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Introduction

Asset price shocks pose difficult problems for monetary authorities, and despite considerable debate, no consensus has yet emerged on the appropriate strategy for monetary policymakers in the presence of such shocks.

Different views about the appropriate role of monetary policy in the presence of shocks in asset markets do not relate to the final objectives of monetary policymakers, but rather on the optimal policy that needs to be implemented to achieve the Central Bank's final target. One view is that monetary policy should do no more than follow the standard precepts of inflation targeting. Proponents of this view would acknowledge that rising asset prices often have expansionary effects on the economy, and might sometimes also provide a signal for incipient inflationary pressures, so that some tightening of monetary policy might be appropriate. According to this view, however, policy should only respond to observed changes in asset prices to the extent that they signal current or future changes to inflation and/or output gap. There should be no attempt to use policy either to gently lean against a suspected asset-price bubble while it is growing or, more aggressively, to try to burst it. This view of the appropriate monetary policy response to asset-price bubbles has been recently advocated by Bernanke and Gertler (2002). An alternative view stresses that monetary policy should aim to do more than respond to actual and expected developments in inflation and the output gap. Cecchetti, Genberg, Lipsky and Wadhwani (2000), prominent proponents of this alternative view, put the argument in these terms:

> "Central banks seeking to smooth output and inflation fluctuations can improve [...] macroeconomic outcomes by setting interest rates with an eye toward asset prices in general, and misalignments in particular [...] .*Raising interest rates modestly as asset prices rise above what are estimated to be warranted levels, and lowering interest rates modestly when asset prices fall below warranted levels, will tend to offset the impact on output and inflation of [asset-price] bubbles, thereby enhancing overall macroeconomic stability*. In addition, if it were known that monetary policy would act to 'lean against the wind' in this way, it might reduce the probability of bubbles arising at all, which would also be a contribution to greater macroeconomic stability. (p. 429, italics added)"

There is however no universal optimal response to asset market's misalignments, and the case for responding to a particular asset price shock depends on the specific characteristics of the monetary transmission mechanism.

Starting from the above considerations, one of the purposes of this study is to analyse interactions among monetary policymakers in the presence of shocks in asset markets. In chapter two we explore the role of the central bank in responding to asset price shocks; we do so using a theoretical framework. This analysis will be undertaken in the contest of a simple theoretical game with no uncertainty. In this structure the concepts of co-ordination, co-operation and commitment between two countries are of vital importance in the evaluation of policy rules. Various behavioural assumptions regarding the relationship of monetary authorities with each other will produce different policy rules.

Economic policies may have international spillover effects, positive and/or negative, that affect other countries in addition to their domestic effects. These effects emerge through trade, interest rates, exchange rates, terms of trade and the international movements of capital in search of higher yields. Policy co-ordination is a way to internalise these potentially harmful spillovers. This is the principal argument for policy co-ordination.

Different monetary and exchange rate policies have from time to time led to tension among countries. A way to overcome this problem is forming a monetary union (e.g. Europe). The union's member countries agree to fully consolidate their monetary policies so that there can no longer arise spillovers from that policy sphere (except to the extent that the financial sectors could continue to diverge between the countries).

In particular, we address the following issues: a) the impact on the Central Bank's policy response to a shock in the asset market and b) how the resulting policy change will affect the Central Bank's response in the foreign country.

It is evident that financial markets' responses to monetary policy actions undertaken by either the home and/or foreign Central Bank depend on a combination of domestic and foreign influences. These influences manifest themselves through two channels. The first and most immediate relates to movements in the exchange rates and interest rates in the international money, capital and foreign exchange markets. The second channel is due to changes in domestic real activity and prices. These channels have both direct and indirect effects on the economy, and the latter can partially or totally offset the initial effects of the former. For example, changes in equilibrium prices will affect both private incomes and wealth. The existence of a wealth effect associated with asset market fluctuations has been analysed by Morck, Shleifer and Vishny (1990), Goodhart and Hoffman (2001) and Mishkin (2001) and is beyond dispute. A fall in asset market prices due to restrictive monetary policy will erode personal wealth. In addition, lower asset prices are associated with lower private sector investment resulting in greater employment uncertainty and lower confidence, particularly because layoffs typically increase during such periods, and individuals will reduce their marginal propensity to consume. Since consumption represents a great percentage of GDP, even small changes in consumer spending could affect economic growth.

Higher inflation due to loose monetary policy can have a negative impact on the asset markets, because increasing inflation results in moderating long-term interest rates, thus reducing the present value of future profits. In addition, as higher inflation is normally associated with volatile inflation, this has a further negative effect on the firm because typically it incites investors to demand higher risk premiums. This takes the form of increased spreads of corporate bonds and commercial paper interest rates relative to Treasury yields.

Any action by the Central Bank against an asset market shock is likely to encounter political opposition: economic agents which profit directly from the bubble, economic agents which, while not profiting directly from the bubble, would nevertheless be harmed if the Central Bank tightened monetary policy, and members of the public who are swept along in the general euphoria.

The power of a Central Bank to act against an economic bubble may depend on the bank's own political position. Other things being equal, a politically independent central bank is likely to have somewhat greater discretion to act against a bubble than a politically dependent one.

As we have shown above, there is however not a complete consensus about the conduct of monetary policy under the circumstances of shocks in the asset market. The predominant view at the moment seems to be that Central Banks should only respond to asset price movements if they are expected to affect future CPI inflation and the output gap (Bernanke and Gertler, 1999). Besides the interest rate, the exchange rate is usually considered to be the most important determinant of aggregate demand and a channel of monetary policy transmission in open economies. That is why several central banks adopted, in the early-mid 1990s, a Monetary Conditions Index, a weighted average of

the short-term interest rate and the exchange rate as an operating target or an indicator for monetary policy.
A more recent development is the interest in the role of housing and equity prices for the design of monetary policy. Housing and equity prices may affect demand via direct and indirect wealth effects. A change in property and equity prices affects consumer wealth, which may induce consumers to change their consumption plans. A more indirect wealth effect of asset price movements operates via households' and firms' balance-sheets.
Thus, from a theoretical point of view Goodhart and Hofmann (2002, page 3) assert that " there seems to be a strong case also to consider property and share prices as determinants of aggregate demand, which would imply a direct reaction of monetary policy to movements in these asset prices". This issue has proven to be highly controversial. Cecchetti, Genberg, Lipsky and Wadwhani (2000) and Goodhart and Hofmann (2001) argue in favour of a direct response of monetary policy to asset price movements which are not in line with perceived fundamentals, while Bernanke and Gertler (1999) and Gertler, Goodfriend, Issing and Spaventa (1998) are more sceptical.

Starting from the above considerations, in chapter three we address the following issues: 1) the importance of the Financial Condition Index (FCI hereafter) in explaining a potential misalignment in asset markets; 2) the use of the FCI as an important short term indicator to guide the conduct of monetary policy.

The first step is to describe how to construct a FCI for four countries (US, UK, EU and Canada) and to prove that it can provide useful additional indicators of future changes in output and consequently inflation. Moreover, the analysis is important because it takes into account the different channels of monetary transmission. It is evident that financial markets' responses to monetary policy actions undertaken by the Central Bank depend on a combination of domestic and foreign influences. In particular, in chapter 3, we focus our analysis on three asset prices: exchange rates, house prices and stock prices. For example, changes in equilibrium prices will affect both private incomes and wealth. Our contribution to the literature is to attempt to solve two of the main criticisms that affect the FCIs': the parameter inconstancy problem and the non exogeneity of regressors. Chapter three will be divided into two parts. In the first we suggest a methodology on how to explain the impact of financial markets on real output. We build a Financial Condition Index for the four countries using the Kalman Filter algorithm; this methodology allows us to capture the changes of the weights of each financial variable in explaining the output gap. In the second we analyze the interactions between FCIs and monetary policy in each single country. We estimate forward-looking Taylor rules augmented for FCI in order to analyze the Central Bank's reaction to a misalignment in the asset market. This analysis will be undertaken in the contest of a simple backward looking model of the economy described by the aggregate demand – aggregate supply framework. The standard and augmented Taylor rule will be used to define the optimal monetary policy. The concept of FCI and the way it is constructed are fundamental in the evaluation of the resulting policy rules that will emerge under different behavioral assumptions relating to the sensitivity of the monetary authorities willingness to respond to a misalignment in the asset market.

The last chapter of this book will be dedicated to the analysis of changes in policy rates in the belief that such changes, particularly unexpected changes, can influence stock market returns. When reflecting on these issues, greater attention has been paid to the qualitative and quantitative impact of monetary policy changes on stock returns. It sheds some light on the more general debate on the impact of monetary policy shocks on stock market returns.

"In principle, it is acknowledged that there are two main channels through which a central bank can influence asset prices. First, the central bank is able to determine short-term interest rates, which act as a benchmark for short-term returns and are used for discounting the assets' future income streams. Thus, the central bank is able to affect asset prices via agents' expectations about the future path of money market rates (short-run impact).

Second, the long-run perspective about future inflation has an impact on the current prices of long-term assets, since nominal long-term returns usually contain an inflation premium. Given that monetary policy determines inflation in the long run, it has a strong impact on asset prices via inflation expectations (long-run impact)", (Belke and Polleit, 2005, p. 1).

Which policy implications would emerge from the finding of a significant and stable relationship between monetary policy and stock market returns? In our view, there are at least two clear implications. First, by letting short-term rates deviate from a certain level of equilibrium, the Central Bank may have a significant impact on asset prices. Second, in principle the Central Bank is able to reduce stock price volatility by diminishing the uncertainty of future rate changes, hence volatility spillovers to other financial markets could be avoided and the option value of waiting with investment decisions would be reduced.

Moreover, monetary policy exerts a significant impact on financial markets and this is reflected by the appreciable attention that the ECB receives in the financial markets. Estimates of the responsiveness of stock market returns to changes in monetary policy will most likely contribute to effective investment and risk management decisions (Rigobon and Sack, 2004).

Hence, in the final chapter we will explore the possibility of a non-linear relationship between EMU stock returns and ECB's monetary policy innovations. The non-linearity is modelled using different Markov-switching (MS) regime autoregressive models. We intend to investigate the empirical performance of the univariate MS models used to describe the switches between different economic regimes for the 11 EMU countries' stock markets and, furthermore, extending these models to test if the inclusion of monetary policy shock as an exogenous variable provides a more accurate identification of the switches between different economic phases.

Moreover, we investigate if the shocks are both, symmetric or asymmetric throughout the EMU countries and at industry level within each country. Hence, we study asymmetries using an extension of the Markov switching model described by Hamilton (1989) estimated over the period 1992-2005.

It is commonly thought that the final goals of monetary policy are generally expressed in terms of macroeconomic variables (e.g. inflation, unemployment, output, etc.). However, the most direct and immediate effects of monetary policy actions are on the financial markets. In fact, by affecting asset prices and returns, monetary authorities should try to modify economic behaviour in ways that should help to achieve their ultimate objectives. In this way, changes in monetary policy are transmitted through the stock markets via changes in the values of private portfolios (the wealth effect that we consider in the first three chapters of this work), changes in the cost of capital, and by other mechanisms presented in chapter one. For these reasons, it will be useful to try to obtain quantitative estimates of the links between monetary policy innovations and stock prices.

We focus on one specific EU asset market, the stock market, and try to investigate if monetary policy shocks are asymmetric among the EMU countries and among different industry portfolios of five EMU countries.

We measure the persistence of each economic regime, as well as the ability of each MS model to detect the impact of monetary policy on EMU stock markets.
In particular, asymmetries are supposed to exist where the estimated parameters of the alternative MS specifications are indicative of different regime-dependent responses of the stock market. Most of the empirical studies which use an MS modelling approach focus almost exclusively on univariate models. A novelty of this work is that we explicitly assess the dynamic impact of exogenous monetary shocks on the movements of European stock returns in both cases: under high return stable and low return volatile states, that is when there are bull markets and bear markets, respectively. In this respect, our work can be regarded as an extension of the studies by Thorbecke (1997), Peersman and Smets (2001) and Garcia and Schaller (2002).
This chapter has two main objectives. First, we try to measure and analyse in some detail the stock market's response to monetary policy actions, both at the aggregate level for the EMU countries and, at level of industry for five European countries. Second, we try to gain some insights into the reasons for the European stock market's response. An additional innovative feature of our study is that it provides a comparison of the ability of our definitions of policy innovation to detect asymmetries in the EMU stock markets.
In concluding, this book intends to provide an in depth understanding of the monetary transmission mechanism with particular emphasis on the notion that it is possible for a central bank to achieve superior

performance by giving consideration to asset market prices as well as a forecast of future inflation and the output gap. Furthermore this book intends to shed light on the actions that a central bank can and should take to minimize the likelihood of macroeconomic instability arising from a strong change in asset prices.

Chapter One

Asset markets and the Monetary Transmission Mechanism

1. Introduction

The importance of financial markets as central factors in the monetary transmission mechanism has always been recognised because monetary policy operates through these markets. However in the last decades we have assisted to an increasing importance of this topic within monetary economics. There are several factors that can explain why economic researchers have been focusing on financial markets. In the literature on the monetary transmission mechanism, there are three categories of asset prices besides those on debt instruments that are viewed as providing important channels through which monetary policy affects the economy: 1) stock market prices, 2) real estate prices, and 3) exchange rates. In light of their overwhelming role in the composition of the private sector portfolios the focus here will be on equity and real estate prices. Asset price changes affect aggregate spending via changes in consumption and investment spending. An important issue is whether the elasticity of aggregate spending to asset prices is significant enough to bring about large fluctuations in domestic demand, private sector indebtedness and credit risk. Fluctuations of the stock market, which are influenced by monetary policy, have important impacts on the aggregate economy.

The chapter is organised as follow. In the next section we present the role of interdependence and the basic structures of cooperative and non-cooperative games. In the second part we introduce some general observations on credibility and reputation. In the third part we discuss the Timberger's rule. In the fourth and fifth parts we move to a detailed discussion of the monetary transmission mechanism confronting different views, namely money view, bank lending channel, broad credit (asset price) channel. We highlight how the monetary policy propagates through the financial system before affecting real variables. In section 6 we will provide an overview of the main theoretical features of the European central bank's monetary strategy. Section 7 presents the conclusions.

1.1 Introduction to cooperative and non-cooperative games

There can be no doubt about the rapidly increasing interdependence of the different national economies that make up the world economy. Monetary policy in each country affects economic welfare both nationally and internationally, since the policymaker in each country generates externalities in the other countries. This implies that, in an interdependent world, rational policymakers in one country may be expected to condition their actions on the policies pursued in other countries. Thus, international policymaking has unavoidable game aspects.

There are two basic structures of the game that can be analyzed:

1) A *non-cooperative structure* usually leads to socially inefficient outcomes. This is not an exception in the case of monetary policy games between policymakers from different countries. And this is

because, in this type of structure, the externalities that policymakers from different countries generate for each other are not properly internalized. Since national policymakers are sovereign, they are neither rewarded nor penalized for the international effects of the monetary policy that they implement in their home countries.

2) On the other hand, if the externalities were internalized in a *cooperative agreemen*t, all countries could benefit. As we have seen before, the problem with the cooperative outcomes is that the players may have an incentive to cheat, moreover in a type of game where the players are politically sovereign. In this sense, it has been argued in the literature that supranational institutions should play an important role in solving this problem. The game-theoretic aspects of policymaking in an interdependent world have been recognized by an important number of authors.

The literature about macro coordination is considerable and started with the paper of Hamada (1976) and also with Canzoneri & Gray (1985), Rogoff (1985b), Kehoe (1991), Canzoneri & Henderson (1991). The seminal paper about economic coordination among countries was by Hamada (1976, 1985). This started extensive research focusing on the trade policy cooperation among nations. Monetary policy and exchange regime were analyzed using the Hamada diagram where the potential gains of macro coordination became more visible. Using the diagram was possible to show that Nash and Stackelberg equilibria were inferior solutions than coordination. The latter solutions were located in the Pareto contract curve.

In particular, Hamada (1976 and 1985) analysed the interactions between monetary policy and exchange regimes. He conducted the analysis within a static monetary approach to the balance of payments with fixed exchange rates. In these models, it was shown that the non-cooperative solutions were inferior compared to the coordinated equilibrium, as the latter was located on the Pareto contract curve. This provides the classical argument for benefits from coordination in Hamada's (1976) seminal article: all countries could do better by agreeing not to try to export inflation.

Similar results, evincing that cooperation was desirable, was obtained by Canzoneri & Gray (1985) paper. They investigated the result of the same exogenous shock (e.g. an oil shock) for two different blocks of countries: the US case and the rest of the world (hereafter ROW). The analysis develops three types of externalities for the decision made by monetary authorities:

1) The begger-thy-neighbor effect: externality where an expansionary policy in one country exports unemployment to the other (negative externality);

2) the locomotive effect: externality where an expansionary policy in one country raises the GDP in the other (positive externality);

3) the asymmetric effect: externality where the expansion in the US increases the product elsewhere, but the expansion in the ROW decreases the product in the US.

In conclusion, they clearly pointed out that in regimes with positive or negative externalities there is room for coordination, bringing better results than Nash or Stackelberg games. However, in the case of asymmetry externality, the results are not so clear. Walsh (1999) reached a similar conclusion that coordination is desirable in an economic point of view. The major drawbacks related to those models are: a) they are static models; b) all the policy decisions are taken at the same time and do not consider the immediate effects; c) the understanding of the macro coordination becomes more difficult when the policy decisions are not synchronized and when they are gradual; d) the instrument is chosen, in general, in order to simplify the model and not considering practical matters.

On the contrary, Rogoff (1985b) using a monetary model shows that a cooperative solution may be inferior to the non-cooperation, when the authorities do not take into account the reaction of the private sector. When the authorities for both countries try to boost the employment level then the private sector gets afraid of exchange rate depreciation and adjusts the wage and price level increasing inflation. Rogoff said that coordination evolves credibility issues in the commitment of the authorities in fighting inflation.

Kehoe (1991), and Carraro and Giavazzi (1991) rejected Rogoff's (1985b) point of view, presenting a counter example. However in these models, there are questions about credibility and inter-temporal inconsistency, as the assumption of the existence of a common strategy between the private agents and the government cannot be justified.

These models, when there is a common strategy between the private agents and the government, raise questions about credibility and intertemporal inconsistency.

All the above papers are two-country models. When more than two countries are evolved the following cases are presented:

i) all the countries work in coordination;

ii) there is no coordination among them and;

iii) only a sub-set of those countries are willing to coordinate among them.

In the 90's, a great amount of papers consider how monetary policy should be conducted in terms of the inflation targeting approach. The inflation-targeting framework allows us to treat the interaction among the major variables in a simple manner instead of the big econometric models.

Without coordination, monetary rules with more weight in inflation turned out to be less efficient in inflation and output sense. Hence, the more dependent and open a country is the smaller the weight which should be placed on inflation, to avoid an increase in the output and inflation volatilities. The relevance of this kind of model that allows the interaction of two economies is getting more prominent in a more global and integrated world.

In the 90's, the formation of big economic blocks aiming at macroeconomic stabilization is becoming even more important, as one can note in the Euroland. where monetary policy is formulated by one Central Bank.

Finally, it has been recognised that asset prices play an important role in determining business cycles conditions. A significant impact can be found in the role that capital markets play in the modern economic environment. Their impact has gone beyond indirect intermediation; it has a direct effect on activity due to both the deepening and widening of the capital markets. The existence of a wealth effect associated with asset market fluctuations has been also analysed by Dynan and Maki (2001) that studied the response of individual households to changes in stock market wealth. It was found that, over the period 1983-1999, there was a positive relationship between spending of U.S. households that own stocks and movements in the stock market. A second study by Maki and Palumbo (2001) has estimated that, in the second half of the 1990s, US households with high levels of income showed the largest consumption increases, consistent with the fact that these households owned the most stocks and experienced the largest gains in wealth.

Although the statistical link between asset prices and output is not well established (Poterba, 2000, Poterba and Samwick, 1996), it is impossible to negate that an increasing part of households' wealth is locked into the stock market and that at the same time the amount of firms' external financing has increased as never before. With such a central role for asset prices, it is essential for the monetary authorities that pursue an inflation target to take them into consideration, as they will affect aggregate demand. This does not assert that the Central Bank should target asset prices, but it implies that they should be considered for their effect on inflation indirectly via their impact on private sector spending.

1.2 Economic interdependence and co-operation

Literature uses both the terms co-ordination and co-operation[1]. The former is often used to refers to the literature as a whole. Canzonieri and Henderson (1991) also attach a specific meaning to 'coordination':

> *"if there are several solutions to an uncooperative game, coordination is the problem of choosing one solution out of the available options"*

Wallich (1984) determines coordination as "a significant modification of national policies in recognition of international economic interdependence"[2]. Countries have an incentive to coordinate their economic policies because their economies are interdependent. This interdependence arises via trade, financial markets, exchange rate, foreign direct investment and so on. In the model developed in this chapter spillovers emerge though the interest rates.

[1] The two terms are used interchangeably in this study though the former is preferred in this chapter.

[2] Merriam-Webster dictionary defines "to coordinate" as "to bring into a common action, movement, or condition" and "to cooperate" as "to act or work with another or others".

Cooper (1985) determines interdependence as a state where a country's openness and size are such that it is itself affected by the impact of its own actions on the rest of the world. A country's actions need therefore to partly bounce back from the other economies. Consequently, simple openness should not be a sufficient criterion for interdependence. In this chapter change in domestic interest rate affect the prices of assets in the foreign country. This could lead to a change the foreign monetary policy that also could affect the prices of assets of the home country.

According to Cooper, there are four types of interdependence between countries. First, structural interdependence means that the countries are mutually very open so that economic development in one country also affects the other countries. Second, there may be interdependence among the objectives of economic policy. A country is concerned about the other countries reaching their respective policy targets because failure to reach them may reflect negatively on the former. Third, there may be interdependence among exogenous disturbances arising from the rest of the world. This issue is linked to structural interdependence. Fourth, there may be policy interdependence, which means that the optimal course of action depends on the course taken in the other countries and vice versa.

Cooper also discusses different objectives for coordination. First, economic goals may be coordinated. These may consist of common goals, competitive goals or goals that relate to each other through general economic interdependence. Theoretical models usually concentrate on this and assume a common loss function with predetermined policy targets. Second, there may be coordination of or exchange of information on policy goals, economic forecasting, economic structures and future policies (this is the most relevant type of coordination in the European Monetary Union –EMU-). The third type of coordination consists of the choice, magnitude and timing of policies.

When discussing cooperation there always arises the question of trust and the temptation to renege on the internationally agreed procedures if the total net gain from reneging are positive[3]. Reneging may be avoided if the actors are concerned over loss of reputation. Governments with reputation can derive very large benefits from cooperation in the face of permanent shocks (Currie and Levine 1993). The model developed in this chapter is static and reputation has no explicit role.

The topic analyzed in policy coordination literature have their foundation in the discussion, presented in chapter one of this study, over possible time inconsistencies of monetary policies and in the related discussion over rules versus discretion.

The next section will summarize the main ideas of incentive constraints, credibility and time inconsistency, since they adequately comprise the most important issues that have arisen in this literature.

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[3] Cooper (1985) lists five reasons why cooperation may fail. 1) Disagreement over the objectives of cooperation. 2) Different forecasts of the future, different views over the structure of the economies, and the interrelations and dependencies between them, or a wrong model of the economy. 3) Governments may not trust each other. 4) The public may want to maintain freedom of action. %9 No nation may be willing to take the lead in cooperative economic policies because it may lose given that it is profitable to renege from a cooperative regime. Lack of initiative and leadership may also be a problem if the countries are of approximately the same size.

1.3 Credibility and reputation: some general observations

According to Weber (1991), credibility and reputation even though they are often used interchangeably, exhibit clear differences. " Reputation is defined as the probability which the public assigns to the consistent pursuit of low inflation policy"(Weber, 1991, p. 62). Hence, reputation is strictly related to the behaviour of monetary authorities over time. The more positive results the monetary authority obtain, the greater the level of reputation it gains.

Credibility instead, is defined as "the extent to which beliefs concerning a policy conform to official announcements about this policy. To achieve credibility, the authorities must precommit themselves to a particular policy rule....Credibility may thus also be viewed as a measure of the degree to which policy-makers tie their hands on future policies by issuing policy announcements"(Weber, 1991, p. 62). Reputation and credibility are attributes that all the policy makers would like to have. Both attributes give to the policymakers a 'crucial advantage' in reducing inflation with acceptable costs in terms of unemployment and output.

Public authorities have different ways to show they are determined in pursuing an anti-inflationary policy.

First they have to show that, even in cases of a very deep recession, the announced monetary targets will not change. However, following this theory, it could be possible to generate a conflict between monetary authority and the government since the costs in political terms of an anti inflationary policy may be too strong for the government.

Another possibility is when the monetary authorities can seek to influence expectations with some institutional reform, such as change in the exchange rate. The empirical evidence of the assumption that joining the EMS has helped Italy in reducing the level of inflation during the 1980’s is reported in Giavazzi and Giovannini (1988), where it is considered that the decision to join the EMS has produced a shift in expectations. Indeed, they found a very long lag between the start of the EMS and the effect on expectations. In Italy the shift in expectations occurred in 1985, six years after the start of the EMS. Different timing of these shifts occurred for example in France March 1983, and Ireland end of 1982. The timing of these shifts suggests that "governments had to prove that they were prepared to bear the cost of unpopularity before price setters become convinced that the commitment to the new monetary targets was lasting"(Giavazzi and Giovannini ,1988, p. 134).

According to Schelling (1982, p. 78), " the most a government can commit is an input, not an output; a program, not a result. A government can attempt to commit itself on variables it controls; but the promised results are only as credible as the commitment and the theory that generates the results. This is a weakness of any effort to control inflation through expectations".

Some economists believe that if authorities are credible in pursuing a specific anti inflationary policy, it may be able to directly reduce the costs of disinflation by changing inflationary expectations. Since inflationary expectations have a significant influence on current wage and price decisions, a reduction in actual inflation may result. This expectations' effect of credibility gives a sort of premium on establishing the credibility of a monetary disinflation program.

In light of that, we consider the problem of establishing the credibility of such a programme from the perspective of a rational expectations approach to macroeconomic policy.

At the end of the seventies and in the early eighties, some western developed countries faced the inflation problem with this new approach. Especially in the United States, starting with the FED's change in policy in 1979, there was strong emphasis on the credibility of the policy and of the policymakers. The basic idea was that, according to the rational expectation hypothesis, if the policy could be made credible, it would have been possible to disinflate practically without causing any recession at all. Of course, this was an extreme point of view. The argument went like this: if the policy is credible, people immediately adjust their expectations on inflation to the new policy, with its lower rate of growth of money. Thus, the short-run aggregate supply curve will move down immediately when the new policy is announced. In brief, if policy is credible and if expectations are rational, the economy can move to a new long-run equilibrium immediately when there is a change in policy. The experience of the United States and even more the experience of Britain in the eighties, when the Thatcher government was pursuing a resolute anti-inflationary policy that led to a 13 percent unemployment rate, cuts doubt on this optimistic 'costless' approach.

Finally, there are two general principles that should be emphasized in a study of the macroeconomic credibility problem. First, it should be assumed that if policymakers want to build up a very credible policy, a single announcement is not enough. Rational individuals need more to go on than mere announcement. They would pay more attention to the "policymakers' reputation" and to the costs of a new policy.

Second, "...although reasonably clear evidence that a new policy rule will work better is a necessary condition for its credibility, this is not a sufficient condition"(Taylor, 1982, p.83). The problem of time inconsistency[4] adds additional obstacle to credibility.

1.3.1 Credibility and time inconsistency

Credibility[5] and time inconsistency[6] are important issues in policy coordination. Policy makers have incentives, which affect their

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[4] "This notion of what is and what is not credible is closely related to the concept of dynamic or time consistency in policy game...Let p=(p_1, $_p2$,..,$_{pt}$) be a sequence of policies for periods 1 to T and x=(x_1,x_2,...,x_t) be the corresponding sequence of decisions made by the public. The (optimal) choice of 'x_t' generally depends on past values of 'x' and on the sequence of policies, 'p', up to and including period T. A policy 'p' is time consistent if, for each period 't' it maximizes the objective function of the policymakers taking as given previous decisions (x_1,...,x_{t-1}) by the public and provided future policy decisions (p, for s>t) are similarly selected." A. Cukierman, Polgrave dictionary, 1992, pp. 515-516.

[5] Following the pioneering paper by Kydland and Prescott (1977) the well-known seminal contributions are Barro and Gordon (1983), Rogoff (1985), Alesina and Summers (1993). An excellent analytical review of this literature is contained in

credibility and which may lead to time inconsistency. Persson and Tabellini (1990) identify two types of incentive constraints: economic and political. Economic constraints are discussed in this section, while the political ones are skipped all together[7]. Time inconsistency may occur if we assume that the private sector's expectations are rational and the public sector is engaged in discretionary economic policies without credible pre-commitment. Policy is discretionary if it is adjusted optimally each period as the state of world changes. A time inconsistency problem then occurs if policy is optimal ex ante but become sub-optimal ex post. For instance, assume that the government makes a commitment not to raise taxes in the next period, and that the private sector believes this and sets its investment accordingly. The government may then be tempted to renege on its commitment and raise taxes after the investment has taken place. When expectations are rational, this is anticipated by the private sector, the initial policy announcement is not credible and the investment is not made in the first place. Consequently, the economy is worse off as there is neither tax income nor investment.

Walsh (1998). For an exposition of the ECB conduct using the Barro- Gordon model and Rogoff's contribution see De Grauwe *et al.* (1999).

[6] For a more complete explanation of the analysis of time inconsistency in monetary policy see Walsh (1999).

[7] Political constraints arise when agents (policy makers) disagree with principals (residents) over their political role. It is also possible that the government does not seek to maximise the welfare of the society as a whole, but instead the welfare of its own electorate. The government may also have other, politically motivated short-term ambitions. Vaubel (1985) includes a survey of the literature.

Reasons for time inconsistency include labour market imperfections, which lead to an excessive real wage level and unemployment [see e.g. Canzonieri (1985) and Rogoff (1985)], and tax distortions which lead to the level of activity to be below its natural level [see Barro and Gordon (1983)].

The issue of time inconsistency was brought up by Kydland and Prescott (1977). They argued that policies are consistent if in each period policies are set so as to maximise the commonly agreed social objective function taking as given the previous decisions, while also all future policy decisions are made in a similar way. Consistent policy is optimal only if past agents' decisions are not affected by the present policy decisions or if agents' decisions have no direct or indirect effect on the social objective function via the present agents' decisions.

Even with a fixed social objective function and perfect knowledge by the policy makers of the timing and magnitude of the effects of their actions, discretionary policies do not result in the maximisation of the social objective function. This is so because, to quote Kydland and Prescott, "the policy game is not again nature but against rational economic agents". Consequently, optimal control theory cannot be applied in economic planning when agents are rational and make their decisions by taking their previous decisions and all the policy makers' past and future decisions into account.

Next, Calvo (1978) showed that governments have an incentive to generate unexpected inflation. Fischer (1980) analysed dynamic inconsistency and its implications for control theory and optimal policy making. There time inconsistency arises when the government only possesses distortionary control instruments and when expectations of future variables are relevant for current private sector decisions. The problem may also arise if the policy maker's utility function differs from that of the representative individual. The problem may disappear if coordination is introduced.

Barro and Gordon (1983) analyse the time inconsistency of monetary policy through the relative costs and benefits of either a rule based policy regime or one based on discretion. Like many others, they argue that a system of commitment (based on rules or reputation) will create an environment with a lower growth rate of money and thus a lower rate of inflation. In Barro and Gordon, surprise inflation would be the best option for the policy maker because an inflation shock would partly eliminate the existing distortion in the economy and would therefore be worth the extra inflation. The best possible enforceable rule turns out to be a weighted average of the pure regime of rule and discretion and the weights depend on the discount factor between two periods- The lower the discount factor, the higher the weight attributed to discretion and the higher the equilibrium inflation rate. The ideal rule is inferior to the successful cheating game the government would prefer, which is not available as a policy option, however.

1.3.2 Commitment and policy coordination

The question of commitment is closely tied with the discussion over credibility in the previous section where the relationship between the policy maker(s) and the private sector (under rational expectations) brings forth the issue of the time consistency of policies.

A country may back away from the coordinate agreement with the other country in order to acquire short term benefits. In a game theoretic setting this usually results in retaliation by the other party and cooperation is at least temporarily disrupted. Credibility may be obtained either through reputation or institutional settings. According to Currie and Levine (1993) one must have both reputation and cooperation in order to benefit from the policies. Without one or the other, the benefits either do not exist or they may even become negative.

Furthermore, commitment (i.e. reputation) should be universal and include all actors, because incomplete commitment is usually a worse option. In Oudiz and Sachs (1985), policy makers wish to commit with respect to the private sector and thereby influence the expected future exchange rate. This may make the policy makers worse off if they cannot commit with respect to each other. Canzoneri and Henderson (1991) study reputation in repeated games with three countries. They argue that commitment among some but not all policy makers may be counterproductive when commitment is impossible among all of them. Full scale commitment would be better than partial or asymmetric

commitment. Also commitment between policy makers may be counterproductive when they are not able to commit with respect to the private sector.
The international spillovers raise the question of whether countries can gain by coordinating their economic policies. By coordination we here mean agreements about instrument setting. In the next chapter we illustrate the question of policy coordination with a simple model where we investigate the interactions among monetary policymakers in the presence of shocks in asset markets.

1.4 The Tinbergen's Rule

One approach to the analysis of economic policy is to derive the policy targets formally. For example, Theil (1964) postulates a social welfare function, which expresses the relationships among various objectives and the constraints implied by the structure of the economy. The aim is to solve a stochastic optimization problem by maximizing this function or minimizing a weighted function of deviations of actual values from their socially desired levels. This approach leaves open the question of how the social welfare function is determined, assuming that it is possible to arrive at a social evaluation of objectives through democratic processes.
An alternative view sees governments as satisfiers, periodically manipulating instruments all together in discontinuous reactions to crises. Such governments have utility functions with acceptable-level

objectives rather than specific targets. The satisfying levels of objectives are reached by the resolution of conflict between different parts of the organization e.g. the Prime Minister versus the Chancellor of the Exchequer or the Bank of England versus the Treasury. Thus, targets are flexible.

The best known formal approach to macroeconomic policy is Tinbergen's analysis of the relationship between numbers of fixed targets and instruments. This takes as given: (a) the structure of the economy; (b) the objectives and their numerical values; and (c) the nature of the instrument variables. Tinbergen then asks what values must be given to the instrument variables if the policy targets are to be achieved. In algebraic terms, we have a set of equations representing the economic system to be solved. These contain: target variables (values known); and instrument variables (values unknown). Of crucial importance is the relationship between the number of targets (known) and the number of instruments (unknowns).

This analysis gives rise to Tinbergen's Rule: that to achieve any given number of targets, a government must have under its control at least an equal number of independent policy instruments. But there are many difficulties: objectives may be inter-related or inconsistent; instruments may not be independent of each other and some variables may, depending on the policy and the policy environment, be either instruments or objectives.

Further, a government may technically have a policy instrument under its control but be prevented by practical and/or political considerations from using its full range of values. The freedom a government feels it has to change interest rates, for example, may depend on the need to defend a fixed exchange rate or on the proximity of the next election.

The existence of uncertainty produces additional problems. There may be uncertainty over the structure of the economy, or over which is the best model of its operation, as well as over the effects of instruments. In this regard, it can be demonstrated that performance is improved by using more instruments than targets. Each instrument may be imperfectly used but weaknesses may to some extent be offsetting. If one instrument is given the wrong value, other instruments may also need to be given sub-optimal values in order to produce the best available result.

1.5 Asset markets, monetary transmission mechanism and monetary policy settings

> *"Regrettably, history is strewn with visions of . . . 'new eras' that, in the end, have proven to be a mirage. In short, history counsels caution. Such caution seems especially warranted with regard to the sharp rise in equity prices during the past two years. These gains have obviously raised questions of sustainability . . . Why should the central bank be concerned about the possibility that financial markets may be overestimating returns or mispricing risk? It is not that we have a firm view that equity prices are necessarily excessive right now or risk spreads patently too low. Our goal is to contribute as best we can to the highest possible*

growth of income and wealth over time, and we would be pleased if the favorable economic environment projected in markets actually comes to pass. Rather, the F.O.M.C. has to be sensitive to indications of even slowly building imbalances, whatever their source, that, by fostering the emergence of inflation pressures, would ultimately threaten healthy economic expansion."

Alan Greenspan (February 27, 1997)

"We don't view monetary policy as a tool to prick the stock market bubble."

- Alan Greenspan (March 5, 1997)

In the conduct of the monetary policy the concept of 'price stability' is important because it provides the foundation for all kinds of economic activity and the people's livelihood.

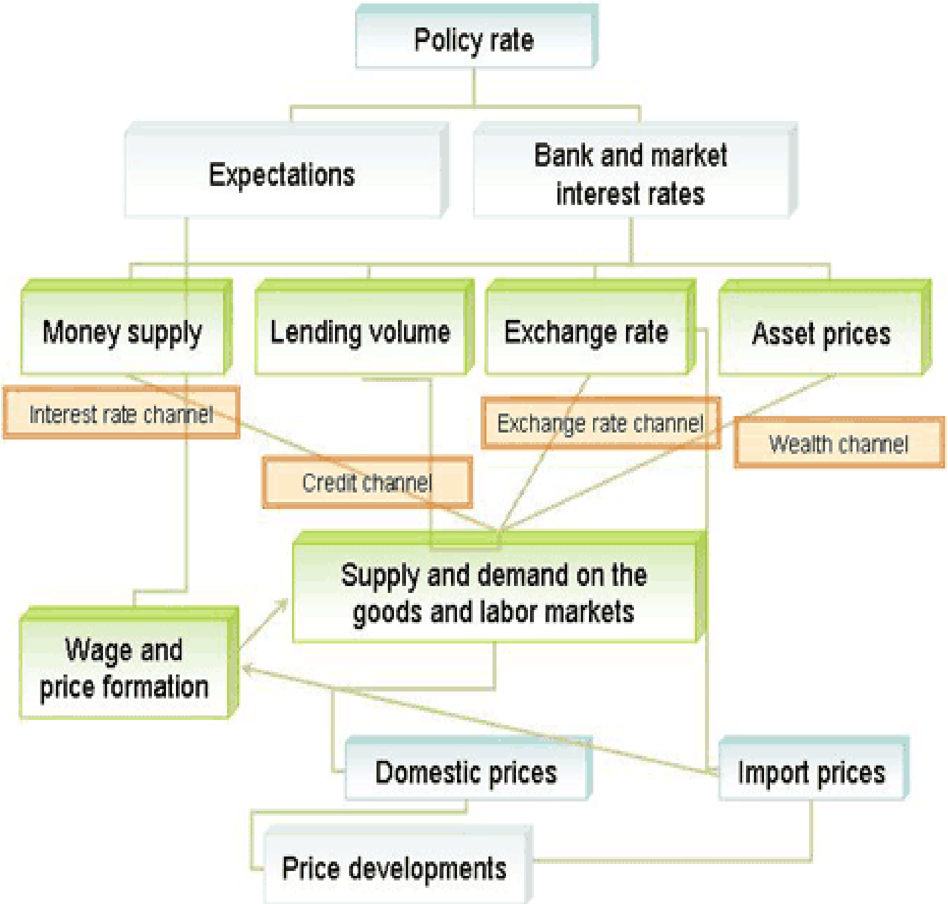
The market economy is a structure within which firms and households make decisions regarding consumption and investment based on prices of individual goods and services. And, the general price level (consumer price index, hereafter CPI) is a concept that consolidates individual prices of various goods and services traded in a country. The choice of this index can be found in maintaining a stable purchasing power of the income and the currency. However, in light of the more recent events, the short-sighted adoption of the CPI as more a meaningful pointer of the stability of the prices would, at this point, seem to be old and equally anachronistic as well as an improbable return to the gold standard.

Despite the traumatic experiences of the 70's, when the inflation caught up to the 15-20%, the monetary authority should look at a more extensive concept of price stability not limited to the common pointers of inflation, but extended also to the misalignment in the financial asset markets. An economy in which the inflation rate is moderated but in which there is excessive speculation and high price volatility, could determine, in the long run, equivalent effects as for an economy where the CPI erodes the wealth at 10-15% rates per year. This phenomenon has in fact the same monetary origin (excessive presence of liquidity in the system) and, although the apparent benefit of the first one (bubble) with respect to the second (high inflation), in the long run these effects turn out to be similar.

Every monetary policy impulse (e.g. an interest rate change by the central bank, change in the monetary base resulting from changes in the minimum reserve rate) has a lagged impact on the economy. Moreover, it is uncertain how exactly monetary policy impulses are transmitted to the price level or how real variables develop in the short and medium term.

The difficulty of the analysis is to adjust the effects of the individual channels for external factors. The effect of such external factors – e.g. supply and demand shocks, technical progress or structural change – may be superimposed on the effect of central bank measures, and it is difficult to isolate monetary policy effects on various variables for analytical purposes. Moreover, the time lag in the reaction of the real sector to monetary measures renders the analysis more difficult. Hence, monetary policy must be forward looking. The below diagram shows the four main monetary transmission mechanisms.

Diagram 1



1.5.1 Monetary policy and asset markets: an overview

The interaction between asset prices, the real economy, and monetary policy is by no means a new matter for central bankers and economists, but the development of asset markets in the last few years has brought the question to the forefront of the policy debate. However, this area contains a number of difficult issues.

The literature review highlights that the optimal monetary policy response is not necessarily easy to characterise. As shown in Smets (1997) and Dupor (2002b), the optimal response very much depends on the underlying source of the asset price increase. In particular, the direction of the policy response may be different depending on whether asset prices are driven by improved productivity or over-optimistic expectations. Given the uncertainty surrounding estimates of equilibrium values of asset prices, such an assessment of the sources of the shocks will in general not be an easy task. As discussed in Dupor (2001) and illustrated in the paper of Smets and Wouters (2003), non-fundamental asset price shocks may introduce a trade off between inflation stabilisation and asset price stabilisation. However, compared to cost-push shocks, the time inconsistency problem would appear to be much less as such shocks will typically tend to move the output gap and inflation in the same direction. A characterisation of optimal monetary policy becomes even more complicated when one allows for the probability that a rise in financial imbalances may result in a financial crisis with large negative effects on economic activity and price stability. As shown in Bordo and Jeanne (2002b), the optimality of a pre-emptive tightening of policy will then depend on a careful assessment of the probability of a bubble emerging and an estimate of the costs of such pre-emptive action. Our empirical results may be seen as consistent with recent findings that the build-up of large real, financial and monetary imbalances may provide a good indicator of problems to come (e.g. Borio and Lowe 2002). However, whether a more pre-emptive tightening than historically observed would have been successful in preventing or alleviating the subsequent asset price collapse without imposing too high a cost remains a question for research. Finally, we believe more research needs to be done on the incentive and moral hazard effects of a reactive policy approach, whereby the central bank only responds when the asset price collapse occurs. To the extent that such an approach provides implicit insurance to the private agents against large asset price collapses, it may ex ante lead to a larger run-up in financial imbalances and increase the vulnerability of the private sector to asset market shocks.

A highly important question for central bankers and economists is how should monetary policy respond to movements in asset prices. As Backstrom (2000) argues, this depends on how the central bank chooses to use the information contained in asset prices. Asset prices contain information related to the future path of both inflation and output growth. The key issue is whether asset price movements have some information content for the evolution of inflationary pressures and economic activity that are not detected in any other variable. The dominant view is that monetary policy should focus only on inflation in the goods market and look at asset prices only insofar as they affect inflationary forces on these markets for example through wealth effects on demand, or through interest rate effects on saving and investment.

Even if asset prices should not be a significant object of monetary policy in their own right, they can still be used as an input to monetary policy formulation.
An important aspect is the role played by asset prices during the monetary transmission mechanism because they may incorporate important information regarding the current and future state of the economy. In fact, change in interest rate modifies people's expectations about future economic growth, and thus their profit expectations. This may change the set of discount factors economic agents apply to their profit expectations or to the future stream of services or revenues from the asset they hold (housing for instance).

This analysis put forward the case for a reaction of monetary authorities to asset prices movements. There are several reasons why monetary policy might wish to respond; firstly asset prices misalignments may endanger the stability of the financial system. This case is put forward by Borio and Lowe (2002), they observe that since the 1970 asset prices cycles have been growing in amplitude and size. They argue that even an environment characterised by sound and credible economic policies, financial instability could be a serious threat. According to them, "it is the unwinding of financial imbalances that is the major source of financial instability, not an unanticipated decline in inflation per se". A second potential reason why central banks would like to respond to asset prices is that they play an important role in the transmission of monetary policy. Rising asset prices may have direct impact on the aggregate demand and may, therefore, be associated with growing inflationary pressures. They also influence the collateral values and bank's willingness to lend. The final reason is that asset prices might contain important information concerning the future state of the economy; they incorporate information about financial market expectation of inflation and macroeconomic conditions.

The major debate is not on the role of asset prices in the economy, but rather if and eventually how policy makers (i.e. Central Banks) should take into consideration information deriving from the asset market. In the literature we can identify three views: the first states that assets prices should be considered but only as one of the variables used to forecast inflation. Bernanke and Gertler (1999) argue that when monetary policy operate within a logic of flexible inflation target, it should ignore movements in asset prices that do not appear to be generating inflationary or deflationary pressures. Changes in asset prices should affect monetary policy only to the extent that they affect the central bank's forecast of inflation; once the predictive content of asset prices for inflation has been accounted for, there should be no additional response of monetary policy to asset-price fluctuations. By focusing on the inflationary or deflationary pressures generated by asset price movements, a central bank effectively responds to the "*toxic*" side of asset booms and busts without getting into the business of deciding what a fundamental is and what is not. Bernanke and Gertler (1999, 2001) argue that the potential costs of responding to asset price can be quite large because asset prices can be too volatile relative to their information content. In fact, Bernanke and Gertler (2001) show that a too-aggressive response to a stock price bubble can create significant harm in the economy. Batini and Nelson (2000) find an analogous result for bubbles in the real exchange rate while Mishkin and White (2002), suggests that asset price misalignments should only be a concern when they affect financial stability.

A second view is expressed by Goodhart (1999), Goodhart and Houfmann (2000, 2001)[8]. They believe that the Central Bank should target a broader price index which includes asset prices. This measure has the potential to improve macroeconomic performance if asset prices reliably predict future consumer price inflation. The theoretical foundation of Goodhart's recommendation is based on the pioneering research on the theory of inflation measurement by Alchian and Klein (1973). They argue that since asset prices represent the current money prices of claims on future, as well as current, consumption, an accurate measure of inflation should include asset prices. They also argued that asset prices can serve as good proxies for the inflation information left out of conventional measures. Using a VAR methodology they find that the Financial Condition Index is a useful instrument to forecast in-

[8] Goodhart (2001) writes: "So long as asset price changes are not incorporated in the measure of inflation which the authorities are required to stabilize, the authorities are likely to express audible worries about 'exuberance' and 'sustainability', but in practice find themselves largely incapable of any (pre-emptive) action in response to asset price change themselves in advance of any (consequential) effects coming through onto current goods and services prices, paralysed in practice".

sample future inflation[9]. If a central bank were to follow Goodhart's recommendation and use this broader measure of inflation, an increase in asset price inflation could prompt tighter monetary policy even if conventionally measured inflation were low and stable. As Filardo (2000) argued though, this policy implication depends on the strong assumption that asset price inflation accurately reflects future consumer price inflation.

The third view is that asset prices should be made an integral part of monetary policy; in this case, monetary authorities should try to act to stabilize their value around the fundamentals. Cecchetti, *et al.* (1999) argue that a central bank concerned in stabilizing inflation about a specific target level is likely to achieve superior performance by adjusting its policy instruments not only in response to its forecast of future inflation and the output gap as the traditional Taylor rule would suggest, but to asset prices as well. They demonstrate that monetary policymakers should react to perceived misalignments in asset prices to reduce the likelihood of asset price bubbles forming. More generally Cecchetti *et al* (2000, p.24), analyzing objectives and rule of monetary policy makers reach the conclusion that a *complex* rule is always more advisable than a *simple* Taylor rule. He states that "there is no reason to believe that information on output and inflation is always capable of adequately summarizing what policy needs to do to respond to the shocks hitting the economy". Bernanke and Gertler (2001) are very

[9] Out-of sample results do not seem to provide satisfactory results.

critical of Cecchetti *et al.* (1999) methodology. They argue that if Cecchetti *et al.* had accounted for stochastic, instead of deterministic, asset price bubbles, and also if they allow for the possibility that shocks other than a bubble may be driving asset prices, they would have found no useful role for asset prices beyond that that is reflected in expectations for future inflation[10]. Filardo (2000) shows that while there are benefits for the monetary authority to respond to asset price changes even when it cannot distinguish between the "bubble" and the "fundamental" part of the asset price inflation, the monetary authority's desire to respond to asset prices falls dramatically as its preference to smooth interest rates rises. He argues that even though asset prices contain useful information about inflation and output, the cost in terms of interest rate volatility can be so high as to cause the monetary authority to largely disregard the information. This result is consistent with Bernanke and Gertler's conclusion that by responding to stock prices, a central bank could worsen economic outcomes. In another paper Filardo (2000) concludes that a monetary authority generally benefits from responding to asset prices only as long as there is no uncertainty about the macroeconomic role of asset prices. If the monetary authority is uncertain about whether asset prices have an independent role in the context of a macro-model or simply reflecting

[10] Cecchetti *et al.* "optimize" the policy rule with respect to a single scenario, a bubble shock lasting precisely five periods, rather than with respect to the entire probability distribution of shocks, including shocks other than bubble shocks. Effectively, their procedure yields a truly optimal policy only if the central bank knows with certainty that the stock market boom is driven by non-fundamentals and knows exactly when the bubble will burst, both highly unlikely conditions.

other economic fundamentals, then the expected costs in terms of economic volatility of responding to asset prices may exceed the expected benefits.

1.5.2 Monetary policy and stock markets: review of literature

There is an extant literature on the relationship between stock market returns and monetary policy which, in general, centres on issue of whether monetary policy has an impact on stock returns and, whether this impact is asymmetric in bear and bull markets. We focus on four main aspects of the literature: 1)the relationship between stock prices and output; 2) the relationship between monetary policy shock and stock returns; 3) the asymmetric effects of monetary policy innovation on stock returns; 4) the impact of ECB's monetary policy on EUM stock market returns.

Stock prices are typically regarded as a leading indicator of output. Furthermore, if we accept that the stock market influences real activity, then investor sentiment[11] such as fads and fashions that cause stock prices to diverge from their fundamental values could also indirectly affect real activity. There is extensive empirical evidence that asset price changes tend to lead output growth in industrial countries. Various empirical studies have found a positive correlation between

[11] The term investor sentiment refers to beliefs held by some investors that cannot be rationally justified. Shiller (1984, 1987) was among the first to suggest that fads and fashions, as well as fundamentals, influence asset prices.

lagged stock market returns and current output growth. Most of the studies in this area have employed U.S. data; see for instance Fama (1990), and Schwert (1989). Similar evidence was presented by Mullins and Wadhwani (1989) for Japan, Germany and the United Kingdom, by Choi et al (1999) for the G-7 countries, and by Asprem (1989) for several other European countries. Bayoumi *et al* (2000) employed a panel of emerging market economies and advanced economies. He finds that the correlation is as strong in emerging market economies as in advanced economies. The other asset price found to generally have a significant predictive power on economic activity is the government bond yield spread. Property prices tend to be less forward looking, due to fixed supply in the short run and traded in less liquid markets, and more contemporaneously correlated with output growth. The leading indicator properties of property prices are considerably stronger regarding the output gap which is a closer indicator of business cycles conditions.

Although the instrument set by monetary policymakers is typically interest rate, monetary policy affects the economy through other asset prices besides those on debt instruments. Thus, movements in these other asset prices are likely to play an important role in how monetary policy is conducted. Following the financial deregulation and the increased globalization of capital markets since the early 1980s, industrial economies have witnessed a clear upward trend in asset prices. Alongside this trend, stock land and property prices have undergone swings around typical business cycle frequencies ranging from three to ten years. For some countries such as Japan and the Scandinavian counties during the late 1980s and the early 1990s, these swings had disruptive effects on domestic financial systems and contributed to prolonged recessions. In the U.K. case of 1990-92, the financial system withstood the asset price collapse but the ensuing recessions was anyway severe. Asset price fluctuations are highly correlated with business cycles in the industrialized world [see Bayoumi *et al* (2000)]. The current juxtaposition of low and stable consumer price inflation with asset price volatility, which in turn is correlated with output fluctuations, has motivated an intense debate about the complex interrelationships between asset prices, growth and inflation and the challenges that they pose to the broader task of macroeconomic stabilization. Fluctuations in asset prices play an important role in the context of the monetary policy transmission mechanism.

Researchers who have investigated long-run relationships between macroeconomic variables and stock market indices focused their attention on determining the dynamic relationships between *a priori* variables and a representative stock market index [Mukherjee and Naka (1995), Kwan and Shin (1999), Maysami and Koh (2000), Hondroyiannis and Papapetrou (2001), Shamsuddin and Kim (2003)]. The proxy variables chosen by these researchers varied from one stock market to another. Also, the analytical methods varied noticeably.

It is clear that the relationship between stock prices and returns in particular countries and economic variables has received great attention over recent years. For example, Mukherjee and Naka (1995) in a study that investigated the Japanese stock market returns found, using a better performing vector error correction model (VECM) compared to the vector autoregressive model (VAR) model, that the Japanese stock market was cointegrated with a group of six macroeconomic variables. Their findings were robust to different combinations of macroeconomic variables in six-dimension systems. Kwan and Shin (1999) utilised a VECM to find that the Korean stock price indices were cointegrated with a set of macroeconomic variables, which included exchange rates and money supply, and that the set of variables provided a direct long-run equilibrium relationship with each stock price index. They also found that stock price indices were not a leading indicator for the macroeconomic variables.

Maysami and Koh (2000) when investigating the long-term equilibrium relationships between the Singapore stock index and selected macroeconomic variables and Singaporean stock returns found, using a VECM, that the Singapore stock market is interest and exchange rate sensitive. They also found that the Singapore stock market was significantly and positively cointegrated with the stock markets of Japan and the USA.

Hondroyiannis and Papapetrou (2001) examined macroeconomic influences on the stock market for Greece. Among the macroeconomic variables investigated were interest rates and exchange rates. They too found that stock prices do not lead changes in real economic activity but that the macroeconomic activity and foreign stock market changes only partially explained Greek stock price movements. They found that oil price changes did explain Greek stock price movements and had a negative impact on economic activity.

Numerous statements made by central banks' chairmen, for instance Mr. Greenspan, indicate that governors believe that soaring stock prices create imbalances in the economy that threaten long-run economic growth. Hence, the natural question is if these concerns have been activated into monetary policy decisions. The academic literature does not offer a decisive answer to this question. Mishkin (2001) acknowledges that the most serious economic downturns are often associated with financial instability but does not discuss specifically the impact of a stock market crash on the economy. Bernanke and Gertler (1999) argue that a central bank dedicated to a policy of flexible inflation targeting should pay little attention to asset inflation because a proper setting of interest rates to achieve the desired inflation target will also stabilize asset prices. Cogley (1999) argues that deliberate attempts to puncture asset price bubbles may destabilize the economy.

Bordo and Jeanne (2001) re-evaluate the model of Bernanke and Gertler (1999) and argue that asset price reversals can be very costly in terms of declining output, such as in the case of Japan. They go further to argue that traditional monetary policy may be unable to correct asset price disturbances. Fair (2000) uses a macroeconomic model to offer quantitative evidence of the Bordo and Jeanne (2001) claim that the Fed may be unable to correct asset price disturbances. Fair shows that the negative effects from the loss of wealth following a stock market crash dominate the positive effects from the Fed lowering interest rates immediately after such a crash. Cecchetti (1998) discusses that the policymaker must often trade off variability in output for variability in prices because it is generally not possible to stabilize both. More specifically, Cecchetti, Genberg, Lipsky and Wadhwami (2000) argue that central bankers can improve economic performance by paying attention to asset prices. Cecchetti and Krause (2000) examine in detail the connection between the dramatic changes in the financial structure (a concept much more general than stable asset prices) of numerous countries and conclude that these changes contributed to the stability of both economic growth and low inflation. Tarhan (1995) finds evidence that the Fed affects asset prices. Filardo (2000) reviews carefully the literature on including asset prices in inflation measures and finds little evidence that paying attention by the Fed to asset prices would reliably improve economic stability. However, it is important to highlight that in many cases a severe tightening in monetary policy during stock market bubbles was associated with the burst of the bubble and a crash. A good example was the 1929 Crash of New York Stock Exchange, which followed a tight monetary policy by the Federal Reserve at that time by increasing the rediscount rate from 5% to 6%. Also, in Japan, the rise of discount interest rate from 2.5% to 6% -to stabilize the financial market after the peak during 1989 and 1990- played a role in the stock market crash and in the severe recession.

The result of the above statements is that monetary non-neutrality generate responses of stock market returns to monetary policy shocks that are consistent with the data. And second, the model replicates the heterogeneous responses of the returns on small and large firms documented in the empirical literature, where firm size is usually interpreted as a proxy for financial market access. Gertler and Gilchrist (1994) argue that small firms are more strongly affected by monetary policy shocks since they are likely to be relatively more constrained in financial markets. Ehrmann and Fratzscher (2004), Perez- Quiros and Timmermann (2000) and Thorbecke (1997) show that monetary policy exerts a more important effect on the returns of small firms. These results are interpreted as evidence in favour of the hypothesis that financial market imperfections and in particular the access to credit are important elements of the monetary transmission mechanism. Macroeconomic theory offers basically two complementary views on how financial factors influence the business cycle, namely the bank lending channel and the credit channel. The credit channel emphasizes borrower's balance sheet positions and net worth, whereas the bank lending channel focuses on the special role of the banking sector.

Hence, there has been ample evidence that firm size matters with respect to response towards monetary policy shocks. It has been observed that small firms including tradable ones tend to be more dependent on bank financing compared to large firms. This is because the former has limited access to capital markets. For example interest rate changes will affect the creditworthiness of the small firms. Thus, small firms response to monetary policy shocks is more significant compared to that of large firms, especially in adverse economic conditions. Researches suggested that the effect of asset price changes on the economy is transmitted through the balance sheets of households, firms and financial intermediaries as it affects their ability to borrow or lend. This is known as “the balance sheet channel”. The deterioration in balance sheets would be magnified on the long run in the form of declining sales and employment implying further weakening in cash flows and spending. This is known as “financial accelerator” effect. However, recently, the significance of these findings has been declining in few markets. This is due to the continuous financial innovation, which reduce the extent of firms to be bank-dependent. A new financial innovation that is getting to be a known practice is asset securitization techniques in which firm size and asset mix are no longer constraints to access debt markets.

Various studies mostly examined different stock markets, provided evidence consistent with the above theoretical background. Hess and Lee (1999), based on pre- and post-war periods in USA, UK, Japan, and Germany, showed that the response of stock returns to inflation varies over time and depending on whether it is a money supply or demand shock. Evidence showed that supply shocks result in a negative contemporaneous relationship between stock returns and inflation. Demand shock generates a temporary positive contemporaneous relation between stock returns and inflation, which is followed by negative relation. Thorbecke (1997) examined the relation between monetary policy and stock returns. He conducted the empirical estimation using impulse-response functions and variance decompositions from a VAR model depending on US monetary and stock market data. He showed that expansionary monetary policy increases stock returns. Booth and Booth (1997) using Federal funds rate and discount rate have confirmed these results. They showed also, that a restrictive monetary policy stance lowers monthly returns of both large and small stock portfolio. They concluded that monetary policy has explanatory power in forecasting stock portfolio returns. Patelis (1997) confirmed these findings by estimating a VAR model to examine the impact of the Federal Reserve monetary policy on US markets.

McQueen and Roley (1993) examined the stock market responses to macroeconomic news across different economic states. They used monthly time series of unemployment rate, money supply (M1) announcements, inflation rate and discount rate. The authors provided evidence that the stock market's response to macroeconomic news depends on the state of the economy. These results had been confirmed by Li and Hu (1998) showing that stock market responses to macroeconomic shocks varies across different stages of the business cycle. Furthermore, the authors provided evidence that the size of the firm matters. They showed that during restrictive monetary policy periods small caps tend to perform poorer compared to the large caps.

Due to the increasing evidence that monetary policy contributes in the predictability of stock returns. Chami *et al* (1999) examined the possibility that the stock market could be one of the monetary policy transmission channels in addition to the money and credit channels.

Using US monetary data, the authors confirmed that there is a degree of predictability of stock returns from monetary indicators and concluding that the stock market is a channel for transmitting monetary policy.

Another important aspect of the literature is related to the asymmetric effects of monetary policy innovation on small and large firms' stock returns. Bernanke and Gertler (1989), Gertler and Gilchrist (1994), Kiyotaki and Moore (1997), studying theories about the imperfect capital market, predict the presence of asymmetries in the variation of small and large firms' risk over the economic cycle. Small firms with little collateral should be more strongly affected by tighter credit market conditions in a recession state than large, better collateralized ones. Such theories do not simply have the cross-sectional implication that small firms' risk will be more strongly affected by tighter credit markets in all economic states. Based on the idea that a decline in a borrower's net worth raises the agency cost on external finance, the theories identify asymmetries in the effect of tighter credit market conditions on risk during recessions and expansions. In a recession, small firms' net worth, and hence their collateral, will be lower than usual and tighter credit markets will be associated with stronger adverse effects than during an expansion when these firms' collateral is higher. Large firms are less likely to experience similarly strong asymmetries over time since they have uniformly higher collateral across economic states.

Therefore, as Bernanke and Gertler (1989) pointed out, a recession may result in a flight to quality[12], causing investors to stay away from the high-risk small firms and switch towards better collateralized, and hence safer, large firms.

Gertler and Gilchrist (1994), for example, argue that the informational asymmetries that increase firms' cost of external capital are most important to young firms, firms exposed to large idiosyncratic risks, and firms that are poorly collateralized, all of which tend to be smaller firms. Since small and large firms use very different sources of financing and have very different degrees of access to credit markets, they ought to be differently affected by credit constraints. Combining this with the finding that credit constraints are time-varying and bind most during recessions leads to the conclusion that small firms should be more adversely affected by worsening credit market conditions during a recession state.

The clearest direct link between firm size and asymmetries in the effect of monetary shocks on firm profitability has perhaps been provided by Cooley and Quadrini (2001, 2006). These authors present a general equilibrium model in which firm size is the key source of heterogeneity. Firms borrow from financial intermediaries to establish working capital, using cumulated equity as collateral. Since the probability of firm failure is the main source of risk, both the amount of

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[12] Flow of funds from riskier to safer investments in times of marketplace uncertainty or fear. For example, the flow could be from risky investments to safer investments within a given country, or from higher-risk countries to lower-risk countries.

capital a firm can borrow and its borrowing rate are determined by the firm's collateral. Small firms' marginal profits are most sensitive to shocks as a result of their operating on a smaller scale. Since collateral is universally lower in a recession state, their model implies that small firms' risk and the expected profit per unit of borrowed funds should be relatively higher in this economic state. The higher sensitivity of small firms' profits and asset values with respect to credit market shocks and their higher probability of becoming credit constrained or of defaulting means that small firms' relative risk should increase around recessions.

When the economy is hit by monetary shocks, the response of small and large firms differs substantially, with small firms responding more than big firms. As a result of the financial decisions of firms, monetary shocks have a persistent impact on output. Finally, they found that monetary shocks lead to considerable volatility in stock market returns.

Chen (2005) investigates whether monetary policy has asymmetric effects on stock returns using different measures of monetary policy stance. Empirical evidence suggests that monetary policy has larger effects on stock returns in bear markets.

Finally, the introduction of the Euro has been a significant event in the globalisation of financial markets. It is intended to create broader, deeper and more liquid financial markets in Europe, and thus its main purpose is to improve the European economy. A significant part of past research, such as Corhay *et al.* (1993), Choudhry (1996), Serletis and King (1997), Gerrits and Yuce (1999), Dickinson (2000), Billio *et al.*

(2001) and Yang *et al.* (2003) among others, focuses on major European stock markets.

Ehramann and Fratzscher (2002) model the degree of interdependence of the U.S. and European interest rate markets by focusing on the reaction of these markets to macroeconomic news and monetary policy announcements. They show that the connection of the Euro area and the U.S. money markets has steadily increased over time, with the spillover effects from the U.S. to the Euro area being somewhat stronger than in the opposite direction.

1.6 Asset markets and monetary transmission mechanism

In the literature on the monetary transmission mechanism, there are three categories of asset prices besides those on debt instruments that are viewed as providing important channels through which monetary policy affects the economy: 1) stock market prices, 2) real estate prices, and 3) exchange rates. In light of their overwhelming role in the composition of the private sector portfolios the focus here will be on equity and real estate prices. Asset price changes affect aggregate spending via changes in consumption and investment spending. An important issue is whether the elasticity of aggregate spending to asset prices is significant enough to bring about large fluctuations in domestic demand, private sector indebtedness and credit risk.

Fluctuations of the stock market, which are influenced by monetary policy, have important impacts on the aggregate economy.

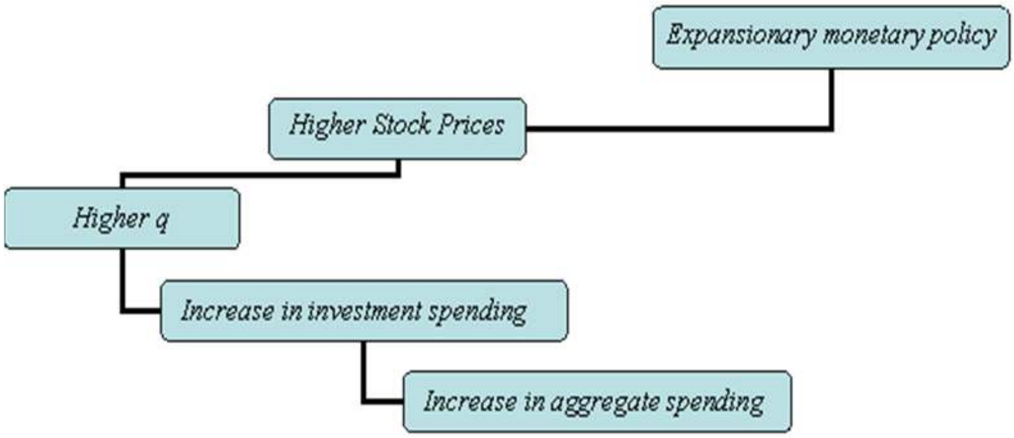
Transmission mechanisms involving the stock market are of three types:

1) stock market effects on investment.

Tobin's q-theory (Tobin, 1969) provides an important mechanism for how movements in stock prices can affect the economy. Tobin's q is defined as the market value of firms divided by the replacement cost of capital. If q is high, the market price of firms is high relative to the replacement cost of capital, and new plant and equipment capital is cheap relative to the market value of firms. Companies can then issue stock and get a high price for it relative to the cost of the facilities and equipment they are buying. Investment spending will rise because firms can now buy a lot of new investment goods with only a small issue of stock.

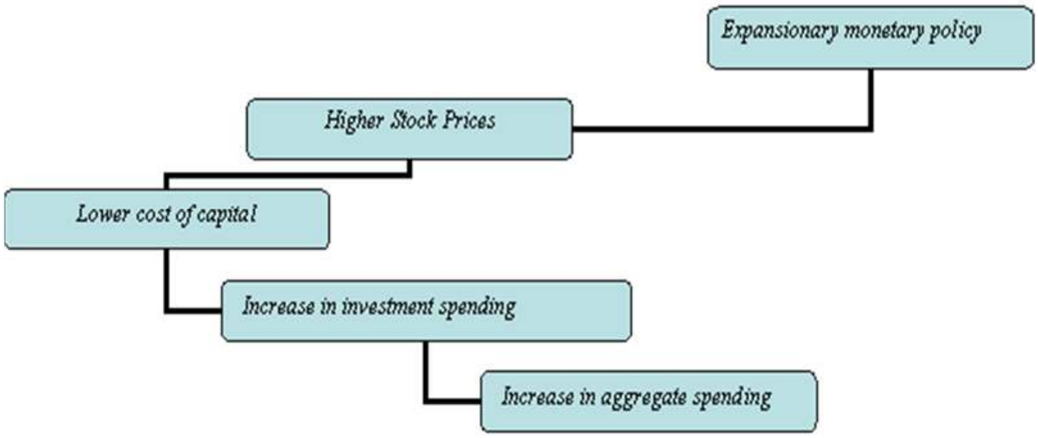
The main idea in the Tobin-q model is that a link exists between stock prices and investment spending. How would monetary policy then affect stock prices? Expansionary monetary policy which lowers interest rates makes bonds less attractive relative to stocks and results in increased demands for stocks that bids up their price. Combining this with the fact that higher stock prices will lead to higher investment spending, leads to the following transmission mechanism of monetary policy:

Diagram 2



In addition when stock prices increase it now becomes cheaper for firms to finance their investment by issuing shares instead of bonds, since each new share that is issued produces more funds. Thus a rise in stock prices will lead to higher investment spending. Therefore the transmission mechanism can also take the following form:

Diagram 3



Morck, Shleifer and Vishny (1990) review several theories concerning the causal direction of the underlying positive relationship between stock returns and the investment component of output growth.

Changes in asset prices are found to have significant effects on private investment in most of the industrialised world. In the U.S. the impact of changes in stock prices on investment appears to have been particularly strong with the Tobin's q having risen by 75 percent between 1992 and 1998 to reach its highest level since World War II. Studies for other countries also yield a strong relationship between stock prices and investment for Australia, the United Kingdom, and Japan [see Andersen and Subbaraman (1996), Bayoumi (1999)]. In France, Germany, and the Netherlands however, the link between asset prices and investment is less pronounced [see IMF (2000)]. One potential explanation for the historically smaller role for stock prices in continental Europe is the difference in corporate laws and traditions, as witnessed by less frequent takeovers, the great importance accorded to employees in decision making and the higher gearing ratios. These features imply that managers tend to be less responsive to the stock market relative to their counterparts in the Anglo-Saxon countries. Studies show that investment in Germany has been less sensitive to changes in stock prices relative to the United States and the United Kingdom. On the other hand, there is evidence that property prices – rather than stock prices- have a more significant effect on investment in continental Europe and Japan, consistent with the more widespread use of property collateral against loans and the greater role of bank credit in firm's financing. The relationship among monetary policy, stock market and investment have an implicit role in the analysis undertake in chapters three and four of the book.

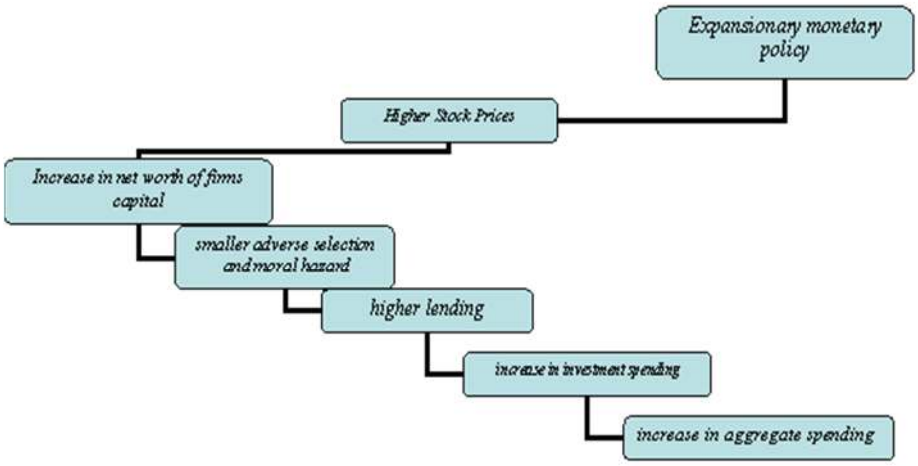
2) firm balance-sheet effects.

The presence of asymmetric information problems in credit markets provides another transmission mechanism of monetary policy that operates through stock prices. This mechanism is often referred to as the “credit view” and it works through the effect of stock prices on firms’ balance sheets so it is also referred to as the balance-sheet channel [see e.g. Bernanke and Gertler (1995) and Bernanke Gertler and Gilchrist (1999)].

The smaller the net worth of business firms, the more severe is the adverse selection and moral hazard problems in lending to these firms. Lower net worth means effectively less collateral for the loans so potential losses from adverse selection are higher. A decline in net worth increases the severity of the adverse selection problem and therefore leads to decreased lending to finance investment spending. The lower net worth of business firms implies also more pronounced moral hazard since the owners of the firms have a lower equity stake, giving them greater incentives to engage in risky investment projects. Undertaking riskier investment projects makes it more likely that lenders will not be paid back, thus a decrease in net worth will lead to a decrease in lending and hence in investment spending.

Monetary policy can affect firms’ balance sheets and aggregate spending through the mechanism presented in diagram 4:

Diagram 4

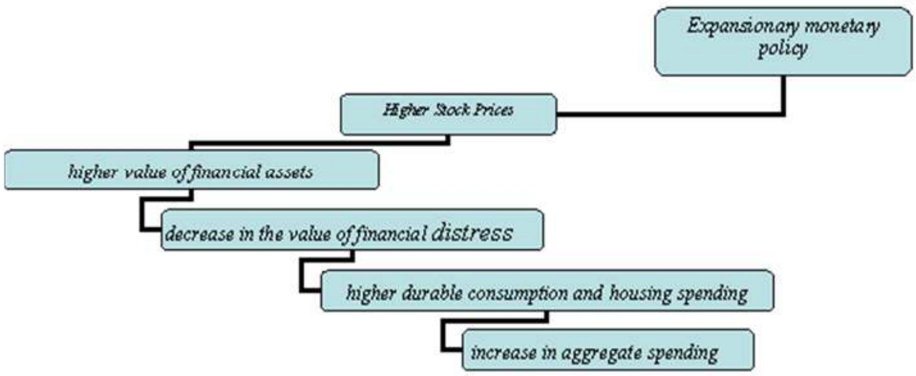


3) household wealth effects.

Another way of looking at the balance-sheet channels of monetary transmission mechanism is to consider household balance sheets, particularly liquidity effects on consumer durables and housing expenditures. In the liquidity effects view balance sheet effects work through their impact on consumer's desire to spend rather than on the lender's desire to lend. Because of asymmetric information about their quality, consumer durables and housing are very illiquid assets. If, as a result of a negative income shock, consumers need to sell their consumer durables or housing to raise money, they would expect a loss because they could not get the full value of these assets in a distress sale. In contrast, if they held financial assets (bank deposits, stocks, bonds) they could sell them quickly for their full market value and raise the cash. Hence if consumers expect a higher likelihood of financial distress, they would rather be holding fewer illiquid consumer durable and housing assets and more liquid financial assets.

An important factor influencing the consumer's estimate of financial distress is his/her balance sheet. When consumers have a large amount of financial assets relative to their debt their estimate of probability of financial distress is low, and they will be more willing to purchase housing or consumer durables. When stock prices rise the value of financial assets rises as well, leading to an increase in consumer expenditure since consumers have a more secure financial position and a lower estimate of the likelihood of suffering financial distress. This leads to the following transmission mechanism:

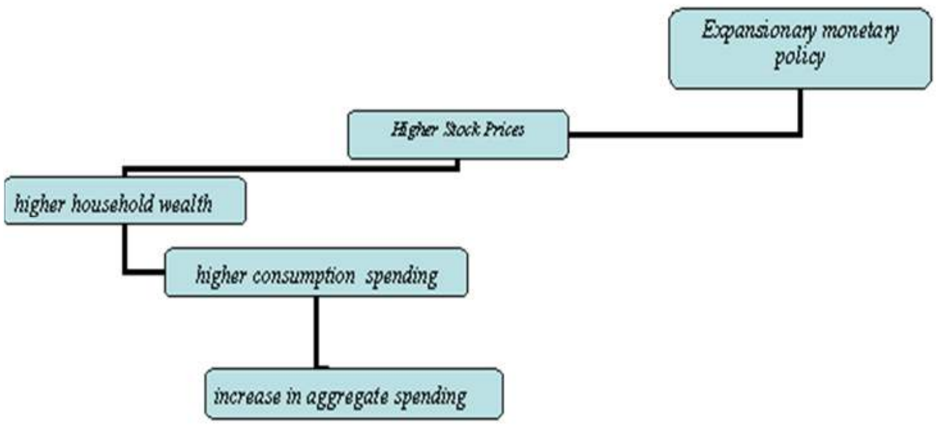
Diagram 5



3.1) Household wealth effects

Another balance-sheet channel operating through consumption spending involves household wealth effects. The life cycle model of Modigliani (1971) states that consumption is determined by the lifetime resources of consumers. An important component of consumers' lifetime resources is their financial wealth, a major component of which is common stocks. Thus, expansionary monetary policy which raises stock prices, raises the value of household wealth, thereby increasing the lifetime resources of consumers which causes consumption to rise. This produces the following transmission mechanism:

Diagram 6



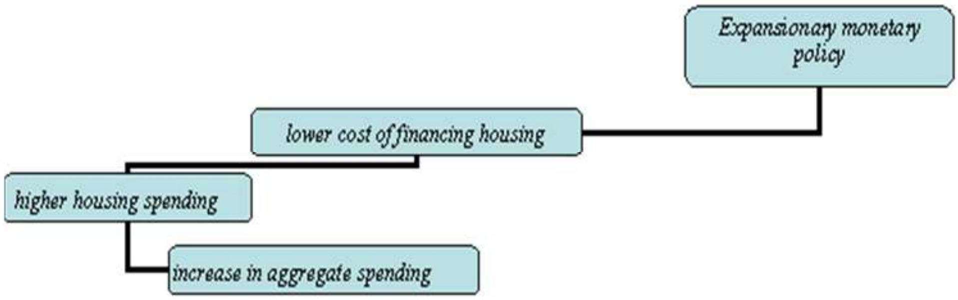
Research has found that this transmission mechanism is quite strong in the U.S. but the size of the wealth effect is still controversial [see

Lettau et al (2000)].

Another set of asset prices which plays an important role in the monetary transmission mechanism are real estate prices. Real estate prices have been closely related to the business cycle in the industrialized world [IMF (2000)]. For some countries like Japan the correlation is even stronger. Real estate prices can affect aggregate demand through three channels: direct effects on housing expenditure, household wealth, bank balance sheets.

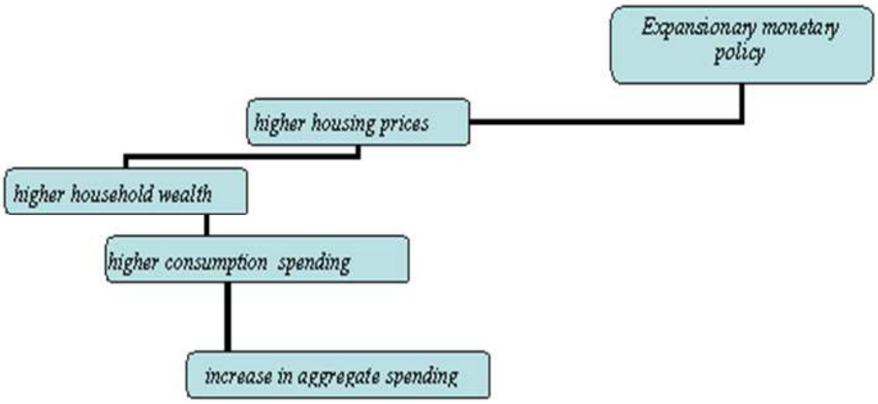
Monetary expansion lowers interest rates and thus decreases the cost of financing houses and so increases their price. With higher house prices relative to its construction cost, construction firms find it more profitable to build houses and thus housing expenditure increases and aggregate spending also increases.

Diagram 7



Housing prices are an important component of household wealth, thus an expansionary monetary policy which raises housing prices also raises household wealth and therefore consumption spending.

Diagram 8



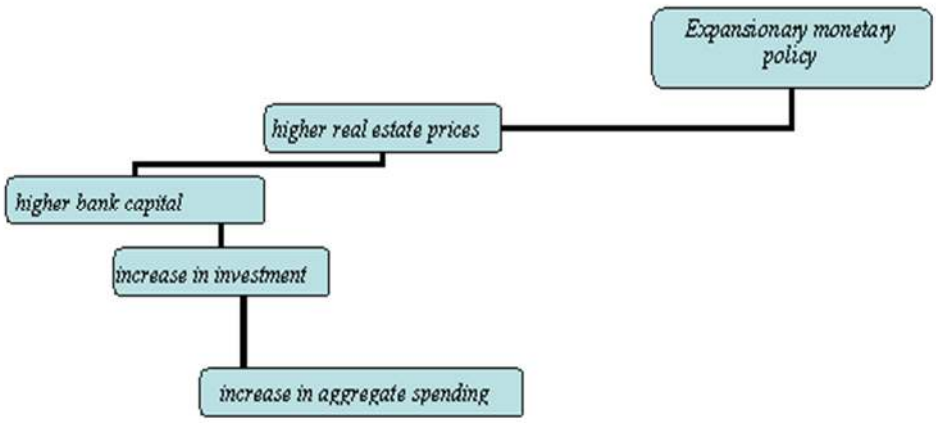
The wealth effect of higher housing and equity prices on consumption is expected to be stronger in countries where property and stock ownership are more prevalent among households – that is, where stock market capitalisation and the ratio of housing wealth to income are higher.

There is evidence that changes in real property and stock prices have significant effects on private consumption spending in most of the industrialised world. However, estimates of the magnitude of this effect vary considerably across countries and are highly dependent on the type of asset in question. The effect of stock prices on consumption appears to be strongest in the US. In contrast, studies for other countries have not found any significant effect of stock prices on private consumption in Italy and France, whereas for Canada, Germany, Japan, the Netherlands and the U.K. the effects are significant but smaller than in the U.S. [see Boone et al (1998)]. This appears to reflect the smaller share of stock ownership relative to other financial assets in these countries, as well as the more concentrated distribution of stock ownership across households in continental Europe when compared with the United States.

The effects of changes in real property prices on consumption appear to be stronger in European Union countries. Rising property prices can affect consumption not only through higher realised home values but also by the household's ability to refinance a mortgage or take out (or expand) home equity loans of credit based on higher property values. The two latter channels, in particular, have become increasingly important in European Union countries in recent countries, thus bolstering the sensitivity of consumption to property price cycles. Boone et al (1998) estimated that the elasticity of consumption to property prices is about 10 percent per year and in the Netherlands to be 7 percent over two years. There is also evidence that property price cycles have been a major determinant of consumption growth – being far more important than stock prices - in Australia and in some other European countries operating through the credit channel [see Kent and Lowe (1998)].

Finally, banks engage in a substantial amount of real estate lending, in which the value of real estate acts as a collateral. If real estate prices rise as a result of monetary expansion then bank loans losses decrease which increases their bank capital. Higher bank capital allows banks to engage in more lending and since banks are special with many customers dependent upon then investment and aggregate demand will increase.

Diagram 9



When the opposite happens and real estate prices fall, this transmission mechanism has often been described as "capital crunch" and was operational in the U.S. in the early 1990's and has been an important source of stagnation in Japan during the 90's.

An important aspect emerging from the literature is the important role played by asset prices during the monetary transmission mechanism. They, in fact, may contain important information regarding the current and future state of the economy. In fact change in interest rate modifies people's expectations about future economic growth, and thus their profit expectations. This may change the set of discount factors economic agents apply to their profit expectations or to the future stream of services or revenues from the asset they hold (housing for instance).

The next chapters of this book analyse, under different aspects, the case for a reaction of monetary authorities to asset prices movements. There are several reasons why monetary policy might wish to respond. First is that asset price misalignments may cause danger to the stability of the financial system. This case is put forward by Borio and Lowe (2002), they observe that since the 1970 asset prices cycles have been growing in amplitude and size. They argue that even an environment characterised by sound and credible economic policies, financial instability could be a serious threat. According to them, "it is the unwinding of financial imbalances that is the major source of financial instability, not an unanticipated decline in inflation per se".

A second potential reason why central banks would like to respond to asset prices is that, as analysed previously, they play an important role in the transmission of monetary policy. Rising asset prices may have direct impact on the aggregate demand and may, therefore, be associated with growing inflationary pressures. They also influence the collateral values and bank's willingness to lend.

The final reason is that asset prices might contain important information concerning the future state of the economy; they incorporate information about financial market expectation of inflation and macroeconomic conditions.

The major debate is not on the role of asset prices in the economy, but rather if and eventually how policy makers (i.e. Central Banks) should take into consideration information deriving from the asset market.

If the monetary authority is uncertain about whether asset prices have an independent role in the context of a macro-model or simply reflecting other economic fundamentals, then the expected costs in terms of economic volatility of responding to asset prices may exceed the expected benefits. The IMF (2000) also warns that since asset markets place greater reliance on information and are generally more competitive than some goods and labour markets, macroeconomic policy authorities should be extra cautious when pitting their judgment against those of the market. Another argument against asset price inflation targeting is that all asset pricing models empirical predictions are subject to wide margins of error, and they involve the modelling of non-directly observable expectations on the underlying determinants of asset prices.

The discussion of the monetary transmission mechanism indicates that real estate and stock prices do have an important effect on aggregate demand and thus must be monitored closely to evaluate the stance of monetary policy. Within the framework of a standard loss function in which the central bank minimizes a weighted average of squared deviations of inflation from its target level and output from potential output, optimal monetary policy will react to changes in real estate and stock market prices. However, depending on the nature of shocks to these prices the optimal response of monetary policy would differ. Our purpose is to discuss those important issues in the model we will construct in chapter two. The question of whether monetary authorities can improve their performance by trying to prevent asset price bubbles from happening in the first place, since subsequent collapses of these asset prices might be highly damaging to the economy (as they were in Japan in the 1990s) will be discussed in chapter three.

Chapter Two

Optimal Monetary Policy and Asset Market shocks under Cooperative and Non-cooperative Games

2.1 *Introduction*

The purpose of this chapter is to analyse interactions among monetary policymakers in the presence of shocks in asset markets. This analysis will be undertaken in the contest of a simple theoretical game with no uncertainty. In this framework the concepts of co-ordination, co-operation and commitment between two countries are fundamental in the evaluation of the resulting policy rules that will emerge under different behavioural assumptions regarding the relationship of the monetary authorities with each other.

Economic policies may have international spillover effects, positive and/or negative, that affect other countries in addition to their domestic effects. These effects emerge through trade, interest rates, exchange rates, terms of trade and the international movements of capital in search of higher yields. Policy co-ordination is a way to internalise these potentially harmful spillovers. This is the principal argument for policy co-ordination.

Different monetary and exchange rate policies have from time to time led to tension among countries. A way to overcome this problem is forming a monetary union (e.g. Europe). The union's member countries agree to fully consolidate their monetary policies so that there can no longer arise spillovers from that policy sphere (except to the extend that the financial sectors could continue to diverge between the countries).

In particular, we address the following issues: the impact on the Central Bank's policy response to a shock in the asset market and how the resulting policy change in one country will affect both the Central Bank response and the asset market in the other country.

The first step in providing answers to the question considered above is to describe how asset markets respond to a monetary policy change initiated either by the home or foreign Central Bank. It is evident that financial markets' responses to monetary policy actions undertaken by either the home or foreign Central Bank depend on a combination of domestic and foreign influences. These influences manifest themselves through two channels. The first and most immediate relates to movements in the quoted prices such as exchange rates and interest rates in the international money, capital and foreign exchange markets. The second channel is due to changes in domestic real activity and prices. These channels have both direct effects and indirect effects on the economy, and the latter can partially or totally offset the initial effects of the former. For example, changes in equilibrium prices will affect both private incomes and wealth. The existence of a wealth effect associated with asset market fluctuations is beyond dispute. A fall in asset market prices due to restrictive monetary policy will erode personal wealth. In addition, lower asset prices are associated with lower private sector investment resulting in greater employment uncertainty and lower confidence, particularly because layoffs typically increase during such periods, so that individuals will stop spending. Since consumption represents a great percentage of GDP, even small changes in consumer spending could affect economic growth.

Higher inflation due to lax monetary policy can have a negative impact on the asset market, because increasing inflation results in moderating long-term interest rates, thus reducing the present value of future profits. In addition, as higher inflation is normally associated with variable inflation, this has a further negative effect on the firms because typically it incites investors to demand higher risk premiums. This takes the form of increased spreads of corporate bond and commercial paper interest rates relative to Treasury yields.

The present work uses a formal model within a policy game in order to analyse an optimal reaction of the Central Bank to a shock in the asset market. We consider two large economies, e.g. country "a" and "c", with an accommodate and conservative central bank respectively and different games in which we assume that both central banks react to bubbles shock in their asset markets.

These price bubbles, in recent years, appear to have developed in the real estate markets in several developed countries, including the United States, Australia, the United Kingdom, Italy, France, the Scandinavian countries and Japan. Often these price increases in land have been accompanied by rapid raises in the price of equity securities in the domestic market. Because of the importance of real estate and equity security prices to economic activity, real estate and share price bubbles can damage the economy if they break and lead to price crashes.

These bubbles pose an intriguing question of political and economic organization, and raise questions about the efficacy of central bank intervention in an era in which the nation-state and its fundamental institutions are under pressure from a variety of pressures, technological, political, and economic. One authority that will often have a degree of control over a bubble economy is the Central Bank. This is because the central bank typically controls the money supply and short term interest rates. The money supply and interest rates, in turn, are key factors in the development and continuation of bubbles in real estate and equity markets. Such bubbles appear, typically, when interest rates are low and credit is cheap. By tightening monetary policy and raising interest rates, the central bank can inhibit or even destroy a bubble.

On the other hand, while the central bank does have a degree of regulatory power, there are significant costs and uncertainties that may make it difficult for the central bank to intervene. These include the following:

1) a central bank's response to a share market bubble in its own economy may be influenced by concern for the effects on share markets in other countries;
2) the central bank may be constrained by considerations of international relations, especially in the area of exchange rate policy: it may be difficult to harmonize international authorities on economic policy with the rapid developments in a bubble economy;
3) the authority of a central bank to control a price bubble may be uncertain, because the bubbles may not affect the broader

economic indicators typically relied on by central banks in formulating monetary policy;

4) the bubble economy may be the result, in part, of financial deregulation which has the effect of directing bank credit into particular economic sectors, especially real estate. Depending on applicable law, the central bank may not have the authority to deal with the underlying root causes of the credit surplus;
5) the tools available to the central bank to act against bubbles are likely to have effects on economic activity outside the bubble, and accordingly a central bank must use these tools with caution.

Any action by the central bank against a price bubble is likely to encounter political opposition from a variety of sources: interests which profit directly from the bubble, interests which, while not profiting directly from the bubble, would nevertheless be harmed if the central bank tightened monetary policy, and members of the public who are swept along in the general euphoria.

The central bank's ability to act against a bubble economy during the early stages is likely to be adversely affected by uncertainty about whether the phenomenon is really a bubble, or rather a series of price increases based on economic fundamentals.

The central bank may need the support of politicians if it is to act decisively against a bubble economy, especially during the early stages when the price increases are likely to enjoy widespread popular support. If such support is not forthcoming, the central bank may not be able to take firm enough action to deal with the situation.

The power of a central bank to act against a bubble economy may depend on the bank's own political position; other things equal, a politically independent central bank is likely to have somewhat greater discretion to act against a bubble than a politically dependent one.

In this chapter we explore these questions concerning the role of the central bank in responding to assets price bubbles. We do so in a particular theoretical context. The structure of this chapter is as follows: section 2.2 will develop a model of strategic interaction between two monetary authorities and will allow for an explicit role of the asset markets in the structure of the economy in the light of the above discussion. The same section analyses the impact of shocks in the asset markets and their effects on monetary policy and discusses the welfare implications of different forms of non-cooperative behaviour. Section 2.3 presents the results of the simulation. Section 2.4 contains the conclusions.

2.2 The model

Following the pioneering contributions of Hamada (1976, 1985), Canzoneri and Gray (1985), Cooper (1985), Canzoneri and Henderson (1991) and more recently Lambertini (1997) and Frowen and Karakitsos (2000), we develop a formal model within a policy game in order to analyse an optimal reaction of the Central Bank to shocks in the asset markets and a Phillips curve shock.. In doing this, we consider different games in which we assume that two central banks, one conservative and one accommodate (subscript "c" and "a" henceforth) react to shocks in their asset markets.

We assume that monetary policy is the result of equilibria of cooperative and non cooperative policy game[13]. The central banks of two big countries are unlikely to coordinate their monetary policies for several reasons. First because they could disagree about the underlying economic model (for instance, one economy could be more flexible while the other could presents more rigidities like in the labour market); second, when national welfare is perceived (relatively) unaffected by adverse exchange rate movements (at least up to a certain value of the exchange rate); finally, when commitments to coordinated macroeconomic policies have not been honoured in the past. Central banks react to each other on the basis of some knowledge of the interdependence of their various policies. We consider four different games with various equilibria: the first two are based on Stackelberg equilibria, the third is based on Nash equilibrium and the fourth is the coordinated equilibrium where both countries are cognisant of the interactions of their policies and internalise the international spillover effects. In the first we consider that the accommodate central bank is

[13] We adopt the terminology of Canzoneri and Henderson where coordination refers to the way policymakers settle on one solution out of several in a non-cooperative game. (1991, page 4)

the leader and the conservative is the follower. In the second we reverse the role. The third is based on a Nash equilibrium that implies also a non-co-operative solution[14]. Finally, we consider, as a benchmark model for the simulation, a cooperative game in which both monetary authorities minimize their loss functions (maximizing their national welfares) so that no single country can be made better off without making another worse off.

The subsequent analysis is based on the following assumptions:

1) The world exists for a single period or one-shot game and consists of two countries: “a” and “c”;
2) each central bank optimises an objective function that penalises deviations of inflation from target, and output gap. Of great importance is the weight that the central bank attaches to each

[14] In general, the problem with any cooperative game is that policymakers have an incentive to cheat. Implicit in any cooperative game structure is the ability of policymakers to commit to binding agreements.
A comparison of the outcome of the non-cooperative Nash equilibrium with the equilibrium in which the policymakers cooperate, and the public expect cooperation, confirms the following proposition:
Rogoff proposition: under complete information, policy cooperation lowers welfare. Hence, international policy cooperation is counterproductive.
However, the above proposition has been criticized by Carraro and Giavazzi (1991). In fact, they affirm that is the policymakers have the choice to cooperate or not, the not-cooperative equilibrium is not sub-game perfect. The *Carraro-Giavazzi* proposition is: *assume complete information. If the central bank can sign binding agreements to cooperate, the non-cooperative Nash equilibrium is not a sub-game perfect equilibrium of the sequential game.*
The proof of the above proposition is that once the public has formed its expectation, there are only two players left. In this context, co-operation between them is unambiguously superior.

component of the objective function. Hence, in the present work the country "a" is assumed to be balanced in its pursuit of monetary policy and this implies that the weights attached to inflation and growth are the same; while, the country "c" is tied by its narrow mandate to maintain price stability and this implies that the weight attached to inflation is higher than that of the country "a";

3) purchasing power parity is assumed to hold;
4) asset market fluctuations impact future consumption choices and therefore future rates of inflation. More precisely, price adjustments in asset markets affect the value of household's wealth and, consequently, spending.

We present a simple symmetric model[15] which is the static equivalent of a conventional aggregate demand –aggregate supply model augmented with the asset market. Hamada (1979) called this approach "strategic" because it "is based on the joint reactions and counteractions of each participating country"[16].

The model used by the CBa consists of the following:

$$\pi_a = \overline{\pi}_a + \alpha(y_a - \overline{y}_a) + \varepsilon \qquad (1)$$

[15] We assume that the size of the two economies is almost the same. Hence, we can assume that the two models are symmetric to each another. The structural parameters for the two countries are equal.

[16] Hamada (1979), pag. 299.

$$y_a = \bar{y}_a - \beta(r_a - \bar{r}_a) + \beta_1 S_a + \beta_2 e_a \qquad (2)$$

$$S_a = \overline{S_a} - \gamma_1(r_a - \bar{r}_a) - \gamma_{2c}(r_c - \bar{r}_c) + \gamma_3(y_a - \bar{y}_a) + \varepsilon_1 \qquad (3)$$

$$e_a = \pi_a - \pi_c \qquad (4)$$

Equation (1) is the Phillips curve where inflation "π" will increase or decrease relative to the target level $\bar{\pi}$ in response to positive/negative values of output and an exogenous Phillips curve shock[17]. In the absence of shocks $\bar{\pi}$ is also its expected value.

Equation (2) links the output gap to the domestic interest rates, the asset market (S_1) and exchange rate. $r_a - \bar{r}_a$ (Δr_a henceforth) is the deviation of the interest rate from its equilibrium value, that is, the value that ensures the Bank's loss function is at the bliss point.

Equation (3) describes the behaviour of the asset market. It is defined as deviation from its long run equilibrium ($\overline{S_a}$). Both the domestic and foreign interest rates influence the value of the asset market negatively[18]. The foreign interest rate has a negative impact on the asset markets and this can be rationalized as follows. A rise in the domestic interest rate has a negative effect because higher interest rates decrease investment and subsequently aggregate demand. Meanwhile, a rise in the foreign interest rate will have a contractionary effect on the foreign economy thus reducing exports to that economy. The reduction in

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[17] Batini and Nelson (2000).

[18] The fundamental question about the relation between interest rates and asset prices hinges on the relation between money tomorrow and money today. A stock share (or some other asset) represents a claim to receive some amount of money tomorrow.

profits of the domestic firms will lead investors to expect a decrease in domestic asset prices.

Moreover, in eq. (3) an increase in output will boost the profits of firms, which in turn causes an increase in the asset values. Lastly, we consider an unexpected shock in the asset market denoted by (ε_1).

Finally, in equation (4) "e_a" denotes the change in the exchange rate of country "a" expressed in the currency of country "c". As mentioned above, purchasing power parity is assumed to hold. This implies that real exchange rate is constant. Therefore, nominal exchange rate changes must correspond to inflation differentials.

Under these assumptions, if a country is experiencing an unexpected increase in the value of the asset market[19], the central bank could use the interest rate (e.g. increase) in order to "cool down" the market.

The equivalent model for CBc is:

$$\pi_c = \bar{\pi}_c + \alpha(y_c - \bar{y}_c) + \varepsilon \tag{5}$$

$$y_c = \bar{y}_c - \beta(r_c - \bar{r}_c) + \beta_1 S_c + \beta_2 e_c \tag{6}$$

$$S_c = \overline{S_c} - \gamma_1(r_c - \bar{r}_c) - \gamma_{2a}(r_a - \bar{r}_a) + \gamma_3(y_c - \bar{y}_c) + \varepsilon_2 \tag{7}$$

$$e_c = \pi_c - \pi_a \tag{8}$$

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[19] In accordance with Bernanke and Gertler (1999) we agree that central banks sould not respond to asset prices movements unless they affect their inflation forecast;

Since we are assuming a symmetric model, equations (5)-(8) follow the same descriptions we made above.

We assume that the shocks ε, ε_1 and ε_2 are independent and identically distributed (iid) with zero mean and constant variance. An unexpected shock in the asset market implies a persistent deviation from its long-run equilibrium. For the sake of simplicity, we assume that only policy makers can observe the shocks in real time. This allows us to avoid additional terms describing surprises for the economic agents.

In each model the following restrictions apply. All the coefficients are positive but less than one. The first inequality, $\beta \ \phi \ \beta_1$, implies that the effect on output of domestic monetary policy exceeds the wealth. The second assumption regarding the comparative spillover effect is expressed by the following inequality, $\gamma_{2a} \ \phi \ \gamma_{2c}$.

In both models the transmission of monetary impulses operates through one main channel: the interest rate. More precisely, the effects of a monetary contraction have a negative impact on the domestic asset market. This causes a further decrease in output due to the wealth effect in addition to the contraction of aggregate demand. As output contracts domestic inflation decreases.

The general form of the loss function of the central banks[20] is given by:

[20] The model has been simplified somewhat here in order to focus on asset market.

$$L_i = \frac{1}{2}\left[w_i(\pi_i - \overline{\pi}_i)^2 + (y_i - \overline{y}_i)^2\right] \tag{9}$$

where the subscript 'i' refers to the country. w_i is the degree of inflation aversion that policymakers attach to inflation. When w_i is one, the central bank is balanced in its pursuit of monetary policy with respect to the two conflicting targets of inflation and unemployment. The higher the value of the weight (w_i) associated with the inflation deviation, the greater the bank's inflation aversion. $\overline{y}$ denotes the potential output and $\overline{\pi}$ the inflation rate that corresponds to the potential output.

The two bliss points are consistent with the level of potential output and inflation target such that $L_i = f\left[\overline{\pi}_i, \overline{y}_i, \overline{r}_i\right] = 0$.

Subject to equation (7), each central bank optimises its own objective function with respect to the economic models, eq. (1)-(6), which allows for the interdependence of these economies.

The optimal combination of policy instruments is achieved, for each country, when the loss function is maximized subject to the economic model. Moreover, under the assumption that the model is defined as deviations from full employment, the loss function of the central banks should be equal to zero if there are no shocks in the system. That is, both economies are at their bliss points.

In this game, the choice of a single central bank is conditioned (taking as given) on the choices of the other.

The following equation describes the optimal monetary policy for each country:

$$\frac{\partial L_i}{\partial \Delta r_i} = \frac{\partial L_i}{\partial \Delta \pi_i}\left[\frac{\partial \Delta \pi_i}{\partial \Delta y_i}\frac{\partial \Delta y_i}{\partial \Delta r_i} + \frac{\partial \Delta \pi_i}{\partial \Delta r_i}\right] + \frac{\partial L_i}{\partial \Delta y_i}\left[\frac{\partial \Delta y_i}{\partial \Delta r_i} + \frac{\partial \Delta y_i}{\partial S_i}\frac{\partial S_i}{\partial \Delta r_i}\right] = 0 \tag{10}$$

Equation (10) describes the solution and can be applied to all cases in the subsequent discussion. Substituting eq. (1)-(4) into eq.(9) and setting the partial derivative equal to zero as in eq.(8), yields the first-order condition and the following CBa reaction function:

$$r_a = -\frac{\beta_1 \gamma_{2,c} r_c}{\beta + \beta_1 \gamma_1} - \frac{\alpha (\beta_1 \gamma_3 - 1)^3 \varepsilon}{(\beta + \beta_1 \gamma_1)(B + G)} + \frac{\beta_1 \varepsilon_a}{\beta + \beta_1 \gamma_1} - \frac{\beta_2 (\beta_1 \gamma_3 - 1 - \beta_2 \alpha)^2 \pi_a}{(\beta + \beta_1 \gamma_1)(B + G)} + \frac{\beta_2 \pi_c}{\beta + \beta_1 \gamma_1} \tag{11}$$

or CBa's reaction function express in terms of r_c:

$$r_c = -\frac{(\beta + \beta_1 \gamma_1) r_a}{\beta_1 \gamma_{2,c}} - \frac{\alpha (\beta_1 \gamma_3 - 1)^3 \varepsilon}{(B + G)\beta_1 \gamma_2} + \frac{\varepsilon_a}{\gamma_{2,c}} + \frac{\beta_2 \pi_c}{\beta_1 \gamma_{2,c}} - \frac{\beta_2 (-\beta_1 \gamma_3 + 1 + \beta_2 \alpha)^2 \pi_a}{(B + G)\beta_1 \gamma_{2,c}} \tag{11a}$$

where $\alpha^2 \beta_1^2 \gamma_3^2 - 2\alpha^2 \beta_1 \gamma_3 + \alpha^2 = B$ and

$$\beta_1^2 \gamma_3^2 - 2\beta_1 \gamma_3 - 2\beta_1 \gamma_3 \alpha \beta_2 + 1 + 2\alpha \beta_2 + \alpha^2 \beta_2^2 = G$$

given that B, G and $\beta_1 \gamma_{2,c} \neq 0$.

The equivalent reaction function for the CBc is:

$$r_c = -\frac{\beta_1 \gamma_{2,a} r_a}{\beta + \beta_1 \gamma_1} - \frac{w \alpha (\beta_1 \gamma_3 - 1)^3 \varepsilon}{(\beta + \beta_1 \gamma_1)(\beta w + G)} + \frac{\beta_1 \varepsilon_c}{\beta + \beta_1 \gamma_1} - \frac{\beta_2 (\beta_1 \gamma_3 - 1 - \beta_2 \alpha)^2 \pi_c}{(\beta + \beta_1 \gamma_1)(\mathrm{B} w + G)} \\ + \frac{\beta_2 \pi_a}{\beta + \beta_1 \gamma_1} \tag{12}$$

given that B, G and $\beta + \beta_1 \gamma_1 \neq 0$.

The coefficients that describe the spillover effect of the foreign monetary policy to the domestic stock market influence the slopes of the two reaction functions. The greater the spillover effect of one country's monetary policy on the economy of the other country the steeper the slope of the reaction function will be.

From the above solution we derive the following conclusion:

Proposition 1

Given that $\beta \phi \beta_1$ and $\gamma_{2,a} \phi \gamma_{2,c}$, *the reaction function of the CBa is steeper than the reaction function of the CBc, and the CBa intercept lies above that of the CBc.*

Proof:

From equations (9) and (10) we compare the slopes and the intercepts of both reaction functions; given our assumptions ($\beta \phi \beta_1$ and $\gamma_{2,a} \phi \gamma_{2,c}$) we conclude that for the slopes the following inequality holds:

$$\left| -\frac{\beta + \beta_1 \gamma_1}{\beta_1 \gamma_{2,c}} \right| \phi \left| -\frac{\beta_1 \gamma_{2,a}}{\beta + \beta_1 \gamma_1} \right| \qquad (13)$$

Once we have established the reaction functions of both countries and defined their relative forms, next step is to derive three equilibria as results of non-cooperative games. In doing so, we consider a one-shot game, but with the so-called "pre-play stage". This stage implies that both monetary authorities, before choosing the optimal level of their respective interest rates, have to make a preliminary decision regarding a non-cooperative or cooperative game. "Assume that there are two instants, t_1 and t_2, at which the two authorities can move. These instants are purely logical entities, and do not belong to calendar time; they represent the pure strategies available to players at the first (pre-play) stage"[21].

The most interesting thing of the pre-play stage is that, if both authorities want to choose at the same instant (t_1 or t_2), the consequent equilibrium of the second stage could be the Nash or the cooperative equilibrium. If, on the other hand, one authority chooses t_1 while the

[21] Lambertini and Rovelli, page 13, 2002.

other chooses t_2, the final solution in stage two will be a Stackelberg equilibrium with the country that has chosen t_1 to act as leader[22].

2.2.1 Game1: Nash equilibrium

In this section, each Central Bank is supposed to behave in a non-cooperative way, and to set, at the same instant, the policy on the basis of the objective function, without considering the consequences on the other players' welfare.

The Nash equilibrium point (N) is achieved through the intersection of eq. (11-12), solving we obtain:

$$\Delta r_a{}^N =$$

$$\frac{\alpha\,(\beta_1\gamma_3 - 1)^3\,(\beta_1\gamma_{2,c}\,w\,\mathrm{B} + \beta_1\gamma_{2,c}\,w\,G - \beta_1\gamma_1\beta\,w - \beta_1\gamma_1 G - \beta^2 w - \beta\,G)\,\varepsilon}{(\mathrm{B} + G)\,(\beta\,w + G)\,A}$$
$$- \frac{\gamma_{2,a}\,\beta_1{}^2\,\varepsilon_c}{A} + \frac{\beta_1\,(\beta_1\gamma_1 + \beta)\,\varepsilon_a}{A} + \frac{\beta_2 A_3 p_c}{(\mathrm{B}\,w + G)\,A} - \frac{\beta_2 A_4 p_a}{(\mathrm{B} + G)\,A} \tag{14}$$

---

[22] "The extended game is a two-stage game where the first stage concerns the choice of timing, while the second stage is the proper policy game where policy instruments are to be set according to the sequence selected at the previous stage", Lambertini and Rovelli, page 13, 2002.

$\Delta r_c{}^N =$

$$- \frac{\alpha (\beta_1 \gamma_3 - 1)^3 (-\beta \beta_1 \gamma_{2,c} w - \beta_1 \gamma_{2,a} G + \beta B w + \beta w G + B \beta_1 \gamma_1 w + \beta_1 \gamma_1 w G) \varepsilon}{(B + G)(\beta w + G) A} + \frac{(\beta_1 \gamma_1 + \beta) \beta_1 \varepsilon_c}{A} - \frac{\beta_1^2 \gamma_{2,c} \varepsilon_a}{A} - \frac{\beta_2 A_1 p_c}{(B w + G) A} + \frac{\beta_2 A_2 p_a}{A (B + G)} \qquad (15)$$

where $(\beta + \beta_1 \gamma_1 - \beta_1 \gamma_{2,c})(\beta + \beta_1 \gamma_1 + \beta_1 \gamma_{2,a}) = A$

$A,\ B \ \ and \ \ G \neq 0$, and we deduce

Proposition 2 Assume that $\varepsilon_c \ and \ \ \varepsilon_a = 0$ and keep constant $\pi_a \ and \ \ \pi_c$. Then the following holds:

$$w \succ \frac{G(-\beta_1 \gamma_{2,a} + \beta + \beta_1 \gamma_1)}{(\beta + B + G)(-\beta - \beta_1 \gamma_1 + \beta_1 \gamma_{2,c})} \qquad (16)$$

Proof:

given that $\gamma_1 \succ \gamma_{2a}, \gamma_{2c}; \beta \succ \beta_1$ it follows that (16) is negative. Since w is defined as positive, the last inequality holds. This connotes that, in a Nash game an exogenous Phillips curve shock forces the accommodate central bank to use a more restrictive monetary policy, compared to the CBc *($\Delta r_a{}^N \succ \Delta r_c{}^N$).* Hence the banks’ reactions differ significantly in the face of an exogenous Phillips curve shock which determines a tighter monetary policy for the CBa, while for the CBc the sign of the impact on monetary policy depends crucially upon the value of w_i that is, the degree of inflation aversion that the CBc attach to inflation.

An interesting aspect of the Nash solution is that both central banks' reactions to a domestic asset market shock are identical which follows from the symmetry of some coefficients between the countries. The CBa's reaction to a shock in the country "c" asset market and/or exchange rate movement is smaller than the CBc's reactions to similar shocks in the country "a" asset market. This follows from the assumption $\gamma_{2a} \phi \gamma_{2c}$ that is, the spillover effect of the CBa's monetary policy on foreign asset market is more pronounced than that of the CBc on the country "a" asset market.

2.2.2 Game2: Stackelberg equilibria

Under the Stackelberg regime, monetary authorities no longer act simultaneously. It is now assumed that one player (the Stackelberg leader) has a first-mover advantage when selecting policy, and takes into account the response of the other player (the follower) to the policy measures. Thus, the leader chooses the optimal strategy subject to the follower's reaction function, and the follower's committed response is to simply take the leader's policy as given and minimise its loss. We think that the leader-follower policy regime is interesting in as much as it allows to highlight of the strategic aspects of the decision-making process in the context of differential inflation-aversion coefficients.

In the Stackelberg equilibrium, monetary leadership is the usual way to capture the notion of central bank independence [Petit (1989), Hughes Hallett and Petit (1990), Debelle (1996)].

2.2.3 Stackelberg equilibrium with CBa as leader

The leader's problem is:

$$\min_{\Delta r_a} L_a = \frac{1}{2}\left[w_a(\pi_a - \overline{\pi}_a)^2 + (y_a - \overline{y}_a)^2\right] \tag{17}$$

s.t.: CBc's reaction function of eq.(12)
where w_a, the weight that the CBa attaches to inflation is unity because it is assumed, according to its mandate, to be "balanced" in its pursuit of monetary policy.
Proceeding by substitution and setting the partial derivative with respect to Δr_a of the leader's objective function equal to zero, we obtain the first- order condition:

$$\frac{\partial L_a}{\partial \Delta r_a} = 0 \tag{18}$$

yielding:

$$\Delta r_a^{Sa} = -\frac{H_6\,\alpha\,(\beta_1\gamma_3 - 1)^3\,\varepsilon}{A\,(B+G)\,(wB+G)} + \frac{\varepsilon_a\,\alpha\,\beta_1^{\,2}\,(\gamma_1+\beta)}{A} - \frac{\alpha\,\beta_1^{\,2}\,\gamma_{2,c}\,\beta\,\varepsilon_c}{A} - \frac{H_4\,\beta_2\,\pi_a}{(B+G)\,A} + \frac{H_5\,\beta_2\,\pi_c}{A\,(wB+G)} \tag{19}$$

$$\Delta r_c^{Sa} = - \frac{\alpha\,(\beta_1\gamma_3 - 1)^3 H_7\,\varepsilon}{A\,(B+G)\,(w\,B+G)} + \frac{\alpha\,\beta_1^{\,2}\,(\gamma_1+\beta)\,\varepsilon_c}{A} - \frac{\alpha\,\beta_1^{\,2}\,\gamma_{2,a}\,\beta\,\varepsilon_a}{A} + \frac{\beta_2\,((\beta_1\gamma_2\alpha^2 + \beta_1^{\,3}\gamma_2\alpha^2\gamma_3^{\,2} - 2\,\beta_1^{\,2}\gamma_2\alpha^2\gamma_3)\,w + H_4)\,\pi_c}{A\,(w\,B+G)} + \frac{\beta_2 H_8\,\pi_a}{A\,(B+G)} \tag{20}$$

From the above it follows:

Proposition 3 *Assume that* $\varepsilon = 0$ *and keep constant* ε_c, π_a *and* π_c*.Then the following inequality holds:*

$$\alpha\,\phi\,\left|\frac{\gamma_2\,\beta_1\,(\beta + \beta_1\gamma_1 + \beta_1\gamma_2)}{A\,\beta_1\gamma_1 + A\,\beta - \beta_1\gamma_2\beta - \beta_1^{\,2}\gamma_2\gamma_1 - \beta_1^{\,2}\gamma_2^{\,2}}\right|$$

when the two countries face a shock in the country "a" stock market.

Proof:

Following the proof of proposition 2, in the Stackelberg equilibrium with CBa as leader, it is possible to identify a range of value for the parameter "α" such that CBa's monetary policy is less restrictive compare to the monetary policy reaction of the conservative central bank.

A corollary of the above is that for this range of asset shock the CBc's policy when acts as follower will be less restrictive compare to its Nash equilibrium. Since $\beta_1^2\gamma_{2,c} \phi \alpha\beta\beta_1\gamma_{2,a}$, equivalent conclusion can be reached for the CBa policy.

2.2.4 Stackelberg equilibrium with CBc as leader

In this case, the leader's problem is given by:

$$\min_{\Delta r_c} L_c = \frac{1}{2}\left[w_c(\pi_c - \overline{\pi}_c)^2 + (y_c - \overline{y}_c)^2\right] \tag{21}$$

s.t.: CBa's reaction function of eq.(11)

where w_c, the weight that the CBc attaches to inflation, is assumed to be greater than unity because of the conservative Central Bank that, by assumption, it is tied by its narrow mandate to "maintain price stability".

Solving by substitution and setting the partial derivative with respect to Δr_2 of the leader's objective function equal to zero, we obtain the first-order condition:

$$\frac{\partial L_c}{\partial \Delta r_c} = 0 \tag{22}$$

$$\Delta r_a^{Sc} =$$

$$-\frac{H_6\,\alpha\,(\beta_1\,\gamma_3-1)^3\,\varepsilon}{A\,(B+G)\,(w\,B+G)}+\frac{\varepsilon_a\,\alpha\,\beta_1^{\;2}\,(\gamma_1+\beta)}{A}-\frac{\alpha\,\beta_1^{\;2}\,\gamma_{2,c}\,\beta\,\varepsilon_c}{A}-\frac{H_4\,\beta_2\,\pi_a}{(B+G)\,A}+\frac{H_5\,\beta_2\,\pi_c}{A\,(w\,B+G)}$$

(23)

$$\Delta r_c^{Sc} =$$

$$-\frac{\alpha\,(\beta_1\,\gamma_3-1)^3\,H_7\,\varepsilon}{A\,(B+G)\,(w\,B+G)}+\frac{\alpha\,\beta_1^{\;2}\,(\gamma_1+\beta)\,\varepsilon_c}{A}-\frac{\alpha\,\beta_1^{\;2}\,\gamma_{2,a}\,\beta\,\varepsilon_a}{A}+\frac{\beta_2\,((\beta_1\,\gamma_2\,\alpha^2+\beta_1^{\;3}\,\gamma_2\,\alpha^2\,\gamma_3^{\;2}-2\,\beta_1^{\;2}\,\gamma_2\,\alpha^2\,\gamma_3)\,w+H_4)\,\pi_c}{A\,(w\,B+G)}+\frac{\beta_2\,H_8\,\pi_a}{A\,(B+G)}$$

(24)

Proposition 4 *Assume that* $\varepsilon = 0$ *and keep constant* ε_a, π_a *and* π_c *.Then, under a shock in the country "c" stock market we get:*

$$\gamma_{2,c} \;\phi\; \left|-\gamma_1-\beta\right|$$

Proof:

Following the assumption that $\gamma_1 \;\phi\; \gamma_{2,a} \;\phi\; \gamma_{2,c}$, in the Stackelberg equilibrium with CBc as leader, the above inequality never holds. This implies that, in this scenario, the CBc's monetary policy is more restrictive compare to the policy reaction of the accommodate central bank.

2.2.5 Cooperative equilibrium (the benchmark model)

Two countries obtain macroeconomic coordination when they minimize a joint objective function with same weight on the output gap, under the control of their respective monetary instruments, Δr_a and Δr_c. In this case, the two monetary authorities' problem is given by:

$$\min_{\Delta r_a, \Delta r_c} L_{Co} = L_a + L_c = \left\{ \frac{1}{2}\left[(\pi_a - \bar{\pi}_a)^2 + (y_a - \bar{y}_a)^2\right] + \frac{1}{2}\left[w_2(\pi_c - \bar{\pi}_c)^2 + (y_c - \bar{y}_c)^2\right] \right\} \qquad (25)$$

s.t.: CBa's reaction function of eq.(11)and CBc's reaction function of eq.(12)

where w_c, the weight that the CBc attaches to inflation, is assumed to be greater than unity because it is tied by its narrow mandate to keep the prices stable.

Solving by substitution and setting the partial derivative with respect to Δr_2 of the leader's objective function equal to zero, we obtain the first-order condition:

$$\Delta r_a^{Co} = \frac{\alpha(\beta_1\gamma_3-1)^3 H_{11}\varepsilon}{(wB+G)(B+G)A}+\frac{\beta_1\beta\varepsilon_a}{A}-\frac{\beta\beta_1^2\gamma_2\varepsilon_c}{A}-\frac{\beta_2 H_{12}p_a}{(B+G)A}+\beta_2\big((\alpha^2\beta-2\beta_1^2\gamma_1\alpha^2\gamma_3-2\beta_1\alpha^2\beta\gamma_3+\beta_1\gamma_1\alpha^2+\beta_1^2\alpha^2\gamma_3^2\beta+\beta_1^3\gamma_1\alpha^2\gamma_3^2)w+H_8\big)p_c/((wB+G)A) \tag{26}$$

$$\Delta r_c^{Co} = -\frac{(\beta_1\gamma_3-1)^3 H_9\alpha\varepsilon}{A(B+G)(wB+G)}+\frac{\beta\beta_1\varepsilon_c}{A}-\frac{H_1\beta_2 p_c}{A(wB+G)}-\frac{\beta\beta_1^2\gamma_2\varepsilon_a}{A}+\frac{H_{10}\beta_2 p_a}{A(B+G)} \tag{27}$$

In a cooperative game structure, players can frictionless bargain and make binding agreements about how to play the game. However, despite the fact that cooperative games yield efficient outcome, the problem with any cooperative game is that policymakers have an incentive to cheat. Implicit in any cooperative game structure is the ability of policymakers to commit to binding agreements.

2.2.6 International coordination and non-coordination policy: an evaluation

In the final part of this section we provide an analysis of the outcomes of the Nash, Stackelberg and cooperative equilibria in absence of any shocks in the two countries. In figure 2.1, we depict the change of the country "a" interest rate (Δr_a) on the vertical axis and the equivalent change for country "c" (Δr_c) on the horizontal axis, their positions and slopes follow the solutions of equations (11) and (12).

The intersection of the two reaction functions denotes the Nash equilibrium (*N*). The locus of points between Φ_a and Φ_c (respective bliss points), derived when the isoloss curves of the two countries are tangential to each other, represents the contract curve derived from all different, potential cooperative games.

We start evaluating these outcomes commencing with the Nash non-cooperative equilibrium which is reached when there is no incentive for either economy to change its policy position, taking the other's policy as given. Consistent with proposition 1, CBa's reaction function is steeper than that of the CBc. This implies that in the presence of a domestic asset market shock, the CBc will follow a tighter monetary policy compared to the one followed by the CBa.

In the Stackelberg game, one of the two players (the leader) realises that there is a better position to be achieved than the Nash equilibrium. This occurs when the leader chooses policy assuming that it will influence the policy choice of the follower, and ignoring the latter's choice. Assuming that the CBa acts as leader, the Stackelberg equilibrium is denoted at point S_a (Fig. 1). At this point the isoloss curve G_a is tangential to CBc's reaction function. This is the closest isoloss curve to point Φ_a that country "a" can reach given the whole range of possible reactions of the opther country. Alternatively when the CBc acts as leader, the equivalent Stackelberg equilibrium is point S_c.

Comparing the Nash and Stackelberg non-cooperative equilibria, the two Stackelberg solutions are certainly superior both when the CBa acts as leader or follower. However, when the CBa acts as leader, whether the Nash solution dominates the Stackelberg solution will depend crucially upon the slope of its reaction function. The greater the slope of the CBa's reaction function, the more likely that the Nash solution will be the less desirable of the two. When the CBc acts as leader, it achieves a lower isoloss curve compared with the Nash equilibrium. The Stackelberg equilibrium is preferable to the Nash even in the case where the CBc acts as follower to the CBa's leadership. Both the Nash and Stackelberg equilibria are inefficient, as they do not lay on the contract curve Φ_a-Φ_c that is derived from the joint minimization of the loss functions in a cooperative game.

Next analyse regards the impact of a shocks in the CBc asset market on domestic and foreign monetary policy.

Assuming a positive shock in the country "c" asset market that shifts the CBc's reaction function to the right, as shown in equation (12). The new Nash equilibrium implies tighter monetary policy for the CBc while for the CBa, a less tight monetary policy is required.

Figure 2.2 analyses the impact of the shock in the CBc asset market on Δr_a and Δr_c, starting when the CBa acts as leader.

In this case, the Stackelberg "a" equilibrium is affected by the shock. The new equilibrium will be at a lower level of interest rates for the CBa and at a higher level for the CBc. Moreover, in terms of social welfare, the equilibrium now is on a lower isoloss curve compared with the previous one. In this scenario, the leader has, undoubtedly, an advantage. As matter of fact, the CBa would set its interest rate at low level in order to aid output to converge to $\bar{y}$, whilst the CBc is faced with a positive shock in the asset market that requires a rising of the rate with the subsequent real economy slowing. Therefore, the follower has to fix the interest rate at a higher level compared with the previous Stackelberg equilibrium.

Finally, we analysis the impact of a shock in the country "a" asset market on domestic and foreign monetary policy.

Consider a positive shock in the country "a" asset market that shifts the CBa's reaction function to the right as shown in equation (11). The new Nash equilibrium implies a tighter monetary policy for the CBa, while for the CBc a less tight monetary policy is required. Figure 2.3 shows the effects of this shock for different games. The Stackelberg "a" equilibrium is not affected by the shock. However, in terms of social welfare, the equilibrium now is on a higher isoloss curve compared with the previous CBa's reaction function while, considering the Stackelberg "c" leader equilibrium, it is worse for country "c" compared to the Stackelberg "a" leader equilibrium and, in terms of social welfare, the equilibrium is on a higher isoloss curve compared with the previous Stackelberg "c" leader equilibrium.

Moreover, comparing the Nash and Stackelberg non-cooperative equilibria, the Stackelberg solution is certainly superior for the CBa leader implying a less tight monetary policy. However, the Nash solution dominates the Stackelberg solution for the CBc when acts as follower.

For the CBa, the higher the response of asset prices to foreign interest rates the greater the required change in the interest rates to re-establish the Nash equilibrium.

Moreover, the required increase in the country "a" rate would vary positively with the size of the wealth effect (coefficient β_1) and the sensitivity of the asset prices (in both countries) to domestic and foreign rates (γ_{2a} and γ_{2c}). The increase in the country "a" rate will be ameliorated the lower the response of asset prices to foreign interest rate. Considering the problem from the CBc's point of view, whether a positive shock in the country "a" asset market requires an easing of monetary stance (Δr_c) will depend upon the coefficients β_1, γ_{2a} and γ_{2c}.

What is interesting in this case is that the greater the impact of wealth in aggregate demand the less able will the CBc be to reduce rates.

2.3 Calibration of the model

Propositions 2 , 3 and 4 state that different shocks in the two stock markets may have different impact on the conduct of monetary policy if we consider different equilibria emerging in the games. However, the complexity of the expressions makes it impossible to determine analytically which of the cases mentioned above are most likely to emerge. To provide a more definitive analysis, we report some simulations in this section.

The aim of the simulations is to compare the outcomes for inflation, output gap, stock market and exchange rate for the various cooperative and non cooperative scenarios assuming a positive shock in one of the two stock markets
In doing this, we calibrate the parameters of the structural model presented in section 3 that is, to find a stylized model in order to simulate different reactions of the monetary authorities to shocks in the stock market. Some of the model's parameter values are chosen on the basis of standard values in the literature. Other parameters are chosen on the basis of previous empirical studies. Where econometric evidence

is not available, the parameters are calibrates in a way to ensure plausible dynamic behaviour by the impulse responses. In particular, we refer to the works of Batini and Haldane (1999), Kontonikas and Montagnoli (2003), Kontonikas and Ioannidis (2004), Ball (1998) and Walsh (1999) for the US. For the asset market in the US and for most of the European countries, we refer to Conover et al (1999) and Goodhart (2000).

For the calibration, we set $\alpha = 0.4$ (the impact of the output gap on inflation). This value is in line with previous empirical estimates of the Phillips curve. For the IS equation, we set $\beta = 0.8$ and $\beta_1 = 0.3$, in line with empirical findings based on different countries in Goodhart (2000), while the coefficient of the exchange rate is set as $\beta_2 = 0.4$. For the sake of simplicity, we assume that the impact of domestic asset market, coefficient β_1, on the domestic output is the same in both economies ("a" and "c") in accordance to Goodhart and Hofmann (2000) that found this difference very small for two big economies like USA and Europe.

For the asset market equation, we set the impact of the foreign interest rate change on domestic asset markets in the following way: $\gamma_{ac} = 0.15$ and γ_{2a} =0.08. This assumption appears to be more plausible empirically than an equally weighted foreign interest rate formulation (e.g. $\gamma_2 = 0.3$). Hence, the weaker spillover effect from country "c" to country "a" has been incorporated into the simulation model by differentiating the parameter of the sensitivity of the asset prices to foreign rates ($\gamma_{2c} \neq \gamma_{2a}$).

Finally, the effect of a change in the domestic output gap on the domestic asset market is expressed by the parameter γ_3 that is set equal to 0.5.

Table 2.1 summarized the parameter values used in the simulation that are based on the assumptions made above.

Those parameters are meant to represent two stylized facts. First, an increase in the asset price has an impact on the output gap and, throw the wealth effect, on consumption and inflation. This is based on the assumption that country "a" and country "c" asset markets are complete and developed markets. Secondly, that the spillover effect of the CBa monetary policy on country "c"'s asset market is bigger that the spillover effect of the CBc monetary policy on the other asset market.

The calibrated values are reasonable a priori and, of course, the simulation results are only indicative of the stylized facts. However the results are affected by any change in the structural parameters.

A preliminary analysis without using true data is conducted on equations (17), (21) and (25) in order to simulate the impact of a decrease of CBc's degree of inflation aversion on the loss functions in the four policy games. Figures 2.4 and 2.5 describe the results of these simulations. Comparing the two figures we can note that in both cases a decreasing in the degree of inflation aversion (parameter "w") generate a convergence towards a lower level of losses. However, this convergence is greater for the CBa than the CBc as it could be expected from the assumption of the model. Hence, country "a" could benefit more of a decreasing of the CBc' degree of inflation aversion especially when we consider a Nash equilibrium and a Stackelberg country "a" leader equilibrium. On the contrary under a cooperative game none of the two countries seems to benefit more of a decrease of the value of the parameter "w".

2.3.1 Simulation analysis

In this section we implement a simulation using true data for two big countries, USA and Europe. In our view the monetary authorities of these two countries can better represent the "conservative" and the "accommodate" central bank assumed in the model where, of course, the first is associated with the European Central Bank (ECB) and the second with the Federal Reserve (FED). Hereafter country "a" refers to USA and country "c" to Europe as well as CBa is the FED and CBa is the ECB. Hence, the choice of the sample was essentially based on the need of including all the main events that embodies the launch of the Euro and subsequent changes in monetary policies.

The simulation results are based on a sample of 120 monthly observations started from January 1994 to December 2004 for USA and EMU countries. We focus our analysis on five variables for both countries: short-term interest rates, the exchange rate, the stock prices, the output gap (y_t) and inflation rates (π_t). The variables are constructed as follows: π_t is equal to $100*[\ln(CPI_t/CPI_{t-12})]$, HCPI for the EUM; the output gap (y_t) is the difference between actual and potential output.

The latter is calculated as the percentage deviation of the natural logarithm of the monthly industrial production from a Hodrick-Prescott trend; Two out of three financial markets are proxied by variables: *r, s*. They are, respectively, the percent gap between the actual and potential interest rate (called natural rate that is, the rate consistent with stable inflation and output equal to potential), and stock price misalignment. Following Laubach and Williams (2003) methodology we estimate the natural rate of interest for the whole period. Moreover, following Goodhart and Hofmann (2001), we also calculate the long-term of the assets prices using the above mentioned Hodrick-Prescott filter methodology. In this work we assume that the stochastic shocks to the model are only applied to the error terms, much as in the rest of the economic literature.

2.3.2 Optimal monetary rules under different games

In this section we present some details about how to obtain the optimal equilibrium rule. The optimal monetary policy rules with cooperative and non cooperative games are obtained by simulation using expressions (15) to (16), (19) to (20), (23) to (24) and (26) to (27) with parameters given in table 2.1. These rules are function of five arguments (ε, ε_1, ε_2, π_a *and* π_c) as shown by expressions below. The coefficients of these arguments are taken for the specific case with w = 1.5, the weight attributed to the inflation gap in the ECB loss functions. Therefore:

Nash optimal monetary rules

$$\Delta r_a{}^N = 0.4227\varepsilon + 0.1252\varepsilon_1 - 0.0082\varepsilon_2 + 0.4132\pi_a - 0.1248\pi_c \tag{28}$$

$$\Delta r_c{}^N = 0.7162\varepsilon - 0.0078\varepsilon_1 + 0.12525\varepsilon_2 + 0.5847\pi_c - 0.19514\pi_a \tag{29}$$

Stackelberg (BCa leader) optimal monetary rules

$$\Delta r_a{}^{Sa} = 0.2155\varepsilon + 0.051\varepsilon_1 - 0.0052\varepsilon_2 + 0.4036\pi_a - 0.0782\pi_c \tag{30}$$

$$\Delta r_c{}^{Sa} = 0.6329\varepsilon - 0.0272\varepsilon_1 + 0.051\varepsilon_2 + 0.4323\pi_c - 0.2011\pi_a \tag{31}$$

Stackelberg (BCc leader) optimal monetary rules

$$\Delta r_a{}^{Sc} = 0.3386\varepsilon + 0.051\varepsilon_1 - 0.0052\varepsilon_2 + 0.4824\pi_a - 0.08985\pi_c \tag{32}$$

$$\Delta rc^{Sc} = 0.6028\varepsilon - 0.00272\varepsilon_1 + 0.051\varepsilon_2 + 0.5325\pi_c - 0.1863\pi_a \tag{33}$$

Cooperative optimal monetary rules

$$\Delta r_a{}^{Co} = 0.3154\varepsilon + 0.284\varepsilon_1 - 0.0128\varepsilon_2 + 0.2799\pi_a - 0.0253\pi_c \tag{34}$$

$$\Delta r_c{}^{Co} = 0.5377\varepsilon - 0.068\varepsilon_1 + 0.284\varepsilon_2 + 0.3784\pi_c - 0.1566\pi_a \tag{35}$$

The optimal rules coefficients depend on the structural parameters of the models (1)-(4) and (5)-(8) and the weight given to inflation gap in the loss functions.

For all the optimal monetary rules the signs of the coefficients are consistent to the economic theory. An interesting aspect of these solutions is that for both Stackelberg equilibria the coefficient of the stock markets shocks are symmetric.

2.3.3 Impulse response functions in the presence of a shock in the US, EU asset markets and exchange rate market

Once we have determined the optimal policy rules, next step refers to the analysis of the impulse response functions. We consider the effect of the innovation of the USA, EU stock market and exchange rate market respectively on the future state of the economy. In particular, we focus our analyses on the response to one percent shock of the above variables to the output, inflation, stock markets and exchange rate of both countries. The results from the impulse response functions are presented in figures 2.4, 2.5 and 2.6. Each response is provided with the associated asymptotic confidence bands. Figure 2.4 plots, for both countries, the responses of output, inflation, stock market and exchange rate to a shock in the USA stock market. Following an unexpected increase of the US asset market, the patterns of the output responses are similar in both countries that is, a positive shock in the USA stock market increases output gaps. Different responses are obtained when we consider the effects on the inflation in the two countries. Despite the fact that the patterns are similar, the magnitude of the impact is slightly different. After an initial decrease (roughly two months), the inflations increase. The time profile of the incremental effect between the two countries differ in only one respect: while the response on USA inflation converge after almost 20 month, the EU inflation shows a persistence effect. Moreover, a positive shock in the US stock market leads to an appreciation of the exchange rate that last for about 10 months. The sequence of events can be the follows: a positive shock in the US stock market can generate an inflow of capitals from the rest of the world. This inflow has a positive effect on the current account and consequently it determines an appreciation of the currency. Finally, figure 2.4 shows a negative effect on the EU stock market.

Figure 2.5 plots, for both countries, the responses of output, inflation, stock market and exchange rate to a shock in the EU stock market. Following an unexpected increase of the European stock market, the patterns of the output responses are dissimilar in the two countries that is, a positive shock in the EU stock market increases output gap in the USA while, for the first six months it has a negative impact on the EU output gap. Different responses are also obtained when we consider the effects on the inflation in the two countries. The patterns are different. After an initial delay, the EU inflation show a slightly decrease soon after followed by a very low increases. On the contrary, the US inflation shows a positive effect. In fact, after an initial increase (roughly two months), the inflation decreases but still the effect remain positive and persistent. Furthermore, a positive shock in the EU stock market leads to a slightly appreciation of the exchange rate that last only for two months. Soon after, the euro/dollar exchange rate shows a reverse trend of depreciation. Finally, apart from an initial positive effect on the US stock market, that last for about four months, the remain timing shows an impact very close to zero. Figures 2.4 and 2.5 describe a sort of "wealth channel" in which prices adjustments in one of the asset market (e.g. stock market) affect the value of households' wealth and therefore, spending. This in turns affect, via integrated financial markets, prices adjustment in the other asset market too, creating another "wealth channel" in the other country. This channel differs for the order of magnitude and sign according to the assumptions made in the model used. The greater the coefficient β_2 is and the greater the impact of the foreign interest rate change on domestic asset markets (γ_{1u} and γ_{1e}) the stronger will be two spillover effect between the two economies.

This is also consistent with the assumption made in eq. 4 and 8 of the model used in this work that is, if the PPP holds, the exchange rate determination is related to the inflation differential between the two countries.

2.3.4 Optimal monetary rules and welfare losses under different equilibria and different shocks: a comparison.

The results of eqs. 28-35 obtained for different games and different shocks are plotted in figures 2.7.1-2.7.3 for the ECB and figures 2.8.1-

2.8.3 for the FED[23] (country "c" and "a" respectively). In particular, Figures 2.7.1-2.7.3 describe the behaviour of the ECB optimal monetary policy for different games and different shocks. After 1999 it is possible to divide the sample into two sub-samples: before and after the 2002. The first period was characterised by a depreciation of the Euro against the Dollar while the second period shows a strong appreciation of the Euro/$ currency.

Before 2002 the Cooperative equilibrium was the game that minimise the policy rules alternatively with the Stackelberg EU leader game. The sub sample 2001-2002 in figures 2.7.2-2.7.3 show that the Stackelberg equilibria games were the ones that minimise the policy rules.

Figures 2.8.1-2.8.3 show that, as above, under all the possible shocks and for most of the sample period under investigation, the Stackelberg US leader game is the one that minimizes the FED policy rule. The Stackelberg US follower scenarios imply a tighter monetary policy in case of shock 1 and 2 (Phillips curve shock and US stock market shock) while under shock 3 (EU stock market shock) Nash and Cooperative scenarios show almost the same results. As depicted in figure 2.8.1-2.8.3, with Nash, Cooperative and Stackelberg US follower games the FED gets higher policy roles while under the Stackelberg US leader equilibria (foe shocks 1-3) a less tighter monetary policy is required.

[23] All the figures 4-7 follow the same criterion: last number of the variables' name refers to a different shock. In particular, "1" stands for a Phillips curve shock, "2" for a CBa asset market shock and "3" for an CBc asset market shock. The sample considered is from May 1994 to December 2004.

Figures 2.9.1-2.9.3 and 2.10.1-2.10.3 show the results of different welfare losses for USA and EU respectively under different equilibria and different shocks. According to the model presented in this work and the simulation analyses, losses are caused by shocks (Phillips curve shock and asset markets shocks) at home and abroad, which lead to the output gap and inflation gap deviating from their targets. The loss depends on the magnitude of the shock and the game chosen. In particular, under a Phillips curve shock, figure 2.9.1 shows that when the FED plays as leader in the Stackelberg scenario, the loss is minimised. Figures 2.9.2 and 2.9.3 show that, under all the other possible shocks, the cooperative game is the one that minimizes the welfare loss while the Nash game is the worst solution in case of an stock markets shocks. A Stackelberg FED follower is the less volatile compared to the others scenarios in case of an EU stock market shock.
From figures 2.10.1-2.10.3 we get a bit different results. Cooperative game minimises the welfare loss only in case of a shock in the EU stock market. For the other two shocks, the Stackelberg EU follower minimise the welfare loss.
Tables 2.2 and 2.3 summarize and compare all the possible scenarios. In order to simplify the analysis, we have defined the choice of the Central Banks as “Most preferred”, “Less preferred” and “Least preferred”.
“Most preferred” is referred to a scenario where the social loss is minimized with a less tight monetary policy; “Less preferred” is

referred to a scenario worse than the previous one and "Least preferred" is characterised by the worst measure achieved;

When we look at the situation in which the FED is facing a shock in the European asset market, both the players (FED and ECB) would prefer to play the cooperative game. In fact, this is the situation in which they minimize their loss functions. However, for the FED, even in case of a shock in the domestic asset market the cooperative game is the one considered "most preferred". Different is the situation for the ECB. It is assumed, according to its mandate, to be more inflation oriented in its pursuit of monetary policy. Table 2.3 shows that the Stackelberg follower equilibrium, when both economies are facing with a symmetric Phillips curve shock, is the "most preferred" for the ECB especially if the shock is of such a big magnitude that could have strong effect on the inflation. In this case the ECB would prefer this scenario while the FED would minimise its optimal policy rule and its loss function in a cooperative game.

From the results of tables 2.2 and 2.3 can be shown that ECB is less interested in cooperation with the FED while, for the latter, cooperation represent the first best solutions in all games. The launch of the Euro as an international currency can create difficulties in financing the USA current account deficits if the US dollar is no longer the main international currency. If this is the case, in order to attract international capitals, USA returns have to be higher; which could have a respectable impact on the USA economy. Moreover, in terms of exchange rate fluctuations, it may become less stabilising for the USA economy while

Europe could benefit from the regime shift in terms of inflation and output. In short, Euro currency potentially can reduce the incentives of ECB to cooperate while it may raise the motivations of the FED to do this. Nevertheless, this is a theoretical analysis of cooperation considering the EMU countries as a block. More pragmatic, much of the future of international cooperation will depend on the way the European countries succeed in specking with one voice (Benassy-Quere et al 1998).

2.4 Conclusions

This chapter has re-examined the issue of international macroeconomic policy coordination, taking advantage of recent developments in theoretical methods used in the literature to study monetary policy optimization.

All the recent attention on the asset market and on monetary policy rules has inspired a natural question: should a central bank also react to asset price movements when it sets its monetary policy? The movements in the asset markets have stimulated a great discussion among economists about the role the asset market should play in influencing monetary policy decisions.

The review of the literature, however, does not offer a conclusive answer to whether, and how, a central bank should respond to asset "shocks". This work examines, theoretically, in a cooperative and non-cooperative game framework, the optimal monetary policy assuming that the central bank considers the information from the asset market. In particular, we examined the impact of shocks in the asset markets, exchange rate shock and Phillips curve on domestic and foreign monetary policy.

The results from the impulse response functions show that, following an unexpected increase of the US asset market, the patterns of the output responses are similar in both countries that is, a positive shock in the USA stock market increases output gaps. Different responses are obtained when we consider the effects on the inflation in the two countries. Despite the fact that the patterns are similar, the magnitude of the impact is slightly different.

Moreover, following an unexpected increase of the European stock market, the patterns of the output responses are dissimilar in the two countries that is, a positive shock in the EU stock market increases output gap in the USA while, for the first six months it has a negative impact on the EU output gap. Different responses are also obtained when we consider the effects on the inflation in the two countries.

Finally, we found that, under a cooperative game, the FED minimise its loss functions in all the three potential shocks we examined. Different is the situation for the ECB where, it minimises its loss function with less tighter monetary policy only in the cooperative scenario with a shock in the EU stock market and when it acts as follower in the Stackelberg game with a Phillips curve shock.

Appendix 1

Due to the large amount of coefficients involved in the derivation of the model under different games, the following substitutions were applied in this chapter:

$$
\begin{aligned}
&2\beta_1^{\,2}\gamma_{2,c}\gamma_3-\beta_1^{\,3}\gamma_{2,c}\gamma_3^{\,2}-\beta\beta_1\gamma_{2,a}w+2\beta_1^{\,2}\gamma_{2,a}\gamma_3\alpha\beta_2-\beta_1\gamma_{2,c}\alpha^2\beta_2^{\,2}+w\beta_1^{\,3}\gamma_1\gamma_3^{\,2}\\
&\quad+\beta w\alpha^2\beta_2^{\,2}+\beta w\beta_1^{\,2}\gamma_3^{\,2}-2\beta_1\gamma_{2,a}\alpha\beta_2-\beta_1\gamma_{2,a}-2\beta w\alpha^2\beta_1\gamma_3-2w\beta_1^{\,2}\gamma_1\gamma_3\\
&\quad+\beta w\alpha^2+w\beta_1\gamma_1-2\beta w\beta_1\gamma_3+2\beta w\alpha\beta_2+\beta w+\beta w\alpha^2\beta_1^{\,2}\gamma_3^{\,2}\\
&\quad+\beta_1^{\,3}\gamma_1 w\alpha^2\gamma_3^{\,2}+w\beta_1\gamma_1\alpha^2\beta_2^{\,2}+\beta_1\gamma_1 w\alpha^2-2\beta w\beta_1\gamma_3\alpha\beta_2-2w\beta_1^{\,2}\gamma_1\gamma_3\alpha\beta_2\\
&\quad-2\beta_1^{\,2}\gamma_1 w\alpha^2\gamma_3+2w\beta_1\gamma_1\alpha\beta_2=H
\end{aligned}
$$

$$
\begin{aligned}
&\beta_1^{\,3}\gamma_{2,c}w\alpha^2\gamma_3^{\,2}-2\gamma_{2,c}\beta_1^{\,2}w\alpha^2\gamma_3+\beta_1\gamma_{2,c}\alpha^2\beta_2^{\,2}+\beta_1\gamma_{2,a}w\alpha^2+\beta_1\gamma_1\alpha^2\beta_2^{\,2}\\
&\quad+\beta\alpha^2\beta_2^{\,2}-2\beta_1^{\,2}\gamma_{2,c}\gamma_3\alpha\beta_2-2\beta_1^{\,2}\gamma_1\gamma_3\alpha\beta_2-2\beta\beta_1\gamma_3\alpha\beta_2+2\beta_1\gamma_{2,a}\alpha\beta_2\\
&\quad+2\beta_1\gamma_1\alpha\beta_2+2\beta\alpha\beta_2+\beta_1^{\,3}\gamma_1\gamma_3^{\,2}+\beta_1^{\,3}\gamma_{2,a}\gamma_3^{\,2}+\beta\beta_1^{\,2}\gamma_3^{\,2}-2\beta_1^{\,2}\gamma_1\gamma_3\\
&\quad-2\beta_1^{\,2}\gamma_{2,c}\gamma_3-2\beta\beta_1\gamma_3+\beta_1\gamma_1+\beta_1\gamma_{2,c}+\beta=H_1
\end{aligned}
$$

$$
\begin{aligned}
&-2\beta\beta_1\gamma_3\alpha\beta_2+\beta+\beta\alpha^2-2\beta\beta_1\gamma_3+2\beta\alpha\beta_2+\beta\beta_1^{\,2}\gamma_3^{\,2}+\beta\alpha^2\beta_2^{\,2}+\beta\alpha^2\beta_1^{\,2}\gamma_3^{\,2}\\
&\quad-2\beta\alpha^2\beta_1\gamma_3+2\beta_1\gamma_1\alpha\beta_2+2\beta_1\gamma_{2,a}\alpha\beta_2+\beta_1\gamma_{2,a}\alpha^2\beta_2^{\,2}+\beta_1\gamma_{2,c}-2\beta_1^{\,2}\gamma_1\gamma_3\\
&\quad+\beta_1\gamma_1\alpha^2\beta_2^{\,2}+\beta_1^{\,3}\gamma_1\alpha^2\gamma_3^{\,2}-2\beta_1^{\,2}\gamma_{2,a}\gamma_3-2\beta_1^{\,2}\gamma_1\gamma_3\alpha\beta_2+\beta_1^{\,3}\gamma_1\gamma_3^{\,2}\\
&\quad+\beta_1^{\,3}\gamma_{2,a}\gamma_3^{\,2}-2\beta_1^{\,2}\gamma_1\alpha^2\gamma_3+\beta_1\gamma_1+\beta_1\gamma_1\alpha^2-2\beta_1^{\,2}\gamma_{2,c}\gamma_3\alpha\beta_2=H_2
\end{aligned}
$$

$$
\begin{aligned}
&-\beta_1{}^3\gamma_{2,c}\,w\,\alpha^2\gamma_3{}^2-\beta_1{}^3\gamma_{2,a}\,w\gamma_3{}^2+2\,\beta_1{}^2\gamma_{2,a}\,w\,\alpha^2\gamma_3+2\,\beta_1{}^2\gamma_{2,a}\gamma_3\,\alpha\,\beta_2\,w\\
&\quad+2\,\beta_1{}^2\gamma_{2,c}\,w\gamma_3-\beta_1\gamma_{2,c}\,\alpha^2\beta_2{}^2\,w-\beta_1\gamma_{2,a}\,w\,\alpha^2-2\,\beta_1\gamma_{2,a}\,\alpha\,\beta_2\,w+\beta_1{}^3\gamma_1\gamma_3{}^2\\
&\quad-2\,\beta_1{}^2\gamma_1\gamma_3-2\,\beta_1{}^2\gamma_1\gamma_3\,\alpha\,\beta_2+\beta_1\gamma_1+2\,\beta_1\gamma_1\,\alpha\,\beta_2+\beta_1\gamma_1\,\alpha^2\beta_2{}^2+\beta\,\beta_1\gamma_1\,w\\
&\quad-\beta_1\gamma_{2,c}\,w+\beta\,\beta_1{}^2\gamma_3{}^2-2\,\beta\,\beta_1\gamma_3-2\,\beta\,\beta_1\gamma_3\,\alpha\,\beta_2+\beta+2\,\beta\,\alpha\,\beta_2+\beta\,\alpha^2\beta_2{}^2+\beta^2 w\\
&\quad=H_3
\end{aligned}
$$

$$
\begin{aligned}
&\beta_1\gamma_{2,c}\,\alpha^2\beta_2{}^2+\beta_1\gamma_1\,\alpha^2\beta_2{}^2+\beta\,\alpha^2\beta_2{}^2-2\,\beta_1{}^2\gamma_1\gamma_3\,\alpha\,\beta_2+2\,\beta_1\gamma_1\,\alpha\,\beta_2\\
&\quad-2\,\beta_1{}^2\gamma_{2,c}\gamma_3\,\alpha\,\beta_2+2\,\beta\,\alpha\,\beta_2+2\,\beta_1\gamma_{2,a}\,\alpha\,\beta_2-2\,\beta\,\beta_1\gamma_3\,\alpha\,\beta_2+\beta_1\gamma_{2,c}\,\alpha^2\\
&\quad+\beta_1{}^3\gamma_{2,a}\gamma_3{}^2+\beta_1{}^3\gamma_{2,a}\,\alpha^2\gamma_3{}^2-2\,\beta_1{}^2\gamma_{2,c}\,\alpha^2\gamma_3-2\,\beta\,\beta_1\gamma_3+\beta+\beta\,\beta_1{}^2\gamma_3{}^2+\beta_1\gamma_1\\
&\quad-2\,\beta_1{}^2\gamma_{2,a}\gamma_3+\beta_1{}^3\gamma_1\gamma_3{}^2+\beta_1\gamma_{2,c}-2\,\beta_1{}^2\gamma_1\gamma_3=H_4
\end{aligned}
$$

$$
\begin{aligned}
&\beta\,w\,\alpha^2\beta_1{}^2\gamma_3{}^2-2\,\beta\,w\,\alpha^2\beta_1\gamma_3+\beta\,w\,\alpha^2+\beta_1{}^3\gamma_1\,w\,\alpha^2\gamma_3{}^2-2\,\beta_1{}^2\gamma_1\,w\,\alpha^2\gamma_3+\beta_1\gamma_1\,w\,\alpha^2\\
&\quad+\beta_1{}^3\gamma_1\gamma_3{}^2-2\,\beta_1{}^2\gamma_1\gamma_3-2\,\beta_1{}^2\gamma_1\gamma_3\,\alpha\,\beta_2+\beta_1\gamma_1+2\,\beta_1\gamma_1\,\alpha\,\beta_2+\beta_1\gamma_1\,\alpha^2\beta_2{}^2\\
&\quad+\beta\,\beta_1{}^2\gamma_3{}^2-2\,\beta\,\beta_1\gamma_3-2\,\beta\,\beta_1\gamma_3\,\alpha\,\beta_2+\beta+2\,\beta\,\alpha\,\beta_2+\beta\,\alpha^2\beta_2{}^2+\beta_1\gamma_{2,c}\,\alpha^2\beta_2{}^2\\
&\quad-2\,\beta_1{}^2\gamma_{2,a}\gamma_3\,\alpha\,\beta_2+2\,\beta_1\gamma_{2,c}\,\beta_2\,\alpha-2\,\beta_1{}^2\gamma_{2,a}\gamma_3+\beta_1\gamma_{2,c}+\beta_1{}^3\gamma_{2,c}\gamma_3{}^2=H_5
\end{aligned}
$$

$$
\begin{aligned}
&-\beta_1\gamma_{2,a}\,w-\beta_1\gamma_{2,a}\,w\,\alpha^2+2\,\gamma_{2,c}\,\beta_1{}^2\,w\,\alpha^2\gamma_3-2\,\beta_1\gamma_{2,a}\,\alpha\,\beta_2\,w+2\,\beta_1{}^2\gamma_{2,c}\,w\gamma_3\\
&\quad+2\,\beta_1{}^2\gamma_{2,a}\gamma_3\,\alpha\,\beta_2\,w+\beta_1\gamma_1\,\alpha^2\beta_2{}^2+\beta_1\gamma_1+\beta-\beta_1\gamma_{2,a}\,w\,\alpha^2\beta_2{}^2-2\,\beta\,w\,\alpha^2\beta_1\gamma_3\\
&\quad+2\,\beta_1\gamma_1\,\alpha\,\beta_2+\beta\,w\,\alpha^2+\beta\,\alpha^2\beta_2{}^2+\beta\,\beta_1{}^2\gamma_3{}^2+\beta_1{}^3\gamma_1\gamma_3{}^2+2\,\beta\,\alpha\,\beta_2-2\,\beta\,\beta_1\gamma_3\\
&\quad-2\,\beta_1{}^2\gamma_1\gamma_3-2\,\beta\,\beta_1\gamma_3\,\alpha\,\beta_2+\beta\,w\,\alpha^2\beta_1{}^2\gamma_3{}^2+\beta_1{}^3\gamma_1\,w\,\alpha^2\gamma_3{}^2+\beta_1\gamma_1\,w\,\alpha^2\\
&\quad-\beta_1{}^3\gamma_{2,c}\,w\,\gamma_3{}^2-2\,\beta_1{}^2\gamma_1\,w\,\alpha^2\gamma_3-\beta_1{}^3\gamma_{2,c}\,w\,\alpha^2\gamma_3{}^2-2\,\beta_1{}^2\gamma_1\gamma_3\,\alpha\,\beta_2=H_6
\end{aligned}
$$

$$-\beta_1^{\,3}\gamma_{2,a}\gamma_3^{\,2}+2\,\beta_1^{\,2}\gamma_{2,a}\gamma_3-\beta_1\gamma_{2,a}w\alpha^2+2\,\beta_1^{\,2}\gamma_{2,c}\gamma_3\,\alpha\,\beta_2-\beta_1\gamma_{2,c}\alpha^2\,\beta_2^{\,2}$$
$$+2\,\beta_1^{\,2}\gamma_{2,a}w\alpha^2\gamma_3+w\,\beta_1^{\,3}\gamma_1\gamma_3^{\,2}+\beta\,w\alpha^2\beta_2^{\,2}+\beta\,w\,\beta_1^{\,2}\gamma_3^{\,2}-\beta_1\gamma_{2,a}$$
$$-2\,\beta\,w\alpha^2\beta_1\gamma_3-2\,w\,\beta_1^{\,2}\gamma_1\gamma_3+\beta\,w\alpha^2+w\,\beta_1\gamma_1-2\,\beta\,w\,\beta_1\gamma_3+2\,\beta\,w\,\alpha\,\beta_2+\beta\,w$$
$$+\beta\,w\alpha^2\beta_1^{\,2}\gamma_3^{\,2}+\beta_1^{\,3}\gamma_1\,w\alpha^2\gamma_3^{\,2}+w\,\beta_1\gamma_1\alpha^2\beta_2^{\,2}+\beta_1\gamma_1\,w\alpha^2-2\,\beta_1\gamma_{2,c}\beta_2\,\alpha$$
$$-2\,\beta\,w\,\beta_1\gamma_3\,\alpha\,\beta_2-2\,w\,\beta_1^{\,2}\gamma_1\gamma_3\,\alpha\,\beta_2-2\,\beta_1^{\,2}\gamma_1\,w\alpha^2\gamma_3+2\,w\,\beta_1\gamma_1\,\alpha\,\beta_2$$
$$-\beta_1^{\,3}\gamma_{2,c}w\alpha^2\gamma_3^{\,2}=H_7$$

$$\beta_1\gamma_{2,a}\alpha^2\beta_2^{\,2}-2\,\beta_1^{\,2}\gamma_{2,a}\gamma_3\,\alpha\,\beta_2+2\,\beta_1\gamma_{2,c}\beta_2\,\alpha+\beta_1^{\,3}\gamma_{2,a}\gamma_3^{\,2}-2\,\beta_1^{\,2}\gamma_{2,c}\gamma_3+\beta_1^{\,3}\gamma_1\gamma_3^{\,2}$$
$$-2\,\beta_1^{\,2}\gamma_1\gamma_3-2\,\beta_1^{\,2}\gamma_1\gamma_3\,\alpha\,\beta_2+\beta_1\gamma_1+2\,\beta_1\gamma_1\,\alpha\,\beta_2+\beta_1\gamma_1\,\alpha^2\beta_2^{\,2}+\beta_1\gamma_{2,c}$$
$$+\beta_1^{\,3}\gamma_1\,\alpha^2\gamma_3^{\,2}-2\,\beta_1^{\,2}\gamma_1\,\alpha^2\gamma_3+\beta_1\gamma_1\,\alpha^2+\beta\,\alpha^2\beta_1^{\,2}\gamma_3^{\,2}-2\,\beta\,\alpha^2\beta_1\gamma_3+\beta\,\alpha^2$$
$$+\beta\,\beta_1^{\,2}\gamma_3^{\,2}-2\,\beta\,\beta_1\gamma_3-2\,\beta\,\beta_1\gamma_3\,\alpha\,\beta_2+\beta+2\,\beta\,\alpha\,\beta_2+\beta\,\alpha^2\beta_2^{\,2}=H_8$$

$$2\,\beta_1^{\,2}\gamma_{2,c}\gamma_3-\beta_1^{\,3}\gamma_{2,c}\gamma_3^{\,2}-\beta_1\gamma_{2,a}w\alpha^2+2\,\beta_1^{\,2}\gamma_{2,a}\gamma_3\,\alpha\,\beta_2+2\,\beta_1^{\,2}\gamma_{2,a}w\alpha^2\gamma_3$$
$$+w\,\beta_1^{\,3}\gamma_1\gamma_3^{\,2}+\beta\,w\alpha^2\beta_2^{\,2}+\beta\,w\,\beta_1^{\,2}\gamma_3^{\,2}-\beta_1\gamma_{2,c}-2\,\beta\,w\alpha^2\beta_1\gamma_3-2\,w\,\beta_1^{\,2}\gamma_1\gamma_3$$
$$+\beta\,w\alpha^2+w\,\beta_1\gamma_1-2\,\beta\,w\,\beta_1\gamma_3+2\,\beta\,w\,\alpha\,\beta_2-\beta_1\gamma_{2,a}\alpha^2\beta_2^{\,2}+\beta\,w+\beta\,w\alpha^2\beta_1^{\,2}\gamma_3^{\,2}$$
$$+\beta_1^{\,3}\gamma_1\,w\alpha^2\gamma_3^{\,2}+w\,\beta_1\gamma_1\,\alpha^2\beta_2^{\,2}+\beta_1\gamma_1\,w\alpha^2-2\,\beta_1\gamma_{2,c}\beta_2\,\alpha-2\,\beta\,w\,\beta_1\gamma_3\,\alpha\,\beta_2$$
$$-2\,w\,\beta_1^{\,2}\gamma_1\gamma_3\,\alpha\,\beta_2-2\,\beta_1^{\,2}\gamma_1\,w\alpha^2\gamma_3+2\,w\,\beta_1\gamma_1\,\alpha\,\beta_2-\beta_1^{\,3}\gamma_{2,c}w\alpha^2\gamma_3^{\,2}=H_9$$

$$\beta_1^{3}\gamma_1\alpha^2\gamma_3^{2}+\beta_1^{3}\gamma_1\gamma_3^{2}+\beta_1^{3}\gamma_{2,c}\gamma_3^{2}-2\beta_1^{2}\gamma_1\alpha^2\gamma_3-2\beta_1^{2}\gamma_1\gamma_3\alpha\beta_2-2\beta_1^{2}\gamma_1\gamma_3$$
$$+\beta\alpha^2\beta_1^{2}\gamma_3^{2}+\beta\beta_1^{2}\gamma_3^{2}-2\beta_1^{2}\gamma_{2,a}\gamma_3\alpha\beta_2-2\beta_1^{2}\gamma_{2,c}\gamma_3+\beta_1\gamma_1\alpha^2+\beta_1\gamma_1\alpha^2\beta_2^{2}$$
$$+2\beta_1\gamma_1\alpha\beta_2+\beta_1\gamma_1-2\beta\alpha^2\beta_1\gamma_3-2\beta\beta_1\gamma_3\alpha\beta_2-2\beta\beta_1\gamma_3+\beta_1\gamma_{2,a}\alpha^2\beta_2^{2}$$
$$+2\beta_1\gamma_{2,c}\beta_2\alpha+\beta_1\gamma_{2,a}+\beta\alpha^2+\beta\alpha^2\beta_2^{2}+2\beta\alpha\beta_2+\beta=H_{10}$$

$$\beta_1^{3}\gamma_{2,a}w\gamma_3^{2}+\beta_1\gamma_{2,a}w+2\beta_1\gamma_{2,a}\alpha\beta_2 w-2\beta_1^{2}\gamma_{2,c}w\gamma_3-2\beta_1^{2}\gamma_{2,a}w\alpha^2\gamma_3$$
$$+\beta_1\gamma_{2,c}\alpha^2\beta_2^{2}w-\beta_1\gamma_1\alpha^2\beta_2^{2}-\beta_1\gamma_1-\beta+2\beta w\alpha^2\beta_1\gamma_3-2\beta_1^{2}\alpha\gamma_3 w\gamma_{2,c}\beta_2$$
$$+\beta_1^{3}\alpha^2\gamma_{2,a}w\gamma_3^{2}-2\beta_1\gamma_1\alpha\beta_2-\beta w\alpha^2-\beta\alpha^2\beta_2^{2}-\beta\beta_1^{2}\gamma_3^{2}-\beta_1^{3}\gamma_1\gamma_3^{2}$$
$$-2\beta\alpha\beta_2+2\beta\beta_1\gamma_3+2\beta_1^{2}\gamma_1\gamma_3+2\beta\beta_1\gamma_3\alpha\beta_2-\beta w\alpha^2\beta_1^{2}\gamma_3^{2}-\beta_1^{3}\gamma_1 w\alpha^2\gamma_3^{2}$$
$$-\beta_1\gamma_1 w\alpha^2+2\beta_1^{2}\gamma_1 w\alpha^2\gamma_3+2\beta_1^{2}\gamma_1\gamma_3\alpha\beta_2+\beta_1\alpha^2\gamma_{2,c}w=H_{11}$$

$$\beta\alpha^2\beta_2^{2}+\beta_1\gamma_{2,c}\alpha^2\beta_2^{2}+\beta_1\gamma_1\alpha^2\beta_2^{2}-2\beta_1^{2}\gamma_{2,a}\gamma_3\alpha\beta_2-2\beta\beta_1\gamma_3\alpha\beta_2+2\beta\alpha\beta_2$$
$$+2\beta_1\gamma_1\alpha\beta_2-2\beta_1^{2}\gamma_1\gamma_3\alpha\beta_2+2\beta_1\gamma_{2,c}\beta_2\alpha+\beta_1^{3}\gamma_{2,a}\alpha^2\gamma_3^{2}+\beta_1\gamma_{2,c}\alpha^2$$
$$-2\beta_1^{2}\gamma_{2,c}\alpha^2\gamma_3+\beta\beta_1^{2}\gamma_3^{2}+\beta_1^{3}\gamma_1\gamma_3^{2}+\beta_1\gamma_1-2\beta\beta_1\gamma_3+\beta+\beta_1^{3}\gamma_{2,a}\gamma_3^{2}$$
$$-2\beta_1^{2}\gamma_1\gamma_3+\beta_1\gamma_{2,c}-2\beta_1^{2}\gamma_{2,a}\gamma_3=H_{12}$$

Table 2.1 **Parameters values of the structural models**			
α	0.4	γ_{2a}	0.15
β	0.8	γ_{2c}	0.08
β_1	0.3	γ_3	0.5
β_2	0.4	w_c	1.5
γ_1	0.4		

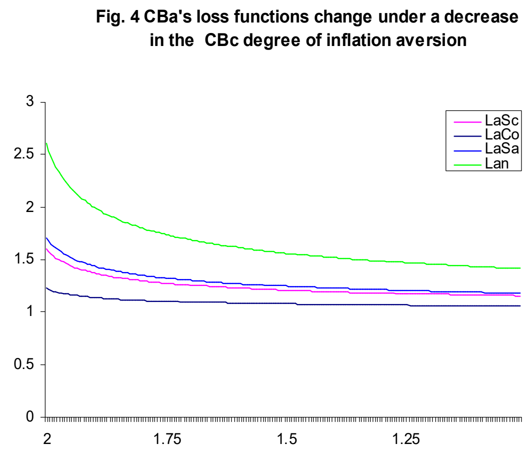
Table 2.2 FED		
	Shock in the "a" country's Asset Market	***Shock in the "c" country's Asset Market***
Nash equilibrium	Social Welfare	Social Welfare
	*	*
	Least Preferred	***Least Preferred***
Cooperative equilibrium	Social Welfare	Social Welfare
	***	***
	Most Preferred	***Most Preferred***
Stackelberg equilibria		
CBa Leader	Social Welfare	Social Welfare
	**	**
	Less Preferred	***Less Preferred***
CBa Follower	Social Welfare	Social Welfare
	**	**
	Less Preferred	***Less Preferred***
	Phillips Curve Shock	
Nash equilibrium	Social Welfare	
	*	
	Least Preferred	
Cooperative equilibrium	Social Welfare	
	*	
	Least Preferred	
Stackelberg equilibria		
CBa Leader	Social Welfare	
	**	
	Less Preferred	
CBa Follower	Social Welfare	
	***	
	Most Preferred	

Legend

* describes the order of preferences of monetary authority with respect to the social loss. We define the choice of the Central Banks as Most preferred, Less preferred and Least preferred.
Most preferred is referred to a scenario where the social Loss is minimized;
Less preferred is referred to the second choice after the most preferred;
Least preferred is the third choice after the less preferred.

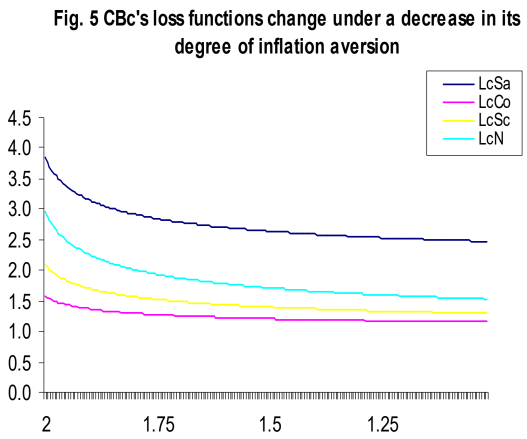
Table 2.3 ECB		
	Shock in the "a" country's Asset Market	**Shock in the "c" country's Asset Market**
Nash equilibrium	Social Welfare	Social Welfare
	*	*
	Least Preferred	***Least Preferred***
Cooperative equilibrium	Social Welfare	Social Welfare
	*	***
	Least Preferred	***Most Preferred***
Stackelberg equilibria		
CBc Leader	Social Welfare	Social Welfare
	**	**
	Less Preferred	***Less Preferred***
CBc Follower	Social Welfare	Social Welfare
	***	**
	Most Preferred	***Less Preferred***
	Phillips Curve Shock	
Nash equilibrium	Social Welfare	
	*	
	Least Preferred	
Cooperative equilibrium	Social Welfare	
	*	
	Least Preferred	
Stackelberg equilibria		
CBc Leader	Social Welfare	
	***	
	Most Preferred	
CBc Follower	Social Welfare	
	**	
	Lesst Preferred	

Fig. 2.4



Note: The above figure describes a situation where we consider the effect of a decrease of the degree of inflation aversion of the CBc in the country "a". LaSc is the loss for the CBa in the Stackelberg Country "c" as leader,; LaCo is the loss in the cooperative game; LaSa is the loss in the Stackelberg country "a" as leader; LaN is the loss in the Nash game.

Fig. 2.5



Note: The above figure describes a situation where we consider the effect of a decrease of the degree of inflation aversion of the CBc in the country "c". LacSc is the loss for the CBc in the Stackelberg Country "c" as leader,; LcCo is the loss in the cooperative game; LcSa is the loss in the Stackelberg country "a" as leader; LcN is the loss in the Nash game.

Figure 2.6.1 Impulse responses to 1% shock to the USA stock market

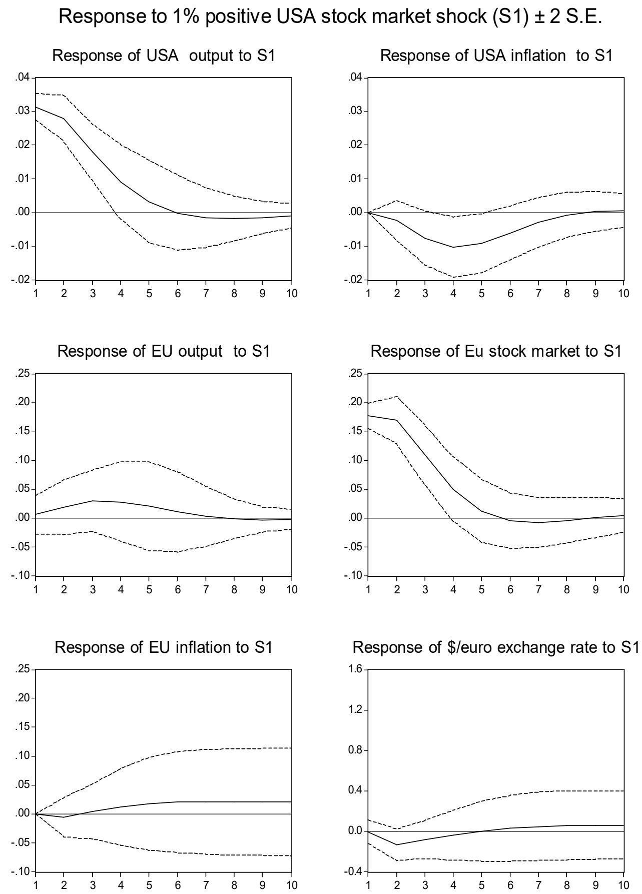


Figure 2.6.2 Impulse responses to 1% shock to the EU stock market

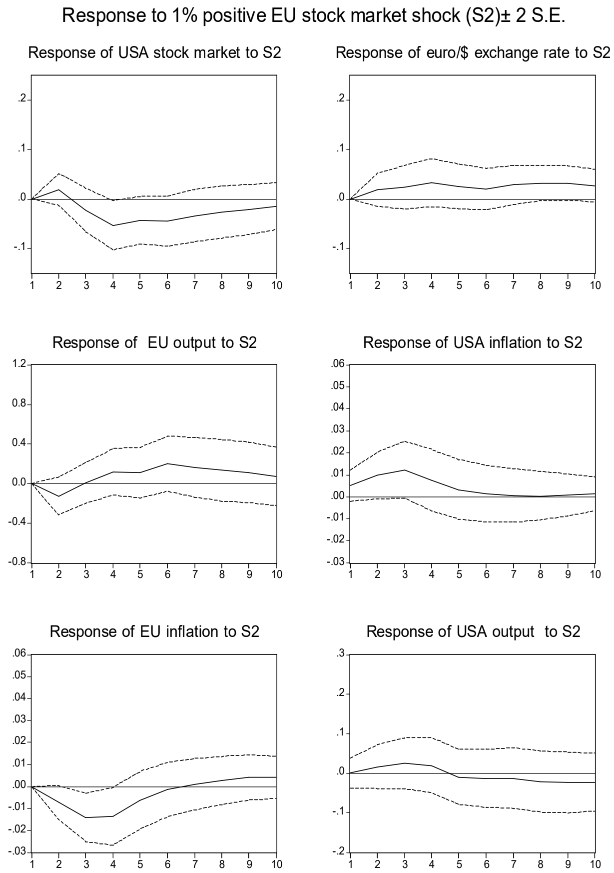


Fig. 2.7.1

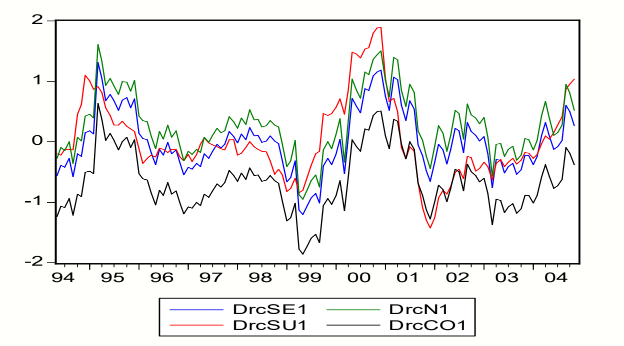


Fig. 2.7.2

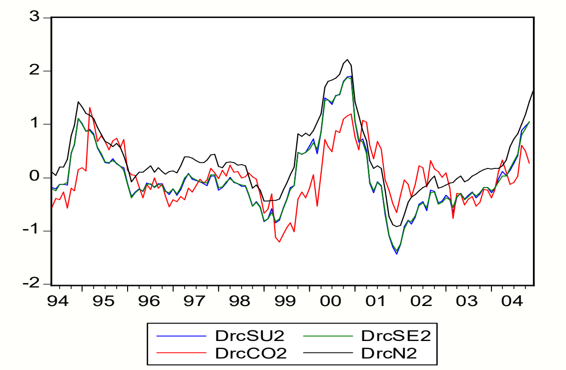


Fig. 2.7. 3

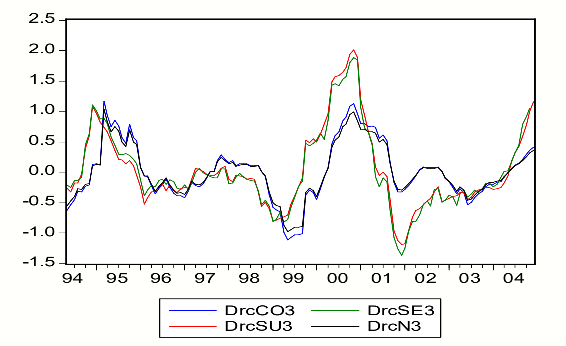


Fig. 2.8.1

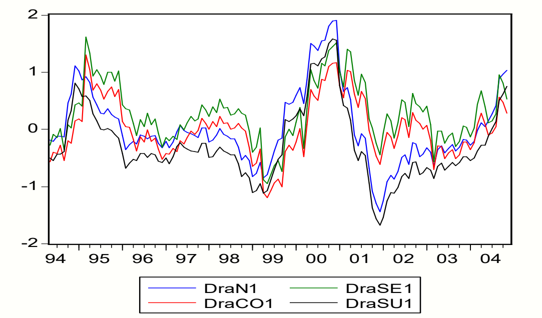


Fig. 2.8.2

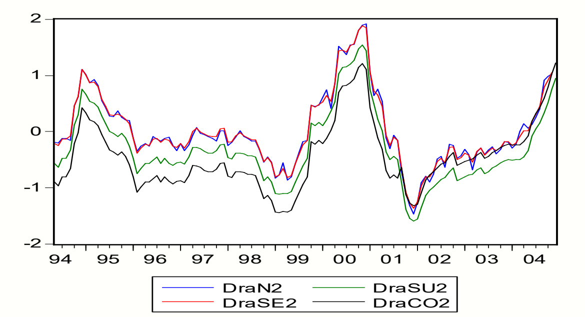


Fig. 2.8. 3

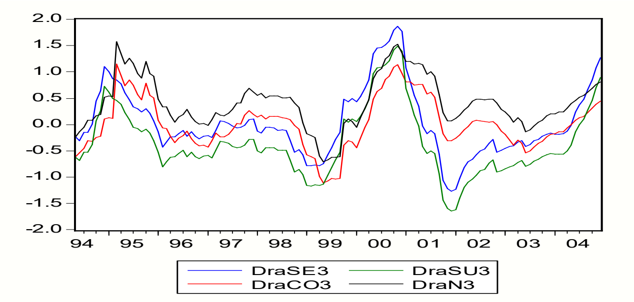


Fig. 2.9.1

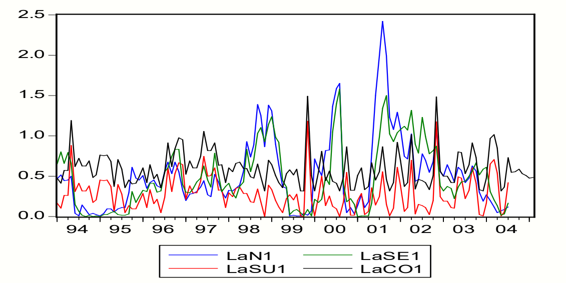


Fig. 2.9.2

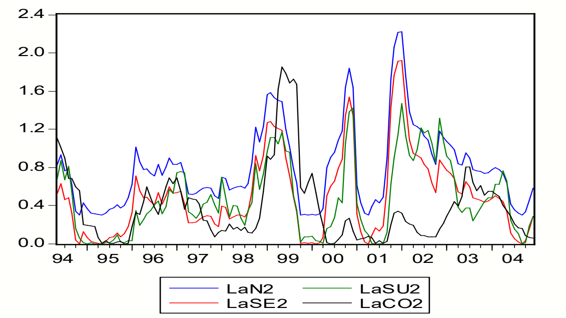


Fig. 2.9.3

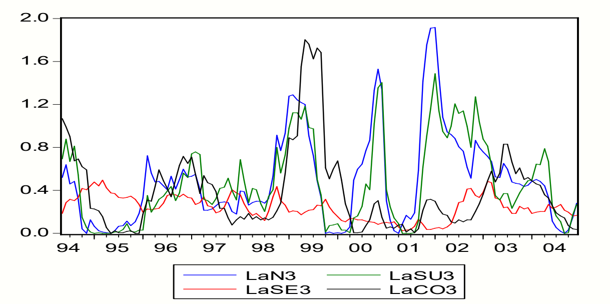


Fig. 2.10.1

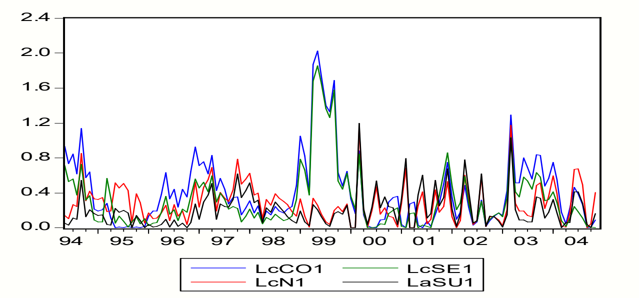


Fig. 2.10.2

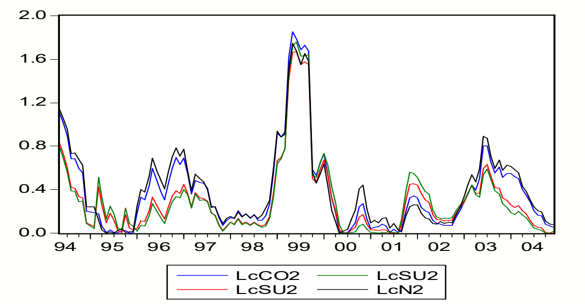
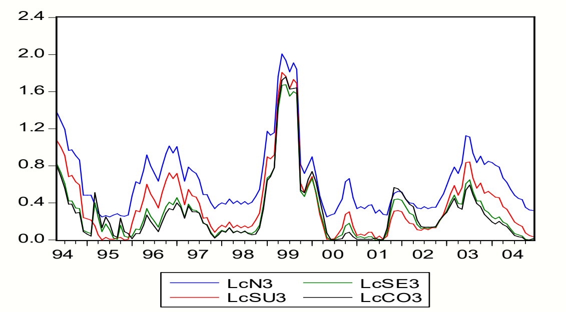


Fig. 2.10.3



Chapter Three

Financial Condition Index and interest rate settings: a comparative analysis

3.1. Introduction

> *"The key aim of monetary policy for most central banks is to keep inflation low and steady. However in a market-oriented economy, central banks cannot control inflation directly. They have to use instruments such as interest rates, the effects of which on the economy are uncertain.....Decisions on monetary policy are based on a variety of indicators. Some central banks use money growth or exchange rate as the sole guide to decisions. Others take a more eclectic approach and consider a range of factors in assessing inflation conditions" (G. Hoggarth, 1996).*

In the last thirty years, there has been a widespread move towards financial liberalisation, both within and across national borders. This economic development brought researchers to investigate the link between asset prices, inflation and the conduct of monetary policy. Alchian and Klein (1973) were the first to assert that focusing only on Consumer Price Index as an indicator of inflation could be misleading because it reflects only the change in prices in the real sector. Monetary authorities should also consider inflation from the financial sector. More recently Goodhart explicitly writes: "My dictionary defines inflation as a fall in the value of money, not a rise in the consumer price index. If I spend my money now on obtaining a claim on future housing services by buying a house, or on future dividends by buying an equity, and the price of that claim on housing or on dividends goes up, why is that not just as much inflation as when the price of current goods and services rises?" (Goodhart, 2001, p.3). These two views have recently received great strength by the development in capital markets and the new environment hypothesis, Borio and Lowe (2002). They argue that the presence of a credible stabilisation program, an improved supply side[24] and a credible monetary policy could create favourable ground for financial instability. High levels of monetary credibility lead to well-anchored inflation expectations. And this, in turn, has led to many economic benefits. But Borio and Lowe (2002) argue that this is a potential problem here. People can come to believe that a central bank will always be able to guard against swings in inflation or recovery the economy from a recession. At the same time investors could believe that the central bank would take decisive action to prevent the stock market from falling but not from rising Miller et al (2002).

Recently there has been an increasing interest in the role of asset prices for the conduct of monetary policy. There is however no full consensus about the conduct of monetary policy under the circumstances of shocks in the asset markets. The predominant view at the moment seems to be that central banks should only respond to asset price

[24] They are identified as improvements in the technology, labour market reforms, and productivity gains.

movements if they are expected to affect future CPI inflation and the output gap (Bernanke and Gertler, 1999). Besides the interest rate, the exchange rate is usually considered to be the most important determinant of aggregate demand and channel of monetary policy transmission in open economies. That is why several central banks adopted, in the early-mid 1990s, a Monetary Conditions Index (MCI hereafter), a weighted average of the short-term interest rate and the exchange rate as an operating target (Bank of Canada, Reserve Bank of New Zealand) or an indicator (Bank of Norway, Bank of Finland, Bank of Iceland) for monetary policy.

A more recent development is the interest in the role of housing and equity prices for the design of monetary policy. Housing and equity prices may affect demand via direct and indirect wealth effects. A change in property and equity prices affects consumer wealth, which may induce consumers to change their consumption plans (Modigliani, 1971).

Case *et al* (2001) suggests that property prices have a stronger effect on household consumption than equity prices. A more indirect wealth effect of asset price movements operates via households' and firms' balance-sheets.

Thus, from a theoretical point of view Goodhart and Hofmann (2002, page 3) assert that " there seems to be a strong case also to consider property and share prices as determinants of aggregate demand, which would imply a direct reaction of monetary policy to movements in these asset prices. This issue has proven to be highly controversial.

Cecchetti, Genberg, Lipsky and Wadwhani (2000) and Goodhart (2001) argue in favour of a direct response of monetary policy to asset price movements which are not in line with perceived fundamentals, while Bernanke and Gertler (1999) and Gertler, Goodfriend, Issing and Spaventa (1998) are more sceptical".

Starting from the above considerations, in this chapter we address the following issues: 1) the importance of the Financial Condition Index (FCI hereafter) in explaining a potential misalignment in asset markets; 2) the use of the FCI as an important short term indicator to guide the conduct of monetary policy.

The first step in providing answers to the questions considered above is to describe how to construct a FCI for four countries (US, UK, EU and Canada) and to prove that it can provide useful additional indicators of future changes in output and consequently inflation. Moreover, the analysis is important because it takes into account of the different channels of monetary transmission. It is evident that financial markets' responses to monetary policy actions undertaken by the Central Bank depend on a combination of domestic and foreign influences. These influences can be described in the following two ways: the first and most immediate relates to movements in the quoted prices such as exchange rates and interest rates in the international money and foreign exchange markets; the second one is due to changes in domestic real activity and prices. These channels have both direct effects and indirect effects on the economy. In particular, we focus our analysis on three asset prices: exchange rates, house prices and stock prices. For example, changes in equilibrium prices will affect both private incomes and wealth. The existence of a wealth effects associated with asset market fluctuations has been analysed among others by Morck, Shleifer and Vishny (1990), Goodhart and Hoffman (2000, 2001) and Mishkin (2001). A sharp increase in asset market prices will increase personal financial wealth, in addition, higher asset prices are associated with higher private sector investment and consumption resulting in greater expected employment level so that individuals will increment their spending. Since consumption represents a great percentage of GDP, even small changes in consumer spending could affect the expected inflation rate and economic growth.

In light of that, our contribution to the literature is referred to the attempt of solving two of the main criticisms that affect the FCIs': the parameter inconstancy problem and the non exogeneity of regressors. This chapter is divided in two parts. In the first one we suggest a methodology in order to account for the impact of financial markets on real output; we build a Financial Condition Index for the four countries using the Kalman Filter algorithm. This methodology allows us to capture the changes of the weights of each financial variable in explaining the output gap. In the second we analyze the interactions between FCIs and monetary policy in each single country. We estimate forward-looking Taylor rules augmented for FCI in order to analyze the Central Bank's reaction to a misalignment in the asset market. This analysis will be undertaken in the contest of a simple backward looking model of the economy described by the aggregate demand – aggregate supply framework. The standard and augmented Taylor rule will be used to define the optimal monetary policy. The concept of FCI and the way it is constructed are fundamental in the evaluation of the resulting policy rules that will emerge under different behavioral assumptions regarding the sensitivity of the monetary authorities to respond to a misalignment in the asset markets.

The structure of the chapter is as follows: the Roles of Monetary Conditions Index is described in section 2. The construction of the FCI and the results for the four countries are derived in section 3. Section 4 proceeds by estimating forward-looking Taylor rules augmented for FCI and present the empirical results. Section 5 concludes.

3.2 The Roles of Monetary Conditions Index

Over the past decade or so, the framework and strategy of central banks in implementing monetary policy has continually evolved along with a rapidly changing economic and financial environment at home and abroad. An increase in the volume and volatility of the international capital flows coupled with an intensified financial innovation have made financial markets and economic systems more and more interdependent. As the domestic financial market becomes more closely linked to the global financial system, the exchange rate becomes an increasingly important factor as a channel through which monetary policy may have potential impacts on the real sector.

Towards the late 1980s, central banks of many industrialized nations have turned their attention towards an inflation targeting regime as the focal point of their monetary policy. The list includes the central banks of New Zealand, Canada, England, Sweden, Finland, Australia, Spain and Israel (Green 1996, Svensson 1997, Kahn *et al* 1998).

The framework and strategy in implementing an inflation targeting-oriented monetary policy rests upon the basic assumption that monetary policy affects the economic system and in particular, the inflation rate, through two main transmission mechanisms : (i) the interest rate, which influences the level of expenditure and investment, and (ii) the exchange rate, which influences the price of imports, and ultimately the inflation level. In view of this, a continued depreciation (appreciation) in the exchange rate would require an increase (decrease) in the interest rate in order to sustain the target rate of inflation.

As interest rates and exchange rates are both important channels through which monetary policy affects economic activity and inflation, it has been argued that, combining both interest and exchange rates in a single policy indicator, a Monetary Conditions Index (MCI hereafter), may serve as a better indication of the overall policy stance (Freedman 1995, Nadal-De Simone et.al.1996). For this reason, central banks of many industrialized countries place importance on the construction and implementation of the MCI. The MCI is designed to indicate the stance (the degree of tightening or loosening) of monetary policy during a given period.

Using the MCI which encompasses movements in both interest rates and exchange rates may help the monetary authorities to gain a better assessment of the overall monetary conditions.

This is because the information content contained in the MCI would characterize the degree of pressure that monetary policy is placing on the economy and, therefore, on inflation rate. Nonetheless, the potential adopting of a MCI-oriented monetary policy, and therefore an inflation-targeting regime, calls for a more detailed analysis of whether interest rate and exchange rate variables are particularly important factors determining future inflationary pressures.

The basic definition of the Monetary Condition Index provides information about whether and to what extent the monetary framework conditions have been relaxed or tightened during a defined period.

Originally, the MCI was meant to provide a measure of the degree of ease or tightness in monetary conditions relative to a base period. In this way, the MCI should capture the effect that monetary policy has on the economy both through interest rates and the exchange rate[25]. Hence,

---

[25] The Bank of Canada (1992) calculates it "as the change in the 90-day commercial paper rate since January 1987 plus one third of the percentage change in the exchange rate of the Canadian dollar against the currencies of our major trading partners, also since 1987".

The formula is:

MCI = (CP90-7.9) + (100/3) x (ln(C6)-ln(91.33))

where:

it is defined as the weighted total of the changes in the real effective exchange rate of the domestic currency and the short-term real interest rate against a defined base period.

The MCI is then a combination of rate variables[26], which helps countries in managing liquidity within the overall framework of monetary policy. It is a weighted sum of the changes in the short-term interest rates and exchange rate relative to a base period.

The weights, which are determined by econometric models, are reflective of the importance of the respective variables in influencing the target macro (dependent) variable. More open the economy is more will be the weight age to the exchange rate.

Some of the countries where MCI is used are New Zealand (inflation target), Canada (operating target) and Sweden (leading indicator). The respective weights are determined by central banks from econometric modelling. The respective weights are determined by central banks from econometric modelling. The exchange rate is found to be half as important in New Zealand and one-third as important in Canada, compared with the domestic short-term interest rates.

- CP90 = Canadian 90-day Commercial Paper Rate
- C6 = Canadian dollar index against C-6 currencies (1992 = 100)
- 7.9 = The average 90-day commercial paper rate for Jan. 87
- 91.33 = The average C-6 exchange rate for Jan. 87
- In Jan. 1987, the MCI = 0

[26] The developed economies are shifting from targeting quantity variables to rate variables, as the former no longer explains appropriately the changes in aggregate demand and supply. Some of the rate variables targeted are short-term interest rates, exchange rate or inflation.

3.2.1 From Monetary Condition Index to Financial Condition Index

In the formulation and implementation of monetary policy, the central bank needs to select an appropriate set of policy tools to implement its monetary policy. This is viewed as necessary for the attainment of ultimate targets of monetary policy. The central banks of many industrialized countries, such as the central banks of New Zealand, Canada, Sweden, and Norway, are aware of the necessity of creating a new frame-work for conducting monetary policy so as to be a clear indicator of the central bank's policy stance and allow for a better communication with participants in the money markets. At the same time, the adoption of a MCI-oriented monetary policy is seen as an essential framework for use to follow and estimate the likely effects that monetary policy actions may have on the economy (especially in terms of the level of inflation) which is a direct responsibility of the central bank. An inflation targeting framework for monetary policy was first adopted by New Zealand's central bank in March 1990, followed by the central bank of Canada in February 1991. The framework and strategy of implementing inflation targeting-oriented monetary policy fundamentally stresses on the condition that "inflation targets" must clearly be the ultimate target of monetary policy (Kahn, et.al. 1999). Under an inflation-targeting regime, the monetary authorities normally have to make announcement of the target or a range of inflation target for the future[27].

It is interesting to note, however, that the management of monetary policy under the framework of monetary targeting primarily targets the inflation level, just as the management of monetary policy under the inflation targeting regime. Under this regime, short-term interest rates tends to be pushed upwards in the event that forecasted inflation shows a tendency of stabilizing at a higher level than the "established targeted inflation."[28].

Under an inflation targeting framework for monetary policy, there will be monetary indicators that uses the Monetary Conditions Index, which is a kind of monetary indicator that shows whether a central bank's monetary policy at any one point in time is relatively loose or tight, and to what degree. This indicator therefore acts as an indicator of operating target within an administration of monetary policy (Freedman, 1995).

Indicator of this kind reflects the degree of influence that the monetary policy has on the overall economy — especially on the level of inflation. Overall, a MCI index has a base-year equivalent to 100, as is the case of New Zealand, and serves as a benchmark indicating the

[27] If the inflation projection for the next 1-2 years is believed to fall outside the range of the official target, a series of policy actions needs to be carried out in order to bring the inflation level back into the targeted range. The monetary authorities may have to send a signal reflecting a change in the policy stance by adjusting short-term interest rates or intervening in the foreign exchange market.

[28] For more details on this matter see Svensson (1997), among others.

direction and outlook of the future inflation. Formulating and conducting monetary policy under the MCI framework (in addition to other economic and monetary indicators) is therefore considered a policy strategy that is forward looking.

The use of the MCI as part of the central bank's monetary policy administration is based on the premise that both the interest rate and the exchange rate are important and influential factors of the overall economic condition especially to the inflation rate. When the interest rate rises or the exchange rate strengthens, the effect is for the economy to decelerate in the future and eventually lead to a weakening of the pressure on price levels. In contrast, when the interest rate falls or the exchange rate weakens, the effect is for expenditures, consumption and investments to rise in the future, which may eventually lead to a higher level of inflation .

Because the interest rates and the exchange rate are both important and influential channels that link the monetary policy to the real sector, the central banks of many countries tend to face with an increasing difficulty in sending a clear signal to the market about the direction and tendency of the monetary policy.

From the above statements, coupled with the fact that both the interest rate and the exchange rate are continuously changing makes it very difficult for the central bank of many nations to estimate whether the monetary conditions at a certain point in time is relatively tight or relaxing and thus may cause the inflation rate to fall or to rise. This is especially the case where the interest rate is adjusted upwards (downwards) while the exchange rate weakens (strengthens).

The assessment of liquidity conditions in the financial system and the monetary policy stance of the central banks requires a careful consideration of the behaviour of the interest rates and the exchange rate. Therefore, a MCI index can be served as an informative indicator for liquidity conditions in the financial system. It also provides useful information regarding the central bank’s monetary policy stance by comparing the effects of interest rate and exchange rate on the inflation rate.

As mentioned above, it is important to evaluate monetary conditions in order to show how tight (easy) monetary policy is and thus its likelihood to lead to a lower (higher) inflation level. In order to do this effectively, it is crucial for the monetary authorities to simultaneously consider the behaviour of the movements of both the interest rates and the exchange rate.

Such an interactive movement may be expressed in equation (1) as follows:

$$MCI = w_r(r_t - r_b) + w_e(e_t - e_b) \tag{1}$$

where $w_r + w_e = 1$, r_t and e_t are interest rates and exchange rates at time t, respectively; r_b and e_b are interest rates and exchange rates during a given base year. The exchange rate variables in equation (1) are expressed in terms of logarithms.

Within an analytical framework of the CPI, the base indicator of economic activity and inflation is a variable that appears in equation (1) which in turn is the interest rate r, and the exchange rate e. The most important factor is weight w, derived from the subsequent empirical analysis. The value of this weight provides a useful information regarding the relative importance of the weight given to the interest rates (w_r) compared to the weight given to the exchange rates (w_e), which stipulates the direction of demand (economic activity) or inflation level.

Based on the theoretical discussion in the literature it is hypothesized that the model explaining the behaviour of the inflation can be formulated as follows :

$$\pi_t = \beta_0 + \beta_1 \Delta r_t + \beta_2 \Delta e_t + \beta_{i,j} Z_j + \mu_t \qquad (2)$$

where, $\beta_1 \pi 0; \beta_2 \pi 0$, Δ is the difference operator, π is inflation, "r" is interest rate, "e" is nominal effective exchange rate, Z is a set of additional fundamental variables and μ is error term following a white noise process.

A formulation of inflation determining model like (2) is based on an eclectic view of different theories of inflation determination. A preference for this type of specification is not an arbitrary choice.

Indeed, it is based upon a priori knowledge of the economic structure which, in many aspects, might appears to be different from country to country. It is important to note also that the weight of interest rate (w_r) together with the weight of the exchange rate (w_e) in equation (1) can be calculated from the coefficients from equation (2) which equal :

$$w_r = \frac{|\beta_1|}{(|\beta_1| + |\beta_2|)} \text{ and } w_e = \frac{|\beta_2|}{(|\beta_1| + |\beta_2|)}$$

Given all the advantages of having this indicator, the concept is criticised on its analytical foundation, as the interest rate is exogenous, while the exchange rate is endogenous, so cannot be used as a substitute. It is hard to believe that resorting to an MCI target will make the task of the central bank easier. It will also not help in removing policy uncertainties among the economic agents. MCI remains as one of the considerations of the central bank and the focus often shifts from MCI to one or more specific macro variables.

To that extent, the MCI adds to the list of confusion. Since the MCI is based on fixed coefficients and the relationship between the underlying variables need not be constant, there is a risk of policy mischance.

It would be worth noting, however, that some important factors that might have potential influence on behaviour of the inflation rate have not yet been included in equation (2). We incorporate some additional factors such as house market and stock market in the subsequent paragraph where our attempt will be focused on the construction of the Financial Condition Index (FCI) .

The FCI, on the contrary, is a wider indicator of the monetary framework conditions, to some extent also a measure of the orientation of monetary policy, combined in a single variable. Mayes and Viren (2001) assert that “the main value of the indicator is that it in turn is thought to be related to future values of economic activity or inflation. Thus it provides continuously updated information about the future, whereas traditional economic forecasts are only updated monthly or quarterly ”[29].

Goodhart has long argued that central banks should lead to a broader price index which includes the prices of assets, such as houses and equities. If the prices of goods and services and those of assets move in step, then excluding the latter does not matter. But if the two types of inflation diverge, as now, a narrow price index could send central bankers astray. There are really two issues in play here. One has to do with the notion that monetary policy ought to battle deviations of asset prices from their "fundamental" value. The other is related to the presumption that asset prices give us a truer measure of the purchasing power of money. This concept was explored several years ago by Cecchetti *et al* (2000). However, the idea that asset prices should receive some consideration in the construction of aggregate price movements remained a largely dormant issue until Alchian and Klein, (1973) proposed that we focus on measuring the purchasing power of money generally, rather than on prices of current consumption

[29] Mayes and Viren (2001), page 8.

specifically. Instead of looking at the cost of a particular basket of goods and services meant to measure current consumption, as is typically done by most consumer price indices, they suggest focusing on the current cost of expected life-time consumption. Asset prices provide the requisite information on the price of expected future consumption.

A key question, then, is to ask how policy would have been different if it had been based on these measures. Next sections of this chapter attempt to estimate this taking into account the fact that asset prices appear to be on the unusual and somewhat dramatic run-up in certain asset prices in recent years. In our approach, failure to include asset prices appears to induce a bias in the estimate of the inflation trend that may have an impact on our understanding of the broader movements in real economic variables.

3.3 Constructing the FCI

Constructing a Financial Condition Index is, however, a no easy task as many authors have highlighted, since this index should be able to capture the current development of financial markets and, at the same time, it should give a good indication of the future economic activity. Moreover a correctly estimated FCI should "provide(s) continuously updated information about the future, whereas traditional economic forecasts are only updated monthly or quarterly (or half yearly in the case of the published Eurosystem forecast)" Mayes and Viren (2001, p.8)[30].

Based on the equation 1 presented in the previous section we can describe an extended MCI, or FCI comprising in addition to the exchange rate also property and share prices:

$$FCI_i = \sum w_{q,i} \left(\Gamma_{q,i} \right) \tag{3}$$

The weights $w_{q,i}$ depend on the respective effect of ($\Gamma_{q,i}$) that is, the exchange rate, the share prices and the property prices on aggregate demand.

The inclusion of the exchange rate provides additional information about the exchange rate channel, through which aggregate demand is affected by the relative price of imports and exports. Stock prices are most intuitive to describe the wealth channel while property prices are used in the FCIs of Goodhart and Hofmann (2001) and, subsequently, Mayes and Virén (2001). Both studies find that property prices have stronger explanatory and predictive power for inflation than do equity prices. The former study also finds that in country like Canada the impact of housing prices on the output gap is larger than that of the exchange rate.

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[30] It is beyond the aim of this work to discuss why the FCIs are superiors to other financial variables, for instance Monetary Condition Indexes; for a discussion on this issue see Smets (1997) and Mayes and Viren (2001).

In general, the FCI provides useful information about inflation and monetary policy. However, Grande (1997) stress not only the problem of how to extrapolate the relevant information from a composite index but also the problem of the additional assumptions required to implement it. In this paragraph, thus, we will construct an indicator which has the characteristics described above.

The first step of our analysis lies on the construction of an aggregate measure of a Financial Conditions Index. Following Goodhart and Hofmann (2001) we will focus our analysis on three assets[31]: the real effective exchange rate, real house prices and real share prices[32]. In this section we explain how FCIs can be derived and how FCIs can be used, especially by central banks in formulating their monetary policy. In order to construct an FCI, the first problem to face is how to determine the weight of the single asset. Goodhart and Hofmann (2001) suggest three different methodologies.

The first one is based on simulation of a large scale of macro-econometric model; the second one is based on a system with reduced-form aggregate demand equations; and the third one uses a VAR

[31]The short-term interest rate is sometimes considered a measure of stance in itself and, since it is highly correlated with the policy instrument, we do not include it in eq. 3.

[32] Mayes and Viren (2001) present an accomplished description of the choice of different assets used in the past papers (see also Goodhart and Hofmann (2001), Goldman and Sachs (2001), Mayes and Viren (1998) and Eika et al. (1997)) and the dissimilar approaches to the FCIs based on the transmission mechanism's problems.

impulse response methodology. They explain the difficulties related to the first way and choose the second and the third analyses.

They empirical results show that overall both approaches are very similar. However, there is a problem related with the different analyses proposed: despite the size of the sample used, the weight associated with each financial variable is fixed. In fact it is likely that firms and households portfolios change with the business cycles or in presence of particular events. In the present work, we will try to overcome this problem proposing an alternative way to calculate the weight of each single asset. We use a Kalman Filter algorithm in order to capture the changes of the weights over time.

Following the pioneering contribution of Alchian and Klein (1973) and more recently Eika et al. (1997), Mayes and Viren (1998), Goodhart (2000), Mayes and Viren (2001) and Goodhart and Hofmann (2001), we formulate a formal model of the economy in order to show the importance of financial variables in the conduct of monetary policy. In doing this, we present a simple model which is the equivalent of a conventional backward looking aggregate demand –aggregate supply augmented with the asset markets (an extender version of Redebusch and Svensson (1999) as suggested by Goodhart and Hofmann (2001)) and we apply this model to four countries, US, UK, Canada and EUM:

$$y_t = \beta_1 + \sum_{i=1}^{g_1} \beta_{1,i} y_{t-i} + \sum_{j=1}^{g_2} \beta_{2,j} ri_{t-j} + \sum_{l=1}^{g_3} \beta_{3,j} re_{t-l} \sum_{n=1}^{g_4} \beta_{4,j} rh_{t-n} \sum_{m=1}^{g_5} \beta_{5,j} rs_{t-m} + \mu_t \quad (4)$$

$$\pi_t = \phi_1 + \sum_{i=1}^{k_1} \phi_{1,i} \pi_{t-i} \sum_{j=1}^{k_2} \phi_{2,j} y_{t-j} + \eta_t \quad (5)$$

where π_t is equal to 100*[ln(CPI_t/CPI_{t-12})], RPI for UK and HCPI for the EUM; and the output gap (y_t) is the difference between actual and potential output, is calculated as the percentage deviation of the natural logarithm of the monthly industrial production from a Hodrick-Prescott trend (HP henceforth); The interest rate gap is proxied by the variable ri_t,. It is the percent gap between the actual and potential real interest rate (called natural rate that is, the rate consistent with stable inflation and output equal to potential). Following Laubach and Williams (2003) methodology we estimate the natural rate of interest for the whole period. There is, however, another way to present equation (4) and it includes the use of interest rate spread as explanation variable for the output. In general, the relationship between spreads and output is positive and, essentially, reflects the expectations of financial market participants regarding future economic growth. A positive spread between long-term and short-term interest rates is associated with an increase in real economy activity, while a negative spread is associated with a decline in real activity.

The reason which explains the above relationship is related to the effects of monetary policy. For example, when monetary policy is tightened, short-term interest rates rise; long-term rates also typically rise but usually by less than the current short rate, leading to a downward-sloping term structure. The monetary contraction can eventually reduce spending in sensitive sectors of the economy, causing economic growth to slow and, thus, the probability of a recession to increase. Estrella and Mishkin (1998) show that the monetary policy is an important determinant of term structure spread. In particular, they observe that the credibility of the central bank affects the extent of the flattening of the yield curve in response to an increase in the central bank rate. Bordo and Haubrich (2004) provide regression-based statistical evidence using U.S. data from 1875 to 1997 and Baltzer and Kling (2005) perform a similar exercise with German data from 1870 to 2003. Both papers conclude that predictability varies over time and that it seems to be related to monetary policy credibility. The use of spreads as proxy of interest rate gap is beyond the scope of this work but, undoubtedly, it can be an interesting input for future researches.

The financial markets are proxied by three variables: *rh, re, rs*. They are, respectively, the deviation from the long run equilibrium of the real effective exchange rate, real house price and real stock price. According to Gautier *et al* (2004) we follow Ravn and Uhlig (2002) and we calculate the long-term of the assets prices using the above HP filter methodology with a high smoothing parameter of 129,600 instead of the standard 1,600[33]. The smoothing parameter λ, which penalizes the acceleration in the trend relative to the cycle component, depends on the frequency of observations. Ravn and Uhlig (2002) have demonstrated that λ = 129,600 is preferable for monthly data and we use this value[34].

The choice of this sample is essentially based on the need of including all the main events that determine substantial changes in government and monetary policies. The choice of inflation targeting (Canada February 1991 3%; UK October 1992 5.6%) and the launch of the EMU (1999) are only a few but significant examples of these changes. In light of this, for most of the countries the sample 1985-2005 was chosen.

3.3.1 The methodology applied in constructing time varying FCIs

The objective of this sub-section illustrates the methodology applied using financial variables like exchange rate, stock prices and house market index, in order to circumvents the parameter inconstancy. Since it is most likely that there have been regime changes, shocks and other structural breaks within the sample period we will try to address this

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[33] Appendix 3 presents the sources of the variables.

[34] The smoothing parameter λ determines the smoothness of the trend estimates. A low value produces a filter that follow actual growth closely and is therefore very volatile, while a higher value produces smoother trend estimates that follow actual output less closely. In more detail, for monthly data, a filter with λ=129,600, cycles that last about 20 years are considered cyclical.

problem constructing FCIs[35] for the four countries using the Kalman Filter algorithm. This methodology allows us to capture the changes of the weights over time.

One of the central conditions to achieve identification when we deal with financial variables is that the structural form shocks are orthogonal to one another. That is, we assume that the error term is orthogonal to the variables on the right side of the equation (6) below. In reality, this condition may not be satisfied, in particular if asset price shocks are driven by common shocks, as indicated by past experiences. Common shocks for asset prices within a country may be news about economic fundamentals in the respective country, such as changes in the conduct of the monetary policy or announcements of releases of relevant macroeconomic data. Moreover, there may be common shocks for international asset prices, such as oil price shocks.

Following the approach commonly used in the related literature we address the issue that the three series re_{it}, rS_{it}, and rh_{it} are nearly orthogonal or uncorrelated. The correlation between them measure the extent to which each series provide "orthogonal information". The former problem is related to the possibility that financial variables are simultaneously determined. This can occur either because they cause each other as or because they have some common omitted determinants. For instance, we assume that the real stock market is nearly orthogonal to the real house market. One reason for a violation

[35] We construct a modified version of Goodhart – Hoffman FCI

of this condition would be a contemporaneous response of monetary policy to the stock and the house market.

Generally speaking, ignoring this potential correlation might reduce the efficiency of the estimates, or even produce biased estimates if these variables are correlated with other included explanatory variables. To examine the impact of controlling for this correlation, we estimate (eq.6) a system of three equations one for exchange rate (re), one for the stock market (rS) and another for the house market, while allowing for their error terms to be correlated. That is, Seemingly Unrelated Regression Estimation (SURE) are estimated for this purpose.

$$\begin{cases} re_{it} = \alpha_{1t} + \sum_{n=1}^{k_1} \beta_{1,j} rh_{it-n} + \sum_{m=1}^{k_2} \beta_{2,j} rs_{it-m} + \mu_{eit} \\ rh_{t} = \alpha_{2t} + \sum_{s=1}^{k_4} \beta_{3,j} re_{it-s} + \sum_{f=1}^{k_5} \beta_{4,j} rs_{it-f} + \mu_{hit} \\ rs_{t} = \alpha_{3t} + \sum_{v=1}^{k_7} \beta_{5,j} rh_{it-v} + \sum_{l=1}^{k_8} \beta_{6,j} re_{it-l} + \mu_{Sit} \end{cases} \tag{6}$$

The above set of equations that has contemporaneous cross-equation error correlation so that the equations seem unrelated which states that the idiosyncratic shocks of the three markets are independent. This method, also known as the multivariate regression, or Zellner's method, estimates the parameters of the system, accounting for heteroskedasticity, and contemporaneous correlation in the errors across equations. The estimates of the cross-equation covariance matrix are based upon parameter estimates of the unweighted system. In equation 6 we use impulses in a separate system so we can investigate the relationship among the impulses (re, rh and rS). The residuals from this system of equations are then our new financial market variables (μ_{eit} = Rre, μ_{Sit} = RrS and μ_{hit} = Rrh, henceforth).   Figures A3.1 and A3.2 (appendix 1)show the residuals of the estimations of eq 6 for the four countries. On these new variables (RRe, RRs and RRh) the standard two unit root tests have been employed, namely the ADF (Augmented Dickey-Fuller) and Phillips Perron test (Table A3.1). Since the residuals of the Sure system are calculate from variables that are the difference between actual and natural values (HP filter) of financial assets, these tests are made simply to double check what has already been expected by the econometric theory when using the Hodrick Prescott filter. These both give us an opinion regarding the persistence of the series during the investigated samples and serve as a reference when interpreting the results from the estimated model with time-varying parameters. Results from the unit root tests are given in appendix 1.

3.3.2 The Kalman filter methodology

An additional problem in analysing FCI from the econometric point of view is related to the identification of "good" weights. A way to solve this problem is based on a typical reduced-form model consists of an IS equation relating the output gap to interest rates, exchange rates and other asset prices, and a Phillips Curve relating inflation to the output gap (eqs 4 and 5). Generally the choice of explanatory variables depends on their statistical significance in the model. The coefficient estimates then determine the weight of each variable. This methodology is perhaps the most widely used in the construction of FCIs. However, its simple assumption that all asset prices are exogenous to each other and to the real economy may lead to estimation bias.

The theoretical literature also indicates that FCIs weights are likely to be time-dependent, having both impact and subsequent effects. If weights evolve over time, there is a real problem of ensuring an adequate data set that is capable of picking up the effects.

With these considerations in mind, we then proceed to the construction of the FCIs. First we estimate eq. (5), using the new variables generate by the system in (6). In order to recover the parameter dynamics overtime, we employ the Kalman filter algorithm; our second step refers to the definition of the index using the time varying coefficients.

The Kalman filter is a popular method which can be used to estimate unobserved variable(s), provided they appear as explanatory variables in a model that can be written in a "state space form". A state space representation is one made up of *measurement* equations, expressing observed or *signal* variables as a function of unobserved or *state* variables, and some *transition* equations, governing the path of the unobserved variables. Hence the Kalman filter is a convenient way of working out the likelihood function for unobserved component models[36]. For that, the system must be written in a state space form, with a measurement equation in a matrix format:

$$y_t = Z.X_t + \gamma_t \quad \text{with} \quad \gamma_t \sim N(0,H) \qquad [7a]$$

where y_t is the value of output gap, while X_t is a matrix of dimension *(Txk)* which includes all the explanatory variables plus a constant; the state vector *Z*, a (*kx1*) vector that contains all the slope coefficients, which are now varying through time and γ_t represents residuals with variance/covariance matrix H.. The transition equation in a matrix format:

$$Z_t = T.Z_{t-1} + v_t \qquad \text{with } v_t \sim N(0,Q) \qquad [7b]$$

where T is a vector of parameters and v a vector of residuals with variance/covariance matrix Q.

Such a model may be estimated by means of a Kalman filter, a recursive procedure which, combined with a maximum likelihood estimation method, gives optimal estimates of unobserved components. This method has been used for a number of applications, such as estimating expectations (Cuthberson *et al.,* 1992), estimating the underlying structural rate of unemployment (among others, Gordon

[36] See Cuthbertson, Hall and Taylor (1992), Harvey *et al* (1992) and Hamilton (1994).

1998, Irac 1999), or estimating potential output (Smets 1998, Kichian 1999).

In principle, with this method all the parameters of the model may be estimated. In practice, there might be a trade-off between the number of parameters being estimated and the convergence of the likelihood function. More specifically, a key variable to the estimation of such models is the relative smoothness of the unobserved variable, which is governed by the relative size of the error variances in [7a] and [7b]. The higher the ratio of the variance of the transition to the measurement equation residuals, referred to as the "signal-to-noise ratio" (Q/H), the more explanatory power is given to the unobserved variable, and the better the fit of the measurement equation. In the limit, for very large values of Q, the unobserved variable may soak up all the residual variation in the measurement equation. Alternatively if Q is zero, then it will be estimated as a constant. In practice, most studies fix the signal-to-noise ratio so that the estimated unobserved variable is relatively smooth, with fluctuations which are judged to be reasonable from one period to another, which Gordon (1998) qualifies as "the [unobserved variable] can move around as much as it likes, subject to the qualification that sharp quarter-to-quarter zigzags are ruled out"[37].

The time varying methodology allows us to recover an unobservable factor that could affect the output gap. For each single variable of the

[37] See Bank of England (1998) for a survey. Some exceptions are Apel and Jansson (1999) for Sweden, Kichian (1999) for Canada. These are countries specific studies, using quite sophisticated models.

model it is therefore possible to observe how the respective coefficient has changed over time by the effect of changing in the weight attached to each single asset price.

We then apply a time varying parameters model as follow:

$$Y_{it} = \alpha_{it} + \beta_{1it} Rre_{it-n} + \beta_{2it} RrS_{it-n} + \beta_{3it} Rrh_{it-n} + \gamma_{it} \tag{8}$$

where i is the country, γ_{it} is an independent white noise and the coefficients are assumed to be random walks. This can be written in state space form where the observation equation is

given by (8) above and the state equations are given by:

$$\begin{bmatrix} \alpha_t \\ \beta_{1it} \\ \beta_{2it} \\ \beta_{3it} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \alpha_{t-1}, \ldots \alpha_{t-n} \\ \beta_{1t-1}, \ldots \beta_{1t-n} \\ \beta_{2t-1}, \ldots \beta_{2t-n} \\ \beta_{3t-1}, \ldots \beta_{3t-n} \end{bmatrix} + \begin{bmatrix} v_{it} \\ v_{1it} \\ v_{2it} \\ v_{3it} \end{bmatrix} \tag{9}$$

The model in equations (8) and (9) was initially estimated by maximum likelihood and the estimated variances are presented in Table 3.1a. However, as our attention is directed towards the issue of time-variation in the parameters, we want to establish the relevance of this modelling choice. Moreover, since we consider very important the time variation in parameters and its implication in defining a more reliable FCI index, we need to tests five hypotheses regarding the constancies of all or part of the parameters in eq.(9). Accordingly, we test five hypotheses:

1. $H_0^1 : \sigma_v^2 = \sigma_{v1}^2 = \sigma_{v2}^2 = \sigma_{v3}^2 = 0$ which implies that all parameters in eq. 8 are constant;

2. $H_0^2 : \sigma_v^2 = 0$ which implies a constant intercept but time variation in the persistence parameters;

3. $H_0^3 : \sigma_{v1}^2 = 0$ which implies a time-varying intercept but a constant Rre parameter.

4. $H_0^4 : \sigma_{v2}^2 = 0$ which implies a time-varying intercept but a constant RrS parameter.

5. $H_0^5 : \sigma_{v3}^2 = 0$ which implies a time-varying intercept but a constant Rrh parameter.

In order to test these hypotheses, we next estimate the restricted versions of the model; the hypotheses in 1), 2) 3) 4) and 5) can then be tested using likelihood ratio test (LR test) This test statistics follow a χ^2 distribution with R degrees of freedom under the null hypothesis[38]. The results from these five tests are given in Table 3.1b.

[38] A likelihood ratio test is calculated as the ratio of the likelihood of the sample data at the hypothesised value of β to the maximum of the likelihood function (i.e. evaluated at the MLE). Hence we calculate (for H_0: $\beta = \beta_0$ vs ≠)

$LR = \lambda = L(\beta_0)/L(\beta_{ML})$

$\lambda < 1$. If it is near to 1 we accept H_0, if not we reject. We now need the distribution of λ. In some simple problems this can be worked out, but usually not. Fortunately it can be shown that $-2 \ln \lambda \sim \chi^2$ in large samples, with *q* degrees of freedom where *q* is the number of restrictions in H_0. Now, large values of the test statistic (minus twice the log-likelihood ratio) reject H_0.

Table 3.1a Variance of the parameters from Kalman filter of equations (8) and (9).				
Variance	USA	EUM	Canada	UK
σ^2_v	4.872×10^{-8}	5.52×10^{-11}	3.57×10^{-7}	2.27×10^{-5}
σ^2_{v1}	3.931×10^{-5}	1.21×10^{-5}	2.91×10^{-4}	3.99×10^{-4}
σ^2_{v2}	2.811×10^{-3}	6.07×10^{-6}	7.03×10^{-6}	1.15×10^{-4}
σ^2_{v3}	8.153×10^{-6}	5.41×10^{-10}	5.67×10^{-4}	3.38×10^{-3}
$\boldsymbol{\sigma^2_\mu}$	2.259×10^{-7}	1.69×10^{-12}	6.80×10^{-3}	4.45×10^{-5}

Table3.1b Likelihood Ratio Test (LR test)

		USA	EUM	CANADA	UK
$H_0^1 : \sigma_v^2 = \sigma_{v1}^2 = \sigma_{v2}^2 = \sigma_{v3}^2 =$	$\chi^2_{LR}(4)$ ♦	796.72 **	504.69 **	996.15**	894.98 **
$H_0^2 : \sigma_v^2 = 0$	$\chi^2_{LR}(1)$	670.51 **	489.22 **	119.26**	258.22 **
$H_0^3 : \sigma_{v1}^2 = 0$	$\chi^2_{LR}(1)$	667.07 **	401.37 **	312.14**	297.18 **
$H_0^4 : \sigma_{v2}^2 = 0$	$\chi^2_{LR}(1)$	664.93 **	433.66 **	310.95**	271.56 **
$H_0^5 : \sigma_{v3}^2 = 0$	$\chi^2_{LR}(1)$	667.85 **	368.74 **	394.15**	274.83 **
Sample		1981:01 2005:04	1991:10 2005:04	1981:01 2005:04	1981:01 2005:04

♦ $\chi^2_{LR}(R)$ are the test statistics from the likelihood ratio tests of whether the variances in the equations for the parameters of the model are zero. ** significant at the 1% level;

First, it can be noted that $H_0^1 : \sigma_v^2 = \sigma_{v1}^2 = \sigma_{v2}^2 = \sigma_{v3}^2 = 0$ is forcefully rejected for all four countries and we conclude that some kind of time-variation in coefficients seems important. The tests support also that the constant intercepts for all the countries are time-varying. Rejecting $H_0^3:0, H_0^4:0$ and $H_0^5:0$ it connotes that the RRe, the RRh and RRs are not constant, respectively.

In conclusion, the null hypotheses are rejected for all the countries and for all the five tests. Based on the above tests, we conclude that the unrestricted models in equations (8) and (9) are preferred and we do not need to impose any restriction on them.

Having estimated the dynamic coefficients of the unrestricted model in eq. (9), we define the contribution of each asset market (*q)* at time *t* in our FCI index as:

$$w_{q,i,t} = \frac{\left|\Gamma_{q,i,t}\right|}{\left|\sum_{q=1}^{3}\left(\Gamma_{q,i,t}\right)\right|} \tag{10}$$

Finally, eq.(11) describes how we construct the Financial Index :

$$FCI_{i,t} = \sum_{q=1}^{3}\left(W_{i,q,t}\right)\left(\Gamma_{q,i,t}\right) \tag{11}$$

Before going on with the analysis we should discuss briefly about the property of the FCIs In Table 3.2, we present some illustrative statistics for each of these four FCIs separately. As shown in Table 3.3, two out of four sample means are positive (USFCI) and (EUFCI) while the other two are negative (CNFCI) and (UKFCI). From the standard deviation of these four variables, it is observed that the US and EU FCIs are more volatile than the Canada and UK FCIs. Among the variables, the first-order autocorrelation of monthly data ranges from 0.065 (UMD) to 0.199 (S/H). Furthermore, it is observed that the first-order autocorrelation coefficients of the small stocks are slightly bigger than those of the large stocks, implying that the small stocks are slightly more persistent than the large stocks. The measures of skewness and kurtosis[39] are reported to indicate whether our FCIs are normally distributed. The signs of skewness and kurtosis vary depending on the portfolio returns, confirming that in most cases their empirical distributions have heavy tails relative to the normal distribution. Two out of four FCIs, the Jarque-Bera statistics reject normality at any conventional level of statistical significance.

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[39] Skewness is a measure of the symmetry (or deviations form symmetry) of the distribution of the data. It is the 'third moment' of the frequency distribution. Normal distribution has zero skewness. If skew is positive then the frequency distribution has a long 'right tail'. If data has negative skewness, then large negative returns are more common than large positive returns.
Kurtosis measures the degree of peakness. The normal distribution has Kurtosis = 3. If the data has more peakedness than the normal distribution then kurtosis >3 and this is known as leptokurtosis. Whereas, lower peak is called platykurtosis.

Table 3.2

	Sample	Mean	Std. dev.	Skewness	Kurtosis	J-B	ρ
USFCI	81-05	0.037732	0.169036	2.659852	12.00034	756.0284	0.00000
CNFCI	82-05	-0.00356	0.018761	-0.23505	2.417847	3.872637	0.144234
UKFCI	85-05	-0.00097	0.04814	0.274829	3.580777	6.500843	0.038758
EUFCI	91-05	0.0082	0.056111	0.778084	4.124192	25.49113	0.000003

Table 3.3

Table 3

Autocorrelation and Partial Correlation Coefficients at different lags

	UKFCI		EUFCI		USFCI		CNFCI	
	AC	*PAC*	*AC*	*PAC*	*AC*	*PAC*	*AC*	*PAC*
1	0.89	0.89	0.92	0.92	0.88	0.88	0.68	0.68
2	0.76	-0.13	0.8	-0.25	0.73	-0.15	0.46	-0.01
3	0.65	0.01	0.71	0.11	0.62	0.08	0.41	0.19
4	0.57	0.04	0.63	0	0.54	0.02	0.38	0.07
5	0.47	-0.12	0.57	0.03	0.49	0.08	0.38	0.11
6	0.39	0.03	0.5	-0.07	0.44	-0	0.34	0.01
7	0.33	0.03	0.43	-0.01	0.37	-0.14	0.31	0.05
8	0.27	-0.03	0.36	-0.13	0.31	0.07	0.28	-0
9	0.25	0.11	0.28	-0	0.27	0.03	0.24	-0.01
10	0.21	-0.09	0.22	0.03	0.23	-0.05	0.21	-0.01
11	0.16	-0.08	0.19	0.12	0.19	-0.04	0.17	-0.03
12	0.1	-0.06	0.18	-0.01	0.14	-0.06	0.14	-0.01
13	0.05	-0.02	0.16	0.01	0.09	0.02	0.11	-0.04
14	0.01	-0.01	0.15	0.02	0.06	-0.01	0.08	-0.02
15	-0.03	0.01	0.14	0.07	0.03	-0.02	0.05	-0.04
16	-0.07	-0.06	0.14	0.01	0.02	0.04	-0.01	-0.09

Table 3.3 shows the autocorrelation results for all of the variables examined. To identify the autocorrelation among different lags, the first

step is to calculate the autocorrelation coefficients for each specified number of lags on all variables. Sixteen lags were calculated for each variable. According to the results, all observed autocorrelation of each variable falls outside the confidence limits. Therefore, all the variables are significantly autocorrelated within their time series. Moreover, the results of the partial autocorrelation coefficients at various lags indicate that in the FCIs for all the countries exhibit significant levels of autocorrelation at the lag 7 periods, even when lower-order effects have been removed.

Finally, figures A3.4a to A3.4d in appendix 1 show the FCI for the four countries. The FCIs present different ranges. The USFCI is the most volatile (-0.3; +0.8) and fluctuate around the value of zero during the period. The volatility for the US increases in the period 2000-2002. The UKFCI fluctuate around zero within a range of (-0.15; +0.2) as well as the CNFCI that fluctuate around zero within a range of (-0.08; +0.08). Finally, the EUFCI shows quite a strong persistence along the period 1998-2000 compared to the US, UK and CN FCIs. The range is within the band of (–0.15;+0.2) and fluctuate around the value of zero.

Given that our FCIs are a weighted sum of our chosen variables, their interpretation as a measure of stance is not clear *a priori*. Hence we argue that, because we have constructed the variables in terms of difference or simply its deviation from its stochastic trend or its equilibrium value, the higher is the FCI, the looser is the “financial stance” and the higher is expected growth. In general we can assert that the ideal value of the FCI should be close to zero. In order to better understand the interpretation of the FCI we follow Gauthier *et al* (2004) and decompose each variable in our FCI $\Gamma_{q,i,t}$, into its permanent and transitory component. From eq. 3 we obtain:

$$\Gamma_{q,i,t} = \overline{\Gamma}_{q,i,t} + \mathrm{T}c_{q,i,t} \tag{11a}$$

where the permanent component is the equilibrium value of the variable “q” for country “i” at time “t”, $\overline{\Gamma}_{q,i,t}$, and $Tc_{q,i,t}$ is its deviation from equilibrium. Taking the first difference of eq 11a we get:

$$\Delta\Gamma_{i,t} = \Delta\overline{\Gamma}_{q,i,t} + \mathrm{T}c_{q,i,t} + Tc_{q,i,t-1} \tag{11b}$$

where $\Delta\Gamma_{i,t} = \Gamma_{q,i,t} - \Gamma_{q,i,t-1}$ and

$\Delta\overline{\Gamma}_{i,t} = \overline{\Gamma}_{q,i,t} - \overline{\Gamma}_{q,i,t-1}$.

Now it is plausible to assume that the equilibrium value of the $\overline{\Gamma}_{q,i,t}$ changes very slowly, so that we can approximate the one period change, as:

$$\Delta\Gamma_{i,t} = \mathrm{T}c_{q,i,t} + Tc_{q,i,t-1} \tag{11c}$$

This assumption can be made if the time period is not so long (e.g. monthly, quarterly, semi annual) otherwise it would be complicated to compare the value of the FCI of many years ago with its value today in terms of stance. The reason of this statement can probably be found in the change over that period of the equilibrium values of each single variable. If however the time period is not long, from one fixed policy action date to another, it seems reasonable to assume that equilibrium levels of the variables have not changed much, if they have changed at all. Hence under this assumption, an increase in housing prices, directly stimulates housing supply, and indirectly, through the credit channel, increases the borrowing capacity of consumers and firms which stimulates investment and consumption. Since housing prices enter positively in eq. 4 and consequently in the FCI, they are indicative of a looser "financial stance" and signal higher output growth. Symmetrically, a positive change in the short-term interest rate for example, means a tighter money market; Since the short-term interest rate is negatively related in the IS curve of eq 4, it will affect negatively the assets markets and decreases the FCI, which implies lower expected output growth. In general, as we underlined in chapter one, there are three categories of asset prices besides those on debt instruments that are viewed as providing important channels through which monetary policy affects the economy: 1) stock market prices, 2) real estate prices, and 3) exchange rates. Asset price changes will affect aggregate spending via changes in consumption and investment spending but also fluctuations of the asset markets that are influenced by monetary policy, have important impacts on the aggregate economy. If the FCI is capable to capture these changes, then it can be seen as a good information tool for the monetary authority.

3.4 FCI and Forward-looking Taylor Rules

In this section we provide the estimates of standard forward-looking interest rate rules and of rules which allow for Financial Condition Index to be a target and an information variable for the Central Bank. There is one point that we would like to underline before moving to the estimation and it is referred to the choice of the instruments. In economic series it is easy to find instruments that fulfill the orthogonality condition between regressors and error term. In the past this assumption has been tested using a test of the validity of over identifying restrictions (*J*-stat, see Davidson and Mckinnon, 1993).

Stock et al (2002) and Hahn and Hausman (2003) among others have shown that the use of weak instruments[40] can lead to biased estimations even in large sample.
Recent econometric literature discusses the problems of weak instruments in IV regressions and solves them by computing ad hoc statistics and confidence intervals directly. These test statistics pay attention to weak instruments. Most of them are constructed by using large samples properties and are efficient under weak instruments asymptotic, however some of them work well even for a small sample. Different methods are suggested and most of them are considered here:

1) Anderson-Rubin statistics (AR) (1949)
2) The Conditional-Likelihood ratio statistic, Moreira (2003)
3) The Klibergen (2002) k-statistics

For applied works and a small number of instruments the preferred statistics is the Anderson-Rubin, which has well known properties for small samples and it is shown to be totally unaffected by the presence of weak instruments, the exclusion of relevant instruments, and the error distribution in the reduced form for the endogenous explanatory variable, Dufour (2003).
To check for this effect, we amend the Anderson-Rubin procedure as follows:

[40] Weak instrument describes an instrument that does not contribute much to explaining the instrumented variable.

$$AR = F_{\psi = 0} = \frac{\left(RSS_{R}^{*} - RSS_{UR}^{*}\right)/ K}{RSS_{UR}^{*} / \left((T - K\right)} \quad (8)$$

The Anderson-Rubin statistic is pivotal and is distributed as a χ^2 with k degree of freedom as the number of instruments. This procedure provides a joint test of all endogenous variables while being robust to many problems, including weak instruments.

The AR test in its generalized form developed by Dufour and Jasiak (2001) is applicable to univariate models that use limited information, and where one or more of the right-hand-side variables are possibly endogenous. In view of this, the AR test assesses the exclusion of an explanatory variable in the regression which can be conducted using the standard F test or its chi-square asymptotic variant, under the null hypothesis of strong exogeneity.

More formally, consider a limited-information simultaneous-equations system:

$$y = Y\delta + X_1 k + u \quad (8a)$$

where y is an $nx1$ dependent variable, Y is an nxm matrix of endogenous variables, $X1$ is an $n\ x\ k1$ matrix of exogenous variables, and u is an error term that satisfies standard regularity conditions typical of IV regressions. In this context, consider hypothesis of the form:

$H : \delta = \delta^0$

Define $\overline{y} = y + Y\delta^0$ so that, under the null hypothesis, (8a) implies that

$$\overline{y} = X_1 + u$$

In view of this, the AR test assesses the exclusion of X_2 (of size nxk_2) in the regression of $\overline{y}$ on X_1 and X_2, which can be conducted using the standard F-test or its chi-square asymptotic variant (see Dufour and Jasiak (2001)).

Let $X = (X_1; X_2)$, and define

$M = 1\text{-}X(X'X)^{-1}X';$

$M_1 = 1\text{-}X_1(X'_1 X_1)^{-1}X'_1;$

The statistic then takes the form

$$AR = \frac{\left[\left(y - Y\delta^{0}\right)' M_{1} \left(y - Y\delta^{0}\right) - \left(y - Y\delta^{0}\right)' M \left(y - Y\delta^{0}\right) \right] / k_{2}}{\left(y - Y\delta^{0}\right)' M \left(y - Y\delta^{0}\right) / \left(n - k_{1} - k_{2}\right)}$$

(8b)

Under the null hypothesis, and imposing strong exogeneity and identically, independently distributed (i.i.d.) normal errors, AR~ $F(k_2, n - k_1 - k_2)$; the normality and i.i.d. hypotheses can be relaxed so that, under standard regularity conditions and weakly exogenous regressors, $(k_2 \text{ x } AR) \overset{asy}{\sim} X_2\,(k_2)$.

The test can be readily extended to accommodate additional constraints on the coefficients of the exogenous variables; see Maddala (1974), Dufour and Jasiak (2001), Dufour and Taamouti (2003), and Dufour (2004).

Specifically, consider a hypothesis of the form

$H : \delta = \delta^0, k_1 = k_1^{\,0}$

where k_1 is a subset of k i.e., $k = (k'_1 = k'_2)'$. Partition the matrix X_1 (into X_{11} and X_{12} submatrices) accordingly, and let

$\breve{y} = y - Y\delta^{0} + X_{11} k_{1}$

The restricted model then becomes

$$\breve{y} = X_{12} k_{12} + u$$

and the test can be carried out as above.

Table 3.4 Weak instruments: Anderson-Rubin statistics

Variables	*USA* $K_{un}=46$	*Critical value* (χ^2 / K_{un})	*EMU* $K_{un}=29$	*Critical value* (χ^2 / K_{un})	*Canada* $K_{un}=40$	*Critical value* $(\chi^2\ K_{un} /)$	*UK* $(K_{un}=30)$	*Critical value* (χ^2 / K_{un})
FCI	0.2724**	0.9515	0.743**	1.5094	0.2807**	1.0943	0.8287**	1.4591
Output gap 'y'	0.206**	0.9515	0.278**	1.5094	0.4027**	1.0943	0.1065**	1.4591
Inflation 'π'	0.034**	0.9515	0.695**	1.5094	0.0347**	1.0943	1.387**	1.4591
Interest rate	0.066**	0.9515	0.924**	1.5094	0.8998**	1.0943	1.105**	1.4591
World oil price	0.048**	0.9515	1.214**	1.5094	1.1040♦	1.0943	0.0180**	1.4591

***10 percent level of significance, **5 percent level of significance**

While the test in its original form was derived for the case where the first-stage regression is linear, Dufour and Taamouti (2003) show that it is in fact robust to: (i) the specification of the model for Y, and (ii) excluded instruments; in other words, the test is valid regardless of whether the first-stage regression is linear, and whether the matrix X_2 includes all available instruments. As argued in Dufour (2004), since one is never sure that all instruments have been accounted for, the latter property is quite important.

Most importantly, this test (and several variants discussed in Dufour 2004) is the only truly pivotal statistic whose properties in finite samples are robust to the quality of instruments. The results of the AR tests for each country are presented in the table 3.4.

We do not reject the null hypothesis at 5% level for all the variables except for Canada world oil price for which the null hypothesis is rejected at 10% level. .

3.4.1 Benchmark Taylor Rule: specification and estimation

Given the important role played by asset prices in the monetary transmission mechanism and, considering that they may contain important information regarding the current and future state of the economy, the primary objective of this sub-section is to estimate forward-looking Taylor rules augmented for the FCIs we have found above.

Generally, policy makers are aware of the growing importance of asset prices in the economy, especially after the extraordinary growth rates registered in this sector (especially in the nineties). Most leading central bankers are now wondering whether and how they can take these developments into account in the setting up and running of their monetary strategies. A consensus seems to be emerging around the idea that, if financial assets are indeed among the leading indicators of the economy, central bankers should not worry about them and therefore take any action until price developments endanger overall price stability.

For the purposes of the analysis the most important aspect is given by value and the significance of the FCIs' coefficients. In the following part of this chapter we estimate two Taylor rules for each four countries. In all the cases we expect to find a positive and statistically significance value of the inclusion of contemporary Financial Condition Index that is, the inclusion of the FCI should be superior, although marginally, to a benchmark Taylor Rule specification.

Following Clarida *et al.* (1998) we assume that the Central Bank has an operating target for the nominal short term interest rate that is based upon the state of the economy. Our benchmark model is the Standart Taylor rule, where interest rate is set according to the evolution of the output gap and expected inflation. In each period, the actual interest rate partially adjusts towards the target value. Svensson (1997) justifies the partial adjustment mechanism by including the change in interest rates in the Central Bank's loss function[41]. Combining the target rule with the partial adjustment mechanism we obtain the empirical form of the monetary policy reaction function:

[41] One of the main problems when working with forward looking and current variables is that they can be correlated with the error term. This in turn can lead to biased estimates of the coefficients. GMM technique can be a valid instrument to overcome these problems.

$$R_t = \left(1 - \sum_{i=1}^{l} \varphi_i\right)\left\{a + \beta(E_t[\pi_{t+n}] - \pi^*) + \gamma E_{t-1}[\tilde{y}_t]\right\} + \sum_{i=1}^{l} \varphi_i R_{t-i} + u_t \qquad (9)$$

where $\sum_{i=1}^{l} \varphi_i \in [0,1]$ measuring the degree of interest rate smoothing, π^* is the inflation target (implicit or explicit), and $\alpha = r^* - \beta\pi^*$, with r^* denoting the long-run equilibrium nominal interest rate. Due to the fact that monetary policymakers cannot observe $\tilde{y}_t$ when setting R_t, we replace the actual value of the output gap with its expected level, $E_{t-1}[\tilde{y}_t]$[42]; The error term, u_t, represents a white noise monetary policy shock. We consider an inflation forecast horizon of one year, therefore we set n equal to 12 in our estimation.

In order to estimate the model, unknown expected future variables are replaced with their ex-post realized values. This leads us to Equation 4:

$$R_t = \left(1 - \sum_{i=1}^{l} \varphi_i\right)\left\{a + \beta(\pi_{t+n} - \pi^*) + \gamma \tilde{y}_t\right\} + \sum_{i=1}^{l} \varphi_i R_{t-i} + \omega_t \qquad (10)$$

The set of orthogonality conditions implied by Equation (10) is:

[42] See McCallum and Nelson, 1999, and Orphanides *et al*, 2000 for a further discussion of the uncertainties faced by the policymaker with respect to output.

$$E_t\left[R_t - \left(1-\sum_{i=1}^{l}\varphi_i\right)\left\{a+\beta(\pi_{t+n}-\pi^*)+\gamma \tilde{y}_t\right\}+\sum_{i=1}^{l}\varphi_i R_{t-i}\middle| I_t\right]=0 \qquad (11)$$

where I_t represents all the variables in the Central Bank's information set available at time t when the interest rate is chosen. I_t is a vector of variables that are orthogonal to ω_t. These instruments are lagged variables that help forecasting inflation and output, and contemporaneous variables that are uncorrelated with the exogenous monetary policy shock, u_t. The benchmark reaction function given by Equation (10) is estimated using the Generalised Method of Moments (GMM). The instruments employed in the estimation include a constant and six lags of the nominal short-term interest rate, inflation, output gap, and a world commodity price index (agricultural raw materials). Since the number of instruments is greater than the number of elements of the parameter vector [φ_i, α, β, γ], we test for the validity of the over-identifying restrictions using the Hansen (1982) *J*-statistic. As pointed out by Clarida *et al.* (1998), failure to reject orthogonality implies that the Central Bank considers lagged variables in its reaction function, only to the extent that they forecast future inflation or output.

The GMM estimation results in Tables A.3.2 to A.3.5, column 2, indicate that the benchmark specification satisfies the dynamic stability criterion since the estimated inflation coefficient, β, is greater than one[43] The output gap coefficient, γ, is positive and statistically significant at the 1 % level in all the estimates. The sum of the interest rate smoothing parameters is close to one for all the four Central Banks under consideration, indicating a high level of persistence in short term interest rates. Finally, the *J*-statistic indicates that the over-identifying restrictions of the benchmark model are not rejected.

3.4.2 Interest rate and FCI

As pointed out in the previous section, asset prices contain important information about future aggregate demand and consequently inflation pressures. Also, there are theoretical arguments in favour of including asset price inflation in the reaction function of the Central Bank. Cecchetti *et al*. (2000) find that, on the basis of simulations, it would be desirable to include asset inflation in the Taylor rule. Augmented Taylor rule are usually estimates including each single variable independently in the model no matter the importance of that particular market at that time. However, as described in many data[44], the composition of households and firms total assets changes over time and this is likely to be considered when monetary authority set the interest

[43] If β was smaller than the stability threshold of one, then this would imply a positively sloped aggregated demand, with output decreasing in response to an inflation shock (Taylor, 1998).
[44] See OECD Economic Outlook.

rate. The Financial Condition Index calculated in the previous paragraph should overcome this issue, since it is a weighted index.

Thus, we proceed by considering alternatives to our benchmark specification, by allowing asset prices to enter in the Taylor rule. The augmented reaction functions we consider are of the form[45]:

$$R_t = \left(1 - \sum_{i=1}^{l} \varphi_i\right)\left\{a + \beta(E_t[\pi_{t+n}] - \pi^*) + \gamma E_{t-1}[\tilde{y}_t] + \omega \chi_{t-n}\right\} + \sum_{i=1}^{l} \varphi_i R_{t-i} + \varepsilon_t \tag{12}$$

where x_{t-n} denotes the relevant financial condition index and ω the relevant coefficient. We assume that n is equal to zero We use contemporaneous, and not expected, Financial Condition Index due to the well known difficulties involved in forecasting asset price movements. Also, weak form efficiency implies that the current asset price reflects all past history, thus there is no need to incorporate lags. This implies that at every disequilibria at time t, Central Banks intervene at time t+1 when $\omega > 0$.

Table 3.5 presents a statistics summary of the residuals from the benchmark and the augmented Taylor rules. Figure 3.5 shows the behaviour of the residuals from the two Taylor rules estimations for each single country.

[45] See Kontonikas and Montagnoli (2003) for a theoretical derivation of Eq. (12).

Tab. 3.5 Statistics of the residuals from the benchmark Taylor rule and the augmented Taylor rule

	UKBAS	UKFCI	CNBAS	CNFCI	EUBAS	EUFCI	USBAS	USFCI
Mean	-0.01541	-0.01003	0.154887	0.080247	0.028237	-0.04442	0.014012	-0.02918
Median	-0.0089	-0.00829	0.141015	0.054878	0.044491	-0.02524	0.016257	-0.01519
Maximum	0.490817	0.531867	2.254068	1.691511	0.646095	0.530841	0.980333	0.62302
Minimum	-0.3669	-0.41491	-1.27722	-1.17465	-0.69513	-1.0022	-0.97741	-0.88877
Std. Dev.	0.158091	0.146212	0.500055	0.349011	0.186987	0.210785	0.302605	0.176727
Skewness	0.295066	0.222273	0.950286	1.236778	-0.11571	-0.96688	0.09431	-0.80603
Kurtosis	3.922697	4.769246	6.481201	9.245376	5.282518	6.261475	4.681332	8.703224
Jarque-Bera	5.548267	15.39132	72.75559	208.6948	24.3434	66.492	13.23885	162.4553
Probability	0.062404	0.000455	0	0	0.000005	0	0.001334	0
Sum	-1.71019	-1.11307	17.19243	8.907453	3.134351	-4.93078	1.555358	-3.23904
Sum Sq. Dev.	2.74922	2.351558	27.50606	13.39895	3.846058	4.887314	10.07269	3.435563

The visual inspection of the plots in figure 3.5 and the statistics presented in the above table show that the volatility of the residuals of the benchmark Taylor rules are bigger than the volatility of the augmented Taylor rules (with the FCI) for three out of four countries. The volatility of the residuals of the Europe benchmark Taylor rule is smaller than the augmented one.

Give an interpretation of the estimation results presented in tables 3.1 to 3.4 (appendix 2) is not an easy task; Except for the Euro area, all cases analysed in this work have a positive and statistically significance of the inclusion of contemporary value of Financial Condition Index in the Taylor rule[46]. Asset price parameter in the monetary policy rule is positive for three of the four countries. UK shows a non-neglectable effect of FCI in its interest rate. Central Banks always stress that they do not have any other objective than to keep the level of inflation within the target –when it exists- or at a level that is compatible with the overall economic outlook, therefore a positive FCI does not have an immediate interpretations. Gauthier *et al*. (2004) argue "that the higher the FCI, the looser the 'financial stance' and the higher the expected growth…[hence]… an increase in housing prices directly stimulates housing supply, and, indirectly, through the credit channel, it increases the borrowing capacity of consumers, which stimulates consumption. Because housing prices are positively weighted in the FCI, a higher level is indicative of a looser 'financial stance' and signals higher output growth"[47].We can suggest two alternative explanations: firstly asset market might have a role in interest rate setting because they contain information about future level of asset prices and output particularly when they diverge from their fundamental value. Second, if we accept that Central Banks do not only have the objective of monetary stability but also of financial stability, then asset prices can play an important role in monetary policy. In a context characterized by asymmetric information, financial markets determine the value of the collateral, hence, fixing the cost of capital; in other words they delimit

[46] We checked whether having t-n lags in the FCI suggested by Bernake and Gertler (1999) and Chadha *et al.* (2003) made a difference. Overall the inclusion of lags do not qualitatively and quantitatively improve

[47] Gauthier *et al*., pp. 23-24, 2004.

the amount of capital firms are able to borrow. In such environment, an increase in the Bank's interest rate has a more than proportional impact on the cost of capital. Given this, a monetary policy should always consider the level of the business cycles and the level of indebtedness. Failing in doing so might cause financial instability in the system.

Finally, we should try to answer the question why, for the EU, is not statistically significance of the inclusion of contemporary value of Financial Condition Index in the Taylor rule. Ehrmann *et al* (2005) found that in the euro area there is no significant relationship between equity markets and short-term interest rates. Furthermore, there is evidence for a much larger response of stock markets to changes in monetary policy in Europe. For a monetary union like the euro area, which comprises twelve individual countries, the matter is somewhat more complex. The introduction of the euro in 1999 and the conduct of the single European monetary policy for the euro area as a whole by the European Central Bank (ECB) made it necessary for the financial systems of twelve euro area countries to become more integrated. Indeed, a fully integrated money market and a sufficiently high degree of integration of other financial markets is a prerequisite "a conditio sine qua non" for the smooth and effective implementation of monetary policy and for its balanced transmission across national boundaries.

There are additional components of complexity that enter in the conduct of monetary policy when financial markets are not well integrated in the european currency area. First, central banks tend to use asset prices to extract information from asset prices about what markets

expect about future states of the economy. If there is not one integrated market for the assets used but several fragmented ones, the information about the economy of the currency area as a whole may be more noisy than otherwise the case. For example, it may be difficult to control perfectly for all the local factors that influence prices in the different market segments. Second, if market prices for the same asset diverge across the area, then the overall wealth effects on area wide inflation and growth may become blurred. Finally, disaggregated asset markets may contribute to a heterogeneous transmission of monetary policy to the economy. European financial markets are still not really perceived as a substitution for an investor across the countries but just inside the asset markets of each single country.
For this reason, the interrelationship between financial markets and monetary policy is particularly important in Europe but, the structural changes that took place in Europe's financial markets as a result of EMU and other developments maybe needs more and significant adjustments.

3.5 Conclusions

Stating from the seminal work of Alchian and Klein (1973) it is often argued that the forward-looking nature of asset prices makes them good proxies for the information left out of conventional inflation measures. It is also widely accepted that asset price inflation developments are closely associated with general inflation trends. This work investigated the role of asset prices in the conduct of monetary policy in United States, Canada, Euro Area and United Kingdom. We constructed Financial Condition Indexes for the four countries using the Kalman Filter algorithm. This methodology allowed us to capture the changes of the weights over time. Second, we proceeded by estimating forward-looking Taylor rules augmented for FCI. The results from the Taylor rules suggest that the Financial Condition Index enter positively and statistically significant into the FED, Bank of England and Bank of Canada interest rate setting. This gives a positive view for the use of the FCI as an important short term indicator to guide the conduct of monetary policy in three out of four countries analyzed.

Appendix 1

Table A3.1 Unit root test

Variables	*USA*	*EMU*	*Canada*	*UK*
RRe	ADF =-4.338** PP=-3.404*	ADF =-3.364* PP=-2.852♦	ADF =-3.197* PP=-3.076*	ADF = -3.873** PP= -3.695**
RRh	ADF =-4.225** PP=-3.979**	ADF =-3.522** PP=-3.235*	ADF =-2.113* PP=-2.159*	ADF = -14.101** PP=-2.745♦
RRs	ADF =-4.293** PP=-4.363**	ADF =-1.948* PP=-1.640♦	ADF =-3.518** PP=-3.668**	PP =-2.566* PP=-4.116**
	** significant at the 1% level; *significant at 5% level; ♦ significant at the 10% level. ADF= Augmented Dickey Fuller; PP= Phillips Perron			
Sample	1982:01 2005:04	1991:10 2005:04	1982:01 2005:04	1985:01 2005:04

Figure A3.1 EU and Canada residuals of the SURE

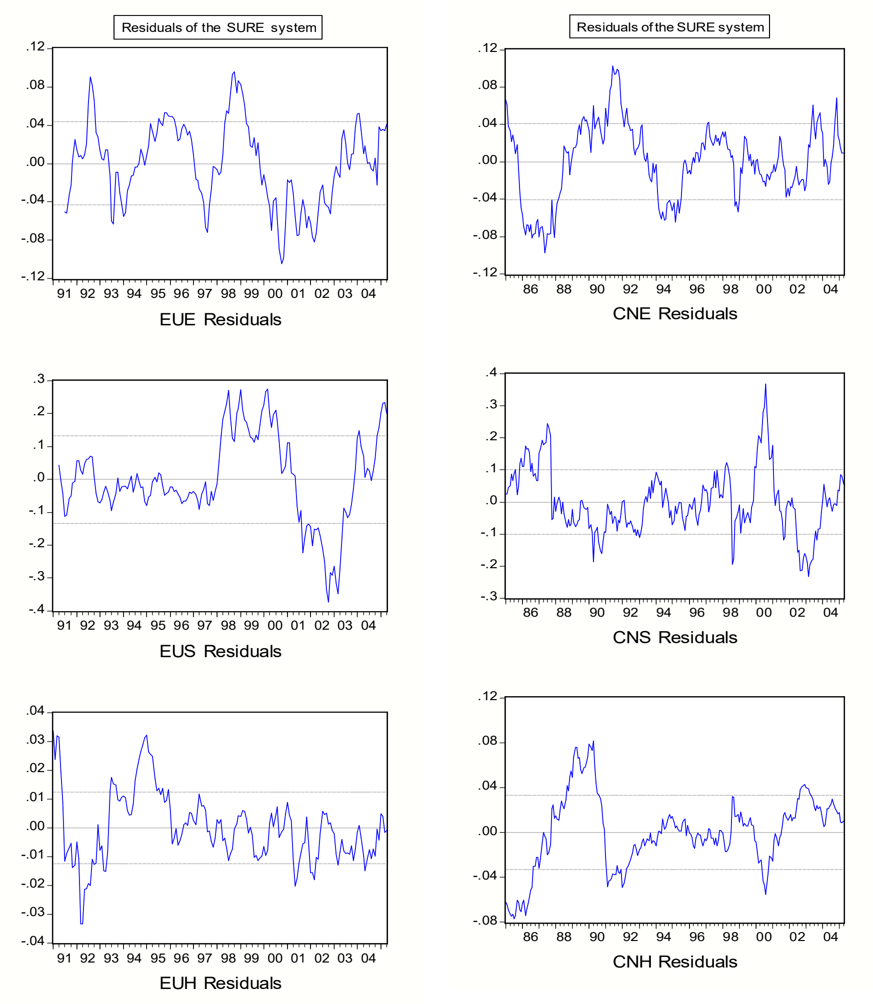


Figure A3.2 UK and US residuals of the SURE

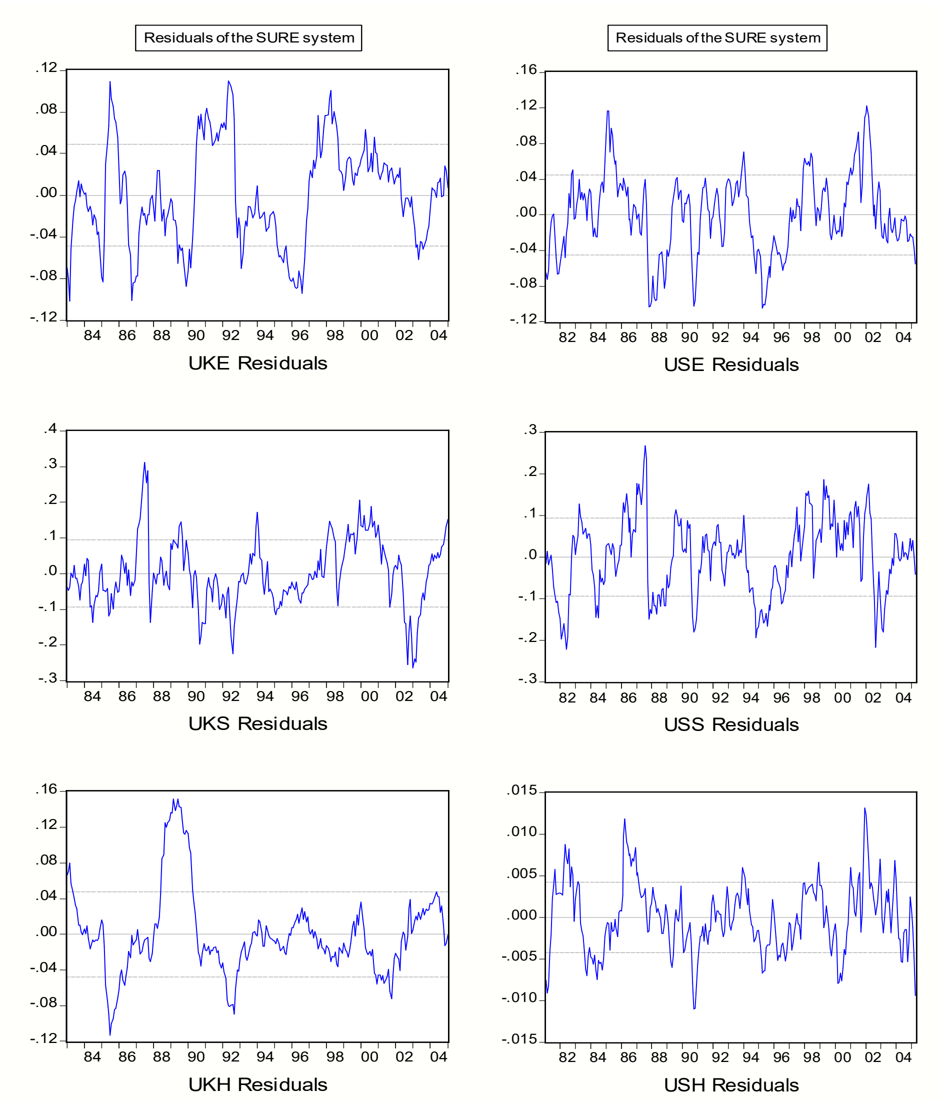


Figure A3.3

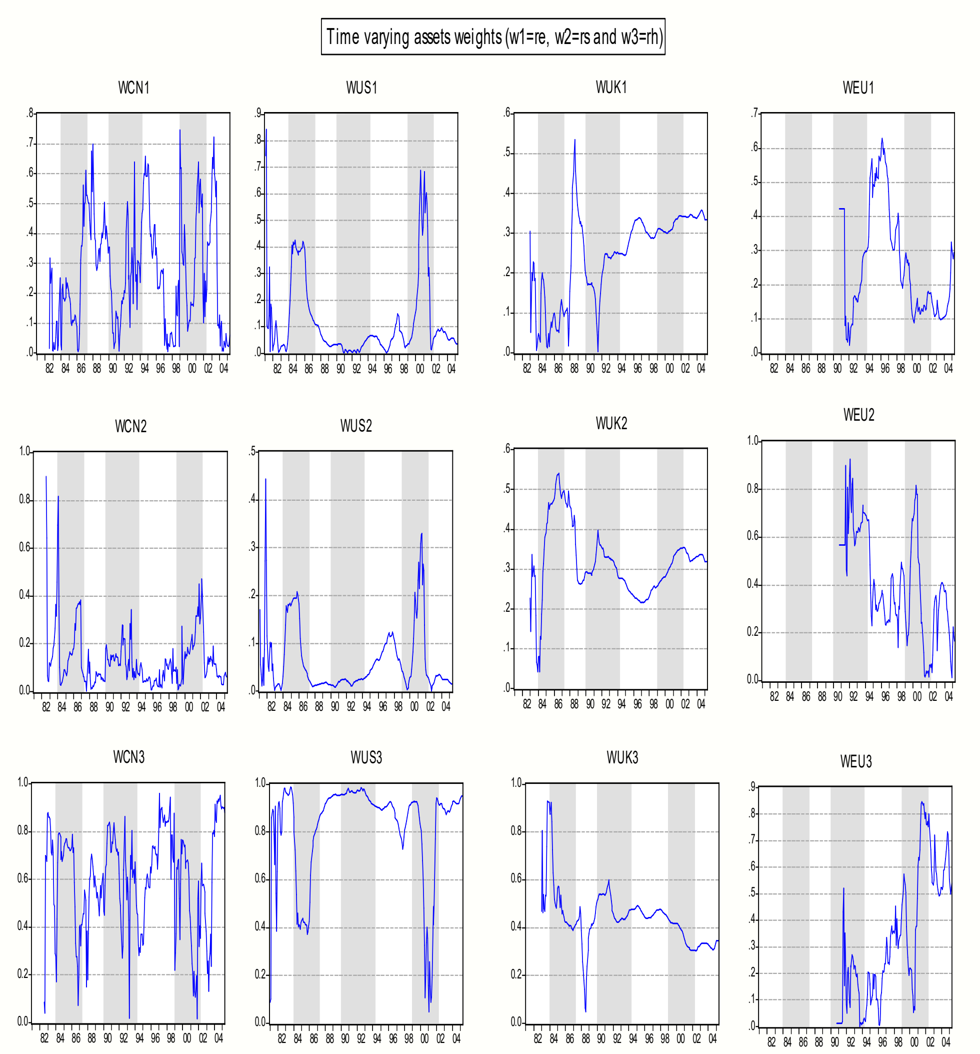

Time varying assets weights (w1=re, w2=rs and w3=rh)
WCN1
WUS1
WUK1
WEU1
WCN2
WUS2
WUK2
WEU2
WCN3
WUS3
WUK3
WEU3

Figure A3.4a-d FCIs

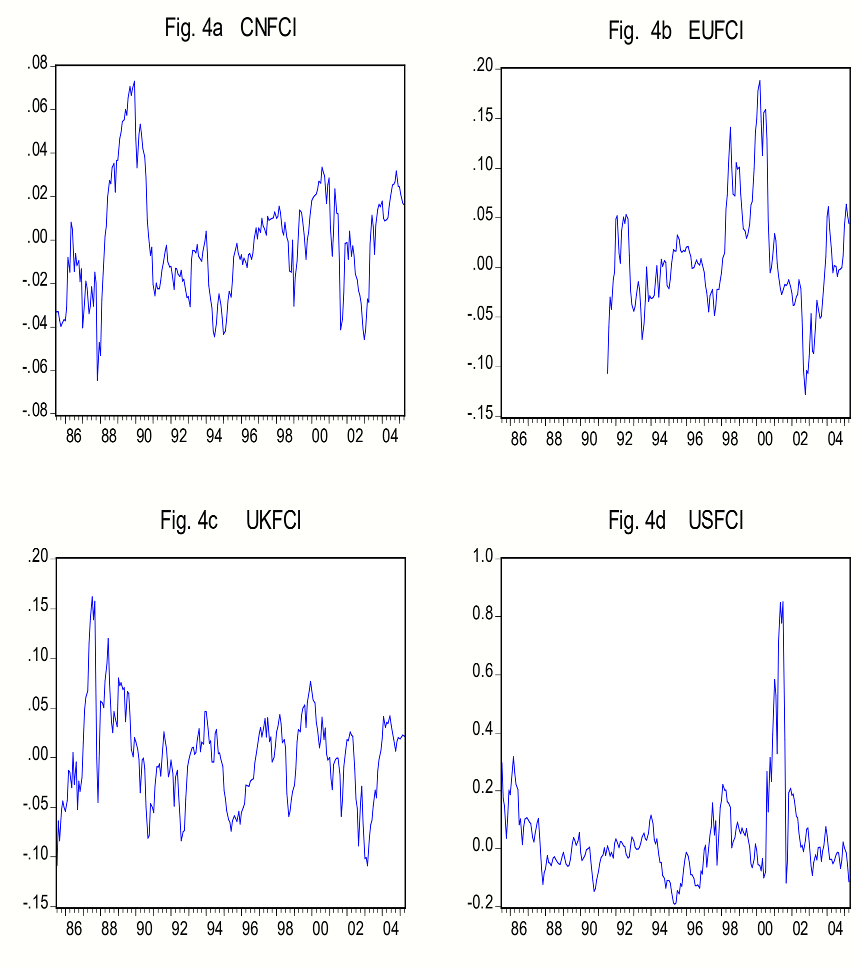


Fig. A3.5 Plots of the residuals from the baseline and the augmented Taylor rules

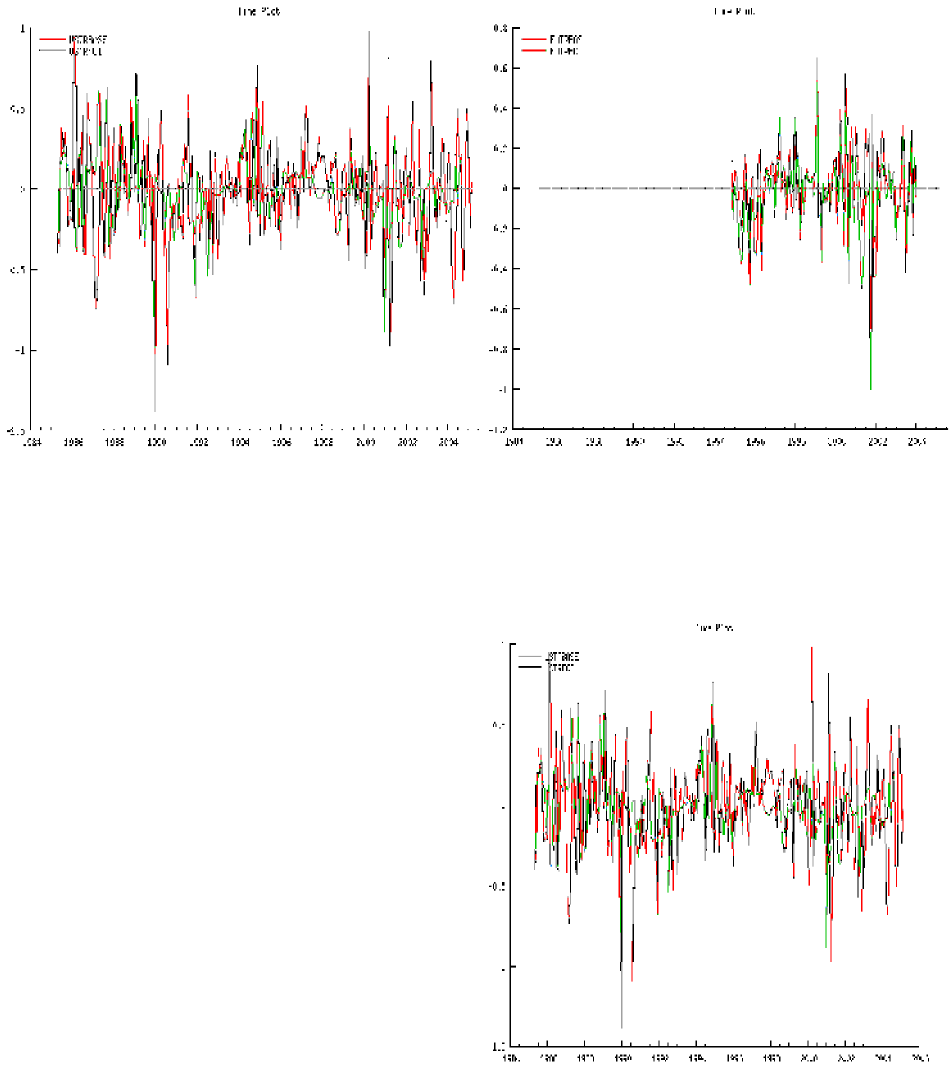


Fig. A3.6a EU Taylor rule residuals spectrum

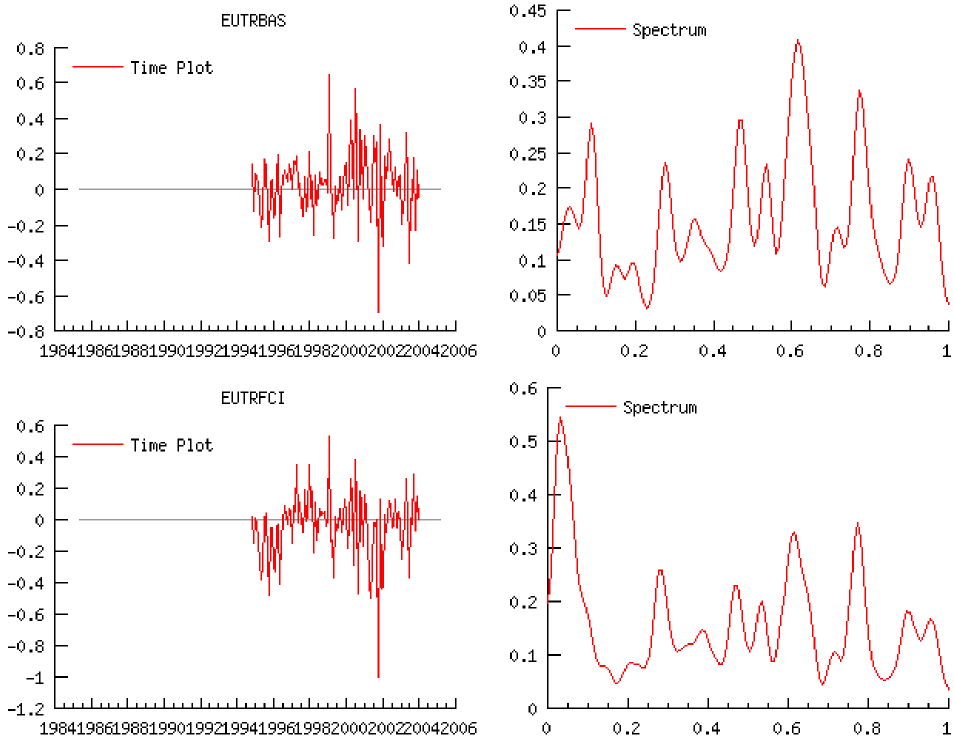


Fig. 3.6b US Taylor rule residuals spectrum

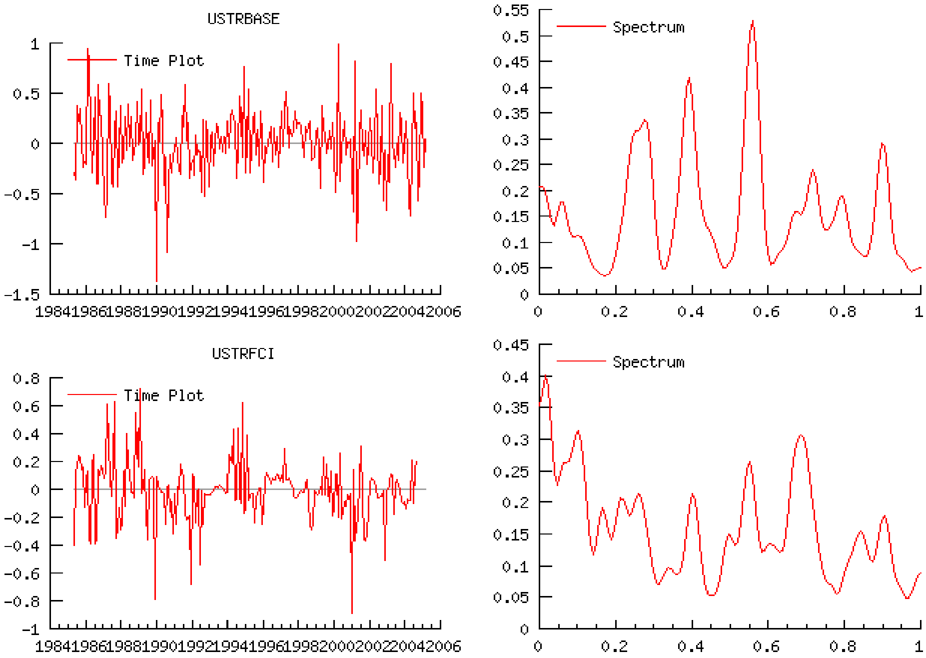


Fig. 3.6c UK Taylor rule residuals spctrum

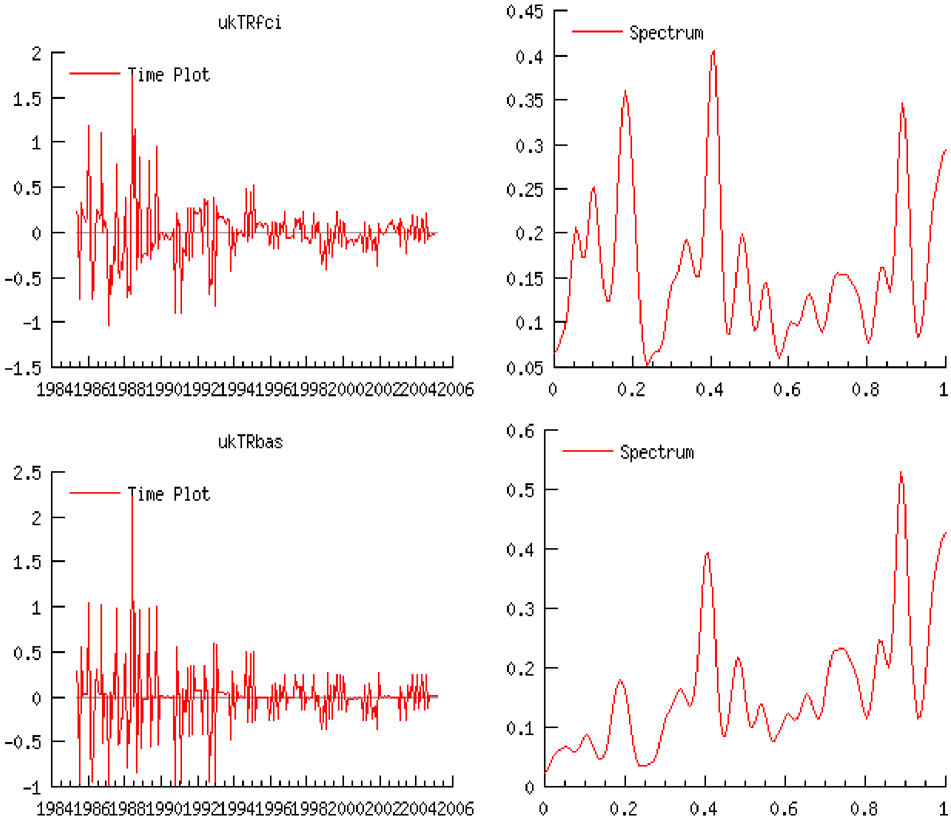
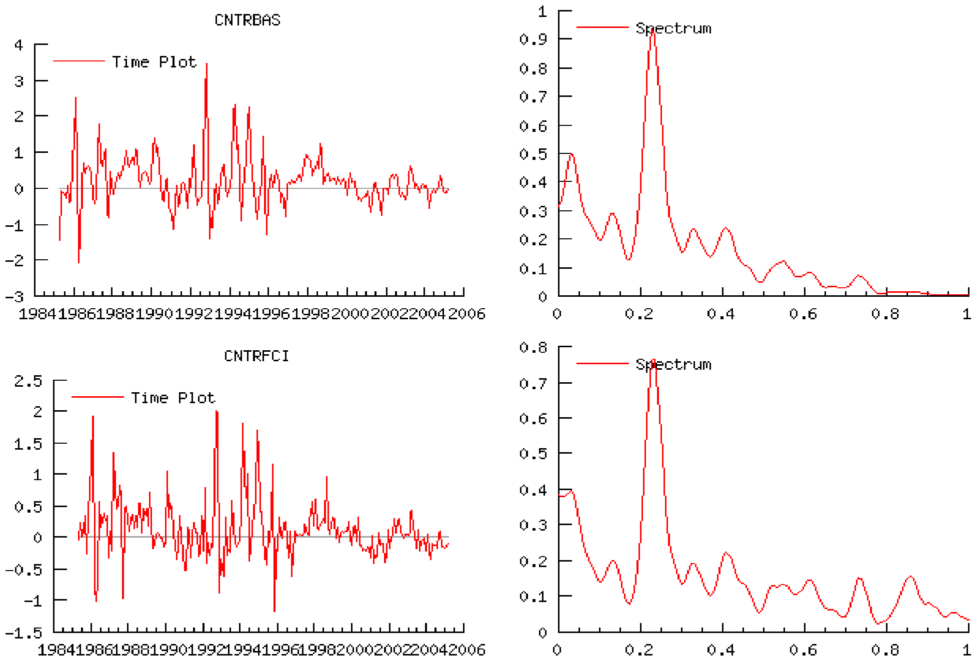


Fig. 3.6d Canada Taylor rule residuals spectrum



Appendix 2

Table A3.2: GMM Estimates of US Forward Looking Taylor Rule, 1985:05-2005:5

	a	β	γ	$\sum_{i=1}^{l}\varphi_i$	$X_t = [\pi_t^{FCI}]'$	J- Stat.
Benchmark Model	1.208***	1.400*	0.290***	0.970***	---	0.099
Augmented Model 1	0.306***	1.657**	0.232**	0.980**	0.103**	0.071

Note:

1. Estimates are obtained by GMM estimation with correction for MA(12) autocorrelation. Two-stage least squares estimation is employed to obtain the initial estimates of the optimal weighting matrix.
2. In the benchmark model the instruments used are a constant and lags 1 to 6 of the nominal short term interest rate, inflation, output gap, and a world commodity price index (agricultural raw materials). In the model that includes asset price inflation, lags 1 to 6 of the constructed FCI is also included.
3. *J*-stat denotes the test statistic for overidentifying restrictions.
4. *, **, *** indicate level of significance of 10%, 5%, and 1% respectively.

Table A3.3: GMM Estimates of EU Forward Looking Taylor Rule, 1995:01-2005:05

	a	β	γ	$\sum_{i=1}^{l}\varphi_i$	$X_t = [\pi_t^{FCI}]'$	J- Stat.
Benchmark Model	0.998*	1.283**	0.818**	0.932**	---	0.132
Augmented Model 1	1.053***	1.843***	0.408**	0.922***	0.136	0.211

Note: See Table 1.

Table A3.4 GMM Estimates of Canada Forward Looking Taylor Rule, 1985:05-2005:05

	a	β	γ	$\sum_{i=1}^{l}\varphi_i$	$X_t=[\pi_t^{FCI}]'$	J- Stat.
Benchmark Model	0.608**	1.302**	0.973**	0.960**	---	0.142
Augmented Model 1	0.112**	1.655**	0.998*	0.955***	0.128***	0.206

Note: See Table 1

Table A3.5 GMM Estimates of UK Forward Looking Taylor Rule, 1985:05-2005:05

	a	β	γ	$\sum_{i=1}^{l}\varphi_i$	$X_t=[\pi_t^{FCI}]'$	J- Stat.
Benchmark Model	1.867***	1.170***	0.694**	0.777.**	---	0.139
Augmented Model 1	1.080***	1.630***	0.485**	0.960***	0.415**	0.150

Note: See Table 1

Appendix 3

Coun try	**Interest Rate**	**Exchange Rate**	**CPI**	**House Price**	**Output**	**Stock price**
USA	US TREASURY BILL RATE - 3 MONTH	US REAL EFFECTIVE EXCHANGE RATE INDEX - CPI BASED	US CPI - ALL URBAN SAMPLE ALL ITEMS	US AVERAGE PRICE OF HOUSE SOLD*	US INDUSTRIAL PRODUCTIO N - TOTAL INDEX	**US DOW JONES INDUSTRIAL S SHARE PRICE INDEX**
UK	UK TREASURY BILL RATE - 3 MONTH	UK REAL EFFECTIVE EXCHANGE RATE INDEX - CPI BASED	UK RPI - ALL ITEMS EXCLUDING MORTGAGE INTEREST	UK HALIFAX HOUSE PRICE INDEX - ALL HOUSES	UK INDUSTRIAL PRODUCTIO N - TOTAL INDEX	**FTSE ALL SHARE - PRICE INDEX**
EUM	RT.MM.EUR. EURIBOR.3 MONTH	EU REAL EFFECTIVE EXCHANGE RATE INDEX - CPI BASED	HICP - OVERALL INDEX EURO AREA	Eurostat**	EU INDUSTRIAL PRODUCTIO N - TOTAL INDEX	**EM SHARE PRICE INDEX**
Cana da	CN TREASURY BILL RATE - 3 MONTH	CN REAL EFFECTIVE EXCHANGE RATE INDEX - CPI BASED	CN CPI	CN HOUSING PRICE INDEX	CN INDUSTRIAL PRODUCTIO N - TOTAL INDEX	**CN TORONTO STOCK EXCHANGE COMPOSITE SHARE PRICE INDEX**
Source: All data are from the IMF-Financial Statistics collected by DATASTREAM **Source: (*) National Association of Home Builders; (**) Eurostat.**						

Chapter Four

Is the Impact of ECB Monetary Policy on EMU Stock Market Returns asymmetric?

4.1 Introduction

The last two decades have witnessed the primacy of monetary policy as the main tool used by policymakers in the stabilisation of inflation and output. Concurrently, commentators and analysts pay close attention to changes in policy rates in the belief that such changes, particularly unexpected changes, can influence stock market returns. Moreover, with increasingly integrated global markets, attention is paid not only to domestic policy changes but also to how foreign policy and foreign economic conditions can affect the domestic economy. Reflecting these issues, greater attention has been paid to the qualitative and quantitative impact of monetary policy changes on stock returns. It sheds some light on the more general debate on the impact of monetary policy shocks on stock market returns.

"In principle, it is acknowledged that there are two main channels through which a central bank can influence asset prices. First, the central bank is able to determine short-term interest rates, which act as a benchmark for short-term returns and are used for discounting the assets' future income streams. Thus, the central bank is able to affect asset prices via agents' expectations about the future path of money market rates (short-run impact).

Second, the long-run perspective about future inflation has an impact on the current prices of long-term assets, since nominal long-term returns usually contain an inflation premium. Given that monetary policy determines inflation in the long run, it has a strong impact on asset prices via inflation expectations (long-run impact)", (Belke and Pollet, 2005).

Which policy implications would emerge from the finding of a significant and stable relationship between monetary policy and stock market returns? In our view, there are at least two clear implications. First, by letting short-term rates deviate from a certain level of equilibrium, the central bank may have a significant impact on asset prices. Second, in principle the central bank is able to reduce stock price volatility by diminishing the uncertainty of future rate changes, hence volatility spillovers to other financial markets could be avoided and the option value of waiting with investment decisions would be reduced.

Moreover, monetary policy exerts a significant impact on financial markets and this is reflected by the appreciable attention that the ECB receives in the financial markets. Estimates of the responsiveness of stock market returns to changes in monetary policy will most likely contribute to effective investment and risk management decisions (Rigobon and Sack, 2004).

In this chapter we explore the possibility of a non-linear relationship between EUM stock returns and ECB's monetary policy innovations. The non-linearity is modelled using different Markov-switching (MS) regime autoregressive models. We intend to investigate the empirical performance of the univariate MS models used to describe the switches between different economic regimes for the 11 EUM countries' stock markets and, furthermore, extending these models to verify if the inclusion of monetary policy shock as an exogenous variable improves the ability of each specification to identify. Moreover, we investigate if the shocks are both, symmetric or asymmetric throughout the EUM countries and at level of industry portfolio inside each single country. Hence, we study asymmetries using an extension of the Markov switching model described by Hamilton (1989) estimated over the period 1992-2005.

It is commonly thought that the final goals of monetary policy generally are expressed in terms of macroeconomic variables (e.g. inflation, unemployment, output, etc..). However, the most direct and immediate effects of monetary policy actions are on the financial markets. In fact, by affecting asset prices and returns, monetary authorities should try to modify economic behaviour in ways that should help to achieve their ultimate objectives. In this way, changes in monetary policy are transmitted through the stock markets via changes in the values of private portfolios (the wealth effect analysed in the previous three chapters of this work), changes in the cost of capital, and by other mechanisms presented in chapter one. For these reasons, it will be useful to try to obtain quantitative estimates of the links between monetary policy innovations and stock prices.

Following the wide literature on this topic, we have considered a different definition of monetary policy shock. This new measure of innovation in monetary policy comes directly from the results we have obtained in chapter three. The empirical results showed that only for three out of four countries Taylor's rule the FCI was found with the right sign and significant while, for the EU Taylor rule, it was statistically not significant. Our explanation of that result was basically concentrate on the composition of the EU financial markets and, for some extend, on the different degree of integration of these markets among them. In this final chapter we focus our attention on the relationship on one specific EU asset market, the stock market, and try to investigate if the monetary policy shocks are asymmetric among the EUM countries and also, the impact of a policy innovation among the different sectors of the single country. In doing so, the residuals of the estimated Taylor rule of the previous chapter can be used as proxy of the monetary shock.

We measure the persistence of each economic regime, as well as the ability of each MS model to detect the impact of monetary policy on EUM stock markets. Our empirical findings can be summarized as follows. First, the null hypothesis of linearity against the alternative of a MS specification is always rejected by the data. This suggests that regime-dependent models should be used if a researcher is interested in obtaining statistically adequate representations of the output growth process. Second, three-regime MS models typically outperform the corresponding two-regime specifications in describing the business cycle features for each country. Third, the introduction of this different monetary shock specifications is never rejected. Fourth, it contribute to a better description of the impact of monetary policy on stock markets. Finally, models with exogenous shocks variables generally outperform the corresponding univariate specifications which exclude shocks from the analysis.

Starting with the work of Hamilton (1989), the Markov-switching (MS) autoregressive time series models have emerged as an interesting alternative to describe specific features of economic series. As an example, a relevant number of empirical regime-switching models have been proved to be able to capture nonlinearities and asymmetries which are present in many macroeconomic variables (Krolzig, 1997; Clements and Krolzig, 2001, Shiu-Sheng Chen, 2005). Since policy shocks are generally acknowledged to have important effects on both economic activity and macroeconomic policy, our study concentrates on the analysis of the dynamic relationship between these shocks and the conditions on stock markets for the EUM countries. Our investigation of how monetary innovation affect the stock returns in the EU markets is based on the comparison of alternative MS models.

Our model selection strategy comprises the following criteria: i) model fit, as summarized by the standard error of the residuals; ii) value of the log-likelihood function; iii) values of means and/or intercepts estimated in the different economic regimes; iv) relation between the probability of regime switching and the monetary policy shock.

In particular, asymmetries are supposed to exist where the estimated parameters of the alternative MS specifications are indicative of different regime-dependent responses of stock market. Most of the empirical studies which use an MS modelling approach focus almost exclusively on univariate models. A novelty of this work is that we explicitly assess the dynamic impact of exogenous monetary shocks on the movements of European stock returns in both cases: under high return stable and low return volatile states, that is when there are bull markets and bear markets, respectively. In this respect, our work can be regarded as an extension of the studies by Thorbecke (1997), Peersman and Smets (2001) and Garcia and Schaller (2002).

This chapter has two main objectives. First, we try to measure and analyse in some detail the stock market's response to monetary policy actions, both at the aggregate level for the EUM countries and, at level of industry for five European countries. Second, we try to gain some insights into the reasons for the European stock market's response. An additional innovative feature of our study is that it provides a comparison of the ability of our definitions of policy innovation to detect asymmetries in the EUM stock markets.

The chapter is structured as follows. Section 4.2 reviews the empirical literature on the macroeconomic effects of monetary innovations. Section 4.3 presents the data. Section 4.4 describes the MS framework and our model selection strategy. Section 4.5 introduces the MS specifications which are relevant to the empirical analysis. In Section 4.6 we present and discuss the empirical findings obtained by using MS models. Section 4.7 concludes.

4.2 Review of econometric studies

In the research of economics time series, especially the macroeconomic and financial series, the conventional framework with a fixed density function or a single set of parameters may not be suitable and it is necessary to include the possible structural change in the analysis (Chang-Jin Kim, 2003). Since the early 1980s, models based on economic fundamentals have been poor at explaining the movements, for instance, in the exchange rate markets. This has exploded a blast of interest in time-varying parameter models. One notable set of models are switching regressions with latent state variables, in which parameters move discretely between a fixed number of regimes, with the switching controlled by an unobserved state variable.

Since the publication of James Hamilton's seminal 1989 *Econometrica* paper many authors have employed Markov-switching to model regime change in economic time series. Examples include investigations of business cycle asymmetry (Hamilton, 1989; Lam, 1990), heteroskedasticity in time series of asset prices (Schwert , 1989b and 1996; Garcia and Perron, 1996), the effects of oil prices on U.S. GDP growth (Raymond and Rich, 1997), labor market recruitment (Storer, 1996), the dividend process (Driffill and Sola, 1998), and government expenditure (Rugemurcia, 1995).

A Markov regime-switching model enhances traditional performance measures by allowing an assessment of the investment strategy to dynamic factor exposure through time. The regime-switching model combines several sets of model parameters (coefficients) into one system, and which set of parameters should be applied depends on the regime the system is likely in at certain time. For instance, a two-regime model:

$$Y(t) = \begin{cases} = X(t) \times b_1, S(t) = 1, \\ = X(t) \times b_2, S(t) = 0. \end{cases}$$

S (t) is the state variable which changes through time and cannot be observed by investors. *S (t)* is determined by Markov chain:

$P\ (S_{t+1} = j |\ S_t = i) = p_{ji}$

Markov regime-switching model has been applied in a variety of fields including stock market and asset returns (Turner, Startz, and Nelson 1990) and (Ramaprasad Bhar, 2000).

In terms of the structure of the remaining chapter, following an overview of the relevant methodologies employed by the existing studies of the impact of monetary innovations on stock markets, this work argues for Markov Switching Modelling as an alternative methodological approach to the issue of analysing the above mentioned impact on European financial markets. A prototype Markov Switching Model is then applied to the case of and its empirical results are then presented.

There is mounting evidence that empirical models of many economic time series, particularly macroeconomic and financial series, are characterized by parameter instability. This has sparked an explosion of interest in time-varying parameter models. One notable set of models are switching regressions with unknown sample separation, in which parameters move discretely between a fixed number of regimes, with the switching controlled by an unobserved state variable.

The vast literature spawned by Hamilton (1989) has typically assumed that the regime shifts are exogenous of all realizations of the regression error. However, the earlier literature on switching regressions, such as Maddala and Nelson (1975), was often concerned with endogenous switching, as the primary applications of switching regression models in this literature were in limited dependent variable contexts such as self-selection and market disequilibrium problems.

As pointed out in the previous section, in this chapter we work with switching regressions of the type considered by Hamilton (1989) and various extensions, but relax the exogenous switching assumption. We show that the empirical results from monthly returns on the 11 EMU stock markets indices suggest that, measuring monetary policy innovation as residuals from the Taylor's rule, a contractionary monetary shock strongly lowers stock returns in both bull and bear markets. Furthermore, monetary policy has larger effects on returns in the bear-market regime. This result may provide evidence supporting models which emphasize the important role of finance constraints.

Finally, it has been shown that contractionary monetary policy leads to a higher probability of switching to a bear-market regime. Thus, a tightening monetary policy may depress stock returns in two different ways: it lowers the returns directly and makes the returns more likely to shift to low-return regimes (bear markets).

For both of these estimation techniques, we show that for serially dependent state processes, such as a Markov-switching state process, the lagged state can provide information necessary for identification, providing it is uncorrelated with the current regression error. This is true even though the lagged state is unobserved. Additional information is obtained when the transition probabilities of the switching process are influenced by exogenous variables, as in the so called "time-varying transition probability" case.

Why are we motivated to investigate Markov-switching regressions with endogenous switching? Many of the model's applications are in macroeconomics or finance in situations where it would be natural to assume that the state is endogenous. As an example, in many models the estimated state variable has a strong business cycle correlation, often corresponding with recessions. This can be seen in recent applications of the regime-switching model to identified monetary VARs, such as Sims and Zha (2002) and Owyang (2002). It is not hard to imagine that the shocks to the regression, such as the macroeconomic shocks to the VAR, would be correlated with recessions. As another example, some applications of the model contain parameters that represent the reaction of agents to realization of the state (see for example Turner, Startz and Nelson (1989)). However, it is likely that agents do not observe the state, but instead draw inference based on some information set, the contents of which are unknown to the econometrician. Use of the actual state to proxy for this inference leads to a regression with measurement error in the explanatory variables, and thus endogeneity.

In the next section we examines the asymmetric effects of monetary policy using a modified version of the Markov-switching mode.

4.3 Methodology

The switching process is nowadays frequently used in finance and economics. This kind of process takes into account the changes of state of a time series. In finance for instance, it is well known that the volatility of a time series could change, because of a depression, for example. A large literature exists concerning Markov-switching process. One of its properties is that the change of state has an unique probability. This is due to the Markov definition of the model. Unfortunately, a consequence of this is that it is difficult to control the changes of state. In this respect, our work can be regarded as an extension of the studies Maheu and McCurdy (2000) and in Perez-Quiros and Timmermann (2000), Akifumi Isogai *et* al (2004), and Shiu-Sheng Chen (2005). An additional innovative feature of our study is that it provides a new definition of monetary policy shocks to detect asymmetries in the stock markets returns.

4.3.1 Monetary policy innovation, stock market returns within a Regime-Switching model

As mentioned in paragraph 4.2, the empirical relationship between central bank policy and stock market returns can be relevant under two critical topics that is, in financial and monetary economics. Several proposed monetary transmission mechanisms link changes in central bank policy to the stock market, which in turn affects output via consumer expenditure as well as investment spending. With respect to the former, a decrease in interest rates should boosts stock prices and therefore financial wealth, which should raises consumption through the wealth effect too (Modigliani 1971).

In this section we describe a general econometric framework which allows for regime switching in the dynamics of stock markets returns. We investigate the ability of Markov Switching model to capture asymmetric reactions of stock markets returns to monetary policy shocks under different states of the stock markets. The first specification is:

$$X_{i,t} = \phi_0 s_t + \phi_i s_t X_{i,t-n} + \mu_t \qquad (4.1)$$

Where s_t is governed by an unobservable, discrete, first order Markov chain that can assume *k* values (states), $\mu_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$. and i=1,2,3,…n indexes returns on European Stock markets.

The second specification is given by:

$$X_{i,t} = \phi_0 s_t + \phi_i, s_t X_{i,t-n} + \phi_r, s_t r_t + \varepsilon_t \qquad (4.2)$$

Where s_t is governed by an unobservable, discrete, first order Markov chain that can assume *k* values (states), $\varepsilon_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$. , r_t is the innovation in monetary policy and i=1,2,3,…n indexes returns on European Stock markets.

In what follows, we assume that the ECB's systematic policy is specified by a Taylor rule, as in eq. 3.10 chapter three. A contractionary policy shock is captured by a positive innovation, ω_t. The effects of this policy shock on stock returns has been categorized into two main channels: the money channel and bank leading channel. However, in our study, we are not focusing on identifying those channels. Our aim is to establish that a tighter monetary policy ultimately results in a decrease of stock returns and, as final remark, that the effects of monetary policy on stock returns can be asymmetric. That is, a monetary policy can have different impact in bull and bear markets.

The introduction of Markov switching allows the coefficients ϕ_i in equations (4.1) and (4.2) and ϕ_r to switch between the two different states $S_t = 0$ and $S_t = 1$. If our conjecture that stock markets returns at times has specific effects is correct, the unobserved state variable St is a latent dummy variable equaling either 0 or 1, which indicates bull/bear markets.

Nevertheless, we do not impose neither different signs on the coefficients a priori nor force the process to switch into the other regime at a certain time. The only restriction we impose is that there are two different regimes, while everything else is determined from the data in the estimation.

The series S_t, $t = 1, 2, \ldots, T$ provides information about the regime the economy is in at date t. If S_t were known before estimating the model, we could apply a dummy variable approach. In the Markov-switching approach, however, we assume S_t to be not observed, and we estimate the evolution of the regimes endogenously from the data. It is assumed that the transition between the two states is governed by a first order Markov process with the transition probabilities p and q, which can be summarised in form of a transition matrix P:

$$\begin{bmatrix} p & 1 - q \\ 1 - p & q \end{bmatrix}$$

The transition probabilities are defined as follows:

$$\begin{aligned} p &= \Pr\left[S_t = 1 \middle| S_{t-1} = 1\right] \\ 1 - p &= \Pr\left[S_t = 0 \middle| S_{t-1} = 1\right] \\ q &= \Pr\left[S_t = 0 \middle| S_{t-1} = 0\right] \\ 1 - q &= \Pr\left[S_t = 1 \middle| S_{t-1} = 0\right] \end{aligned}$$

Here we assume a first order Markov process, i.e., the probability of being in a particular state in period t only depends on the state in period t - 1. To force p and q to lie between 0 and 1, and to keep the model set-up for the constant transition probabilities similar to the case of the time-varying transition probabilities, we employ the following specification in the estimation:

$$p = \frac{\exp(p_1)}{1 + \exp(p_1)} \text{ and } q = \frac{\exp(q_1)}{1 + \exp(q_1)}$$

The model can be estimated using an iterative Maximum Likelihood procedure maximising the following likelihood function[48]:

$$\ln L = \sum_{t=1}^{T} \ln \sum_{t=0}^{1} \Pr\left[S_t = i \middle| \Psi_{t-1}\right] \frac{1}{\sqrt{2\pi\sigma(S_t)}} \exp \frac{-\mu^2(S_t)}{2\sigma^2(S_t)}$$

with $\Pr = \left[S_t = i \middle| \Psi_{t-1}\right]$ denoting the probability of being in state 0 or 1 in period t and ψ_{t-1} denoting all available information up to period t – 1.

In general, equation (4.1) is called a MS-AR(k) model.

4.3.2 Description of the Data

All data used in this chapter are nominal and largely follow previous studies on EUM and therefore cover 11 countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Spain

[48] See Appendix 1 for more details about the likelihood function.

and Portugal, respectively. The sample period is January 1992 through September 2005, thus the number of observation is 164. The data set also comprises the monthly stock markets at level of industry portfolio for five single countries, two small, Belgium and Netherlands, and three big countries, France, Germany and Italy in order to check if the magnitude of the impact and/or the timing of been in a specific state could change from country to country and from sector to sector. The Stock markets data aggregate for countries and for industry portfolios are from Datastream. Most of the macroeconomic data we used for the Taylor rules are from the International Financial Statistics databases (IFS), while the sources for the nominal interests rates are from each single Central Bank database. The data are as following.

Figure 4.1 and table 4.1 presents the monetary policy shocks of the EUM countries generated from the residuals of the baseline Taylor rules as presented in chapter three. Results of the estimated Taylor rules before and after the Monetary Union are presented in appendix 2, table A.

Moreover, we work with 11 stock aggregate stock markets returns available at monthly frequency. The first letter of the variables' name identify the country[49], while for the industry portfolios we restrict the number of countries to five (Belgium, France, Germany, Italy and Netherlands) and consider six basic common portfolios industry:

[49] O for Austria, B for Belgium, Fn for Finland, F for France, G for Germany, Gr for Greece, Ir for Ireland, I for Italy, N for Netherlands, P for Portugal and E for Spain.

chemical (CH), industrial (IND), insurance (INS), oil (OIL), technology (TEC) and pharmacy (PH). For three countries (France, Germany and Italy) we look at other two additional industry portfolios: automobile (AU) and telecommunication (TEL).

Figure 4.2a and figure 4.2b show the plots of the 11 aggregate EUM stock markets and stock returns and table 4.2a and 4.2b the relative descriptive statistics.

Figure 4.3 - 4.7 show the plot of the industry portfolio returns for each single country, while table 4.2 – 4.6 the corresponding descriptive statistics.

Finally, as preliminary analysis for the next paragraph we created for the five EU countries series reflecting an upswing or downswing of the economies. There series are generated in order to describe the stage of the business cycle and therefore, they will be used to describe whether the output gap is increasing or decreasing. They will be constructed using the differences of the smoothed output gap[50].

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[50] For the smoothed output gap we have chosen the Hodrick-Prescott filter with a relative small λ =1000 because the objective was to filter out only the short-term movement of the output gap.

Figure 4.7a Business cycles of 5 EUM countries

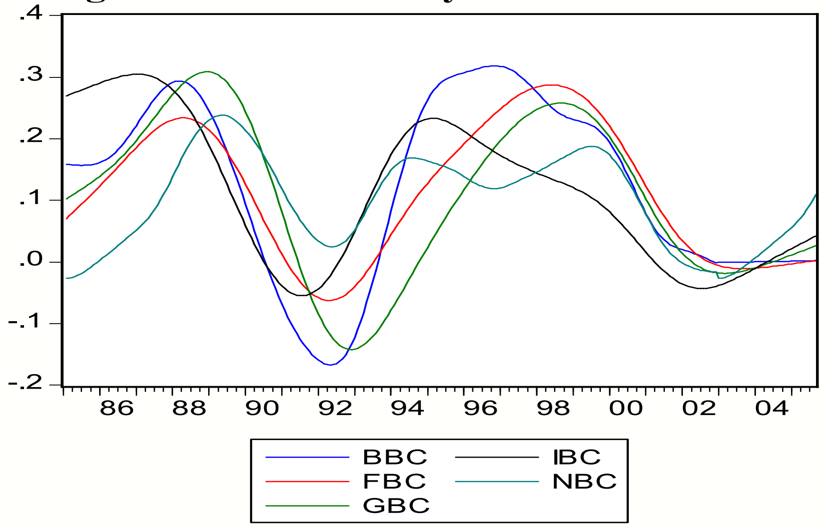

Figure 4.7a plots the paths of the series from 1985 to 2005. The figure shows that overall the countries follow similar business cycle and, most important result for the next section analysis, the convergence process of the business cycle among the countries has increased with the launch of the euro.

4.4 The Empirical Findings

In this section we present an empirical procedure aimed to compare alternative Markov Switching models. It is worth noting that the empirical approach applied here is open-ended. Any kind of results is possible. For instance, we may find evidence that monetary policy innovation has little impact on stock returns in bull markets, in bear markets or both. From another point of view, it may be evident that monetary policy shock has similarly strong effects in both bull and bear markets.

The starting point is to test for the presence of nonlinearities in the data. Unfortunately, testing for the number of regimes in an MS model is difficult. The main problem arises from the presence of unidentified nuisance parameters under the null of linearity, which invalidates the conventional testing procedures. (Krolzig, 1997).

The nuisance parameters give the likelihood surface sufficient freedom so that one cannot reject the possibility that the apparently significant parameters could simply be due to sampling variation. The scores associated with parameters of interest under the alternative may be identically zero under the null.

Davies (1987) derived an upper bound for the significance level of the likelihood ratio test statistic under nuisance parameters. Formal tests of the Markov switching model against the linear alternative employing a standardized likelihood ratio test designed to deliver (asymptotically) valid inference have been proposed by Hansen (1992, 1996a), Garcia (1998), but are computationally demanding.

Alternatively one may use the results of Ang and Bekaert (2002) which indicate that critical values of the χ^2 □$(r+n)$ distribution can be used to approximate the LR test, where r is the number of restricted parameters and n is the number of nuisance parameters. In this work the null hypothesis of linearity against the alternative of a Markov switching will be tested using the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes[51].

The switching process is nowadays frequently used in finance and economics. In finance for instance, it is well known that the volatility of a time series could change, because of a depression, for example generating the so called "bull" and "bear" effects on stock markets. A large literature concerning the Markov-switching process exists. One of its properties is that the change of state has an unique probability. This is due to the Markov definition of the model. Unfortunately, a consequence of this is that it is difficult to control the changes of state.

More formally, we test the null hypothesis of a single-regime model ($\mu 1 = \mu 2$), against the regime switching model of eq. (4.1) and (4.2). Testing the null restriction $\mu 1 = \mu 2$ is not straightforward. For instance, under the null there is in fact only one regime that governs the exchange rate, so that the regime staying probabilities p11 and p22 are not identified. This makes the asymptotic distribution of the usual tests (likelihood ratio, Wald and Lagrange multiplier) no longer $\chi 2$ (Hansen (1992))[52].

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[51] See Hansen, 1992 for details.

[52] A generally applicable solution for the testing problems mentioned above is given by Hansen (1992, 1996). His approach can be summarized as follows. The null restriction is equivalent to $\mu 2 \;\; \mu 1 = 0$. Under this null, p11 and p22 are not identified. Hansen proposes to consider a fixed value for ($\mu 2 \;\; \mu 1$, p11, p22). For this point, maximize the log-likelihood across the other parameters. Subtracting the log-likelihood under the null and dividing this difference by its standard deviation yields

4.4.1 EMU countries' results

We first estimate the model without multiple equilibria using ordinary least squares, in order to test a purely linear model. The parameters estimates, together with associated p-values, likelihood function values and diagnostic statistics of eq. 4.1 are reported in table A4.1 (appendix 2). The results provide strong evidence in favour of a two state regime-switching specification. The explanatory power of the linear models seem to be poor. Some coefficients do not have the expected signs and are statistically not significant. As shown in Table A4.1, the relation improves when the model is estimated taking into account an additional state. The fits of the models are considerably better, as evidenced by a lower σ^2_u and a higher log likelihood. Moreover, the plot in figure 4.8 shows that the models with multiple equilibria seem to capture well the episode of sharp movements in the EUM stock markets returns.

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the standardized likelihood ratio for the (μ2 μ1, p11, p22) under consideration. Hansen's test statistic LR is the supremum of these standardized likelihood ratios over all parameter combinations (μ2 μ1, p11, p22) that are possible under the alternative. In practice Hansen suggests to take the supremum over a finite grid of parameter combinations. The asymptotic p-value of LR is not known by itself, but Hansen shows that it is smaller than or equal to the asymptotic p-value using the distribution of another variable. He advises to use this upper bound, though it makes the test conservative (too few rejections of the null). He also explains how the bound can be approximated via simulation. Finally, the p-value bound depends on a bandwidth number M, and Hansen suggests to compute the p-value for different M (see Hansen (1996) for details). In this work we follow Hansen's method.

The second relevant issue is how to determine the number of states required by each model to be an adequate characterisation of the observed data. Our empirical procedure follows Psaradakis and Spagnolo (2003), who suggest to select the number of regimes using Akaike Information Criterion (AIC hereafter). Using Monte Carlo experiments they show that selection procedures based on the AIC are generally successful in choosing the correct dimension, provided that the sample size and parameter changes are not small. We compute the value of the Akaike information criterion for the linear models and the corresponding Markov switching models in tables A4.1-A4.2 . The values reported indicate that a switching model is favourite for all the EMU countries. Moreover, the two regime models outperform the corresponding single regime models in terms of the residuals diagnostic for linear and non linear dependence.

The coefficients $\phi_{r,1}$ indicate how the stock returns respond to the impact of monetary policy innovation in bull markets. On the other hand, the coefficients $\phi_{r,2}$ can be interpreted as the monetary policy effect on stock returns in bear markets. Now we have to specify how to interpret a monetary policy shock when it is generated as residuals from the Taylor rule. By specifying the ECB policy function as a Taylor rule, we assume that the European Central bank uses the interest rate (the interest rate on the main refinancing operations) as its main monetary policy instrument. In other words, this interest rate is not a state variable, but rather it is the main control variable of the European Central Bank. From this perspective, an unanticipated positive shock to the Taylor rule equation (tighter monetary policy) may results in lower future, expected and realized inflation and, consequently lower stock returns[53]. Looking at table A4.2, the coefficients show that a contractionary monetary policy leads, in most cases, to a decrease in stock return, no matter if the stock market is in bull or bear regime. The two countries with a higher stock returns reaction, as a result of a positive monetary policy innovation, are Italy and Portugal, both for the bear markets. For these two countries, higher stock returns can be explained as a sort of "price puzzle" effect [Sims (1992)]. To the extend that not all the capital market is immediately adjustable to changes of monetary policy, a portion of higher borrowing costs will be passed on to consumers and thereby will result in higher price level at

[53] According to the generalized Fisher hypothesis, equity stocks, which represent claims against the real assets of a business, may serve as a hedge against inflation. Consequently, investors would sell financial assets in exchange for real assets when expected inflation is pronounced. In such a case, stock prices in nominal terms should fully reflect expected inflation and the relationship between these two variables should be found positively correlated ex ante. The literature. Empirical evidence is rather mixed and could be classified into the following three categories: a) Research findings which provide support in favour of a positive relationship between inflation and stock market returns; b) Studies which provide evidence of a negative relationship between the inflation rate and the stock market returns. [Fama, 1981], suggests that there is a negative correlation between stock returns and the level of inflation. The negative relationship exists due to the correlation between inflation and future output. In particular, since stock prices reflect firms' future potential earnings, an economic downturn predicted by a rise in inflation will depress stock prices; c) Studies which provide mixed results. Usually these studies report negative correlations between stock prices and inflation in the short run which are followed by positive correlations in the long run.

short horizons. In this way, can be plausible to consider adjustment of private portfolio choice that, in the short run, can determine a positive stock return reaction to monetary policy shock. Barth and Ramey (2001) labelled this mechanism as the “cost channel”.

Figure 4.8 plots the smoothing probability of state 1 (bull market), the high return state, using estimation of equation 4.3. Simply taking 0.5 as the cut-off value for State 1 or 2, we use the smoothing probability to infer the bull and bear markets. Hence, the period with smoothing probabilities greater than 0.5 are associated to a bear market while, periods with smoothing probabilities less than 0.5 are related to bull markets. In most cases, the smoothing probabilities estimated from nominal returns (figure 4.8) infer consistent periods of bull and bear market.

The smoothed probabilities are conditional on all available returns and the same maximum likelihood estimates. The main thing to notice about the probabilities is that, for Germany, France, Finland, Greece, Belgium, Austria and Netherlands stock markets returns, there are seemingly periodic 3–6-year regime shifts (state 1 or 2) during the period 1991 - 2005. While for the rest of the EUM countries there are also regime shifts (state 1 or 2) in the same period but they come at much less regular intervals 1-3 years.

This historical pattern of regime changes suggests that bull and bear regime from 1991 till 2005 for the EMU countries can be substantially divided into two main groups each one related to the duration of the single regime. As we’ll explain in more details farther in this section, regime durations can play important rule for central bank monetary policy implications.

Furthermore, for the majority of the countries analyzed the results show that a positive monetary policy innovation lowers stock returns. An economic interpretation of this statement could be that when central bank rises short term interest rate, bonds and money market mutual funds look more attractive relative to stocks. In this situation firms have to pay higher rates on their borrowing, which reduces firms earnings. Both of which should, in theory, bring stock markets returns down. However, table A2 shows different signs of $\phi_{r,1}$ and $\phi_{r,2}$ for Italy and Finland. The former country presents a positive sign for the regime 2 (bear market) with a p-value of 0.045 while the latter shows a positive sign for regime 1 (bull market) but with a p-value of 0.036. The variance of the two states (σ^2_{S1} and σ^2_{S2}) changes from country to country. In particular, for Italy, France, Netherlands, Austria, Greece and Finland the variance of state 1 is smaller than the variance of state 2.

Finally, we have to look at the possible asymmetric effects of policy innovation on the aggregate EMU stock returns. The asymmetric effects of monetary policy come out in the estimations since we have $|\phi_{r,2}| > |\phi_{r,1}|$. From table A2 it is also discernible that the asymmetric effect ,$|\phi_{r,2}| > |\phi_{r,1}|$, holds in most cases (Germany, Italy, France, Belgium, Netherlands, Portugal Ireland Greece and Finland,

respectively) implying that changes in monetary policy instrument have a stronger impact during bear markets.
This is in line with results from other empirical studies. In particular, Pagan and Sossounov (2003), Edwards et al. (2003) and Chen (2005). The latter found similar results for the United Stated using monthly returns on the Standard & Poor's S&P 500. He also find that monetary policy has larger effect on stock returns in bear markets.

4.4.2 Five EMU countries industry portfolios results

This section is devoted to the presentation and discussion of our empirical findings for five countries industry portfolios returns: France, Germany, Italy that we define big countries and Belgium and Netherlands that we assume as small countries. As explained in section 4.4.2, for all five countries industry sectors, we consider six basic common portfolios industry: chemical (CH), industrial (IND), insurance (INS), oil (OIL), technology (TEC) and pharmacy (PH). For the three big countries (France, Germany and Italy) we look at other two additional industry portfolios: automobile (AU) and telecommunication (TEL).
Table A3 presents the estimates of regime switching model for the selected countries industry portfolios and monetary policy innovations. Overall, we can asserts that the signs of the coefficients and the asymmetric impact of monetary policy is, in general, similar to the results obtained above for the aggregate stock markets returns.

Germany

According to the estimates smoothed probabilities, regime 1 and 2 are presented in appendix 2, fig 4.13. The main thing to notice about the probabilities is that, for pharmacy, insurance, chemical and telecommunication industry sectors, there are long period about 6–8-years regime 1 from 1991 to 2005 while for the rest of the industry sectors there are also regime shifts (state 1 or 2) in the same period but they come at much less regular intervals 1-5 years.

This historical patterns of regime changes suggest that bull markets (state 1) is the prevailing regime from 1991 till 1999 for most of the German industry sectors.

Furthermore, for all the industry sectors analyzed the results show that a positive monetary policy innovation lowers stock returns. Hence, when ECB rises short term interest rate, bonds and money market mutual funds look more attractive relative to stocks and, in theory, bring stock markets returns down. The variance of the two states (σ^2_{S1} and σ^2_{S2}) changes from sector to sector. In particular, for chemical, industrial, technology, automobile and telecommunication the variance of state 1 is greater than the variance of state 2.

Finally, we have to look at the possible asymmetric effects of policy innovation on the sector returns. The asymmetric effects of monetary policy come out in the estimations since we can have $|\Gamma_{r,2}| \frac{>}{<} |\Gamma_{r,1}|$. From table A3 it is also evident that the asymmetric effect,

$\left|\Gamma_{r,2}\right| > \left|\Gamma_{r,1}\right|$, holds in all cases implying that changes in European monetary policy instrument can have stronger impact in Germany during bear markets.

France

The plot of the estimates smoothed probabilities of regime 1 and 2 are presented in appendix 2, fig 4.11. It is worth pointing out that, there are long period about 4–6 years regimes 1 or 2 from 1991 to 2005 only for oil, chemical, pharmacy and telecommunication sectors, while for the rest of the industry sectors there are also regime shifts (state 1 or 2) in the same period but they come at much less regular intervals 1-3 years.

Figure 4.11 shows that even for France, bear markets (state 2) is the prevailing regime from 1991 till 1999 for most of the industry sectors.

Moreover, for all the industry sectors analyzed the results show that a positive monetary policy innovation lowers stock returns. Hence, a monetary policy shock that rises short term interest rate bring France industry portfolios returns down. The data available for France indicates that the variance of the two states (σ^2_{S1} and σ^2_{S2}) changes from sector to sector. In particular, for pharmacy and automobile the variance of state 1 is greater than the variance of state 2.

Hence, we have to look at the asymmetric effects of monetary policy shock on the sector returns. As above, the asymmetric effects of monetary policy come out in the estimations since we can have

$\left|\Gamma_{r,2}\right| \gtrless \left|\Gamma_{r,1}\right|$. From table A3 it is also patent that the asymmetric effect , $\left|\Gamma_{r,2}\right| > \left|\Gamma_{r,1}\right|$, holds in all cases except for the pharmacy sector implying that changes in European monetary policy instrument can have stronger impact in France during bear markets.

Italy

The results obtained for the Italian sectors are, however, similar to the ones above mentioned for the other two big countries. Fig 4.12 in appendix 2 presents the estimates smoothed probabilities of regime 1 and 2. More precisely, it is worth noting how these probabilities for pharmacy, oil, chemical, technology and telecommunication industry sectors last for long period about 6–8-years regime 1or 2 from 1991 to 2005. While for the rest of the industry sectors there are also regime shifts (state 1 or 2) in the same period but they come at much less regular intervals from 6-12 months to 4 years.

The historical patterns of regime changes for industry sectors suggests that bull markets (state 1) is the prevailing regime for pharmacy (1995-2004), chemical telecommunication from 1991 till 1999, while regime 2 dominates for most of the other industry sectors.

Furthermore, the results of all the industry sectors analyzed, except the oil sector, show that a positive monetary policy innovation lowers stock returns. Hence, when ECB rises short term interest rate it bring stock markets returns down. According to the results obtained for the oil sector, the impact of monetary shocks should have an opposite effects since we found a positive sign for regime 2 (bear market) with a p-value of 0.045. The variance of the two states (σ^2_{S1} and σ^2_{S2}) changes from sector to sector. In particular, for chemical, technology and telecommunication the variance of state 1 is greater than the variance of state 2.

Finally, it is worth pointing out that, looking at the possible asymmetric effects of policy innovation on the sector returns, table A3 indicate that the asymmetric effect , that is $|\Gamma_{r,2}| > |\Gamma_{r,1}|$, holds in all cases except for the industry sector implying that changes in European monetary policy instrument can have stronger impact in Italy during bear markets.

Belgium

This is the first of the two small countries we have considered for our empirical analysis. According to the estimates smoothed probabilities, regime 1 and 2 are presented in appendix 2, fig 4.9. The main thing to notice about the probabilities is that, pharmacy and chemical sectors exhibit the longest period about 8–10-years regime 1 from 1991 to 2005. On the contrary, industry and technology sectors present quite long period of regime 2 at regular intervals 2-8 years from 1997 to 2005.

Furthermore, for all the industry sectors analyzed the results show that a positive monetary policy innovation lowers stock returns. Hence, a monetary policy shock that rises short term interest rate bring Belgian industry portfolios returns down. The variance of the two states (σ^2_{S1} and σ^2_{S2}) changes from sector to sector. In particular, for chemical, pharmacy, industrial and technology the variance of state 1 is greater than the variance of state 2.

Finally, we look at the asymmetric effects of ECB policy innovation on the sector returns. From table A3 it is also discernible that the asymmetric effect, $\left|\Gamma_{r,2}\right| > \left|\Gamma_{r,1}\right|$, holds in all cases implying that changes in European monetary policy instrument can have stronger impact in Belgian industry sectors returns during bear markets.

Netherlands

The empirical results of the last country for the period 1991- 2005 are presented in appendix 2 table A3. In addition, according to the estimates smoothed probabilities, regime 1 and 2 are presented in appendix 2, fig 4.10. The main thing to notice about the probabilities is that, chemical, industry and insurance sectors follow a similar paths and that for them the switch from regime 1 to 2 started in about 1997. Overall, there are long period about 2–6-years regimes 1or 2 from 1991 to 2005. This historical patterns of regime changes give mixed results suggesting that bull and bear markets alternate from 1991 till 2005 for most of the Dutch industry sectors.

Furthermore, for all the industry sectors analyzed, except for chemical and oil sectors, the results show that a positive monetary policy innovation lowers stock returns. Hence, when ECB rises short term interest rate it brings Dutch stock returns down both in bull and bear markets. However, according to the results obtained for the oil and chemical sectors, the impact of monetary shocks should have an opposite effects since we found positive signs for regime 1 (bull market) with a p-value of 0.05 and 0.056 respectively. The variance of the two states (σ^2_{S1} and σ^2_{S2}) for chemical, industrial and insurance sectors of state 1 is greater than the variance of state 2.

Finally, looking at the asymmetric effects of policy shocks on the sector returns, table A3 shows that the asymmetric effect , $|\Gamma_{r,2}| > |\Gamma_{r,1}|$, holds in all cases implying that changes in European monetary policy instrument can have stronger impact in Dutch industries sectors during bear markets.

4.4.3 The expected duration of "bull" and "bear" markets

Finally, tables A4-A6 present the conditional of being in state one or two that is, the expected duration of a typical "bull" and "bear" market in Industry portfolios. The results show a longer duration for the three big countries in bear markets and a substantial similar duration an average (bull 24 months, bear 23 months) for EUM aggregate stock markets returns. In particular, the bear state dominates for six out of eleven EMU countries. More precisely, it is worth noting that different duration implies different impact of monetary policy shock on each single EUM stock market. For instance, tables A2 and A5 show for Netherlands a value of the coefficient $\Gamma_{r,1}$ of -0.081 with a duration of bull market of 18.51 months while for Finland the same coefficient has a positive sign of 0.059 (p-value 0.036) and a duration of 43.47. Clearly, since the EMU countries have common currency and common monetary policy, the same shock tends to move the two stock markets apart in opposite directions. Table A6 extends the analysis to the industry portfolio of the five EMU countries. The following results may be drawn. First of all, oil, insurance and technology sectors present a situation where duration of bull market is grater than bear market for four out of five countries analyzed (except Netherlands for oil, except Belgium for insurance and except Italy for technology). Secondly, analysing pharmacy and chemical sectors we note that duration of bull market is greater than bear market only for two out of five countries. Finally, automobile sector has a duration of bull market greater than bear market only for two out of three countries (except Germany) while telecommunication only for one out of three countries (except Italy and Germany).

4.4.4 Policy implication

The policy implications of the above analysis can be summarized as follows. The result that systematic portion of monetary policy shock has significant impact on stock returns has important policy implications. Investors should be concerned with the unanticipated monetary policy because they will be surprised and the immediate effect of monetary policy shock will be large. Moreover, our findings show that these effects will be larger with bear stock markets. The outcomes observed in this chapter are consistent with the claim by Edwards et al. (2003), Lunde and Timmermann (2004), and Chen (2005).

An interesting feature of the results in Figures 4.8 -4.13 is that, at a first glance, it appears that aggregate stock markets seem to have faced the effects of the launch of the Euro in 1999. On the contrary, single country industry portfolios show that the smooth probability of change in regimes due to the new currency is less pronounced and affect only some industries.

This finding is consistent with the hypothesis that positive monetary policy shock (e.g. contractionary policy) is an event that decrease future cash flow. Moreover, the finding from country size and industry portfolios indicate that monetary policy have larger asymmetric effect in industry portfolios of big countries (Italy, France and Germany) compared to the same industry portfolios of small countries (Netherlands and Belgium). However, the sign of the impact is for both groups the same.

Moreover, if the ECB follows a contractionary monetary policy then the effect on the stock market returns will be lengthier and larger in bear markets. On the other hand, following the same policy, the effect of the ECB policy on the EMU stock markets returns will be smaller in bull markets. The results suggest that monetary policy is not neutral, at least in the short run and, there is some role for anticipated ECB monetary policy to affect the stock market but that this role will also have asymmetric impacts on each single EMU country's stock market.

4.5 Conclusions

This chapter has explored, using Markov switching models, the dynamic relationship between stock market returns and the monetary policy innovation in 11 EUM countries and, in particular, for five countries at each single industry portfolios. Presumably, stock market movements reflect positions taken by market participants based on their assessment about the current state of the economy. Given the forward-looking behaviour of stock market investors, this chapter has explored the possibility of asymmetric effects of centralised monetary policy (ECB) when stock markets are not fully integrated. Stock market returns were represented by nonlinear dynamic factors at the monthly frequency. In the analysis undertaken here, the following important conclusions may be drawn. The findings, in line with results from previous empirical studies, indicate that for the EUM stock markets there is statistically significant relationship between policy innovations and stock markets returns. This finding is consistent with the hypothesis that positive monetary policy shock (e.g. contractionary policy) is an event that decrease future cash flow. Moreover, the finding from country size and industry portfolios indicate that monetary policy have larger asymmetric effect in industry portfolios of big countries (Italy, France and Germany) compared to the same industry portfolios of small countries (Netherlands and Belgium). However, the sign of the impact is for both groups the same.

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Hence, if the ECB follows a contractionary monetary policy then the effect on the stock market returns will be lengthier and larger in bear markets. The results suggest that monetary policy is not neutral, at least in the short run and, there is some role for anticipated ECB monetary policy to affect the stock market but that this role will also have asymmetric impacts on each single EMU country's stock market.

Appendix 1

There are four main challenges in regime-switching model[54]:

1) *Estimation of Parameters.*

Let us consider the time series y_t, its conditional density function $f(y_t \mid Y_{t-1}; \Theta)$, where $Y_{t-1} = \{y_{t-1}, y_{t-2}, ...\}$ is the set of all past observations on y_t and Θ is a parameter vector to be estimated[55]. The simplest two-state case in which the structural changes occur at the particular time T_1, its density function changes to $f(y_t \mid 1, Y_{t-1})$ for T_1 observations and $f(y_t \mid 2, Y_{t-1})$ for other $T - T_1$ observations. The likelihood function is:

$$\prod_{t=0}^{T_1} f(y_t \mid 1, Y_{t-1}) \prod_{t=0}^{T_1} f(y_t \mid 2, Y_{t-2})$$

For example, the time series $y_t = u_i + u_t$, where $u_t \sim i.i.d.\mathrm{N}(0, \sigma_i^2)$.

For $i = 1, 2$, the density function is:

$$f(y_t \mid i, Y_{t-1}) = \frac{1}{\sqrt{2\pi\sigma_i^2}} \exp\left[-\frac{1}{2} \frac{(y_t - u_i)^2}{\sigma_i^2} \right]$$

This setup can be easily extended to the case with multiple structural changes by increasing the possible value of the index i from 2 to any given number J. Here we can replace the index i in the density function $f(y_t \mid i, Y_{t-1})$ by a discrete variable s_t, whose possible values are 1, 2, . . . , J and the density function generalizes to $f(y_t \mid s_t, Y_{t-1})$.

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54 This appendix is extracted from "Estimation of Markov Regime-Switching Model" by Yang Zijian, CCFEA, Essex University.

55 We will denote the density function simply by $f(yt \mid Yt-1)$ for easing the analysis.

Consider this time series $y_t = u_{s_t} + u_t$, where $u_t \sim i.i.d.\mathrm{N}(0, \sigma_i^2)$. The density function becomes:

$$f(y_t \mid s_t, Y_{t-1}) = \frac{1}{\sqrt{2\pi\sigma_{s_t}^2}} \exp\left[-\frac{1}{2}\frac{(y_t - u_{s_t})^2}{\sigma_{s_t}^2}\right]$$

There are *2J* parameters here, which are *J* different means and *J* different variances.

Note that the variable s_t, which can be referred to as regime indicator, is a random variable, it has its own distribution and cannot be observed, which means that we cannot construct the likelihood function by using $f(y_t \mid s_t, Y_{t-1})$[56]. Consequently, we must have the density function $f(y_t \mid Y_{t-1})$ by eliminating the unobserved term s_t. If the past information Y_{t-1} does not help in evaluating the distribution of s_t, we can use an approach here: we name a conditional likelihood $P(s_t, \mid Y_{t-1})$, and multiply it to the conditional density $f(y_t \mid s_t, Y_{t-1})$:

$$f(y_t \mid Y_{t-1}) = \sum_{s_t=1}^{J} f(y_t \mid s_t, Y_{t-1}) \cdot P(s_t \mid Y_{t-1}) \tag{1}$$

The unobserved term s_t eliminated by sum up all the possible values of it. The corresponding likelihood is:

$$\prod_{t=1}^{T} f(y_t \mid Y_{t-1}) = \prod_{t=1}^{T}\sum_{s_t=1}^{J} f(y_t \mid s_t, Y_{t-1}) \cdot P(s_t \mid Y_{t-1})$$

We assume the conditional likelihood $P(s_t, \mid Y_{t-1})$ are fixed values and denoted by π_{s_t}, so we can treat them as parameters as well, just like

[56] $f(yt \mid st, Yt-1)$ should be $f(yt \mid st = j, Yt-1)$, here we suppress the notation.

other parameters. Under these assumptions, we can get the likelihood function:

$$L(\mu_1,\ldots,\mu_J,\sigma_1^2,\ldots,\sigma_J^2,\pi_1,\ldots,\pi_J)=\prod_{t=1}^{T}\sum_{s_t=1}^{J}\frac{\pi_{s_t}}{\sqrt{2\pi\cdot\sigma_{s_t}^2}}\cdot\exp\left[-\frac{1}{2}\frac{(y_t-u_{s_t})^2}{\sigma_{s_t}^2}\right]$$

This example is a simple mean/variance model without dynamics. Now we consider a dynamic model with regime-switching.

Suppose y_t is an AR (p) model with AR coefficients, together with the mean and variance, depending on s_t :

$$y_t=\mu_{s_t}+\sum_{j=1}^{p}\phi_{j,s_t}y_{t-j}+\mu_t,\quad \text{where } u_t\sim i.i.d.\mathrm{N}(0,\sigma_{s_t}^2).$$

The corresponding density function is:

$$f(y_t\mid s_t,Y_{t-1})=\frac{1}{\sqrt{2\pi\sigma_{s_t}^2}}\cdot\exp\left[-\frac{\mu_t^2}{2\sigma_{s_t}^2}\right]$$

$$=f(y_t\mid s_t,y_{t-1},\ldots,y_{t-p}),$$

where

$$\mu_t=y_t-\mu_{s_t}-\sum_{j=1}^{p}\phi_{j,s_t}y_{t-j}.$$

The density function of y_t now depends on p terms in Y_{t-1} in addition to s_t.

So far we have assumed the density function $f\ (y_t\mid s_t\ ,\ Y_{t-1})$ depends only on the current value of the regime indicator s_t. However, the time series y_t in many cases is affected by the past values of s_t. In other words, it is usually necessary to allow the density function of y_t to depend on not only the current value but also the past values of the regime indicator s_t so that it must be written as

$$f(y_t \mid s_t, S_{t-1}, Y_{t-1}),$$

where $S_{t-1} = \{s_{t-1}, s_{t-2}, \ldots\}$ is the set of all the past information on s_t.

Now consider the generalized model of above example, which includes ARCH terms.

Suppose y_t is an AR (p)-ARCH (n) model with the mean, AR and ARCH coefficients depending on s_t:

$$y_t = \mu_{s_t} + \sum_{j=1}^{p} \phi_{j,s_t} y_{t-j} + \mu_t,$$

$$\mu_t = \sqrt{h_t}\upsilon_t, \qquad \text{where } \upsilon_t \sim i.i.d.\mathrm{N}(0, \sigma_{s_t}^2).$$

$$h_t = \omega_{s_t} + \sum_{j=1}^{n} \alpha_{j,s_t} \mu_{t-j}^2,$$

then the density function is:

$$f(y_t \mid s_t, Y_{t-1}) = \frac{1}{\sqrt{2\pi\left(\omega_{s_t} + \sum_{j=1}^{n} \alpha_{j,s_t} u_{t-j}^2\right)}} \cdot \exp\left[-\frac{1}{2}\frac{u_t^2}{\left(\omega_{s_t} + \sum_{j=1}^{n} \alpha_{j,s_t} u_{t-j}^2\right)}\right]$$

$$= f(y_t \mid s_t, y_{t-1}, \ldots, y_{t-p-n}),$$

where

$$u_{t-j} = y_{t-j} - \mu_{s_{t-j}} - \sum_{k=1}^{p} \phi_{k,s_{t-j}} y_{t-j-k}, \text{ for } j = 0, 1, \ldots, n.$$

Since both s_t and its past values S_{t-1} in the conditional density $f(y_t \mid s_t, S_{t-1}, Y_{t-1})$ are unobservable, we now need to specify the more complicated conditional probability $P(s_t\ ,\ S_{t-1}|\ Y_{t-1})$ to conduct the following calculation:

$$f(y_t \mid Y_{t-1}) = \sum_{s_t, S_{t-1}} f(y_t \mid s_t, S_{t-1}, Y_{t-1}) \cdot P(s_t, S_{t-1} \mid Y_{t-1}),$$

where the summation runs through all the possible values of s_t as well as every term in S_{t-1}. Hamilton (1989, 1993, and 1994) concentrates on simpler cases where S_{t-1} contains only finitely many terms.

Hamilton Approach

Hamilton confines his analysis to the cases where the density function of y_t depends only on finitely many past values of s_t :

$$f(y_t \mid s_t, S_{t-1}, Y_{t-1}) = f(y_t \mid s_t, s_{t-1}, \ldots, s_{t-m}, Y_{t-1}) \qquad (2)$$

for some finite integer m, and the corresponding conditional likelihood is $P(s_t,s_{t-1}, \ldots, s_{t-m}|\ Y_{t-1})$, he starts with the assumption that s_t follows a first-order Markov chain:

$$P(s_t \mid S_{t-1}, Y_{t-1}) = P(s_t \mid s_{t-1}) \equiv p_{s_{t-1}s_t}$$

where $p_{s_{t-1}s_t}$, which is called the transition probability, is specified as a constant coefficient that is independent of time t (time-invariant). The conditional likelihood $P\ (s_t\ , \ldots, s_{t-m}|\ Y_{t-1})$ can then be calculated iteratively through two equations as follows:

$$P(s_t, \ldots, s_{t-m} \mid Y_{t-1}) = \sum_{s_{t-m-1}=1}^{J} P(s_t \mid s_{t-1}, \ldots, s_{t-m-1}, Y_{t-1}) \cdot P(s_{t-1}, \ldots, s_{t-m-1} \mid Y_{t-1})$$

$$= \sum_{s_{t-m-1}=1}^{J} p_{s_{t-1}s_t} \cdot P(s_{t-1}, \ldots, s_{t-m-1} \mid Y_{t-1})$$

$$=\begin{cases} p_{s_{t-1}s_t}\cdot P(s_{t-1},\ldots,s_{t-m}\mid Y_{t-1}), m>0, \\ \sum_{s_{t-1}}^{J} p_{s_{t-1}s_t}\cdot P(s_{t-1}\mid Y_{t-1}), m=0 \end{cases} \tag{3}$$

for $t = 2, 3. \ldots, T$. Note that the left-hand side term $P(s_t, \ldots, s_{t-m}| Y_{t-1})$ differs from the second term on the right-hand side $P(s_{t-1}, \ldots, s_{t-m-1}| Y_{t-1})$ in that all of the s_t terms are one period ahead. The term $P(s_{t-1}, \ldots, s_{t-m-1}| Y_{t-1})$, in which the first s_{t-1} term and Y_{t-1} are both subscripted by the same period of time, is then computed as follows:

$$P(s_t,\ldots,s_{t-m}\mid Y_t)=\frac{f(y_t\mid s_t,\ldots,s_{t-m},Y_{t-1})\cdot P(s_t,\ldots,s_{t-m}\mid Y_{t-1})}{\sum_{s_t=1}^{J}\Lambda\sum_{s_{t-m}=1}^{J}f(y_t\mid s_t,\ldots,s_{t-m},Y_{t-1})\cdot P(s_t,\ldots,s_{t-m}\mid Y_{t-1})}$$

$$=\frac{f(y_t\mid s_t,\ldots,s_{t-m},Y_{t-1})\cdot P(s_t,\ldots,s_{t-m}\mid Y_{t-1})}{f(y_t\mid Y_{t-1})} \tag{4}$$

for $t = 1, 2, \ldots, T$. Giving initial values $P(s_1, s_o, s_{-1}, \ldots, s_{-(m-1)}| Y_o)$, we can calculate $P(s_t,\ldots,s_{t-m}\mid Y_{t-1})$ by using (3) and (4) iteratively.

Now the problem is how to determine the initial values for these equations. Here are some useful approaches.

Initial Values: To determine the J_{m+1} initial values $P(s_1, s_o, s_{-1}, \ldots, s_{-(m-1)}| Y_o)$, we first note that if we further assume that

$P(s_{-j}\mid s_{-j-1},s_{-j-2},\ldots,Y_o)=P(s_{-j}\mid s_{-j-1})\equiv P_{s_{-j-1}s_{-j}},$

for $j = 0, 1, 2, \ldots$, then we have

$$P(s_1,s_o,s_{-1},\ldots,s_{-(m-1)}\mid Y_o)=p_{s_os_1}\cdot p_{s_{-1}s_o}\Lambda\ p_{s_{-(m-1)}s_{-(m-2)}}\cdot P(s_{-(m-1)}\mid Y_o)$$

Hence, given the m terms of transition probabilities $p_{s_os_1}\cdot p_{s_{-1}s_o}\Lambda\ p_{s_{-(m-1)}s_{-(m-2)}}$, we have to determine J values for the

$P(s_{-(m-1)} | Y_o)$ term for the J possible states of $s_{-(m-1)}$. The easiest approach is to assume they are some given constants such as the same number $J-1$ for each of them. An alternative is to make them fixed parameters just like the way we assume transition probabilities $p_{s_{t-1}s_t}$ are fixed parameters.

A third and more elaborate approach is based on the assumption $P(s_{-(m-1)} | Y_o) = P(s_{-(m-1)})$ and the relationship between the unconditional probabilities $P(s_t)$ of the first-order Markov chain s_t and its transition probabilities $P(s_t | s_{t-1}) = p_{s_{t-1}s_t}$. To see how it works, let us first put the transition probabilities $P(s_t = j | s_{t-1} = i) = p_{ij}$, for all possible i and j, into a $J \times J$ matrix as follows:

$$\underset{J\times J}{\mathrm{P}} = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{J1} \\ p_{12} & p_{22} & \cdots & p_{J2} \\ \vdots & \vdots & & \vdots \\ p_{1J} & p_{2J} & \cdots & p_{JJ} \end{bmatrix},$$

which will be referred to as the transition matrix of s_t.

After we specify $f(y_t | s_t, s_{t-1}, \ldots, s_{t-m}, Y_{t-1})$ and $P(s_t, s_{t-1}, \ldots, s_{t-m} | Y_{t-1})$, the calculation of the density function of yt can then be simplified to

$$f(y_t | Y_{t-1}) = \sum_{s_t=1}^{J} \cdots \sum_{s_{t-m}=1}^{J} f(y_t | s_t, \ldots, s_{t-m}, Y_{t-1}) \cdot P(s_t, \ldots, s_{t-m} | Y_{t-1}). \tag{5}$$

The likelihood function for the (quasi) maximum likelihood estimation is then

$$\prod_{t=1}^{T} f(y_t \mid Y_{t-1}). \qquad (6)$$

It should be emphasized that, besides those original parameters in the conditional density function $f(y_t \mid s_t, s_{t-1}, \ldots, s_{t-m}, Y_{t-1})$, the J ($J - 1$) transition probabilities $p_{s_{t-1}s_t}$ will also have to be estimated. Furthermore, if the probabilities $P(s_{-(m-1)} \mid Y_o)$ are treated as parameters, then the number of parameters to be estimated will be increased by J.

A big challenge here is that the likelihood function is usually ill behaved with many local maxima. In the process of searching the global maximum, we must use any of the iterative numerical algorithms for nonlinear optimization, and we should try alternative initial values as many as possible to get the solution that really yields the largest likelihood value.

Another important thing must be noted in practice. When the number of regimes is greater than two, another common problem with the estimation is that some of the transition probabilities $p_{s_{t-1}s_t}$ may not be estimable simply because the data do not include the corresponding cases of switching. For example, if in the sample we do not observe any switching from regime 1 to regime 3, then the transition probability P_{13} from regime 1 to regime 3 is unidentified and cannot be estimated. We would not know this before estimation so that the estimation inevitably involves many rounds of time-consuming unsuccessful experiments until we can finally get those transition probabilities that have to be assigned with the zero value a priori and excluded from estimation.

2) Filtering Problem.

Having $P\ (s_t, s_{t-1}, \ldots, s_{t-m} |\ Y_t)$, we can eliminate the $s_t, s_{t-1}, \ldots, s_{t-m}$ terms as follows:

$$P(s_t \mid Y_t) = \sum_{s_{t-1}=1}^{J} \Lambda \sum_{s_{t-m}}^{J} P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_t)$$

This is called the filtering probability. Basing on observation it can "filter out" the unobserved state of world.

3) Predicting Problem.

In the same way, we can also calculate all the predicting probability. The probability $P(s_t \mid Y_r)$ becomes to predicting probability as we restrict r < t. For instance, the one-step ahead predicting probability $P(s_t \mid Y_{t-1})$ can be calculated by "integrating out" the $s_t, s_{t-1}, \ldots, s_{t-m}$ terms in $P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_{t-1})$:

$$P(s_t \mid Y_{t-1}) = \sum_{s_{t-1}=1}^{J} \Lambda \sum_{s_{t-m}}^{J} P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_{t-1})$$

4) Smoothed Problem.

On the other hand, when r > t, we can have the so-called smoothed probability $P(s_t \mid Y_r)$. This is for retrieving all the past states of the world. For example, $P(s_{t-j} \mid Y_r)$, for *j = 1, 2, ..., m*, can be easily calculated as

$$P(s_{t-j} \mid Y_t) = \sum_{s_t=1}^{J} \Lambda \sum_{s_{t-j+1}=1}^{J} \sum_{s_{t-j-1}=1}^{J} \Lambda \sum_{s_{t-m}=1}^{J} P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_t)$$

A special smoothed probability $P(s_t \mid Y_T)$, which is based on all T observations of y_t, can be calculated as (Hamilton, 1989)

$$P(s_t \mid Y_T) = \sum_{s_{t-1}=1}^{J} \Lambda \sum_{s_{t-m}}^{J} P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_T)$$

where

$$P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_T) = P(s_t, s_{t-1}, \ldots, s_{t-m} \mid Y_t) \prod_{j=t+1}^{T} \frac{f(y_j \mid s_t, \ldots, s_{t-m}, Y_{j-1})}{f(y_j \mid Y_{j-1})}$$

Once the parameter estimates are obtained, we usually compute all the filtering probabilities $P(s_t \mid Y_t)$ and smoothed probabilities $P(s_t \mid Y_T)$. These probabilities can help us decide which regime y_t belongs to at each point of time. We will generally infer that y_t is in state j if $P(s_t = j \mid Y_t) = \max_k P(s_t = k \mid Y_t)$ or $P(s_t = j \mid Y_T) = \max_k P(s_t = k \mid Y_T)$. In most applications filtering probabilities and smoothed probabilities would lead to very similar conclusions.

Appendix 2

Table A GMM Estimates of EUM Forward Looking Taylor Rules, 1985:01-2005:09

	Belgium	**Italy**	**France**	**Germany**	**Netherlands**	**Ireland**
Coefficients						
α	0.977**	0.973**	0.982***	1.008**	1.021**	0.976***
β	1.523*	1.166***	1.360**	1.352**	1.192**	1.794**
γ	0.770*	0.179**	0.175**	0.818**	0.889***	0.924**
$\sum_{i=1}^{l} \varphi_i$	0.509***	0.928**	0.601**	0.986*	0.916**	0.905**
J-stat	0.192	0.201	0.091	0.114	0.110	0.142
	Greece	**Spain**	**Portugal**	**Finland**	**Austria**	
α	0.983*	0.970***	0.974*	0.972**	0.849**	
β	1.570**	1.789**	1.014*	1.122**	1.754**	
γ	0.252**	0.806**	0.740**	0.305***	0.144*	
$\sum_{i=1}^{l} \varphi_i$	0.845**	0.838***	0.946**	0.901**	0.916**	
J-stat	0.067	0.237	0.155	0.088	0.099	

Note:

1) Estimates are obtained by GMM estimation with correction for MA(12) autocorrelation. Two-stage least squares estimation is employed to obtain the initial estimates of the optimal weighting matrix;
2) In the benchmark model the instruments used are a constant and lags 1 to 6 of the nominal short term interest rate, inflation, output gap, and a world commodity price index (agricultural raw materials);
3) *J*-stat denotes the test statistic for over-identifying restrictions;
4) *, **, *** indicate level of significance of 10%, 5%, and 1% respectively.

Figure 4.1 EUM Monetary Policy Innovations

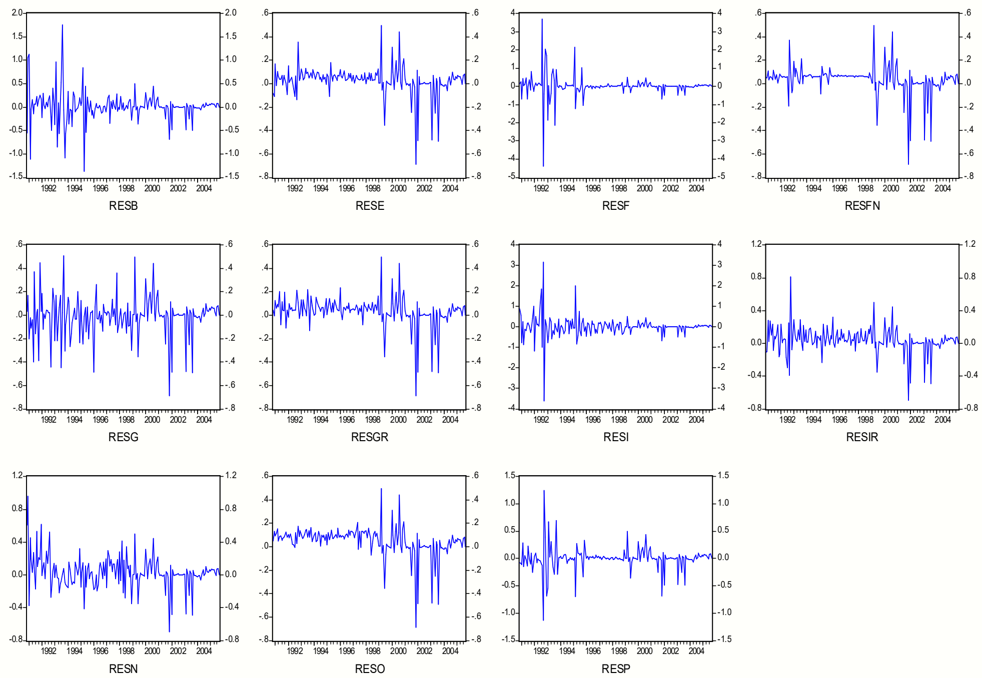


Table A4.1 Descriptive Statistics

	RESB	*RESF*	*RESG*	*RESI*	*RESN*	*RESP*
Mean	0.007234	0.006425	-0.01062	0.013253	0.032798	0.001138
Maximum	1.756936	3.673407	0.507469	3.145871	0.957323	1.250975
Minimum	-1.37516	-4.39936	-0.69083	-3.626	-0.69083	-1.13618
Std. Dev.	0.324252	0.603905	0.169519	0.517224	0.198521	0.218071
Skewness	0.367819	-0.80192	-0.58055	-0.22753	0.44844	-0.06727
Kurtosis	11.2898	27.41001	6.070841	24.40911	6.964946	14.30409
Jarque-Bera	516.5784	4463.223	80.38749	3420.07	123.2504	953.1793
Observations	179	179	179	179	179	179

	RESFN	*RESGR*	*RESIR*	*RESO*	*RESE*
Mean	0.003428	0.003309	0.003753	0.004997	0.002781
Maximum	0.498592	0.498592	0.498592	0.498592	0.498592
Minimum	-0.69083	-0.69083	-0.69083	-0.69083	-0.69083

Std. Dev.	0.111738	0.111755	0.112176	0.111759	0.111743
Skewness	-2.0191	-2.01495	-2.00245	-2.06014	-2.00142
Kurtosis	19.51745	19.49642	19.23867	19.61722	19.46694
Jarque-Bera	2156.451	2150.774	2086.347	2186.102	2141.905
Observations	179	179	179	179	179

Figure 4.2a EUM stock markets

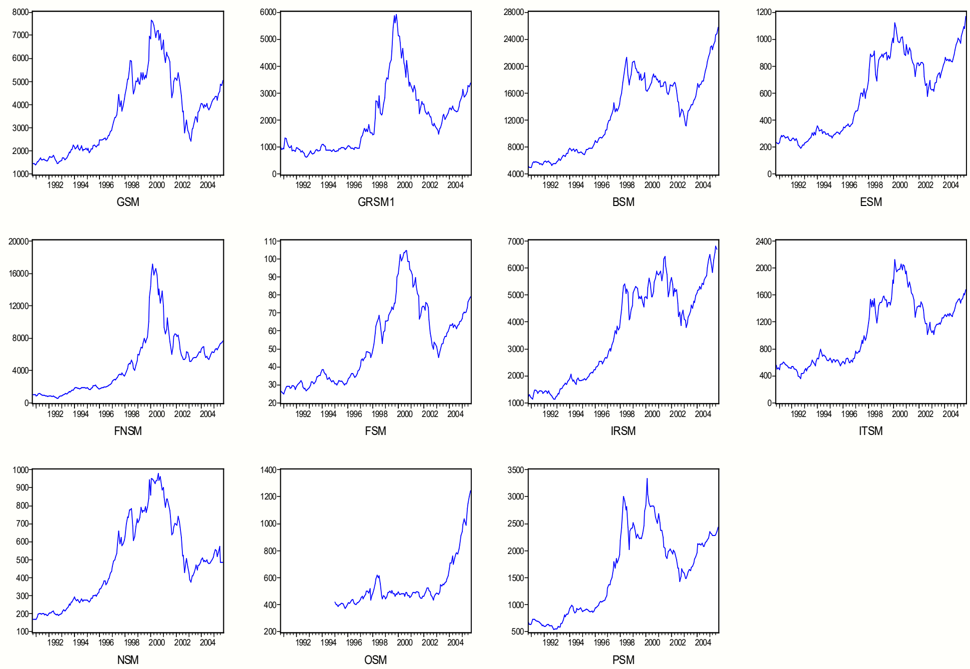


Table A4.2.a	BSM	ESM	FNSM	FSM	GRSM1	GSM
Mean	15494.13	727.1649	6177.352	61.22305	2432.627	4300.214
Maximum	24829.78	1123.75	17092	104.62	5921.98	7644.5
Minimum	6859.35	268.85	1648	29.89	833.01	1922.6
Std. Dev.	4352.891	234.4982	3668.544	20.14986	1223.187	1469.295
Skewness	-0.286502	-0.580279	1.160491	0.311682	0.884933	0.340245
Kurtosis	2.37914	2.197354	4.124626	2.417572	3.46556	2.354426
Jarque-Bera	3.806935	10.61939	35.47597	3.881623	17.86225	4.692435
Observations	128	128	128	128	128	128

	IRSM	ITSM	NSM	OSM	PSM
Mean	4455.622	1254.327	589.6066	537.9906	1926.103
Maximum	6810.94	2124.43	978.54	1200.8	3332.3
Minimum	1849.48	552.77	264.71	372.9	863.3
Std. Dev.	1338.828	422.2817	194.7748	168.4807	610.4763
Skewness	-0.529403	-0.055399	0.251157	2.147047	-0.19859
Kurtosis	2.20288	2.170524	2.045031	7.169113	2.224132
Jarque-Bera	9.367845	3.734968	6.209524	191.044	4.051857
Observations	128	128	128	128	128

Figure 4.2b EUM stock market returns

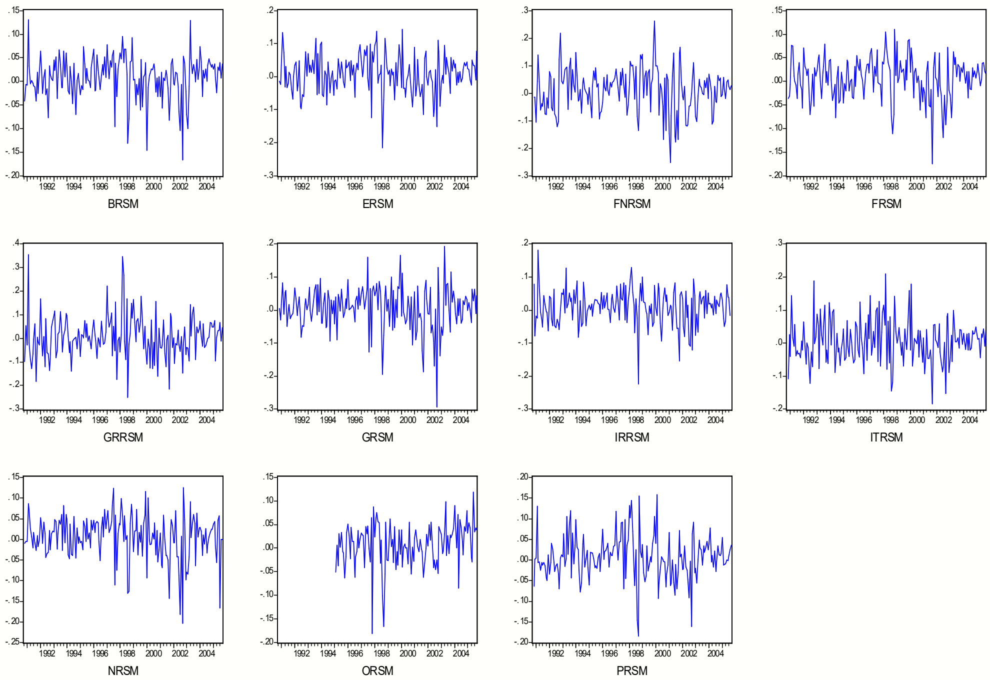


Table A4.2.b	BRSM	ERSM	FNRSM	FRSM	GRRSM	GRSM
Mean	0.009917	0.010592	0.010898	0.007322	0.010674	0.006859
Maximum	0.12895	0.142338	0.261512	0.110146	0.345946	0.193712
Minimum	-0.166222	-0.215142	-0.252379	-0.175032	-0.251423	-0.293327
Std. Dev.	0.04673	0.057274	0.082455	0.045706	0.088068	0.071515
Skewness	-1.115531	-0.633864	-0.32055	-0.810926	0.344694	-0.860137
Kurtosis	5.278176	4.567498	3.658103	4.659231	4.786899	5.365104
Jarque-Bera	53.80421	21.5063	4.466744	28.48743	19.41124	45.25995
	127	127	127	127	127	127

Observations

	IRRSM	ITRSM	NRSM	ORSM	PRSM
Mean	0.010129	0.006978	0.00453	0.00829	0.007861
Maximum	0.129283	0.20825	0.125561	0.118795	0.158557
Minimum	-0.223708	-0.184827	-0.204473	-0.180821	-0.18477
Std. Dev.	0.052757	0.06455	0.059555	0.045592	0.0553
Skewness	-1.138054	0.187189	-0.956964	-0.973851	-0.183155
Kurtosis	5.720889	3.85522	4.408987	5.746347	4.72238
Jarque-Bera	66.58984	4.612002	29.88927	59.98617	16.40828
Observations	127	127	127	127	127

Figure 4.3 Belgium Industry portfolios

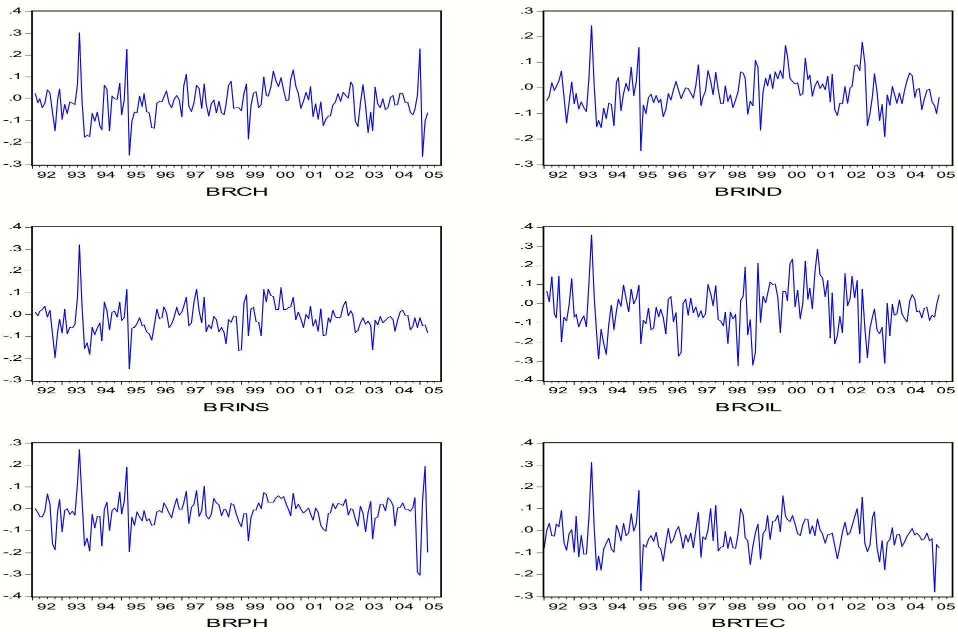


Table A4. 3	BRCH	BRIND	BRINS	BROIL	BRPH	BRTEC
Mean	-0.017412	-0.015464	-0.019222	-0.029575	-0.014361	-0.020977
Maximum	0.303066	0.242961	0.319522	0.358082	0.269138	0.311411
Minimum	-0.261981	-0.245243	-0.248256	-0.323542	-0.302397	-0.27932
Std. Dev.	0.078599	0.071047	0.068491	0.121378	0.072961	0.075433
Skewness	0.254573	0.207847	0.417339	0.035417	-0.589561	0.231564
Kurtosis	5.398965	4.240589	6.660879	3.464403	6.91801	5.992061
Jarque-Bera	39.8445	11.34108	93.40403	1.462054	110.91	60.73082
Observations	159	159	159	159	159	159

Figure 4.4 France Industry portfolios

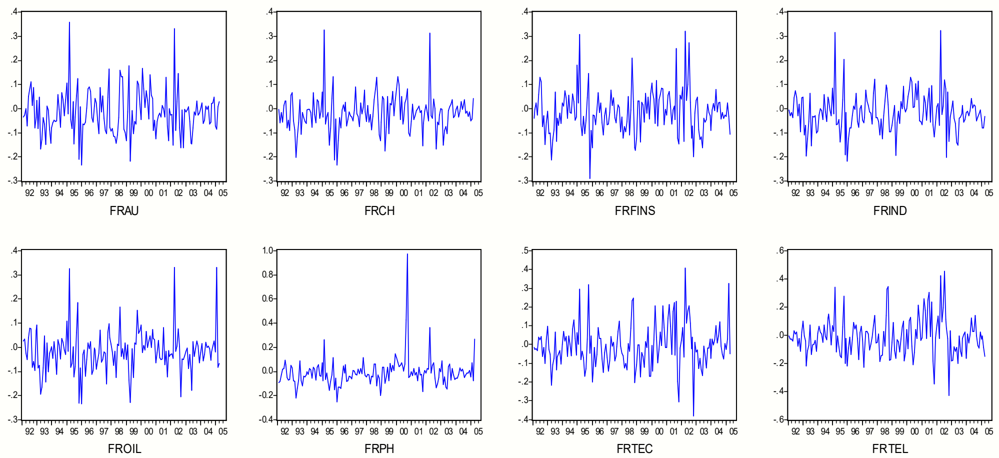


Table A4. 4	FRAU	FRCH	FRFINS	FRIND	FROIL	FRPH	FRTEC	FRTEL
Mean	-0.017438	-0.019247	-0.013494	-0.015475	-0.016441	-0.011559	-0.00705	-0.00837
Maximum	0.356199	0.326519	0.320757	0.323368	0.33072	0.9726	0.406546	0.454317
Minimum	-0.234473	-0.234396	-0.28894	-0.217324	-0.233647	-0.250105	-0.38145	-0.42807
Std. Dev.	0.090861	0.07426	0.091041	0.080126	0.085705	0.116447	0.11649	0.134647
Skewness	0.792515	0.822405	0.653462	0.743927	0.887723	4.303758	0.530068	0.598803
Kurtosis	5.101682	7.784851	5.129369	6.095479	7.068856	35.35974	4.52386	4.52699
Jarque-Bera	45.61846	168.5346	41.0949	77.65503	129.743	7381.508	22.68643	24.79258
Observations	158	158	158	158	158	158	158	158

Figure 4.5 Germany Industry portfolios

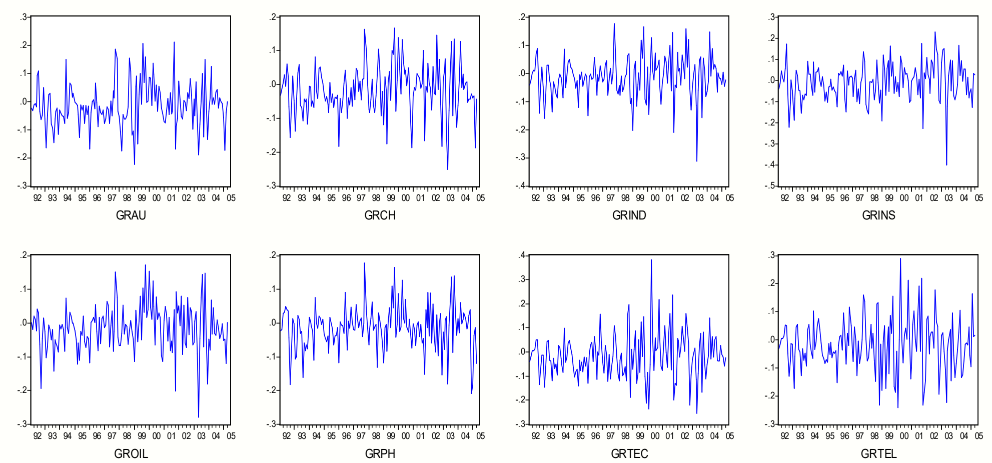


Table A 4. 5	GRAU	GRCH	GRIND	GRINS	GROIL	GRPH	GRTEC	GRTEL
Mean	-0.013979	-0.016489	-0.014381	-0.009882	-0.015145	-0.013875	-0.01738	-0.01752
Maximum	0.211476	0.167807	0.177056	0.229835	0.171709	0.177913	0.381253	0.290312
Minimum	-0.224669	-0.250841	-0.311751	-0.400582	-0.280174	-0.208208	-0.25417	-0.24019
Std. Dev.	0.077549	0.072326	0.071942	0.087786	0.067669	0.063565	0.092119	0.092126
Skewness	0.33295	-0.120948	-0.351919	-0.441804	-0.200165	-0.197849	0.591741	0.19137
Kurtosis	3.697705	3.733257	4.838248	4.883882	4.547679	4.350743	4.962403	3.64276
Jarque-Bera	6.162679	3.949694	25.66885	28.68475	16.93068	13.12468	34.79224	3.707554
Observations	159	159	159	159	159	159	159	159

Figure 4.6 Italy Industry portfolios

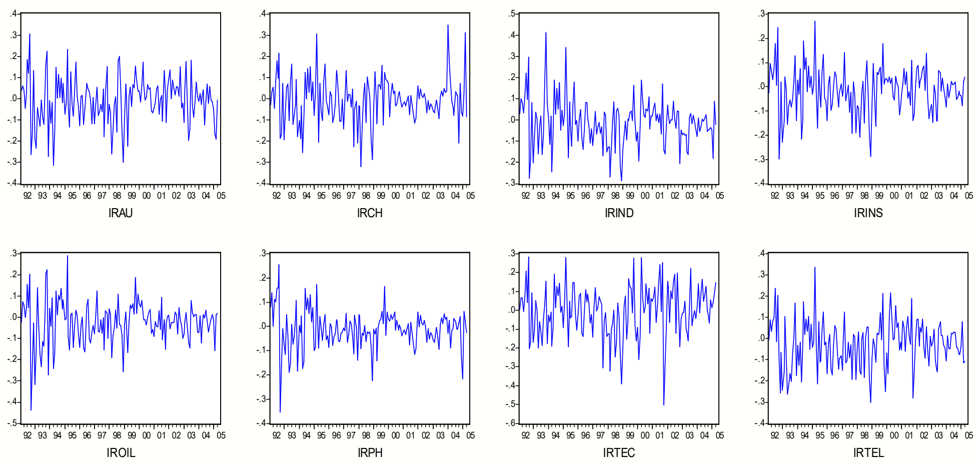


Table A4. 6	IRAU	IRCH	IRIND	IRINS	IROIL	IRPH	IRTEC	IRTEL
Mean	-0.006359	-0.006739	-0.012048	-0.015846	-0.023564	-0.01144	-0.00451	-0.02588
Maximum	0.305898	0.347689	0.412445	0.268807	0.289575	0.255082	0.283929	0.335031
Minimum	-0.313488	-0.320284	-0.287141	-0.297088	-0.438733	-0.352417	-0.50316	-0.30078
Std. Dev.	0.108877	0.104962	0.109035	0.093262	0.100992	0.079651	0.133889	0.110692
Skewness	-0.239661	0.101487	0.374228	-0.176032	-0.450445	-0.400638	-0.46137	0.045305
Kurtosis	3.41567	4.314768	4.665008	3.784427	5.021118	5.505607	3.762692	3.237734
Jarque-Bera	2.666773	11.72502	22.0774	4.897695	32.43946	45.84575	9.49457	0.428821
Observations	159	159	159	159	159	159	159	159

Figure 4. 7 Netherlands Industry portfolios

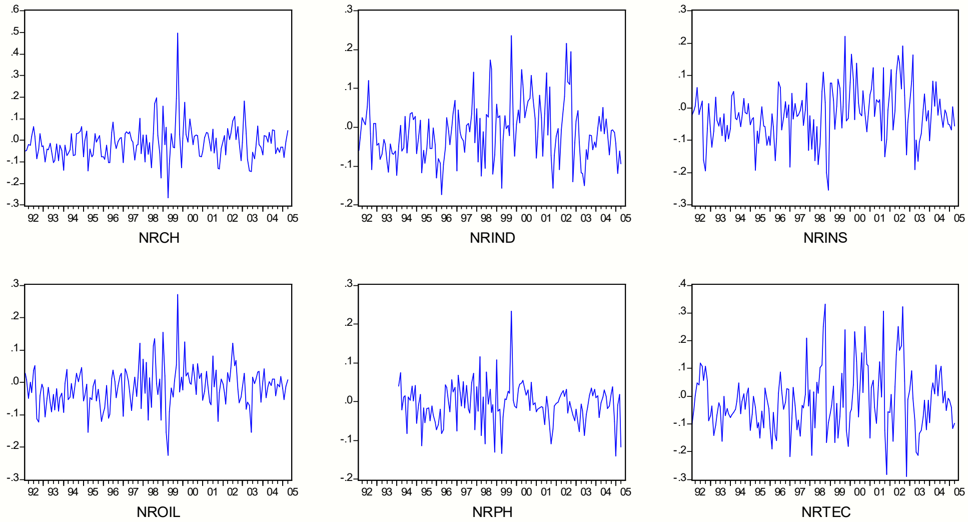


Table A4. 7	NRCH	NRIND	NRINS	NROIL	NRPH	NRTEC
Mean	-0.007302	-0.008704	-0.014302	-0.011144	-0.006478	-0.014297
Maximum	0.497245	0.235593	0.221758	0.271802	0.233673	0.33096
Minimum	-0.266657	-0.173929	-0.253623	-0.226727	-0.139719	-0.289963
Std. Dev.	0.085733	0.077462	0.085199	0.064869	0.051691	0.117445
Skewness	1.525559	0.544815	0.025067	0.365946	0.329941	0.60442
Kurtosis	11.31103	3.573919	3.266119	5.812789	5.954503	3.719965
Jarque-Bera	440.9022	8.531296	0.412496	47.51689	51.55048	11.1355
Observations	158	158	158	158	135	158

Table A1

Estimates of Regime Switching Model for European Stock Markets Returns

This table reports estimation results for the model

$$X_{i,t} = \phi_{0,s_t} + \phi_i X_{i,t-n} + \mu_t$$

Where s_t is governed by an unobservable, discrete, first order Markov chain that can assume k values (states), $\mu_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$. and i=1,2,3,…n indexes returns on European Stock markets. Data are monthly and obtained from Datastream, IMF - Financial Statistics and National Central Banks datasets. The sample period is 1991:01 – 2005:09. P-values are reported in parentheses.

	Italy		*Germany*		*France*		*Spain*	
Parameter	Linear	Markov	Linear	Markov	Linear	Markov	Linear	Markov
$\phi_{0,1}$	0.007 (0.148)	0.006 (0.000)	0.007 (0.150)	0.0358 (0.000)	0.004 (0.162)	0.005 (0.000)	0.008 (0.049)	0.009 (0.000)
$\phi_{0,2}$		0.059 (0.003)		0.023 (0.016)		0.034 (0.000)		0.021 (0.001)
ϕ_i	-0.049 (0.509)	-0.021 (0.001)	-0.006 (0.963)	0.042 (0.002)	0.307 (0.000)	0.345 (0.001)	0.075 (0.318)	0.078 (0.085)
p_{11}		0.909		0.980		0.977		0.902
p_{22}		0.943		0.990		0.943		0.886
σ^2_u	0.0041	0.004	0.0043	0.004	0.0027	0.0019	0.0035	0.003
σ^2_{S1}		0.034		0.0854		0.035		0.071)
σ^2_{S2}		0.078		0.0421		0.059		0.036
Log-likelihood	235.59	246.76	294.21	296.39	258.66	261.36	259.28	259.40
AIC	-2.62	-2.73	-2.61	-2.65	-3.57	-3.77	-2.89	-2.88
LR test	9.54 (0.068)		15.89 (0.013)		21.73 (0.012)		17.40 (0.063)	

The bottom row concerns the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992)'s method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

	Belgium		Netherlands		Austria		Portugal	
Parameter	Linear	Markov	Linear	Markov	Linear	Markov	Linear	Markov
$\phi_{0,1}$	0.008 (0.020)	0.021 (0.000)	0.006 (0.163)	0.121 (0.000)	0.002 (0.000)	0.019 (0.112)	0.006 (0.114)	0.016 (0.000)
$\phi_{0,2}$		0.033 (0.005)		0.063 (0.003)		0.054 (0.010)		0.008 (0.001)
ϕ_i	0.164 (0.027)	0.147 (0.000)	0.044 (0.562)	0.040 (0.000)	-0.126 (0.000)	0.036 (0.000)	0.186 (0.012)	0.092 (0.005)
p_{11}		0.892		0.944		0.972		0.89
p_{22}		0.958		0.904		0.945		0.92
σ^2_u	0.002	0.0015	0.0029	0.022	0.009	0.002	0.003	0.002
σ^2_{S1}		0.065		0.033		0.033		0.074
σ^2_{S2}		0.033		0.075		0.065		0.029
Log-likelihood	306.37	310.89	238.90	239.24	253.54	255.72	287.75	288.97
AIC	-3.41	-3.45	-2.99	-3.28	-1.82	-2.63	-3.06	-3.37
LR test	12.77 (0.052)		18.59 (0.047)		15.26 (0.096)		9.91 (0.061)	

The bottom row concerns the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992)'s method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

	Ireland		Greece		Finland	
Parameter	Linear	Markov	Linear	Markov	Linear	Markov
$\phi_{0,1}$	0.008 (0.035)	0.029 (0.010)	0.006 (0.300)	0.082 (0.000)	0.007 (0.202)	0.055 (0.000)
$\phi_{0,2}$		0.014 (0.000)		0.018 (0.000)		0.017 (0.000)
ϕ_i	0.092 (0.218)	0.079 (0.000)	0.067 (0.369)	0.028 (0.013)	0.368 (0.000)	0.104 (0.001)
p_{11}		0.921		0.963		0.977
p_{22}		0.947		0.977		0.964
σ^2_u	0.003	0.002	0.008	0.004	0.008	0.006
σ^2_{S1}		0.069		0.049		0.055
σ^2_{S2}		0.041		0.104		0.105
Log-likelihood	324.47	326.56	180.11	180.94	223.06	235.37
AIC	-3.03	-3.51	-2.01	-1.99	-2.34	-2.63
LR test	15.02 (0.014)		10.23 (0.036)		10.87 (0.051)	

The bottom row concerns the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992)'s method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

Table A2

Estimates of Regime Switching Model for European Stock Markets Returns and Monetary Policy Innovations

This table reports estimation results for the model

$$X_{i,t} = \phi_0 s_t + \phi_i X_{i,t-n} + \phi_r s_t r_t + \mu_t$$

Where s_t is governed by an unobservable, discrete, first order Markov chain that can assume *k* values (states), $\mu_t \sim i.i.d.\mathrm{N}(0,\sigma^2_{s_t})$. , r_t is the innovation in monetary policy and i=1,2,3,…n indexes returns on European Stock markets. Data are monthly and obtained from Datastream, IMF - Financial Statistics and National Central Banks dataset. The sample period is 1991:01 – 2005:09. P-values are reported in parentheses.

	Italy		***Germany***		***France***		***Spain***	
Parameter	Linear	Markov	Linear	Markov	Linear	Markov	Linear	Markov
$\phi_{0,1}$	0.007 (0.104)	0.041 (0.005)	0.007 (0.178)	0.0321 (0.001)	0.004 (0.157)	0.051 (0.026)	0.008 (0.048)	0.012 (0.011)
$\phi_{0,2}$		0.007 (0.000)		0.0065 (0.000)		0.0607 (0.000)		0.025 (0.000)
ϕ_i	-0.062 (0.380)	0.076 (0.001)	-0.005 (0.945)	0.0056 (0.000)	0.304 (0.000)	0.047 (0.000)	0.073 (0.333)	0.036 (0.000)
$\phi_{r,1}$	-0.043 (0.000)	-0.044 (0.005)	-0.043 (0.134)	-0.037 (0.015)	-0.005 (0.297)	-0.0117 (0.005)	-0.018 (0.635)	-0.0223 (0.003)
$\phi_{r,2}$		0.0726 (0.045)		-0.0796 (0.000)		-0.0921 (0.000)		-0.0176 (0.065)
p_{11}		0.916		0.978		0.977		0.901
p_{22}		0.929		0.981		0.943		0.887
σ^2_u	0.004	0.003	0.005	0.004	0.0024	0.0018	0.0036	0.0031
σ^2_{S1}		0.035		0.084		0.035		0.070
σ^2_{S2}		0.076		0.041		0.059		0.034
Log-likelihood	246.77	255.75	236.06	251.73	314.75	325.02	259.40	263.60
AIC	-2.72	-2.80	-2.60	-2.76	-3.48	-3.57	-2.86	-2.89
LR test	11.40 (0.043)		14.34 (0.017)		22.13 (0.005)		12.92 (0.028)	

The bottom row concerns the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992)'s method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

	Belgium		***Netherlands***		***Austria***		***Portugal***	
Parameter	Linear	Markov	Linear	Markov	Linear	Markov	Linear	Markov
$\phi_{0,1}$	0.007 (0.015)	0.025 (0.000)	0.006 (0.134)	0.006 (0.005)	0.002 (0.000)	0.009 (0.014)	0.006 (0.114)	0.008 (0.001)
$\phi_{0,2}$	(0.000)	0.033 (0.000)		0.012 (0.000)		0.045 (0.000)		0.189 (0.000)
ϕ_{i}	0.175 (0.016)	0.032 (0.000)	0.045 (0.549)	0.027 (0.041)	-0.125 (0.000)	0.081 (0.036)	0.185 (0.013)	0.081 (0.000)
$\phi_{r,1}$	-0.03 (0.002)	-0.037 (0.000)	-0.017 (0.410)	-0.081 (0.000)	0.026 (0.000)	-0.306 (0.000)	-0.005 (0.763)	-0.056 (0.005)
$\phi_{r,2}$		-0.043 (0.001)		-0.108 (0.045)		-0.0287 (0.138)		0.0611 (0.112)
p_{11}		0.911		0.946		0.973		0.895
p_{22}		0.968		0.900		0.946		0.925
σ^2_u	0.002	0.0011	0.003	0.002	0.009	0.002	0.0032	0.0024
σ^2_{S1}		0.065		0.035		0.034		0.074
σ^2_{S2}		0.034		0.077		0.035		0.029
Log-likelihood	310.89	316.98	269.12	282.32	164.48	219.19	274.63	288.75
AIC	-3.44	-3.48	-2.89	-3.09	-1.80	-2.39	-3.03	-3.17
LR test	12.01 (0.039)		22.04 (0.004)		16.41 (0.091)		11.87 (0.041)	

The bottom row concerns the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992)'s method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

	Ireland		Greece		Finland	
Parameter	Linear	Markov	Linear	Markov	Linear	Markov
$\phi_{0,1}$	0.008 (0.035)	0.009 (0.000)	0.007 (0.277)	0.0015 (0.025)	0.007 (0.199)	0.005 (0.000)
$\phi_{0,2}$		0.025 (0.018)		0.0308 (0.000)		0.003 (0.000)
ϕ_{i}	0.097 (0.201)	0.101 (0.000)	0.056 (0.451)	0.002 (0.035)	0.367 (0.000)	0.035 (0.000)
$\phi_{r,1}$	-0.016 (0.660)	-0.010 (0.005)	-0.076 (0.201)	-0.064 (0.133)	-0.017 (0.733)	0.059 (0.036)
$\phi_{r,2}$		-0.0385 (0.045)		-0.0847 (0.000)		-0.129 (0.086)
p_{11}		0.920		0.965		0.977
p_{22}		0.947		0.978		0.964
σ^2_u	0.006	0.003	0.008	0.006	0.006	0.004
σ^2_{S1}		0.069		0.049		0.055
σ^2_{S2}		0.040		0.104		0.114
Log-likelihood	271.80	282.10	180.94	190.73	210.45	217.65
AIC	-3.00	-3.09	-1.99	-2.07	-2.31	-2.37
LR test	10.08 (0.000)		20.60 (0.016)		9.39 (0.067)	

The bottom row concerns the Hansen test (linearity versus two-states Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992)'s method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

Table A3

Estimates of Regime Switching Model for Industry portfolios in five European countries and Monetary Policy Innovations

This table reports estimation results for the model

$$y_{i,t} = \Gamma_0 s_t + \Gamma_i y_{i,t-n} + \Gamma_r s_t r_t + \varepsilon_t$$

Where s_t is governed by an unobservable, discrete, first order Markov chain that can assume *k* values (states), $\varepsilon_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$., r_t is the innovation in monetary policy and i=1,2,3,…n indexes returns on single country industry portfolios. Data are monthly and obtained from Datastream, IMF - Financial Statistics and National Central Banks dataset. The sample period is 1991:01 – 2005:09. P-values are reported in parentheses.

ITALY	***CH***	***PH***	***IND***	***INS***	***OIL***	***TEC***	***AU***	***TEL***
Parameter								
$\Gamma_{0,1}$	-0.0048 (0.016)	0.055 (0.005)	0.035 (0.006)	0.0983 (0.000)	0.0047 (0.022)	0.0164 (0.000)	0.0552 (0.000)	0.014 (0.001)
$\Gamma_{0,2}$	-0.0059 (0.009)	0.0134 (0.000)	0.0112 (0.000)	0.0016 (0.000)	0.0308 (0.005)	-0.0291 (0.001)	0.0114 (0.000)	0.0065 (0.005)
Γ_i	0.193 (0.007)	0.066 (0.001)	0.071 (0.000)	0.076 (0.001)	0.0204 (0.035)	-0.0081 (0.097)	0.0263 (0.054)	0.064 (0.027)
$\Gamma_{r,0,1}$	-0.021 (0.000)	-0.020 (0.018)	-0.054 (0.004)	-0.043 (0.000)	-0.039 (0.000)	-0.072 (0.052)	-0.043 (0.000)	-0.057 (0.000)
$\Gamma_{r,0,2}$	-0.034 (0.000)	-0.019 (0.005)	-0.061 (0.000)	-0.047 (0.000)	0.0046 (0.045)	-0.103 (0.024)	-0.066 (0.000)	-0.116 (0.001)
p_{11}	0.979	0.952	0.807	0.895	0.991	0.975	0.931	0.832
p_{22}	0.949	0.985	0.847	0.845	0.954	0.989	0.923	0.955
σ^2_u	0.006	0.007	0.007	0.003	0.005	0.012	0.007	0.007
σ^2_{S1}	0.090	0.018	0.036	0.041	0.047	0.014	0.055	0.134
σ^2_{S2}	0.017	0.093	0.115	0.082	0.127	0.008	0.115	0.062
Log-likelihood	201.52	208.55	186.36	235.35	340.70	132.93	173.01	179.00
AIC	-2.20	-2.27	-2.03	-2.57	-3.75	-1.43	-1.88	-1.94

FRANCE	***CH***	***PH***	***IND***	***INS***	***OIL***	***TEC***	***AU***	***TEL***
Parameter								
$\Gamma_{0,1}$	-0.091 (0.054)	0.063 (0.005)	0.036 (0.000)	0.0151 (0.001)	0.0077 (0.018)	0.0221 (0.006)	0.0257 (0.000)	0.006 (0.000)
$\Gamma_{0,2}$	0.0106 (0.011)	0.083 (0.022)	0.0954 (0.020)	0.0065 (0.000)	0.0362 (0.005)	0.0614 (0.001)	0.0154 (0.000)	0.0183 (0.000)
Γ_{i}	0.1306 (0.005)	0.095 (0.001)	0.0241 (0.000)	0.0198 (0.010)	0.0417 (0.000)	0.0296 (0.000)	0.0170 (0.005)	0.0301 (0.000)
$\Gamma_{r,0,1}$	-0.084 (0.033)	-0.086 (0.001)	-0.069 (0.005)	-0.014 (0.005)	-0.011 (0.014)	-0.061 (0.040)	-0.081 (0.034)	-0.0094 (0.015)
$\Gamma_{r,0,2}$	-0.089 (0.005)	-0.085 (0.047)	-0.074 (0.000)	-0.052 (0.085)	-0.046 (0.105)	-0.079 (0.000)	-0.088 (0.001)	-0.017 (0.015)
p_{11}	0.833	0.888	0.834	0.833	0.987	0.988	0.833	0.984
p_{22}	0.829	0.985	0.822	0.821	0.952	0.955	0.823	0.920
σ^2_u	0.004	0.009	0.003	0.003	0.002	0.002	0.005	0.002
σ^2_{S1}	0.031	0.682	0.034	0.044	0.041	0.040	0.080	0.044
σ^2_{S2}	0.054	0.048	0.065	0.098	0.067	0.068	0.053	0.071
Log-likelihood	273.53	243.41	252.25	206.99	261.36	258.66	202.03	269.72
AIC	-3.00	-2.66	-2.76	-2.26	-2.86	-2.83	-2.20	-2.96

GERMANY	***CH***	***PH***	***IND***	***INS***	***OIL***	***TEC***	***AU***	***TEL***
Parameter								
$\Gamma_{0,1}$	0.0152 (0.000)	0.0011 (0.000)	0.0061 (0.000)	0.0128 (0.005)	0.0275 (0.000)	0.0746 (0.000)	0.0117 (0.005)	0.0712 (0.000)
$\Gamma_{0,2}$	-0.098 (0.000)	0.0268 (0.003)	0.0712 (0.000)	-0.178 (0.000)	-0.0217 (0.001)	0.0422 (0.000)	-0.0145 (0.011)	0.0318 (0.005)
Γ_{i}	0.102 (0.086)	0.0904 (0.001)	0.0309 (0.000)	0.0925 (0.005)	0.0488 (0.000)	0.0223 (0.049)	0.0152 (0.000)	0.0173 (0.093)
$\Gamma_{r,0,1}$	-0.0177 (0.005)	-0.092 (0.000)	-0.015 (0.037)	-0.0189 (0.035)	-0.0367 (0.000)	-0.005 (0.000)	-0.022 (0.024)	-0.014 (0.000)
$\Gamma_{r,0,2}$	-0.023 (0.035)	-0.118 (0.005)	-0.037 (0.000)	-0.051 (0.000)	-0.039 (0.015)	-0.026 (0.001)	-0.047 (0.000)	-0.021 (0.000)
p_{11}	0.916	0.982	0.954	0.678	0.986	0.976	0.920	0.990
p_{22}	0.916	0.982	0.954	0.978	0.986	0.976	0.92	0.985
σ^2_u	0.972	0.943	0.963	0.971	0.984	0.952	0.966	0.986
σ^2_{S1}	0.073	0.018	0.072	0.045	0.039	0.107	0.099	0.112
σ^2_{S2}	0.040	0.066	0.031	0.098	0.058	0.041	0.044	0.043
Log-likelihood	252.57	363.62	253.75	212.06	167.82	197.73	222.97	178.50
AIC	-2.77	-4.01	-2.78	-2.31	-1.82	-2.15	-2.43	-1.94

NETHERLANDS	***CH***	***PH***	***IND***	***INS***	***OIL***	***TEC***
Parameter						
$\Gamma_{0,1}$	0.0312 (0.005)	0.0141 (0.007)	0.0092 (0.038)	0.0269 (0.011)	0.0176 (0.001)	0.0139 (0.005)
$\Gamma_{0,2}$	0.0193 (0.000)	0.0169 (0.000)	0.0704 (0.001)	0.0122 (0.000)	0.0288 (0.005)	0.0677 (0.000)
Γ_{i}	0.0242 (0.001)	0.0186 (0.000)	0.0284 (0.001)	0.0302 (0.001)	0.0424 (0.000)	0.0254 (0.001)
$\Gamma_{r,0,1}$	0.0096 (0.056)	- 0.0012 (0.005)	-0.036 (0.005)	- 0.0097 (0.000)	0.0013 (0.052)	-0.031 (0.006)
$\Gamma_{r,0,2}$	-0.098 (0.020)	-0.027 (0.000)	-0.075 (0.000)	- 0.0179 (0.005)	- 0.0109 (0.104)	-0.055 (0.000)
p_{11}	0.919	0.932	0.916	0.932	0.932	0.988
p_{22}	0.979	0.927	0.974	0.974	0.927	0.981
σ^2_{u}	0.004	0.002	0.004	0.005	0.002	0.011
σ^2_{S1}	0.103	0.029	0.102	0.105	0.029	0.068
σ^2_{S2}	0.043	0.051	0.044	0.051	0.052	0.132
Log-likelihood	233.92	324.48	230.80	203.36	279.91	315.02
AIC	-2.56	-3.57	-2.52	-2.22	-3.07	-3.46

BELGIUM	***CH***	***PH***	***IND***	***INS***	***OIL***	***TEC***
Parameter						
$\Gamma_{0,1}$	0.0177 (0.000)	0.0044 (0.001)	0.0022 (0.000)	0.0134 (0.002)	0.0064 (0.000)	0.0092 (0.015)
$\Gamma_{0,2}$	0.0148 (0.008)	0.0352 (0.000)	0.0926 (0.024)	0.0582 (0.004)	0.0078 (0.001)	0.0130 (0.000)
Γ_{i}	0.0200 (0.014)	0.0361 (0.000)	0.0106 (0.005)	0.0281 (0.045)	0.0186 (0.000)	0.0197 (0.005)
$\Gamma_{r,0,1}$	-0.032 (0.000)	- 0.0101 (0.005)	- 0.0105 (0.022)	-0.065 (0.005)	- 0.0029 (0.000)	- 0.0168 (0.005)
$\Gamma_{r,0,2}$	-0.036 (0.000)	-0.047 (0.005)	-0.016 (0.000)	-0.066 (0.085)	- 0.0107 (0.000)	- 0.0291 (0.000)
p_{11}	0.544	0.865	0.988	0.989	0.897	0.867
p_{22}	0.987	0.982	0.967	0.974	0.902	0.754
σ^2_{u}	0.003	0.014	0.002	0.004	0.002	0.010
σ^2_{S1}	0.148	0.392	0.055	0.062	0.026	0.125
σ^2_{S2}	0.045	0.021	0.027	0.079	0.055	0.046
Log-likelihood	255.72	333.46	264.21	146.66	158.22	143.64
AIC	-2.80	-3.67	-2.90	-1.58	-1.71	-1.50

Table A4

Conditional of being in state one or two, the expected duration of a typical "bull" and "bear" market in European Stock Markets Returns

This table reports duration results for the model

$$X_{i,t} = \phi_0 s_t + \phi_i X_{i,t-n} + \mu_t$$

	Italy	*Belgium*	*Germany*	*Portugal*	*France*	*Austria*	*Spain*	*Greece*
Duration								
Bull State 1 [1/(1- p_{11})]	10.989	9.259	35.714	9.090	43.478	35.714	10.204	27.027
Bear State 2 [1/(1- p_{22})]	17.543	23.809	55.555	12.5	17.543	18.181	8.7719	43.478
	Ireland	***Finland***	***Netherlands***	**Average Duration**				
Bull State 1 [1/(1- p_{11})]	12.658	43.478	17.857	23.224				
Bear State 2 [1/(1- p_{22})]	18.867	27.777	10.416	23.131				

Table A5

Conditional of being in state one or two, the expected duration of a typical “bull” and “bear” market in European Stock Markets Returns

This table reports duration results for the model

$$X_{i,t} = \phi_0 s_t + \phi_i X_{i,t-n} + \phi_r s_t r_t + \varepsilon_t$$

	Italy	*Belgium*	*Germany*	*Portugal*	*France*	*Austria*	*Spain*	*Greece*
Duration								
Bull State 1 [1/(1-p_{11})]	11.904	11.235	41.667	9.524	43.478	37.037	10.101	28.571
Bear State 2 [1/(1-p_{22})]	14.084	31.250	52.631	13.334	17.543	18.518	8.849	45.454

	Ireland	*Finland*	*Netherlands*	**Average Duration**
Bull State 1 [1/(1-p_{11})]	12.50	43.478	18.518	24.3648
Bear State 2 [1/(1-p_{22})]	18.867	27.778	10.0	23.482545

Table A6

Conditional of being in state one or two, the expected duration of a typical "bull" and "bear" market in Industry portfolios

This table reports duration results for the model

$$y_{i,t} = \Gamma_0 s_t + \Gamma_i y_{i,t-n} + \Gamma_r s_t r_t + \mu_t$$

Italy	*CH*	*PH*	*IND*	*INS*	*OIL*	*TEC*	*AU*	*TEL*	**Average Duration**
Duration									
Bull State 1 [1/(1-p11)]	47.619	20.834	5.181	9.523	111.11	40.0	14.492	5.952	31.839
Bear State 2 [1/(1-p22)]	19.607	66.667	6.5359	6.451	21.739	90.909	12.987	22.223	30.889

France	*CH*	*PH*	*IND*	*INS*	*OIL*	*TEC*	*AU*	*TEL*	**Average Duration**
Duration									
Bull State 1 [1/(1-p11)]	5.988	8.928	6.024	5.988	76.923	77.923	5.988	62.5	33.176
Bear State 2 [1/(1-p22)]	5.847	66.667	5.617	5.586	20.833	22.223	5.649	12.5	25.407

Germany	*CH*	*PH*	*IND*	*INS*	*OIL*	*TEC*	*AU*	*TEL*	**Average Duration**
Duration									
Bull State 1 [1/(1-p_{11})]	11.905	55.556	21.739	45.455	71.429	41.667	12.500	66.667	40.864
Bear State 2 [1/(1-p_{22})]	35.714	17.544	27.027	34.483	62.500	20.833	29.412	71.429	37.368

Belgium	*CH*	*PH*	*IND*	*INS*	*OIL*	*TEC*	**Average Duration**
Duration							
Bull State 1 [1/(1-p_{11})]	12.346	14.706	11.905	14.706	14.706	83.333	25.284
Bear State 2 [1/(1-p_{22})]	47.619	13.699	38.462	38.462	13.699	52.632	34.095

Netherland	*CH*	*PH*	*IND*	*INS*	*OIL*	*TEC*	**Average Duration**
Duration							
Bull State 1 [1/(1-p_{11})]	2.193	7.407	83.333	90.909	9.709	7.519	33.512
Bear State 2 [1/(1-p_{22})]	76.923	55.556	30.303	38.462	10.204	4.065	35.919

Figure 4.8 Smoothed Probabilities EUM Stock Markets Returns

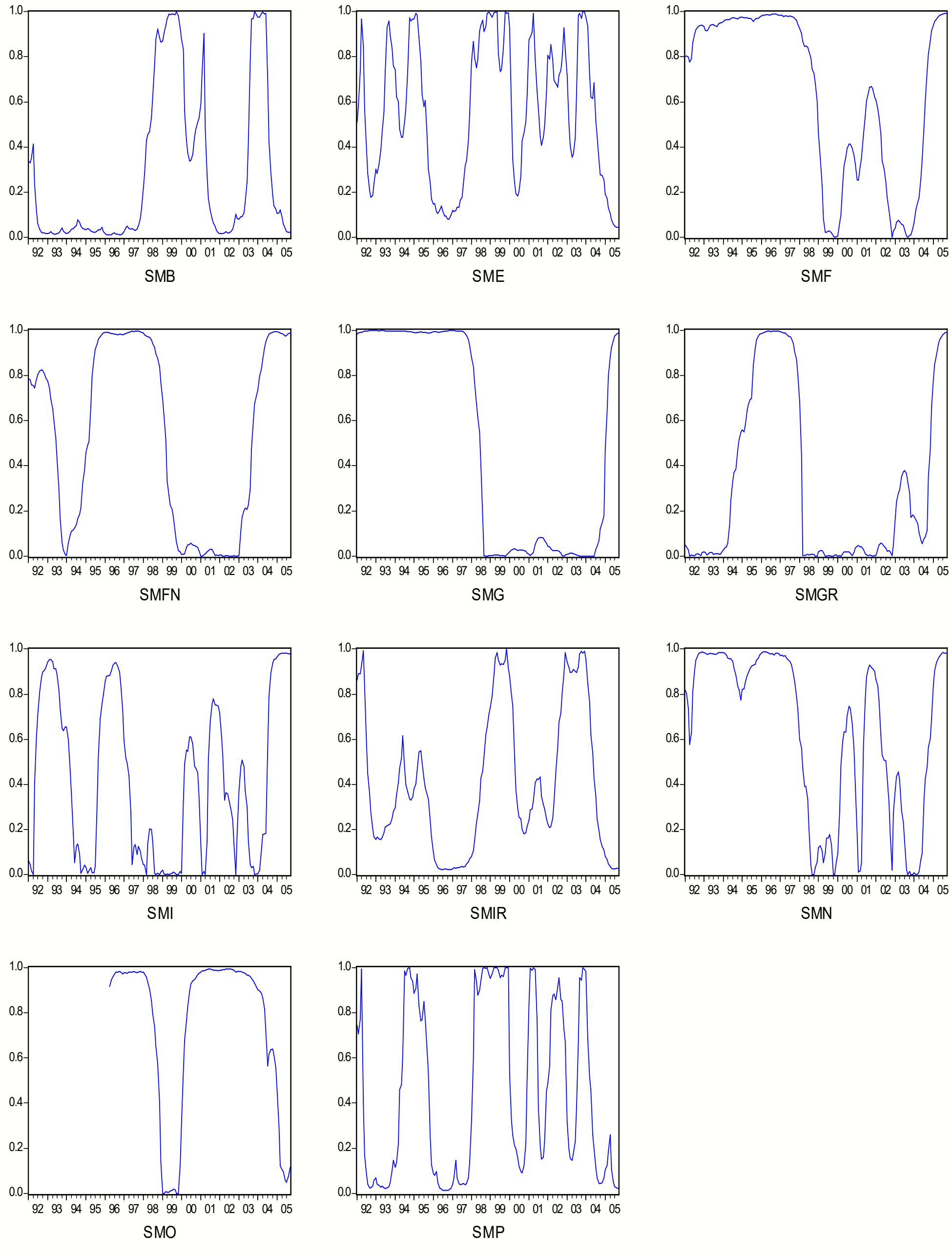


Figure 4.9 Smoothed Probabilities Belgium Industry Portfolios

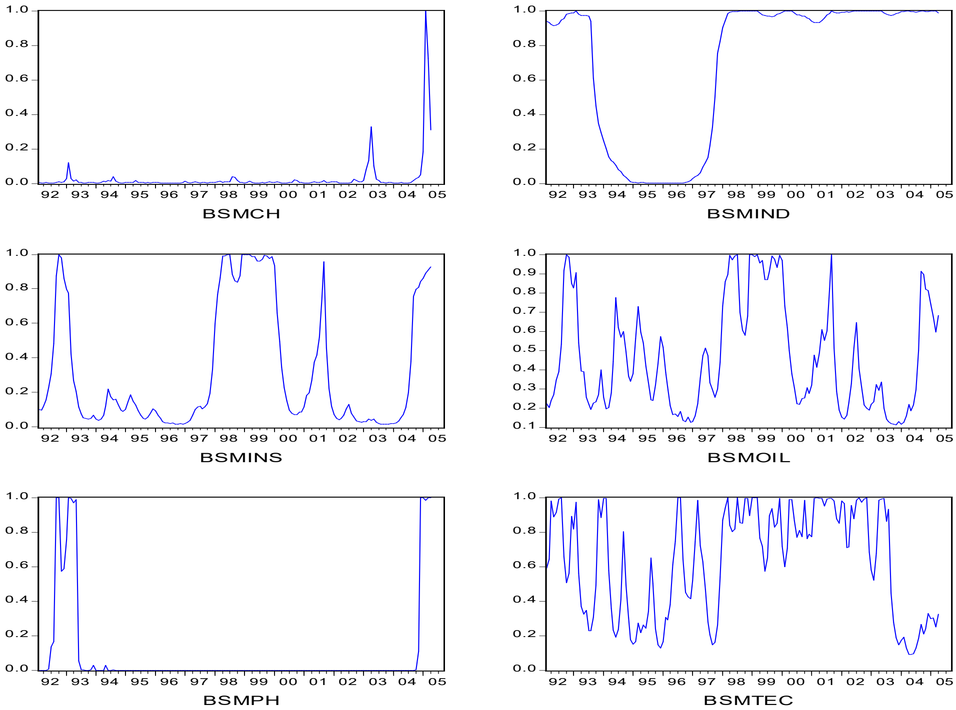


Figure 4.10 Smoothed Probabilities Netherlands Industry Portfolios

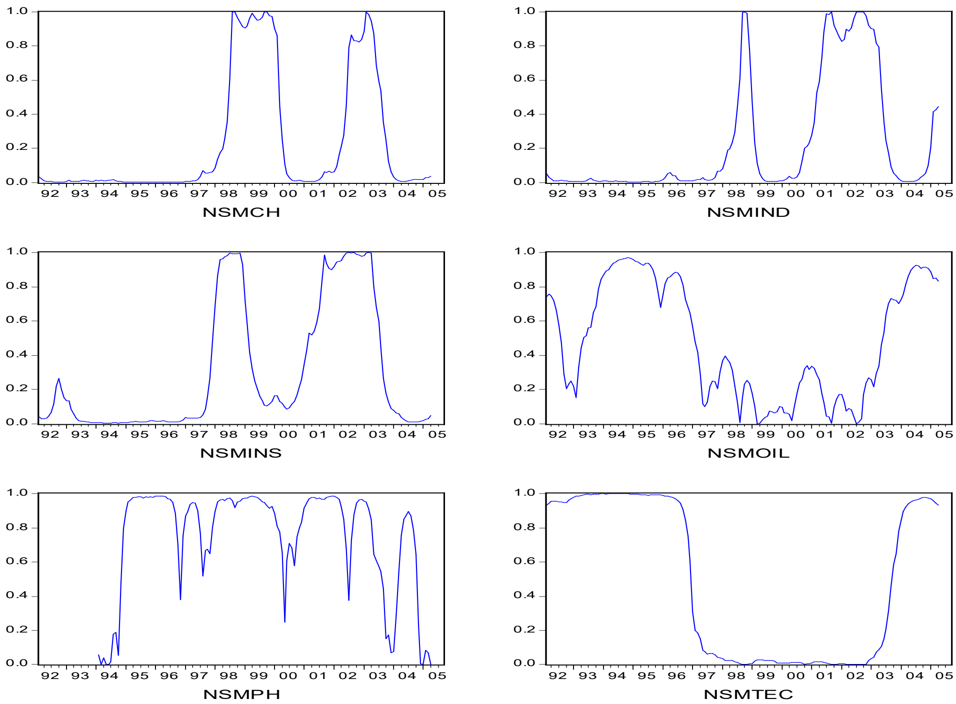


Figure 4.11 Smoothed Probabilities France Industry Portfolios

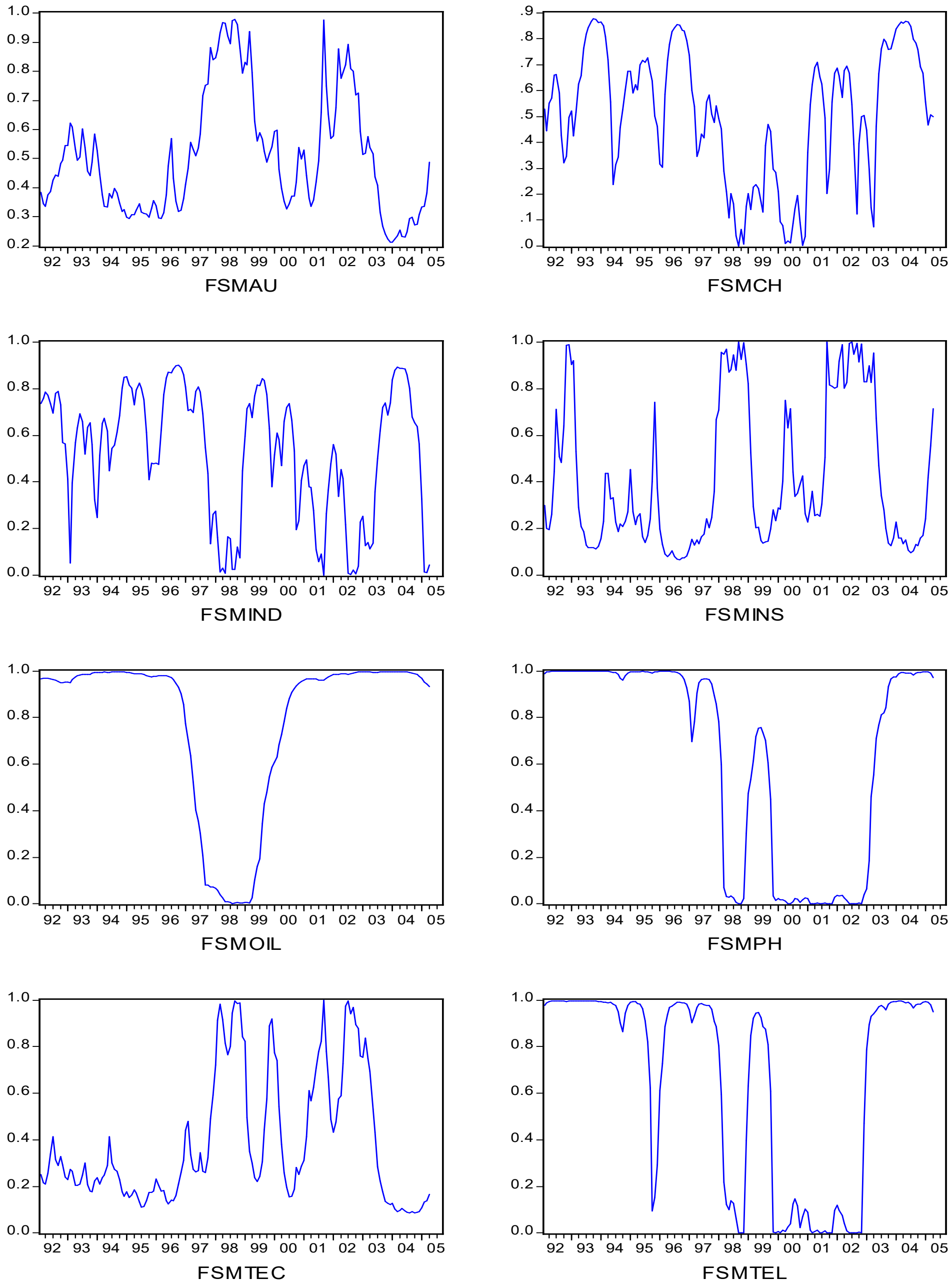


Figure 4.12 Smoothed Probabilities Italy Industry Portfolios

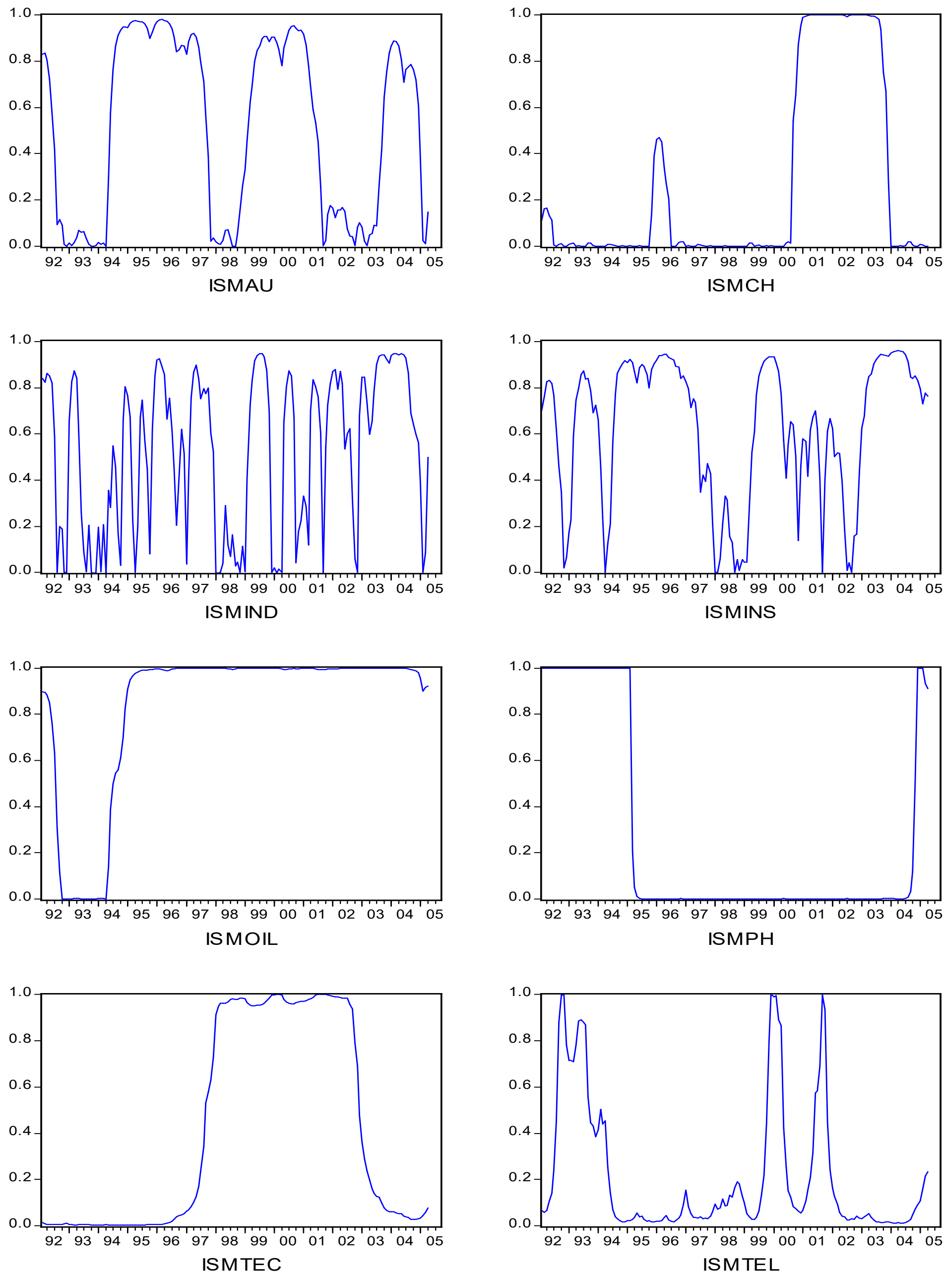
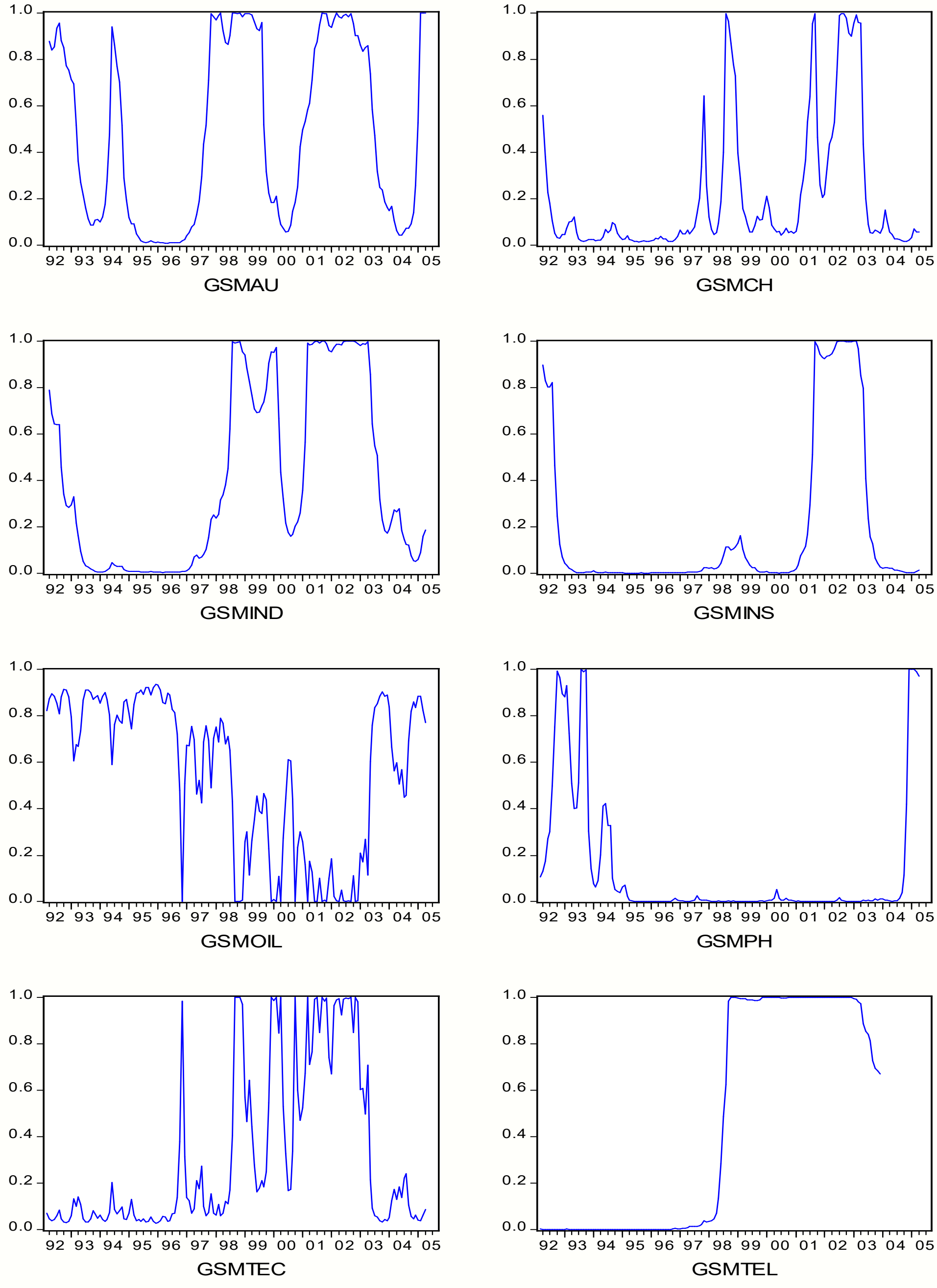


Figure 4.13 Smoothed Probabilities Germany Industry Portfolios



Conclusions

Can the central bank improve macroeconomic stability by reacting to asset prices (Cecchetti et al, 2000)? Our intuition that this should be the case is based on two arguments: 1) if we agree with Poole (1970) that a central bank has to "lean against the wind" of significant asset price movements (misalignments) when these movements are generated in the asset markets themselves; 2) when significant asset price misalignments occur, they create undesirable instability inflation that may be exacerbated when the misalignment is eventually eliminated. A monetary policy intervention would be desirable even if it would mean a temporary departure from the short term inflation target. In this study we have examined the robustness of these arguments both theoretically and empirically. The theoretical model has been presented in chapter two. This chapter has re-examined the issue of international macroeconomic policy coordination, taking advantage of recent developments in theoretical methods used in the literature to study monetary policy optimization.

The review of the literature, however, does not offer a conclusive answer to whether, and how, a central bank should respond to asset "shocks". This chapter examined, theoretically, in a cooperative and non-cooperative game framework, the optimal monetary policy assuming that the central bank considers the information from the asset market. In particular, we examined the impact of shocks in the asset

market, exchange rate shock and the Phillips curve on domestic and foreign monetary policy.
The results from the impulse response functions show that, following an unexpected increase of the US asset market, the patterns of the output responses are similar in both countries, that is, a positive shock in the USA stock market increases output gaps. Different responses are obtained when we consider the effects on the inflation in the two countries. Despite the fact that the patterns are similar, the magnitude of the impact is slightly different.
Moreover, following an unexpected increase of the European stock market, the patterns of the output responses are dissimilar in the two countries that is, a positive shock in the EU stock market increases output gap in the USA while, for the first six months it has a negative impact on the EU output gap. Different responses are also obtained when we consider the effects on the inflation in the two countries.
Finally, we found that, under a cooperative game, the FED minimises its loss functions in all of the three potential shocks we examined. The situation is different for the ECB where, it minimises its loss function only in the cooperative scenario with a shock in the EU stock market.

A general statement asserts that asset price misalignments are difficult to measure. However, this should not be the reason to ignore them. In fact, asset prices contain information about future inflation that can be incorporated into inflation forecasts used in the monetary policy process. Stating the seminal work of Alchian and Klein (1973) it is often argued that the forward-looking nature of asset prices makes them good proxies for the information left out of conventional inflation measures. It is also widely accepted that asset price inflation developments are closely associated with general inflation trends. Chapter three investigated the role of asset prices in the conduct of monetary policy in the United States, Canada, Euro Area and United Kingdom. We constructed Financial Condition Indexes for the four countries using the Kalman Filter algorithm. This methodology allowed us to capture the changes of the weights over time. Second, we proceeded by estimating forward-looking Taylor rules augmented for FCI. The results from the Taylor rules suggest that the Financial Condition Index enter positively and statistically significant into the FED, Bank of England and Bank of Canada interest rate setting. This gives a positive view for the use of the FCI as an important short term indicator to guide the conduct of monetary policy in three out of the four countries analyzed. Why is the inclusion of the contemporary value of the Financial Condition Index in the Taylor rule not statistically significant, for the EU? Among several possible explanations we stress that disaggregated asset markets may contribute to a heterogeneous transmission of monetary policy to the economy. European financial markets are still not really perceived as a substitution for an investor across the countries but just inside the asset market of each individual country. For this reason, the interrelationship between financial markets and monetary policy is particularly important in Europe but, the structural changes that took place in

Europe's financial markets as a result of the EMU and other developments maybe needs more significant adjustments.

Last question we tried to find an answer to was: which policy implications would emerge from the finding of a significant and stable relationship between monetary policy and stock market returns? In our view, there are at least two clear implications. First, by letting short-term rates deviate from a certain level of equilibrium, the central bank may have a significant impact on asset prices. Second, in principle the central bank is able to reduce stock price volatility by diminishing the uncertainty of future rate changes, hence volatility spillovers to other financial markets could be avoided and the option value of waiting with investment decisions would be reduced.

Moreover, monetary policy exerts a significant impact on financial markets and this is reflected by the considerable attention that the ECB receives in the financial markets. Estimates of the responsiveness of stock market returns to changes in monetary policy will most likely contribute to effective investment and risk management decisions (Rigobon and Sack, 2004).

In chapter four we explored the possibility of a non-linear relationship between EMU stock returns and the ECB’s monetary policy innovations. The non-linearity was modelled using different Markov-switching (MS) regime autoregressive models. We investigated the empirical performance of the univariate MS models used to describe the switches between different economic regimes for the 11 EMU countries’ stock markets and, furthermore, extending these models to test if the inclusion of monetary policy shock as an exogenous variable provides a more accurate identification of the switches between different economic phases.

Moreover, we investigated if the shocks were both, symmetric or asymmetric throughout the EMU countries and at level of industry portfolio inside each single country. Hence, we studied asymmetries using an extension of the Markov switching model described by Hamilton (1989) estimated over the period 1992-2005. Presumably, stock market movements reflect positions taken by market participants based on their assessment about the current state of the economy. Given the forward-looking behaviour of stock market investors, chapter four has explored the possibility of asymmetric effects of centralised monetary policy (ECB) when stock markets are not fully integrated. Stock market returns were represented by nonlinear dynamic factors at the monthly frequency. In the analysis undertaken here, the following important conclusions may be drawn. The findings, in line with results from previous empirical studies, indicate that for the EMU stock markets there is a statistically significant relationship between policy innovations and stock markets returns. This finding is consistent with the hypothesis that positive monetary policy shock (e.g. contractionary policy) is an event that decreases future cash flow. Moreover, the finding from country size and industry portfolios indicate that monetary policy has a larger asymmetric effect in industry portfolios of big countries (Italy, France and Germany) compared to that of small countries (Netherlands and Belgium). However, the sign of the impact is the same for both groups.

An interesting feature of the results is that aggregate stock markets seem to respond to the effects of the launch of the Euro in 1999. On the contrary, single country industry portfolios show that the smooth probability of change in regimes due to the new currency is less pronounced and affects only some industries.

Hence, if the ECB follows a tight monetary policy then the effect on the stock market returns will be lengthier and larger in bear markets. The results suggest that monetary policy is not neutral, at least in the short run and, there is some role for unanticipated ECB monetary policy to affect the stock market but that this role will also have asymmetric impacts on each single EMU country's stock market.

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The developments in asset markets have influenced researchers to focus on the interaction between monetary policy and the financial system. The aim of this research is twofold; firstly, we want to investigate the importance of asset market shocks for the real economy and if the use of asset price movements for the central banks can improve macroeconomic stability. We provide an overview of the role of the financial system for the whole economy. We discuss policy credibility, time–inconsistency, and commitments, and then make a survey of policy coordination literature. We also present a brief description of the conduct of the European Central Bank's monetary policy. We show the importance of the financial sector in transmitting the monetary policy actions. We also construct a model of a policy game in order to analyse the optimal reaction function of the Central Bank to a shock in the asset market. In doing so, we consider a cooperative game and three different non-cooperative games: Nash equilibrium, Stackelberg equilibria (with an accommodate and conservative central bank respectively and different games in which we assume that both central banks react to a shock in their asset markets. Finally, we address the following issues: 1) the importance of the Financial Condition Index (FCI hereafter) in explaining a potential misalignment in asset markets; 2) the use of the FCI as an important short term indicator to guide the conduct of monetary policy. Moreover, we explore the possibility of a non-linear relationship between EMU stock returns and ECB's monetary policy innovations. The non-linearity is modelled using different Markov-switching (MS) regime autoregressive models. We investigate the empirical performance of the univariate MS models used to describe the switches between different economic regimes for the 11 EMU countries' stock markets and, furthermore, extending these models to test if the inclusion of monetary policy shock as an exogenous variable provides a more accurate identification of the switches between different economic phases.

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