol{\beta}'_{ov}$ is estimated as follows:

$$\begin{pmatrix} 0.000 & 1.000 & 0.000 & 0.000 & 16.810 & -16.810 & 0.000 & 0.000 & 0.170 & -1.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 1.439 & -1.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.060 & 0.091 & 0.000 & 0.000 & 0.000 & 0.275 & -0.112 & -1.000 & 2.311 \\ 0.000 & 0.000 & 0.000 & 1.000 & -1.000 & 0.786 & 0.000 & 0.000 & 0.000 & 0.000 \end{pmatrix}$$

while $\boldsymbol{b}_1 = (-0.002\ \ 0.000\ \ -0.013\ \ 0.000)'$.

Convergence was achieved by the Newton–Raphson and batch–sequential algorithms with a tolerance of $1\times 10^{-4}$ after 18 iterations. The imposition of 33 restrictions in the $\boldsymbol{\beta}$ matrix represents 17 over–identifying restrictions, resulting in a likelihood ratio of 113.682

and a restricted maximum likelihood of 3541.531. Hence, the over–identified long–run structure is rejected by the analytical critical values of 24.769 (10% level) and 25.587 (5% level). However, the poor performance of the LR test in small samples is well documented (c.f. GLPS, p. 140). For this reason, a bootstrap procedure was employed (details may be found in the Appendix) resulting in critical values of 130.508 (90%) and 139.709 (95%), providing support for the proposed over–identifying structure[11].

The inclusion of an output gap of the form $(1, -1)$ in equation 5.20 associated with the restriction $\phi_{13} = 1$ is not rejected by the LR statistic and results in sharper impulse response functions compared to the weaker form in which $\phi_{31}$ is freely estimated. However, the estimation results are improved considerably by weakening the restriction that $\phi_{34} - \phi_{35} = 0$ in the investment function. The divergent parameter estimates in this case suggest that the level of investment is strongly affected by the level of output, not simply by the output gap.

The inclusion of the output gap in either strong- or weak–form in the reaction function and inflation equation resulted in poor estimation results. Their removal carries the implication that inflation is modelled as a cost–push phenomenon and that the central bank is modelled as a simple inflation–targeter. Furthermore, the imposition of a (1 -1) relationship between inflation and wage inflation in equation 5.23 was not rejected and resulted in improved dynamic performance of the model.

Convergence failure was frequently encountered when experimenting with specifications that omitted the interest rate from the inflation equation and, where convergence was achieved, the LR statistic was typically inflated. Its inclusion reflects the notion that interest expense is a cost faced by firms and may be passed on to consumers in a situation of mark–up pricing. In order to model this proposition, it follows that one should include the interest rate which affects not only the effective cost of the existing debt–stock but also the cost of obtaining new credit, as opposed to the debt–service cost which only directly captures the former. Furthermore, it should be clear that it is the nominal interest rate that should be included in this case as inflation is the left–hand–side variable[12]. Hence, equation 5.23 states that wage costs are fully passed through to the price level in the long–run, while interest rate (capital) costs are only partially passed through. Such a result could be used as a justification for incomes policy as opposed to (or possibly in concert with) monetary policy in the pursuit of low and stable inflation.

[11] The non–parametric method was employed with 5000 replications, 3126 (62.52%) of which converged to a tolerance of $1\text{x}10^{-4}$ within 1000 iterations using the Newton–Fourier and batch–sequential algorithms.

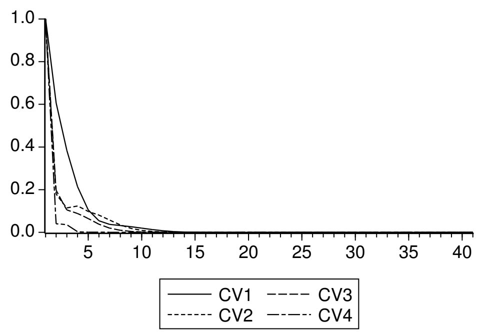
[12] Although the four long–run relationships remain uniquely identified under the proposed specification, the inflation equation is rendered rather similar to the reaction function. For this reason, estimation results must be interpreted with some care.

Empirical testing of the model provided little support for the inclusion of deterministic trend terms in either the reaction function or the inflation specification, indicating that the series co–trend. This co–trending is entirely consistent with economic theory under the assumptions that inflation is a cost–push phenomenon and that monetary policy attempts to meet an inflation target.

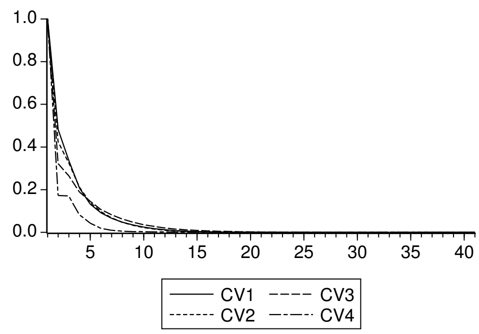
### 5.4.3 Dynamic Analysis

#### Persistence Profiles

While impulse responses derived from integrated systems do not necessarily die out as the forecast horizon increases, the effects of reduced–form shocks on the long–run relationships are temporary. The persistence profiles of the four cointegrating vectors under the exact and over–identifying restrictions are plotted in Figure 5.2.




(a) Exact Identification




(b) Over Identification

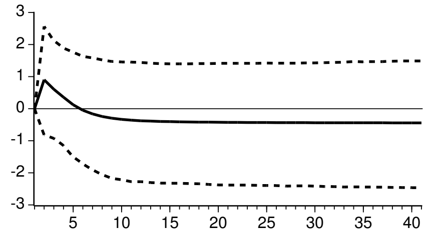
Figure 5.2: Persistence Profiles of the Cointegrating Vectors

The persistence profiles exhibit no over–shooting in either the exactly- or over–identified case and die away to zero very rapidly, indicating no excess persistence of shocks and demonstrating the equilibrium properties of the model. Structural stability testing based on the determinental equation confirms the stability of the system under either specification.

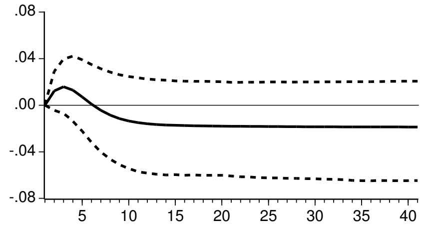
#### Impulse Responses Following an Interest Rate Shock

The principal interest of this chapter lies in identifying the effects of interest rate innovations on the core endogenous variables. Figures 5.3 and 5.4 plot the generalised and orthogonalised impulse response functions (GIRFs and OIRFs, respectively) following a one standard deviation positive interest rate innovation.

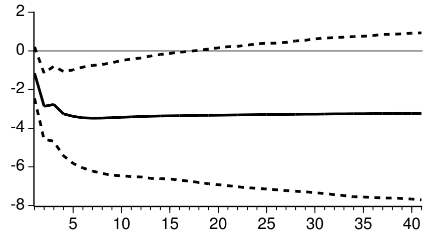
Bootstrapped 90% confidence intervals are included in the figures to provide an indi-



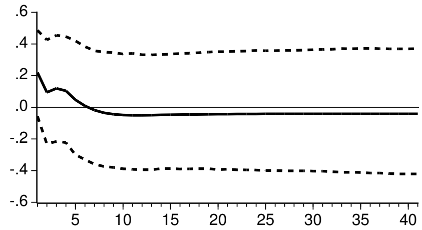

(a) $p^o$ (percentage change)



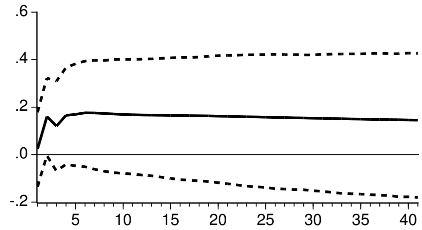

(b) $y^*$ (percentage change)



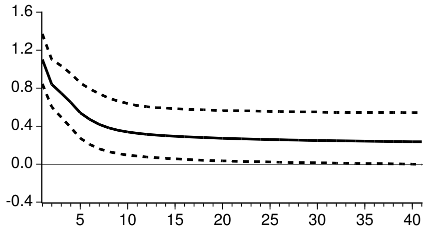

(c) $q$ (percentage change)



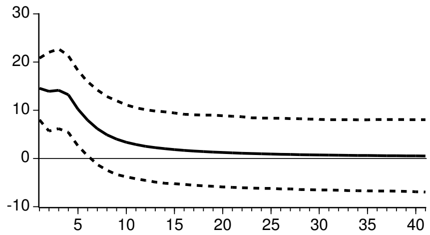

(d) $\Delta w - \Delta z$ (% per annum)



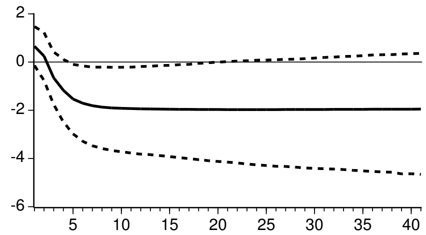

(e) $\Delta p$ (% per annum)



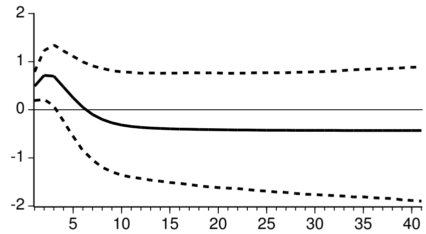

(f) $r$ (% per annum)



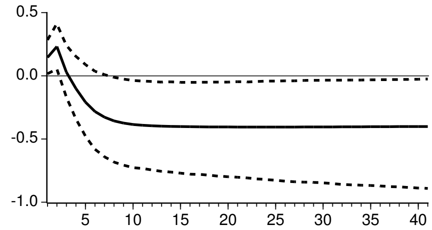

(g) $d$ (percentage change)




(h) $f$ (percentage change)

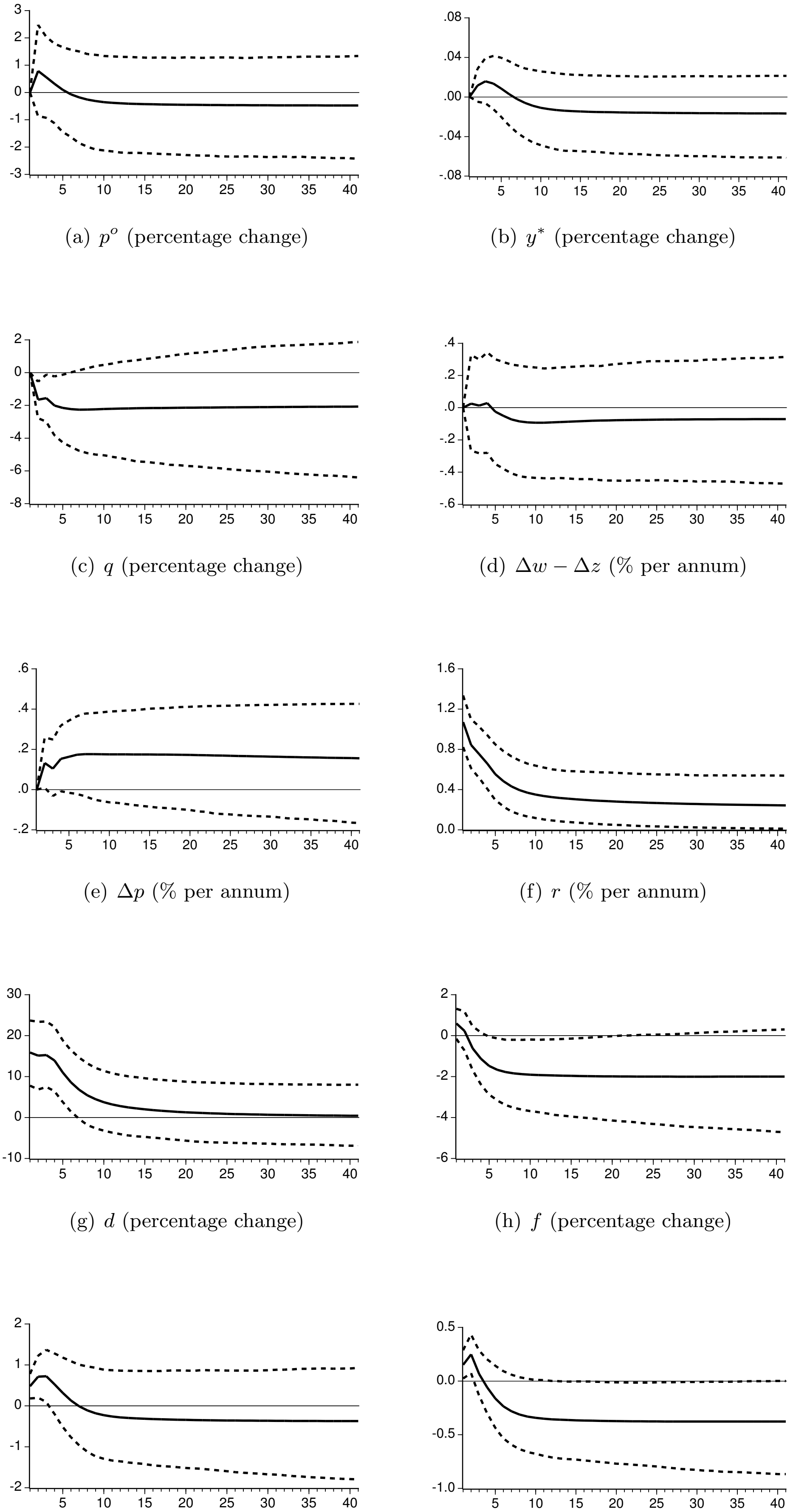



(i) $i$ (percentage change)




(j) $y$ (percentage change)

Figure 5.3: GIRF of a $1\sigma$ Shock to the Interest Rate on all Variables




(a) $p^o$ (percentage change)

(b) $y^*$ (percentage change)

(c) $q$ (percentage change)

(d) $\Delta w - \Delta z$ (% per annum)

(e) $\Delta p$ (% per annum)

(f) $r$ (% per annum)

(g) $d$ (percentage change)

(h) $f$ (percentage change)

(i) $i$ (percentage change)

(j) $y$ (percentage change)

Figure 5.4: OIRF of a $1\sigma$ Shock to the Interest Rate on all Variables

cation of statistical significance[13]. However, the reliability of intervals computed in this way may be questionable, certainly at longer horizons (c.f. Kilian, 1998; 1999)[14]. For this reason, it must be emphasised that they are at most suggestive of the level of significance. Hence, in some cases where the reported interval includes zero, the reader may tentatively consider that a shift in the empirical distribution of the IRFs provides some evidence of an effect that may be of interest.

The IRFs demonstrate that an increase in the interest rate of one standard deviation depresses Tobin's $q$, which presumably reflects a contraction of the stock market. This is also reflected in a significant economic retrenchment at longer horizons, albeit preceded by non–negligible positive impact effects on investment and output. The figures suggest that this initial phase of overshooting lasts for up to one year following the interest rate shock, although no significant decrease in investment is observed at longer horizons. This suggests that the contractionary effect on the economy arises through other channels, the most obvious of which is the negative stock market wealth effect.

The figures provide strong evidence that increases in the interest rate are associated with a simultaneous increase in the real cost of servicing real debt for up to 6 quarters and a longer–term reduction in the internal funds of firms. This combination reduces the ability of firms to remain solvent in the face of further liquidity shocks. Given the use of aggregate data, one cannot draw strong inferences regarding the microeconomic consequences for individual firms and sectors. However, the divergence between the financial inflows and outflows of firms at the aggregate level will be reflected in a shift in the financing spectrum toward the increasingly unstable Ponzi end. While the impulse responses are derived from a reduced–form model, rendering structural inference impossible, the results nevertheless provide strong support for Minsky's contention that the interest rate implement of monetary policy may be destabilising. This is the case because while an interest rate shock need not be a monetary policy shock, the operating procedures of modern central banks ensure that a monetary policy shock is always an interest rate shock (certainly when the interest rate under consideration is the Federal funds rate).

Interestingly, the interest rate is seen to have little effect on either wage inflation or price level inflation beyond the observation of a mild and insignificant price puzzle.

[13]These intervals are based on the non–parametric method described in the Appendix and allow for parameter uncertainty. Of the 5000 replications, convergence was achieved in 3192 cases, resulting in a convergence rate of 63.84%. Initial testing indicates that the convergence rate may exceed 77% when the maximum number of iterations used in the computation of the ML estimates is increased from 1000 to 5000 but the observed four–fold increase in computational time renders this approach impractical as the number of bootstrap replications becomes large.

[14]Alternative methods of computing confidence intervals for impulse response functions, including that proposed by Kilian, are unproven in large system models such as that developed here.

While it could be argued that this is an artefact of the cost–push inflation specification, the result suggests that inflation–targeting monetary policy may be ineffective (c.f. Ball and Sheridan, 2003; Angeriz and Arestis, 2006).

#### Impulse Responses Following an Inflation Shock

Figures 5.5 and 5.6 present GIRFs and OIRFs for all variables in response to a positive inflation shock. Such a shock may come about as the result of changes in inflation expectations or as the result of a variety of supply shocks, for example. What is particularly interesting about the figures is that the inflationary shock has a profound negative effect on the real cost of debt–service on impact and that this effect lasts for approximately three quarters. This reduction in the burden of debt reflects the inflationary erosion of the loan principle. However, what is remarkable is the fact that this negative effect is relatively short–lived when compared to the persistence of the inflationary pressure which remains non–zero across the entire horizon. This suggests that firms may take advantage of high inflation environments to increase their leverage in the expectation of continuing inflation.

With the exception of the cost of debt–service, the inflationary shock has no other significant effects at the 90% level[15]. This would suggest that monetary policy has not responded to inflation in a systematic manner over the sample period. This result is not surprising given the relatively long sample period that includes a number of different policy regimes pursued by the Fed.

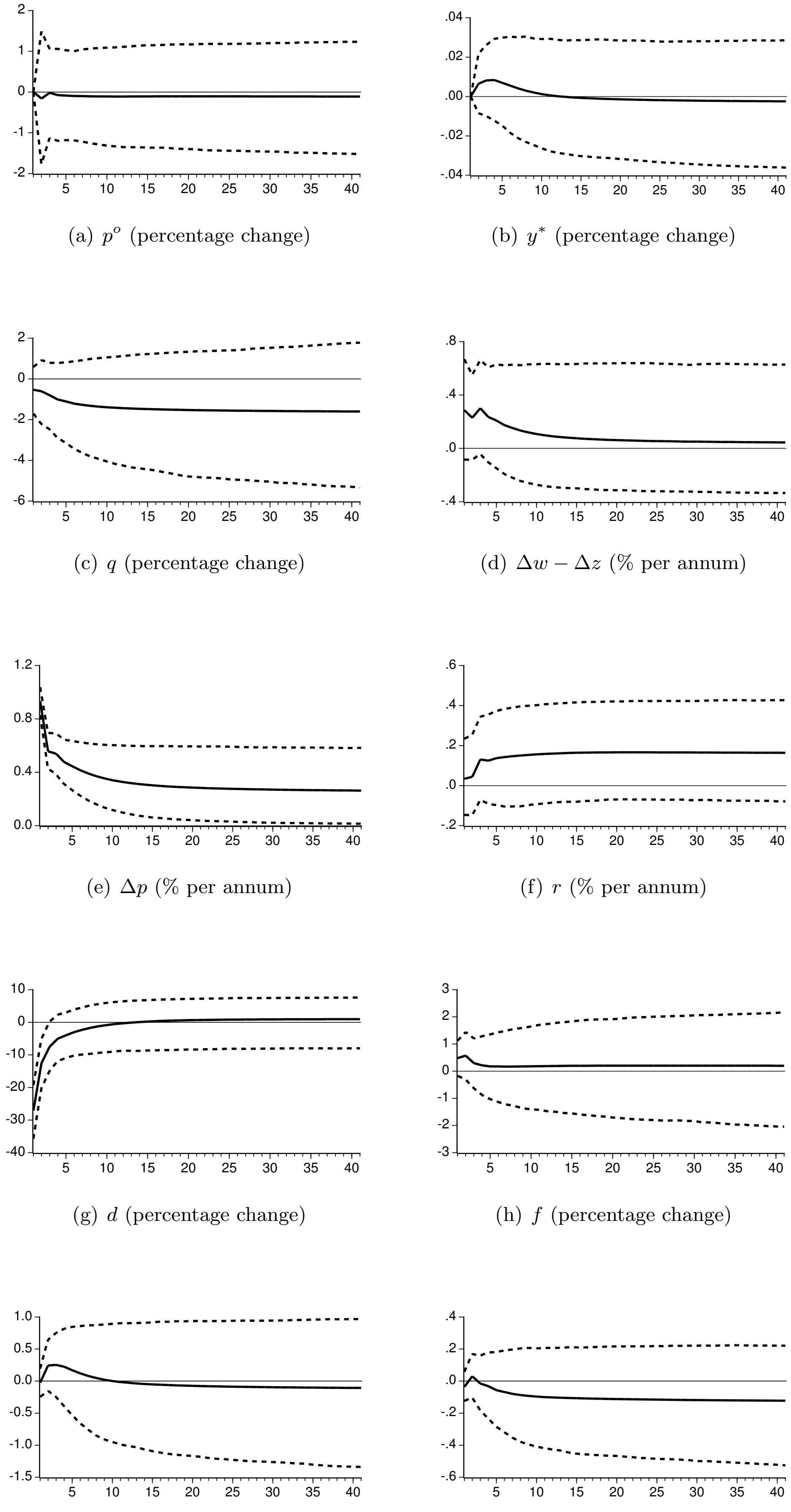
#### Impulse Responses Following a Shock to the Valuation Ratio

Figure 5.7 presents the responses of the variables to a positive shock to the valuation ratio[16]. Such a shock may reflect an episode of irrational exuberance, in which equity values become inflated relative to the replacement cost–of–capital assets.

The shock is associated with a significant lagged increase in realised output, starting after three quarters and lasting for approximately five quarters. Furthermore, this economic stimulus is accompanied by a large, although apparently insignificant, increase in investment spending which can be attributed to two principle phenomena. Firstly, the increase in the valuation ratio is likely to reflect an increasingly bullish sentiment in the broader economy, which acts as a stimulant to investment as expectations grow increasingly optimistic. Secondly, in a bull market, firms find it easier and cheaper to borrow

[15] The empirical distribution of many of the IRFs does however shift, which could be interpreted as suggestive of some latent effect. For example, the empirical distribution of interest rate IRFs shifts upward, placing more of the probability mass above zero at every horizon.

[16] Note that the OIRFs are identical to the GIRFs in this case due to the variable ordering and are, therefore, not reported separately.



(a) $p^o$ (percentage change)

(b) $y^*$ (percentage change)

(c) $q$ (percentage change)

(d) $\Delta w - \Delta z$ (% per annum)

(e) $\Delta p$ (% per annum)

(f) $r$ (% per annum)

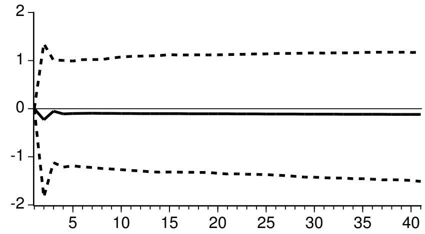
(g) $d$ (percentage change)

(h) $f$ (percentage change)

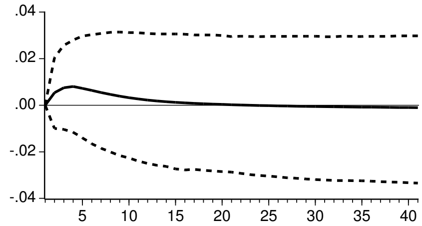
(i) $i$ (percentage change)

(j) $y$ (percentage change)

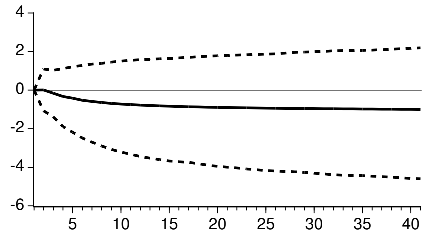
Figure 5.5: GIRF of a $1\sigma$ Shock to Inflation on all Variables



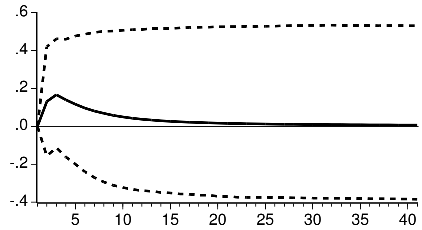
(a) $p^o$ (percentage change)



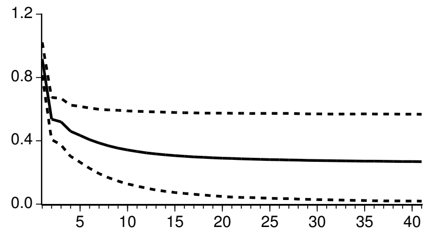
(b) $y^*$ (percentage change)



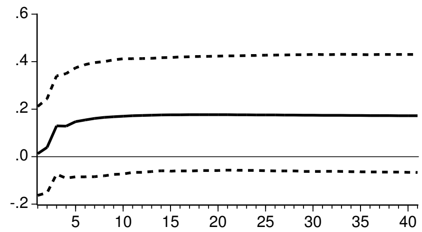
(c) $q$ (percentage change)



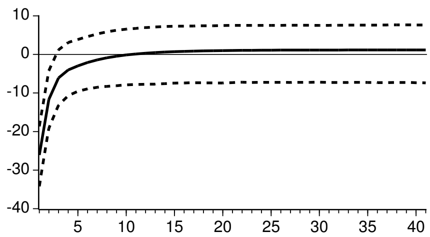
(d) $\Delta w - \Delta z$ (% per annum)



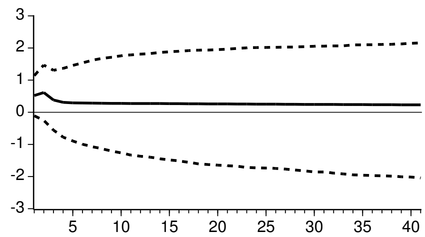
(e) $\Delta p$ (% per annum)



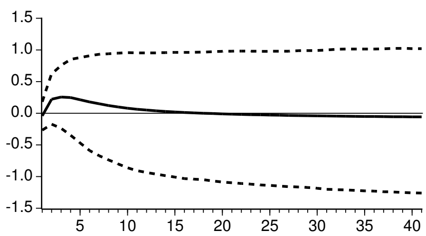
(f) $r$ (% per annum)



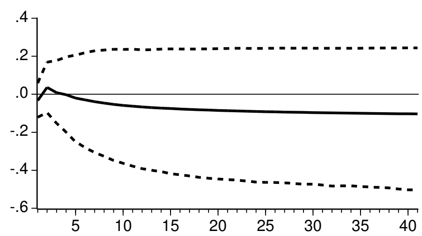
(g) $d$ (percentage change)



(h) $f$ (percentage change)

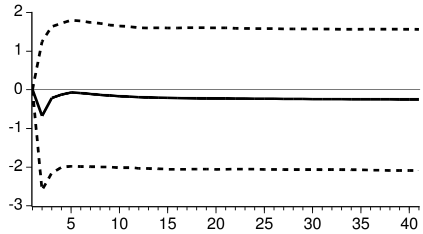


(i) $i$ (percentage change)

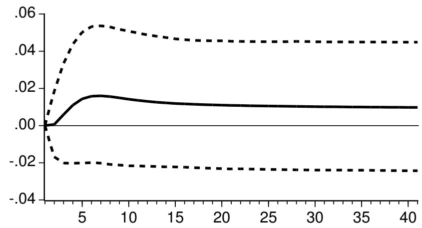


(j) $y$ (percentage change)

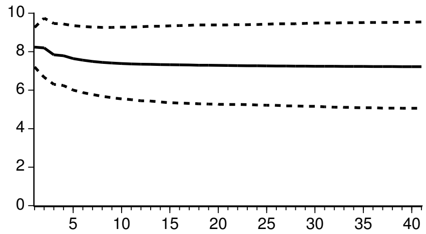
Figure 5.6: OIRF of a $1\sigma$ Shock to Inflation on all Variables



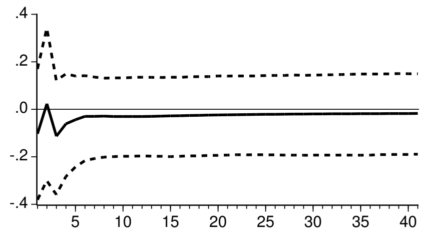

(a) $p^0$ (percentage change)



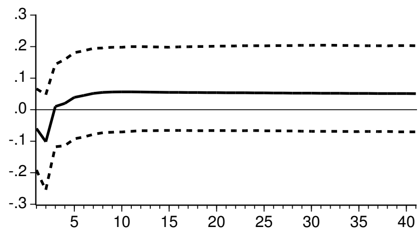

(b) $y^*$ (percentage change)



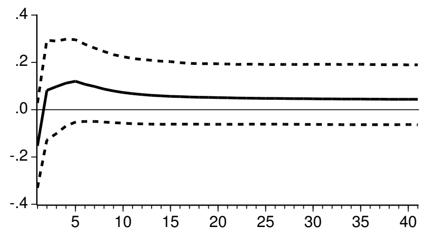

(c) $q$ (percentage change)



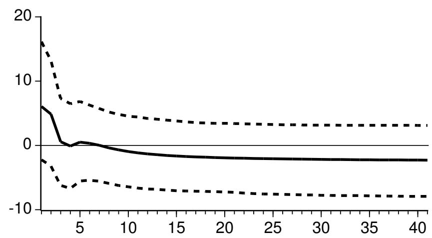

(d) $\Delta w - \Delta z$ (% per annum)



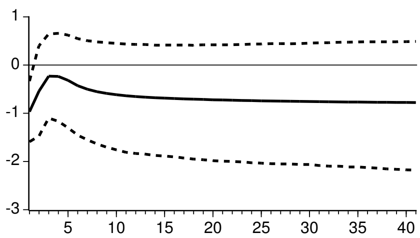

(e) $\Delta p$ (% per annum)



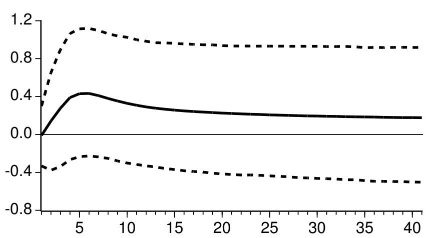

(f) $r$ (% per annum)



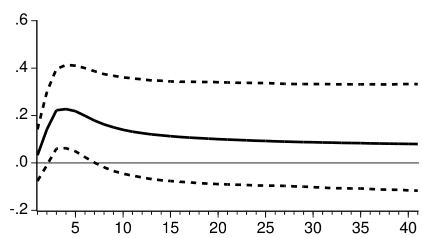

(g) $d$ (percentage change)




(h) $f$ (percentage change)




(i) $i$ (percentage change)




(j) $y$ (percentage change)

Figure 5.7: GIRF/OIRF of a $1\sigma$ Shock to Tobin's $q$ on all Variables

on the financial markets, easing their resource constraints (see Section 2.3.2 on the broad credit channel). This effect undoubtedly contributes to the negligible impact of the shock on the debt–servicing cost in all but the very short–run. Interestingly, the shock exerts a modest negative impact effect on internal funds.

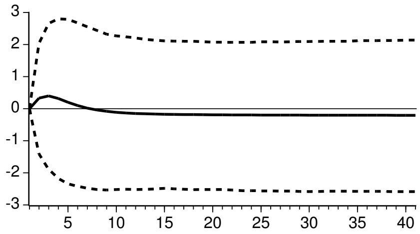
No significant effect is recorded on wage and price level inflation, indicating that asset price inflation is not passed through to retail prices. This suggests that measures of core inflation do not adequately reflect conditions in financial markets. Hence, contrary to the assertion of many monetary economists and central bankers alike, core inflation seems to be an insufficient summary statistic for economy–wide inflationary pressure. In this case, one could argue that monetary policy may be improved by paying greater attention to asset market sentiment (see Svensson, 2000, for a similar discussion about extending the range of variables in the reaction function). In the contemporary era of widespread financial turmoil and distress, such arguments may prove more persuasive than in the past.

#### Impulse Responses Following an Investment Shock

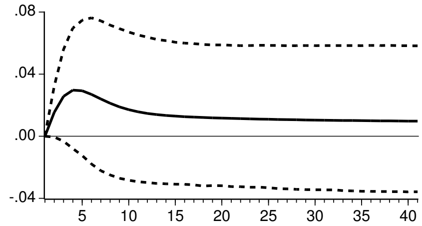
A positive investment shock provides a significant economic stimulus which is evident in a number of the impulse responses presented in Figures 5.8 and 5.9. Firstly, increased investment spending induces a significant increase in aggregate output which lasts for four quarters before dying away. A similar response pattern is observed for potential output, although the effect is statistically insignificant after all but the first quarter.

As would be expected, the investment boom is associated with substantial increases in the real cost of debt–servicing lasting for almost two years, and with similar increases in the central bank base rate. This interest rate response to an investment shock would suggest a concern with inflationary pressure. While the investment shock does seem to exert a positive influence on inflation, it proves statistically insignificant.

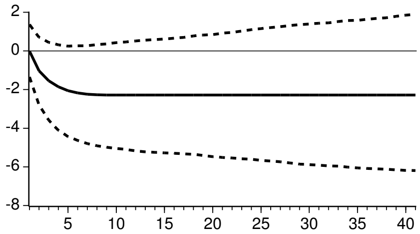
Interestingly, the investment boom is associated with a marginally insignificant decline in the valuation ratio. Given Kilian's reservations over the accuracy of the reported critical values, one must remain open to the possibility that this effect is non–negligible. This would suggest that an investment boom is associated with a reduction in Tobin's $q$. Such a result is intuitively reasonable when one recalls that a real investment boom in this model is associated with an increase in the value of fixed capital installed but not necessarily with a stock–market boom. In this case, the denominator of Tobin's $q$ will increase while the numerator remains relatively unchanged, resulting in the observed decline.



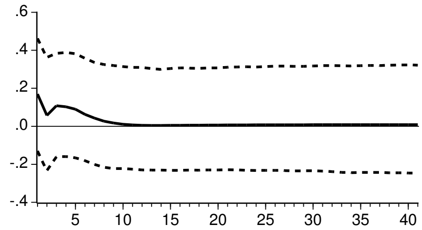

(a) $p^o$ (percentage change)



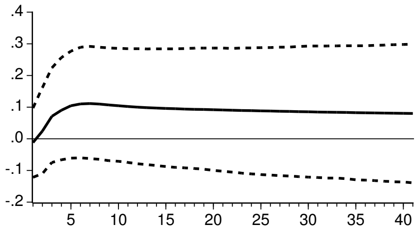

(b) $y^*$ (percentage change)



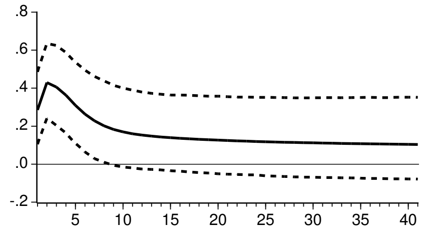

(c) $q$ (percentage change)



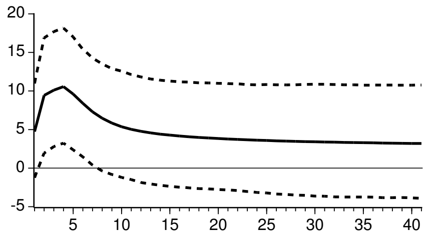

(d) $\Delta w - \Delta z$ (% per annum)



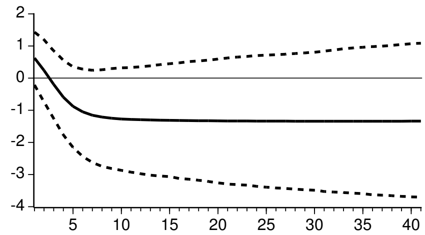

(e) $\Delta p$ (% per annum)



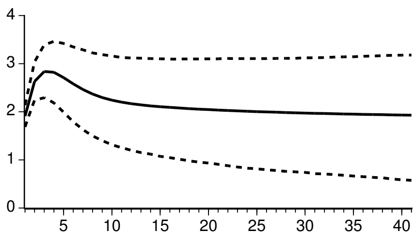

(f) $r$ (% per annum)



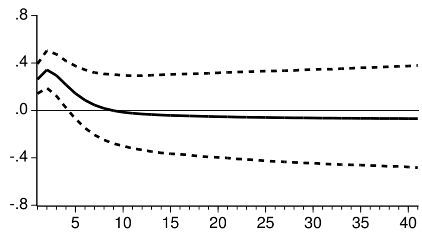

(g) $d$ (percentage change)




(h) $f$ (percentage change)

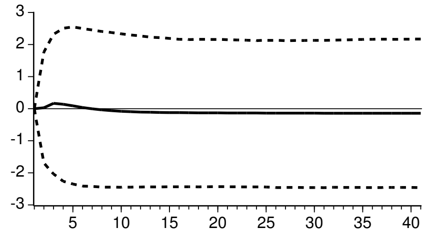



(i) $i$ (percentage change)

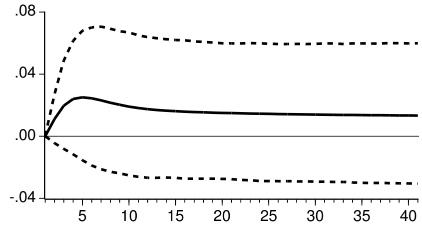



(j) $y$ (percentage change)

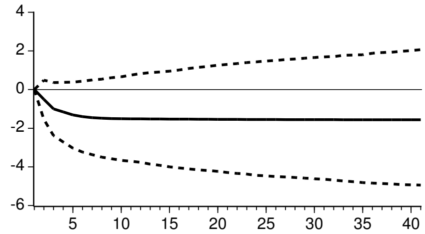
Figure 5.8: GIRF of a $1\sigma$ Shock to Investment on all Variables



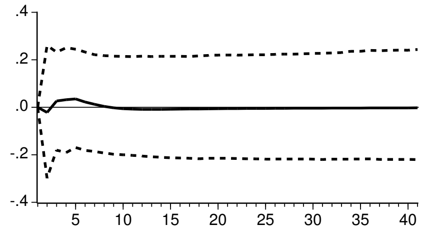

(a) $p^o$ (percentage change)



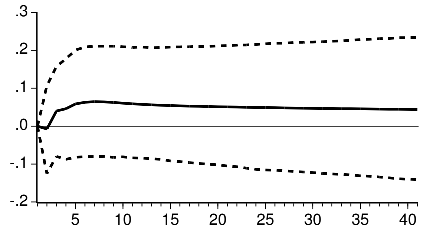

(b) $y^*$ (percentage change)



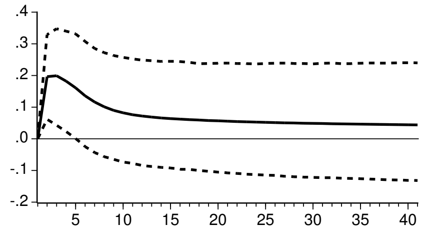

(c) $q$ (percentage change)



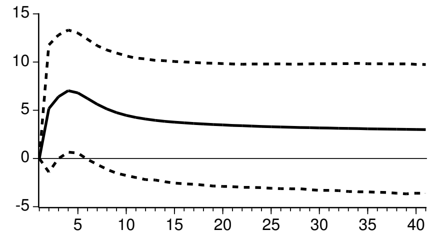

(d) $\Delta w - \Delta z$ (% per annum)



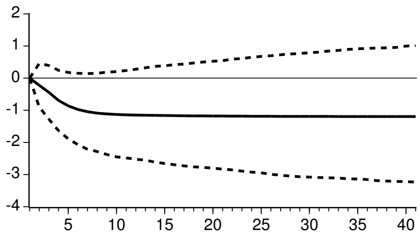

(e) $\Delta p$ (% per annum)



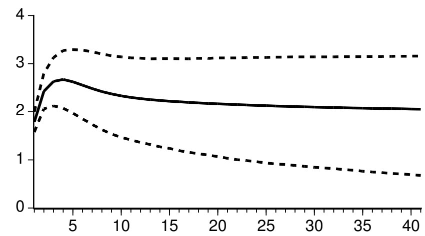

(f) $r$ (% per annum)



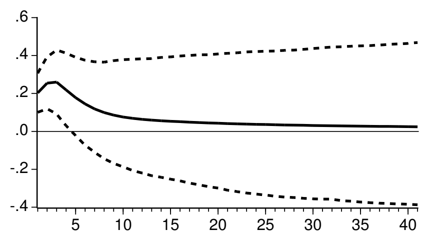

(g) $d$ (percentage change)




(h) $f$ (percentage change)




(i) $i$ (percentage change)




(j) $y$ (percentage change)

Figure 5.9: OIRF of a $1\sigma$ Shock to Investment on all Variables

### 5.4.4 Forecasting

Table 5.5 presents various analytical statistics indicating that the in–sample forecasting performance of the model is reasonably good. The model correctly predicts 71.3% of directional changes and achieves a Kuipers score of 0.423, indicating that the number of correct predictions significantly exceeds the number of erroneous predictions[17]. Furthermore, the predictive failure test of Pesaran and Timmermann (1992) reports a value of 3.777, significantly exceeding the 1% critical value of the standard normal density. Hence, one may conclude that the model exhibits promising in–sample forecasting performance, certainly in terms of directional change.

| | |
|---|---|
| Hit Rate | 0.713 |
| Kuipers Score | 0.423 |
| Pesaran–Timmermann Statistic | 3.777 |

Table 5.5: In–Sample Forecasting Performance

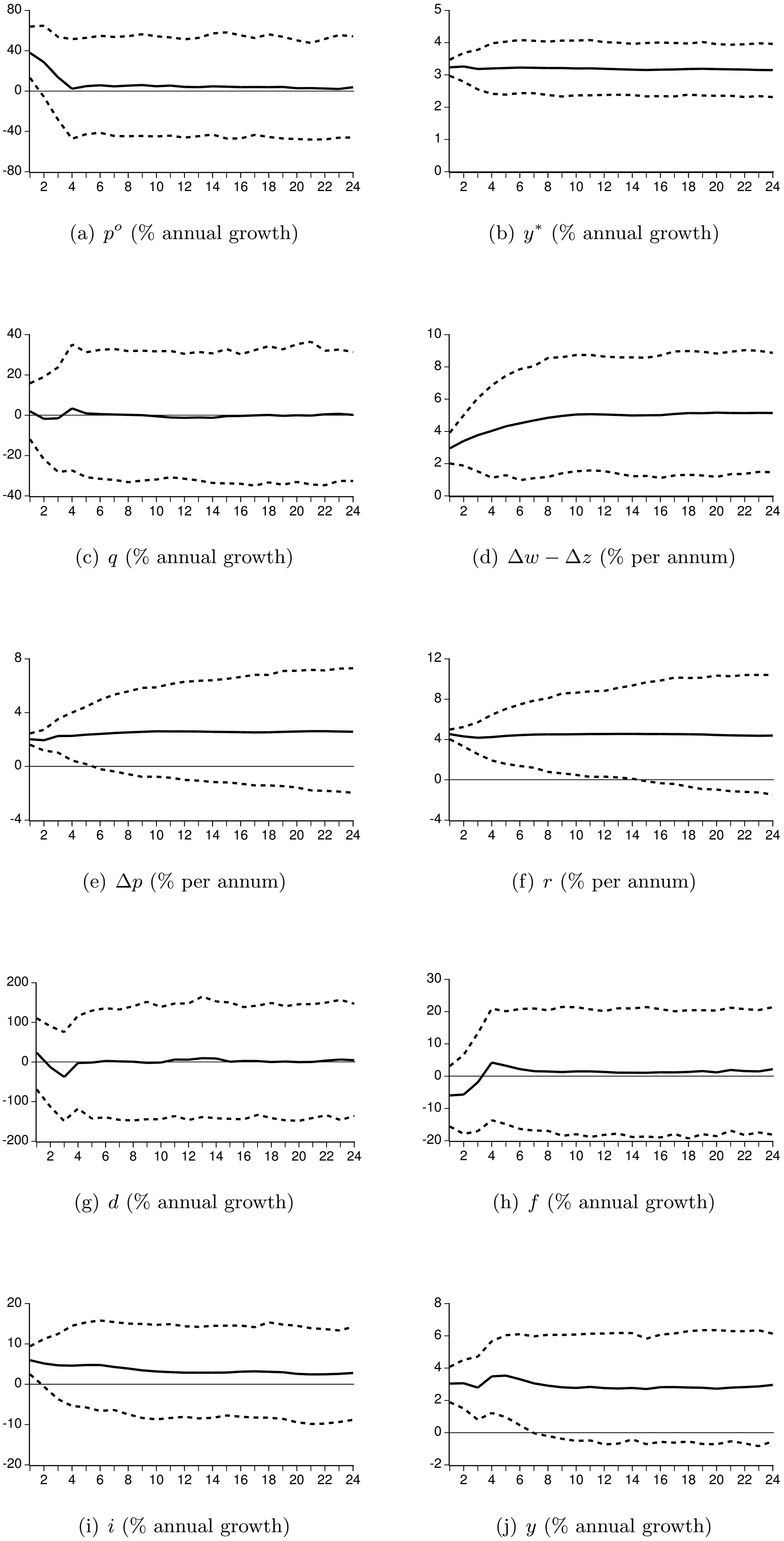
Figure 5.10 presents four–quarter moving average central forecasts of the levels of the interest rate, wage and price inflation, and the growth rates of the remaining variables[18]. As is well known, the degree of confidence that one should place in such forecasts decreases with the forecast horizon. In general, one would expect that attempting to forecast further than four to six quarters ahead based on a simple model of the type deployed here would be unwise. Longer horizons are provided in the diagrams simply to demonstrate the tendency of the central forecasts to converge on the observed historical average in the long–run.

The model predicts that the sharp increases in the price of oil that characterise the end of the sample used in estimation will gradually recede until 2008q4 whereupon more normal price growth will resume (panel (a)). Interestingly, however, the model predicts no overshooting, suggesting that the price of oil will not fall substantially from its quarterly peak price. Similar views were regularly proffered at the time reflecting the belief that oil price inflation had been driven largely by realised and expected increases in demand from emerging economies, most notably China and India. However, in reality oil prices have fallen markedly from their peak. Hence, although the model correctly identifies the end of the recent bout of oil price inflation, it fails to adequately capture the transitory nature of the shock.

Panels (b) to (j) suggest that the time path of the remaining variables will be relatively

[17]The Kuipers score is defined $H - F$ where $H$ is the hit rate and $F$ the false alarm rate. Therefore, a random walk model would be expected to generate an average Kuipers score of precisely zero in repeated trials, while a positive value reflects more 'hits' than 'misses'.

[18]The figures include 90% confidence intervals computed by non–parametric simulation allowing for future uncertainty. 5000 iterations were employed. Details of the computational procedure may be found in the Appendix. The relevant computer code is included in the enclosed CD.



(a) $p^o$ (% annual growth)

(b) $y^*$ (% annual growth)

(c) $q$ (% annual growth)

(d) $\Delta w - \Delta z$ (% per annum)

(e) $\Delta p$ (% per annum)

(f) $r$ (% per annum)

(g) $d$ (% annual growth)

(h) $f$ (% annual growth)

(i) $i$ (% annual growth)

(j) $y$ (% annual growth)

Figure 5.10: 4 Quarter Moving Average Central Forecasts of all Variables

stable in the longer–term following substantial volatility in the short–run. Recalling that the reliability of such forecasts over anything but a short timeframe is questionable, the analysis offered below focuses largely on this initial volatile period.

Panel (c) predicts a mild reduction in Tobin's $q$. Given that $q$ is the ratio of market value to the replacement cost of capital, a reduction in its level may be brought about either by a contraction in the stock market or by an increase in the capital stock. Given that investment growth is predicted to decelerate relatively markedly in the short–run (panel (i)), one may be reasonably confident that the decline in $q$ can be attributed to predicted losses in the stock markets.

The deceleration of investment growth noted above is associated with short–run turbulence in the rate of growth of debt–servicing costs (panel (g)), internal funds (panel (h)) and output (panel (j)). The model predicts that the internal funds of firms will shrink substantially at a rate of 7% per annum in the short–run before the growth rate gradually recovers after four quarters. At the same time, the debt–servicing costs of firms are forecast to shrink at an annual rate reaching 25% in 2008q3. Taken together, these effects provide little evidence of financial fragility, as the rate of growth of internal funds exceeds that of debt–servicing costs in all but the very short–run. The forecasts do, however, suggest that the short–term outlook for firms may be rather bleak.

The predicted reduction in the real debt–servicing obligations of firms could be attributed to any of three phenomena; a reduction in the interest rate, an increase in the rate of inflation, or a reduction in the amount of borrowing. Panel (f) forecasts relative constancy of the base rate, which should translate into similar constancy of the lending rates faced by borrowers, at least if one assumes that the mark–up charged by commercial banks remains relatively constant. Similarly, panel (e) forecasts only minor inflationary pressure. Hence, it seems that the predicted fall in debt–servicing costs is rooted in reduced borrowing/lending, an observation which is consistent with our subsequent experience of the financial crisis.

The forecasts reveal one final point of interest. Panel (d) indicates substantial upward pressure on productivity–adjusted wages. Despite the specification of a long–run cost–push inflationary process, the effect on price level inflation is muted, if it is present at all. For this reason, the central bank base rate is forecast to remain remarkably stable despite the substantial economic upheavals documented above.

With the benefit of hindsight, it is clear that the forecasts derived from the model present a rather more optimistic picture than actually came to pass. However, that the forecasts identified signs of weakness in various sectors of the economy using a dataset covering just the first quarter of the subprime crisis is a credit to the model.

## 5.5 Implications for Monetary Policy

The principal finding that the interest rate may be destabilising when used as an implement of monetary policy raises a number of issues for policymakers. Firstly, are there any viable alternative interest rate rules which could alleviate these destabilising influences without fundamentally undermining the dual mandate of price stability and sustainable growth? Secondly, are there any alternative tools at the disposal of policymakers which could be employed in asset market management, and would such intervention be desirable?

The general view of central bankers toward smoothing asset market cycles is eloquently captured by ex–Chairman Greenspan (2002, ¶17) as follows:

> [N]othing short of a sharp increase in short–term rates that engenders a significant economic retrenchment is sufficient to check a nascent bubble. The notion that a well–timed incremental tightening could have been calibrated to prevent the late 1990s bubble is almost surely an illusion. Instead, we...need to focus on policies to mitigate the fallout when it occurs and, hopefully, ease the transition to the next expansion.

This view represents an asymmetric policy stance (Posen, 2006; Roubini, 2006). Numerous reasons underlie the reluctance of central bankers to intervene in asset markets, ranging from a dogmatic acceptance of the tenets of the efficient markets model to the purportedly insuperable difficulties in identifying bubbles *ex ante*. However, an energetic debate has developed in the literature over the possibility of a more proactive role for monetary policy, a position which is rapidly gaining ground in the current turbulent economic environment[19].

### 5.5.1 Asset Prices and Monetary Policy

There exists a general (although by no means universal) consensus among economists that asset price terms should not enter the interest rate rule because inflation and the output gap are sufficient summary statistics (c.f. Bernanke and Gertler, 1999; 2001 and Posen, 2006). Four main reasons underlie this popular view. Firstly, the so–called *Schwartz Hypothesis* (Schwartz, 1988; 1998) that price level instability begets financial instability[20]

[19]Indeed, many commentators in the financial press have blamed the credit crisis on the easy money policies of the Greenspan Fed (c.f. Roach, 2007).

[20]Schwartz argues that instability of the price level (particularly disinflation) may cause financial instability. She stresses that it may exacerbate the problems associated with informational asymmetries and

is typically offered as a justification for the narrow focus of monetary policy on price level stabilisation. Secondly, the 'targets–and–instruments' approach originated by Tinbergen (1952) has been embraced by the new consensus and used to strengthen this defense of IT policies on the grounds that the number of targets should be at most equal to the number of instruments. Thirdly, many commentators highlight the difficulties in identifying bubbles, let alone forecasting them. Fourthly, it is often argued that the cost–benefit analysis of bubble–pricking interest rate policies is unfavourable due to the collateral damage that would be inflicted on non–bubble sectors of the economy (c.f. Posen, 2006; Nickell, 2005). Moreover, should the central bank mistake asset price inflation based on productivity gains with a bubble, then the enaction of bubble–pricking measures is likely to stifle a genuine economic boom and may even instigate a depression (Bernanke, 2002; 2003).

A substantial and growing minority has dissented from this view. They argue, firstly, that the Schwarz Hypothesis has recently been violated by the existence of bubbles during prolonged periods of low and stable inflation (e.g. the dotcom bubble and the growth phase of the current housing bubble). Such an observation is, however, entirely consistent with the Minskyan position, which stresses that prolonged periods of stability are likely to lower the financial safety margins of economic agents and may, thereby, contribute to asset market cyclicality. Secondly, speculative excesses are distributionally sub–optimal, diverting investment from productive to speculative ends. Thirdly, in the event of a large price correction, the solvency of financial institutions may be compromised due to the increased incidence of default on collateralised borrowing in a situation of widespread negative equity (Schwartz, 2002). Fourth, there is little reason to believe that the identification of asset price misalignments poses more significant problems than those encountered in the estimation of many other variables used in policymaking, including potential output and the equilibrium exchange rate (c.f. Cecchetti et al., 2000; Roubini, 2006, pp. 92-3).

If it is perceived that the overheating of certain key markets is likely to precipitate costly medium- to long–term equilibrium corrections, it may be desirable for the central bank to raise the interest rate, missing its short–term inflation target in order to avert longer–term instability and distress (c.f. Goodhart, 1996). Underlying this approach is the

introduce greater uncertainty in the lending process, especially as regards the evaluation of the expected returns to debt–funded investment projects. Bordo and Wheelock (1998, esp. pp. 44-5) note that although Schwartz does not explicitly model the linkage between price instability and financial instability, her work is compatible with various theories of financial distress including the monetary misperceptions approach of Lucas (1972, 1973) and the financial fragility/debt–deflation theory associated originally with Fisher (1933a, 1933b) and, more recently, with Minsky (1977) among others. The authors also note that uncertainty over future inflation may result in the application of additional 'inflation risk premiums' to the lending rate thereby increasing the cost–of–capital (p. 42). Moreover, to the extent that uncertainty over the future path of the price level hampers attempts by lenders to distinguish good loan prospects from bad, a lemons premium in the sense of Akerlof (1970) may be added to the interest rate, further depressing equilibrium investment.

proposition that it may be desirable to conduct monetary policy based on a multi–faceted mandate given an appropriate hierarchical structure of goals. Such a hierarchy may define different policy regimes reflecting the most pressing concern facing the economy at a given point in time.

Authors in the counter–consensus field have tended to adopt one of three positions, the first of which holds that asset market conditions should enter the central bank objective function directly, i.e. that asset prices should be *targeted* by monetary policy (see Roubini and the references therein). Filardo (2004) develops a simple linear stochastic control model of an economy in which asset price bubbles are a non–trivial state variable. Importantly, his model assumes a causal role for asset price bubbles but not for the fundamental component of asset prices. In this framework, he shows that an optimal policy rule should include a bubble term if the monetary authority can distinguish between bubbles and fundamentals and, perhaps more significantly, that it should include asset prices if the bank cannot reliably separate the various components. Furthermore, Filardo proposes that the central bank's choice of whether or not to react to asset price bubbles should be framed in terms of minimising the expected loss from each respective policy in a Bayesian framework. Quite simply, given an assumed structure of the paradigm/model uncertainty, one can calculate the expected loss associated with each policy and pursue that which minimises this loss.

The second position is that the central bank could target a level of inflation based on a newly defined inflation metric incorporating various asset price indices, appropriately weighted (Alchian and Klein, 1973; Goodhart and Hofmann, 2000; Goodhart, 2001). Goodhart, 2001, stresses that house price inflation should be given a larger weight in a 'proper' inflation measure due to the fact that housing represents a considerable proportion of the household asset portfolio and is a significant determinant of consumer spending. A similar observation is made by Cecchetti et al. (2000).

The final approach, associated with Cecchetti et al. (2000), is that policymakers should consider but not target asset prices. While this approach represents a compromise between the dominant view and asset–price targeting, it is difficult to imagine how policy could react to asset prices without actively targeting them and while maintaining its transparency (see Allsopp, 2002 for a similar view). However, an intuitive way of approaching this issue is to think of the monetary policy decision in terms of constrained optimisation. In such a framework, the central bank is free to pursue anti–inflationary monetary policy as long as it does not risk precipitating a crash in the financial markets insodoing. If it is felt that further interest rate rises may contribute to unacceptable levels of financial fragility, then the central bank must desist. This idea simply reflects the fact that the primary responsibility of the central bank is, and (in many cases) always has been, to ensure the stability of the financial system. Hence, the academic view of IT policies may be overly simplistic in the sense that it does not acknowledge the existence of such constraints despite the fact that such issues are presumably discussed during the deliberations of the relevant policy committees.

The typical objection to the inclusion of asset prices in the objective function is that the manipulation of the interest rate to prick bubbles is likely to cause unacceptable collateral damage[21]. References to the 'blunt tool' (Bernanke, 2006) or 'blunderbuss' (Palley, 2006) of interest rate policy are commonplace. Furthermore, the empirical results adduced in this chapter suggest that the use of the interest rate as a means of checking the growth of perceived bubbles is potentially destabilising and, therefore, ill–advised. Such concerns have triggered the development of an innovative literature focusing on alternative policy instruments.

### 5.5.2 An Alternative to the Interest Rate

Even if one accepts the controversial theoretical case for asset–price–targeting interest rate policies, the political will required for their implementation would most likely be lacking. However, the narrow focus of the NCM on the interest rate implement diverts attention from available alternatives, including (possibly heterogeneous) capital and margin requirements and more direct prudential measures.

Palley (2004) proposes an alternative means by which central banks can smooth asset market cycles, which relies on their ability to set heterogeneous reserve requirements. However, in contrast to the existing model of reserve requirements, Palley proposes that reserves should be held against the assets of financial institutions rather than their liabilities. He distinguishes between systems of asset–based and liability–based reserve requirements (ABRR and LBRR, respectively) as follows (p. 50):

> [i]n a LBRR system, reserve requirements affect the relative rates paid on liabilities and have no effect on loan rates [while under] an ABRR system, they

[21] An excellent example of this view is Nickell (2005). He shows that, even when asset market fluctuations can be identified with certainty, "the relatively long lags in the monetary transmission mechanism make the appropriate response to asset price misalignments very hard to calibrate" (p. 11). Nickell estimates the interest rate innovation required to smooth the recent housing boom in the UK at 300 basis points maintained for 13 quarters based on the Bank of England macroeconomic model. Even under the highly favourable assumptions that the short–term nature of the rate rise is known to the public and that expected inflation remains fixed at 2%, Nickell demonstrates that the policy would reduce GDP by more than 0.5% and inflation by 1% causing the MPC to undershoot its target (p. 18). In the more plausible case that these strong assumptions were not met, the impact would be magnified.

have no effect on the rates paid on liabilities, and instead affect the relative rates charged on loans.

In a conventional LBRR system, financial institutions are required to hold reserves in proportion to the volume of deposits on their books. Changes in relative reserve ratios change the relative cost associated with different types of deposits. Financial institutions will then pass these costs on to depositors in the form of lower returns. By contrast, manipulating the reserve ratios in an ABRR system changes the value of reserve assets that a financial institution must hold against different classes of asset. Such changes will then, presumably, be passed on to borrowers, directly changing the cost–of–capital.

An ABRR system has a number of appealing features. Firstly, a central bank acting in this way could directly intervene in markets that it considers overheated without recourse to the interest rate. Palley (2004, pp. 47-51) provides a simple algebraic formalisation of this principle. Hence, ABRR allows policymakers to target specific markets without inflicting the type of collateral damage that would be associated with an interest rate innovation. Secondly, in an environment with $n$ classes of asset subject to reserve requirements, the monetary authority would gain an additional $n-1$ policy instruments, thereby relaxing the constraints imposed by Tinbergen's (1952) targets–and–instruments framework (Palley, 2004; 2006). Thirdly, Schwartz (2002) stresses that the use of quantity constraints to curtail unsafe lending in excessively bullish markets directly protects the portfolios of financial institutions from large corrections in the value of collateral assets[22]. This safeguarding of the liquidity of financial institutions is achieved without relying on the promise of lender of last resort interventions, which Minsky famously argued serve to reduce risk premia, thereby actively contributing to financial fragility (c.f. Minsky, 1986b, p. 64 and also Wray, 2001, p. 6). Fourthly, Palley argues that the stabilisation properties of ABRR are superior to those of LBRR on the grounds that reserves are made available as borrowers default, thereby counter–cyclically providing liquidity to banks when they find it most difficult to raise it in the market[23].

Beyond the direct effects on the composition of lending working through cost mechanisms, changes in capital requirements brought about by the central bank are likely to have strong signalling effects. Historical experience suggests that signals emanating from

[22] Schwartz advocates a similar approach to Palley, stressing that the central bank should engage in the active management of reserve requirements in order to ensure that the balance sheets of financial institutions are not compromised in the event of a substantial equilibrium correction in the price of collateral assets. With an uncomfortable sense of prescience, Schwartz stresses that it is the role of the central bank to ensure that taxpayers' money is not used to reinforce the balance sheets of failing financial institutions where it can be avoided by judicious pre–emptive action (p. 2).

[23] Palley argues that further benefits associated with ABRR include their contribution to public finances through increased seigniorage revenue, and their more direct influence over non–bank financial institutions.

central banks exert a profound and fast–acting effect on market participants. Probably the best recent example is the so–called 'irrational exuberance' speech by Alan Greenspan on December 5, 1996. In his address to the American Enterprise Institute, Greenspan wondered whether "irrational exuberance [had] unduly escalated asset values" and warned that "we should not underestimate or become complacent about the complexity of the interactions of asset markets and the economy" (Greenspan, 1996). In response to this mild note of concern, markets around the world faltered, losing as much as 2% overnight. Although the effect was short–lived, it is likely that a stronger signal would have a more significant impact. Once a central bank has established the credibility of this new policy implement then it is likely that a cautionary announcement would be sufficient to cool markets appropriately, reducing the frequency of policy interventions.

### 5.5.3 A Simple ABRR Rule

Consider an economy with $n$ distinct classes of asset, $h_i$, each associated with a price level $p_i^h$. The rate of inflation of the price of asset $i$ is defined in the usual manner as $\pi_{i,t}^h = \Delta p_{i,t}/p_{i,t-1}$. Focusing solely on lending for simplicity, the institution of an ABRR system relies on the assumption that the central bank can identify loans associated with each asset class (i.e. there are $n$ classes of loans, $L_i$). The approach discussed below could be readily extended to the more general case in which other types of asset held by financial institutions are also subject to heterogeneous reserve requirements.

In an ABRR system, banks and other financial institutions are induced to hold non interest–bearing reserves against their outstanding loans in the proportion $\alpha_{i,t}$. The total quantity of reserves associated with asset $i$ is $\alpha_{i,t}L_{i,t}$. In the simplest case, assuming for now that the central bank base rate is exogenously fixed at the level $\bar{r}$, the opportunity cost of this reserve holding is $\bar{r}\alpha_{i,t}L_{i,t}$. In order to cover their operating costs and the risk of default, and to generate an operating profit, financial institutions will add a mark–up, $m_i$, to their costs[24]. Hence, the interest rate on class $i$ lending will be equal to $(1 + m_i)(1 + \alpha_{i,t})\bar{r}$, which reduces to the familiar case of $(1 + m_i)\bar{r}$ if the reserve requirement on asset $i$ is zero. This leads to a simple rule of the form:

$$\pi_{i,t}^h - \psi_{i,t} = (1 + m_i)(1 + \alpha_{i,t})\bar{r} \tag{5.24}$$

[24]Note that it is assumed that the mark–up may differ between different loan classes. This reflects different operating costs faced by the bank, as well as different probabilities of default. In general, there is little reason to believe that the mark–up is time–invariant: it would be relatively straightforward to accommodate a time–varying mark–up although it would not change the principle insights gained from the analysis.

where $\psi_{i,t}$ represents a 'fair' or sustainable return on investments in the $i$th asset class. It should be clear that $\psi_{i,t}$ is essentially an asset price inflation target. Recalling that $\bar{r}$ is determined exogenously, the policy instrument in this setting is the reserve requirement, $\alpha_{i,t}$. The principle is that the reserve requirement should be set in such a way as to equate the excess return on an investment with the cost of borrowing. The adjustment made to the return is not necessarily intended simply to compensate for the risk of the investment but also provides for a fair return on an investment[25].

In the more general case in which the base rate is determined by a simple inflation–targeting interest rate rule, one may write:

$$\pi^h_{i,t} - \psi_{i,t} = (1 + m_i)(1 + \alpha_{i,t}) r_t \quad (5.25)$$

$$r_t = \beta_0 + \beta_1 (\pi_t - \pi^*) \quad (5.26)$$

It is clear that, in this case, should the value of $\alpha_{i,t}$ remain unchanged while the base rate is increased due to rising inflationary pressure, the cost of class $i$ borrowing will increase. Assuming that the inflationary pressure was not rooted in wealth effects arising from inflation of the price of asset $i$, the cost of borrowing will come to exceed the adjusted return, depressing investment in that asset. Should the central bank wish to avoid this effect, it must decrease the reserve requirement $\alpha_{i,t}$ in proportion to the increase in the base rate, $\Delta r_t$. By contrast, if the inflationary pressure was thought to have been caused by inflation of the price of asset $i$, the correct response on the part of the central bank would be to increase $\alpha_{i,t}$ to equalise the cost of class $i$ borrowing and the adjusted return on class $i$ investments, while leaving the base rate unchanged. In such a setting, the source of inflationary pressure would be of paramount importance in the determination of the appropriate policy response and the interplay of reserve requirements and the base rate as implements of monetary policy becomes clear.

In practice, the fair rate of return on an asset would probably be defined as an acceptable range rather than a point target, giving the central bank a degree of discretion in its actions. In general, the wider the range, the greater the discretion of the policymaker. In such a setting, the central bank need not vary the $n$–vector of reserve requirements, $\boldsymbol{\alpha}$, in response to changes in the base rate to maintain precise parity between the left- and right–hand–sides of equation 5.25 at all times. Rather, it would be charged with ensur-

[25] Clearly, there is a minimum interest rate below which banks will not lend irrespective of the values of $\pi^h_{i,t}$, $\psi_{i,t}$ and $\alpha_{i,t}$. In particular, if $\pi^h_{i,t} < \psi_{i,t}$ the interest rate on lending will not become negative; banks will simply refuse to lend.

ing that individual markets do not become dangerously overheated, as would be reflected in the appearance of a significant imbalance between the adjusted return on asset $i$ and the associated cost of borrowing. This reflects the assumption that small imbalances between the adjusted rate of return and the cost of borrowing are not unduly harmful, and represents an acknowledgement of the fact that monetary policymaking is not an exact science.

In order to operate such a system, the central bank must be able to estimate the mark–up vector, $\boldsymbol{m}$, and to associate loans on the balance sheets of financial institutions with the relevant asset classes. The position of the central bank at the heart of the financial system provides it with a natural advantage in gathering information pertaining to these parameters and in estimating their values. Furthermore, the central bank must estimate an appropriate target level of inflation for each asset class. While Schwartz (2002, p. 23) stresses that the central bank "is not the arbiter of the correct level of asset prices", it has become clear in recent months that markets left unfettered and free may be rather self–destructive. The task of estimating an appropriate vector of asset price inflation targets would be conceptually similar to the identification of current price level inflation targets. It seems prudent to define the upper bound of the acceptable range with reference to the historical experience of previous bubbles. If, for example, house price inflation in excess of 5% per annum has been associated with bubbles in the past, then it may be considered that the relevant reserve requirement should be increased when house price growth exceeds this threshold. Such judgments are not pursued here but are left to expert analysis.

## 5.6 Concluding Remarks

The evidence adduced in this chapter suggests that the manipulation of the interest rate by the central bank in order to achieve an inflation target is potentially destabilising. Raising the interest rate reduces the internal funds of firms and simultaneously increases their debt–burden, thereby undermining their ability to service their debts. Furthermore, the results suggest that core inflation may be an insufficient summary statistic on which to base monetary policy decisions, as it fails to properly reflect conditions in the asset markets which, as we are all becoming increasingly aware, can have significant and long–lasting real effects. In this sense, monetary policy may be improved by responding to a range of asset market indicators as well as to traditional inflation measures and the output gap.

The dominant position (certainly among practitioners) that asset bubbles should not be a concern of monetary policy during their expansion, but that policy should be eased following a price correction, represents an asymmetric policy stance. Particularly to the extent that easy money policies on the part of a central bank may inflate bubbles, it seems likely that macroeconomic performance could be improved if the central bank were to explicitly acknowledge its role in shaping the development of conditions in the financial and asset markets.

By extension of this reasoning, it could be argued that the central bank should attempt to manage the expansion of bubbles, thereby either reducing the fallout should the bubble burst, or potentially averting the burst altogether (see Bordo and Jeanne, 2002, on preemptive policies to deflate bubbles and Filardo, 2004, on their strategic management). The contention that monetary policy should not respond to asset price misalignments on the grounds that they are unobservable is undermined by the fact that many of the variables already involved in policymaking are similarly unobservable (Cecchetti et al., 2000). Moreover, Filardo (2004) has shown that even if the estimation of the extent of market disequilibrium is not feasible then, under certain assumptions, it is optimal for the monetary authority to respond to the level of asset prices. An alternative approach is to acknowledge that conditions in financial markets may impose constraints on the monetary policy decision. In this way, the monetary authority may pursue anti–inflationary interest rate policies provided that they do not conflict with its fundamental responsibility to maintain financial stability.

This leaves open the issue of how best to deal with sectoral asset price misalignments. In the words of Chairman Bernanke, the interest rate implement is a 'blunt tool' which has economy–wide effects. Considered in conjunction with the findings of this chapter, it is unlikely that the interest rate is the appropriate tool with which to respond to sectoral bubbles. Furthermore, the logic of Tinbergen's (1952) targets–and–instruments approach suggests that the use of a single policy implement to achieve multiple goals is not feasible unless those goals are perfectly mutually consistent. There is no particular reason to think that this would be the case in the context of asset price stabilisation; some markets may be excessively bullish while others are performing poorly. The manipulation of capital requirements by loan–type in the manner advocated by Palley (2004; 2006) represents an alternative to interest rate policy in such situations. Furthermore, this combined approach to monetary policymaking has the potential to reduce the volatility of the interest rate, thereby reducing the likelihood of the emergence of widespread financial fragility.

# Chapter 6

# Monetary Policymaking in an Open Economy

## 6.1 Introduction

Recent years have seen a gradual shift in the operating regimes of many modern central banks toward inflation–targeting, in which the monetary authority commits to set the interest rate in such a way as to achieve a desired level of inflation (or more accurately forecast inflation). Underlying this paradigm shift is the New Consensus macroeconomic model, which stresses the need for a nominal anchor in the economy and focuses on demand side explanations of inflation. The assumption that agents are Ricardian renders fiscal policy impotent, leaving monetary policy as the only viable means of stabilising macroeconomic fluctuations.

While the institutional arrangements surrounding IT strategies vary from country to country, it is possible to identify a number of common elements. Probably the most fundamental commonality is the choice of the targeted measure of inflation. In general, most inflation targeters attempt to stabilise CPI or some variant thereof either below a threshold or, more often, within a band. CPI measures the price of a representative basket of goods and, as such, includes imported products and services. When expressed in this way, it is clear that fluctuations in the exchange rate may pass through to the rate of CPI inflation (this effect is evident in the six equation New Consensus model discussed in Section 2.2). This leads to two propositions. Firstly, particularly for a small open economy, it is essential that models of monetary policy explicitly account for the relationship between the interest rate, the exchange rate and the broader macroeconomy (c.f. Svensson, 2000, especially p. 158, and also the Report of the House of Lords Select Committee on the Monetary Policy Committee at the Bank of England, which estimates that more than 60% of the inflation–damping effect of a 100 basis point interest rate hike maintained for one year comes about through the exchange rate channel in the first year (House of Lords, 1999, ¶4.34 and Table A)). Secondly, and perhaps less obviously, by targeting an inflation metric that incorporates imported goods, the monetary authority implicitly responds to the exchange rate to some degree.

Despite the importance of open economy effects in the monetary policy decision process, much of the existing literature on inflation–targeting employs a closed economy framework. Prominent examples of closed economy models include Bernanke and Blinder (1992), Bernanke et al. (1999), Clarida et al. (1999; 2000), McCallum (2001) and Meyer (2001a). As well as omitting arguably the single most important channel of monetary policy transmission in the short–run, such models cannot illuminate the interaction between monetary policy and the government budget deficit, the current account and the capital account. In the case of the small and highly open UK economy, these effects are of paramount importance, particularly given the large budget deficit operated by the Labour Government in recent years.

The purpose of this chapter is to assess the performance of a variety of inflation–targeting policies in the context of a stock–flow consistent (SFC) open economy model. The model is an extension of the advanced open economy framework of Godley and Lavoie (2006, ch. 12) which models two interdependent economies with financial and trade relations. The addition of a simple conflicting claims process to the Godley–Lavoie framework introduces persistent inflation, providing a basis for the analysis of inflation–targeting policies. Furthermore, the specification of the marginal propensities to consume out of income and wealth as negative functions of the real interest rate introduces cyclicality, motivating the use of stabilisation policy. Using this framework, a number of candidate stabilisation regimes are compared to the benchmark case of non–intervention, including simple procyclical inflation–targeting, interest rate leadership and combinations involving countercyclical fiscal policy.

Each closure of the model is subjected to three different shocks and the adjustment path and subsequent trajectory of each economy is mapped. The three scenarios involve a step decrease in UK exports, an increase in UK real wage pressure and an expansionary income tax cut in the US. Each of these shocks works through the model in a different way, testing the ability of each candidate policy rule to cope with heterogeneous disturbances. The results suggest that the source of inflationary pressure is of fundamental importance in identifying the correct response. Moreover, the simulations indicate that the combination of fiscal and monetary policy measures yields superior stabilising performance compared to simple monetary policy rules (c.f. Leith and Wren-Lewis, 2000; 2006; 2008). The model also provides evidence of the indeterminacy of the effects of the exchange rate channel of monetary transmission identified by Arestis and Sawyer (2004), although with the added complication that the means by which the government chooses to fund its deficit is important in determining the path of the exchange rate.

The chapter progresses in five sections. Section 6.2 outlines the underlying accounting structure and presents the model equations in detail. Section 6.3 investigates the stabilisation performance of each candidate IT policy in the wake of the three shocks mentioned above. Section 6.4 draws out a number of policy implications, while Section 6.5 concludes.

## 6.2 Inflation–Targeting in an Open Economy SFC Model

The stock–flow consistent approach to macroeconomic modelling originated in the 1960's jointly at Yale, under the leadership of James Tobin, and at Cambridge, where it was associated with Wynne Godley. SFC modelling is based on a rigorous treatment of the interlinkages between the various sectors of the economy. An SFC model is built on a formal double–entry accounting structure from which accounting identities are derived. In such a system, there is a counterparty to all transactions and the origin and destination of all flows are made explicit. The advantage of such a rigorous approach is that it ensures that, at all times, the model describes "a logically coherent world" (Godley and Lavoie 2006, p. 11). Simply put, ensuring continuous stock–flow consistency results in a model that is built on solid foundations.

SFC modelling provides considerably richer insights than traditional equilibrium–based approaches to modelling due to its inherent dynamics; flows are simply changes in the value of stocks through time (i.e. $x_t + \Delta x_{t,t+1} = x_{t+1}$). In constructing and simulating an SFC model, one's primary interest is not the steady state of the model but rather the traverse between (steady) states. Furthermore, the completeness of the accounting framework illuminates the sequence of events that comprise this traverse, lifting the lid of the famous 'black box'. Indeed, the clarity with which SFC modelling presents the inter–sectoral and international flows of funds renders it an unusually powerful tool for the analysis of open economic models.

The advantage of model–based simulation compared to estimation is that it "guarantees us an Olympian knowledge of the true structure that is generating the observations" (Brainard and Tobin, 1968, p. 99). Given the often contradictory nature of empirical research into exchange rate determination, and the regularity with which supposedly inviolable identities are rejected by empirical testing (see, for example, the survey of Froot and Thaler, 1990), this is an enviable property of the model which lends courage to my conviction that it is the appropriate strategy to pursue in the current context.

One must not lose sight of the fact that the results of model–based simulations are generally somewhat sensitive to the parameterisation of the model and, to a lesser degree, to the choice of initial conditions. As with any modelling exercise, the output is only as reliable as the input. Godley and Lavoie approach the issue of parameterisation by the use of 'stock–flow norms' similar in spirit to Kaldorian stylised facts and normal ratios. This is the approach followed throughout this chapter.

The model developed here is a modified and extended version of Godley and Lavoie's (2006) advanced open economy model. Equations defining the real wage aspirations of workers and a simple partial adjustment process for nominal wages are added to the basic model to introduce inflationary forces. Furthermore, the marginal propensities to consume out of disposable income and wealth are endogenised as negative functions of the real interest rate in order to generate cyclical behaviour in the aftermath of a shock. Using this framework, simple procyclical inflation targeting (IT) and leader–follower interest rate rules are investigated both in isolation and in conjunction with countercyclical fiscal policy.

The model remains simple in a number of ways. The commercial banking sector is omitted in the interests of tractability, firms do not invest either in fixed capital goods or inventory accumulation, the model abstracts from growth and all business profits are assumed to be immediately distributed to households. Despite these simplifying assumptions, the model still contains more than one hundred equations.

### 6.2.1 Notational Conventions

Following Godley and Lavoie, the two countries in the model are identified using \$ and £ symbols and, occasionally, with reference to 'the Fed' or 'the Bank of England', for example. It should be noted, however, that the model has not been calibrated to these countries and that the terminology is used simply for comparability with the existing work in the field. The following notational conventions are used throughout this chapter:

i. A superscript '\$' or '£' denotes the country of issuance of an asset;

ii. A subscript '\$' or '£' denotes the country where an asset is held;

iii. A subscript '$d$' denotes demand. In the case of foreign assets, demand is denominated in the currency of the demanding country;

iv. A subscript '$s$' denotes supply. In the case of international assets, supply is denominated in the currency of the issuing country;

v. Capital letters denote nominal values, lower case and Greek letters signify real quantities and parameters, respectively;

vi. A subscript '$e$' denotes an expected value;

vii. '$xr^{\$}$' is the Sterling value of the Dollar. $\$1 = £xr^{\$}$ and $xr^{£} = 1/xr^{\$}$; and

viii. '$\Delta$' is the backward difference operator and a '$d$' prefix indicates a proportional rate of change (i.e. $dxr^{\$}_{e} = \Delta xr^{\$}_{e}/xr^{\$}$).

The terminology used in the model should be relatively self–explanatory. A glossary of all the variables and parameters contained in the model may be found in the Appendix.

### 6.2.2 The Balance Sheet and Transactions–Flow Matrices

The accounting framework underpinning the model is described by Tables 6.1 and 6.2 which present the balance sheet and transactions–flow matrices, respectively. One should note that the model consists of two distinct economies, each of which is comprised of four sectors: households, firms, government and an independent central bank. The financial assets in the model are UK and US government bills, which are internationally traded, and high–powered money which is only used by domestic agents. Gold appears on the balance sheet of the central bank as a remnant of the Bretton Woods era in the Godley and Lavoie model but is included here to provide a means by which the model may be easily modified to represent a situation in which the international asset held by the central banks is not a liability of either government. Although this line of enquiry is not pursued here, it remains a potentially fruitful avenue for further research. The government is assumed to derive income both from levying income taxes on its subjects and from appropriating the operating profits of the national central bank. This is not, however, intended to suggest that the independence of the central bank is incomplete. It is merely a convenient simplification of the modelling.

In any stock–flow consistent model, all rows and columns in the transactions–flow matrix must simultaneously sum to zero to ensure that the accounting underlying the model is consistent. Similarly, all columns in the balance sheet matrix must sum to zero, although rows defining stocks of physical assets (gold in this case) need not. However, while the sum of the row entitled 'gold' in the balance sheet matrix is non–zero, the resulting positive value is balanced exactly by the sum of the entries in the row entitled

| | UK Economy | | | | | US Economy | | | | $\Sigma$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | H/holds | Firms | Govt | CB | | H/holds | Firms | Govt | CB | |
| Base money | $+H^{£}$ | | | $-H^{£}$ | | $+H^{\$}$ | | | $-H^{\$}$ | 0 |
| £ bills | $+B^{£}_{£}$ | | $-B^{£}$ | $+B^{£}_{cb£}$ | $\cdot xr^{£}$ | $+B^{£}_{\$} \cdot xr^{£}$ | | | | 0 |
| \$ bills | $+B^{\$}_{£} \cdot xr^{\$}$ | | | $+B^{\$}_{cb£} \cdot xr^{\$}$ | $\cdot xr^{£}$ | $+B^{\$}_{\$}$ | | $-B^{\$}$ | $+B^{\$}_{cb\$}$ | 0 |
| Gold | | | | $+au^{£} \cdot p^{£}_{g}$ | $\cdot xr^{£}$ | | | | $+au^{\$} \cdot p^{\$}_{g}$ | $+\sum au \cdot p^{\$}_{g}$ |
| Balance | $-V^{£}$ | | $-V^{£}_{g}$ | $-V^{£}_{cb}$ | $\cdot xr^{£}$ | $-V^{\$}$ | | $-V^{\$}_{g}$ | 0 | $-\sum au \cdot p^{\$}_{g}$ |
| $\Sigma$ | 0 | 0 | 0 | 0 | $\cdot xr^{£}$ | 0 | 0 | 0 | 0 | 0 |

Table 6.1: Balance Sheet Matrix

| | UK Economy | | | | | US Economy | | | | $\Sigma$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | H/holds | Firms | Govt | CB | | H/holds | Firms | Govt | CB | |
| Cons. | $-C^{\pounds}$ | $+C^{\pounds}$ | | | | $-C^{\$}$ | $+C^{\$}$ | | | 0 |
| Gov. purch. | | $+G^{\pounds}$ | $-G^{\pounds}$ | | | | $+G^{\$}$ | $-G^{\$}$ | | 0 |
| Trade | | $-IM^{\pounds}$ | | | $\cdot xr^{\pounds}$ | | $+X^{\$}$ | | | 0 |
| | | $+X^{\pounds}$ | | | $\cdot xr^{\pounds}$ | | $-IM^{\$}$ | | | 0 |
| GDP | $+Y^{\pounds}$ | $-Y^{\pounds}$ | | | | $+Y^{\$}$ | $-Y^{\$}$ | | | 0 |
| Tax | $-T^{\pounds}$ | | $+T^{\pounds}$ | | | $-T^{\$}$ | | $+T^{\$}$ | | 0 |
| CB profits | | | $+F^{\pounds}_{cb}$ | $-F^{\pounds}_{cb}$ | | | | $+F^{\$}_{cb}$ | $-F^{\$}_{cb}$ | 0 |
| Interest on: | | | | | | | | | | 0 |
| £ bills | $+r^{\pounds}_{b-1} \cdot B^{\pounds}_{\pounds-1}$ | | $-r^{\pounds}_{b-1} \cdot B^{\pounds}_{-1}$ | $+r^{\pounds}_{b-1} \cdot B^{\pounds}_{cb\pounds-1}$ | $\cdot xr^{\pounds}$ | $+r^{\pounds}_{b-1} \cdot B^{\pounds}_{\$-1} \cdot xr^{\pounds}$ | | | | 0 |
| \$ bills | $+r^{\$}_{b-1} \cdot B^{\$}_{\pounds-1} \cdot xr^{\$}$ | | | $+r^{\$}_{b-1} \cdot B^{\$}_{cb\pounds-1} \cdot xr^{\$}$ | $\cdot xr^{\pounds}$ | $+r^{\$}_{b-1} \cdot B^{\$}_{\$-1}$ | | $-r^{\$}_{b-1} \cdot B^{\$}_{-1}$ | $+r^{\$}_{b-1} \cdot B^{\$}_{cb\$-1}$ | 0 |
| $\Delta$ stock of: | | | | | | | | | | 0 |
| Cash | $-\Delta H^{\pounds}$ | | | $+\Delta H^{\pounds}$ | | $-\Delta H^{\$}$ | | | $+\Delta H^{\$}$ | 0 |
| £ bills | $-\Delta B^{\pounds}_{\pounds}$ | | $+\Delta B^{\pounds}$ | $-\Delta B^{\pounds}_{cb\pounds}$ | $\cdot xr^{\pounds}$ | $-\Delta B^{\pounds}_{\$} \cdot xr^{\pounds}$ | | $+\Delta B^{\$}$ | | 0 |
| \$ bills | $-\Delta B^{\$}_{\pounds} \cdot xr^{\$}$ | | | $-\Delta B^{\$}_{cb\pounds} \cdot xr^{\$}$ | $\cdot xr^{\pounds}$ | $-\Delta B^{\$}_{\$}$ | | | $-\Delta B^{\$}_{cb\$}$ | 0 |
| Gold | | | | $-\Delta au^{\pounds} \cdot p^{\pounds}_{g}$ | $\cdot xr^{\pounds}$ | | | | $-\Delta au^{\$} \cdot p^{\$}_{g}$ | 0 |
| $\Sigma$ | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |

Table 6.2: Transactions–Flow Matrix

'balance'. This indicates that the stock of gold held by the two central banks is equal to the sum of the net worth of households, governments and the UK central bank. This ensures that the matrix as a whole is balanced.

Following Godley and Lavoie, it is assumed that the UK central bank holds US treasury bills for settlement purposes but that the US central bank does not hold UK bills. Furthermore, given that the price of gold is assumed to be fixed in Dollar terms, its price in Pounds may fluctuate as a result of exchange rate movements. Hence, the UK central bank may accrue capital gains or losses and may, therefore, have non–zero net wealth[1]. By contrast, the US central bank must, at all times, have precisely zero net wealth in this model. Finally, it should be stressed that uses of funds appear with a negative sign in the transactions–flow matrix even though the agent may be accumulating assets. Although households are accumulating financial assets when they buy bonds, it must not be forgotten that they are expending funds in order to make the purchase.

### 6.2.3 Firms' Equations

The following equations define the UK firm sector:

$$
\begin{aligned}
Y^{£} &= C^{£} + G^{£} + X^{£} - IM^{£} && (6.1)\\
y^{£} &= s^{£} - im^{£} && (6.2)\\
N^{£} &= y^{£}/pr^{£} && (6.3)\\
WB^{£} &= N^{£} \cdot W^{£} && (6.4)\\
UC^{£} &= \frac{WB^{£} + IM^{£}}{s^{£}} && (6.5)\\
p_s^{£} &= \left(1 + \phi^{£}\right) \cdot UC^{£} && (6.6)\\
s^{£} &= c^{£} + g^{£} + x^{£} && (6.7)\\
S^{£} &= p_s^{£} \cdot s^{£} && (6.8)
\end{aligned}
$$

Equations 6.1 and 6.2 define nominal and real output with recourse to the familiar national accounts identity. Equation 6.3 defines the level of employment in the economy as the ratio of output to the productivity of labour. The nominal wage bill is defined by equation 6.4 as the product of the nominal wage and employment. Similarly, equation 6.5 defines the unit costs faced by firms as the sum of the wage bill and nominal imports divided by real sales. Note that the denominator in this case is real sales and not real

[1]Note that capital gains are not transactions (i.e. there is no counterparty) and so they do not appear in the transactions–flow matrix.

output as the latter excludes imports. Furthermore, the reader should note that the capital stock does not enter into the model and so labour is the sole input in the productive process. The sales price is determined as a simple mark–up ($\phi^{£}$) over unit costs (equation 6.6). Equations 6.7 and 6.8 express real and nominal sales once again using the national accounts identity.

Similarly for the US one may write:

$$Y^{\$} = C^{\$} + G^{\$} + X^{\$} - IM^{\$} \tag{6.9}$$

$$y^{\$} = s^{\$} - im^{\$} \tag{6.10}$$

$$N^{\$} = y^{\$}/pr^{\$} \tag{6.11}$$

$$WB^{\$} = N^{\$} \cdot W^{\$} \tag{6.12}$$

$$UC^{\$} = \frac{WB^{\$} + IM^{\$}}{s^{\$}} \tag{6.13}$$

$$p_s^{\$} = \left(1 + \phi^{\$}\right) \cdot UC^{\$} \tag{6.14}$$

$$s^{\$} = c^{\$} + g^{\$} + x^{\$} \tag{6.15}$$

$$S^{\$} = p_s^{\$} \cdot s^{\$} \tag{6.16}$$

### 6.2.4 Household Equations

The following equations define income, wealth and the consumption decision for UK households:

$$YD_r^{£} = Y^{£} + r_{-1}^{£} \cdot B_{£s-1}^{£} + r_{-1}^{\$} \cdot B_{£s-1}^{\$} \cdot xr^{\$} - T^{£} \tag{6.17}$$

$$YD_{hs}^{£} = YD_r^{£} + \Delta xr^{\$} \cdot B_{£s-1}^{\$} \tag{6.18}$$

$$\begin{aligned} V^{£} &= V_{-1}^{£} + YD_{hs}^{£} - C^{£} \\ &= V_{-1}^{£} + YD_r^{£} - C^{£} + \Delta xr^{\$} \cdot B_{£s-1}^{\$} \\ &= V_{-1}^{£} + NAFA^{£} + CG^{£} \end{aligned} \tag{6.19}$$

$$yd_{hs}^{£} = \frac{YD_{hs}^{£}}{p_{ds}^{£}} - v_{-1}^{£} \cdot \frac{\Delta p_{ds}^{£}}{p_{ds}^{£}} \tag{6.20}$$

$$v^{£} = V^{£}/p_{ds}^{£} \tag{6.21}$$

$$c^{£} = \alpha_1^{£} \cdot yd_{hse}^{£} + \alpha_2^{£} \cdot v_{-1}^{£} \tag{6.22}$$

$$yd_{hse}^{£} = \frac{1}{2} \cdot \left(yd_{hs}^{£} + yd_{hs-1}^{£}\right) \tag{6.23}$$

$$C^{£} = c^{£} \cdot p_{ds}^{£} \tag{6.24}$$

Equation 6.17 defines the regular disposable income of UK households as GDP plus interest income less tax on regular income. The Haig–Simons (Haig, 1921; Simons, 1938) definition of disposable income adjusts regular disposable income to take account of capital gains arising through exchange rate fluctuations (equation 6.18). Equation 6.19 notes that nominal wealth accumulates when nominal Haig–Simons disposable income exceeds nominal consumption. A simple re–arrangement of the equation reveals that the change in nominal wealth is equal to the sum of the net accumulation of financial assets ($NAFA$) and capital gains ($CG$).

Real Haig–Simons disposable income is defined by equation 6.20 in a manner which adjusts appropriately for the erosion of the purchasing power of money which comes about through inflation, and the obvious ramifications that this has for the purchasing power of the stock of household wealth. Equation 6.21 defines real wealth as nominal wealth deflated by the domestic price level (which is discussed later). Equation 6.22 states that the household consumption decision is based on real magnitudes as opposed to nominal magnitudes. This implies that households are aware of the inflationary erosion of purchasing and do not suffer from money–illusion. The consumption function takes expected real Haig–Simons disposable income as one of its arguments; this is described by a simple adaptive expectations equation of the form of equation 6.23. The nominal value of consumption is then retrieved by simply multiplying real consumption by the domestic price level. As usual, equivalent expressions may be constructed for the US economy as follows:

$$
\begin{aligned}
YD_r^{\$} &= Y^{\$} + r_{-1}^{\$} \cdot B_{\$s-1}^{\$} + r_{-1}^{£} \cdot B_{\$s-1}^{£} \cdot xr^{£} - T^{\$} && (6.25)\\
YD_{hs}^{\$} &= YD_r^{\$} + \Delta xr^{£} \cdot B_{\$s-1}^{£} && (6.26)\\
V^{\$} &= V_{-1}^{\$} + YD_{hs}^{\$} - C^{\$} \\
&= V_{-1}^{\$} + YD_r^{\$} - C^{\$} + \Delta xr^{£} \cdot B_{\$s-1}^{£} \\
&= V_{-1}^{\$} + NAFA^{\$} + CG^{\$} && (6.27)\\
yd_{hs}^{\$} &= \frac{YD_{hs}^{\$}}{p_{ds}^{\$}} - v_{-1}^{\$} \cdot \frac{\Delta p_{ds}^{\$}}{p_{ds}^{\$}} && (6.28)\\
v^{\$} &= V^{\$}/p_{ds}^{\$} && (6.29)\\
c^{\$} &= \alpha_1^{\$} \cdot yd_{hse}^{\$} + \alpha_2^{\$} \cdot v_{-1}^{\$} && (6.30)\\
yd_{hse}^{\$} &= \frac{1}{2} \cdot \left( yd_{hs}^{\$} + yd_{hs-1}^{\$} \right) && (6.31)\\
C^{\$} &= c^{\$} \cdot p_{ds}^{\$} && (6.32)
\end{aligned}
$$

The $\alpha$ parameters in the consumption function represent the marginal propensities to consume out of disposable income and wealth. Godley and Lavoie treat these propensities as exogenous throughout their modelling. However, given that the focus of this chapter is on monetary policy, it seems preferable to endogenise these parameters, specifying them as functions the real interest rate[2]. In this way, an interest rate hike may reduce consumption and thereby aggregate activity. In the case of the marginal propensity to consume out of income, this may be represented as follows:

$$\begin{aligned}
\alpha_1^{£} &= \widetilde{\alpha_1^{£}} - \mu_{\alpha_1}^{£}\left(rr^{£} - \widetilde{rr^{£}}\right)\left(1 - z1^{£}\right)\left(1 - z2^{£}\right) + z1^{£}\cdot\alpha_{1L}^{£} + z2^{£}\cdot\alpha_{1U}^{£} && (6.33)\\
\alpha_1^{\$} &= \widetilde{\alpha_1^{\$}} - \mu_{\alpha_1}^{\$}\left(rr^{\$} - \widetilde{rr^{\$}}\right)\left(1 - z1^{\$}\right)\left(1 - z2^{\$}\right) + z1^{\$}\cdot\alpha_{1L}^{\$} + z2^{\$}\cdot\alpha_{1U}^{\$} && (6.34)\\
z1^{£} &= 1 \quad \text{iff} \quad \alpha_1^{£} < \alpha_{1L}^{£} && (6.35)\\
z1^{\$} &= 1 \quad \text{iff} \quad \alpha_1^{\$} < \alpha_{1L}^{\$} && (6.36)\\
z2^{£} &= 1 \quad \text{iff} \quad \alpha_1^{£} > \alpha_{1U}^{£} && (6.37)\\
z2^{\$} &= 1 \quad \text{iff} \quad \alpha_1^{\$} > \alpha_{1U}^{\$} && (6.38)\\
rr^{£} &= \frac{1 + r^{£}}{1 + \pi_{ds}^{£}} - 1 && (6.39)\\
rr^{\$} &= \frac{1 + r^{\$}}{1 + \pi_{ds}^{£}} - 1 && (6.40)
\end{aligned}$$

The $\mu_{\alpha_1}$ parameters measure the strength of the response to the changes in the real interest rate and the $z1$ and $z2$ series ensure that the value of the marginal propensity to consume does not move outside the band defined by $\alpha_{1L}$ and $\alpha_{1U}$ for each country. Equations 6.39 and 6.40 offer the standard definition of the real interest rate. A tilde symbol denotes the value taken by a variable in the initial steady state, reflecting the assumption that this initial state is the equilibrium targeted by stabilisation policies (this is discussed in more depth later). Equivalently, the marginal propensity to consume out of wealth is modelled as follows:

$$\begin{aligned}
\alpha_2^{£} &= \widetilde{\alpha_2^{£}} - \mu_{\alpha_2}^{£}\left(rr^{£} - \widetilde{rr^{£}}\right)\left(1 - z3^{£}\right)\left(1 - z4^{£}\right) + z3^{£}\cdot\alpha_{2L}^{£} + z4^{£}\cdot\alpha_{2U}^{£} && (6.41)\\
\alpha_2^{\$} &= \widetilde{\alpha_2^{\$}} - \mu_{\alpha_2}^{\$}\left(rr^{\$} - \widetilde{rr^{\$}}\right)\left(1 - z3^{\$}\right)\left(1 - z4^{\$}\right) + z3^{\$}\cdot\alpha_{2L}^{\$} + z4^{\$}\cdot\alpha_{2U}^{\$} && (6.42)\\
z3^{£} &= 1 \quad \text{iff} \quad \alpha_2^{£} < \alpha_{2L}^{£} && (6.43)\\
z3^{\$} &= 1 \quad \text{iff} \quad \alpha_2^{\$} < \alpha_{2L}^{\$} && (6.44)
\end{aligned}$$

[2] An early discussion of the effect of the interest rate on consumption propensities was provided by Milton Friedman (1957) in relation to the Permanent Income Hypothesis.

$$
\begin{aligned}
z4^{£} &= 1 \quad \text{iff} \quad \alpha_2^{£} > \alpha_{2U}^{£} && (6.45)\\
z4^{\$} &= 1 \quad \text{iff} \quad \alpha_2^{\$} > \alpha_{2U}^{\$} && (6.46)
\end{aligned}
$$

### 6.2.5 Household Portfolio Equations

The portfolio decisions of households are modelled following the principles laid out by Brainard and Tobin (1968) and Tobin (1969). They formalised the notion that a household cannot increase the proportion of its wealth that is held in any one asset class without reducing its relative holdings of other asset classes. That is to say that the proportions of household wealth allocated to each asset class must sum to unity. In the interest of simplicity, the portfolio equations are constructed using nominal rates of return as opposed to real rates. It follows that the results will be equivalent in either case as the differential between nominal rates of return is equal to that between equivalent real rates. Consider the approximate real rate of return on two different assets, defined as the appropriate nominal rates less the rate of inflation which is common in both cases: $r_1 = i_1 - \pi$ and $r_2 = i_2 - \pi$. It follows that $r_1 - r_2 = (i_1 - \pi) - (i_2 - \pi) = i_1 - \pi - i_2 + \pi = i_1 - i_2$.

Equations 6.47, 6.48 and 6.49A represent the portfolio equations for UK households, where the transactions demand for money has been omitted in the interests of simplicity. However, in a setting in which expectations are prone to frustration, there must be a buffer asset to absorb the resulting fluctuations without violating the accounting framework. Following Godley and Lavoie, it is assumed that cash holdings perform this role and so equation 6.49 is used rather than equation 6.49A. The 'A' suffix indicates that this equation is omitted from the simulated model.

$$
\begin{aligned}
B_{£d}^{£} &= V^{£} \cdot \left(\lambda_{10} + \lambda_{11} \cdot r^{£} + \lambda_{12} \cdot \left(r^{\$} + dxr_e^{\$}\right)\right) && (6.47)\\
B_{£d}^{\$} &= V^{£} \cdot \left(\lambda_{20} + \lambda_{21} \cdot r^{£} + \lambda_{22} \cdot \left(r^{\$} + dxr_e^{\$}\right)\right) && (6.48)\\
H_d^{£} &= V^{£} - B_{£d}^{£} - B_{£d}^{\$} && (6.49)
\end{aligned}
$$

$$
H_d^{£} = V^{£} \cdot \left(\lambda_{30} + \lambda_{31} \cdot r^{£} + \lambda_{32} \cdot \left(r^{\$} + dxr_e^{\$}\right)\right) \qquad (6.49\text{A})
$$

Focusing once again on the three standard portfolio equations (6.47, 6.48 and 6.49A), the Brainard–Tobin constraints are most easily visualised if the system is re–written in matrix form as follows:

$$\begin{bmatrix} B^{£}_{£d} \\ B^{\$}_{£d} \\ H^{£}_{d} \end{bmatrix} = \begin{bmatrix} \lambda_{10} \\ \lambda_{20} \\ \lambda_{30} \end{bmatrix} \cdot V^{£} + \begin{bmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} \\ \lambda_{21} & \lambda_{22} & \lambda_{23} \\ \lambda_{31} & \lambda_{32} & \lambda_{33} \end{bmatrix} \cdot \begin{bmatrix} r^{£} \\ r^{\$} + dxr^{\$}_{e} \\ 0 \end{bmatrix} \cdot V^{£}$$

The vertical adding up constraints imply that $\sum_i \lambda_{i0} = 1$ and $\sum_i \lambda_{ij} = 0$ for $i, j = 1, 2, 3$. The symmetry constraints associated with Friedman (1978) imply that $\lambda_{12} = \lambda_{21}$, $\lambda_{13} = \lambda_{31}$ and $\lambda_{23} = \lambda_{32}$. However, because the nominal rate of return on cash holdings is zero, the last two of these conditions are obsolete.

Taken together, Tobin's vertical constraints and Friedman's symmetry constraints imply a set of horizontal adding up constraints, as noted by Godley (1996):

$$\lambda_{11} = -\left(\lambda_{12} + \lambda_{13}\right) \quad ; \quad \lambda_{22} = -\left(\lambda_{21} + \lambda_{23}\right) \quad ; \quad \lambda_{33} = -\left(\lambda_{31} + \lambda_{32}\right)$$

The logic underpinning the portfolio equations requires that the coefficient on the own rate of return in each equation is positive while those on the rates of return associated with other assets are negative. Hence, in the $3 \times 3$ matrix of $\lambda$'s, only the prime diagonal values are positive.

The nominal rate of return on US bills is equal to the nominal interest rate plus the expected change in the exchange rate over the relevant timeframe, $dxr^{\$}_{e}$. Godley and Lavoie (pp. 459-60) assume that $dxr^{\$}_{e} = dxr^{£}_{e} = 0$, which implies that investors expect the exchange rate to remain unchanged. Alternatively, one could impose uncovered interest parity, although its aforementioned unsatisfactory empirical performance, coupled with various theoretical concerns (see Godley and Lavoie, pp. 459-60, for more detail), cautions against this approach.

Similarly, the portfolio decisions of US households are modelled according to equations 6.50-6.52/6.52A and are subject to the same constraints on the $\gamma$ parameters.

$$\begin{aligned} B^{\$}_{\$d} &= V^{\$} \cdot \left(\gamma_{10} + \gamma_{11} \cdot r^{\$} + \gamma_{12} \cdot \left(r^{£} + dxr^{£}_{e}\right)\right) && (6.50) \\ B^{£}_{\$d} &= V^{\$} \cdot \left(\gamma_{20} + \gamma_{21} \cdot r^{\$} + \gamma_{22} \cdot \left(r^{£} + dxr^{£}_{e}\right)\right) && (6.51) \\ H^{\$}_{d} &= V^{\$} - B^{\$}_{\$d} - B^{£}_{\$d} && (6.52) \end{aligned}$$

$$H^{\$}_{d} = V^{\$} \cdot \left(\gamma_{30} + \gamma_{31} \cdot r^{\$} + \gamma_{32} \cdot \left(r^{£} + dxr^{£}_{e}\right)\right) \qquad (6.52A)$$

### 6.2.6 Government Equations

Equation 6.53 defines nominal tax revenues accruing to the UK Government as a proportion, $\theta^{£}$, of regular household income. Nominal government spending is the product of the price level and real government spending, which is assumed to be determined exogenously in this simple closure of the model (equations 6.54 and 6.55). The public sector borrowing requirement ($PSBR$) is defined by equation 6.56 as the sum of nominal government expenditures and the cost of servicing existing public debt. Equation 6.57 states that bills are issued in the amount required to cover the $PSBR$ after accounting for government revenues derived from tax receipts and the profits of the central bank.

$$
\begin{aligned}
T^{£} &= \theta^{£} \cdot \left(Y^{£} + r^{£}_{-1} \cdot B^{£}_{£s-1} + r^{\$}_{-1} \cdot B^{\$}_{£s-1} \cdot xr^{\$}\right) && (6.53)\\
g^{£} &= \overline{g^{£}} && (6.54)\\
G^{£} &= p^{£}_{ds} \cdot g^{£} && (6.55)\\
PSBR^{£} &= G^{£} + r^{£}_{-1} \cdot B^{£}_{s-1} - \left(T^{£} + F^{£}_{cb}\right) && (6.56)\\
B^{£}_{s} &= B^{£}_{s-1} + G^{£} - T^{£} + r^{£}_{-1} \cdot B^{£}_{s-1} - F^{£}_{cb} && (6.57)
\end{aligned}
$$

The US Government may be described similarly as follows:

$$
\begin{aligned}
T^{\$} &= \theta^{\$} \cdot \left(Y^{\$} + r^{\$}_{-1} \cdot B^{\$}_{\$s-1} + r^{£}_{-1} \cdot B^{£}_{\$s-1} \cdot xr^{£}\right) && (6.58)\\
g^{\$} &= \overline{g^{\$}} && (6.59)\\
G^{\$} &= p^{\$}_{ds} \cdot g^{\$} && (6.60)\\
PSBR^{\$} &= G^{\$} + r^{\$}_{-1} \cdot B^{\$}_{s-1} - \left(T^{\$} + F^{\$}_{cb}\right) && (6.61)\\
B^{\$}_{s} &= B^{\$}_{s-1} + G^{\$} - T^{\$} + r^{\$}_{-1} \cdot B^{\$}_{s-1} - F^{\$}_{cb} && (6.62)
\end{aligned}
$$

### 6.2.7 Inflationary Forces

Inflationary pressure is introduced into the model as a conflicting claims process in which workers enter nominal wage negotiations with a target real wage in mind. In the UK economy, the target real wage is defined by equation 6.63 as a function of labour productivity and the employment rate (i.e. a measure of the size of the 'reserve army' of unemployed labour). The nominal wage then adjusts toward the targeted real wage at the rate $\Omega^{£}_{3}$ (equation 6.64). Equation 6.65 offers the standard definition of the rate of sales price inflation, although this includes the price of exported goods. In order to define an appropriate domestic price index, it is necessary to remove exports. Equations 6.66 and 6.67 define the nominal value and real quantity of domestic sales, respectively, while equation 6.68 defines the domestic sales deflator. It is then a simple matter to define the rate of inflation of domestic sales. Godley and Lavoie argue that the price of domestic sales is approximately equivalent to CPI inflation (p. 455). This is particularly important in the current application, as it suggests that it is $\pi_{ds}$ rather than $\pi_s$ that should be the target of monetary policy.

$$\omega^{T£} = \Omega_0^{£} + \Omega_1^{£} \cdot pr^{£} + \Omega_2^{£} \cdot \left(N^{£}/N_{fe}^{£}\right) \tag{6.63}$$

$$W^{£} = W_{-1}^{£} \cdot \left(1 + \Omega_3^{£} \cdot \left(\omega_{-1}^{T£} - W_{-1}^{£}/p_{-1}^{£}\right)\right) \tag{6.64}$$

$$\pi_s^{£} = \frac{p_s^{£}}{p_{s-1}^{£}} - 1 \tag{6.65}$$

$$DS^{£} = S^{£} - X^{£} \tag{6.66}$$

$$ds^{£} = c^{£} + g^{£} \tag{6.67}$$

$$p_{ds}^{£} = \frac{DS^{£}}{ds^{£}} \tag{6.68}$$

$$\pi_{ds}^{£} = \frac{p_{ds}^{£}}{p_{ds-1}^{£}} - 1 \tag{6.69}$$

The corresponding equations for the US economy are:

$$\omega^{T\$} = \Omega_0^{\$} + \Omega_1^{\$} \cdot pr^{\$} + \Omega_2^{\$} \cdot \left(N^{\$}/N_{fe}^{\$}\right) \tag{6.70}$$

$$W^{\$} = W_{-1}^{\$} \cdot \left(1 + \Omega_3^{\$} \cdot \left(\omega_{-1}^{T\$} - W_{-1}^{\$}/p_{-1}^{\$}\right)\right) \tag{6.71}$$

$$\pi_s^{\$} = \frac{p_s^{\$}}{p_{s-1}^{\$}} - 1 \tag{6.72}$$

$$DS^{\$} = S^{\$} - X^{\$} \tag{6.73}$$

$$ds^{\$} = c^{\$} + g^{\$} \tag{6.74}$$

$$p_{ds}^{\$} = \frac{DS^{\$}}{ds^{\$}} \tag{6.75}$$

$$\pi_{ds}^{\$} = \frac{p_{ds}^{\$}}{p_{ds-1}^{\$}} - 1 \tag{6.76}$$

### 6.2.8 Trade and the Balance of Payments

The treatment of trade in the model follows directly from that of Godley and Lavoie (pp. 453-5). They carefully formulate equations 6.77 and 6.78 defining the UK price of imports and exports (respectively), providing three thought experiments which justify the restrictions imposed on the parameter values $\nu_i$ and $\upsilon_i$. Real imports and exports of the UK economy are defined by equations 6.79 and 6.80, which stress the role of relative prices and income. These four equations are log–linearised for convenience. Finally, equations 6.81 and 6.82 define the GDP deflator in each country.

$$\begin{aligned}
ln\left(p_m^{£}\right) &= \nu_0 + \nu_1 \cdot ln\left(xr^{£}\right) + (1-\nu_1) \cdot ln\left(p_y^{£}\right) + \nu_1 \cdot ln\left(p_y^{\$}\right) && (6.77)\\
ln\left(p_x^{£}\right) &= \upsilon_0 + \upsilon_1 \cdot ln\left(xr^{£}\right) + (1-\upsilon_1) \cdot ln\left(p_y^{£}\right) + \upsilon_1 \cdot ln\left(p_y^{\$}\right) && (6.78)\\
ln\left(x^{£}\right) &= \epsilon_0 - \epsilon_1 \cdot \left\{ln\left(p_m^{\$}\right) - ln\left(p_y^{\$}\right)\right\} + \epsilon_2 \cdot ln\left(y^{\$}\right) && (6.79)\\
ln\left(im^{£}\right) &= \mu_0 - \mu_1 \cdot \left\{ln\left(p_{m-1}^{£}\right) - ln\left(p_{y-1}^{£}\right)\right\} + \mu_2 \cdot ln\left(y^{£}\right) && (6.80)\\
p_y^{£} &= Y^{£}/y^{£} && (6.81)\\
p_y^{\$} &= Y^{\$}/y^{\$} && (6.82)
\end{aligned}$$

The remaining trade equations follow by the symmetrical nature of trading in a two–country system. The price of UK exports is the price of US imports, the quantity of US exports must be equal to the quantity of UK imports and so on. These symmetry requirements result in the following eight equations:

$$\begin{aligned}
p_x^{\$} &= p_m^{£} \cdot xr^{£} && (6.83)\\
p_m^{\$} &= p_x^{£} \cdot xr^{£} && (6.84)\\
x^{\$} &= im^{£} && (6.85)\\
im^{\$} &= x^{£} && (6.86)\\
X^{£} &= x^{£} \cdot p_x^{£} && (6.87)\\
X^{\$} &= x^{\$} \cdot p_x^{\$} && (6.88)\\
IM^{£} &= im^{£} \cdot p_m^{£} && (6.89)\\
IM^{\$} &= im^{\$} \cdot p_m^{\$} && (6.90)
\end{aligned}$$

Having developed an understanding of the nature of the trade relationships between the two economies, it is useful to define the current and capital account balance in each case. Equation 6.91 represents the UK current account balance, including net exports and net interest income but omitting capital gains arising due to exchange rate fluctuations. Equation 6.92 is the capital account balance including the official settlement accounts and, as such, is equal in magnitude to the current account (i.e. they sum to zero). In a two country model where the international settlement asset is a financial liability of one government, the balance of payments, when constructed in this way, will always be precisely equal to zero. Equation 6.93 defines the capital account balance of the UK economy excluding the official settlement accounts, $KA2^{£}$, and is likely to be of greater interest than $KA1^{£}$.

$$CA^{£} = X^{£} - IM^{£} + r^{\$}_{-1} \cdot B^{\$}_{£s-1} \cdot xr^{\$} - r^{£}_{-1} \cdot B^{£}_{\$s-1} + r^{\$}_{-1} \cdot B^{\$}_{cb£s-1} \cdot xr^{\$} \quad (6.91)$$

$$KA1^{£} = \Delta B^{£}_{\$s} - \Delta B^{\$}_{£s} \cdot xr^{\$} - \left\{\Delta B^{\$}_{cb£s} \cdot xr^{\$} + \Delta au^{£} \cdot p^{£}_{g}\right\} \quad (6.92)$$

$$KA2^{£} = \Delta B^{£}_{\$s} - \Delta B^{\$}_{£s} \cdot xr^{\$} \quad (6.93)$$

The equivalent definitions for the US economy are:

$$CA^{\$} = X^{\$} - IM^{\$} + r^{£}_{-1} \cdot B^{£}_{\$s-1} \cdot xr^{£} - r^{\$}_{-1} \cdot B^{\$}_{£s-1} - r^{\$}_{-1} \cdot B^{\$}_{cb£s-1} \quad (6.94)$$

$$KA1^{\$} = \Delta B^{\$}_{£s} + \Delta B^{\$}_{cb£s} - \Delta B^{£}_{\$s} \cdot xr^{£} - \left\{\Delta au^{\$} \cdot p^{\$}_{g}\right\} \quad (6.95)$$

$$KA2^{\$} = \Delta B^{\$}_{£s} - \Delta B^{£}_{\$s} \cdot xr^{£} \quad (6.96)$$

### 6.2.9 Central Bank Equations

The UK central bank is modelled as follows:

$$H^{£}_{s} = H^{£}_{d} \quad (6.97)$$

$$B^{£}_{£s} = B^{£}_{£d} \quad (6.98)$$

$$B^{£}_{cb£s} = B^{£}_{cb£d} \quad (6.99)$$

$$B^{£}_{cb£d} = B^{£}_{cb£d-1} + \Delta H^{£}_{s} - \Delta B^{\$}_{cb£s} \cdot xr^{\$} - \Delta au^{£} \cdot p^{£}_{g} \quad (6.100)$$

$$p^{£}_{g} = p^{\$}_{g} \cdot xr^{\$} \quad (6.101)$$

$$F^{£}_{cb} = r^{£}_{-1} \cdot B^{£}_{cb£s-1} + r^{\$}_{-1} \cdot B^{\$}_{cb£s-1} \cdot xr^{\$} \quad (6.102)$$

$$r^{£} = \overline{r^{£}} \quad (6.103)$$

Equations 6.97 and 6.98 note that high powered money and bills are supplied to households on demand, in a manner consistent with horizontalist models of the money supply process (c.f. Moore, 1988). Equation 6.99 states that domestic treasury bills are supplied to the UK central bank in a similar fashion.

The balance sheet equations for the respective central banks differ because the UK central bank is assumed to hold US treasury bills for settlement purposes, while no such holding of foreign bills appears on the balance sheet of the US central bank. In a flexible exchange rate system, the value of these bills may change in accordance with exchange rate fluctuations, opening up the possibility of capital gains and losses for the UK central bank. Hence, in a flexible exchange rate regime, the balance sheet of the UK central bank can only be evaluated in differences as opposed to levels (equation 6.100). The last term in this equation refers to the change in the stock of gold. Following Godley and Lavoie, it is assumed that no gold changes hands at present but it is included in the model to permit further experimentation with the use of gold as a settlement asset rather than US T–bills. The price of gold, at present, is assumed to be exogenously fixed in US dollars, although the UK price can still fluctuate as a result of exchange rate movements (equation 6.101).

Equation 6.102 defines the operating profit of the UK central bank, which consists of its interest income on both domestic and foreign bill holdings. Furthermore, it is assumed that these profits are transferred in their entirety to the government (hence their appearance in the $PSBR$ in equation 6.56). Finally, equation 6.103 states that the rate of interest on Treasury bills is set exogenously as the policy implement of the central bank. Hence, in this model money is endogenous and the central bank manipulates an interest rate to achieve its stabilisation goals.

The US central bank is modelled as follows:

$$H_s^{\$} = H_d^{\$} \tag{6.104}$$

$$B_{\$s}^{\$} = B_{\$d}^{\$} \tag{6.105}$$

$$B_{cb\$s}^{\$} = B_{cb\$d}^{\$} \tag{6.106}$$

$$B_{cb\$d}^{\$} = H_s^{\$} - au^{\$} \cdot p_g^{\$} \tag{6.107}$$

$$p_g^{\$} = \overline{p_g^{\$}} \tag{6.108}$$

$$F_{cb}^{\$} = r_{-1}^{\$} \cdot B_{cb\$s-1}^{\$} \tag{6.109}$$

$$r^{\$} = \overline{r^{\$}} \tag{6.110}$$

Note that the US central bank does not hold foreign bills for settlement purposes and that the price of gold is fixed in Dollar terms. For this reason, there is no possibility of capital gains accruing to the US central bank and so its balance sheet may be presented in levels form (equation 6.107). Similarly, the profits of the US central bank are simply equal to the interest income it derives from its holdings of domestic bills.

The basic model is completed by a discussion of exchange rate determination. Equations 6.111 and 6.112 simply define the equivalence of the supply and demand for foreign bill holdings measured in a common currency. The reader should recall that the demand for a foreign asset is assumed to be measured in the domestic currency, while the supply is denominated in the foreign currency. The supply of US bills to the UK central bank is assumed to be exogenously determined (equation 6.113) while the supply of foreign bills to UK households is defined as a residual (equation 6.114).

$$B^{\pounds}_{\$s} = B^{\pounds}_{\$d} \cdot xr^{\$} \tag{6.111}$$

$$B^{\$}_{cb\pounds d} = B^{\$}_{cb\pounds s} \cdot xr^{\$} \tag{6.112}$$

$$B^{\$}_{cb\pounds s} = \overline{B^{\$}_{cb\pounds s}} \tag{6.113}$$

$$B^{\$}_{\pounds s} = B^{\$}_{s} - B^{\$}_{cb\pounds s} - B^{\$}_{\$s} - B^{\$}_{cb\$s} \tag{6.114}$$

$$xr^{\pounds} = \frac{B^{\$}_{\pounds s}}{B^{\$}_{\pounds d}} \tag{6.115}$$

$$xr^{\$} = 1/xr^{\pounds} \tag{6.116}$$

$$rxr^{\pounds} = xr^{\pounds} \cdot \frac{p^{\pounds}_{ds}}{p^{\$}_{ds}} \tag{6.117}$$

$$rxr^{\$} = xr^{\$} \cdot \frac{p^{\$}_{ds}}{p^{\pounds}_{ds}} \tag{6.118}$$

The exchange rate $xr^{\pounds}$ is determined endogenously as the ratio of foreign bills supplied to UK households to the demand for these bills (equation 6.115). Hence, the model represents a flexible exchange rate system. The exchange rate $xr^{\$}$ is simply the reciprocal of $xr^{\pounds}$ (equation 6.116) while the real exchange rate in each case is defined by equations 6.117 and 6.118. Lastly, it is worth noting that the redundant equation is written as follows[3]:

$$B^{\pounds}_{s} = B^{\pounds}_{\pounds s} + B^{\pounds}_{\$s} + B^{\pounds}_{cb\pounds s} \tag{6.57A}$$

### 6.2.10 Stabilisation Policies

The basic structure of the model is complete; all that remains is to define the various stabilisation policies under scrutiny. The purpose of this chapter is to explore the nature of price–stabilising monetary policy in an open economy setting with flexible exchange rates. This institutional structure closely approximates current economic arrangements in

[3] In all simulated scenarios, the redundant equation is satisfied to a high degree of precision throughout the simulation period.

many countries. To this end, a procyclical inflation targeting interest rate rule embodying the so–called *Taylor principle* is added to the model and tested. For comparative purposes, a modified version of the rule in which the UK central bank reacts to the interest rate set by the Fed is also tested. Furthermore, both of these monetary policy frameworks are tested in the presence of a countercyclical fiscal policy regime.

### Procyclical Inflation–Targeting Monetary Policy

A simple inflation–targeting interest rate rule may be added to the model by endogenising the bill rates $r^{£}$ and $r^{\$}$ as follows:

$$r^{£} = \left\{\widetilde{rr^{£}} + \pi^{£}_{ds} + \varrho^{£} \cdot \left(\pi^{£}_{ds} - \widetilde{\pi^{£}_{ds}}\right)\right\} \cdot z5^{£} \quad (6.103\text{-IT})$$

$$r^{\$} = \left\{\widetilde{rr^{\$}} + \pi^{\$}_{ds} + \varrho^{\$} \cdot \left(\pi^{\$}_{ds} - \widetilde{\pi^{\$}_{ds}}\right)\right\} \cdot z5^{\$} \quad (6.110\text{-IT})$$

where equations 6.103-IT and 6.110-IT replace equations 6.103 and 6.110. The use of the initial steady state rate of inflation as the target reflects the notion that both economies are initially in equilibrium with zero inflation gaps. Hence, the shocks simulated below represent a perturbation which moves the system out of this equilibrium state. The $z5$ parameters ensure that the zero lower bound on the nominal interest rate is respected:

$$z5^{£} = 1 \quad \text{iff} \quad r^{£} > 0 \quad (6.119)$$

$$z5^{\$} = 1 \quad \text{iff} \quad r^{\$} > 0 \quad (6.120)$$

More sophisticated models could incorporate a range of additional features including a response to the output gap (thereby moving closer to the Taylor rule) or a simple interest rate smoothing mechanism. Perhaps more importantly, one could develop forward–looking rules in the spirit of Clarida et al. (1998; 1999; 2000). However, the simple specification presented here captures the core principles of an inflation targeting regime and will be sufficient to provide some interesting insights. This is model 'IT'.

### Leader–Follower Interest Rate Setting

An extensive literature has grown around the observation that combinations of international interest rates are cointegrated over various horizons, which has led a number of authors to suggest that global interest rates are converging (see Devine, 1997, for a critical survey). Regional convergence has been attributed to the emergence of leader–follower relationships among central banks. Examples of this approach include the so–called *German Dominance Hypothesis* that was widely discussed during the European Monetary System (examples include Goodhart, 1990, pp. 478-9, and Laopodis, 2001) and the notion of US leadership (c.f. Pain and Thomas, 1997). Indeed, interest rate differentials are often mentioned in the financial press: a recent example imploring the Bank of England to cut interest rates following the Fed's example is provided by Wolf (2008). It is straightforward to model a system in which the UK central bank responds to the US interest rate decision by replacing equations 6.103 and 6.110 as follows, yielding model 'LF':

$$r^{£} = \left\{\zeta \cdot \left(\widetilde{rr^{£}} + \pi^{£}_{ds} + \varrho^{£} \cdot \left(\pi^{£}_{ds} - \widetilde{\pi^{£}_{ds}}\right)\right) + (1-\zeta) \cdot r^{\$}\right\} \cdot z5^{£} \tag{6.103-LF}$$

$$r^{\$} = \left\{\widetilde{rr^{\$}} + \pi^{\$}_{ds} + \varrho^{\$} \cdot \left(\pi^{\$}_{ds} - \widetilde{\pi^{\$}_{ds}}\right)\right\} \cdot z5^{\$} \tag{6.110-LF}$$

where the parameter $\zeta$ determines the degree to which the UK interest rate is set with regard to domestic inflationary pressures relative to foreign interest rates.

**Countercyclical Fiscal Policy**

In order to smooth domestic price inflation, the Government could engage in counter–cyclical fiscal policy (see Setterfield, 2007, for a similar approach). A very simple version of this strategy representing countercyclical anti–inflationary government spending policy can be modelled by replacing equations 6.54 and 6.59 with the following:

$$g^{£} = g^{£}_{-1} - \varsigma^{£}_{1} \cdot z6^{£} + \varsigma^{£}_{2} \cdot z7^{£} \tag{6.54-CFP}$$

$$g^{\$} = g^{\$}_{-1} - \varsigma^{\$}_{1} \cdot z6^{\$} + \varsigma^{\$}_{2} \cdot z7^{\$} \tag{6.59-CFP}$$

The inflation target in this case is defined as a band as opposed to the point target that was used in the monetary policy rules. The following four equations define the indicator variables $z6$ and $z7$ for each country. These take the value of one if the upper or lower limit of the band is exceeded (respectively) and zero otherwise[4].

[4] For simplicity, it is assumed that the inflation target band is common to both countries although this assumption could easily be relaxed.

$$z6^{£} = 1 \text{ iff } \pi^{£}_{ds-1} > \pi^{£U}_{ds} \tag{6.121}$$

$$z7^{£} = 1 \text{ iff } \pi^{£}_{ds-1} < \pi^{£L}_{ds} \tag{6.122}$$

$$z6^{\$} = 1 \text{ iff } \pi^{\$}_{ds-1} > \pi^{\$U}_{ds} \tag{6.123}$$

$$z7^{\$} = 1 \text{ iff } \pi^{\$}_{ds-1} < \pi^{\$L}_{ds} \tag{6.124}$$

The intuition behind these equations is simple. If inflation exceeds the upper bound of the acceptable region, the government reduces its spending in order to reduce demand. Similarly, if inflation falls below the lower limit, the government increases its spending to stimulate the economy[5].

The use of a band target rather than a point target in the case of the fiscal policy rule is motivated by the feasibility of the policy concerned. A point target would imply the operation of a simple automatic stabiliser, whereby government spending or net transfers are adjusted in response to every slight movement of inflation about the targeted level. The operation of such a system would be infeasibly complex, and the resulting volatility of government spending would undoubtedly meet with fierce political resistance. Even if such opposition could be overcome, it is unlikely that government spending could be varied in precisely the increment required for stabilisation. By contrast, the band target proposed here may be thought of as representing a system of pseudo–discretionary intervention, in which the fiscal authority reigns in spending in the presence of inflationary pressure, and expands its spending to stimulate the economy when inflation is low.

It should be clear, however, that by specifying an active role for government spending, the model is not rendered devoid of automatic stabilisers. Indeed, it is in the nature of proportionate income taxation that it is distinctly procyclical. The combination of this tax regime with the anti–inflationary spending policy described above would be associated with a countercyclical budget deficit consistent with Minsky's (1982; 1986b) view of Big Government. It is, however, inconsistent with the fiscal austerity embodied in the Stability and Growth Pact, and imposed on many state governments in the US in the form of balanced budget requirements.

The complementarities between fiscal and monetary policies may be analysed using combinations of the CFP and IT/LF closures of the model. The combination of CFP with autonomous IT provides model 'CFPIT', while when used in conjunction with the leader–follower rule, the CFP equations yield model 'CFPLF'.

[5]Of course, the lower bound of real government expenditure is also zero but this lower bound is never approached in any of the simulations undertaken in this chapter, so its imposition is not necessary.

## 6.3 Simulation Results

Godley and Lavoie (2006, pp. 466-7) run their simulations from the starting point of a full stationary state in which the current and capital accounts are balanced, as is the government budget in each country. Such a strategy is not possible in the current context due to the introduction of persistent inflationary forces which ensure that the nominal government deficit is positive when real government debt is unchanging (c.f. Godley and Cripps, 1983, pp. 244-5; Godley and Lavoie, 2006, p. 369)[6]. For this reason, the simulations presented here start from a steady state in which real wealth is constant (i.e. $\Delta v^{£} = \Delta v^{\$} = 0$).

The following experiments are conducted for each of the candidate stabilisation policies discussed above:

i. a step decrease in real exports from the UK (an explicitly open economy shock);

ii. an increase in the autonomous component of the target real wage in the UK (a cost shock); and

iii. an expansionary decrease in the rate of US income tax (a demand shock);

In all cases, the model is solved over the timeframe 1950-2050 and the shock occurs in the year 1960[7]. As with the Godley–Lavoie models, these years simply provide an index of time and should not be interpreted literally; it would be equally valid to refer to periods 1 to 101.

### 6.3.1 A Step Decrease in Real Exports from the UK

The first experiment involves a reduction of the parameter $\epsilon_0$ in equation 6.79 from -2.1 to -2.2, resulting in a step decrease in UK real exports. Figure 6.1 presents the effect of this shock under each policy stance on four core variables: inflation relative to the target band defined by the fiscal authority, real GDP and the nominal and real Sterling exchange rates. In order to bring forth the key mechanisms involved in the traverse between steady states (many of which are common to all experiments) the discussion of the first experiment is considerably more detailed than the remaining two.

The leftmost column of Figure 6.1 (i.e. panels (a), (f) and (k)) reports the situation under the benchmark case of no policy intervention. The reduction in UK exports causes an initial fall in real output which is associated with deflation and growing current account

[6] Godley and Lavoie's chapter 12 models do provide for inflation arising through changes in the price of traded goods brought about by exchange rate movements, although the observed rate of inflation is considerably smaller than that considered here and generally returns to zero relatively swiftly.

[7] The computer code used to perform these simulations is provided on the enclosed CD.

and budget deficits in the UK[8]. In order to fund its deficit, the UK government increases its issuance of bills, exerting downward pressure on Sterling and leading to both nominal and real depreciation. The immediate effect of the fall in UK real exports on the US economy is a brief decline in inflation resulting from the sharp fall in nominal imports which enter firms' mark–up pricing rules. This effect is, however, rapidly dominated by the demand–pull inflationary pressure arising from the sharp increase in real activity. In the medium–term, the prevailing trends in each country reverse: US real output falls below its initial level and the economy experiences mild deflation, while both real GDP and inflation in the UK are slightly higher than their starting levels. This reversal is brought about by the gradual depreciation of the pound and a worsening of the terms of trade, resulting in an improvement in the UK trade account in the medium–term but a deterioration of the US trade account. Similar results are achieved by Godley and Lavoie using their open economy model (pp. 479-81).

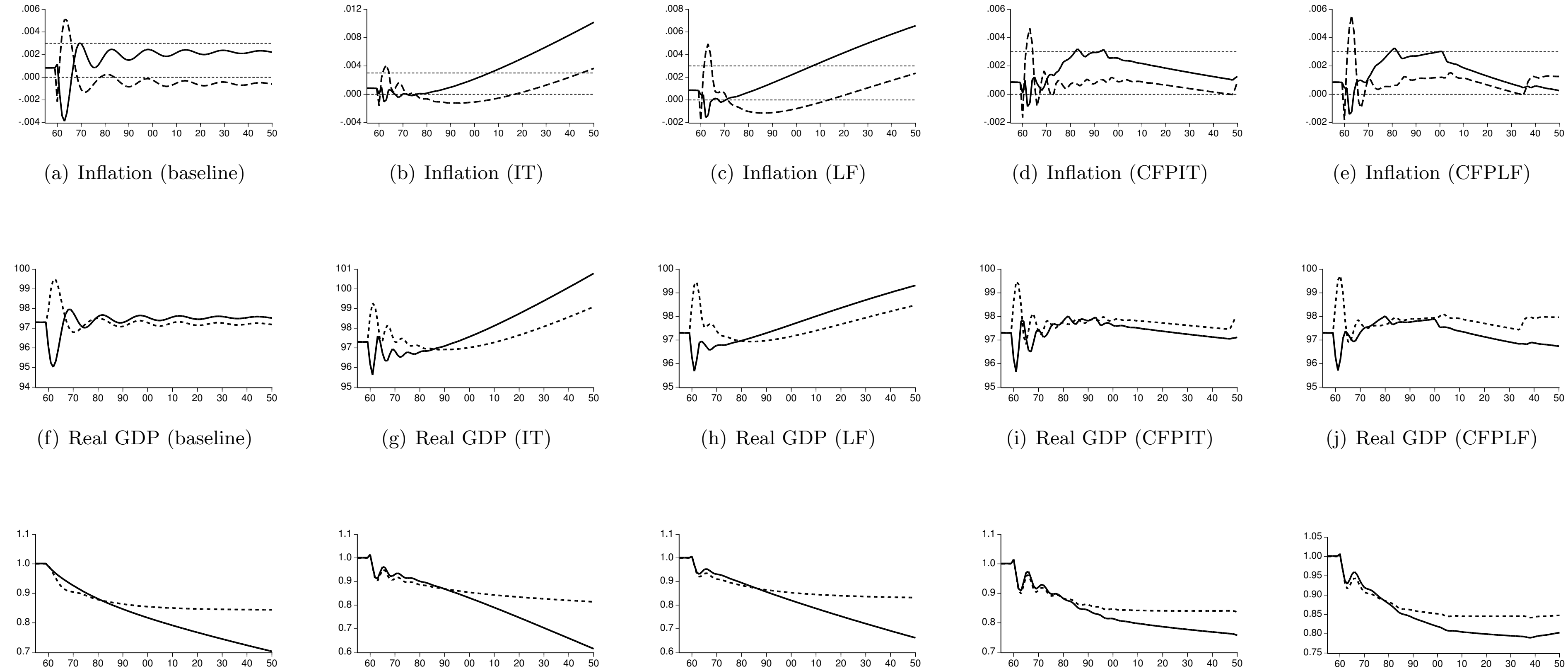
The cyclicality characterising the economic response to the shock under the benchmark case of non–intervention results from the endogeneity of the marginal propensities to consume out of income and wealth. The mechanism generating the cycles may be described as follows. Increased inflation resulting from an initial shock reduces the real rate of interest, stimulating consumption. This, in turn, erodes real wealth, reducing consumption and inflation. In time, real wealth recovers and consumption increases again. This process continues with decreasing amplitude throughout the simulation period. In the remaining two experiments, the effect is considerably more pronounced. The existence of such cyclical behaviour in the model renders it highly suitable for testing stabilisation policies.

It should be noted that relative purchasing power parity (PPP) holds to a high degree of precision in the steady state. It is, however, disturbed by the shock to UK exports and is then gradually restored through the adjustment of relative prices. Relative PPP is represented as follows:

$$\frac{xr^{£}}{xr^{£}_{-1}} = \frac{\Delta p^{\$}_{ds}}{\Delta p^{£}_{ds}}$$

The implication is that persistent inflation differentials lead to continuous changes in the nominal exchange rate, as can be seen in Figure 6.1 (and, indeed, in the other three experiments). However, the real exchange rate, $rxr^{£}$, defined by equation 6.117, adjusts gradually before settling at a new, lower, steady state value.

[8]Note that budget deficit, current and capital account figures are not reported here in the interest of brevity, but are automatically generated by the computer code on the enclosed CD.



(a) Inflation (baseline) (b) Inflation (IT) (c) Inflation (LF) (d) Inflation (CFPIT) (e) Inflation (CFPLF)

(f) Real GDP (baseline) (g) Real GDP (IT) (h) Real GDP (LF) (i) Real GDP (CFPIT) (j) Real GDP (CFPLF)

(k) Exchange rate (baseline) (l) Exchange rate (IT) (m) Exchange rate (LF) (n) Exchange rate (CFPIT) (o) Exchange rate (CFPLF)

Figure 6.1: The Effect of a Decrease in $\epsilon_0$ on Selected Indicators
Rows 1 & 2: the solid line represents the UK and the heavy dashed line the US. Row 3: the solid line is the nominal exchange rate, $xr^{£}$, while the dashed line is the real rate, $rxr^{£}$.

The second column (panels (b), (g) and (l)) presents the situation under procyclical inflation–targeting interest rate policy. Here, the initial deflationary pressure in the US, owing to the fall in nominal imports, causes the Fed to cut the interest rate, with the Bank of England doing likewise but to a lesser extent. Meanwhile, the current account surplus enjoyed by the US in the short–run, and the associated increase in real GDP, provokes inflation, leading the Fed to reverse its position and raise the interest rate. The maintenance of low interest rates by the Bank of England in the short–run reduces the interest income of households in both countries, reducing consumption and restraining demand, leading to disinflationary and even deflationary pressure. This erratic and uncoordinated sequence of interest rate innovations causes considerable exchange rate volatility and results in moderately high frequency cyclical behaviour in the short- to medium–term. After this initial period of fluctuation, the negative impact of higher interest rates on the marginal propensity to consume is dominated by two effects. Firstly, higher interest rates are associated with increased interest income received by households on their bond holdings. This could be called a rentier effect (see Lavoie, 1995, and Smithin, 1996). Secondly, the policy regime has resulted in a substantial nominal depreciation of Sterling (larger than in the benchmark case) as higher interest rates in the UK have led to a dramatic expansion of the government debt, increasing the supply of UK bills overseas and depressing their price.

The figures presented in the third column (panels (c), (h) and (m)) are derived under the leader–follower closure, where the Bank of England responds to the Fed's interest rate decisions in real time. In response to initial deflationary pressure, the Fed lowers the interest rate, stimulating demand through the effect on consumption. The sharp increase in real activity associated with the current account surplus causes rapid demand–driven inflation, although the effect is relatively short–lived. During this time, the Bank of England has been setting its interest rate partly to combat domestic deflation and partly in response to the US decision (the weighting parameter, $\zeta$, in equation 6.103-LF is set at 0.5). This results in a degree of indecision. In the medium–term, the rentier channel and the Sterling depreciation dominate the contractionary effect of higher interest rates on consumption, resulting in gradually increasing inflation in both countries. However, the trend is noticeably slower than in the IT closure of the model because Sterling has not depreciated as substantially, owing to the maintenance of lower interest rates and the resulting slower expansion of the government debt.

The fourth column (panels (d), (i) and (n)) presents the results of combined inflation–targeting interest rate policy and countercyclical fiscal policy, which results in relatively good stabilisation performance (note that the bands drawn in the top row of Figure 6.1 only actually refer to the fiscal policy rule as monetary policy is conducted in relation to a point target). In response to initial deflationary pressure in the UK, the government embarks on a series of expansionary spending increases, stimulating demand and resulting in a large increase in the budget deficit. By contrast the US government cuts its spending in response to excessive inflation, cooling the economy and resulting in a budget surplus. The UK budget deficit is funded by the issuance of government bills which brings about a second round stimulus to real activity through the rentier channel. Alongside these fiscal interventions, the central banks of both countries have been manipulating their interest rates in accordance with the Taylor principle. This combination of policies maintains inflation within the range deemed acceptable by the fiscal authorities and also achieves reasonable stabilisation of real output. Similarly, the Pound does not fall as markedly as in the preceding scenarios, with the nominal exchange rate gradually stabilising throughout the simulation period.

Finally, the fifth column (panels (e), (j) and (o)) relates to the combination of counter-cyclical fiscal policy and US interest rate leadership. In such a setting, both governments are ready to reduce their spending when inflation exceeds the upper bound, while the Bank of England will consider the Fed's interest rate decision before setting its own. This policy mix again succeeds in stabilising the rate of inflation within the range targeted by the fiscal authority, although with slightly less success than the previous case. Real output is declining in both countries in the long–run due to the combination of fiscal austerity and the Bank of England's adherence to its US–centric interest rate rule. It is interesting to note that the Sterling exchange rate reaches a plateau in this case and then starts to recover very slightly. One apparent advantage of leader–follower interest rate setting is that the reduced interest rate differential leads to greater stability of the exchange rate. This is certainly an argument that would be familiar to proponents of the European Monetary Union.

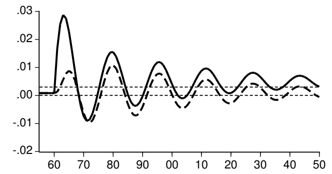
### 6.3.2 An Increase in the UK Target Real Wage

The second experiment introduces a cost shock in the UK economy, as the autonomous component of the UK real wage target, $\Omega_0^{£}$, increases from -0.1 to 0. In the benchmark case, the mark–up pricing rules operated by firms result in marked inflationary pressure in the UK which is passed through, to a lesser degree, to the US economy. High rates of inflation initiate the familiar cyclical pattern, although its amplitude is considerably greater than in the previous experiment reflecting the larger scale of the shock. Once again, the amplitude of the cycles decreases through time, suggesting that the model is converging toward a steady state in which real activity in the UK is considerably lower than in the initial steady state, while the level of US real GDP is comparable[9]. The growth of the UK budget deficit leads to an increased supply of UK bills abroad, depressing the nominal exchange rate.

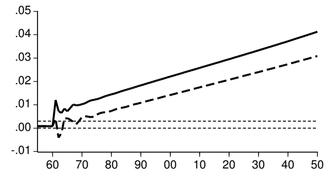
In the case of procyclical IT, the initial inflationary shock causes the UK central bank to raise the interest rate markedly. This is followed by a mild bout of deflation in the US, associated with falling interest rates. This combination leads to a strong appreciation of Sterling in the short–run. However, after some initial cooling effect, the higher interest rates in the UK prove inflationary, with the price level increases passing through to the US economy relatively rapidly. The negative effect of higher interest rates on the consumption propensities is apparently outweighed by the rentier effect and the very large Sterling depreciation resulting from the increased issuance of bills necessitated by the growing budget deficit. This is most likely caused by the fact that the initial rate hike is so large in the UK: it is possible that the introduction of policy inertia may yield substantially different results in this case. The ever increasing rate of inflation leads the central banks in both countries to raise their interest rates *ad infinitum*, further reinforcing the expansionary effect arising through the rentier channel and leading to the rapid expansion of real GDP, exponential growth of the government budget deficit and a very sharp depreciation of the Pound. The emergence of an exponential growth path indicates that IT cannot be maintained in this case.

Column three presents the case of US interest rate leadership, which yields very similar results to the standard IT closure in this case, albeit slightly attenuated. Even though the initial shock in the UK proves deflationary in the US, the very large interest rate hike introduced by the domestic portion of the Bank of England's reaction function outweighs the negative influence coming from the Fed. The resulting interest rate differential is associated with the rapid expansion of the UK government debt, leading to a profound nominal depreciation of Sterling (although admittedly a negligible effect on the real rate). This combination results in a strong expansionary influence on both economies arising through the rentier and exchange rate channels. The point that comes across most strongly in this case is that foreign monetary policy decisions can be transmitted rapidly and forcefully to the domestic economy.

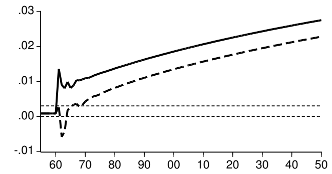
[9]The frequency of the cycles is determined by the $\mu$ parameters in equations 6.33, 6.34, 6.41 and 6.42, defining the consumption propensities in each economy. Beyond a threshold, the imposition of larger values associated with higher frequency cycles tends to cause convergence failure.



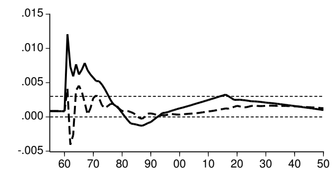

(a) Inflation (baseline)



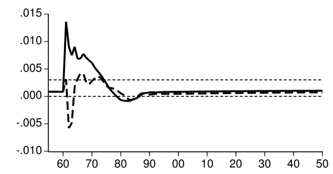

(b) Inflation (IT)



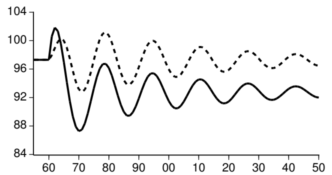

(c) Inflation (LF)



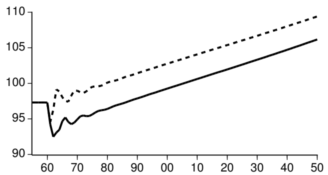

(d) Inflation (CFPIT)



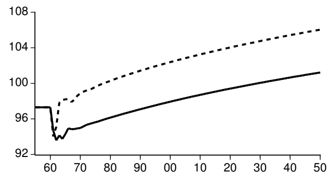

(e) Inflation (CFPLF)



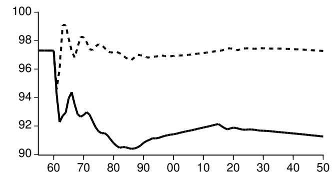

(f) Real GDP (baseline)



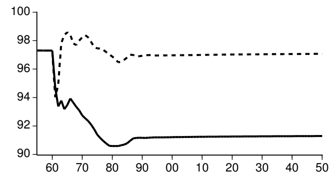

(g) Real GDP (IT)



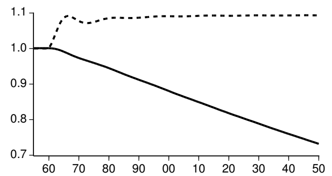

(h) Real GDP (LF)



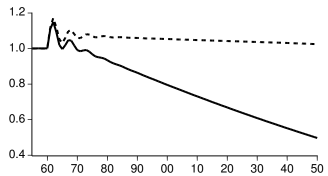

(i) Real GDP (CFPIT)



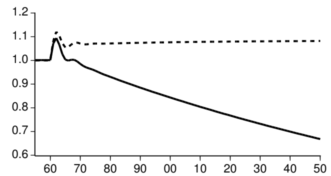

(j) Real GDP (CFPLF)



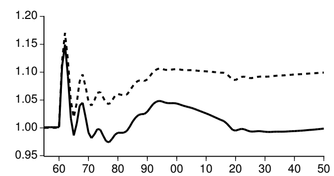

(k) Exchange rate (baseline)



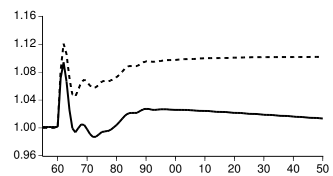

(l) Exchange rate (IT)




(m) Exchange rate (LF)




(n) Exchange rate (CFPIT)




(o) Exchange rate (CFPLF)

Figure 6.2: The Effect of an Increase in $\Omega_0^{\pounds}$ on Selected Indicators

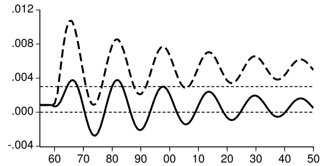
The fourth column reports the results of the CFPIT closure, which again succeeds in stabilising inflation after an initial period of marked overshooting. The cost of this stabilisation is that the reduction in UK government spending leads to a deep contraction of UK real activity in the short–run and to a long–run reduction of approximately 7% in UK real GDP. The Sterling exchange rate overshoots strongly following the shock due to the large rate rise enacted by the central bank. Following this initial turbulence, the nominal exchange rate settles to roughly its initial level in the long run, although the real exchange rate has appreciated by approximately 10%. In a setting of combined monetary and fiscal policy, the effect of anti–inflationary fiscal and monetary innovations on the exchange rate reinforce one–another to some extent. When inflation is high, the government reduces its spending which, *ceteris paribus*, reduces the budget deficit and the supply of bills, causing an appreciation of the exchange rate. Similarly, when the rate of inflation is high, the central bank raises the interest rate, causing the currency to appreciate. As long as the policies act in a consistent manner, then this can result in rapid and relatively effective stabilisation of the nominal exchange rate, as is observed here.

The final column shows the results of the CFPLF closure. Stabilisation in this case is highly effective, with a true steady state being reached after only 25 periods. This remarkable performance results from the reduced volatility of the exchange rate in a setting in which the Bank of England responds to the interest rate decision of the Fed.

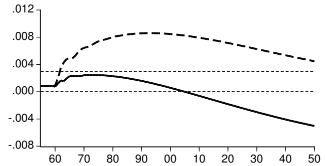
### 6.3.3 An Expansionary US Income Tax Cut

The third experiment involves an expansionary cut in the rate of income tax in the US, associated with a decrease in the parameter $\theta^{\$}$ in equation 6.58 from 0.20 to 0.19. In the absence of policy intervention, the increased disposable income of US households results in permanently higher domestic inflation and real GDP in the US. The effect is passed through to the UK to a limited extent due to the increased demand for its exports. The tax cut causes a budget deficit in the US, and the resulting increase in the supply of US financial instruments causes a strong nominal appreciation of Sterling, although the real exchange rate remains largely stable. Once again, strong cyclicality results from the endogenous response of consumption and, indirectly, wealth to inflation.

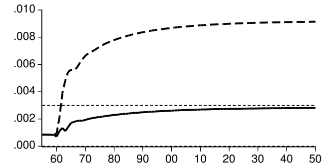
In the case of simple IT, the initial inflationary pressure causes both the Fed and the Bank of England to raise their interest rates. This action succeeds in constraining consumption growth although, after inflation and output return to their initial values, they overshoot and decline. Interest rate cuts at this point fail to stimulate demand as the rentier effect dominates the increased consumption propensity and real wealth declines.



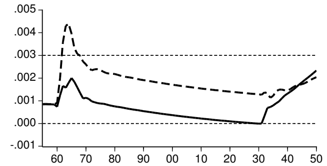

(a) Inflation (baseline)



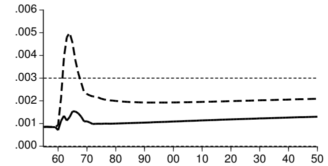

(b) Inflation (IT)



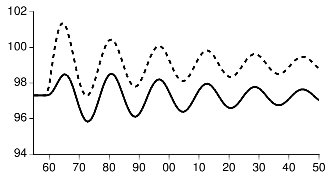

(c) Inflation (LF)



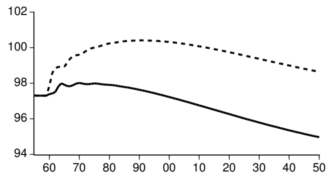

(d) Inflation (CFPIT)



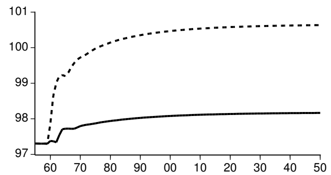

(e) Inflation (CFPLF)



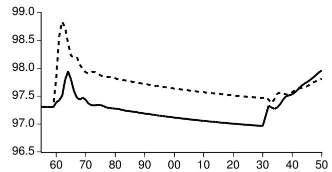

(f) Real GDP (baseline)



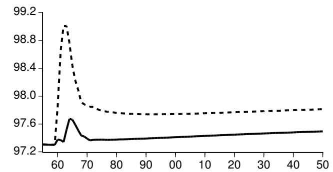

(g) Real GDP (IT)



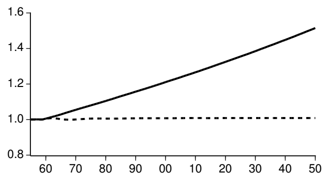

(h) Real GDP (LF)



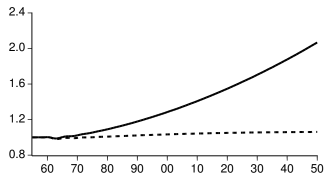

(i) Real GDP (CFPIT)



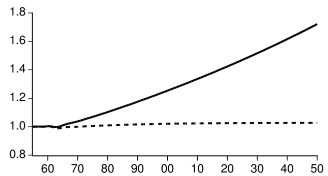

(j) Real GDP (CFPLF)



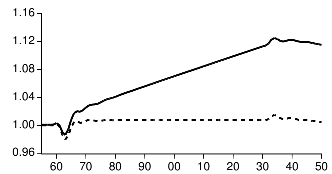

(k) Exchange rate (baseline)



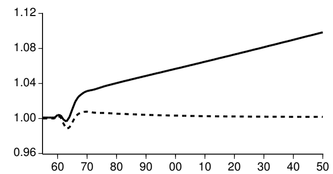

(l) Exchange rate (IT)




(m) Exchange rate (LF)




(n) Exchange rate (CFPIT)




(o) Exchange rate (CFPLF)

Figure 6.3: The Effect of an Expansionary Decrease in $\theta^{\$}$ on Selected Indicators

The appreciation of the Pound is particularly marked in this case due to the combination of a substantial US government budget deficit coupled with a more modest, but still large, UK surplus.

US leadership achieves reasonably rapid stabilisation of inflation but at a very high level in the US. In the new steady state, the reduction in the consumption propensity brought about by the higher interest rates is balanced by the increased income accruing to households through their asset holdings. The maintenance of a high interest rate in the US results in rapid growth of the government budget deficit which exerts strong downward pressure on the Dollar (indeed, the Dollar depreciates significantly despite the fact that US interest rates are much higher than those in the UK).

Countercyclical fiscal policy in conjunction with autonomous inflation targeting provides rapid inflation stabilisation in both countries. However, once again, this combination of policies does not result in a steady state but rather in gradual swings which are eventually corrected by fiscal policy intervention. By contrast, when the simple IT rule is replaced by the leader–follower strategy, a new steady state is reached in which US output and inflation are higher than their starting values, while the UK economy settles back to a level comparable to its initial state. The Dollar depreciation in both closures using fiscal policy is considerably less marked than in the other regimes, reflecting the reduced variability of the budget deficits in each country.

## 6.4 Implications for Monetary Policy

While the model developed here is simplistic in a number of ways, it nevertheless provides a range of interesting insights into the dilemmas facing policymakers charged with domestic stabilisation in a world characterised by both financial and real linkages. Closed economy models cannot address issues regarding the effect of stabilisation policies on the budget deficit, the balance of payments or the exchange rate, among other things. Furthermore, closed economy models cannot illuminate the transmission of shocks internationally, whether exogenous, or the result of overseas policy interventions. Similarly, the model may be considered more generally applicable than the majority of open economy models which assume that the country under scrutiny is small and, therefore, that it cannot influence events in the world economy. The modelling of mutually interdependent economies in a fully consistent manner provides a considerably richer analysis.

The stabilisation performance of autonomous inflation targeting regimes proved uninspiring in the three experiments conducted above. This result is consistent with the work of Ball and Sheridan (2003) and Angeriz and Arestis (2006), who doubt that inflation targeting has had any notable impact on the rate of inflation or its variance, arguing instead that IT policies have typically been adopted once an economy has already entered an era of lower, more stable inflation. Alternatively, this result may be reconciled with the existing empirical literature supporting the efficacy of IT policies if one believes that much of this research has failed to adequately control for the influence of automatic stabilisers and discretionary fiscal interventions. In order to properly account for these influences, empirical analyses would, at a minimum, have to include terms capturing changes in the average and marginal tax rates faced by economic agents, the composition of the tax and benefit systems, the level and composition of net government transfers, and public expectations of future fiscal policy interventions. I am not aware of any studies that have attempted such an analysis.

In general, the maintenance of a smaller interest rate differential under the leader–follower closure resulted in superior stabilisation of output and inflation than autonomous IT. However, the leader–follower rule does not generally succeed in stabilising inflation and output. Furthermore, there is little reason to believe that such arrangements work well for either the dominant country or the follower, except to the extent that the follower central bank may be able to import some of the credibility of its dominant counterpart. Other than this, the criticisms of one–size–fits–all policies that have surrounded European arrangements apply.

The improvement associated with the use of an LF policy as opposed to IT serves to underline the importance of the exchange rate channel of monetary transmission in an open economy setting. However, the operation of this channel is not entirely straightforward (Arestis and Sawyer, 2004). Consider an anti–inflationary rate hike by the Bank of England. Immediately following the policy intervention, increased demand for UK bills causes an appreciation of the exchange rate, as one might expect. However, the increased cost of servicing existing government debt leads to a growing budget deficit, which is assumed here to be funded by the issuance of yet more bills. The increased supply of UK government liabilities then causes the Pound to depreciate. Hence, it is by no means clear that the effect of an interest rate hike acting through the exchange rate channel is contractionary, certainly in countries with significant export industries. Moreover, it follows that the means by which the government chooses to fund the resulting budget deficit can have a profound impact on monetary policy transmission. It is now possible to elaborate on the two mechanisms presented in Section 2.3.6. Following Arestis and Sawyer (2004), the following schemata were propounded (the symbols have been updated for consistency with the current notation):

$$r^{£}\uparrow\longrightarrow xr^{£}\uparrow\longrightarrow\left(X^{£}-IM^{£}\right)\downarrow\longrightarrow Y^{£}\downarrow$$

$$r^{£}\uparrow\longrightarrow xr^{£}\uparrow\longrightarrow p_m^{£}\downarrow\longrightarrow Y^{£}\uparrow$$

where the same is true for the US economy. While these mechanisms remain valid in general terms, the linkage between higher interest rates and a nominal appreciation is dependent on the means by which the government chooses to fund its budget deficit. In the model presented here, the deficit is funded by the increased issuance of bills which may actually lead to a nominal depreciation as follows:

$$r^{£}\uparrow\longrightarrow xr^{£}\ \&\ PSBR^{£}\uparrow\longrightarrow B_s^{£}\uparrow\longrightarrow xr^{£}\downarrow$$

Hence, it follows that the overall effect of an interest rate hike operating through the exchange rate channel is highly complex and time–varying. This challenges the naïve assumption that raising the interest rate will necessarily lead to a nominal appreciation in anything but the short–run[10].

While the discussion so far has focused on the open economy, it should be noted that it is not clear that the stabilisation performance of simple interest rate rules would improve even in a closed economy model. In their closed economy growth model, which contains a well developed banking sector, Godley and Lavoie (pp. 417-22) demonstrate that monetary policy aimed at the maintenance of a constant real interest rate in the presence of expansionary fiscal policy generates wild fluctuations as the initial contractionary effect of higher interest rates comes to be dominated by the rentier effect identified above. Similarly, they find that, should the central bank attempt to neutralise the fiscal stimulus, it will be compelled to raise interest rates exponentially.

Moving away from the important issue of whether procyclical IT policies would be stabilising in a model with commercial banks (a question that I hope to address in future work), one effect that is particularly apparent in the experiments conducted herein is the rentier channel of monetary transmission. Quite simply, by raising the interest rate, the central bank imposes more onerous debt–servicing obligations on the government, resulting in a tendency toward a growing budget deficit (or a dwindling surplus). At the same time

[10]Of course, the government could choose to fund its deficit by raising taxes instead of increasing its borrowing. However, this would, in all likelihood, largely negate the stabilising influence of countercyclical spending policies and may even prove destabilising. Hence, the use of both taxation and spending as part of a coherent fiscal package must be approached with care.

that the government issuance of bills increases, the income of the rentier class that holds such financial assets is increasing, leading either to higher consumption, or to more rapid wealth accumulation. In either case, the effect is expansionary. Depending on the relative importance of this group within society, the rentier effect could be quite profound. In the simulations performed here, the rentier channel often dominates the effect of interest rates on the consumption propensities, leading to an expansionary influence of higher interest rates. While this result may be overturned with different parameterisations and choices of initial conditions, it nevertheless cautions that one should not naïvely assume that raising the interest rate will always prove contractionary.

In general, it follows that procyclical inflation targeting monetary policy can only stabilise inflation if the moderating effect that it exerts through increasing the cost–of–capital, for example, outweighs this expansionary effect brought about through the rentier channel and, in some cases, through its complex interaction with the exchange rate. The degree to which such policy succeeds will depend on the relative importance of savers/investors and borrowers in the economy, and on the degree to which economic activity is export–oriented.

The most resonant result to come from the modelling undertaken above is that the combination of a simple countercyclical fiscal policy rule with either of the candidate monetary policy rules yields greatly improved stabilisation performance. This effect is not achieved when countercyclical fiscal policy is employed in isolation: this results in very large, high frequency cycles (not reported). Hence, a combined monetary and fiscal approach is required to stabilise the model. This result stands in stark contrast to the New Consensus position, but is consistent with the revival of Keynesian fiscal activism that has been brought about by the ongoing credit crisis. Furthermore, it is consistent with the Post Keynesian emphasis on active fiscal policy (see, for example, Arestis and Sawyer, 2006) and with the work of Chadha and Nolan (2004) and Leith and Wren-Lewis (2000; 2006; 2008). In light of these results, the assumption of Ricardian agents that underlies the NCM's dismissal of fiscal policy must be revisited as a matter of urgency if models in that tradition are to provide meaningful economic insights.

The strength of fiscal policy as a stabilisation tool comes, in part, from the status of government spending and taxation as substantial components of GDP, which has the implication that a reduction in government spending is immediately contractionary, at least in the short–run. Further second round effects are brought about through the effect on the portfolio choices of domestic and foreign agents. Of course, the effectiveness of fiscal policy must be viewed not only as a reason to actively engage in countercyclical fiscal policy, but also as a warning against its careless and ill–conceived use.

## 6.5 Concluding Remarks

The estimation of empirical exchange rate models is widely regarded as one of the more challenging aspects of modern applied economics (see Cheung et al., 2005, and Engel, 2006). The results of such exercises are often weak in a statistical sense and contradictory. This chapter has pursued an alternative modelling strategy built around a rigorous double–entry accounting framework and a simple set of behavioural equations. The principle advantage of this approach is that it provides a powerful tool for counterfactual analysis which ensures that the most simple of accounting rules are respected at all times. From this strong foundation, one can be confident of uncovering interesting effects and relationships through experimentation with, and development of, the model.

Simulations of various scenarios using the stock–flow consistent model developed herein provide little support for the notion that autonomous rule–based inflation targeting monetary policy is stabilising. Of course, these results must be interpreted with care as the model does not contain a commercial banking sector and, therefore, omits an important mechanism through which monetary policy may influence the macroeconomy. However, the results stress that the interaction between the interest rate and the exchange rate is complex, and that it cannot be taken for granted that a monetary tightening is contractionary in all cases. Indeed, the existence of a rentier channel of monetary policy whereby higher interest rates provide an economic stimulus further complicates the picture.

The principle conclusion of the modelling herein is that a combination of monetary and fiscal policy is required to stabilise the economy. Neither policy on its own was found to be successful in any of the three experiments. This stands in contrast to a substantial empirical literature in support of the stabilising properties of IT policies. However, the validity of many of these studies may be called into question as they have typically failed to control for the effect of automatic stabilisers. It is quite possible that much of the economic stability that has been attributed to enlightened monetary policy since the mid 1990's was, in fact, due to the countercyclicality of the budget deficit arising passively by these means.

That the CFPLF strategy tends to outperform the other candidate policy regimes reflects the unintentional influence that autonomous IT exerts over the exchange rate. This result begs the question of whether rules that explicitly take account of the exchange rate may yield preferable outcomes. More generally, it is quite possible that inflation–targeting, whether pursued through monetary or fiscal means, is not an optimal stabilisation policy[11].

[11]This chapter has simply investigated the feasibility of inflation–targeting through monetary and fiscal means but has not addressed the desirability of such policies.

These results have profound implications for the New Consensus macroeconomic model which adheres to the notion of Ricardian equivalence. Current events in the world economy have demonstrated with unusual clarity that governments around the world believe that fiscal policy can have significant real effects. If modern macroeconomics is to remain useful, it must acknowledge this fact with all haste.

The modelling undertaken here has been necessarily selective and is, therefore, open to further development in a number of areas. Opportunities for further work can be broadly divided into two categories: those that develop the model itself and those that develop the modelling strategy. Among the former, the development of a model including a banking sector providing both commercial and household loans should be considered a priority, alongside the modelling of realistic forward–looking policy rules. The resulting model would be highly sophisticated and could be used to supplement the DSGE models so popular with contemporary central banks for the purposes of policy appraisal.

In terms of the latter, as with any model–based simulation, the price that one pays for the 'Olympian knowledge' of the data generating process referred to by Brainard and Tobin (1968) is that the simulation results may be rather dependent on the parameterisation of the model (and, to a lesser degree, the initial conditions). The use of Bayesian techniques provides a means by which to explicitly account for such parameter and model uncertainties. Simulating various permutations of the model subject to the Occam principle *entia non sunt multiplicanda praeter necessitatem* and averaging the outcomes appropriately could improve the robustness of the results. Examples of such techniques include Raftery, Givens, and Zeh (1995) and Poole and Raftery (2000)[12]. Clearly, the opportunities for further research into the field are many and varied.

[12]Raftery et al.'s (1995)initial work on Bayesian synthesis for the International Whaling Commission was subject to the Borel–Kolmogorov paradox regarding the sensitivity of the results to reparameterisations of the model, deriving from conditioning on a null set. Subsequent work on Bayesian melding addresses this issue.

# Chapter 7

# Concluding Remarks and Policy Prescriptions

## 7.1 Summary

The central contention of this thesis has been that monetary policy must adapt to conditions in the domestic, and indeed global, economy. While the New Consensus model has been a reliable workhorse during the recent era of low and stable inflation, its suitability in a setting of high and volatile inflation remains unclear. Indeed, Charles Goodhart (2007, p. 13) has characterised it as a "fair weather" model, incapable of dealing with the current financial crisis. As the events of the post–Greenspan era have shown, when inflationary pressure arises through cost channels and asset markets slump, a simple focus on inflation targeting seems somewhat myopic. Recent months have seen many central banks missing their targets and a return to old fashioned Keynesian fiscal stimuli as governments around the world grapple with the threat of imminent (or, in many cases, ongoing) recession.

This thesis set out to investigate three challenges facing monetary policymakers in the twenty–first century and to identify any required evolution of the policy framework. These challenges included accelerating innovation in the payments system, the growing frequency and severity of asset market cycles, and the increasing openness of the global economy. The common threads that link these three are the increasing sophistication of ICT in use in everyday life and the ineluctable process of globalisation. Developments in ICT have made contactless electronic payments a reality and have the potential to revolutionise both retail and wholesale payments systems. Similarly, the development of sophisticated trading platforms and models, combined with the increasing ease and speed with which information can be accessed, has reduced transactions costs and led to a substantial deepening of financial markets around the world. Finally, the process of globalisation fuelled by the ICT revolution has reduced the significance of national boundaries and physical separation. The last few decades have seen the development of an increasingly complex web of social, political and economic interactions which has been accompanied by a striking increase in capital mobility and the near universal removal or reduction of capital controls. Simply put, the modern world is a considerably smaller place than it once was.

In order to place the thesis in context, Chapter 2 undertook a thorough review of the currently dominant New Keynesian monetary policy model and the underlying transmission mechanism between interest rate policy, aggregate demand and inflation. In general terms, the three challenges identified in this thesis can be discussed in relation to the channels of monetary transmission. Concerns have been raised over the potential for e–money to disrupt the link between central bank reserves and market interest rates. The Minskyan Financial Fragility Hypothesis is essentially a belief that the credit channels may be very strong and potentially destabilising. Finally, the ongoing globalisation of the world economy is placing more emphasis on the exchange rate channel in the process of monetary transmission.

In addition to reviewing the New Keynesian monetary policy literature, Chapter 2 identified a number of significant lacunae in this dominant framework. In particular, the chapter struck a cautionary note about the desirability of inflation–targeting monetary policy, stressing that price stability should only be pursued if it does not conflict with the attainment of full employment and rapid, sustainable economic growth. Furthermore, a number of concerns were raised over the neglect of the supply side and the assumed long–run neutrality of money. Similarly, the assumption of Ricardian households and the resulting ineffectiveness of fiscal policy was challenged. Finally, the narrow focus of the New Keynesian literature on the interest rate as the sole implement of stabilisation policy was traced back to the work of Poole (1970) and a range of alternative instruments were identified. This critical appraisal highlighted various weaknesses in the dominant paradigm, many of which proved relevant in developing a thorough understanding of the challenges faced by modern central banks in subsequent chapters.

Chapter 3 investigated the contention that the uptake of electronic monies could undermine the ability of the central bank to conduct effective monetary policy. Two extreme and relatively high profile scenarios have been discussed in the literature: firstly, that e–money may completely displace central bank money and, secondly, that e–money schemes may come to offer settlement with finality. The first represents a challenge to the central bank's monopoly over the issuance of currency while the second challenges its monopoly over the provision of settlement facilities. However, following Palley (2001a) in his analysis of traditional US–style policy arrangements (i.e. before the commencement of interest payments on deposits on October $9^{th}$, 2008), it was argued that a substitution away from central bank money by households and non–bank firms would actually simplify the task of the central bank (Woodford, 2000; 2001a). By contrast, the development of private settlement facilities would pose a serious challenge to central banks operating in this manner. In such a system, the central bank relies on the existence of a small but highly inelastic demand for settlement balances arising from the settlement needs of commercial banks. In its absence, and assuming that the non–bank demand for currency is perfectly interest inelastic, it follows that the linkage between reserves and interest rates would cease to operate. However, as both Palley and Woodford (2000; 2001a) were quick to point out, a Lombard system, such as that used by the Bank of Canada, would remain effective after some minor modifications. Hence, if e–settlement systems were to develop, the central bank could continue to operate monetary policy by simply paying interest on deposits. Many have already argued in favour of this to remove what is seen as a *de facto* tax on banks.

These extreme scenarios diverted attention from a number of less fanciful effects of e–money developments. These include the possibility of bank runs, circumventive innovation, misreporting of macroeconomic statistics, systemic risks, social exclusion and the erosion of privacy. However, it was argued that the extent to which these effects will prove significant depends on the degree to which the new technology is adopted.

Using data from the CPSS surveys, the adoption of e–money in the Euro Area was found to be significantly less advanced than in Singapore, with evidence of pronounced regional disparities between member states. To date, e–money has made only minor inroads into the retail payments infrastructure, and its growth seems to be moderating. In order to evaluate the medium–term prospects of e–money technologies, a range of forecasting models were deployed on a previously unexploited European dataset. The preferred Bayesian average model indicated that e–money usage will continue to grow at a moderate rate in the Euro Area as a whole but that the probability of a significant shift toward increased electronification is unlikely in the medium–term. Indeed, the sigmoid adoption hypothesis analysed using a Gompertz specification suggested that e–money usage has almost reached its apogee. However, such modelling relies on the assumed constancy of the technology. Therefore, while it may be the case that e–money products as we know them now have little growth potential, it does not follow that further innovation will not revolutionise the industry, providing it with a fresh impetus.

Given that the high profile threats have been largely defeated in the literature and that the growth prospects for the new technology seem only moderate, regulators must guard against complacency. On the one hand, regulation must seek to maintain the security and stability of the financial system. On the other, if one believes that the electronification of the payments system may be associated with substantial efficiency gains, then regulators may seek to promote innovation, particularly where they are concerned not just with systemic security but with the maintenance of a well–functioning financial system. The issue of balancing these two goals was the focus of Chapter 4, which compared and critically analysed the European, American and Singaporean regulatory frameworks before laying down some principles of an optimal regulatory strategy.

Comparison of the regulatory frameworks of the three key players revealed substantial differences in their respective approaches to the new technology. Despite being arguably the most important market, the US has enacted deeply inadequate regulation that fails to provide appropriate incentives for innovation, while unnecessarily impeding the rollout of nationwide schemes. By contrast, the European framework is extensive but has been criticised from some quarters for stifling innovation. Finally, the Singaporean system is somewhat underdeveloped at present but has an air of anticipation about it in the run–up to the state–issuance of electronic legal tender and the adoption of common technological standards for e–purse systems.

Comparing the regulatory approaches of each country in this way revealed a number of deficiencies in each framework which an optimal strategy would seek to address. The introduction of a common framework across states, the adoption of passporting provisions and the revision of the scale–invariant security provisions are necessary in the US. The European system could benefit from liberalisation of the regulation surrounding small ELMIs, and from the relaxation of laws restricting the payment of interest on outstanding stored value. Finally, the Singaporean system requires greater formalism and the introduction of better defined risk–bearing regulations less reliant on commercial banks.

The chapter continued by proposing some core characteristics of an optimal regulatory structure. Among the most important recommendations are the need for harmonised regulation and a unified technological environment across national boundaries, the imposition of stringent asset backing requirements of the type imposed on commercial banks, the necessity to maintain redeemability and exchange rate parity and the legalisation of formal interest payments on outstanding balances. Furthermore, the chapter presented a case for legalising the extension of credit in the form of e–money by registered credit institutions. It was argued that this would extend the range of goods and services which may be purchased on credit and would also reduce the risks of circumventive innovation in this direction. At a pragmatic level, it seems preferable to formalise such activities rather than to encourage firms to engage in them outside the spirit of the law.

In the longer–term, regulatory reform is inevitable. The efficacy of any system of regulation decreases with age as various methods of avoidance and evasion are discovered. Two key issues were identified as long–run challenges to e–money regulation. Firstly, the potential development of fractional reserve systems and, alongside this, the desirability of extending the lender of last resort facility to e–money issuers should they be deemed systemically important.

Chapter 5 investigated the Minskyan proposition that active interest rate policy may be destabilising. The FFH asserts that anti–inflationary interest rate hikes will weaken the balance sheets of firms by increasing their debt–servicing obligations while simultaneously increasing the costs associated with the prudential retention of earnings. The combination of these effects reduces the ability of firms' to service their debts, resulting in increased financial fragility and a general shift from hedge to speculative and Ponzi financing structures.

With reference to the discussion of the transmission mechanism in Chapter 2, the Minskyan scheme can be thought of as a situation in which the interest rate and bank lending channels are very strong and potentially destabilising. More specifically, the FFH is associated with a countercyclical external financing premium in the sense of Bernanke and Gertler (1989), a result with particular resonance at the present time. However, despite its contemporary relevance, relatively little applied research effort has been devoted to the FFH. A small literature has grown around simulated and chaotic models in the Minskyan tradition although there is a notable lack of empirical evidence. Chapter 5 attempted to address this lacuna by deploying a sophisticated CVARX model estimated subject to an over–identifying long–run structure embodying many of Minsky's key propositions.

The analysis of impulse response functions following a positive interest rate shock demonstrated that elevated interest rates would increase the debt–servicing obligations of firms while simultaneously decreasing their internal funds. While the observed dynamic adjustment is consistent with Minsky's key proposition that monetary policy may be destabilising, it is not possible to interpret the interest rate shock as a monetary policy shock without imposing a contemporaneous identifying structure. However, the results nevertheless provide strong support for the Minskyan position, because while an interest rate shock need not be a monetary policy shock, the reverse is not true: a monetary policy shock is always an interest rate shock (at least where the interest rate considered is the Federal funds rate). Furthermore, the results revealed no evidence of a significant effect of the interest rate on inflation, an observation potentially consistent with the work of Ball and Sheridan (2003) and Angeriz and Arestis (2006) which suggests that IT policies may be ineffective. However, this result should be treated with care due to the long estimation sample during which the Federal Reserve has pursued a number of different policy regimes (formal IT not being among them).

The analysis of a positive shock to the valuation ratio provided insights into the macroeconomic consequences of irrational exuberance. Of particular interest was the finding that such an asset market surge does not pass through to price level inflation, indicating that inflation–targeting monetary policy will not respond to asset market conditions even indirectly. This contradicts the popular claim that the inflation gap captures all information relevant to the policy decision[1]. Given the strong influence of monetary policy over the stock market and the latter's influence over the rate of fixed capital formation, it seems likely that monetary policy may be improved by responding to a range of asset market indicators as well as to traditional inflation measures and the output gap. Furthermore, if one accepts the linkage between interest rates, investment and productive capacity, then it follows that monetary policy may be non–neutral in the long–run in the sense that hysteretic effects may be significant. Such considerations must also feed into the policy rule.

Interesting results were also derived from inflation and investment shocks. Firstly, there is evidence that suggests that firms may take advantage of inflationary environments to increase their leverage, on the assumption that the inflationary shock will persist. Similarly, while the shock to Tobin's $q$ could be considered a nominal investment shock in a sense, the response to a real investment shock yielded quite different results indicating a strong monetary tightening in response to increased inflationary pressure. Moreover, there is some evidence that the investment shock raises potential output, further questioning the assumed long–run neutrality of money.

These results raise a number of issues for monetary policymakers. Firstly, the asymmetry inherent within modern policy arrangements is likely to foster the expansion of bubbles. Indeed, many in the financial press have been quick to blame the easy money policies of the Greenspan Fed for the inflation of the US asset and housing bubbles (c.f. Roach, 2007). It is likely that macroeconomic performance could be improved if the central bank were to explicitly acknowledge its role in shaping conditions in the asset markets.

[1]It is possible that the output gap would reflect the shock but a growing body of literature has argued for its omission from the policy rule (Christiano and Gust, 1999).

By extension of this reasoning, it could be argued that the central bank should attempt to manage the expansion of bubbles, thereby either reducing the fallout should the bubble burst, or potentially averting the burst altogether.

The contention that monetary policy decisions should be made with regard to their impact on asset markets does not, however, amount to suggesting that the central bank should set the interest rate to achieve a targeted level or growth path of asset prices. The interest rate can only be meaningfully used to achieve a single policy goal or multiple perfectly consistent goals (Tinbergen, 1952). Furthermore, Chairman Bernanke (2006) has acknowledged that the interest rate is a 'blunt tool' with wide–ranging effects, and that the collateral damage associated with bubble–pricking strategies may be substantial (c.f. Nickell, 2005). Hence, asset price terms should only be included in the reaction function as constraints to the interest rate decision rather than formalised targets. To the extent that monetary policymakers consider a wide range of indicators during their deliberations, it is likely that such constraints are already applied to the interest rate decision to some degree on an informal level.

The most fundamental responsibility of the central bank has always been to ensure the stability of the financial system. One can imagine a hierarchy of goals such that the central bank may target inflation as long as this does not endanger systemic stability. These goals may be mutually consistent in fairweather periods (see Goodhart, 2007, for a similar view) but the FFH suggests, at a minimum, that there are limits to the central bank's freedom to set the interest rate in an anti–inflationary manner. Should an inflation–targeting central bank realise that the pursuit of its target is inconsistent with its responsibilities toward the financial system, then it must always desist. The mandate of the Bank of England provides a relevant example. Should the Bank fail to meet the target, the Governor is obliged to write an open letter addressed to the Chancellor of the Exchequer explaining this failure. Thus, the MPC can opt to miss the target range if they believe that this is in the best interests of the economy. While the New Keynesian literature recognises constrained discretion, the link to the primary role of the central bank as guardian of the financial system is seldom explicit.

The final conclusion arising from Chapter 5 challenges the widespread belief that the interest rate is the sole implement of monetary policy. In light of Minsky's FFH and the objections outlined above, it is highly unlikely that the interest rate is the appropriate tool with which to respond to sector–specific asset price misalignments. However, the central bank has the ability to set differential reserve requirements on entries in commercial banks' balance sheets. The chapter concludes that an ABRR system (Palley, 2004; 2006) represents a feasible alternative to interest rate policy in the management of asset market bubbles and that it may possess desirable systemic properties.

Chapter 6 addressed issues associated with monetary policymaking in an open economy. The vast majority of the literature in the field assumes a closed economy for simplicity. However, given the importance of the exchange rate channel of monetary policy and the significant interplay of the interest rate and the current and particularly capital accounts, the results of such models may be called into question. However, the estimation of empirical open economy models is notoriously difficult and typically involves the imposition of identifying restrictions invoking uncovered interest rate parity despite the damning lack of supporting empirical evidence documented by Froot and Thaler (1990), among others. An alternative approach has been the simulation of open economy DSGE models. These rely on the specification and solution of an optimisation problem for each group of agents in the model in a rational expectations framework. However, their reliance on strong behavioural assumptions is open to criticism: the degree to which the decisions of *Homo sapiens* can be approximated by those of *Homo economicus* is unclear.

The modelling approach pursued in Chapter 6 does not invoke such strong assumptions and has the further advantage that it does not rely on the concept of the 'small open economy' subject to global shocks but too small to cause them in its own right. Rather, the chapter deploys a comprehensive two–country stock–flow consistent framework built around a rigorous double–entry accounting framework and employing the minimum of behavioural assumptions. This approach provides a powerful tool for counterfactual analysis that ensures that the most simple of accounting rules are respected at all times. As a result of the consistency of stocks and flows, it is possible to track flows of funds through the respective economies at the sectoral level, gaining profound insights into the mechanisms by which shocks are transmitted. To the best of my knowledge, this represents the first serious attempt at developing an SFC model with which to analyse open economy stabilisation policy.

The model is a modified and extended version of the advanced open economy model of Godley and Lavoie (2006, ch. 12). This basic framework was extended in three ways. Firstly, the addition of a cost–push inflationary mechanism to the model introduced nominal growth, providing the inflationary forces targeted by the central bank. Secondly, the marginal propensities to consume out of disposable income and wealth were endogenised as negative functions of the real interest rate, thereby introducing a simple interest rate channel into the model. Furthermore, this modification generated endogenous cycles following an economic perturbation, motivating the use of stabilisation policy. Finally, four distinct closures were defined representing alternative approaches to economic stabilisation, each of which was compared to the benchmark case of no stabilisation policy.

The model was used to analyse the performance of each stabilisation regime in the wake of three economic shocks: a step decrease in UK real exports; an increase the autonomous component of the UK target real wage equation; and an expansionary US income tax cut. Each shock was found to work through the model differently, providing a thorough test of the various closures of the model. A number of interesting conclusions arose from the simulations. Firstly, procyclical monetary policy in isolation proved incapable of stabilising the economy, resulting in an explosive trajectory in all cases. Similarly, inflation–targeting fiscal policy failed to stabilise the cyclicality of the model following a shock. The combination of inflation targeting monetary and fiscal policies (i.e. CFPIT and CFPLF) resulted in good stabilisation in most cases, with the combination of fiscal policy and US leadership yielding the best performance in general.

The apparent inability of monetary policy to stabilise the economy may, at first, seem inconsistent with the facts of experience. The result is potentially consistent with the aforementioned work on the ineffectiveness of IT policies. Equally, the result is consistent with the view that IT policies may be effective but only in concert with countercyclical fiscal policy (c.f. Leith and Wren-Lewis, 2000; 2006; 2008). It is very difficult to adequately control for the effect of automatic stabilisers and discretionary fiscal interventions, and it is likely that much of the literature which tests IT rules has failed to adequately disentangle the effects of monetary and fiscal policies. Hence, the New Keynesian neglect of fiscal policy may be unwarranted. This result begs further research attention, particularly in the current economic climate in which governments are increasingly turning to fiscal stimulus packages to revitalise their economies.

The results also suggest that the choices made by the fiscal authorities will influence the effect of monetary policy. In particular, the means by which the government chooses to finance its deficit is of fundamental importance. The model assumes that the deficit is funded through the issuance of bonds and this has profound implications for the exchange rate. Indeed, a counter–inflationary interest rate hike was found to result in depreciation of the nominal exchange rate in the medium- to long–term due to its effect on the budget deficit, indicating that the exchange rate channel may be considerably more complex than is often assumed (Arestis and Sawyer, 2004). These results reflect the fundamental interdependence of monetary and fiscal policy decisions observed by Chadha and Nolan (2004).

Finally, the results also demonstrate an effect that is often overlooked: by increasing the interest rate to combat inflation, the central bank increases the interest income of those agents holding financial assets, providing an expansionary stimulus through a 'rentier channel'. With the chosen parameterisation, this channel proved rather strong and was only reinforced by the government's choice to fund its deficit through increased bill issuance. In fact, taken together, these effects tended to dominate the interest rate channel of monetary policy operating through the endogeneity of the savings propensities. These results challenge the conventional wisdom that higher interest rates are always contractionary. Rather, the interest rate operates through a range of channels that are highly complex and may act in opposite directions. The overall effect over any given timeframe is fundamentally dependent on the parameterisation of the system.

The principle conclusion arising from Chapter 6 is that a combination of monetary and fiscal policy is required to stabilise the economy. Neither policy proved successful in any of the three experiments in isolation. This result has profound implications for the New Consensus macroeconomic model which adheres to the notion of Ricardian equivalence. Pragmatism favours the application of the famous 'cat theory' of Deng Xiaoping, which would suggest that the most successful policy is that which should be pursued. If modern macroeconomics is to remain useful, it must acknowledge the role of fiscal policy.

## 7.2 Key Policy Implications

The analysis presented in this thesis has a number of implications for monetary policy and stabilisation policy in a more broadly defined sense. The most important of these are grouped into four broad categories and briefly summarised below.

**Regulatory Issues**

i. The channel system of monetary policy possesses a number of appealing characteristics relative to the traditional approach operated (until recently) by the US. It is more resilient to evolutions of the payments system and has consistently achieved lower volatility of the overnight rate (c.f. Brookes and Hampton, 2000, on this last point). Hence, at a minimum, the Fed should continue paying interest on balances after the resolution of the ongoing financial crisis, and should consider adopting the channel system in the longer–term.

ii. Central banks should strive to adopt a uniform framework for the regulation of e–money along the lines of that discussed in Chapter 4, with a particular emphasis on common technological standards to facilitate interoperability and increase the effective liquidity of e–money. There may be a role for the BIS in providing a nexus for cross–country cooperation.

### Policy Implements

iii. Chapter 5 stressed that the central bank must acknowledge that its freedom to pursue IT policies is constrained by its responsibility to ensure the stability of the financial system. It must also strive to minimise interest rate volatility.

iv. ABRR could be used to cool overheated markets while bolstering the ability of commercial banks to absorb losses associated with loan defaults in a setting of falling collateral values. This may also tame inflation arising through asset market wealth effects, leaving interest rate policy to deal with generalised inflationary pressures, thereby reducing interest rate volatility.

v. In addition to ABRR, the central bank also has the ability to engage in direct prudential and regulatory intervention and moral suasion in order to guide the lending activities of banks.

vi. Points iii. to v. rely on the feasibility of the *ex ante* identification of bubbles. While empirical tests perform disappointingly (c.f. Gurkaynak, 2005) there is scope for a more pragmatic approach based on a range of indicators including Tobin's $q$, the house–price to earnings ratio, and the inflation rates and degree of leveraging in various asset markets. The literature on financial conditions indices may be useful in this regard (c.f. Mayes and Virén, 2001).

### The Role of Fiscal Policy

vii. Chapter 6 revealed that fiscal policy may be a powerful tool of stabilisation policy. The use of automatic stabilisers and discretionary fiscal intervention is common in practice and the academic literature must catch up if it is to remain useful in guiding policy.

viii. Monetary and fiscal policies are interdependent and so coordination between the government and central bank is essential if policies are to be mutually consistent.

### Modelling Issues

ix. There exists an unexploited complementarity between choice–theoretic micro–founded DSGE models and the wealth of detail provided by SFC models, particularly regarding the traverse between (steady) states. This combination could provide a powerful framework around which to marshall one's thoughts.

x. Closed economy models may be useful for studying particular economic effects but they cannot be used to gain reliable insights into the operation of monetary policy in general as they omit the most important channel of monetary transmission.

xi. The results of Chapter 6 suggest that modellers should be aware of the fact that an interest rate hike can exert expansionary as well as contractionary effects and that the operation of monetary policy is highly complex.

## 7.3 Opportunities for Continuing Research

Research, by its nature, is a domain in which knowledge typically progresses in many small steps. Therefore, it seems fitting to close by identifying some interesting and potentially fruitful paths for future work.

The work undertaken in Chapter 3 could be extended in two main ways. Firstly, the development of a theoretical model of e–money demand would be an interesting exercise and it may provide various insights into the appropriate regulatory response. Much of the existing research on e–money demand employs the crude assumption that substitutions will be complete either in all transactions up to a specified size, or for all denominations of currency below a threshold. Shifting the focus on to the attributes of e–money may prove fruitful.

Secondly, the forecasting exercises could be extended in a number of ways. Firstly, the use of informative Bayesian priors in the computation of optimal weights may improve forecasting performance. This approach was not pursued in Chapter 3, however, as it is contingent on the assumption that the 'true model' is contained within the candidate set, a condition which is unlikely to be fulfilled given the set of relatively naïve candidate models employed in estimation. Nevertheless, the inclusion of more sophisticated candidate models and the use of a more sophisticated averaging approach may yield some improvement in forecasting performance.

The assessment of e–money regulation undertaken in Chapter 4 cannot be readily extended for the group of countries considered. However, once the launch of SELT is complete and CEPAS 2.0 has been adopted, a review of the key policy recommendations may prove interesting. Furthermore, as e–money schemes develop and their usage becomes more widespread, various additional regulatory issues may present themselves.

The Minskyan model developed in Chapter 5 opens a number of avenues for further research. Perhaps most interestingly, while the model delivers strong support for Minsky's contention that the interest rate implement may be destabilising, it does not address his other key proposition; that stability is destabilising. Research into this area may yield interesting results and may help to inform the direction of monetary policy into the future and, in particular, following the current financial crisis.

In terms of extending the estimated model, the identification of structural shocks by imposing restrictions on the contemporaneous matrix, $\boldsymbol{A}_0$, could yield interesting results and would strengthen the inferences that could be drawn regarding the destabilising influence of specific monetary policy shocks as opposed to generic interest rate shocks. Similarly, the imposition of tentative restrictions on the loading matrix, $\widetilde{\boldsymbol{\alpha}}$, may sharpen the forecasts derived from the model. On the subject of forecasting, it would be interesting to see how the model would perform on an updated dataset including the current crisis, although reliable data is unlikely to be available within the next two or three years.

Moving in a slightly different direction, the development of a Minskyan SFC model including a well–developed banking sector, and possibly distinguishing between manufacturing firms which rely heavily on debt–financing of inventories and other, less debt–dependent firms, may yield valuable insights into the current crisis. Such a model would be able to provide deep insights into the linkages between monetary policy and financial fragility and may help in defining a sustainable range over which interest rates may be used to target inflation.

The open economy SFC model developed in Chapter 6 may be further developed in three principle directions. Firstly, and most importantly, the inclusion of a banking sector extending loans to firms, and possibly households, would introduce credit channels of monetary policy into the model. Furthermore, the inclusion of equity markets would introduce stock–market wealth effects into the model, resulting in an unusually well developed model of the transmission mechanism of monetary policy. While the development of such a large model would be highly challenging, its usefulness for policy analysis is self–evident.

The consideration of different fiscal regimes also represents an interesting avenue for continuing research. In the present model, income tax operates as an automatic stabiliser while government spending is used to target inflation. An interesting approach would be to assume that government spending is designed to achieve full employment and to investigate the common objection to such strategies concerning their inflationary bias. Similarly, there is scope to test alternative means of funding the government budget deficit through, for example, fiscal prudence associated with reduced future spending and increased taxation, as opposed to the simple assumption of increased bond issuance employed herein.

Finally, the application of Bayesian techniques to SFC models in general would reduce their sensitivity to the initial conditions and the choice of parameterisation. An alternative approach popular within the DSGE literature is to calibrate the model to specific economies using existing empirical literature and stylised facts. This approach could prove useful in the discussion of policy at the national level.

In conclusion, the fact that this thesis has opened up so many avenues for interesting and fruitful research reinforces my initial conviction that the topics covered have hitherto received insufficient research attention. It is my profound hope that the work contained herein, in conjunction with my ongoing research, will succeed in stimulating discussion of these important issues.

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# Data and Technical Appendix

## Notes on Chapter 3

### Comparative Graphical Analysis

The data used in the construction of Figures 3.4 and 3.5 comes from a variety of sources. Data on e–money outstanding, notes and coins in circulation and transferable deposits was retrieved from CPSS reports 54, 60, 74 and 82 country table 2 (CPSS, 2003; 2004; 2006; 2008). The Euro Area e–money series was unavailable prior to 2000 and was completed using the year–end value from the ECB's monthly e–monetary aggregate published in table bsi_emoney. Similarly, the data for notes and coins in circulation in the EU was retrieved from Eurostat series ICP.M.U2.N.000000.4.INX. Exchange rate data used to convert values into US$ was retrieved from country table 1 and completed for the Euro Area using Eurostat table ert_bil_eur_a. GDP data used in construction of the magnitudes relative to GDP was retrieved from Eurostat table daa10000 and from IFS series 57699B..ZF for Singapore. Population data used in the calculation of per capita values was sourced from Eurostat table demo_ppavg for the Euro Area and CPSS Table 1 for Singapore.

The data used in Figures 3.6-3.10 was mostly retrieved from CPSS reports 54 (for 1997-9), 74 (for 2000-1) and 82 (for 2002-6). Population data was retrieved from country table 1 in CPSS report 54 and comparative table 1 in CPSS reports 74 and 82. Where revision anomalies were apparent, data from report number 66 (CPSS, 2005) was substituted in some cases and extrapolation and interpolation were employed. The details of the data sources and manipulations are recorded in Table A1. Note that, where values are reported as 'negligible' by the CPSS, a value of zero is assumed.

### Forecasting

The sources of the data used in the forecasting exercises and the transformation procedures employed are recorded in Table A2. The complete dataset is included on the accompanying CD, as are the Eviews macros used in estimation of all three models and the computation of the accompanying bootstrap standard errors. Unit root testing (not reported) confirms

| Fig. | CPSS Tables Used | Notes |
|---|---|---|
| 3.6 | #54, Table C13<br>#74, Table C7a<br>#82, Table C7a | Italian credit transfer data for 2000 comes from #54 to smooth a revision anomaly. Dutch e–money data for 1997 is extrapolated from the 5 year growth rate. Figures are re–scaled to sum to 100. |
| 3.7 | #54, Table C14<br>#74, Table C9a<br>#82, Table C9a | Italian cheque data for 2000-3 comes from #66 and from 2004-6 is extrapolated using #82 growth rates. Singaporean cheque data for 2002 is from #74 and from 2003-6 is extrapolated using #82 growth rates. Figures are re–scaled to sum to 100. |
| 3.8 | #54, Tables CS6 & C8<br>#74, Table C10<br>#82, Table C10 | Missing French debit card data is interpolated between 2000 and 2004. |
| 3.9 | #54, Tables C5 & CS6<br>#74, Table C11b<br>#82, Table C11b | Belgian ATM data breaks in 2002. Data from #66 is used for 2002-3 and 2004-6 is extrapolated using the growth rate observes after the break. |
| 3.10 | #54, Tables C6 & C8<br>#74, Table C11b<br>#82, Table C11b | |

**Note:** CS denotes a country–specific table in the CPSS report indicated while C denotes a comparative table.

Table A1: Data Sources for Figures 3.6 - 3.10

| Variable | Description (Data Source) and Transformation Procedure |
|---|---|
| $m_{hp}$ | Total e–money outstanding (ECB: bsi_emoney) seasonally adjusted using Census–X12 and divided by M2 (International Financial Statistics, IFS: 59MBUZW), also seasonally adjusted using X12. The resulting series is indexed, HP filtered ($\lambda = 14,400$) and logged. |
| $c$ | Currency in circulation (Eurostat: BSI.M.U2.N.C.L10.X.1.Z5.0000.Z01.E), adjusted with X12 relative to adjusted M2. The resulting series is indexed and logged. |
| $d$ | Demand deposits (IFS: 34B.UZW) adjusted using X21 relative to adjusted M2. Demand deposit data is extrapolated for 2008m4&5 based on monthly growth rates over the previous 12 months. The resulting series is indexed and logged. |
| $y$ | Industrial production (Eurostat: STS.M.I4.Y.PROD.NS0020.4.000) deflated by HICP (Eurostat: ICP.M.U2.N.000000.4.INX). The resulting series is indexed and logged. |
| $r$ | 1 month Euribor (Eurostat: FM.M.U2.EUR.4F.MM.EURIBOR1MD.LST). The resulting series is logged. |
| $q$ | NASDAQ adjusted closing price (Yahoo! Finance) deflated by HICP. The resulting series is logged. |
| $z$ | The mean of broadband subscribers per 100 inhabitants (World Development Indicators, WDI: IT.NET.BBND.P2), internet users per 100 (WDI: IT.NET.USER.P2), mobile phone subscribers per 100 (WDI: IT.CEL.SETS.P2) and PCs per 100 (WDI: IT.CMP.PCMP.P2). Series are extrapolated using the average 5 year growth rate where necessary (99% adoption of cellphones in 2008 is assumed to avoid it exceeding 100%) and linearly interpolated. The resulting series is indexed and logged. |

Table A2: Data Sources for Chapter 3 Forecasts that all variables are I(1) with the exception of $z$, which the tests indicate may be I(2). However, it seems unlikely from a theoretical point of view that $z$ should be I(2) so the analysis proceeds on the assumption that it is I(1).

## Notes on Chapter 5

### Data Sources and Manipulations

The sources of the data used in the estimation of the Minskyan macroeconomic model and the transformation procedures employed are recorded in Table A3. The abbreviations are interpreted as follows:

(N)SA: (Not) seasonally–adjusted;

X12: Seasonally–adjusted using the US Census Bureau's X12 method;

FRB: Federal Reserve Board of Governors;

BEA: Bureau of Economic Analysis;

NIPA: National Income and Product Accounts, provided by the BEA;

IFS: International Monetary Fund International Financial Statistics;

FoF: Flow of Funds Accounts (Release Z1);

BLS: Bureau of Labor Statistics; and

FRED: Federal Reserve Economic Data Service.

The complete dataset is included on the CD provided with this thesis and is accompanied by all of the programmes used in its construction. Similarly, the Gauss code used to estimate the model and to compute the bootstrap critical values and confidence intervals is provided on the CD.

Note that in order to maintain the annual rate characteristics of the Federal funds rate, inflation and wage inflation, the series are logged as follows:

$$r_t = \frac{1}{4} ln \left( 1 + \frac{R_t}{100} \right)$$

| Symbol | Description | Notes (data sources and series codes in parentheses) |
|---|---|---|
| $y_t$ | Realised output | The log of real GDP (NIPA: GDP Table 1.1.6 row 1, SA) converted into index form (2000Y=100). |
| $y_t^*$ | Potential output | Computed using the translog process described in the main text. The series is expressed as an index relative to the realised value of output in the year 2000 and then logged. |
| $r_t$ | Federal funds rate | The log of the Federal funds rate (FRB: H15/H15/RIFSPFF_N.M) converted from monthly to quarterly frequency. |
| $\Delta p_t$ | Inflation | The logarithmic approximation of GDP deflator inflation (NIPA: GDP Table 1.1.4 row 1). |
| $f_t$ | Internal Funds | Book value of US internal funds of the nonfinancial corporate sector (FoF: FA1060000305.Q, SA), deflated by the GDP deflator, indexed and logged. |
| $q_t$ | Tobin's Q | The ratio of the market value of corporate equity (FoF: FL103164003.Q, NSA, X12) to the linearly interpolated net corporate total fixed capital stock (NIPA: Fixed Assets Table 6.1), both deflated by the GDP deflator. The resulting series is indexed and logged. |
| $i_t$ | Investment | Corporate non–financial gross fixed capital investment (FRB: Z1/Z1/FA105019005.Q, SA) deflated by the GDP deflator, indexed and logged. |
| $d_t$ | Real debt–service cost | Defined as the product of the bank prime loan rate (FRB: H15/H15/RIFSPBLP_N.M) less the rate of inflation, and the deflated stock of outstanding corporate credit market liabilities excluding equities (FoF: FL384104005.Q, SA). The loans rate is converted from monthly to quarterly frequency and the series indexed and logged. |
| $\Delta w_t - \Delta z_t$ | Productivity–adj. wage inflation | A logarithmic approximation computed as 400 times the difference between the first difference of the log of hourly compensation (BLS: PRS88003103, SA) and the log of hourly output (BLS: PRS88003093, SA) for the non–financial corporate sector. The series is logged. |
| $p_t^o$ | Oil price | West Texas Intermediate spot oil price (FRED: OILPRICE, NSA, X12) converted from monthly to quarterly frequency, indexed and logged. |

Table A3: Data Sources and Manipulations for the Chapter 5 Model

## Data Used in the Computation of Potential Output

The sources of the data used in the computation of potential output are recorded in Table A4. The production functions (both translog and Cobb–Douglas) are estimated using real quantities that are not logarithmically transformed or indexed.

Potential labour input ($L^*$) is variously defined as follows:

$$L_1^* = CLF \times \left(H^{MAX} + OVH^{HP}\right) \times \left(\frac{100 - \bar{N}}{100}\right)$$

$$L_2^* = CLF \times \left(H^{MAX} + OVH^{HP}\right) \times \left(\frac{100 - N_t}{100}\right)$$

$$L_3^* = CLF \times \left(H^{MAX} + OVH^{HP}\right)$$

where $CLF$ is the civilian labour force (BLS: LNS11000000, SA), $H^{MAX}$ denotes maximum legal working hours before overtime (a value of 40 is assumed across the whole sample), $OVH^{HP}$ is trend overtime hours calculated by HP filtering ($\lambda = 1600$), $\bar{N}$ is the estimated time–invariant NAIRU and $N_t$ is the time–varying NAIRU.

$\bar{N}$ is estimated from OLS regression of the change in the rate of inflation on a constant and the rate of unemployment (BLS: LNS14000000, SA):

$$\Delta\left(\Delta p_t\right) = a\left(U_t - \bar{N}\right) + v_t$$

$$\therefore \Delta\left(\Delta p_t\right) = -a\bar{N} + aU_t + v_t$$

where $-a\bar{N}$ is the regression constant, $U_t$ is unemployment and $v_t$ is a white noise error process. $\bar{N}$ is retrieved simply by taking the ratio of the constant term to the absolute value of the estimated coefficient on unemployment, $|a|$. This yields $\bar{N} = 5.896$.

The time–varying NAIRU is estimated following Ball and Mankiw (2002). The authors re–write the simple Phillips curve above to obtain the following expression:

$$N_t + \frac{v_t}{a} = U_t + \frac{\Delta\left(\Delta p_t\right)}{a}$$

Given the value of $|a|$ obtained from the estimation of $\bar{N}$ above, the right hand side is estimable. Assuming that $v/a$ represents high frequency white noise, it may be removed

| Symbol | Description | Notes (data sources and series codes in parentheses) |
|---|---|---|
| $Y_t$ | Realised output | Quarterly GDP data in chained 2000 dollars (NIPA: GDP Table 1.1.6 row 1, SA). As a value–added measure, there is no need to include material inputs in the production function. |
| $L_t$ | Realised labour input | The product of civilian employment (BLS: LNS12000000, SA) and hours worked (the sum of regular hours (BLS: CES0500000007, SA) and overtime in the manufacturing sector (BLS: CES3000000009, SA)). Quarterly employment data are generated from monthly data. |
| $L_t^*$ | Pot. labour input | See below. |
| $K_t$ | Utilised capital input | The product of total net capital stock (private and governmental; BEA: NIPA Fixed Asset Table 1.1, row 2) and the utilisation rate (FRB: G17/CAPUTL/CAPUTL.B50001.S.Q). Quarterly capital stock data is computed by linear interpolation. The series is deflated by the GDP deflator. |
| $K_t^*$ | Pot. capital input | Equal to the deflated total net capital stock. |
| $t$ | Technical progress | A simple cumulative sum process, $t = 0, 1, 2, ..., T - 1$. |
| $S_L$ | Labour cost–share | Labour cost is defined as the sum of employee compensation (BEA: NIPA GDP Tables 6.2A-D, row 1), employer social security contributions (BEA: NIPA GDP Tables 6.10B-D, row 1) and pension and insurance contributions (BEA: NIPA GDP Tables 6.11A-D, row 1). All series are deflated by the GDP deflator. The labour share is computed as labour cost/(labour + capital cost). |
| $S_K$ | Capital cost–share | The capital cost is equal to the deflated total net capital stock multiplied by the real loan rate plus deflated depreciation (NIPA: Fixed Asset Table 1.3, row 2). The capital share is computed as capital cost/(labour + capital cost). Note that $S_L$ and $S_K$ sum to unity by construction. |

**Note:** NIPA data referred to in this table is annual and is therefore linearly interpolated to generate quarterly series.

Table A4: Data Used in the Computation of Potential Output by HP filtering yielding an estimate of the time–varying NAIRU[2].

## Descriptive Statistics and Data Analysis

Table A5 presents basic descriptive statistics for the dataset. Many of the series are not normally distributed, typically exhibiting a degree of positive (rightward) skewness and excess kurtosis. A low Jarque–Bera probability indicates that the series is non–normal. On this basis, normality is rejected for four series at the 1% significance level and a further four at the 5% level (the various potential output measures account for three of these).

| | $y$ | $r$ | $\pi$ | $\pi^w$ | $I$ | $c$ |
|---|---|---|---|---|---|---|
| Mean | 4.178 | 0.016 | 0.010 | 0.013 | 4.029 | 4.326 |
| Median | 4.187 | 0.014 | 0.008 | 0.012 | 4.023 | 4.331 |
| Maximum | 4.779 | 0.044 | 0.029 | 0.034 | 4.627 | 5.155 |
| Minimum | 3.564 | 0.002 | 0.002 | -0.007 | 3.365 | 3.634 |
| Std. Dev. | 0.360 | 0.008 | 0.006 | 0.007 | 0.359 | 0.327 |
| Skewness | 0.006 | 1.005 | 1.077 | 0.164 | -0.145 | -0.221 |
| Kurtosis | 1.772 | 4.700 | 3.697 | 2.732 | 2.061 | 2.470 |
| Jarque–Bera | 10.297 | 47.360 | 35.031 | 1.229 | 6.592 | 3.255 |
| Probability | 0.006 | 0.000 | 0.000 | 0.541 | 0.037 | 0.196 |
| Sum | 685.119 | 2.576 | 1.593 | 2.083 | 660.799 | 709.505 |
| Sum Sq. Dev. | 21.097 | 0.010 | 0.005 | 0.008 | 20.964 | 17.479 |

| | $d$ | $q$ | $p^o$ | $y_1^*$ | $y_2^*$ | $y_3^*$ |
|---|---|---|---|---|---|---|
| Mean | 3.100 | 3.714 | 4.446 | 4.262 | 4.262 | 4.278 |
| Median | 3.563 | 3.811 | 4.448 | 4.276 | 4.275 | 4.292 |
| Maximum | 4.680 | 4.713 | 5.503 | 4.892 | 4.896 | 4.908 |
| Minimum | -0.537 | 2.859 | 3.594 | 3.591 | 3.598 | 3.607 |
| Std. Dev. | 1.160 | 0.445 | 0.509 | 0.367 | 0.368 | 0.368 |
| Skewness | -1.075 | 0.036 | 0.072 | -0.088 | -0.070 | -0.088 |
| Kurtosis | 3.381 | 2.102 | 2.179 | 1.910 | 1.893 | 1.909 |
| Jarque–Bera | 32.564 | 5.545 | 4.751 | 8.323 | 8.501 | 8.345 |
| Probability | 0.000 | 0.062 | 0.093 | 0.016 | 0.014 | 0.015 |
| Sum | 508.439 | 609.082 | 729.069 | 698.933 | 698.914 | 701.540 |
| Sum Sq. Dev. | 219.333 | 32.234 | 42.268 | 21.994 | 22.072 | 22.031 |

Table A5: Descriptive Statistics

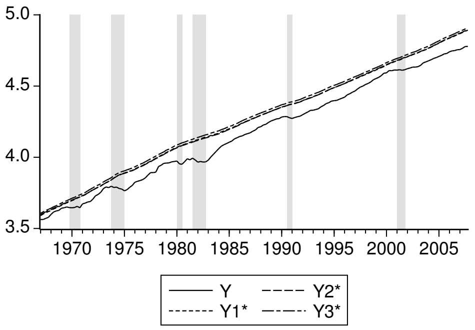
A number of interesting observations may be made based on simple visual inspection of the data plots[3]. Firstly, it is obvious from Figures A1 to A8 that most of the series exhibit trending behaviour, some linearly (in particular output, potential output, investment and

[2]More sophisticated unobservable variable techniques (e.g. Kalman filtering) are gaining popularity in the literature (Roeger, 2006, is a good example) although for our purposes the present method is sufficient.

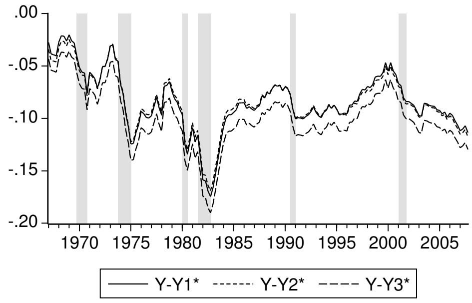
[3]Shaded areas indicate recessions identified by NBER. See `http://www.nber.org/cycles.html` for further details.

cash–flow) and some stochastically (including inflation and the federal funds rate). The increase in stock–prices in the latter part of the twentieth century is easily identifiable in Figures A5 and A6. The fall in the stock market at the turn of the millennium is evident across most of the figures.

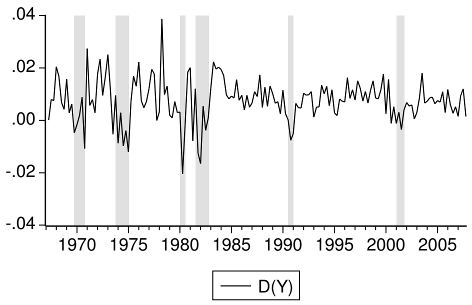
Figures A1(a), (c) and (d) reveal that both realised and potential output have grown relatively consistently since 1967. There are, however, several notable exceptions to this observation, particularly around the OPEC oil shocks of 1973-4 and 1978-9 and the recessionary episodes of 1980-2, 1990-1 and 2001-2. The growth path of GDP has become considerably smoother since the mid–eighties, possibly reflecting increasingly enlightened monetary and fiscal policies.



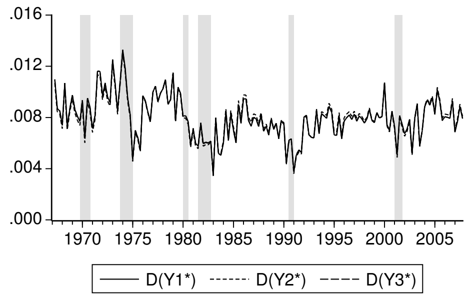

(a) Level of Realised and Potential Output




(b) Implied Output Gap




(c) First Difference of Output



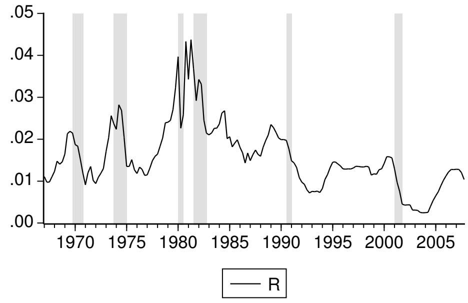

(d) First Difference of Potential Output

Figure A1: Realised and Potential Output and the Implied Output Gap

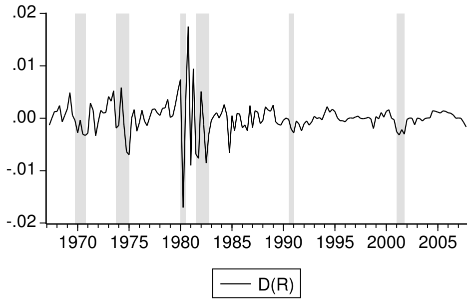
The potential output series derived under the assumptions of a constant NAIRU ($Y_1^*$), a time–varying NAIRU ($Y_2^*$) and zero unemployment ($Y_3^*$) are remarkably similar and all are very smooth. This smoothness is consistent with the fact that the capital stock and labour force evolve relatively slowly owing to the long–term durable nature of investment goods and the relatively stable dynamics of population growth in the short- to medium–term. Figure A1(b) plots the implied output gap $Y - Y^*$ for each potential output series. It is immediately apparent that the distinction between constant and time–

varying NAIRU is inconsequential. Furthermore, the output gap based on the assumption of zero unemployment is somewhat larger than those employing the NAIRU. This follows intuitively from the strict monotonicity of the production function which states that $f(\theta X) > f(X)\ \forall\theta > 1$. Close inspection of Figure A1(b) reveals that the pattern of the output gap is relatively invariant to the definition of potential labour input[4].

It is interesting to note that the implied output gaps are nonstationary when considered across the sample 1967Q1–2006Q4. However, stationarity is only weakly rejected by the ADF test and the rejection is highly sample–sensitive; when the sample length is reduced to 1970Q1–2006Q4 the null hypothesis of a unit root is rejected in all cases. It seems likely that the downward trend in potential output over the early part of the sample reflects the increase in unemployment over the period following the Vietnam war.




(a) Federal Funds Rate Level




(b) First Difference of the Federal Funds Rate

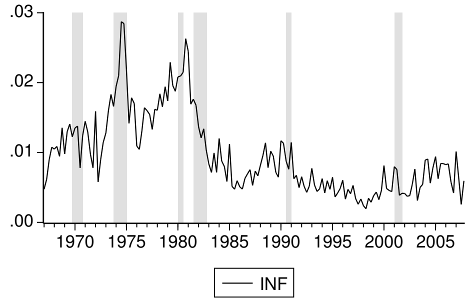
Figure A2: Level and First Difference of the Federal Funds Rate

Figure A2 shows that the federal funds rate has gradually declined over the sample period and has become considerably less volatile. This reduced volatility has been discussed in the literature in terms of policy inertia and interest rate smoothing. This decline in the level of the interest rate has been accompanied by a general decline in the level of price and wage inflation in the economy, a phenomenon known as the 'great moderation' (Figure A3). As one would expect, prices and wages tend to move together in a procyclical manner, indicating that recessionary environments tend to exert deflationary pressure while expansions are characterised by accelerating inflation.

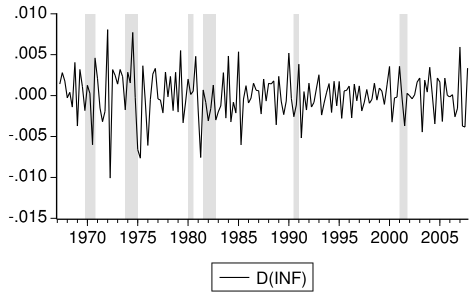
Real cash–flow grows approximately linearly throughout the sample period (Figure A4). Interestingly, the volatility of internal funds increases markedly after 2001, roughly coinciding with the US recession.

Figure A5 reveals that Tobin's $q$ exhibits a reasonably high degree of persistence before reversal of the prevailing trend. The seventies saw a prolonged and deep decline in $q$ which

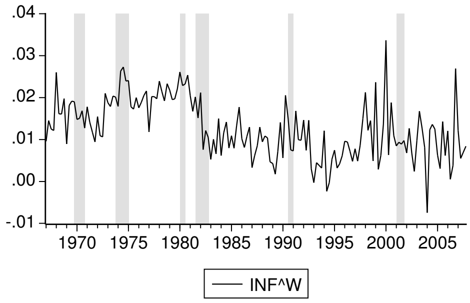
[4]The potential output series computed using a Cobb–Douglas production function (not reported) are very similar to those presented above, suggesting that the method is relatively robust to changes in specification.



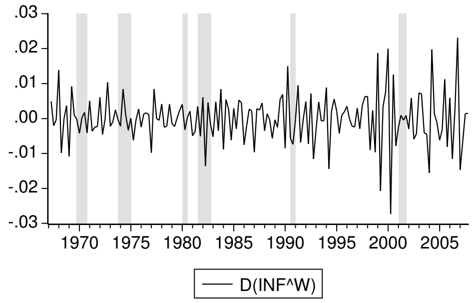

(a) Inflation Level




(b) First Difference of Inflation




(c) Wage Inflation Level

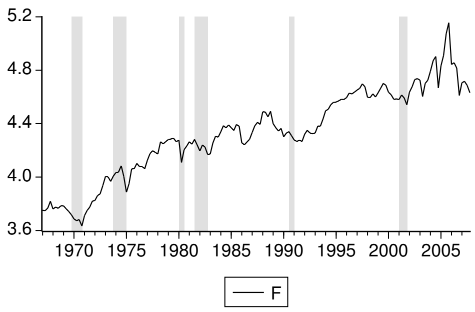



(d) First Difference of Wage Inflation

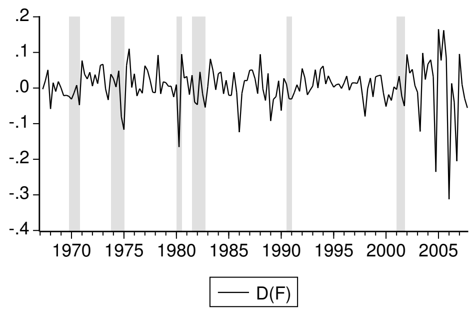
Figure A3: Level and First Difference of Inflation and Wage Inflation

only reversed in 1982 which marked the start of eighteen years of relatively persistent growth of the ratio. The value of $q$ has fallen since the millennium and seems to have reached a relatively steady state since 2003. It is interesting to note that decreases in $q$ seem to lead recessions by approximately one year.

The value of $q$ fluctuates relatively widely and is considerably more volatile than any of the other series. This volatility seems to be largely driven by the stock market: major downturns such as those of the 70's, the 1980-2 recession, the 1987 crash and the 2001-2 recession are clearly visible as large negative spikes. This observation is not surprising

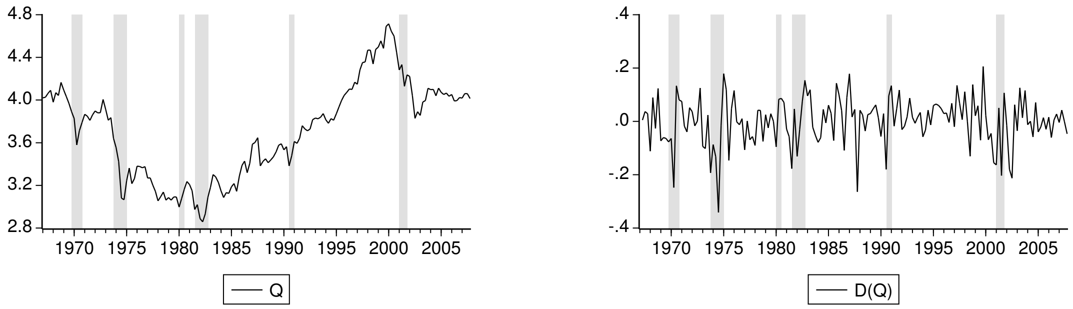



(a) Internal Funds Level




(b) First Difference of Internal Funds

Figure A4: Level and First Difference of Internal Funds

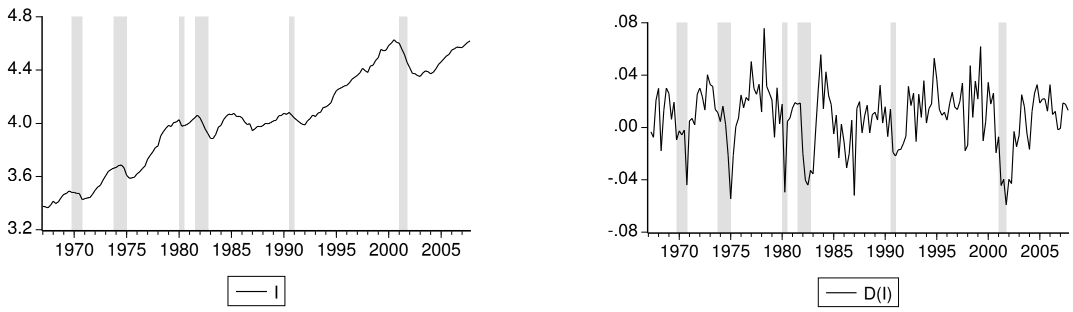



(a) Tobin's $q$ Level (b) First Difference of Tobin's $q$

Figure A5: Level and First Difference of Tobin's $q$

given the relative volatilities of stock market and capital stock data. Furthermore, it lends credibility to the contention that the inclusion of $q$ in the investment function provides a mechanism whereby market sentiment can influence investment decisions.

Investment increases throughout most of the sample with a notable flattening after the recession of the early 80's which is often attributed to tight monetary policy combined with lacklustre fiscal policy (Figure A6). Panel (b) reveals that investment is highly sensitive to the business cycle, falling sharply in recessions. The acceleration of investment spending between 1992 and 2000 reflects the buoyant stock market situation which prevailed throughout the period, underlining the importance of market sentiment for corporate investment.

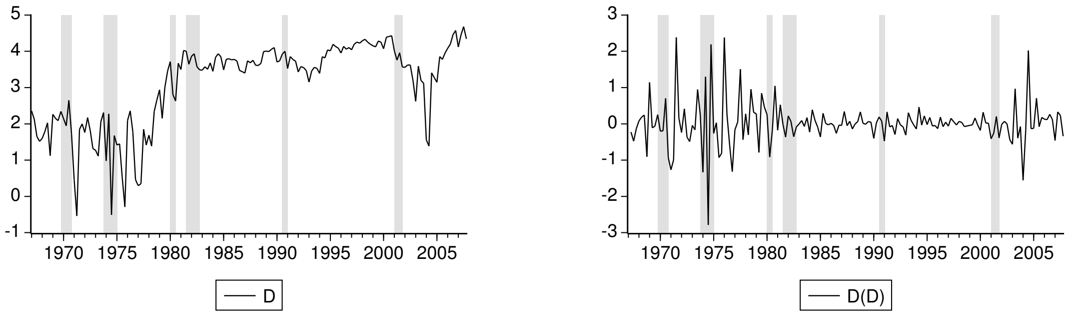



(a) Investment Level (b) First Difference of Investment

Figure A6: Level and First Difference of Investment

The real debt–service cost is defined as the product of outstanding real credit market liabilities and the real prime loans rate (i.e. $d = (R_L - \pi) \cdot L/p$ where $L$ denotes liabilities and $p$ the price level). Hence, it is possible for the series to take negative values. In these instances the interest repayments on existing loans are less than the devaluation of the real loan principal. It should be clear that this measure of debt–service cost reflects only minimal servicing of existing debt (i.e. repayment only of interest, not the principal).

Figure A7(a) shows a marked increase in the burden of debt–service concentrated in

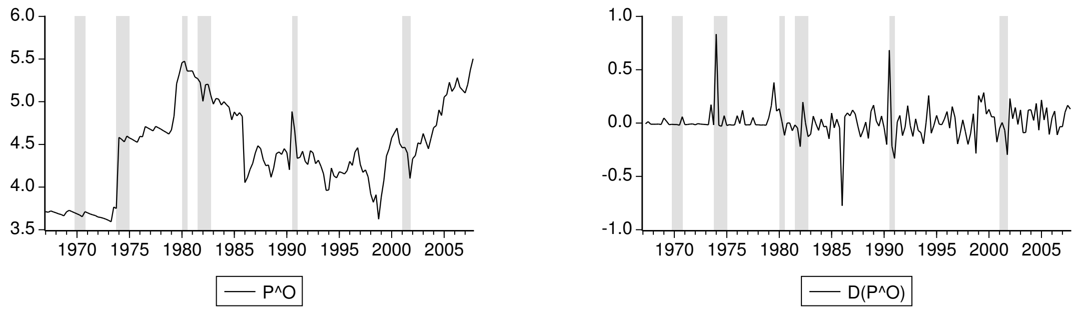



(a) Real Debt–Service Cost Level (b) First Difference of Real Debt–Service Cost

Figure A7: Level and First Difference of Real Debt–Service Cost

the period 1975-82. During this period, high real interest rates exacerbated the burden of existing debt. Until recently real interest rates have gradually fallen, a process which reached a climax in 2001 with the so–called ‘Greenspan gambit’ (clearly visible in panels a and b) . This easy money period induced firms to rely increasingly on debt–funding, to such an extent that the real debt burden remained unchanged. Since 2004, the Federal Reserve has steadily increased interest rates in order to keep inflation in check, a policy which has resulted in the large spike at the end of the series. However, given the alarmingly high indebtedness of firms and households alike, the Fed must act with care in the near future to avoid substantial economic retrenchment (indeed, the current turbulence in the global economy is inextricably linked to the sub–prime debt crisis, and the way that central banks have responded and are continuing to respond is the subject of intense scrutiny).

Lastly, Figure A8 is a common sight in the empirical business cycle literature and needs little introduction beyond noting the recent persistent increase in the price of oil which many commentators attribute both to increasing Chinese demand and to speculative activity.




(a) Oil price level (b) First Difference of Oil Price

Figure A8: Level and First Difference of the Oil Price

The results of ADF testing of the levels and first differences of the variables in the dataset are presented in Table A6. The tests indicate that all variables in the dataset follow

| | $Y$ | $Y_1^*$ | $Y_2^*$ | $Y_3^*$ | $I$ | $c$ |
|---|---|---|---|---|---|---|
| DF(0) | -2.407 | -3.074 | -2.492 | -3.084 | -1.543 | -3.429 $^{a,s,h}$ |
| ADF(1) | -3.231 | -2.576 | -2.331 | -2.588 | -2.495 | -3.310 |
| ADF(2) | -3.913 $^{s,h}$ | -2.565 | -2.437 | -2.572 | -3.262 $^{a,s,h}$ | -2.982 |
| ADF(3) | -4.100 | -2.792 $^{a,s,h}$ | -2.838 $^{a,s,h}$ | -2.795 $^{a,s,h}$ | -3.176 | -3.132 |
| ADF(4) | -4.401 $^{a}$ | -2.769 | -2.796 | -2.773 | -3.244 | -2.475 |
| | $d$ | $q$ | $p^o$ | $r$ | $\pi$ | $\pi^w$ |
| DF(0) | -4.954 $^{a,h}$ | -2.063 $^{a,s,h}$ | -1.827 $^{a,s,h}$ | -2.597 $^{s}$ | -3.175 | -7.345 |
| ADF(1) | -3.813 | -2.111 | -1.770 | -2.378 | -2.357 | -4.712 |
| ADF(2) | -3.237 $^{s}$ | -2.120 | -1.703 | -2.003 | -1.839 $^{s}$ | -3.461 |
| ADF(3) | -2.332 | -2.128 | -1.849 | -2.502 $^{a,h}$ | -1.626 | -2.591 $^{s,h}$ |
| ADF(4) | -1.925 | -2.122 | -1.847 | -2.307 | -1.976 $^{a,h}$ | -2.234 $^{a}$ |

| | $\Delta Y$ | $\Delta Y_1^*$ | $\Delta Y_2^*$ | $\Delta Y_3^*$ | $\Delta I$ | $\Delta c$ |
|---|---|---|---|---|---|---|
| DF(0) | -9.772 $^{s}$ | -7.102 | -7.157 | -7.156 | -7.528 | -13.287 $^{s,h}$ |
| ADF(1) | -6.732 $^{a,h}$ | -4.909 | -4.962 | -4.936 | -4.991 $^{a,s,h}$ | -10.192 |
| ADF(2) | -5.955 | -3.231 $^{a,s,h}$ | -3.282 $^{a,s,h}$ | -3.240 $^{a,s,h}$ | -4.953 | -7.757 |
| ADF(3) | -5.271 | -3.268 | -3.359 | -3.269 | -4.647 | -7.992 $^{a}$ |
| ADF(4) | -5.323 | -3.480 | -3.629 | -3.482 | -5.196 | -6.555 |
| | $\Delta d$ | $\Delta q$ | $\Delta p^o$ | $\Delta r$ | $\Delta \pi$ | $\Delta \pi^w$ |
| DF(0) | -16.914 $^{a,s,h}$ | -11.643 $^{a,s,h}$ | -12.927 $^{a,s,h}$ | -13.880 | -16.741 | -20.636 |
| ADF(1) | -12.149 | -8.387 | -9.289 | -11.151 | -12.699 $^{s}$ | -14.918 |
| ADF(2) | -12.184 | -6.877 | -6.884 | -6.744 | -10.029 | -12.936 $^{s}$ |
| ADF(3) | -10.615 | -6.010 | -6.037 | -6.488 | -6.614 $^{a,h}$ | -10.348 $^{a,h}$ |
| ADF(4) | -7.327 | -5.804 | -6.332 | -4.524 $^{a,s,h}$ | -6.027 | -8.727 |

In the levels case, the Augmented Dickey–Fuller regressions include four lagged first differences of the dependent variable. An intercept and deterministic time trend are included in all cases except $r$, $\pi$ and $\pi^w$ where the trend is omitted. The lower 5% critical values are -2.880 and -3.439 for the intercept only and intercept and trend cases respectively. In the case of differenced data, the ADF regressions again include four lags and an intercept but no deterministic time trend in any case. The lower 5% critical value is -2.880. Superscript '$a$', '$s$' and '$h$' denote the ADF lag length selected by the Akaike, Schwarz and Hannan–Quinn Information Criteria, respectively.

Table A6: Unit Root Tests for Chapter 5 Data difference stationary I(1) processes with the exception of $Y$. This result is significantly at variance with a vast body of empirical literature. However, it seems that it is a peculiarity of the ADF test in this instance as the Phillips–Perron test finds $Y$ to be non–stationary at the 5% level (test statistic = -3.3654, 5% c.v. = -3.438). Furthermore, the ADF tests using AIC or HQC for lag selection indicate that $d$ is I(0) although the SIC selects two lags and the test indicates that $d$ is I(1). Given the strong theoretical reasons for thinking that output and the cost of debt–service are I(1), it seems safe to proceed on this basis.

## Long-Run Macroeconometric Modelling: A Review

The model is estimated following the long–run structural approach of Garratt et al. (2006, hereafter GLPS). This flexible modelling strategy provides a method by which theoretically–motivated restrictions can be imposed on the long–run structure of the model while the short–run remains unrestricted. The over identifying structure may be empirically tested, in effect testing the proposed economic theory. Furthermore, the GLPS methodology generalises the flexible cointegrating VAR approach to account for the presence of exogenous I(1) variables. This section briefly and selectively reviews the GLPS approach, drawing extensively on chapters three and six of their book *Global and National Macroeconometric Modelling: A Long–Run Structural Approach.*

### Unrestricted VAR and VARX

In his seminal presentation of vector autoregression (VAR), Sims (1980) treats all variables as endogenous on the grounds that any endogenous/exogenous distinction is unwarranted and spurious in a situation of true simultaneity. Indeed, Sims' development of the VAR approach was motivated by his rejection of the excessive reliance on tentative economic theories which had characterised the traditional simultaneous equation modelling approach developed by the Cowles Commission. In his new approach Sims would let the data speak for itself.

The assumption that all variables are determined endogenously imposes many limitations on the macroeconometrician. In the present context, there is little justification for assuming endogeneity of potential output and still less for the global oil price. Pesaran, Shin and Smith (2000) propose a general structural VAR which permits the distinction between endogenously and exogenously determined variables which they term VARX. The authors consider the partitioning of the $m$ vector $\boldsymbol{z}_t$ into the $m_y$ vector, $\boldsymbol{y}_t$, of endogenous variables and the $m_x$ vector, $\boldsymbol{x}_t$, of exogenous variables such that $\boldsymbol{z_t} = (\boldsymbol{y}_t', \boldsymbol{x}_t')'$. Hence:

$$\boldsymbol{A}_0\boldsymbol{y}_t = \boldsymbol{A}_1\boldsymbol{y}_{t-1} + \ldots + \boldsymbol{A}_p\boldsymbol{y}_{t-p} + \boldsymbol{B}_0\boldsymbol{x}_t + \boldsymbol{B}_1\boldsymbol{x}_{t-1} + \ldots + \boldsymbol{B}_p\boldsymbol{x}_{t-p} + \boldsymbol{D}\boldsymbol{d}_t + \boldsymbol{\varepsilon_t} \tag{A1}$$

where $\boldsymbol{\varepsilon}_t = (\varepsilon_{1t}, \varepsilon_{2t}, \ldots, \varepsilon_{mt})$ is an $m_y \times 1$ vector of serially–uncorrelated mean–zero random error processes distributed independently of $\boldsymbol{x}_t$ with the positive definite variance–covariance matrix $\boldsymbol{\Omega}$, $\boldsymbol{d}_t$ is a $q \times 1$ vector of deterministic components and $t = 1, 2, \ldots, T$. Dependent on the nature of the deterministic components in $\boldsymbol{d}$, the system is stable when $|\lambda| > 1$ in the determinental equation:

$$|\boldsymbol{A}_0 - \sum_{i=1}^{p} \boldsymbol{A}_i \lambda^i| = 0$$

The reduced form of equation A1 is retrieved by pre–multiplying all terms by $\boldsymbol{A}_0^{-1}$ such that:

$$\boldsymbol{y}_t = \boldsymbol{\Phi}_1\boldsymbol{y}_{t-1} + \ldots + \boldsymbol{\Phi}_p\boldsymbol{y}_{t-p} + \boldsymbol{\Psi}_0\boldsymbol{x}_t + \boldsymbol{\Psi}_1\boldsymbol{x}_{t-1} + \ldots + \boldsymbol{\Psi}_p\boldsymbol{x}_{t-p} + \boldsymbol{\Upsilon}\boldsymbol{d}_t + \boldsymbol{e}_t \tag{A2}$$

where $\boldsymbol{\Phi}_i = \boldsymbol{A}_0^{-1}\boldsymbol{A}_i$, $\boldsymbol{\Psi}_i = \boldsymbol{A}_0^{-1}\boldsymbol{B}_i$, $\boldsymbol{\Upsilon} = \boldsymbol{A}_0^{-1}\boldsymbol{D}$ and $\boldsymbol{e}_t = \boldsymbol{A}_0^{-1}\boldsymbol{\epsilon}_t$ is i.i.d. $(0,\ \boldsymbol{\Sigma})$ where $\boldsymbol{\Omega} = \boldsymbol{A}_0\boldsymbol{\Sigma}\boldsymbol{A}_0'$. In this form the equation can be readily estimated by OLS although the identification of the structural parameters based on the reduced–form parameters is typically non–trivial in practical applications.

**VECM: Estimation and Identification with Exogenous Variables**

Before turning to the case of cointegrating VAR in the presence of exogenous I(1) variables (CVARX) it is instructive to discuss the case in which $\boldsymbol{B}_i = \boldsymbol{\Psi}_i = 0\ \forall i = 0, 1, \ldots, p$, i.e. when all variables are endogenous and the system collapses to a standard VAR($p$). Assuming that the vector $\boldsymbol{d}_t$ comprises constant terms and linear time trends then, by use of the Granger Representation Theorem, it is possible to recast the reduced–form VAR($p$) as a VECM($p-1$) as follows[5]:

$$\Delta\boldsymbol{y}_t = \boldsymbol{a} + \boldsymbol{b}t - \boldsymbol{\Pi}\boldsymbol{y}_{t-1} \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i\boldsymbol{y}_{t-i} + \boldsymbol{v}_t \tag{A3}$$

[5]The nature of the deterministic components included in VECM models has a number of important implications which must be carefully considered during model specification. In particular, the inclusion of linear deterministic trends in the first–differenced VAR model may be associated with quadratic trends in levels where the model contains a unit root. See Pesaran et al. (2000) for a detailed discussion of these issues, in which five cases are identified reflecting different restrictions placed on intercept and time trend coefficients.

where $\mathbf{\Pi} = -\left(\boldsymbol{I}_{m_y} - \sum_{i=1}^{p} \mathbf{\Phi}_i\right)$ and $\mathbf{\Gamma}_i = -\sum_{j=i+1}^{p} \mathbf{\Phi}_j$, $\mathbf{\Pi}$ and $\mathbf{\Gamma}_i$ are $m_y \times m_y$ matrices of unknown coefficients, $\boldsymbol{a}$ and $\boldsymbol{b}$ are $m_y \times 1$ vectors of unknown coefficients and $\boldsymbol{v}_t$ is an $m_y \times 1$ vector of serially uncorrelated reduced–form disturbances defined similarly to $\boldsymbol{e}_t$ above. The condition $|\lambda| \geq 1$ with regards to the determinental equation

$$|\boldsymbol{I}_{m_y} - \mathbf{\Phi}_1\lambda - \mathbf{\Phi}_2\lambda^2 - \ldots - \mathbf{\Phi}_p\lambda^p| = 0$$

precludes the possibility of I(2) variates.

Assuming that all of the $m_y$ elements of the vector $\boldsymbol{y}_t$ are difference stationary (I(1)) processes and that there exist $r < m_y$ linear combinations of these series ($\boldsymbol{\beta}'\boldsymbol{y}_t$) which are stationary (i.e. there are $r$ cointegrating vectors) then the matrix $\mathbf{\Pi}$ has reduced–rank $r$ and may be decomposed into:

$$\mathbf{\Pi} = \boldsymbol{\alpha}\boldsymbol{\beta}' \tag{A4}$$

where $\boldsymbol{\alpha}$ is the $m_y \times r$ loading matrix of equilibrium–correction coefficients. It follows from equation A3 that neither $\boldsymbol{\alpha}$ nor $\boldsymbol{\beta}'$ are uniquely identified by estimation of the matrix $\mathbf{\Pi}$ as it is possible to define any invertible $r \times r$ matrix $\boldsymbol{Q}$ such that:

$$\mathbf{\Pi} = \boldsymbol{\alpha}\boldsymbol{\beta}' = \left(\boldsymbol{\alpha}\boldsymbol{Q}^{-1}\right)\left(\boldsymbol{Q}'\boldsymbol{\beta}'\right) = \boldsymbol{\alpha}_*\boldsymbol{\beta}_*' \tag{A5}$$

where $\boldsymbol{\alpha}\boldsymbol{\beta}'$ and $\boldsymbol{\alpha}_*\boldsymbol{\beta}_*'$ are observationally indistinct. In order to retrieve the loading vector $\boldsymbol{\alpha}$ and cointegrating matrix $\boldsymbol{\beta}$ from estimates of $\mathbf{\Pi}$ requires the imposition of at least $r^2$ restrictions on either the short–run or long–run relations embedded in the model. However, given that long–run economic theory is generally considered significantly more robust than that of the short–run it is natural to impose the $r^2$ restrictions on the matrix $\boldsymbol{\beta}$ ($r$ restrictions of each of the $r$ cointegrating vectors) to overcome the identification problem. Normalising the vectors provides $r$ restrictions leaving $r^2 - r$ restrictions that must be imposed for exact identification.

In single equation models the analysis of cointegration is relatively straightforward. This simple case was analysed by Engle and Granger (1987). Cointegration is defined as the case in which there is at least one linear combination of two or more I(1) series which is I(0). This led Engle and Granger to develop a residual–based unit root test of the null of I(1) residuals against the one–sided alternative in which they are I(0). It follows that if the regressors are cointegrated then the regression residuals must be I(0).

The Engle–Granger approach tests simply for the presence of cointegration. The problem of estimating the number and nature of the cointegrating vectors in system models was approached by Johansen (1988, 1991, 1995). Johansen advances a system maximum likelihood method for testing hypotheses about the rank of the matrix $\mathbf{\Pi}$ based on reduced–rank regression. Johansen's procedure involves testing the null hypothesis:

$$H_0: \ Rank\,(\mathbf{\Pi}) = r, \ r = 0, 1, \ldots, m_y - 1$$

against either of two alternatives:

$$H_{1a}: \ Rank\,(\mathbf{\Pi}) = m_y$$

$$H_{1b}: \ Rank\,(\mathbf{\Pi}) = r + 1$$

where $H_{1a}$ indicates that $\mathbf{\Pi}$ is of full rank while $H_{1b}$ corresponds to the reduced–rank case if $r < m_y - 1$. Johansen develops separate test statistics for each alternative hypothesis, the trace ($LR_{trace}$) for testing $H_{1a}$ and the maximum eigenvalue statistic ($LR_{max}$) for $H_{1b}$. These statistics are defined by:

$$LR_{trace} = -T \sum_{i=r+1}^{m} ln\,(1 - \lambda_i)$$

$$LR_{max} = -T ln\,(1 - \lambda_{r+1})$$

where $\lambda_1 > \lambda_2 > \ldots \lambda_m$ denote the ordered eigenvalues of:

$$\boldsymbol{C} = \boldsymbol{S}_{11}^{-1}\boldsymbol{S}_{10}\boldsymbol{S}_{00}^{-1}\boldsymbol{S}_{01} \quad ; \quad \boldsymbol{S}_{ij} = T^{-1}\sum_{t=1}^{T}\boldsymbol{r}_{it}\boldsymbol{r}'_{jt}, \quad i, j = 0, 1$$

and where $\boldsymbol{r}_{0t}$ and $\boldsymbol{r}_{1t}$ are the residual vectors resulting from the regression of $\Delta\boldsymbol{y}_t$ and $\boldsymbol{y}_{t-1}$ (respectively) on $(\Delta\boldsymbol{y}_{t-1}, \Delta\boldsymbol{y}_{t-2}, \ldots, \Delta\boldsymbol{y}_{t-p+1})$. The test statistics are asymptotically non–standardly distributed so critical values generated by Monte Carlo iterations are reported by Johansen (1995).

Having identified the rank $r$ of the matrix $\mathbf{\Pi}$ (i.e. the number of cointegrating vectors among the variables) it is now necessary to impose the additional $r^2 - r$ exactly identifying restrictions. This can be approached either empirically (c.f. Johansen, 1988, 1991, and Phillips, 1991, for example) or using prior economic theory.

Pesaran and Shin (2002) propose a sophisticated theory–based identification scheme in which the long–run matrix $\boldsymbol{\beta}$ is subjected to $k$ linear restrictions such that:

$$\boldsymbol{R}vec(\boldsymbol{\beta}) = \boldsymbol{f} \tag{A6}$$

where $\boldsymbol{R}$ is a $k \times m_y r$ matrix of known constants, $\boldsymbol{f}$ is a $k \times 1$ vector of known constants and $vec(\boldsymbol{\beta})$ denotes the $m_y r \times 1$ vectorisation of the long–run matrix $\boldsymbol{\beta}$. This approach to identification overcomes many of Sims' criticisms of the Cowles Commission approach given that it requires no endogenous/exogenous dichotomy and it does not impose any restrictions on the short–run dynamics of the model.

Pesaran and Shin use Johansen's concentrated log–likelihood function:

$$\ell_T(\boldsymbol{\beta}) = constant - \frac{T}{2}\left\{ln|\boldsymbol{\beta}'\boldsymbol{A}_T\boldsymbol{\beta}| - ln|\boldsymbol{\beta}'\boldsymbol{B}_T\boldsymbol{\beta}|\right\}$$

where $\boldsymbol{A}_T = \boldsymbol{S}_{11} - \boldsymbol{S}_{10}\boldsymbol{S}_{00}^{-1}\boldsymbol{S}_{01}$ and $\boldsymbol{B}_T = \boldsymbol{S}_{11}$. $\ell_T$ is maximised subject to the restrictions (A6) by forming the Lagrangian (and denoting $\boldsymbol{\theta} = vec(\boldsymbol{\beta})$) as follows:

$$\begin{aligned}\Lambda(\boldsymbol{\theta}, \boldsymbol{\lambda}) &= \frac{1}{T}\ell_T(\boldsymbol{\theta}) - \frac{1}{2}\boldsymbol{\lambda}'\boldsymbol{h}(\boldsymbol{\theta}) \\ &= constant - \frac{1}{2}\left\{ln|\boldsymbol{\beta}'\boldsymbol{A}_T\boldsymbol{\beta}| - ln|\boldsymbol{\beta}'\boldsymbol{B}_T\boldsymbol{\beta}| - \boldsymbol{\lambda}'(\boldsymbol{R\theta} - \boldsymbol{f})\right\}\end{aligned}$$

where $\boldsymbol{h}(\boldsymbol{\theta}) = \boldsymbol{R\theta} - \boldsymbol{f}$ and $\boldsymbol{\lambda}$ is the $k \times 1$ vector of Lagrange multipliers. Three cases can be identified: $k < r^2$ (under identified), $k = r^2$ (exactly identified) and $k > r^2$ (over identified). The last two cases are of considerably greater interest than the first for obvious reasons. The derivation of the ML estimator of $\boldsymbol{\beta}$ is highly complex, particularly in the over identified case and may be found in Pesaran and Shin. A more applied discussion is to be found in Pesaran and Pesaran (1997).

Pesaran and Shin develop a likelihood ratio test of the $k - r^2$ over identifying restrictions based on partitioning the restriction matrices $\boldsymbol{R\theta} = \boldsymbol{f}$ as follows:

$$\begin{pmatrix} \boldsymbol{R}_A\boldsymbol{\theta} \\ \boldsymbol{R}_B\boldsymbol{\theta} \end{pmatrix} = \begin{pmatrix} \boldsymbol{f}_A \\ \boldsymbol{f}_B \end{pmatrix}$$

such that $\boldsymbol{R}_A\boldsymbol{\theta} = \boldsymbol{f}_A$ represents the $r^2$ just identifying restrictions and $\boldsymbol{R}_B\boldsymbol{\theta} = \boldsymbol{f}_B$ denotes the $k - r^2$ over identifying restrictions. Hence the dimensions of the known matrices and vectors $\boldsymbol{R}_A$, $\boldsymbol{R}_B$, $\boldsymbol{f}_A$ and $\boldsymbol{f}_B$ are $r^2 \times m_y r$, $\left(k - r^2\right) \times m_y r$, $r^2 \times 1$ and $\left(k - r^2\right) \times 1$, respectively.

Defining $\hat{\boldsymbol{\theta}}_A$ and $\hat{\boldsymbol{\theta}}_B$ as the ML estimators of $\boldsymbol{\theta}$ derived under the exactly and over identifying restrictions (respectively) allows one to construct the likelihood ratio statistic:

$$LR = 2\left\{\ell_T\left(\hat{\boldsymbol{\theta}}_A\right) - \ell_T\left(\hat{\boldsymbol{\theta}}_B\right)\right\}$$

where $\ell_T\left(\hat{\boldsymbol{\theta}}_A\right)$ and $\ell_T\left(\hat{\boldsymbol{\theta}}_B\right)$ denote the maximised log–likelihood values subject to the relevant set of restrictions[6]. The statistic follows an asymptotic $\chi^2$ distribution with $k - r^2$ degrees of freedom.

Once the cointegrating vectors have been estimated, the short–run parameters ($\boldsymbol{\alpha}$ and $\boldsymbol{\Gamma}_i$) can be simply estimated by OLS regression of the following:

$$\Delta \boldsymbol{y}_t = \boldsymbol{a}_0 + \boldsymbol{\alpha}\boldsymbol{\xi}_t + \boldsymbol{\Gamma}_1 \Delta \boldsymbol{y}_{t-1} + \ldots + \boldsymbol{\Gamma}_{p-1}\Delta \boldsymbol{y}_{t-p+1} + \boldsymbol{v}_t \tag{A7}$$

where $\boldsymbol{\xi}_t = \boldsymbol{\beta}'\boldsymbol{y}_{t-1} - \boldsymbol{b}_0 - \boldsymbol{b}_1 t$[7] is an $r \times 1$ vector of estimated long–run errors, that is to say the deviations from the long–run equilibrium described by the cointegrating vectors. By substituting for $\boldsymbol{\xi}_t$ it is possible to rewrite equation A7 in the form of equation A3 as follows:

$$\Delta \boldsymbol{y}_t = \boldsymbol{a} + \boldsymbol{b}t - \boldsymbol{\alpha}\boldsymbol{\beta}'\boldsymbol{y}_{t-1} + \sum_{i-1}^{p-1} \boldsymbol{\Gamma}_i \Delta \boldsymbol{y}_{t-i} + \boldsymbol{v}_t \tag{A8}$$

where $\boldsymbol{a} = \boldsymbol{a}_0 + \boldsymbol{\alpha}\left(\boldsymbol{b}_0 - \boldsymbol{b}_1\right)$ and $\boldsymbol{b} = \boldsymbol{\alpha}\boldsymbol{b}_1$. Once the dynamic VECM has been estimated one can compute impulse responses and persistence profiles as normal, although one must be aware that while impulses are transitory in the case of stationary variables and long–run vectors they are not for integrated variables. In this case the impulse response should asymptote to a non–zero value as the forecast horizon becomes sufficiently large.

### VECM with Exogenous I(1) Variables

Recalling the partitioning of the $m$ vector $\boldsymbol{z}_t$ into the $m_y$ and $m_x$ vectors $\boldsymbol{y}_t$ and $\boldsymbol{x}_t$ of endogenous and exogenous variables (respectively) the modelling described above may be readily extended to incorporate weakly exogenous I(1) variables (long–run forcing variables in the terminology of Granger and Lin, 1995). In particular, given the general structural VECM of the form:

$$\boldsymbol{A}\Delta \boldsymbol{z}_t = \widetilde{\boldsymbol{a}} + \widetilde{\boldsymbol{b}}t + \widetilde{\boldsymbol{\Pi}}\boldsymbol{z}_{t-1} + \sum_{i=1}^{p-1} \widetilde{\boldsymbol{\Gamma}}_i \boldsymbol{\Delta z}_{t-i} + \boldsymbol{\epsilon}_t \tag{A9}$$

[6] Noting that the maximum value of the log–likelihood is independent of any invertible transformation of the cointegrating space spanned by the exactly identifying restrictions, Pesaran and Shin observe that $\ell_T\left(\hat{\boldsymbol{\theta}}_A\right)$ could be replaced with the ML estimator obtained subject to Johansen's empirical restrictions.

[7] The inclusion of the $r \times 1$ vectors of deterministic terms represents the most general case but they are often set to zero in practice.

GLPS observe that one may write:

$$\begin{pmatrix} \boldsymbol{A}_{yy} & \boldsymbol{A}_{yx} \\ \boldsymbol{0} & \boldsymbol{A}_{xx} \end{pmatrix} \begin{pmatrix} \Delta \boldsymbol{y}_t \\ \Delta \boldsymbol{x}_t \end{pmatrix} = \widetilde{\boldsymbol{a}} + \widetilde{\boldsymbol{b}}t + \widetilde{\boldsymbol{\Pi}} \begin{pmatrix} \boldsymbol{y}_{t-1} \\ \boldsymbol{x}_{t-1} \end{pmatrix} + \sum_{i=1}^{p-1} \widetilde{\boldsymbol{\Gamma}}_i \begin{pmatrix} \Delta \boldsymbol{y}_{t-i} \\ \Delta \boldsymbol{x}_{t-i} \end{pmatrix} + \begin{pmatrix} \epsilon_{yt} \\ \epsilon_{xt} \end{pmatrix} \tag{A10}$$

where:

$$\widetilde{\boldsymbol{\Pi}} = \begin{pmatrix} \widetilde{\boldsymbol{\Pi}}_y \\ \boldsymbol{0} \end{pmatrix} = \begin{pmatrix} \widetilde{\boldsymbol{\alpha}}_y \\ \boldsymbol{0} \end{pmatrix} \boldsymbol{\beta}'$$

and $\boldsymbol{0}$ denotes a null matrix. The $m_y \times m_y$ and $m_y \times m_x$ matrices $\boldsymbol{A}_{yy}$ and $\boldsymbol{A}_{yx}$ represent the contemporaneous effects of the endogenous and exogenous variables (respectively) on the endogenous variables. The $m_x \times m_y$ null matrix in the lower triangle of $\boldsymbol{A}$ obtains from the exogeneity of $\boldsymbol{x}_t$ and indicates that there can be no contemporaneous impacts of the variables in $\boldsymbol{y}_t$ on those in $\boldsymbol{x}_t$.

The matrix $\widetilde{\boldsymbol{\Pi}}$ defines how the long–run errors $\boldsymbol{\xi}_t$ feed back onto the system. The $m_y \times m$ submatrix $\widetilde{\boldsymbol{\Pi}}_y$ characterises how these errors feed back onto the endogenous variables while the restriction that the lower $m_x \times m$ submatrix of $\widetilde{\boldsymbol{\Pi}}$ is a null matrix ensures that the long–run errors do not feed back onto the variables in $\boldsymbol{x}_t$. The null matrices in $\boldsymbol{A}$ and $\widetilde{\boldsymbol{\Pi}}$ together ensure the exogeneity of the variables in $\boldsymbol{x}_t$. Noting the definition of the long–run reduced form errors, $\boldsymbol{\xi}_t = \boldsymbol{\beta}'\boldsymbol{z}_{t-1}$, and recalling that the vector $\boldsymbol{z}_t$ contains both endogenous and exogenous variables, it follows that the exogenous variables can influence the endogenous magnitudes in the long–run; that is to say they are long–run forcing for the system.

Under the assumption of weak exogeneity in which the structural errors from the first $m_y$ and the remaining $m_x$ equations are joint–normally distributed such that $\boldsymbol{\epsilon}_{yt} = \boldsymbol{\Omega}_{yx}\boldsymbol{\Omega}_{xx}^{-1}\boldsymbol{\epsilon}_{xt} + \boldsymbol{\eta}_{yt}$ where $\boldsymbol{\Omega} = \begin{pmatrix} \boldsymbol{\Omega}_{yy} & \boldsymbol{\Omega}_{yx} \\ \boldsymbol{\Omega}_{xy} & \boldsymbol{\Omega}_{xx} \end{pmatrix}$, GLPS decompose equation A10 into the following two equations:

$$\boldsymbol{A}_{yy}\Delta\boldsymbol{y}_t + \boldsymbol{A}_{yx}^*\Delta\boldsymbol{x}_t = \widetilde{\boldsymbol{a}}_y^* + \widetilde{\boldsymbol{b}}_y^* t - \widetilde{\boldsymbol{\Pi}}_y \boldsymbol{z}_{t-1} + \sum_{i=1}^{p-1} \widetilde{\boldsymbol{\Gamma}}_{yi}^* \Delta\boldsymbol{z}_{t-i} + \boldsymbol{\eta}_{yt} \tag{A11}$$

$$\boldsymbol{A}_{xx}\Delta\boldsymbol{x}_t = \widetilde{\boldsymbol{a}}_x + \widetilde{\boldsymbol{b}}_x t - \widetilde{\boldsymbol{\Pi}}_{xx} \boldsymbol{x}_{t-1} + \sum_{i=1}^{p-1} \widetilde{\boldsymbol{\Gamma}}_{xi} \Delta\boldsymbol{z}_{t-i} + \boldsymbol{\epsilon}_{xt} \tag{A12}$$

where $\widetilde{\boldsymbol{a}}_y^* = \widetilde{\boldsymbol{a}}_y - \boldsymbol{\Omega}_{yx}\boldsymbol{\Omega}_{xx}^{-1}\widetilde{\boldsymbol{a}}_x$, $\widetilde{\boldsymbol{b}}_y^* = \widetilde{\boldsymbol{b}}_y - \boldsymbol{\Omega}_{yx}\boldsymbol{\Omega}_{xx}^{-1}\widetilde{\boldsymbol{b}}_x$, $\widetilde{\boldsymbol{\Gamma}}_{yi}^* = \widetilde{\boldsymbol{\Gamma}}_{yi} - \boldsymbol{\Omega}_{yx}\boldsymbol{\Omega}_{xx}^{-1}\widetilde{\boldsymbol{\Gamma}}_{xi}$, $\boldsymbol{A}_{yx}^* =$

$\boldsymbol{A}_{yx} - \boldsymbol{\Omega}_{yx}\boldsymbol{\Omega}_{xx}^{-1}\boldsymbol{A}_{xx}$ and where the vectors $\widetilde{\boldsymbol{a}}$ and $\widetilde{\boldsymbol{b}}$ and the matrix $\widetilde{\boldsymbol{\Gamma}}_{yi}$ are partitioned into endogenous and exogenous sub–vectors and sub–matrices denoted by the subscripts $y$ and $x$, respectively. Based on their decomposition of equation A10 into the conditional VECM for $\Delta\boldsymbol{y}_t$ (equation A11) and the marginal VAR for $\Delta\boldsymbol{x}_t$ (equation A12), GLPS write the full system as:

$$\boldsymbol{A}^*\Delta\boldsymbol{z}_t = \widetilde{\boldsymbol{a}}^* + \widetilde{\boldsymbol{b}}^* t - \widetilde{\boldsymbol{\Pi}}\boldsymbol{z}_{t-1} + \sum_{i=1}^{p-1}\widetilde{\boldsymbol{\Gamma}}_i^*\Delta\boldsymbol{z}_{t-i} + \boldsymbol{\epsilon}_t^* \tag{A13}$$

denoting:

$$\boldsymbol{A}^* = \begin{pmatrix} \boldsymbol{A}_{yy} & \boldsymbol{A}_{yx}^* \\ \boldsymbol{0} & \boldsymbol{A}_{xx} \end{pmatrix}, \ \widetilde{\boldsymbol{\Pi}} = \begin{pmatrix} \widetilde{\boldsymbol{\Pi}}_{yy} & \widetilde{\boldsymbol{\Pi}}_{yx} \\ \boldsymbol{0} & \widetilde{\boldsymbol{\Pi}}_{xx} \end{pmatrix}, \ \widetilde{\boldsymbol{a}}^* = \begin{pmatrix} \widetilde{\boldsymbol{a}}_y^* \\ \widetilde{\boldsymbol{a}}_x \end{pmatrix}$$

$$\widetilde{\boldsymbol{b}}^* = \begin{pmatrix} \widetilde{\boldsymbol{b}}_y^* \\ \widetilde{\boldsymbol{b}}_x \end{pmatrix}, \ \widetilde{\boldsymbol{\Gamma}}_i^* = \begin{pmatrix} \widetilde{\boldsymbol{\Gamma}}_{yi}^* \\ \widetilde{\boldsymbol{\Gamma}}_{xi} \end{pmatrix} \text{ and } \boldsymbol{\epsilon}_t^* = \begin{pmatrix} \boldsymbol{\eta}_{yt} \\ \boldsymbol{\epsilon}_{xt} \end{pmatrix}$$

The reduced form of the system is achieved in the usual way by pre–multiplying all terms by $\boldsymbol{A}^{*-1}$. Identification, estimation and testing then proceed in the usual manner, although care must be taken if imposing restrictions on the loading matrix to ensure their compatibility with the structure outlined above.

## Bootstrapping Procedures

### Bootstrapping for Future Uncertainty

The non–parametric bootstrap method used to compute empirical forecast intervals is explained here with reference to the Gompertz curve estimated in Section 3.6. Recall that the Gompertz model is estimated in the following form:

$$ln\left(\Delta ln y_t\right) = -\gamma t + ln\left(\beta e^{\gamma} - \beta\right) + \epsilon_t \tag{A14}$$

Equivalently, one may write the $h$–step ahead form recursively as:

$$\begin{aligned} ln\widehat{y}_{T+h} &= ln\widehat{y}_{T+h-1} + e^{-\gamma(T+h)+ln(\beta e^{\gamma}-\beta)+\epsilon_{T+h}} \\ &= ln\widehat{y}_{T+h-2} + e^{-\gamma(T+h-1)+ln(\beta e^{\gamma}-\beta)+\epsilon_{T+h-1}} + e^{-\gamma(T+h)+ln(\beta e^{\gamma}-\beta)+\epsilon_{T+h}} \\ &\ \vdots \\ &= ln\widehat{y}_T + \prod_{i=0}^{h-1} e^{-\gamma(T+h-i)+ln(\beta e^{\gamma}-\beta)+\epsilon_{T+h-i}} \end{aligned}$$

In this way, the $h$–step ahead level forecast can be expressed as a function of $ln\widehat{y}_T$ and the errors $\epsilon_{T+1}, \epsilon_{T+2}, ..., \epsilon_{T+h}$. This $h \times 1$ vector of errors is created by resampling the $T \times 1$ vector of estimated residuals $\boldsymbol{\epsilon}$ with replacement. When this process is repeated $B$ times, confidence intervals may be recovered as the appropriate percentiles of the empirical distribution of the forecasts.

**Bootstrapping the LR Statistic**

The likelihood ratio statistic testing the over–identifying restrictions is widely known to be unreliable in finite samples (see GLPS, 2006, p. 140). The exact finite sample distribution of the statistic may be investigated by bootstrapping as follows:

i. Estimate equations A11 and A12 subject to both the exact- or over–identifying restrictions and compute $LR = 2\left\{\ell_T\left(\hat{\boldsymbol{\theta}}_A\right) - \ell_T\left(\hat{\boldsymbol{\theta}}_B\right)\right\}$.

ii. Using the parameter estimates obtained in step (i.), generate $B$ simulated bootstrap samples as follows:

$$\Delta \boldsymbol{y}_t^{(b)} = \widehat{\boldsymbol{a}}_y^* + \widehat{\boldsymbol{b}}_y^* t - \widehat{\boldsymbol{\alpha}}_y \widehat{\boldsymbol{\beta}}_y' \boldsymbol{z}_{t-1}^{(b)} + \sum_{i=1}^{p-1} \widehat{\boldsymbol{\Gamma}}_{yi}^* \Delta \boldsymbol{z}_{t-i}^{(b)} + \widehat{\boldsymbol{\Lambda}} \Delta \boldsymbol{x}_t + \boldsymbol{u}_t^{(b)} \tag{A15}$$

This step relies on the assumption that the estimated model may be treated as the data generating process (DGP). $\Delta \boldsymbol{x}_t$ is treated as fixed and the initial values of $\boldsymbol{y}_t$ are used to account for the observations lost due to the VAR lag structure.

iii. The $T \times m_y$ error matrix $\boldsymbol{u}_t^{(b)}$ may be generated either parametrically or non–parametrically. The parametric method draws the residuals from a multivariate i.i.d. distribution with the same covariance structure as the observed residuals (i.e. compute $\boldsymbol{u}_t^{(b)} = \widehat{\boldsymbol{P}} \cdot i.i.d.N\left(\boldsymbol{0}, \boldsymbol{I}_{m_y}\right)$, where $\widehat{\boldsymbol{P}}$ is the lower–Choleski factor of the residual covariance matrix $\widehat{\boldsymbol{\Sigma}}_{yy}$ associated with the conditional VEC estimation). The non–parametric method involves whitening the estimated residuals $\boldsymbol{\eta}_{yt}$ by defining $\boldsymbol{\varsigma} = \widehat{\boldsymbol{P}}^{-1} \widehat{\boldsymbol{\eta}}_{yt}$ and then resampling from $\widehat{\boldsymbol{P}} \boldsymbol{\varsigma}_t$. The computation carried out in Chapter 5 employs the non–parametric approach.

iv. For each of the $B$ simulated samples generated in this way, compute the LR statistic testing the over–identifying restrictions. Convergence failure is likely to occur in some replications: the simplest way to overcome this problem is to discard these non–converged estimates. In practice, convergence was not achieved in approximately 20% of the replications. The finite sample critical values are then recovered as the appropriate percentiles of the resulting empirical distribution. Bootstrapped critical values for Johansen's cointegration tests may be computed in the same way.

**Bootstrapping the Impulse Response Functions**

Confidence intervals for the impulse response functions (and persistence profiles?) are computed by bootstrapping using the full system model (as opposed to just the conditional VECM used for bootstrapping the LR statistic) in order to properly account for the adjustment process characterising the exogenous variables (c.f. GLPS, pp. 136-7). The computation proceeds as follows:

i. Estimate equations A11 and A12 subject to the over–identifying restrictions (unless one wishes to report impulse response functions based on the exactly identified model);

ii. Compute bootstrap samples under the assumption that the estimated model is the DGP as follows:

$$\Delta \boldsymbol{z}_t^{(b)} = -\widehat{\boldsymbol{\alpha}}\widehat{\boldsymbol{\beta}}'\boldsymbol{z}_{t-1}^{(b)} + \sum_{i=1}^{p-1} \widehat{\boldsymbol{\Gamma}}_i \Delta \boldsymbol{z}_{t-i}^{(b)} + \widehat{\boldsymbol{b}}_0 + \widehat{\boldsymbol{b}}_1 t + \widehat{\boldsymbol{H}}\boldsymbol{\zeta}_t^{(b)} \tag{A16}$$

where $\underset{10\times10}{\widehat{\boldsymbol{H}}} = \begin{pmatrix} \underset{2\times2}{\boldsymbol{I}} & \underset{2\times8}{\boldsymbol{0}} \\ \underset{8\times2}{\widehat{\boldsymbol{\Lambda}}_y} & \underset{8\times8}{\boldsymbol{I}} \end{pmatrix}$ and $\underset{10\times T_t}{\boldsymbol{\zeta}}^{(b)} = \begin{pmatrix} \underset{2\times T}{\boldsymbol{\epsilon}_{xt}^{(b)}} \\ \underset{8\times T}{\boldsymbol{\eta}_{yt}^{(b)}} \end{pmatrix}$.

Note that the choice of either the reduced form or structural models is irrelevant provided that one is consistent. In Chapter 5, the reduced form parameters were used and this is the form presented here;

iii. The simulated errors $\boldsymbol{\zeta}_t^{(b)}$ may be drawn either parametrically or non–parametrically from the estimated residuals;

iv. For each replication, re–estimate the model and compute the impulse response functions in the usual manner, discarding any non–convergent results;

v. Confidence intervals are retrieved from the resulting empirical distribution as described above.

## A Note on the Interpolation Procedure

The interpolation procedure works on the assumption that the value reported for an annual series is the end–of–year value and not the mean across the year. The process involves simple linear interpolation whereby the change from year 1 to year 2 is assumed to have occurred in a smooth linear fashion. Hence, the interpolated value for 2000q1 would be equal to the annual value for 2000 plus one quarter of the difference between 2001 and 2000. In the interest of consistency, where data is converted from monthly to quarterly frequency the end–of–quarter values (i.e. m3, m6, m9 and m12) are taken as the quarterly values.

## A Glossary of Notation in the Chapter 6 SFC Model

| **Parameters** | |
|---|---|
| $\widetilde{\alpha_1^{£}}$ | Value of the UK mpc out of income in the initial steady state |
| $\widetilde{\alpha_1^{\$}}$ | Value of the US mpc out of income in the initial steady state |
| $\alpha_{1L}^{£}$ | Lower bound of UK mpc out of income |
| $\alpha_{1L}^{\$}$ | Lower bound of US mpc out of income |
| $\alpha_{1U}^{£}$ | Upper bound of UK mpc out of income |
| $\alpha_{1U}^{\$}$ | Upper bound of US mpc out of income |
| $\widetilde{\alpha_2^{£}}$ | Value of the UK mpc out of wealth in the initial steady state |
| $\widetilde{\alpha_2^{\$}}$ | Value of the US mpc out of wealth in the initial steady state |
| $\alpha_{2L}^{£}$ | Lower bound of UK mpc out of wealth |
| $\alpha_{2L}^{\$}$ | Lower bound of US mpc out of wealth |
| $\alpha_{2U}^{£}$ | Upper bound of UK mpc out of wealth |
| $\alpha_{2U}^{\$}$ | Upper bound of US mpc out of wealth |
| $\epsilon_0$ | Parameter in the UK real exports equation |
| $\epsilon_1$ | Parameter in the UK real exports equation |
| $\epsilon_2$ | Parameter in the UK real exports equation |
| $\lambda_{10}$ | Parameter in the UK household portfolio equations |
| $\lambda_{11}$ | Parameter in the UK household portfolio equations |

*continued overleaf...*

*...continued from previous page*

| | |
|---|---|
| $\lambda_{12}$ | Parameter in the UK household portfolio equations |
| $\lambda_{20}$ | Parameter in the UK household portfolio equations |
| $\lambda_{21}$ | Parameter in the UK household portfolio equations |
| $\lambda_{22}$ | Parameter in the UK household portfolio equations |
| $\lambda_{30}$ | Parameter in the UK household portfolio equations |
| $\lambda_{31}$ | Parameter in the UK household portfolio equations |
| $\lambda_{32}$ | Parameter in the UK household portfolio equations |
| $\gamma_{10}$ | Parameter in the US household portfolio equations |
| $\gamma_{11}$ | Parameter in the US household portfolio equations |
| $\gamma_{12}$ | Parameter in the US household portfolio equations |
| $\gamma_{20}$ | Parameter in the US household portfolio equations |
| $\gamma_{21}$ | Parameter in the US household portfolio equations |
| $\gamma_{22}$ | Parameter in the US household portfolio equations |
| $\gamma_{30}$ | Parameter in the US household portfolio equations |
| $\gamma_{31}$ | Parameter in the US household portfolio equations |
| $\gamma_{32}$ | Parameter in the US household portfolio equations |
| $\mu_0$ | Parameter in the UK real imports equation |
| $\mu_1$ | Parameter in the UK real imports equation |
| $\mu_2$ | Parameter in the UK real imports equation |
| $\mu^{£}_{\alpha 1}$ | Parameter determining the responsiveness of the UK mpc out of income to the real interest rate |
| $\mu^{\$}_{\alpha 1}$ | Parameter determining the responsiveness of the US mpc out of income to the real interest rate |
| $\mu^{£}_{\alpha 2}$ | Parameter determining the responsiveness of the UK mpc out of wealth to the real interest rate |
| $\mu^{\$}_{\alpha 2}$ | Parameter determining the responsiveness of the US mpc out of wealth to the real interest rate |
| $\nu_0$ | Parameter in the UK import price equation |
| $\nu_1$ | Parameter in the UK import price equation |
| $\nu_2$ | Parameter in the UK import price equation |
| $\widetilde{rr^{£}}$ | UK real interest rate in the initial steady state |
| $\widetilde{rr^{\$}}$ | US real interest rate in the initial steady state |

*continued overleaf...*

*...continued from previous page*

| | |
|---|---|
| $\Omega_0^{£}$ | Parameter in the UK real wage target equation |
| $\Omega_0^{\$}$ | Parameter in the US real wage target equation |
| $\Omega_1^{£}$ | Parameter in the UK real wage target equation |
| $\Omega_1^{\$}$ | Parameter in the US real wage target equation |
| $\Omega_2^{£}$ | Parameter in the UK real wage target equation |
| $\Omega_2^{\$}$ | Parameter in the US real wage target equation |
| $\Omega_3^{£}$ | Parameter determining the speed of wage adjustment in the UK |
| $\Omega_3^{\$}$ | Parameter determining the speed of wage adjustment in the US |
| $\widetilde{\pi_{ds}^{£}}$ | Initial steady state value of inflation in the UK |
| $\widetilde{\pi_{ds}^{\$}}$ | Initial steady state value of inflation in the US |
| $\pi_{ds}^{£L}$ | Lower bound of UK inflation target range (fiscal policy) |
| $\pi_{ds}^{\$L}$ | Lower bound of US inflation target range (fiscal policy) |
| $\pi_{ds}^{£U}$ | Upper bound of UK inflation target range (fiscal policy) |
| $\pi_{ds}^{\$U}$ | Upper bound of US inflation target range (fiscal policy) |
| $\varrho^{£}$ | Parameter determining the strength of the anti–inflationary response of the Bank of England |
| $\varrho^{\$}$ | Parameter determining the strength of the anti–inflationary response of the Fed |
| $\varsigma_1^{£}$ | Parameter in the UK countercyclical fiscal policy rule |
| $\varsigma_1^{\$}$ | Parameter in the US countercyclical fiscal policy rule |
| $\varsigma_2^{£}$ | Parameter in the UK countercyclical fiscal policy rule |
| $\varsigma_2^{\$}$ | Parameter in the US countercyclical fiscal policy rule |
| $\vartheta_1^{£}$ | Parameter in the UK inflation–targeting interest rate rules |
| $\vartheta_1^{\$}$ | Parameter in the US inflation–targeting interest rate rules |
| $\vartheta_2^{£}$ | Parameter in the UK inflation–targeting interest rate rules |
| $\vartheta_2^{\$}$ | Parameter in the US inflation–targeting interest rate rules |
| $\upsilon_0$ | Parameter in the UK export price equation |
| $\upsilon_1$ | Parameter in the UK export price equation |
| $\upsilon_2$ | Parameter in the UK export price equation |
| $\phi^{£}$ | Price mark–up in the UK |
| $\phi^{\$}$ | Price mark–up in the US |

*continued overleaf...*

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| | |
|---|---|
| $\theta^{£}$ | Income tax rate in the UK |
| $\theta^{\$}$ | Income tax rate in the US |
| $\zeta$ | Parameter determining the degree of foreign influence over UK monetary policy |

| **Indicator** | **Variables** |
|---|---|
| $z1^{£}$ | Takes the value 1 when $\alpha_1^{£} < \alpha_{1L}^{£}$ |
| $z1^{\$}$ | Takes the value 1 when $\alpha_1^{\$} < \alpha_{1L}^{\$}$ |
| $z2^{£}$ | Takes the value 1 when $\alpha_1^{£} > \alpha_{1U}^{£}$ |
| $z2^{\$}$ | Takes the value 1 when $\alpha_1^{\$} > \alpha_{1U}^{\$}$ |
| $z3^{£}$ | Takes the value 1 when $\alpha_2^{£} < \alpha_{2L}^{£}$ |
| $z3^{\$}$ | Takes the value 1 when $\alpha_2^{\$} < \alpha_{2L}^{\$}$ |
| $z4^{£}$ | Takes the value 1 when $\alpha_2^{£} > \alpha_{2U}^{£}$ |
| $z4^{\$}$ | Takes the value 1 when $\alpha_2^{\$} > \alpha_{2U}^{\$}$ |
| $z5^{£}$ | Takes the value 1 when $r^{£} > 0$ to ensure the zero lower bound is respected in the UK |
| $z5^{\$}$ | Takes the value 1 when $r^{\$} > 0$ to ensure the zero lower bound is respected in the US |
| $z6^{£}$ | Takes the value 1 when $\pi_{ds-1}^{£} > \pi_{ds}^{£U}$ for use in the UK fiscal policy rule |
| $z6^{\$}$ | Takes the value 1 when $\pi_{ds-1}^{\$} > \pi_{ds}^{\$U}$ for use in the US fiscal policy rule |
| $z7^{£}$ | Takes the value 1 when $\pi_{ds-1}^{£} < \pi_{ds}^{£L}$ for use in the UK fiscal policy rule |
| $z7^{\$}$ | Takes the value 1 when $\pi_{ds-1}^{\$} > \pi_{ds}^{\$L}$ for use in the US fiscal policy rule |

| **Exogenous** | **Variables** |
|---|---|
| $au^{£}$ | Gold held by the UK central bank |
| $au^{\$}$ | Gold held by the US central bank |
| $B_{cb£s}^{\$}$ | Supply of US bills to the UK central bank |
| $dxr_e^{£}$ | Expected Sterling exchange rate change |
| $dxr_e^{\$}$ | Expected Dollar exchange rate change |
| $g^{£}$ | Real expenditure of the UK government† |
| $g^{\$}$ | Real expenditure of the US government† |

*continued overleaf...*

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| | |
|---|---|
| $N^{£}_{fe}$ | Full employment level in the UK |
| $N^{\$}_{fe}$ | Full employment level in the US |
| $p^{\$}_{g}$ | Price of gold in US Dollars |
| $pr^{£}$ | UK labour productivity |
| $pr^{\$}$ | US labour productivity |
| $r^{£}$ | Interest rate on UK bills♣ |
| $r^{\$}$ | Interest rate on US bills♣ |

| **Endogenous Variables** | |
|---|---|
| $\alpha^{£}_{1}$ | Marginal propensity to consume out of income in the UK |
| $\alpha^{\$}_{1}$ | Marginal propensity to consume out of income in the US |
| $\alpha^{£}_{2}$ | Marginal propensity to consume out of wealth in the UK |
| $\alpha^{\$}_{2}$ | Marginal propensity to consume out of wealth in the US |
| $B^{£}_{cb£d}$ | Demand for UK bills arising from the UK central bank |
| $B^{£}_{cb£s}$ | Supply of domestic bills to the UK central bank |
| $B^{\$}_{cb£d}$ | Demand for US bills arising from the UK central bank |
| $B^{\$}_{cb\$d}$ | Demand for US bills arising from the US central bank |
| $B^{\$}_{cb\$s}$ | Supply of domestic bills to the US central bank |
| $B^{£}_{s}$ | Total supply of UK bills |
| $B^{£}_{£d}$ | Demand for UK bills arising from UK households |
| $B^{£}_{£s}$ | Supply of domestic bills to UK households |
| $B^{\$}_{£d}$ | Demand for US bills arising from UK households |
| $B^{\$}_{£d}$ | Supply of US bills to UK households |
| $B^{\$}_{s}$ | Total supply of US bills |
| $B^{£}_{\$d}$ | Demand for UK bills arising from US households |
| $B^{£}_{\$s}$ | Supply of UK bills to US households |
| $B^{\$}_{\$d}$ | Demand for US bills arising from US households |
| $B^{\$}_{\$s}$ | Supply of domestic bills to US households |
| $c^{£}$ | Real consumption of UK households |
| $c^{\$}$ | Real consumption of US households |
| $CA^{£}$ | Current account balance of the UK economy |

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| | |
|---|---|
| $CA^{\$}$ | Current account balance of the US economy |
| $CG^{£}$ | Capital gains accruing to UK households |
| $CG^{\$}$ | Capital gains accruing to US households |
| $C^{£}$ | Nominal consumption of UK households |
| $C^{\$}$ | Nominal consumption of US households |
| $ds^{£}$ | Real domestic sales in the UK |
| $ds^{\$}$ | Real domestic sales in the US |
| $DS^{£}$ | Nominal domestic sales in the UK |
| $DS^{\$}$ | Nominal domestic sales in the US |
| $F^{£}_{cb}$ | Profits of the UK central bank |
| $F^{\$}_{cb}$ | Profits of the US central bank |
| $G^{£}$ | Nominal expenditure of the UK government |
| $G^{\$}$ | Nominal expenditure of the US government |
| $H^{£}_{d}$ | UK households demand for high powered money |
| $H^{£}_{s}$ | Supply of high powered money to UK households |
| $H^{\$}_{d}$ | US households demand for high powered money |
| $H^{\$}_{s}$ | Supply of high powered money to US households |
| $im^{£}$ | UK real imports |
| $im^{\$}$ | US real imports |
| $IM^{£}$ | UK nominal imports |
| $IM^{\$}$ | US nominal imports |
| $KA1^{£}$ | UK capital account balance including official settlement accounts |
| $KA1^{\$}$ | US capital account balance including official settlement accounts |
| $KA2^{£}$ | UK capital account balance excluding official settlement accounts |
| $KA2^{\$}$ | US capital account balance excluding official settlement accounts |
| $N^{£}$ | UK employment |
| $N^{\$}$ | US employment |
| $NAFA^{£}$ | UK net acquisition of financial assets |
| $NAFA^{\$}$ | US net acquisition of financial assets |
| $\omega^{T£}$ | Real wage target of UK workers |
| $\omega^{T\$}$ | Real wage target of US workers |

*continued overleaf...*

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| | |
|---|---|
| $p_{ds}^{£}$ | UK domestic sales price |
| $p_{ds}^{\$}$ | US domestic sales price |
| $p_{g}^{£}$ | Price of gold in Pounds |
| $\pi_{ds}^{£}$ | UK domestic price inflation |
| $\pi_{ds}^{\$}$ | US domestic price inflation |
| $\pi_{s}^{£}$ | UK sales price inflation |
| $\pi_{s}^{\$}$ | US sales price inflation |
| $p_{m}^{£}$ | Price of UK imports |
| $p_{m}^{\$}$ | Price of US imports |
| $p_{s}^{£}$ | UK sales price |
| $p_{s}^{\$}$ | US sales price |
| $p_{x}^{£}$ | Price of UK exports |
| $p_{x}^{\$}$ | Price of US exports |
| $p_{y}^{£}$ | UK GDP deflator |
| $p_{y}^{\$}$ | US GDP deflator |
| $PSBR^{£}$ | UK public sector borrowing requirement |
| $PSBR^{\$}$ | US public sector borrowing requirement |
| $rr^{£}$ | UK real interest rate |
| $rr^{\$}$ | US real interest rate |
| $S^{£}$ | Nominal value of UK sales |
| $S^{\$}$ | Nominal value of US sales |
| $T^{£}$ | Nominal value of UK tax receipts |
| $T^{\$}$ | Nominal value of US tax receipts |
| $v^{£}$ | Real wealth of UK households |
| $v^{\$}$ | Real wealth of US households |
| $V^{£}$ | Nominal wealth of UK households |
| $V^{\$}$ | Nominal wealth of US households |
| $W^{£}$ | Nominal wages in the UK |
| $W^{\$}$ | Nominal wages in the US |
| $WB^{£}$ | UK wage bill |
| $WB^{\$}$ | US wage bill |

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| | |
|---|---|
| $x^{£}$ | Real UK exports |
| $x^{\$}$ | Real US exports |
| $X^{£}$ | Nominal UK exports |
| $X^{\$}$ | Nominal US exports |
| $xr^{£}$ | Exchange rate converting Sterling magnitudes to US Dollars |
| $xr^{\$}$ | Exchange rate converting Dollar magnitudes to Sterling |
| $y^{£}$ | Real UK output |
| $y^{\$}$ | Real US output |
| $Y^{£}$ | Nominal UK output |
| $Y^{\$}$ | Nominal US output |
| $YD^{£}$ | Nominal disposable income of UK households |
| $YD^{\$}$ | Nominal disposable income of US households |
| $yd_{hs}^{£}$ | UK nominal Haig–Simons disposable income |
| $yd_{hs}^{\$}$ | US nominal Haig–Simons disposable income |
| $yd_{hse}^{£}$ | Expected UK real Haig–Simons disposable income |
| $yd_{hse}^{\$}$ | Expected US real Haig–Simons disposable income |

† These variables are endogenous in models IT, LF, CFPIT and CFPLF.

♣ These variables are endogenous in models CFPIT and CFPLF.

Table A7: A Glossary of Notation in the Chapter 6 SFC Model