Essays on Macroeconometric Modelling: 
Housing and Financial Markets 
in the Light of Inflation Targeting Monetary Policy. 
Evidence from the United Kingdom

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ABSTRACT

The aim of this study is to present four essays related to the macroeconometric modelling of specific relations within the economy of the United Kingdom for the period 1992-2012. The focal point of these essays is the link between inflation targeting monetary policy decision making and housing or financial prices. In particular, we investigate whether traditional channels of monetary policy are still in effect under the adopted monetary policy regime. At the same time, findings associated with the specific relation between both asset markets or with the various working assumptions which facilitate our investigation are also reported.

The specific econometric methods employed include the development of structural vector autoregressive (SVAR), Markov regime-switching, as well as, multivariate generalised autoregressive conditionally heteroskedastic (MGARCH) models. The formulation of these models is predicated upon the selection of appropriate approximations for all financial and macroeconomic indicators of interest.

The main findings of the first essay suggest that under the inflation targeting monetary policy regime, innovations in the monetary policy instrument have no direct effect on the stock market as previously suggested by traditional channels of monetary policy. The said innovations though, appear to have a significant negative impact on the housing market. Furthermore, variation in the stock market can be explained by innovations in the housing market. Turning to the second essay, prominent among our results is the fact that innovations in fiscal policy have a significantly negative effect on the stock market (direct impact). In addition, the effects of monetary policy on the stock market also become negative (indirect impact). According to the third essay when both the stock and the housing market are in a highly volatile regime, then contractionary monetary policy pushes both markets to remain at
that regime. Finally, the main outcome from the fourth essay is that the time-varying correlation between monetary policy and housing or financial prices becomes stronger during turbulent times.

Overall, our findings suggest that within an inflation targeting monetary policy regime the effects of monetary policy decisions on the stock market strongly depend on the broader economic conditions. By contrast, traditional monetary policy channels with respect to the housing market appear to be in effect; however, broader economic conditions have a key role to play in this case as well.
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DECLARATION

'Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award'

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ABBREVIATIONS

BoE = Bank of England
CPI = Consumer Prices Index
DCLG = Department of Communities and Local Government
DMO = Debt Management Office
DSGE = Dynamic Stochastic General Equilibrium
ERM = European Exchange Rate Mechanism
FCA = Financial Conduct Authority
FFR = Federal Funds Rate
FLS = Funding for Lending Scheme
FPC = Financial Policy Committee
FSA = Financial Services Authority
HEW = Housing Equity Withdrawal
IFS = Institute of Fiscal Studies
LIBOR = London Interbank Offered Rate
(M)GARCH = (Multivariate) Generalised Autoregressive Conditionally Heteroskedastic
MPC = Monetary Policy Committee
OBR = Office for Budget Responsibility
OECD = Organisation of Economic Cooperation and Development
ONS = Office for National Statistics
PRA = Prudential Regulation Authority
PSNB = Public Sector Net Borrowing
PSND = Public Sector Net Debt
RAMSI = Risk Assessment Model of Systemic Institutions
RPI(X) = Retail Prices Index

(S)VAR = (Structural) Vector Autoregressive

UK = United Kingdom

US = United States

VAT = Value Added Tax
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This journey is dedicated to my parents, Nikolaos and Katerina.

Ioannis Chatziantonionou
University of Portsmouth
July 2013
DISSEMINATION

Papers related to this study:


Related work has been presented to the following conferences:


(2012) "Do stock markets respond to monetary and fiscal policy shocks? ", presented at the 14\textsuperscript{th} International Network for Economic Research Annual Conference, Faculty of Economics, University of Coimbra, 10-13 May, Coimbra, Portugal (with D. Duffy and G. Filis).


(2010) "Housing wealth, financial wealth & consumption; New evidence from the UK", presented at the 7\textsuperscript{th} International Conference on Applied Financial Economics (AFE), Samos, Greece (with C. Floros).
INTRODUCTION

This chapter introduces the elements that comprise the main crux of the thesis. In particular, we begin by highlighting the cardinal role of contemporary monetary policy decision making with respect to monetary and financial stability. This is followed by an overview of the economy of the United Kingdom since 1992. Given the concentrating interest of this study on the inflation targeting monetary policy regime, this particular year marks the starting point of our study, as in 1992, the United Kingdom decided to leave the European Exchange Rate Mechanism (ERM) in order to adopt an inflation targeting monetary policy strategy. Consistent with some of the main issues that we seek to further elucidate, developments in both the housing and the financial market constitute a key consideration in this historical overview. In turn, we present the specific research objectives accounted for by the various modelling approaches of the study. On the basis that this work is merely a collection of essays - that do, however, share a common denominator - innovations and further contributions of the thesis are presented in relation to each particular essay. The chapter closes with a presentation of the general outline of the study.
1.1 Main elements of analysis

The role of central banks as guardians of monetary and financial stability has increased over the years, in both the UK and other European countries and inflation targeting monetary policy has become the overriding mechanism through which decision makers endeavour to promote stability and economic growth. Arguably, policy decisions made by central banks may have a rather considerable bearing on both the state and the outcome of real economic activity.

Developments in monetary policy are reflected not only by changes in the price of money (i.e. the interest rate) but also by changes in the amount of money in circulation. On one hand, affecting short-term interest rates seems to be the most common way in which monetary authorities aim to control inflationary pressures and support economic development. On the other hand, particularly in periods characterised both by low interest rates and low levels of growth, central bankers usually employ quantitive easing as the basic tool for economic recovery\(^1\). The recent global economic downturn that began in August 2007 and its broad effects on various aspects of economic activity have rendered rises in money supply and market liquidity necessary for economic recovery.

It should be noted that monetary policy decision making in the years immediately before the crisis of 2007 has been widely criticized by authors such as Hay (2009), Bernanke (2010), as well as, Blanchard et al. (2010), who among many others, have emphasized the contribution of both the low level of interest rates and the easing of credit supply conditions of that period to the unfolding of the crisis in the first place. However, effort toward recovery is still centred around monetary policy decisions.

An integral part of decision making is the development of macroeconometric models. These

\(^1\) For a thorough analysis of the relevant concepts, the reader is directed to chapter 2 of the present study.
models not only provide useful insight into the potential links that exist among various economic or financial variables but also set the framework in which forecasting regarding the future course of these variables can be made. Undoubtedly, macroeconometric modelling is at the heart of contemporary monetary policy decision making and in this regard various types of models have been developed that aim to support this process. As will be discussed in some detail in the chapters that follow, existing literature distinguishes between theoretically coherent models (i.e. models that predicate their structure on generally accepted principles of economic theory) and empirically coherent models (mainly time series models that are based on linkages and transmission mechanisms proposed by the analysis of empirical data) (see among others Pagan, 2003; Garratt et al., 2012). Within the framework of this study, all econometric models belong to the latter category (i.e. empirically coherent time series macroeconometric models). A more detailed description of the methodology of econometrics is provided in chapter 4 of the study.

Monetary policy measures - once employed – trigger a succession of events aiming to successfully meet the predetermined monetary goals (i.e. a predetermined level of inflation or a desired level of economic growth). The impact of monetary policy decision making on economic activity has been therefore the subject of voluminous studies while various transmission mechanisms linking monetary policy developments to developments in macroeconomic and financial variables have been identified. Indicatively, we quote Mishkin (1996; 2007) who - pertaining to the effects of monetary policy developments on wealth - documents that expansionary monetary policy raises not only housing prices - which constitute a major component of housing wealth - but also stock prices - which constitute a major component of financial wealth - resulting in higher levels of households’ consumption. As will be more thoroughly explained in subsequent chapters, there is an established link between monetary policy decision making and households' wealth (see *inter alia* Mishkin
2001; 2007). In addition, it has been argued that households' wealth can be disaggregated into housing and financial wealth and approximated by housing and financial prices respectively (Ludwig and Slok, 2004; Dvornak and Kohler, 2007). At the same time, authors such as Sousa (2010) have argued that current research has rather neglected the simultaneous investigation of the relationship between housing and financial wealth. Given that the main objective of this study is to shed additional light into the relationship between monetary policy and housing or financial prices, it is understandable that there will be certain implications regarding households' wealth and households' consumption as well.

Another important issue when it comes to monetary policy decision making is the interaction of monetary policy with fiscal policy. Decisions made by the Government may very well fashion current economic conditions within a country and also influence the effectiveness of monetary policy and its subsequent impact on asset prices. Authors such as Afonso and Sousa (2012) and Agnello and Sousa (2013) point out that the interaction between the two policies has been greatly neglected by empirical literature.

On general principles, all of the linkages described above can be credited with setting up the specific framework of our study. However, before we proceed with a more in depth analysis of the particular research objectives, it would be both instructive and useful to present a historical overview of the economy under investigation; that is, the economy of the United Kingdom (UK).
1.2 The UK economy

One of the main concerns during the development of the current framework of analysis was the decision regarding the economy to be investigated. The choice that eventually qualified; that is, the UK economy, successfully addresses most of the points raised during this process. To be more explicit, given that inflation targeting is becoming increasingly important and the overriding strategic choice of many central banks the world over (see among others Walsh, 2009) one of the main concerns was the investigation of an inflation targeting central bank. The Bank of England (BoE) has adopted an explicit inflation target since October 1992 when the UK decided to leave the ERM. Furthermore, BoE, in its effort to make use of every available information in order to facilitate its decision making, considers a variety of time series macroeconometric models (Garratt et al, 2012); a fact that in itself enhances the very motivation underpinning this work, as the adopted modelling approaches could potentially contribute towards the understanding of the complex relations among the variables under investigation and further inform monetary policy.

Another major issue, raised in the process of setting the main framework, involved the selection of the particular interrelations that would constitute the focal point of the thesis. As previously mentioned, it was decided that housing and financial prices would be at the heart of this study, a fact that - by default - stressed the necessity to base our analysis on a country whose relevant markets are both dynamic and influential, and therefore, of particular interest to policy and decision makers. The UK economy exhibits these features at large, and further provides fertile ground for this kind of analysis in many respects, as in recent years, it has witnessed not only significant increases in housing prices (Bean, 2003; ONS, 2013), but also, substantial financial turmoil related to drastic developments in financial markets - both domestically and at the international level (Schwert, 2011). Therefore, shedding light on the
linkages between the variables of interest - which is achieved in this thesis through the investigation of 4 distinct working assumptions - could improve our understanding regarding developments in the UK economy.

Before we explicitly outline all 4 working assumptions employed by the study, we begin by providing a brief historical overview of the UK economic performance.

1.2.1 A brief chronology of recent recessions and current growth prospects

The beginning of the 1990s was marked by the United States' savings and loans turmoil which unfortunately had a negative impact on the economies of most countries closely related to the American economy, including the UK (Walsh, 1993). However, a stable period of economic growth can be reported for the UK in the years that followed this crisis. In particular, as can be shown in figure 1.1 the British economy exhibited a stable increase in its real Gross Domestic Product (GDP) from 1992:Q1 onwards, suggestive of the fact that by that time it had very much recovered from the poor start of the decade. In fact, the UK economy followed this relatively stable growth path for almost throughout the period until the onset of the Great Recession; that is, the global economic meltdown which began in August 2007 in the aftermath of the housing bubble in the United States.

It is also worth noting that the British economy was not severely affected by the Asian crisis triggered by the 1997 devaluation of Thailand's currency\(^2\). More particularly, in the work of Karunatilleka (1999), we find evidence that the Asian crisis severely affected emerging economies such as economies in Eastern Europe and Latin America; and that, although the UK was negatively affected by the crisis - mainly in terms of a decline in international trade (i.e. UK exports to the region), as well as, a reduction in inward foreign investment from South East Asia - this effect was not too severe. Based on evidence provided by Karunatilleka

\(^2\) A detailed analysis of the Asian crisis can be found in the work of Krugman (2008).
(1999) it becomes clear that the UK was not as important a trade partner in the region as were countries such as the United States and Japan, and also, that the proportion of foreign investments in the UK from the region of South East Asia was relatively small.

**Figure 1.1: UK GDP Constant prices (1992:Q1-2012:Q4).**

[Source: ONS Database]

At the same time, authors such as Corry et al. (2011) report that - starting in 1997 - the economic growth in the UK was fuelled by an unprecedented productivity performance which remained at high levels even during the recession period between 2008 and 2009 (although significantly lower than before the crisis). Corry et al. (2011) maintain that the increased productivity of that period can be attributed to investment in human capital and advanced information technologies and not so much to developments in the financial, the real estate or the public sector.

Nonetheless, early on in 2008, the UK economy went back into recession. In fact, according to Hills et al. (2010), between 2008:Q1 and 2009:Q3, real GDP declined by more than 6% (cumulatively), despite the fact that throughout the whole period inflation remained well above the predetermined 2% target. In their economic review of the British economy Hardy
and Perry (2013) report that recovery from the *Great Recession* was well on its way from the third quarter of 2009.

Figure 1.2: UK GDP Growth rate (1992:Q1 - 2012:Q4).
[Source: ONS Database]

Figure 1.2 illustrates GDP growth in the UK for the period 1990:Q1 to 2012:Q4. According to Hardy and Perry (2013) the economy experienced steady growth for five consecutive quarters; that is, until 2010:Q3.

Hardy and Perry (2013) further document an annual average growth rate for the period of the five quarters that followed the recession in the region of 2.2%, while the same rate for the period between the fourth quarter of 2010 and the first quarter of 2013 was 0.5%.

As can be seen in figure 1.2, from the fourth quarter of 2010 and thereafter the UK economy faced mostly moderate negative growth rates. These negative growth rates could potentially set off the alarm and act as a warning sign with regard to a new bout of recession. However, authors such as Hardy and Perry (2013) voice the opinion that it takes more than just a modest fall in output for a recession to be defined and opine that the relatively recent decline
in output is of a scale such that claims in favour of a double-dip recession\textsuperscript{3} cannot be justified.

According to reports prepared by the BoE (2013a, 2013b) GDP growth in the British economy is expected to remain at relatively low levels in the near term. In these reports, it is also argued that the moderate decline in output recorded in the end of 2012 may very well be attributed to an unwinding of the economy following an overshooting during the Olympic Games that took place in London. In spite of the relatively subdued growth that is expected in the near future, the same reports further reflect the optimism of the bank for the medium term and outline the following potential factors that could facilitate higher rates of growth in the longer run:

- Domestic credit conditions are expected to ease even further.
- A positive effect on the economy from the bank's asset purchase program is expected.
- A positive effect from the Funding for Lending Scheme (FLS) which translates into less costly borrowing for commercial banks and thus into higher lending into the real economy.
- The global economic conditions are expected to improve.

Nonetheless, it is highly likely that GDP will remain below its pre-crisis level throughout 2014 (BoE, 2013a; 2013b).

Finally as can be reported by Hardie and Perry (2013) the unemployment rate in the economy rose in March 2013 from 7.7\% to 7.9\%. By contrast, the levels of employment were relatively strong up until February 2013. It is worth noting that according to BoE (2013a) if we contrasted the rise in employment during a period of almost three months up to February

\textsuperscript{3} Further information regarding the discussion on the topic of the double-dip recession can be found in Andrew Sentance's (2010) speech at Thames Valley Chamber of Commerce Group in Reading, as well as, in BoE (2012a1).
2013 to the relatively flat GDP growth of the period, the outcome would of course be low productivity which, understandably, could not contribute to higher growth rates.

**1.2.2 Monetary policy and the current state of inflation**

According to ONS (2013a) and BoE (2013b) Consumer Prices Index (CPI) inflation in the UK was in the region of 2.8% in March 2013. This rate of change was slightly higher than the one recorded in December 2012 (2.7%) and the one recorded in September 2012 (2.2%).

Figure 1.3 shows monthly changes in the inflation rate for the period between 1992:Q1 and 2012:Q4. Apparently, the cost of the representative basket of goods and services bought by households has been steadily increasing throughout the period of study. A clear decline in the rate of change of the price level can be reported during the period of the *Great Recession*. According to ONS (2013a) this decline mainly reflected the restrained economic conditions of that period and more particularly the lack of confidence, tighter credit conditions and subdued business investment, the lower energy prices of the past, as well as, a then recent appreciation of the sterling. As will be explained at length in the chapter that follows, a positive inflation rate is rather desirable as, in general, it is positively associated with growth (Mishkin, 2013). According to Miskin (2011; 2013), price stability is defined as a positive yet relatively low and stable level of inflation which has the benefit of removing uncertainty *from* and promoting efficiency *in* the markets. On top of that, inflation targeting central banks have a very specific inflation target. This target for the BoE has been set (by the Government) to be equal to 2% (BoE, 2013b).

It follows then that the current level of inflation of 2.8% is above the target. In a recent report prepared by the BoE (2013b) it is argued that it is highly probable that the inflation rate will rise even further in the medium term and that it will remain well above the 2% target for a period of approximately two years.
The report attributes this persistent rise in the level of prices primarily to sharp rises in tuition fees and food, to the ability of businesses to pass their increased cost of production along to consumers (e.g. increased retail energy bills), as well as, to moderate rises in the price of oil. Most importantly, as stated in the same report, the transparency that BoE promotes with regard to its monetary policy decision making has managed to keep expectations regarding future inflation relatively stable and therefore BoE can indeed be credited with successfully controlling potential rises in inflation due to realised expectations.

It has also been argued (see BoE 2013c; 2013b) that CPI inflation could return to levels fairly close to the predetermined target of 2% only when productivity growth revives, because higher productivity implies increased effective capacity (i.e. supply of commodities relative to total employment) of the economy to supply goods and services which in turn leads to lower prices.

As a final note, BoE (2013b) has announced that the official bank-rate is to be maintained at 0.5% (the level of the bank rate is already very low), while at the same time, the stock of
asset purchases (*quantitative easing* strategy) will be financed by an issuance of Central Bank’s reserves at 375 billion pounds. The decision of BoE to maintain a very low official bank rate is presented on figure 1.4.

**Figure 1.4**: Monthly BoE official rate (1992:1 – 2012:12).

[Source: BoE Database]

### 1.2.3 The public sector, debt and deficit

According to an Office for Budget Responsibility (OBR) (2013) report, the current public sector net debt (PSND) is expected to follow an increasing path, reaching a peak of 85.6% of GDP in 2016-2017. As mentioned in the report prepared by the OBR (2013) this upward revision of the future level of debt can be attributed to Government plans on further gilt issuances (the amount of gilts outstanding constitutes the bulk of the debt), as well as, to the relatively discouraging projection regarding the future path of UK GDP.

At the same time, ONS (2013d) specifies that the value of PSND (which is also referred to as *non-governmental debt or debt held by the public*) in March 2013 was 75.4% of GDP. This rising path of UK PSND is presented in figure 1.5 which comprises the annual value of PSND as percentage of GDP for the period between 1992 and 2012. It is worth noting that
during the period of the *Great Recession* PSND skyrocketed for an additional reason which was none other than the complete or partial nationalisation of various private banks (Chote et al. 2009). The public sector net borrowing (PSNB) represents the difference between Government spending and revenue.

![Net debt as % of GDP (1992-2012)](image)

**Figure 1.5:** UK Debt held by the public (1992-2012).
[Source: ONS Database]

As shown in figure 1.6 the Government has been spending beyond its potential revenue for most of the period between 1992 and 2012.

![Net borrowing in £ billion (1992-2012)](image)

**Figure 1.6:** UK Net borrowing (1992-2012).
[Source: ONS Database]

Only recently has the UK experienced a decline in its PSNB mainly due to tax increases and
public spending cuts (OBR, 2013). According to a report prepared for the Institute of Fiscal Studies (IFS) by Chote et al. (2009) the significant decline and the negative figures that were recorded in the years that followed Britain's exit from the ERM in 1992 (a period characterised by high levels of growth), may very well be attributed to political decisions of that era that promoted high taxation and spending cuts.

![Figure 1.7: Monthly average yield from British Government Securities 10y nominal par yield (1992:1 – 2012:12).](image)

According to Emmerson et al. (2013) the present fiscal targets, as these are set and pursued by the current Chancellor of the Exchequer, include on one hand the budget to reach a surplus by 2014-2015, while on the other hand, the PSND to be decreasing as a share of GDP by 2015-2016. Turning back to the reports produced by OBR (2013) which predict a rather increasing path for both debt and deficit, it is understandable that these fiscal targets are very difficult to be met, especially at times when stimulating the economy becomes a cardinal priority. It is also worth noting that over the years the cost of borrowing for the British Government has significantly declined (as can be seen in figure 1.7) very much reflecting confidence in the British economy.
1.2.4 The housing market

The recent financial crisis that began in August 2007 has inevitably affected various aspects of economic activity in the UK. Early on in the crisis, confidence waned resulting in the collapse of eminent UK financial institutions and business corporations, rises in unemployment, cutbacks in consumer spending, as well as, downturns in both the stock and the housing market.

Starting with the housing market, Reinold (2011) points out that the credit crunch of 2007 resulted in lower housing prices and tighter lending conditions and less availability of credit; which in turn led to an overall decline in housing market transactions. Figure 1.8 illustrates quarterly UK housing prices in constant prices for the period between 1992:Q1 and 2012:Q4.

![Housing prices](chart)

**Figure 1.8**: UK Housing constant prices (1992:Q1 – 2012:Q4).

[Source: ONS Database]

Bone and O’Reilly (2010) specifically point out that rises in UK housing prices especially between the late 1990s and the mid 2000s have been of greater magnitude than respective rises in the rate of inflation therefore suggesting that the housing boom of that period cannot be attributed to normal growth conditions alone. According to these authors, house prices in the UK rose by an average of almost 200% during the decade between 1997 and 2007. In
effect, Bone and O’Reilly (2010) put forward the argument that especially in periods when profit margins remain very low implying low share prices and interest rates are also low preventing people from keeping their money in a bank account, rational investors will turn to a promising market such as the housing market. UK housing prices - almost throughout the period that began after the crisis of the early 1990s and ended with the credit crunch in late 2007 - rose at a rate faster than the rate of inflation (see also ONS, 2013b).

A thorough analysis of rising housing prices in the UK by Cobham (2013) suggests that the Monetary Policy Committee (MPC) of BoE was well aware of the positive momentum of housing prices for quite a long time and it was in 2002 when it initially began considering potential factors that contributed to this upward – and possibly unsustainable – trend. According to Cobham (2013) rising housing prices had then been attributed to:

- The relative price stability of the period mainly due to a relatively successful inflation targeting monetary policy.
- A potential reallocation of investment from equity markets to the housing market.
- Competition among commercial banks leading to ever lower nominal interest rates.
- A further slowdown in construction output (due to legal complexities or time-consuming planning permission processes).

Whether monetary policy should respond or not to rises in asset prices has been the subject of much controversy (see inter alia Bernanke and Gertler, 2001; Wadhwani, 2008; Blanchard et al., 2010; Allen and Rogoff, 2011). According to Cobham (2013) however, the MPC of BoE maintained their initial view that the bank does not target asset prices. In this spirit, Cobham (2013) further reports that BoE in 2002 decided not to make any corrective move.

Turning to the question of whether the UK housing market was a bubble that broke after the financial crisis of 2007, on one hand, authors such as Blanchard et al. (2010) argue that it is indeed very difficult to identify whether a bubble exists or not (in fact, these authors argue
that it is difficult to identify a bubble even well after the realisation of a crisis). By contrast, authors such as Morley and Thomas (2011) voice the opinion that economic conditions before the credit crunch attracted not only investors but also speculators in the UK housing market\(^4\) potentially contributing towards the creation of an actual housing bubble.

The fact that UK housing prices have been rapidly increasing (at least up until the credit crunch of 2007) due to a shortage in the supply of dwellings has also been reported by authors such as Bean (2003), Barker (2004), Reinold (2011), Whitehead and Williams (2011), as well as, Poon and Garratt (2012). Supply of housing appears to be insufficient compared to a strong demand for new houses supported by accelerating immigration, easy access to credit, as well as, *accommodative* monetary policies (i.e. low interest rates) (Whitehead and Williams, 2011). Authors like Harvey (2007), Hay (2009), as well as, Bone and O’Reilly (2010) also cite low interest rates and availability of credit as the main causes of rising housing prices during the aforementioned period. According to ONS (2013a) construction output currently is at its lowest level since 1998. Furthermore, and according to DCLG (2011) construction output fell below 130,000 properties between the years 2001-2002 and rose to only 169,000 properties between the period 2007-2008, which was far below the anticipated / demanded number of 180,000 to 240,000 new properties. The course of UK housing construction output throughout the period 1992:Q1 – 2012Q4 is presented in Figure 1.9. With reference to low housing supply in the UK, authors such as Bean (2003) and Pan \textit{et al.} (2007) among others, argue that the unique characteristic of the UK housing market; that is, the unequivocally persistent shortage of supply\(^5\), can sometimes lead to counter-intuitive economic results (i.e. the existence of high prices despite weak demand).

\(^4\) For a thorough investigation of the various potential channels through which speculative opportunities can arise in the housing market the reader is directed to the work of Levin and Wright (1997).

\(^5\) According to ONS (2013), construction in the UK during 2013:Q1 was 2.4\% lower than 2012:Q4. Essentially, this level of construction output is estimated to be the lowest since 1998:Q4.
Chapter 1: Introduction

Figure 1.9: UK Housing construction output (1992:Q1 – 2012:Q4).
[Source: ONS Database]

Under the prism of these features it would therefore be interesting to identify potential implications deriving from the housing market to both the formulation and the implementation of monetary policy. Pertaining to the exponential increase in housing prices during the period 1997-2007 and their subsequent sharp decline from then onwards, Hay (2009) documents that this particular trend can be easily explained by the amount of housing-equity released by households. More specifically, the author maintains that the prevailing force driving consumption up to the years of the crisis was in fact the ability of households to borrow against the market value of their dwellings. Since tighter lending conditions were introduced in the years that followed, the amount of housing-equity has considerably decreased thus resulting in significantly lower levels of consumption. An in depth analysis of the housing equity withdrawal can be found in Nickell (2004), Benito et al. (2006), as well as, Reinold (2011). In short, these authors identify a link between higher housing prices and consumer spending through additional borrowing secured on the market value of a property. In particular, Reinold (2011) explains that increased housing prices tend to increase the ratio of the market value of a property to the value of debt which is secured on that property (i.e. a
mortgage loan). In turn, this will increase household equity\textsuperscript{6} and encourage housing equity withdrawal (HEW). The latter is regarded as closely related to consumer spending. In this regard, property owners treat their household equity as a buffer against which they can borrow when they experience a period of poor finances.

Figure 1.10: UK Housing equity withdrawal (1992:Q1 – 2012:Q4).

Quarterly UK housing equity withdrawal for the period 1992-2012 is presented in figure 1.10. It is worth noting that during the credit crunch of 2007 housing prices fell so much that household equity was negative, implying not only that the market value of debt exceeded the market value of the property, but also, that the level of HEW in the UK economy significantly diminished. According ONS (2013b) the economy is still waiting for house prices to return to their pre-crisis levels (and their peak of 2008).

1.2.5 The capital market

As far as the UK capital market is concerned, general indices such as the FTSE-all share index have followed the trend of broad economic developments reflecting to a great extent the economic slowdown of the UK economy that began in August 2007, as well as, the

\textsuperscript{6} This is generally defined as the difference between the market value of a property and the value of the secured debt at a specific point in time (Reinold, 2011).
efforts for recovery thereafter. At the same time the UK capital market suffered significant losses during the period 2008-2009 and only started picking up in the second quarter of 2009. Authors like Arestis and Karakitsos (2009), Hay (2009), Blanchard (2010), Stiglitz (2010), as well as, Whitehead and Williams (2011) among others, advocate that spillovers of the U.S. subprime crisis towards the economies of Eastern Europe along with huge injections of liquidity provided in the form of easily approved loans have in a great degree been responsible for the development of various asset bubbles – including bubbles in international housing and financial markets - which in turn gave way to the global economic meltdown that followed. Figure 1.11 shows the FTSE All-share index, one of the most commonly used UK stock market indicators. According to ONS (2012), the UK stock market has - in principle - an upward trend; however, since 1995 it has become much more volatile. As reported by ONS (2012) the first sharp rise for the UK stock market was in the period between 1996 and 1999; that is, during the dot-com bubble. Immediately after the burst of this bubble, the main stock market indices collapsed by almost 50% in between 2000 and 2003 (figure 1.11).

![FTSE All-share index (1992-2012)](image)

**Figure 1.11:** London Stock Exchange FTSE All-share index (1992:1 – 2012:12).

[Source: Thomson Reuters Datastream]
From then onwards, the UK stock market regained momentum until the years of the *Great Recession* and the credit crunch that followed the 2007 *subprime mortgage crisis* in the United States. During the years of the crisis the main indices fell by around 40% before returning to the path of growth (ONS, 2012). In BoE's (2009) *Financial Stability Report* we find a rather exhaustive list of various events that might have had a key role to play during the credit crunch regarding the subsequent course of the stock market, such as:

- The announcement that BoE has provided liquidity support to Northern Rock (on the 14\textsuperscript{th} of September 2007).
- The announcement by the Government regarding the temporary nationalisation of Northern Rock (on the 17\textsuperscript{th} of February 2008).
- The launch of the Special Liquidity Scheme (SLS) by BoE (on the 21\textsuperscript{st} of April 2008).
- The nationalisation of Bradford and Bingley by the UK Government (on the 29\textsuperscript{th} of September 2008).
- The reduction of BoE's base rate to 0.5% and the simultaneous introduction of the quantitative easing programme (i.e. to a £75 billion asset purchase program) (on the 5\textsuperscript{th} of March 2009). It is worth noting, that the base rate has since remained at this level (see figure 1.4).

As far as the current state of the stock market is concerned, according to BoE (2013b) equity prices maintain an upward trend since June 2012 and this mainly reflects the willingness of investors to hold riskier assets. On a final note, authors such as Bridges and Thomas (2012) provide evidence that the quantitative easing programme (which constitutes an integral part of recent monetary policy decision making) has a positive impact on asset prices.
1.3 Research objectives and contribution

Having established the general framework of analysis; that is, having set the background of our study to be monetary policy decision making in the UK economy, we can now turn to the specific research objectives of the thesis. The purpose of this thesis is to develop four essays on the macroeconometric modelling of the UK economy.

At the heart of our attention lies inflation targeting monetary policy and the subsequent linkages between monetary policy decision making in the UK and housing and financial prices. At the same time, we investigate the impact of a number of factors on those linkages. To the effect that we shed additional light to a rather under-researched relationship, we report any information stemming from our modelling approaches regarding the specific relationship between housing and financial prices.

The second main objective of our study is to investigate the interaction between monetary and fiscal policies and to draw a conclusion regarding the potential influence of fiscal policy on monetary policy with respect to the latter's impact on asset prices.

Consistent with our view that housing and financial prices constitute adequate approximations of housing and financial wealth respectively, any result regarding either one of the assets has direct implications for households' wealth and households' consumption.

Another issue that does not go unnoticed by this study is the fact that the UK is a net oil importing country. A strong link between oil prices and inflation has well been reported by various studies and the role of monetary policy in light of developments in the price of oil has often been at the epicentre of much controversy. We consider innovations in the price of oil to be important in terms of explaining (even only up to a certain extent) the behaviour of the relation among the variables of interest.
The overall contribution of this study is that we shed additional light upon the fashioning of macroeconomic and financial relationships that comes with the adoption of the inflation targeting monetary policy regime. With the aid of models that promote the investigation of under-researched relationships we show that traditional channels and transmission mechanisms related to monetary policy can indeed be challenged under the specific monetary policy strategy. Finally, we provide evidence that the interaction of demand-side macroeconomic policies is a key point to consider in analysing economic developments.

1.3.1 First essay

In this essay a structural VAR model is developed in order to investigate the relationship between monetary policy innovations and asset prices. Furthermore, housing and financial prices are assumed to be close approximations of households' housing and financial wealth respectively and therefore an indirect link between monetary policy and households' consumption in the UK is investigated. A proxy for households' consumption is also included in the model in order to trace direct effects.

The specific contribution of this essay relates to the development of a new SVAR model for the UK economy aiming to trace the effects of inflation targeting monetary policy innovations on housing and financial prices. According to Sousa (2010) empirical studies have largely neglected the interaction between housing and financial markets.

Prominent among our results is that under inflation targeting - and contrary to traditional channels which imply direct effects of monetary policy developments to the stock market - the stock market is not directly influenced by unexpected monetary policy decisions. By contrast, the housing market responds negatively to these shocks. We also find that a large proportion of financial prices variation can be explained by housing market innovations. In addition, given that monetary policy innovations have no direct effect on the stock market
and that housing market innovations have no direct effect on households' consumption, we cannot argue in favour of the existence of a wealth channel for monetary policy in the UK. Finally, households' consumption appears to be directly affected only by innovations in the stock market. A detailed analysis and interpretation of these results is provided in section 6.1 of the study.

1.3.2 Second essay

In this essay a structural VAR model is developed in order to investigate the effects of inflation targeting monetary policy on housing and financial prices considering the interaction between monetary and fiscal policy.

The specific contribution of this essay is the development of a new SVAR model for the UK economy which also incorporates a fiscal policy variable. According to authors such as Afonso and Sousa (2012) and Agnello and Sousa (2013) the interaction between the two policies although important has rather been neglected by empirical literature.

Our results show that when fiscal policy is included in the model monetary policy innovations do have a negative effect on the stock market. In addition, fiscal policy has a direct negative effect on both housing and financial prices. Results are indicative of an indirect channel linking fiscal policy and the stock market through monetary policy. We also provide evidence of crowding out effects in the UK economy and that both macroeconomic policies respond counter cyclically to a shock in inflation.

1.3.3 Third essay

In this essay a Markov regime switching model is developed in order to identify regime switches (i.e. from a highly volatile state to a less volatile state or vice versa) for each asset market.
The contribution of this essay is the development of two new Markov regime switching models for the UK economy (i.e. one for each asset market). Authors such as Nneji et al. (2013) argue that little empirical research has so far taken place regarding the cyclicality of the housing market (in either the UK or the US). In addition, this essay provides further insight regarding the potential influence of monetary policy decisions on the propensity of both markets to move towards a low or a high volatility regime.

We provide evidence that there are at least two potential regimes for each market to find itself in. Furthermore, rises in interest rates push both markets to remain to a highly volatile regime. This is a very important result in connection with the results deriving from the two previous essays. Finally, rises in oil prices also contribute to the propensity of the housing market to remain at a high volatility regime.

1.3.4 Fourth essay

In this essay we develop two multivariate generalised autoregressive conditionally heteroskedastic (MGARCH) models (of the BEKK family) in order to identify the pattern of the time-varying correlation between the monetary policy instrument and the housing or the financial market.

The contribution of this essay is that we provide further insight regarding the time-varying volatility between each asset market and monetary policy.

Prominent among our results is that in both markets the time-varying correlation becomes stronger during turbulent times. Furthermore, the time-varying correlation between the monetary policy variable and housing or financial prices may assume either positive or negative values. We also provide evidence that the volatility of interest rates is perceived positively by the stock market and negatively by the housing market. This is also a very interesting result in connection with the results obtained from the previous models.
A synthesis of the results and a detailed account of the main implications related to the study is presented in chapter 7 of the thesis. On the whole, we believe that the results of this study are of particular interest to policy makers, scholars, as well as, investors in the stock markets.
1.4 Structure of the thesis

This study comprises seven chapters. In chapter 1 we set up the main framework of our analysis, embarked on an overview of the UK economy and provided a short account regarding the scope, the contribution, as well as, the main findings of each one of the four essays of the study.

Chapter 2 gravitates around the conduct of contemporary monetary policy. Key concepts are being presented and discussed and a link between the current UK monetary policy regime and the macroeconometric models employed in this study is attempted. This chapter can also be considered as the first part of the literature review of our study.

Chapter 3 pertains to the literature review associated with the specific transmission mechanisms among the variables of interest. In particular, we present traditional channels and transmission mechanisms related to our particular research objectives in the hope that the information provided in this chapter will be relevant in explaining many of our empirical findings.

Chapter 4 positions our study among the various philosophical approaches towards research. In so doing we manage to link the various philosophical approaches to the specific research objectives of the study. We begin by presenting a historical overview of the main philosophical schools of thought and we then proceed with the main questions that a researcher has to answer in order to appropriately define the nature of their research objectives and concerns. Finally we provide a brief overview of the adopted methodology; that is, the methodology of econometrics.

Chapter 5 presents the data employed in the empirical part of the study. We provide key definitions and information regarding the nature and the functional form of the time series
under investigation. We address concerns regarding the appropriateness of the employed functional form by presenting results from relevant statistical tests. A set of figures comprising descriptive statistics, as well as, diagrams illustrating the intertemporal development of each series is also provided.

Chapter 6 comprises the four empirical essays developed in this study. Given that section 6.1 and 6.2 share the same econometric method (i.e. SVAR modelling) the method is presented only once in section 6.1. In this regard, with the exception of section 6.2 every other section begins by introducing the specific econometric method employed and by providing information regarding the adoption / adjustment of the method for the specific research objectives of the section. Then follows a discussion regarding the particular findings which are presented with the aid of suitable tables and figures.

Chapter 7 concludes the study. A synthesis of some of the main findings presented in each chapter is attempted. We also provide an account regarding the main limitations of the study along with potential opportunities for further study.

As mentioned above, the main body of the literature review related to this study breaks down into two categories; that is, to issues revolving around monetary policy conduct and to issues associated with the transmission mechanisms between monetary policy and asset prices. In chapter 2, we begin by presenting a detailed account of contemporary monetary policy decision making.
LITERATURE REVIEW I:
THE ROLE OF MONETARY POLICY

The aim of this chapter is twofold: First, to provide a concise description of essential concepts and practices that revolve around monetary policy conduct in general and decision making at the Bank of England (BoE) in particular; second, to provide a short discussion on the various econometric modelling approaches related to monetary policy. In this regard, section one is devoted to an overview of basic concepts, aims and instruments regarding contemporary monetary policy decision making. For the most part, these are presented succinctly, because the purpose of the first section is not to reproduce information available in relevant textbooks, but rather, to form a theoretical basis and to serve as a reference point for the sections that follow. Section two presents the prevailing principles that guide monetary policy today and the basic arguments that have led to specific macroeconometric modelling approaches. In turn, key facts with reference to decision making at the BoE are presented in section three.
2.1 Tools, instruments and goals of monetary policy

According to the theory of *money neutrality*, money is of no consequence to long-term growth, as any increase in the amount of money in circulation would sooner or later be accompanied by an equivalent increase in the level of prices (King and Watson, 1992; Olekalns, 1996). However, higher salaries do increase the purchasing power of money in the short-run, potentially leading to inflation. By implication then, changes in nominal variables do appear to have real effects on the economy in the short-run due to rigidities in nominal prices and wages (see inter alia Lucas, 1972; Ball and Romer, 1990).

This view, shared both by Classical and Keynesian economists, has led to the conviction that monetary policy has a key role to play - in promoting macroeconomic stability in the short-run - by controlling the supply of money, as well as, other short or longer-term interest rates of the economy that determine the price of money and heavily influence the levels of consumption and investment (see *inter alia* Lindsey, 1991; King and Watson, 1996). In principle, at times of recession, central banks could choose to stimulate the economy - for example - by increasing the supply of money; whereas, at times of grotesque growth (i.e. a bubble economy that induces inflationary pressures) central banks could bring the economy under control by reducing the supply of money (for a thorough analysis see among others Dornbusch *et al*, 2008).

In practice, central banks directly control the *tools of monetary policy*, such as open market operations (i.e. the central bank either buys or sells Government bonds), the discount rate (i.e. the rate at which central banks lend money to commercial banks such as the base or repo rate in the UK and the discount rate in the US), the reserve requirements, as well as, the interest rate on reserves held in the central bank (Friedman, 1991; Woodford, 2003).

However, Mishkin (2013) puts forward the argument that the effects of employing these tools
to pursue certain goals initially appear on the so called monetary policy instruments such as reserve aggregates (e.g. the monetary base) and short-term interest rates (i.e. the rate at which commercial banks trade their reserves at the central bank with each other, such as the London Interbank Offered Rate - LIBOR in the UK or the Federal Funds Rate - FFR in the US). In turn, monetary policy instruments\footnote{It is worth noting that - for reasons which are not to the present purpose - central banks may not choose to affect both instruments at the same time (Mishkin, 2013).} are expected to attain specific intermediate targets; for example, to increase a specific monetary aggregate (such as M1 or M2) in order for some ultimate monetary policy goal to be accomplished (such as price stability). Figure 2.1 illustrates the monetary policy conduct process.

A very important concept that is usually confused with the concept of money supply - although it is indeed directly related to the latter - is that of the monetary base. The monetary base comprises currency in circulation (held by the public) and reserves of money (held both in accounts at the central bank and physically in the vaults of commercial banks). The reason why the concepts of money supply and the monetary base differ is because altering the monetary base should have a multiple effect on money supply through a recurring process of deposits-creation and re-lending (see among others Bofinger, 2001; Mishkin, 2013). In particular, the relation between the two notions can be described by the following equation:

\[
M = m \times MB ,
\]

where \( M \) stands for money supply, \( MB \) for the monetary base and \( m \) is the money multiplier - a sensitivity measure that describes the effect on the supply of money of a change in the monetary base. On general principles, the money multiplier is expected to be greater than one (Mishkin, 2013); it should be noted however, that, with the onset of the recent financial crisis that began in August 2007 and despite the fact that the monetary base in most affected...
countries did in fact increase by a considerable amount (mainly due to increased lending facilities and programmes that involved extensive asset purchases), the level of money supply increase (measured by some monetary aggregate) in these countries remained relatively low (Ivashina and Scharfstein, 2010; Mishkin, 2013). This can be attributed to the fact that commercial banks would prefer to expand their excess reserves as opposed to inject new money to the real economy by issuing new loans to households and firms (Diamond and Rajan, 2009; Woodford, 2010; Mishkin, 2013). In the shell of a nut, unless rises in the monetary base translate into rises in money in circulation, changes in the monetary base have no impact on money supply.

![Monetary Policy Diagram]

**Figure 2.1:** Monetary policy tools, instruments, intermediate targets and ultimate goals.

[Adapted from Mishkin (2013)]

Monetary policy tools, such as open market operations or discount lending are referred to as *conventional monetary policy tools*. It has been argued (see Mishkin, 2013) that, during normal times, the stabilisation of the economy can be relied upon conventional monetary policy tools. At times of financial turbulence though, when confidence usually wanes and low interest rates are not sufficient to promote economic growth (or it is just impossible to further reduce their level - the so called *zero-lower-bound problem*), central banks usually resort to *non-interest rate* or *unconventional monetary policy tools* that typically entail an expansion
of the central bank's balance sheet (a strategy known as *quantitative easing*).

This approach further includes an effort for managing expectations and is reflected upon the central bank's commitment to certain future policy actions. Managing expectations is closely linked to the idea that monetary policy innovations do affect long-term interest rates through the expectations’ channel (Svensson, 2001; Eggertsson and Woodford, 2003; Bernanke and Reinhart, 2004). A list of unconventional monetary policy tools is shown in figure 2.2.

Particularly worthy of mention, is the fact that most central banks today choose to conduct monetary policy by setting intermediate targets associated with short-term interest rates (e.g. the Libor-rate, the FFR etc.), as opposed to targets relating to innovations in some monetary aggregate (e.g. M1 or M2) (Mishkin, 2013). As will be discussed in the section that follows, short-term interest rate targets are usually based on the Taylor rule, according to which nominal interest rates should rise by more than rises in the inflation rate (see Taylor, 1993; Taylor, 1999).

![Figure 2.2: Non-conventional monetary policy tools.](source: Mishkin (2013))

With reference to long-term monetary policy goals, it has been argued (see among others: Bernanke and Mishkin 1997; Mishkin, 2013) that the primary long-run goal should be price
stability. Price stability is defined as a long-run rather than a short-run goal in order for the monetary authority to be able to pursue short-run expansionary policies that promote other goals such as growth and high employment - by allowing the inflation rate to deviate from the long-run target. Note however, that central banks should always bare the long-run target in mind to avoid the surface of the time-inconsistency problem; that is, too much discretionary policy that spoils the economy (Mishkin, 2013). The recognition that price stability should be the prevailing long-run monetary policy goal is usually reflected on the decision of a central bank to adopt an inflation targeting strategy. We will discuss the particular elements of inflation targeting in the sections that follow.
2.2 The New Neoclassical Synthesis

2.2.1 Basic principles that guide contemporary central banking

In order to better understand how central banks make decisions within the complex economic system they operate, it would be instructive to consider the basic elements that constitute the framework of their overall banking philosophy. In the seminal work of Goodfriend and King (1997) we find a thorough analysis of what has been known as the New Neoclassical Synthesis which has largely formed the basic principles that drive contemporary decision making in central banks the world over.

To begin with, Friedman’s ideas regarding the nature of inflation (see Friedman, 1963; Friedman, 1968) - that were explicitly reflected on his suggestion that expansionary monetary policy (as this can be realised through the growth of some monetary aggregate) would inevitably lead to higher interest rates and higher inflation - had a major impact on many economists and central bankers (Mishkin, 2013). Contrary to the early work of John Maynard Keynes the General Theory of Employment, Interest and Prices (where emphasis was put upon shortfalls in aggregate demand as - according to Keynes - aggregate demand, or rather, the lack of it, was the main cause for the Great Depression that began in the 1930s), Friedman’s monetarist tradition attributed most of the woes of the Great Depression to poor monetary policy decisions (Mishkin, 2011). To Friedman, supply of money was the most important determinant of both aggregate economic activity and inflation. In his opinion, excessive money supply would inevitably lead to inflation. Overtime, Friedman’s view that inflation is always and everywhere a monetary phenomenon (see Friedman, 1963, p.17) came to be the predominant view among economists and central bankers (Mishkin, 2011).

Another very important element of contemporary central banking is the consensus that price stability has important benefits compared to the high costs of inflation. High levels of
inflation act as a tax on cash holdings since they reduce the purchasing power of money overtime (Goodfriend and King, 1997; Mishkin, 2011). According to Lucas (1972) and Briault (1995) one of the most important downsides of high inflation is the uncertainty regarding future and relative prices, which in turn, drives individuals and companies to make inefficient decisions. In addition, highly volatile inflation can be associated with rises in the cost of borrowing. Price stability implies that in the long run, low inflation improves the efficiency of economic choices (Mishkin, 2011). Mishkin (2011) further posits that improved economic efficiency would lead to lower unemployment.

Turning to the relationship between unemployment and inflation, Phillips (1958) and Samuelson and Solow (1960) argued in favour of the renowned *Phillips Curve*; that is, they argued in favour of a long run trade-off between these two macroeconomic variables. Nonetheless, under this assumption, the monetary policy authority would find itself in the middle of two competing goals and would then have to decide about the maximum bearable level of inflation necessary for a specific level of employment to be attained. Authors such as Friedman (1968) and Phelps (1968) put forward the counterargument that there is no long run relation between unemployment and inflation and that in the long run there will always be a natural rate of unemployment irrespective of the level of inflation (i.e. they suggested a vertical long run Phillips curve). A long run relationship can only exist in terms of improved efficiency (Mishkin, 2011).

The New Neoclassical Synthesis also places heavy emphasis upon rational expectations. The theory of rational expectations that was based on *the best guess of the future* was initially

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8 With hindsight, the proposed levels of inflation in the region of 4% to 5% - regarded by Samuelson and Solow (1960) as crucial for the attainment of a low 3% unemployment rate – proved to be unsustainable and led to the Great Inflation of the 1970s (Mishkin, 2011).

9 That is, price stability will remove uncertainty regarding future macroeconomic conditions and potentially lead to an *ideal* allocation of resources and thus to improved social welfare.
introduced by Muth (1961) and was further developed by Lucas (1972, 1973 and 1976) and Sargent and Wallace (1975) who - in trying to investigate the reasons why discretionary policies after the World War II had failed to contain business cycle fluctuations\(^{10}\) and reduce inflation - questioned whether a policy can in fact be successful when the public expects the implementation of the policy\(^{11}\). It follows that the \textit{systematic component} of monetary policy (i.e. anticipated monetary policy) greatly affects the bank’s decisions on policy formulation and implementation. In particular, managing public expectations about future monetary policy decisions has become a key concern for most central banks (Woodford, 2003).

Another concept that was given impetus over the past few years was the \textit{Taylor principle} which entails that the central bank adjusts nominal interest rates in the light of deviations of inflation from its desired level (Taylor, 1993; Woodford, 2001; Gali, 2008). In particular, Taylor (1993) argues that in order for inflation to be contained, nominal interest rates should be greater than the observed \textit{inflation gap}, where inflation gap is defined as the difference between the actual and the desired level of inflation. It follows that real interest rates should also rise in response to rises in the level of inflation. In testament to that, authors such as Gali (2008) and Mishkin (2011) opine that the \textit{Fisherian equation}\(^{12}\):

\[ i_t = E_t(\pi_{t+1}) + r_t, \tag{2.2} \]

(where \(i_t\) is the nominal interest rate at time \(t\), \(E_t(\pi_{t+1})\) is the currently expected future inflation and \(r_t\) is the real interest rate at time \(t\))

which suggests that the current nominal interest rate adjusts \textit{one for one} with currently expected future inflation, is not adequate to describe interest rate adjustments necessary for

\(^{10}\) That is, periods when the economy deviates from its natural / potential level of output and full employment.

\(^{11}\) The \textit{Lucas critique} can be regarded as a justified concern associated with the fact that the effectiveness of any discretionary macroeconomic policy given the importance of rational expectations in economic behaviour will always be contested (Lucas, 1976).

\(^{12}\) Named after the American economist Irvin Fisher (1867-1947).
containing and stabilising inflation in practice. It has also been argued (see Clarida et al. 1998) that during the 1970s many central banks the world over had dismissed the Taylor principle, significantly contributing to the inflationary pressures of that era.

In addition, a general consensus that has emerged within the framework of the New Neoclassical Synthesis is that in the long-run policy is much more successful if it functions on the basis of some monetary policy rule, rather than just being discretionary. Apparently, it may be tempting to try to influence the economy in the short-run (e.g. by pursuing an expansionary policy that would boost output and increase employment); nonetheless, any discretionary expansionary policy would only make employees readjust their expectations about future inflation upwards; a fact that would inevitably lead to considerable increases in both wages and prices (Mishkin, 2013). This is what authors such as Kydland and Prescott (1977) refer to as the time-inconsistency problem. Central banks should therefore adopt longer-term strategies and avoid surprising people with discretionary decisions (Woodford, 2000; Albanesi et al., 2001; Surico, 2008, Mishkin, 2013).

In relation to the time-inconsistency problem, authors such as Alesina and Summers (1993), Cukierman (1993), McCallum (1997), Burger et al. (2001), as well as, Klomp and de Haan (2009) have provided empirical evidence in favour of the view that the central bank, in order to be more effective, has to be insulated from pressures (i.e. coming mainly from the Government) to implement discretionary monetary policy (in order to serve some short-term political expediency) and should therefore be independent, in terms of fully controlling the monetary policy instruments. It should be noted however, that instrument-independence differs from monetary policy goal-setting (i.e. price stability, high employment, economic growth etc.) as in democratic societies where people vote for their leaders it is expected for people to judge - at regular intervals - the performance of the Government on the basis of a goal-setting, resolution and goal-achievement process (Mishkin, 2011).
According to Mishkin (2013) price stability, which is defined as a situation of low and stable inflation, is becoming an increasingly important monetary policy goal as it removes uncertainty from the economy and helps boosting economic growth. In this regard and also considering issues such as time-inconsistency and the effect of expectations on the anticipated policy outcome, a commitment on behalf of the central bank to some *nominal anchor* appears to be imperative (Goodfriend and King, 1997; Woodford, 2003; Freedman and Laxton, 2009; Capistran and Francia, 2010; Mishkin, 2010). We quote Mishkin (2013, p.435) who explains that the nominal anchor is *a nominal variable such as the inflation rate or the money supply, which ties down the price level to achieve price stability...by directly promoting low and stable inflation expectations...A nominal anchor's importance is that it can limit the time-inconsistency problem*. Mishkin (2013) further opines that since price stability should be the overriding goal of monetary policy, the appropriate strategy for central banks to follow should be that of *inflation targeting*.

Mishkin (2013) summarises the basic elements of the inflation targeting strategy:

- There is a public announcement regarding a very specific numerical target for longer term inflation.
- There is a commitment on behalf of the monetary authority that price stability takes precedence over other goals.
- Decisions about monetary policy do not just revolve around monetary aggregates.
- The plans and the objectives of the monetary authority are regularly communicated to the public ensuring increased transparency.
- The central bank has increased responsibility and is accountable for achieving the inflation target.

inflation targeting can be thought of as a monetary policy framework in which transparency and coherence in policy formulation become the overriding priorities of the monetary authority. Bernanke and Mishkin (1997) further argue that inflation targeting – as a policy priority – refers to the medium or the longer term, as opposed to the short term when monetary policy is basically considered to affect real quantities, such as unemployment and output.

Furthermore, Sims (2007) argues that if forecasts regarding the future path of inflation are made public beforehand then it is much easier for economic agents to distinguish between policy changes that take place as part of some systematic response of the monetary authority to the current state on the economy and erratic or unsystematic policy changes.\textsuperscript{13}

In order for both short term and longer term goals to be accomplished, inflation targeting central banks resort to various methods, such as employing a measure for inflation (e.g. CPI)

\textsuperscript{13} Gerlach and Smets (1995) distinguish between the systematic and the unsystematic part of monetary policy; in particular, they argue that the systematic part reflects \textit{average responses} of the central bank to macroeconomic shocks such as innovations in aggregate demand and aggregate supply (i.e. this part represents the standard monetary policy function). Unsystematic monetary policy refers to deviations from these average responses observed over the period of study.
that excludes certain combinations of food and energy prices, allowing the inflation target to fluctuate within a specific range of values, as well as, setting short-term inflation targets to account for various exogenous shocks (i.e. banks announce a higher inflation target in the light of an oil price shock, for example, and then gradually the target reverts to its initially desired value). It is worth noting however, that in the event of a conflict between an intermediate goal and the inflation goal, in the framework of inflation targeting the latter always takes precedence over the former (Bernanke and Mishkin, 1997).

It has also been argued (see among others Bernanke et al., 1999; Bernanke and Gertler, 2001) that financial instability is also important as it can be directly linked to business cycle fluctuations\(^{14}\) (Mishkin, 2011). In relation to this, Mishkin (2011) emphasizes a main drawback of econometric models currently employed by most central banks which is associated with the fact that innovations in the financial sector and broader financial instability issues do not appear to have a firm place in the underlying structure of the models. A summary of the main concessions of the New Neoclassical Synthesis is given in figure 2.3.

### 2.2.2 Econometric modelling of monetary policy

In making policy decisions, central banks have traditionally employed structural macroeconometric models of the *Cowles Commission* persuasion that typically comprise a large number of *behavioural equations* (Lucas, 1976, Sims, 1980; Spanos, 1990; Fair, 2012). Due to their shortcomings, mainly related to the fact that such models do incorporate *ad hoc* specifications in relation to their underlying system of equations and also suffer from the Lucas (1976) critique, alternative time series macroeconometric modelling paradigms - such as the Vector Autoregressive (VAR) methodology and Dynamic Stochastic General Equilibrium (DSGE) models - have emerged to assist policy decision making (see *inter alia*

\(^{14}\) For a thorough investigation of the relation among asymmetric information, financial instability and economic downturn, the reader is directed to the seminal work by Greenwald, Stiglitz and Weiss (1984).
Kydland and Prescott, 1982; Wallis, 1989; Smets and Wouters, 2007; Consolo et al., 2009; Rickman, 2010; Fair, 2012).

In effect, these new modelling approaches have been used in tandem with traditional large-scale simultaneous equations models\(^\text{15}\) that still constitute the cornerstone of monetary policy decision making the world over (Mishkin, 2011). The latter is also true for the Bank of England (Aikman et al., 2009; Burrows et al., 2012).

With reference to VAR models, these have been broadly used by researchers and policy makers (Gerlach and Smets, 1995; Bagliano and Favero, 1998; Leeper, Sims and Zha, 1998; Christiano et al., 2000; Clarida, 2001; Peersman and Smets, 2001) in an effort to decipher the monetary policy transmission mechanism in various economies including the United Kingdom (Mountford, 2005; Castelnuovo and Surico, 2006; Benati, 2008; Sousa and Zaghini, 2008). In addition, Peersman and Smets (2001) explain that VAR models have been widely used for assessing the macroeconomic effects of unexpected innovations on the evolution of interest rates directly controlled by the monetary policy authority. This view is in line with Bagliano and Favero (1998) who maintain that distinguishing (i.e. appropriately identifying) between the systematic and the unsystematic component of monetary policy is of considerable importance to the effect that reliable results can be obtained from the model.

An intuitive way to think of the difference between systematic and unsystematic monetary policy is provided by Christiano et al. (2000) and Giannone et al. (2002) who describe monetary policy by the following equation:

\(^{15}\) According to Pagan (2003), contemporary large-scale macroeconometric models usually take some hybrid form in order to accommodate some of the problems typically associated with this sort of modelling (i.e. a downsizing of the models is usually necessary in order to obtain clarity which will - in turn - facilitate the task of explaining policy issues to the public).
Chapter 2: Literature Review I: The Role of Monetary Policy

\[ i_t = f(\zeta_t) + u_t, \]  
(2.3)

where \( i \) is the monetary policy instrument (i.e. some short-term interest rate), \( f(\zeta_t) \) is a function that represents systematic monetary policy, while \( u_t \) stands for the unanticipated monetary policy shock that may be attributed to the following reasons (see Hamilton, 1997; Bernanke and Mihov, 1998; Christiano et al., 2000; Giannone et al., 2002):

- exogenous shocks that are usually related to disturbances in real economic activity that in turn influence the preferences of the monetary authority,
- self-fulfilling expectations regarding the stance of monetary policy on behalf of the economy's private agents (this is possible mainly when the monetary authority chooses to evade the cost of disappointing economic agents' expectations),
- measurement errors in the original datasets on which decisions were made.

Furthermore, Schorfheide (2005), explicates that VAR models of the Sims (1980) tradition have been extensively used to assess the impact of monetary policy interventions and that these interventions by definition take the form of an unexpected deviation from what is regarded as an anticipated monetary policy response. These effects are typically assessed through the derivation of the impulse response functions (Gerlach and Smets, 1995; Schorfheide, 2005).

It is worth noting however, that prominent among the findings outlined in Sims (2007) - regarding the contribution of structural VARs as auxiliary tools to monetary policy decision making - is that most of the variation in monetary policy instruments can be attributed to the systematic reaction of the monetary authority to current economic conditions, rather than, to erratic decisions made on the basis of random disturbances (shocks). According to Sims (2007, p.2-3) analysing monetary policy with structural VARS has also provided the following useful information:
In most countries and for differing periods, monetary policy can be 'best modelled as an interest rate setting rule'.

Also, 'output responds with a lag and prices with an even longer lag to monetary policy actions. The shapes of these estimated responses conditioned policy discussion and were used as calibration targets for non-VAR modellers'.

A potential problem with VAR modelling approaches in general is that when unexpected deviations from anticipated monetary policy tend to endure then expectations regarding future formulation and implementation of monetary policy may change dramatically and this could render the results obtained from the VAR model unreliable (Gerlach and Smets, 1995; Schorfheide, 2005). This problem can be partially resolved by VAR models that incorporate Markov regime-switching approaches (see Krozlig, 1997; Ehrmann et al., 2001; Rubio-Ramirez et al., 2005; Lanne et al., 2010).

A different approach within the New Neoclassical Synthesis framework, that is admittedly far more theoretically coherent16 - compared to vector autoregressions and structural systems of equations - and has become very popular (in both academic and policy circles), is the development of DSGE models (Rabanal, 2007; Canova and Sala, 2009). DSGE models also incorporate Markov regime-switching approaches and in this regard it is possible to test both short-run and long-run effects under a variety of monetary policy rules and divergent monetary policy regimes (see inter alia Schorfheide, 2005; Fernandez-Villaverde and Rubio-Ramirez, 2007; Liu et al., 2011). On general principles, these models rely on microeconomic foundations that entail optimising behaviour of standard representative forward-looking economic agents (e.g. households and firms) and manage not only to address the Lucas (1976) critique, but also to incorporate several versions of the Taylor rule (Kydland and

16 For a thorough analysis of the differences between theoretically and empirically coherent macroeconometric models, the reader is directed to the work of Pagan (2003).
Prescott, 1982; Smets and Wouters, 2003; Levin et al., 2006). It follows that DSGE models have become very attractive in the New Neoclassical Synthesis framework (Smets and Wouters, 2005). In virtue of the theoretical priors that underpin their structure, these models usually break down into two main categories; namely, Real Business Cycle (RBC) models and New Keynesian (NK) models (Kydland and Presscott, 1982; Clarida et al., 1999). Those in favour of this modelling route put forward the argument that the fact that these models rely on micro-foundations makes the investigation of several aspects of uncertainty - revolving around policy decisions - much more convenient compared to the potentials of investigation stemming from small stylised models of the VAR family (Levin et al., 2006). In principle, DSGE models can be taken to data through the application of standard Bayesian econometric techniques (see inter alia Smets and Wouters, 2003; An and Schroheide, 2007).

Authors such as Consolo et al. (2009) highlight the importance of these models for the formulation and the implementation of monetary policy arguing that in some cases it appears as if DSGE modelling has become the prevailing methodological stance17. The latter is not entirely true though, as on one hand, central banks usually employ a variety of models in order to make decisions (and not just DSGEs) and on the other hand, academic researchers and policy makers try to develop hybrid models on the basis of some combination of all existing modelling options (Pagan, 2003; BoE, 2005). In testament to this, there is a growing literature regarding efforts towards the identification of SVAR models on the basis of commonly accepted theoretical priors typically incorporated in DSGE models (see among others Del Negro and Schorfheide, 2004; Villani, 2009; Liu and Theodoridis, 2010). This is probably because SVAR models are still considered by many the best possible approach towards modelling the short-run dynamics of an economic system (Dungey and Pagan,

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17 By contrast, a critical review of the DSGE approach to macroeconomic modelling can be found in Fair (2012).
Garratt et al. (2012) provide a detailed account of the main types of macroeconometric models that are currently employed by academic researchers and policy makers in the United Kingdom:

- Large-scale macroeconometric models (such as the RAMSI model of the UK Economy employed by BoE) in the tradition of the Cowles Commission.
- Unstructured or Structural VARs (Classical or Bayesian) in the tradition of Sims (1980), Doan et al. (1984), Bernanke (1986), as well as, Sims (1986).

In retrospect, despite the fact that the current framework of the New Neoclassical Synthesis mainly endorses the development of DSGE models, the contribution of any potential modelling approach is very important. On a final note, Sims (2007) opines that both SVARs and DSGEs have a key role to play as far as the formulation and the assessment of policy is concerned, mainly due to the fact that both types constitute probability models of the data; a key notion for any central bank, especially when it comes to explaining uncertainty about the future course of inflation to economic agents.
2.3 Monetary policy at the Bank of England

2.3.1 Constitutional framework, main priorities and econometric modelling

The Bank of England (BoE) was established in 1694 and is the second oldest Central Bank in the world (with the Central Bank of Sweden; namely, Sveriges Riksbank being the oldest one, as it was established in 1668). Initially, BoE was privately owned, serving as the Government’s banker, but in 1946 the bank was nationalised and its capital stock was transferred to HM Treasury (BoE, 1946). According to King (2012), the first step toward an independent BoE was taken in February 1993 when the Bank released its first Inflation Report, while in 1997, BoE assumed the overall statutory responsibility for setting the nation’s interest rate; a development that gained the Bank absolute instrument independence. This independence was marked by the establishment of the Monetary Policy Committee (MPC) (BoE, 1998).

In recent years, BoE’s key responsibilities, apart from acting as a banker for HM Government, further include the management of the country’s gold reserves and the management of the country’s foreign currency assets and liabilities (BoE, 2012c). On the other hand, the bank is no longer involved in the monitoring of the banking system and the management of national debt while the responsibility for both of these tasks has been passed on to the Financial Services Authority (FSA) and the Debt Management Office (DMO) respectively (Mishkin, 2013). Responsible for managing the affairs of the Bank and setting its core purposes and strategic priorities is the Court of Directors. The latter has explicitly defined the core purposes of the Bank as the assurance of monetary stability (e.g. by bolstering confidence in the currency and targeting price stability) and the contribution towards the achievement of financial stability (e.g. by an efficient oversight of the financial system in general) (BoE, 2012c). The Court of Directors reviews its strategy on a quarterly
To reiterate a point made earlier, financial stability is a key concern in the framework of the New Neoclassical Synthesis. According to Mishkin (2013), neither price nor output stability are sufficient to ensure financial stability. In fact, the period of the Great Moderation; that is, the period that began in the early 1980s and ended with the global financial crisis that began in 2007 - and in which, central banks had managed to control inflation and to decrease the volatility of business cycle fluctuations (Taylor, 2009; Mishkin, 2013) - can be thought of as a period in which market participants were willing to take on excessive risks, predicated on the false assumption that only a small amount of risk was present in the economic system (Bean, 2010; Mishkin, 2013). In this regard, price stability might even have helped with the fabrication of the global financial crisis.

An exhaustive list in connection with the bank's main current strategic priorities (as described in BoE, 2012c, p. 29-34 ) entails the following:

\[ \Rightarrow \] Core Purpose I: Monetary stability

- *Keep CPI inflation on track to meet the Government's 2% target*: This relates to the commitment by the MPC to set monetary policy instruments in order to achieve the target set by HM Government, or to bring inflation back to target (i.e. within a reasonable period of time) at times when due to economic shocks or other disturbances it deviates from the adopted level of 2% (BoE, 2013; BoE, 2012c). In so doing, the MPC should consider the impact on the economy of unconventional tools of monetary policy, account for the interaction between monetary and macroprudential policy\(^{18}\), as well as, exploit all available econometric models to facilitate forecasting and policy analysis (BoE, 2012c).

\(^{18}\) e.g. Basel III approaches towards financial regulation (for a thorough discussion see BoE, 2009).
Ensure the Bank has the policies, tools and infrastructure in place to implement monetary policy and issue banknotes: This strategic priority entails that the bank is prepared to support its adopted strategy in the face of disbelief or inflated expectations on behalf of economic agents - mainly concerning what monetary policy can or cannot do - largely generated from the current adverse economic conditions (BoE, 2013; BoE, 2012c). It also implies that the bank will consider potential risks related to a number of issues such as appropriate staffing, appropriate modelling, as well as, reputational consequences in the event of unanticipated outcomes (BoE, 2012c).

Core Purpose II: Financial stability

Maintain stability and improve the resilience of the financial system: In February 2011 the Court of Directors of BoE created an interim Financial Policy Committee (FPC) charged with identifying potential sources of disturbance to the financial system (see BoE, 2012d). The FPC is also responsible for reducing the systemic risk by implementing the appropriate policy tools (BoE, 2012c; BoE, 2012d; Clark, 2012). In this spirit, BoE has to contribute not only to the international discussion on resolutions that promote financial stability, but also, to the development of both preemptive and recovery financial plans.

Deliver macroprudential policy, operating through the FPC: This strategic priority mainly involves the coordination among the FPC, the Financial Services Authority (FSA) and HM Treasury towards the formulation of an international framework of macroprudential regulation (Boe, 2012d; Clark, 2012).

Complete the transition of microprudential supervision and infrastructure oversight: In short, this priority entails close cooperation among the FPC, the Financial Conduct Authority (FCA) and the Prudential Regulation Authority (PRA) in an effort to protect the stability of the financial system from the aggregate behaviour of firms.
(HM Treasury, 2012).

⇒ Supporting Core Purposes:

- **Build and sustain public support for the Bank’s governance and for its monetary policy, macro and microprudential frameworks:** The bank should take every necessary measure to ensure clarity and transparency in all of its operations and decisions (BoE, 2012c; BoE, 2012d).

- **Ensure the Bank has the right people and processes to carry out its core purposes - in particular during this period of transition:** Within the framework of a longer-term business plan within the bank, emphasis should be put upon improving the efficiency of all resources that are put to work.

The price stability (inflation) target is specified (at least once every year) by the Government and then MPC is charged with achieving the target (BoE, 2013; BoE, 2012c). The MPC assembles at least once every month and its decisions become publicly available usually two weeks later (Goodhart, 2000; BoE, 2012c). Furthermore, as is usually the case in most inflation targeting central banks, BoE publishes on a quarterly basis a report on inflation which comprises quarterly projections regarding the level of inflation and output, as well as, lengthy studies of the factors that are likely to affect inflation in the future. Informing the public on a regular basis of the potential inflationary paths is highly important especially when it comes to managing expectations regarding the future level of inflation (Wallis, 2004; Sims, 2007; BoE, 2012c; BoE, 2013).

Turning to econometric modelling at BoE, a point that has already been made is that all types of available models are employed in order to assist monetary policy decision making (Pagan, 2003; Garratt et al., 2012). The basic model employed by BoE for the production of monthly projections regarding the future course of UK’s banks profits, as well as, for performing
stress-tests is the Risk Assessment Model of Systemic Institutions (RAMSI) which is basically a large-scale macroeconometric model that emphasizes the investigation of the banking system as a whole (*top-down* approach) before proceeding to the analysis of individual institutions (Burrows et al., 2012). It is worth noting that projections regarding the future course of macroeconomic variables employed by the RAMSI model (i.e. inflation, output, interest rates) come from *internal BoE macroeconomic models* (e.g. models of the VAR family) (BoE, 2000; Alessandri et al., 2009; Burrows et al., 2012).

VAR models have been traditionally employed by BoE to achieve two supplementary goals; namely, to make projections relating to the macroeconomic variables of interest, as well as, to investigate the impact of economic shocks (BoE, 2000; Dhar et al., 2000).

In addition, DSGE modelling approaches have also been employed by BoE (see among others Andreasen, 2011; Villa and Yang, 2011; Millard, 2011). Recent studies related to monetary policy in the UK that employ similar methods to this study (i.e. VAR / Markov regime switching / MGARCH type models) include Knot and Polenghi (2006), Malik (2010), Barnett et al. (2012), Beirne et al. (2012), Chen and Macdonald (2012), as well as, Martin and Milas (2012).

What deserves increased attention however, is the key notion that econometric models should act as a supplement, rather than just as a substitute of decision making (Price, 1996; Sims, 2007). According to Sims (2007) the *error bands* of the *fan charts* illustrated in the various reports produced by the monetary authority (such as the quarterly *Inflation Report* produced by the MPC) regarding the potential paths of future inflation should strictly reflect *judgmental input* on behalf of the pertinent policy committee - implying that the error bands that are actually produced by econometric models can be used merely as a starting point towards determining the final (published) bands.
2.3.2 Inflation targeting

The first country to introduce the inflation targeting strategy was New Zealand in 1989 (Allen, 1999; Mishkin, 2013). The United Kingdom decided to adopt an inflation targeting monetary policy in October 1992, just one month after the departure of the sterling from the European Exchange Rate Mechanism (ERM) (King, 2012). For the record, it was in 1979 that the European Union embarked on the development of a system of fixed exchange rates in which the exchange rate between any pair of currencies was not expected to fluctuate outside some predetermined and relatively narrow interval (called the snake. In effect, the currencies of all participant countries were pegged to the German mark) (Mishkin, 2013). Truth be told, the narrow bands provided little - if any - room for manoeuvres against speculative attacks and eventually some countries were forced to either devalue or exit the mechanism (Frankel, 2003). The United Kingdom decided to exit the ERM in September 1992 when it had already been established that not even broader bands could stave off future speculative attacks against currencies (Obstfeld and Rogoff, 1995).

The initial inflation target for the United Kingdom was 2.5% linked to fluctuations of the Retail Prices Index (RPI). In December 2003 though, the target for inflation in the United Kingdom was changed to 2% and CPI replaced RPI as the official measure of inflation (ONS, 2011).

Before we proceed with our analysis on the inflation targeting monetary policy of BoE, a brief explanation of the positive inflation target (as opposed to a zero inflation target) would be instructive. Stable prices imply an inflation rate that equals zero, however this is not overly desirable by the central bank mainly for two reasons. At one end of the scale, interest rates cannot fall below zero - the zero lower bound issue19. It is understood that banks cannot

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19 In Krugman et al. (1998) we find a thorough analysis of the concept of the liquidity trap (i.e. the situation in which short-term interest rates fall to zero but at the same time consumers are still not willing to spend and
charge their customers negative rates. However, the real interest rate, as this is defined as the nominal interest rate minus the rate of inflation, may very well assume a negative value when the rate of inflation is higher. In turn, negative real interest rates imply that money loses its value in terms of purchasing power with the passing of time and therefore, consumers will probably choose to increase both spending and borrowing today rather than later. It follows that this could be a desirable policy option during a recession period, however, this option is obviously ruled out in the event of zero inflation (Nishiyama, 2003; Svensson, 2003; Eggertson and Krugman, 2012).

At the other end of the spectrum, it has been generally recognised (BoE, 2012c) that estimated inflation rate levels deviate from actual levels as it is highly laborious and somewhat impractical to record - on a daily basis - every single transaction that takes place in various markets and for different levels of prices (BoE, 2012c). In this regard, BoE estimates the current level of inflation on the basis of only a sample of these transactions, as the latter are typically considered by standard indices employed to measure inflation, such as the Consumer Prices Index (CPI). The result in most cases is an overestimation of the actual level of inflation (BoE, 2012c). That is, actual inflation is always lower than the inflation estimated by BoE. In this regard, setting an inflation target of zero would be misleading. One of the main disadvantages of employing the CPI as a measure for inflation is the fact that this index does not immediately incorporate improvements in the quality of products and changes in consumption habits that could potentially have an important effect on the level of prices in the economy (ONS, 2011). Undoubtedly, increases in the inflation rate that can be attributed to quality improvements are desirable in the sense that consumers end up with a greater value for their money. For all the reasons stated above, we arrive at the conclusion that on general

stimulate the economy at the current levels of short-term interest rates). It follows that positive levels of inflation that entail negative real interest rates could stimulate current consumption (provided that expectations regarding the future course of real interest rates are relatively discouraging) (Svensson, 2003).
principles a moderate amount of inflation in the economy is in fact desirable (see also Mishkin, 2013).

Turning to the question of what the appropriate level of an inflation target should be, the official position of BoE is that higher levels of inflation are typically linked to higher inflation volatility and uncertainty and wane the public’s confidence in the commitment of the central bank for price stability and therefore, the positive target has to be relatively low\textsuperscript{20} (BoE, 2012c).

According to Bean (2003) before the adoption of the inflation targeting strategy, interest rate decisions at BoE could be seen as reactions to either small or big emergencies, rather than well scheduled preemptive monetary policy decisions. Bean (2003) further argues that the adoption of inflation targeting was accompanied by crucial institutional changes that lent a rather forward-looking nature to decision making at BoE (e.g. the institution of a formal meeting between the Chancellor and the Governor of BoE on a monthly basis and the publication of the quarterly inflation report - ensuring that the reasoning underpinning strategic decisions was made publicly available).

King (2012) argues that, on the whole, the decision on behalf of the bank to adopt a specific target for inflation has been a successful one, as inflation - one of the biggest problems in the contemporary UK history - would only average 2.1% in the 20 years that followed a peak of 27% in 1975. Authors such as Bean (2003), Lomax (2004), as well as, King (2012) further provide evidence that the level of expected inflation - measured as the difference between yields on conventional and index-linked gilts - has significantly declined in the years that

\textsuperscript{20} It has been argued (see Blanchard \textit{et al.}, 2010) that a target for inflation in a region between 2\% to 4\% would allow monetary policy to become more expansionary and overcome relatively quickly a recession period. In testament to this, Mishkin (2013) argues that the zero-lower-bound problem is rare and therefore the benefits of a very high level of inflation level are cancelled by the associated costs of retaining a high level of inflation.
followed 1992, wherein the strategy was adopted, implying that inflation expectations can be better controlled under the new framework. We quote King (2012, p.4) who argues that 'even if inflation deviates from the target, as will often be the case, it is expected to return to the target, and so inflation expectations are anchored'.

Lomax (2004) further reports that although the MPC is responsible for achieving the inflation target, the Governor of BoE is charged with preparing a letter to the Chancellor (who represents the Government which is responsible for setting the target in the first place) every time the current level of inflation deviates by 1% from the target that has been set. A point raised by King (2012) though, is that inflation targeting at BoE should be flexible, as in the face of price rigidities, persistently pursuing to keep inflation on target could potentially lead to inefficient output fluctuations21.

Turning to future challenges regarding inflation targeting at BoE, Lomax (2004) identifies three main objectives:

- Ability to appropriately appreciate current conditions: Monthly interest rate decisions should be forward looking reflecting the ability of the monetary policy authority to account for both factors that affect aggregate demand (i.e. spending decisions) and factors that affect aggregate supply (i.e. productivity, labour availability) (Lomax, 2004). This argument is in line with Bean (2003) who states that a tighter monetary policy regime may be appropriate in view of an asset price bubble (resulting in financial instability) - even at times when inflation appears to be way well under control.
- Communication that promotes transparency: BoE should ensure that its decisions are

21 This is in accordance with the New Keynesian view (for a more detailed analysis see Cecchetti et al. 2002; Gali, 2008; Svensson, 2009) that some prices adjust only slowly and thus the monetary authority should expect inflation to only gradually return to the desired level.
well explained to the public and that all factors employed during the decision process are clearly mentioned. The bank is responsible for communicating its policy to the public explaining to economic agents all potential factors (e.g. borrowing constraints or housing prices) that have in turn lead to one decision or another (Lomax, 2004). As an example, Bean (2003) voices the opinion that the bank should provide solid arguments regarding its decision to change the target measure from the RPI(X) to a harmonised CPI. According to Bean (2003) it was important for the bank to communicate its concerns regarding the future course of housing prices.

- Better understanding of the consumer society: It is highly important for BoE to seek ways of further deciphering consumer behaviour. Technological progress (i.e. access to the internet, e-shopping) has significantly contributed to fashioning the way consumers choose and buy products (i.e. on a value for money basis) (Lomax, 2004). In the same line of reasoning Lomax (2004) emphasises the necessity for the bank to assess the degree to which competition in the market could squeeze prices potentially allowing for (or leading to) improvements in productivity.

Be all this as it may, it is indeed too early to judge whether an alternative strategy should be adopted and replace inflation targeting (King, 2012). According to King (2012) both the steps taken towards an independent central bank and the adopted inflation targeting strategy have contributed considerably to price stability in the United Kingdom.

Having established the key role that monetary policy has to play in connection with price and financial stability, we move on to chapter 3 in which we investigate the various transmission mechanisms concerning the relation between monetary policy and asset prices.
3

LITERATURE REVIEW II:
TRANSMISSION MECHANISMS

In this chapter we review the main transmission mechanisms related to the variables under investigation. This second part of the literature review starts with a short note on macroeconometric modelling summarising the basic ideas and arguments underpinning the evolution of contemporary macroeconometrics. In turn, emphasis is put upon the various linkages between monetary policy and asset prices, with a special focus on housing and financial prices. We then provide a succinct account of the relationship between monetary and fiscal policy and argue in favour of a modelling framework that potentially comprises both. Finally, as oil prices are extensively used in this study not only as an initial exogenous shock that triggers developments in the variables of our system, but also, as a control variable which improves our understanding regarding the linkages between monetary policy and asset prices, we conclude the review by providing an account of the macroeconomic effects of oil prices.

It would be instructive at this point to clarify that this chapter concentrates on a concise description of broader issues gravitating around the four working assumptions of the study. In this regard, literature review associated with the specific methods employed or with the interpretation / discussion of the results is reserved for the relevant sections.
3.1 The ongoing debate around macroeconomic modelling

This section merely represents an effort to introduce the reader to the current debate revolving around macroeconometric modelling as a tool for aiding policy decision making. Arguably, the intellectual conflict in connection with the divergent approaches towards describing and investigating real economic activity has its own particular significance in the realms of monetary policy decision making.

Models are widely used in economics as they serve many purposes. According to Dornbusch et al. (2008), models can be used not only to describe the economy but also to provide decision makers useful insight into far more complicated issues regarding economic developments. Dornbusch et al. (2008), further argue that models can be used for forecasting purposes. To quote Garratt et al. (2012, p.1) "models are used to organise and describe our understanding of the workings of the national and global economies, provide a common framework for communication, predict future economic developments under alternative scenarios, and to evaluate potential outcomes of policies and external events". Dornbusch et al. (2008), suggest that economic models can take many forms. On one hand, researchers develop simple theoretical models comprising only a few equations that can be represented by simple diagrams (e.g. the IS/LM model). According to Garratt et al. (2012), simple theoretical models are quite useful when it comes to interpreting basic economic functions and to simplifying complicated economic concepts. On the other hand, researchers develop more sophisticated models (e.g. macroeconometric models) that incorporate a large number of equations, collect relevant numerical data and derive results by investigating the historical behaviour of various important macroeconomic and financial variables (Canova, 2007; Garratt et al., 2012). These models form the basis of forecasting in contemporary policy - decision making (Canova, 2007; Bårdsen and Nymoen; 2009). Authors such as Banerjee et
al. (2009) and Garratt et al. (2012) further argue that macroeconometric modelling is at the heart of monetary policy decision making. In fact, the authors suggest that macroeconometric modelling is extensively employed by Central Banks, Governments, Financial Institutions, as well as, by decision makers in general, throughout the world.

Pagan (2003), in his assessment of the types of macroeconometric models employed by the Bank of England (BoE), draws an explicit distinction between *theoretically coherent* macroeconometric models and *empirically coherent* macroeconometric models. According to Pagan (2003) empirically coherent models such as Vector Autoregressive models (VARs) use mainly time series data in order to assess economic developments and identify linkages between various macroeconomic variables without taking into account important theoretical arguments. Pagan (2003), argues that, in principle, empirically coherent models focus on predicting the future by simply showing what has happened in the past (projection). On the other hand, theoretically coherent models, such as Dynamic General Equilibrium models (DSGEs) are also based on the collection of historical data; however these models consist of a system of *constraint behavioural equations* formed in such a way as to incorporate the fundamental theoretical arguments imposed by the General Equilibrium Theory (Pagan, 2003).

The vector autoregressive (VAR) methodology\textsuperscript{22} was introduced by Sims (1980) as an innovative way to facilitate macroeconomic policy decision making by evading the impossible and very confusing restrictions of the traditional macroeconometric models of the Cowles Commission\textsuperscript{23} family - which usually provided very complicated results. The specific econometric methods employed by this study are empirically coherent models such as VAR

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\textsuperscript{22} A more detailed discussion regarding this type of model can be found in section 1 of chapter 6.

\textsuperscript{23} Refers to the Cowles Foundation, a major econometric society in the US, which can be credited with the development of the dynamic simultaneous equations models that are still being used by central banks the world over.
Chapter 3: Literature Review II: Transmission Mechanisms

models. Before we proceed to the next section though, it would be appropriate to provide a short historical overview of the theoretically coherent models as well.

The need to incorporate theoretical arguments in macroeconometric models had initially been identified by Lucas (1976). His seminal work on the evaluation of econometric policy is considered to be a milestone for macroeconometric modelling. Lucas (1976) voices the opinion that macroeconometric modelling has generally been predicting poorly because both consumers' expectations and firms' expectations on future developments have been completely ignored. In this regard, Lucas (1976) posits that microeconomic principles should be incorporated into macroeconomic models in order for the latter to be able to explain expenditure choices and pricing behaviour in the macroeconomy level.

General equilibrium models can be traced back to the work of Solow (1956). However, general equilibrium models at that time had been mainly theoretical and lacked empirical evidence. On the other hand empirical models produced results that had never been tested against theoretical arguments (Dejong & Dave, 2007). Until 1982 when the seminal work of Kydland and Prescott (1982) made its way to the public, macroeconometric modelling was mainly influenced by the work of Sims (1972, 1980) and Lucas (1976). Kydland & Prescott (1982) are the first to introduce the concept of Dynamic Stochastic General Equilibrium Modelling (DSGE). According to Dejong and Dave (2007) the contribution of Kydland and Prescott (1982) to the scientific branch of macroeconometric analysis can be summarised in the fact that they incorporated in their work Lucas' (1976) propositions on the way macroeconometric modelling should be conducted. Dejong and Dave (2007, p.3) further state that Kydland and Prescott (1982) developed a new type of macroeconometric model which incorporates agent's expectations and serves directly as "the foundation upon which empirical work may be conducted". According to Canova (2007) DSGE models, compared to the backward-looking empirically coherent models, such as VARs, are considered to be both
backward-looking and *forward-looking*. The author explains that DSGE models can be both simply because they not only make use of historical data but they also incorporate micro-foundations, such as agents' expectations on future economic developments.

In conclusion, there is a wealth of macroeconometric (both theoretically and empirically coherent) models available to assist decision makers with the task of identifying transmission mechanisms and producing valuable forecasts. As we saw in the previous chapter (see among others Sims, 2007; Burrows et al., 2012; Garratt et al., 2012) in practice, central banks, academics and other decision makers - in an effort to decipher the workings of real economic activity - try to make use of all available options, as well as, to develop new ones. Finally, reverting to a point made in the introduction of this section, a thorough analysis of the specific macroeconometric models employed by the present study is provided in Chapter 6 where each research objective is exposed and investigated by the relevant method.
3.2 Asset prices and monetary policy

This section provides a detailed account of the various channels through which monetary policy affects both housing and financial markets. In addition, given that the first empirical model of this study is concentrated on the wealth channel of monetary policy we also outline various theoretical considerations, as well as, empirical evidence revolving around the specific relationship between monetary policy decisions, households' wealth and consumption.

3.2.1 Monetary policy transmission mechanisms

There exist various channels through which the effects of monetary policy decisions propagate the economy. Mishkin (1996) distinguishes between traditional interest rate channels and asset price channels. As far as the first category is concerned, the author argues that on general principles expansionary monetary policy leads to a decrease in interest rates which in turn causes a rise in investment spending and a subsequent rise in output. As far as asset price channels are concerned, they comprise monetary effects that propagate the economy through exchange rate, housing price and equity price channels. In the case of the housing and the equity channel, wealth effects constitute an important factor through which both consumption and output are affected (Mishkin, 1996; 2007).

To be more explicit, the analysis provided by Mishkin (2001) implies the transmission mechanisms described below.

With regard to stock market prices:

- Effects on investment:

This category basically revolves around Tobin's q-theory. In short, Tobin's q represents the link between financial markets and markets for goods and services. When market valuation of
firms is greater than the cost of currently produced goods and services (e.g. commodities related to plant equipment) then Tobin's q is high implying that firms can buy more commodities by issuing less amount of shares. In this regard, lower short-term interest rates will direct more people to the stock market further supporting an increase in stock market prices. This implies that firms will then be able to invest even more on new commodities.

- Effects on businesses' balance sheets:

This category refers to the credit channel of monetary policy. When a firm's net worth is low, then issues arise regarding the maximum borrowing capacity of this firm. A low market price for a firm's share implies low net worth which could potentially lead the firm's investors to take on additional risk in order to counterbalance their contained equity stake.

As before, lower short-term interest rates in the economy would lead investors to the stock market, pushing up stock prices and improving businesses' borrowing capacity.

- Wealth effects:

This category basically recognises that market shares are a major component of financial wealth and therefore an important determinant of consumer's wealth in general. Lower short-term interest rates would have a positive effect on the stock market implying a direct improvement of households' wealth conditions.

The idea of a strong link between monetary policy decisions and financial prices is well reported in the work of many authors throughout the years. Early on in the 1970s Modigliani (1971) posits that monetary policy innovations have a significant impact on stock market prices and households' wealth. According to the author common stocks constitute a major component of financial wealth and that rises in the price of common stocks lead to rises in
households’ financial wealth implying that stock prices can be used as a close approximation of financial wealth in general.

- **Liquidity effects:**

This category implies a link between financial assets and households' consumption and investment. In particular, at times of financial distress households would rather hold liquid (e.g. shares) than illiquid (e.g. durable) assets simply because the former type is easier to sell. When households have a sufficient amount of liquid assets that makes them feel safer, then an increase in short-term interest rates that pushed up stock market prices would endorse households' confidence even more and encourage their decisions to buy durable assets as well.

With regard to housing market prices:

- **Direct effects on housing investment:**

This category implies that lower short-term interest rates render borrowing less expensive and thus more people will choose to finance the purchase of a house, leading in turn to higher housing prices. If housing prices are higher than the related construction costs, then construction companies will initiate a circle of investments in the housing market which will have positive effects throughout the economy.

- **Wealth effects:**

On the basis that housing prices reflect households' housing wealth, which is further assumed to be a major component of households' total wealth, then expansionary monetary policy implying easier access to funding would raise housing prices and therefore both housing wealth and consumption.
Chapter 3: Literature Review II: Transmission Mechanisms

- Bank balance sheets:

This is more or less the credit channel of monetary policy. The value of a property acts as collateral for borrowing money. It is therefore understood that an increase in housing prices will allow banks to engage in more lending activities. In such an event, the results in the economy as a whole are also expected to be positive.

The foregone analysis was made considering the effects of expansionary monetary policy (i.e. decreasing interest rates). It follows that in the event of contractionary monetary policy we expect all aforementioned transmission mechanisms to work in the opposite direction. In turn we present some important relevant studies that have taken place over time and outline their findings.

As far as the stock market is concerned, Bernanke and Gertler (1995), King and Watson (1996), Lastrapes (2002), Iacoviello (2005), as well as, Castelnuovo and Nisticò (2010) all support the idea that monetary policy might have a strong effect on output through the channel of stock market wealth. On general principles, all aforementioned authors agree that; assuming an expansionary monetary policy strategy which explicitly entails a decrease in the monetary policy instrument (i.e. the bank rate or the monetary base) equity prices are expected to rise increasing the value of wealth and leading to higher levels of consumption.

As far as the housing market is concerned, authors like Sousa (2010), Iacoviello and Neri (2007), Dvornak and Kohler (2007), as well as, Ludwig and Slok (2002) document that although housing prices fluctuations during the 1970s could be somewhat attributed to the general technological progress of that era, housing prices fluctuations over the last decade can be attributed to a great extent to monetary policy. Iacoviello and Minetti (2003), provide evidence that housing prices are much more sensitive to monetary policy innovations depending on the degree of financial liberalization of the economy under investigation.
Evidence on the impact of monetary policy decisions on housing prices can be found in the recent work of Hay (2009), Mishkin (2009), as well as Kohn (2009), who among many others voice the opinion that asset price bubbles may very well be attributed to monetary policy decisions that entail low interest rates and easy credit criteria. In addition, Carstensen, Hulsewig and Wollmershauser (2009) support the idea that collateral constraints along with the terms of credit generally magnify the impact of monetary policy on the economy.

With reference to agents’ expectations, it can further be evidenced that monetary policy decisions can have a strong impact on investors’ expectations regarding developments in the stock market. According to Kurov (2010) monetary policy news can affect investors’ sentiment which in turn results in fluctuations in the stock market. In addition, Ehrmann, Fratzscher and Rigobon (2010) provide evidence of interdependence between stock market fluctuations and policy decisions for the U.S. economy. Castelnuovo and Nisticò (2010) lay great emphasis to the fact that expectations regarding future stock market returns can be influenced by monetary policy decisions and that asset price changes greatly affect households’ wealth and consumption. Along a similar vein, Mishkin (2007) explains that central banks, by altering the level of short-term interest rates, affect agents’ expectations regarding the future path of housing prices. Case et al. (2005) maintain that an increase in the monetary policy instrument will result in lower housing prices as borrowing becomes less attractive. In a world of efficient housing markets, real housing prices can be computed as the discounted present value of future rents minus depreciation. The discount is based on the user cost of capital\(^{24}\). Mishkin (2007) explains that if agents anticipate a tightening of monetary policy in the future, the user cost of capital will rise, implying lower demand for housing and lower housing construction. Inevitably this chain of events will have a negative impact on aggregate demand and the economy as a whole.

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\(^{24}\) Consider this as the cost of employing the services of a capital asset.
With reference to both stock market and housing prices' response to monetary policy decisions, Bjornland (2008) and Bernanke and Kuttner (2005), proponent that asset prices in general react rather quickly to monetary policy developments and can therefore act as transmitters of such developments in the economy. Due to their timely response to monetary policy shocks, asset prices are considered to be important indicators of the stance of monetary policy. However, Mishkin (2007) advocates that housing prices when compared to stock market prices are not as clearly connected to the potential dynamics of an economy and that higher housing prices may simply reflect some shortage in the supply of housing rather than real increases in output. In this regard, not all assets should be attributed the same features.

3.2.2 Identifying the wealth effect

The idea that an increase in any type of wealth (i.e. stocks, real estate assets, etc.) could lead in higher levels of households' consumption can be traced back to the life-cycle hypothesis of saving and consumption. According to this hypothesis, rises in both housing and financial assets are expected to have a positive effect on households' consumption provided that households' long-run marginal propensity to consume is higher than the real interest rate of the economy. For a thorough analysis of the life-cycle hypothesis of saving and consumption the reader is directed to the seminal work of Modigliani and Brumberg (1954) and Ando and Modigliani (1963).

As we saw earlier, Mishkin (1996, 2001, 2007) provides an essential theoretical account of the propagation of monetary policy decisions in the economy through various direct and indirect channels related to asset prices.

In support of the aforementioned analysis, Ludwig and Slok (2004) provide the general framework in which fluctuations in both the stock and the housing market affect households’ consumption. The focal point of their analysis is that wealth in general can have either
realized or unrealized effects on consumption. At one end of the scale, the realized path suggests that consumption is increased every time economic developments lead to rises in housing market wealth or stock market wealth. Households can either capitalize their gains from the stock market or sell their houses in order to enjoy higher levels of consumption. At the other end of the spectrum, the unrealized path suggests that households’ confidence becomes stronger every time stock prices or housing prices increase and therefore households move to higher levels of consumption simply because they feel wealthier.

According to Ludwig and Slok (2004) both realized and unrealized effects presuppose that households are either stockholders or homeowners or both and that rises in the value of asset prices generate positive expectations regarding the course of these values into the near future. In this regard, people who do not own a house, and wish to buy one in a period of increasing housing prices find it difficult to spend as much as they would have desired because they have to make arrangements for future-loan installments. This is utterly in line with Campbell and Cocco (2007), Mishkin (2007), as well as, Vickers (2000) who put forward the argument that the effects of an increase in housing prices may very well be of a rather reverse nature when it comes to renters or people who generally wish to buy a house in the near future and realize that they have to save more money today.

In addition, Mishkin (2007) and Giuliodori (2005) argue that housing wealth is spread more evenly over the population than financial wealth and therefore changes in housing wealth may have much more substantial effects on consumption than changes in stock prices. This is in line with Dvormak and Kohler (2007) whose discussion is centred around the fact that stock market wealth is in most countries concentrated in the hands of high-income households.

Various studies have been conducted for the UK economy with respect to the consumption-
wealth channel of monetary policy. Most of these studies typically investigate monetary policy effects on consumption separately through either the financial or the housing channel, or aim at assessing the role of financial and housing prices for the overall UK economy.

As far as the housing market is concerned, Aron et al. (2006, 2011) report a strong indirect channel linking UK monetary policy and consumption through housing prices. Aoki et al. (2004) find that higher short-term interest rates have a negative effect on housing prices. Similar results for the UK economy are reported by Iacoviello (2002), Giuliodori (2005), Iacoviello and Minetti (2008), Elbourne (2008), as well as, Bjornland and Jacobsen (2010). Bjornland and Jacobsen (2010) further provide evidence of a bidirectional link between monetary policy decisions and housing prices developments, mainly reflecting the important role of the housing market in the formulation of monetary policy in the UK. A multidirectional linkage between housing prices and monetary variables has also been reported by Case et al. (2005), Goodhart and Hofmann (2008), as well as, Chirinko et al. (2008). Furthermore, Chirinko et al. (2008) argue that shocks in the housing market exert a greater impact on monetary policy decisions compared to shocks in the financial market.

Campbell and Cocco (2007) report a positive elasticity of homeowners’ consumption to housing prices. By contrast, Aron et al. (2006), in accordance with Aoki et al. (2004), report that given a loosening of credit, there is a strong housing wealth effect on consumption which is however realized mainly through the credit channel. In this respect, these authors argue that it is easier access to credit that raises consumption and that previous studies have generally over-estimated the effect of housing wealth and underestimated the effect of financial wealth on consumption.

Turning to the financial market, Bredin et al. (2007) report that UK positive monetary policy shocks have a negative and statistically significant impact on UK industrial level stock
market returns, however, this impact is substantially smaller than the one reported for the US economy.

Case et al. (2005) find that effects of stock market developments on consumption are weak as opposed to developments in housing prices. This is in line with Fernandez-Corugedo et al. (2003) and Slackalek (2009), who show, that housing wealth is in fact more important than financial wealth for the UK economy. On the other hand, Ludwig and Slok (2004), and Bertaut (2002) provides evidence to support the view that it is financial and not housing wealth that exerts the largest impact on UK consumption.
3.3 The interaction between monetary and fiscal policy

This section highlights the fact that empirical research has thus far greatly neglected fiscal policy. Empirical accounts regarding the effects of Government policies on the broader economy are rather scarce which is somewhat imprudent given the grave importance of fiscal policy decision making for the broader economic conditions within a country. Our attention is mainly centred around the effects of insolvent fiscal policy on the appropriate monetary policy conduct, as well as, around the appropriate coordination between the two policies. We conclude this section by summarising relevant empirical studies.

3.3.1 Fiscal policy inconsideration by empirical studies

Despite the fact that the impact of monetary policy on asset prices (especially stock market prices) and the economy in general has been extensively investigated, little empirical research has so far been involved with the respective effects of fiscal policy decision making (see inter alia Afonso and Sousa, 2011; Afonso and Sousa, 2012; Agnello and Sousa, 2013). In particular, Afonso and Sousa (2011) opine that the investigation of the empirical relationship between fiscal policy decision making and asset prices is rather under-researched, as well as, that the effort towards the identification of the underlying transmission mechanisms related to fiscal policy innovations is still at a very early stage.

The limited attention paid to the contribution of fiscal policy to economic developments was initially underscored by Darrat (1988) who - focusing on budget deficit developments and financial prices - voiced the opinion that the evaluation of fiscal policy effects on stock markets had been largely ignored. Considering the view of authors such as Afonso and Sousa (2011) it appears that nothing has changed significantly with respect to incorporating fiscal policy decisions in analysing economic developments ever since. Apparently - and especially in an era marked by a major financial crisis - this could be an issue of foremost importance.
considering the vital role that fiscal policy could play in terms of stabilising the economy (Chatziantoniou et al., 2013).

A detailed account of the various theoretical standpoints regarding fiscal policy is provided in Bernheim (1989). In analysing the effects of fiscal deficits Bernheim (1989) distinguishes among the Keynesian, the Ricardian and the Neoclassical schools of thought.

In short, the Keynesian school assumes relatively myopic consumers and investors with rather high current propensities to consume and invest respectively, who appear to be rather complacent about the effects of a high level of deficit on subsequent generations. These myopic agents will therefore immediately adapt to the new spending and investing opportunities in the event of some discretionary countercyclical fiscal policy (i.e. running a budget deficit during a recession). Neoclassical economists on the other hand, focus on the crowding out effects of fiscal policy on the private sector. To be more explicit a crowding out effect mainly implies that when the Government decides to finance its expenditure by borrowing money (i.e. financing through deficit) then interest rates tend to rise resulting in a decline in consumption and investment. Finally, Ricardians make the assumption that rational households' saving patterns will offset any impact that Government spending may have on aggregate demand and the economy in general.

On a final note, the theoretical framework regarding the effects of fiscal policy on asset prices can be traced back to the work of Tobin (1969), Blanchard (1981), as well as, Quah (1984). In short, there are three channels through which fiscal policy is expected to affect asset prices in general:

- Fiscal policy can have an effect on interest rates (i.e. through Government borrowing).
- There are also solvency issues regarding the sustainability of the Government budget,
which could potentially create very dire conditions (i.e. increased default risk).

- Given that fiscal policy can influence potential output, asset prices - especially stock market prices - could receive important feedback through this channel.

Regarding the specific effect of fiscal policy on the housing market, authors such as Agnello and Sousa (2013) argue that this could mainly be achieved through (i) subsidies regarding the purchase of a new house and (ii) the wealth effect of taxation on households' disposable income. On the basis that housing supply is relatively inelastic in the short-run, Government subsidising regarding new home acquisitions or lower value-added taxes (VATs) regarding new houses could lead to higher housing prices.

### 3.3.2 The importance of coordinating monetary and fiscal policies

Theory suggests that the interaction between monetary and fiscal policy may occur mainly due to the following reasons (see inter alia Muscatelli and Tirreli, 2005; Zoli, 2005):

- The impact of Government inter-temporal budget constraint on monetary policy.
- The direct effects of fiscal policy on macroeconomic variables such as interest and exchanges rates, as well as, inflation.

Considering the first point, Sargent (1999) posits that any central bank may have administrative independence but it is certainly not entirely cut off from fiscal policy decisions. When a Government keeps on financing its expenditure with deficit, monetary growth will be required at the end (Sargent and Wallace, 1981). In turn, this monetisation of Government debt will inevitably lead to inflation. Therefore this process prompts the question of the appropriate selection of monetary policy strategy today; because, if today the central bank chooses to implement a sort of contractionary monetary policy (i.e. implying the increase of short-term interest rates) how high will interest rates have to go in the future when the monetisation will lead to additional inflationary pressures? Given that both monetary and
fiscal policies target inflation and output\textsuperscript{25} we understand that in any similar event the results on the economy will be greatly undesirable. According to Buti et al. (2001) and Sargent (1999), it is understood that the effectiveness of monetary policy greatly depends on Government decisions. It is also self-evident that insolvent fiscal policy contains the ability of monetary policy to successfully subdue inflationary pressures.

Another point for consideration is the fact that unsustainable practices such as uninterrupted / ongoing deficit financing of Government spending could potentially lead to increased sovereign risk premium (i.e. further borrowing becomes more expensive) and thus to increased risk of default (Zoli, 2005). At best, this would lead to currency depreciation and massive capital outflows. Needless to say that if the country's debt is denominated in a foreign currency then the devaluation of the national currency would inevitably add to the country's liabilities. Zoli (2005) further explicates that currency devaluations are usually accompanied by inflationary pressures implying further increases in interest rates.

Authors such as Demertzis et al. (1999), and Dixit and Lambertini (2003) stress the necessity for an appropriate coordination of the two policies because when central banks adopt disinflationary policies and the Government promotes expansionary approaches then outcomes will necessarily be different from the expected ones.

Finally, a more realistic (and timely) approach to the coordination issue is offered by Bernanke (2013). In a recent speech at the US congress, Bernanke (2013) explains that the argument that fiscal stimulus (as opposed to fiscal consolidation) must be supported by the relevant monetary policy, implies that only an expansionary monetary policy stance would not offset the positive impact of expansionary fiscal policy on aggregate demand. In other words, if high government spending (or low taxation) is combined with high interest rates

\textsuperscript{25} Bean (2003b) explains that although it is not explicitly stated, controlling for output variation is a key consideration for BoE even under the inflation targeting regime.
(i.e. tighter or contractionary monetary policy) then the positive impact of this fiscal stimulus on the economy would inevitably be offset. The argument goes both ways of course and in this regard, it has been suggested that without fiscal consolidation (as this is realised by spending cuts and increased taxation) - at times of inflationary pressures for instance - the monetary authorities would have to raise interest rates even more in order to contain demand.

At times of austerity however, when fiscal consolidation is the preferred policy (i.e. the Government will typically choose not to run a budget deficit so as to improve its overall outlook) and yet growth is the desirable outcome for the economy, authors such as Bernanke (2013) stress the fact that deficit-reduction discretionary fiscal policy and especially in the presence of very low interest rates could have a very strong negative impact on growth. To be more explicit, the currently adopted (i.e. for financial stability) fiscal restraints that inevitably lead to lower levels of consumption and investment will not be offset by lower interest rates because the current level of interest rates in the economy is already very low and therefore growth will not be accomplished.

In this regard, it would be very desirable for Governments and Central Banks to seek ways to boost growth without increasing the deficit. The Funding for Lending (FLS) scheme, which typically involves the exchange of assets between BoE and other commercial banks and therefore is highly unlikely to exert any effect on the budget deficit, could be a good example of this approach (OBR, 2012; BoE, 2012e). It is beyond the scope of this study to investigate the particular aspects of such policies; however, it should be clear by now that the interaction between monetary and fiscal policy is indeed a very interesting area of research.

It is therefore understood that the appropriate coordination between the policies is very important. Authors such as Van Aarle et al. (2003) and Afonso and Sousa (2011) maintain that the development of modelling frameworks which incorporate both demand-side policies
is crucial towards better understanding the workings of real economic activity.

3.3.3 Empirical evidence

As already mentioned empirical literature has remained relatively silent with respect to the effects of fiscal policy on economic activity. A short account of the most important relevant studies is provided below.

As far as the specific interaction between the two policies is concerned, Jansen et al. (2008) argue in favour of a strong link between the two policies. In particular, Jansen et al. (2008) provide evidence that the effects of monetary policy decision making on the US stock market vary significantly depending on the stance of fiscal policy (i.e. whether the latter is contractionary or expansionary) and further report that there is indeed a strong interdependence between the two policies. However, Melitz (1997, 2000) in analysing the effects of the two policies using a sample of 15 European countries (including the UK) reports that the two policies tend to move in rather opposite directions implying that when expansionary policies are adopted by one of the two policies then less expansionary policies are adopted by the other. Finally, Wyplosz (1999) documents that both policies act counter cyclically with respect to inflationary pressures.

Evidence regarding the relationship between fiscal policy and the stock market (for various countries the world over) suggests that - on general principles - stock markets tend to favour fiscal policy tightening. In particular, Darrat (1988) documents that fiscal deficit exerts a negative and significant effect on stock prices. Ardagna (2009) using a panel of OECD countries including the UK, reports that a decrease in Government spending positively affects stock market developments. A negative impact from Government spending on the UK stock market can also be reported by Afonso and Sousa (2011), Agnello and Sousa (2013), as well as, Chatziantoniou et al. (2013).
Turning to the housing market, authors such as Afonso and Sousa (2011) and Agnello and Sousa (2013) report that housing prices respond negatively to a positive shock in Government spending, although this response turns positive after 4 to 8 quarters have passed.

Turning to the broader effects of fiscal policy on economic conditions Van Aarle et al. (2003) in his investigation of fiscal policy in various EMU countries verifies that fiscal policy plays a key part in shaping economic conditions within all of these countries. A study by Perotti (2004) reports a positive response of UK consumption and no response from UK investment. Furthermore, authors such as Engen and Hubbard (2004) provide evidence that long-term interest rates tend to respond positively to a fiscal shocks; however, this finding requires further specification as authors such as Upper and Worms (2003), Brook (2003), as well as, Laubach (2003) put forward the argument that such a result depends on the definition of the fiscal shock (i.e. whether the shock under investigation concerns Government spending or Government revenue etc.). Kim and Roubini (2003) find that innovations in budget deficit show the way to improvements in the trade balance of a country. The importance of fiscal policy for economic conditions has also been supported by Laopodis (2010).

By all accounts, research in this area is indeed very small. It is therefore understood - especially given the importance of fiscal policy for shaping broader economic conditions and facilitating the tasks of monetary policy - that current research, should also turn its attention towards deciphering the effects of fiscal policy on the economy and further understanding its interaction with monetary policy.
3.4 The macroeconomic effects of oil prices

This section introduces oil literature in this study. On the basis that (i) oil prices represent an extensively used indicator of global demand which is typically included in monetary policy VAR models (i.e. to accommodate for the so-called price puzzle), (ii) our results suggest a significant link between oil prices and housing prices regime-switching, as well as, (iii) oil prices drive the time-varying correlation between the monetary policy variable and stock prices to higher positive values, we proceed with a concise account of the key notions and views regarding the effects of oil price shocks in the economy.

3.4.1 Oil price shocks and monetary policy

The importance of crude oil as an input of production and its implications for inflationary pressures in the economy has been thoroughly examined in the seminal work of Hamilton (1983). In this article Hamilton (1983) reports that almost all recessions in the United States since the Second World War were preceded by hikes in oil prices and opines that even if this cannot actually be regarded as clear evidence of causality, it should - at least in some cases - be regarded as a factor conducive to those recessions.

However, according to more recent studies conducted by authors such as Hamilton himself (2008a) and Lescaroux and Mignon (2009) the relationship between oil prices and macroeconomic indicators has significantly changed after the 1980s and this can be mainly attributed to the fact that central banks have - ever since - tended to adopt inflation targeting strategies (Bernanke et al, 1997; Blanchard and Gali, 2007; Lescaroux and Mignon, 2009). In this regard, oil price changes no longer affect inflation significantly and thus they are not the main driving force underpinning economic downturns, as Hamilton had suggested back in 1983. According to a report produced by the International Energy Agency (2006) when a country is in a state of economic growth, it is highly likely that it will not be negatively
affected by inflationary pressures due to oil price changes as both increased productivity and investments permit firms to absorb production (input) costs.

With reference to monetary policy, central banks are typically faced with a trade-off between inflation and unemployment (Castillo and Vicente, 2010). In light of an oil price shock the reaction of the monetary policy authority could be to raise interest rates in order to subdue inflationary pressures. Authors such as Bohi (1989) and Bernanke et al. (1997) however, maintain that it is the monetary policy of the Federal Reserve Bank which can be blamed for amplifying the negative effects of oil price shocks\footnote{Throughout this study and unless otherwise specified, the definition 'oil price shock' refers to an increase in the price of crude oil.} - that the US economy had experienced between the 1970s and the 1990s - rather than the price of oil \textit{per se}. Bernanke et al. (1997) explain that contractionary monetary policy in light of an oil price shock is not necessarily the optimal solution, as it would have dire results for the economy as a whole. A neutral policy on the other hand would help the country maintain a certain level of economic growth. By contrast, Hamilton and Herrera (2004) posit that neither oil price shocks \textit{per se} nor monetary policy decisions entail as decisive effects on economic developments as suggested by Bernanke et al. (1997). It is also very important to note that according to DeLong (1997) and Clarida, Gali and Gertler (2000) different regimes of monetary policy could result in substantially different responses of inflation to oil price changes.

As far as the relationship between oil prices and stock markets is concerned, both direct and indirect links have been suggested. According to Jones and Kaul (1996) direct effects of oil prices shocks can be explained on the basis that they constitute additional risk (i.e. an additional factor of economic turbulence) and thus stock market will reflect this shock by a decrease in share prices. The indirect path is the result of the interaction between oil price shocks and monetary policy decisions (described above) which basically entails that higher
oil prices will lead to inflationary pressures and the subsequent increase of interest rates by the monetary policy authority (i.e. contractionary monetary policy) is expected to negatively affect the stock market.

The relationship between the effects of oil prices on the housing market have been greatly neglected by empirical studies. On the basis (i) that housing wealth constitutes a major component of aggregate households' wealth and (ii) that housing market developments are being closely monitored by central banks we believe that this area deserves further attention.

Lee and Ni (2002) report that oil price shocks tends to have a negative effect on the housing market. On general principles we expect higher oil prices that lead to higher inflation will have a negative impact on consumers' willingness (and financial ability) to consume both consumables and durable goods.

3.4.2 Oil importing and oil exporting countries

Another important issue when it comes to assessing oil price shocks is the nature of the country under investigation. To be more explicit, authors such as Jimenez-Rodriguez and Sanchez (2005) maintain that there may be sharp contrasts regarding the effects of an oil price shock, depending on whether the country is a net oil exporter or a net oil importer. In this regard, the focus lies in the balance of trade with respect to oil.

In order to provide a very simple framework of analysis regarding potential monetary policy responses in both net oil exporting and net oil importing countries, we follow Elwood (2001) who uses a rudimentary aggregate demand / aggregate supply (AD/AS) example in order to explain the effects of oil price shocks on the economy.

The model with regard to the net oil exporting country is presented on figure 3.4.1. In principle, an oil price increase is expected to be associated with positive effects on the economy under investigation. To be more explicit, after the shock takes place, the income of
this country is expected to rise (i.e. the AS\textsubscript{1} curve will shift to the right towards AS\textsubscript{2} ) implying a positive income effect. There will be an increase in the cost of production (i.e. a production cost effect); however, it is expected that within a net oil exporting country the income effect would be of such a magnitude that any potential negative influence stemming from the production cost effect would eventually fade away. This will result in a increase in aggregate supply (i.e. Q\textsubscript{1} becomes Q\textsubscript{2}). AD\textsubscript{1} will also shift towards AD\textsubscript{2} mainly reflecting a positive response from aggregate demand to the looming conditions. In turn, developments regarding consumption, investment and employment are also expected to be very positive. This positive environment is also expected to be reflected on the stock market of the country.

Monetary policy will eventually have to interfere when demand-side inflation comes on stage (i.e. \( P\textsubscript{1} \) becomes \( P\textsubscript{2} \)).

![Figure 3.4.1: Effects of increased oil prices on a net oil exporting country.](image)

[Adapted from Elwood (2001)]

We then turn to a net oil importing country. Figure 3.4.2 illustrates the effects of a positive change in oil prices. In this case the production cost effect is expected to be the main driving force of developments within the country. More particularly, the increased cost of production is expected to reduce output in the economy and thus \( Q\textsubscript{1} \) will shift towards \( Q\textsubscript{2} \) implying a
negative *income effect* in the economy. If increased costs of production can be passed along to consumers then aggregate demand will also decline ($AD_1$ shifts towards $AD_2$). In this climate we anticipate effects on consumption, investment and employment to be negative. This will also be reflected on stock markets by a decrease in stock prices. In this case, monetary policy will also have to interfere in order to contain *supply-side* (cost-push) inflation this time.

![Figure 3.4.2: Effects of increased oil prices on a net oil importing country.](image)

[Adapted from Elwood (2001)]

On a final note, Bernanke et al. (1997) using a standard IS/LM framework argue that the appropriate policy for the net oil exporting country would be contractionary monetary policy, while the appropriate policy for the net oil importing country would be expansionary monetary policy. It is worth noting that the above analysis relates mainly to central banks with either an explicit (BoE) or an implicit (FED) inflation target.

### 3.4.3 The origin of an oil price shock

Another important issue when it comes to analysing the effect of oil price shocks on the economy is the origin / source of the shock. Although our study does not make such a distinction, it is worth noting that effects may differ considerably depending on the origin of
the shock.

Indicatively, we quote Hamilton (2009a,b) who draws a distinctive line between *demand-side* oil price shocks and *supply-side* shocks. Further to Hamilton's (2009a,b) origins of oil price shocks, Kilian (2009) further identifies the so-called *precautionary oil price shock* or *oil-specific demand shock*. Demand-side shocks are defined as shocks related to high demand for oil. Considering the industrialisation of countries such as China, a demand-side oil price shock is generally regarded as a shock with positive implications for the economy under investigation. Supply-side shocks are shocks related to interruptions in the supply of oil. These are generally considered to be shocks with negative implications as they are usually associated with war-events or cartel practices. Finally, Kilian's (2009) demand-specific events are related to expectations and concerns regarding the future availability of oil. It follows that realised expectations could move prices up or down.

Hamilton (2009a,b) maintains that oil price shocks are mainly demand driven and thus supply-side shocks do not exert significant impact on oil prices. By implication, supply-side shocks are not expected to significantly affect economic developments. Along a similar vein, Baumeister and Peersman (2012) and Lippi and Nobili (2012) provide evidence in favour of the view that the increased oil price volatility that has been reported from the mid 1980s onwards has in fact been accompanied by a relative decline in the volatility in oil production (i.e. supply of crude oil).

**3.4.4 Oil prices and stock markets**

Contrary to the housing market - which has apparently been neglected by empirical literature at various levels and areas of study - the effects of oil price shocks on the stock market has been extensively investigated. Mounting evidence suggests that the impact of an oil price shock on a net oil importing country will clearly be negative. On the other hand, there is no
conclusive / sufficient evidence in testament of an explicit positive effect on the stock market of a net oil exporting country. Authors such as Gjerde and Sættem (1999), Ciner (2001), Bachmeier (2008), Driesprong et al. (2008), Park and Ratti (2008), Chen (2010), as well as, Filis (2010) among many others have reported a negative impact of oil prices shocks on stock market returns. Sadorsky (1999), Malik and Ewing (2009), as well as, Oberndorfer (2009) report that the negative effects on the stock market are related not only to the level of the price of oil *per se*, but also to oil price volatility. In addition, Haung et al. (1996) investigating the relationship between oil future price returns and US stock market returns document that oil future prices have an isolated negative effect on industrial (i.e. oil companies) share returns. Needless to say that all previously mentioned studies concern the effects of an oil price shock on net oil importing countries. For net oil exporting countries Bashar (2006) and Arouri and Rault (2012) argue in favour of a positive effect, whereas Al-Fayoumi (2009) finds no significant relationship.

It has also been suggested by authors such as Nandha and Faff (2008), Miller and Ratti (2009), Nandha and Brooks (2009), Arouri and Nguyen (2010), as well as Lee and Chiou (2011) that oil price shocks have asymmetric effects on the stock markets in the sense that stock markets prices tend to be more sensitive to positive oil price shocks and less sensitive to negative oil price shocks. By contrast, some authors fail to identify any significant effect of oil price shocks on the stock markets of the countries under investigation. Indicatively we quote Apergis and Miller (2009), Jammazi and Aloui (2010), as well as, Mohanty and Nandha (2011). The foregone examination is indeed very interesting considering that the UK is currently a net oil importing country (see *inter alia* Filis and Chatziantoniou, 2013) a fact that undoubtedly facilitates the analysis of the results obtained in chapter 6 of the present study.

The analysis presented in this chapter concludes the review of the literature that is related to
essential issues gravitating around the research objectives of the study. Literature review related to the specific econometric methods employed or to the analysis of specific empirical findings is included in the relevant sections of chapter 6. Chapters 2 and 3 improved our understanding with respect to the broader theoretical framework underpinning inflation targeting monetary policy and the various links holding together the variables of interest. In this respect, we are ready to proceed with the exposition and analysis of the empirical evidence derived by the adopted methods. However, empirical findings and discussion will not come on stage before we discuss issues relating to the research philosophy of the study. These issues are presented in chapter 4.
The aim of this chapter is to introduce the philosophy of the research strategy, as well as, the methodology employed in this study. We begin by portraying a few of the most important philosophical approaches relating to the understanding of the natural world and the workings of social reality, while at the same time we highlight the main controversies that sparked during a rather long period of time - which spanned from the age of the Antiquity to the centuries marked by the cultural movement of the Enlightenment. In turn, we present a framework of analysis which comprises all cardinal philosophical questions pertaining to the research of social reality, mainly in order to provide a common point of reference between this and other studies. Next, drawing important information from a historical overview of the evolution of the methodology of econometrics - regarded as a field in the broader discipline of economics - we present the philosophical position adopted in this study.
4.1 A brief historical overview of scientific thought

In Plato’s (429 - 347 B.C.) seminal work the Republic (see the recent translation by Waterfield, 2008) we encounter the allegory of the cave, a short dialogue between Socrates (470 - 399 B.C.) and Glaucon, pertaining to a group of people who have been chained inside a cave in such a manner that they are only capable of looking forward to a wall upon which, shadows can be reflected in the flickering light of some fire smouldering somewhere in the cave.

These prisoners are not aware of any alternative reality as they all have been imprisoned since they were small children. Thus, their perception of the world surrounding them is limited to the intimidating passing shadows they see upon the wall in front of them and the voices they hear within the cave itself. Then Socrates makes the assumption that some of the prisoners manage to break free of their fetters. It takes some time but eventually they realise that the intimidating shadows on the wall are just reflections of harmless animal-artefacts and pottery-products being carried around and about the cave by other people. They are bewildered; however soon, the recently unfettered exit the cave.

The sudden transition from gloomy darkness to bright sunlight renders impossible for them to experience the new reality. Again they need time to adjust to the brighter conditions and to realise that they are now closer than before to what is actually real. Initially, the new reality seems blurry and frightening. After they adjust though, they feel lucky for exiting the cave and they swear never to go back again. Nonetheless, if they were to return to the cave after some time had passed, it would be impossible for them (at least in the beginning) to even discern the shapes of the shadows on the wall. That, in turn, would make other prisoners – in particular, those who had never escaped from the cave - to think of a potential break out as something futile and unsafe since it worsens one's eyesight.
This allegory describes a fundamental issue that relates to social research; the simple fact that there is more than one way to view the world. Apparently, contradictory approaches and debate regarding the *appropriate* envisioning of the world can be traced back to at least the times of the ancient Western philosophers (Grix, 2002; Burke-Johnson et al., 2007). Plato's *Republic* is nothing but an effort to represent the *ideal form* of the democratic regime (Ryan et al., 2002). Ideal forms of various concepts and their importance for achieving *true knowledge* are central in the work of Socrates and Plato (Teddlie and Burke-Johnson, 2010).

Bryman (2012) in analysing potential approaches to *theory* (theory being the reasoning behind research) distinguishes between *deductive* and *inductive* theory. According to Bryman (2012) the deduction process has its starting point on the various theoretical considerations that revolve around a particular topic - to borrow Plato's analogy; *what the ideal democracy might be?* - which in turn prompt the researcher to deduce certain hypotheses that need to be empirically tested. By contrast, *induction* entails the collection of data and the derivation of empirical findings before an effort to revisit and inform theory (or in some cases to develop a new theory from the scratch) is made (Butler and Robson, 2001; Bryman, 2012).

In this regard, Plato can be thought of as a strong exponent of the deductive approach, as well as, a *proto-rationalist* given that he is one of the first to argue in favour of the view that the path to absolute truth is indeed *rational thought* (e.g. politicians need to cerebrate first and come up with a set of rational laws that safeguard and promote the ideal form of the democratic regime and *only* then to put these laws into practice) (Teddlie and Burke-Johnson, 2010).

Aristotle (384 - 322 B.C.) on the other hand, challenges Plato's ideal forms and exposes the necessity that researchers acquire knowledge through the systematic observation and categorisation of the natural world (Ryan et al., 2002). According to Aristotle, true
knowledge about the workings and the nature of social reality lies within objects and concepts that actually appear in the natural world and not within their abstract ideal forms (to use a business analogy, analysts should focus on the workings of the actual capital market and not on what the ideal capital market might be) (Ryan et al., 2002).

Because of the heavy emphasis that Aristotle places on observation and human experience as the basic means of acquiring knowledge, he is regarded as one of the first proponents of the empiricism approach (i.e. a proto-empiricist) (Teddlie and Burke-Johnson, 2010). Plato's ideas have also been questioned by Protagoras (a Sophist, 490 - 420 B.C.) who argues in a famous quote that man is the measure of all things and that depending on the observer (eye of the beholder) truth and knowledge may differ considerably (Teddlie and Burke-Johnson, 2010).

Pertaining to the deduction - induction debate, it is evident that Aristotle was rather inclined toward the inductive approach. However, authors such as Walton (1999) and Teddlie and Burke-Johnson (2010) credit Aristotle with having laid the groundwork for a kind of scientific thought that combines both inductive and deductive approaches. His work can be viewed as an effort to take Plato's and Socrates' dialectic approach one step further by considering both what researchers refer to as Aristotle's prior and posterior analytics (see inter alia Walton, 1999; Corcoran, 2009, as well as, Teddlie and Burke-Johnson, 2010).

27 In Walton (1999) we find a brilliant example that improves our understanding regarding Aristotle's combined approach. The author initially makes a statement that reflects the very reasoning of deduction: 'For all x, if x has property F, then x also has property G'. Thus, this generalisation (which in this case could be regarded as reflecting Plato's ideal form of x) implies that 'there are no x such that x has F but does not have G'. According to Walton (1999) the inductive approach would be to analyse the same problem by collecting actual information on x and to subsequently inform the initial statement. A revised - inductive statement might then be something like: 'In most cases (but not always), when x has property F then it also has property G'. Along a similar vein, Teddlie and Burke-Johnson (2010) maintain that Aristotle - by using Socrates' and Plato's dialectic approach - would put well established views (prior analytics / theories pertaining to ideal forms of things and concepts) to the test (posterior analytics) given the information he collected by observing the actual natural world.
In the centuries that followed the Middle Ages (which unfortunately spanned a rather long period; roughly from the 5th century A.D. to the very end of the 15th century A.D.) scientific thought was greatly influenced by the work of the Greek mathematician Euclid (actual dates of birth and death are unknown; however, he was active in Alexandria around 300 B.C.) (Teddlie and Burke-Johnson, 2010). In his book *Elements* Euclid proves - based on reasonable assumptions called *axioms*\(^{28}\) - several hundred geometrical *theorems*\(^{29}\) by using purely *deductive logic* (see Dawson, 2006).

Contemporary philosophers and researchers such as Copernicus (1473-1543), Galileo (1564-1642), Descartes (1596-1650), Pascal (1623-1662), as well as, Newton (1642-1727) are more inclined toward the Euclidean school of thought (see Walton, 1999). In fact, Walton (1999) argues that the sort of *mathematical thinking* that was based on Euclid's deductive logic was the prevailing approach to scientific thought during that period, with only a few exceptions, such as Bacon (1561-1626) and Hume (1711-1776) who were indeed partisans of induction. Be all this as it may, the aftermath was the supersession of Aristotle's combined approach and a new round of controversy between the two approaches. It is worth noting that in a recent study by Ayalon and Even (2008) we find that the deductive approach is still often used as a synonym for mathematical reasoning.

Nonetheless, the researcher, who can be credited with resurrecting Aristotle's approach through the reconciliation of *rational deductive logic* on one hand and *inductive empiricism* on the other, is the German philosopher Immanuel Kant (1724-1804) (Teddlie and Burke-

\(^{28}\) Propositions based on assumptions made about the issue at hand. They need no proof and are assumed to hold at all times (see Ayalon and Even, 2008).

\(^{29}\) e.g. the Pythagorean theorem is based on the axioms of the Euclidean geometry that assume a certain relation among the sides of a right triangle. The Pythagorean theorem does not hold in *spherical geometry* (see Flores, 1993; Saatsi, 2011). In the area of economics, economists usually view a downward-sloping demand curve as a theorem based on axioms that are more or less derived intuitively (Hoover, 2005).
Johnson, 2010). His work is suffused by the view that the human brain is subject to *a priori* limitations and therefore human intuition is somewhat predetermined (see *inter alia* Westphal, 2009; Bernard, 2011). In particular, Kant distinguishes between *phenomena* (what humans can experience given the structure of their brains) and *noumena*\(^{30}\) (the actual shape of the world) and in this regard he asserts that although experience can be a valuable source of truth, certain *a priori* assumptions about the actual - yet unobserved by humans - condition of the natural world are imperative (Westphal, 2009; Teddlie and Burke-Johnson, 2010; Bernard, 2011).

In retrospect, the purpose of this section has been to trace the evolution of scientific thought and present its main contributors from the Antiquity until the age of the Enlightenment. However, before we take our analysis one step further by making a connection between what these (or other) philosophers and researchers have argued and the reasoning behind the present study, it would be instructive to introduce a few more important concepts and to present a general framework regarding the interrelationship of the key components of research. This is achieved in the section that follows.

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\(^{30}\) e.g. the human eye is only able to perceive a three dimensional world; yet, this does not resonate with the view of the *string theory* that there actually exist many more dimensions (a relatively palpable examination of this theory can be found in Hawking and Mlodinov, 2011).
4.2 The building blocks of research

Admittedly, there is more than one perspective in analysing and understanding the nature of social reality (Bryman, 2012). The previous section gave us a rough idea of the differing approaches toward the study of the world. Therefore investigating the various issues revolving around the practice of social research can be a cumbersome task. In fact, the crux of these contradictions is still alive today (see among others Johnson et al., 2007; Bryman, 2012).

Figure 4.1: The building blocks of research.
[Source: Grix (2002)]

In order to put everything into perspective and carry on with our analysis it would be useful to clarify a few crucial terms; that is, to attach some specific meaning to the terminology of research. It is important to understand the meaning of the tools of social research, because each tool serves a specific purpose and - in this regard - inappropriate use could lead to misinterpretations (Grix, 2002). Authors such as Grix (2002) and Hay (2002) maintain that the starting point of all types of research should be the Ontology - Epistemology - Methodology trinity; and in fact, in this particular order. Only after the researcher has answered all important ontological, epistemological and methodological issues should the
discussion about specific methods and data resources step in (Grix, 2002; Hay, 2002). Schematically this is illustrated in Figure 3.1.

### 4.2.1 Ontology

As clearly shown in the previous section, a vital issue when it comes to research is the way the researcher perceives the world. How the world is built or how the researcher believes the world is built is in fact an *ontological* issue (see Marsh and Furlong, 2002). Blaikie (2000), and Hay (2002) argue that ontological considerations are really about assumptions that researchers make regarding the specific aspects that constitute the social reality under investigation. According to Grix (2002) and Bryman (2012) depending on whether social phenomena exist independently of *social actors* or are in fact being constantly fashioned and revised by social actors' activity, we can distinguish between two major ontological positions; that is, we can distinguish between *objectivism* (do we walk on a pre-existing path?) and *constructionism* (or do we construct the path as we walk along?) respectively.

In this regard, considering these two divergent approaches and also in an effort to provide a bridge between this and the previous section, the ontological consideration of those who subscribe to Plato's philosophy might be something like: *Can we approach or perhaps achieve knowledge regarding the absolute / predetermined / fixed true nature of the world by using appropriate methods such as rational thought or Euclidean deductive logic?* By contrast, those who argue in favour of Aristotle's urge for empiricism (even as a supplement to some deductive process) could raise the following consideration: *Should we not take into account the fact that the true nature of social reality is not predetermined but constantly accomplished by various social agents?*

And then Kant's exponents might argue: *We have to find a way to reconcile both rationalism and empiricism because both what we can rationally think and what we can actually observe*
in real life are subject to the limitations of the human intuition and might therefore deviate significantly from what the world really is.

### 4.2.2 Epistemology

Having answered the question of: what is out there to know of?, the researcher then turns to epistemological considerations; that is, to the knowledge-gathering process itself (Grix, 2002). To put it simple, the question then becomes one of: how can we learn about what is assumed to exist out there? (Blaikie, 2000; Grix, 2002). In Bryman (2012) and Saunders et al. (2012) we learn about the two main contradictory positions relating to the epistemological issue. In particular, these authors distinguish between the doctrine of positivism and that of interpretivism.

Positivism highlights the importance for social sciences to adopt methods and practices from the field of the natural sciences; the role of research should then be to put theoretical considerations to the test in order to derive and develop relative laws (Bryman, 2012). In addition, positivism makes the assumption that the researcher does not affect in any way the true nature of the world (in this regard, positivism logically follows the ontological position of objectivism) (Collis and Hussey, 2003). In order to make a connection with our previous discussion we simply point out that the mere fact that this epistemological approach purports to assess various theories by collecting information available in the real world, implies that positivism incorporates both deductive and inductive approaches although according to Bryman (2012) positivism is more closely related to testing than it is to generating theories. It is however true that positivism can be assumed to have a broader meaning. In this spirit, we quote the exact words of Bryman (2012, p.28) who presents the five main principles that emerge from positivism:

- Only phenomena and hence knowledge confirmed by the senses can genuinely be
warranted as knowledge (the principle of phenomenalism).

- **The purpose of theory is to generate hypotheses that can be tested and that will thereby allow explanations of laws to be assessed (the principle of deductivism).**

- **Knowledge is arrived through the gathering of facts that provide the basis for laws (the principle of inductivism).**

- **Science must (and presumably can) be conducted in a way that is value free (i.e. objective).**

- **There is a clear distinction between scientific statements and normative statements and a belief that the former are the true domain of the scientist. This last principle is implied by the first because the truth or otherwise of normative statements cannot be confirmed by senses.**

Positivism has its roots in the work of Auguste Comte (1798-1857) who also coined the term sociology (i.e. the branch of science which focuses on the study of social phenomena) and who - in this regard - is the first in a long line of distinguished sociologists including Karl Marx (1818-1883) and Max Webber (1864-1920) (Teddlie and Burke-Johnson, 2010). Comte is among the first to support the view that scientific approaches employed in the examination of the natural world should also be employed in the study of social phenomena (Macionis and Plummer, 2008). In his work *System of positive philosophy* he argues that his proposed discipline of social physics is all that has been left to conclude a series of outstanding efforts (by scientists such as Galileo and Newton) toward the scientific description of the world (Ball, 2002). In the years that follow, the philosophical school of logical positivism that grew out of the Vienna Circle in the 1920s suggests that scientific knowledge should be based on two mainstays; namely, indisputable axioms relating to the nature of social reality (the deductive dimension) and inference based on empirical data (the inductive dimension) (Hoover, 2005). According to Hoover (2005) Karl Popper (1902-1994) is also regarded as
one of the main contributors to the evolution of positivism, as his falsificationism theory provides a first answer to concerns regarding the ability of the researcher to make generalisations based on a mere portion (i.e. a sample) of reality each time. Such concerns can be found in the early work of Hume (1711-1776) and John Stuart Mill (1806-1873) (Teddlie and Burke-Johnson, 2010).

Cause and effect relationships are a major concern of the present study and they also constitute the core of both Hume's and Mill's concerns regarding the effectiveness of induction for producing robust generalisations. Given that induction is indeed one of the dimensions of the doctrine of logical positivism, it follows that these concerns are of considerable importance. In this respect, it is worth making a small diversion to our discussion in order to elaborate on these issues. In the work of Hume - in particular - we find an initial discussion regarding the relationship between correlation and causation (Teddlie and Burke-Johnson, 2010). Hume (a renowned empiricist of his era) provides three rules / steps to help researchers identify a cause and effect relationship; namely, contiguity (i.e. physical vicinity between cause and effect), temporal precedence (i.e. the cause should always come before the effect), as well as, constant conjunction (i.e. to be able to iterate the same cause many times and get the same effect) (Teddlie and Burke-Johnson, 2010). According to Teddlie and Burke-Johnson (2010) Hume's rule of constant conjunction led many researchers of that period to accept as sufficient evidence for causation the mere presence of high statistical correlations. However, Hume himself was rather sceptical about making generalisations and deducing causality in the presence of high correlation - the so called Hume's riddle of induction (Hoover, 2005). Pertaining to this issue, authors such as Philips (1987) and Hollis (2002) explain that Hume's concern was that no matter how many times researchers repeat an experiment and get the same result, they can never be sure of getting the same result every time they run the experiment (i.e. can we predict the future
based on the past?). John Stuart Mill has also contributed to the issue by arguing that before a causal conclusion is drawn rival or alternative conclusions regarding a cause and effect relationship must be ruled-out (Cook and Campbell, 1979). Mill's suggestion describes the verification problem that also has a bearing on logical positivism and relates to the undeniable fact that empirical findings may in some occasions support contradicting and diverse theories at the same time (Teddlie and Burke-Johnson, 2010). Both problems appear on the inductive dimension of the positivism doctrine; nonetheless, they constitute two fundamental problems of positivism.

Popper's response to Hume's riddle is described at length in McCall (2008). According to McCall (2008), Popper tries to reconcile three seemingly contradicting and incompatible statements associated with Hume's concerns about the inductive approach; in particular:

- that observation and experiments based on scanty data cannot prove any particular natural law or theory,
- that the deductive approach to scientific research entails the constant use of natural laws and theories,
- and that, on the whole, the only path through which natural laws and theories can be proved is the one including observation and experiments.

These three seemingly incompatible principles that summarise (according to Popper) the problem of induction were brilliantly combined in Popper's work to produce what has been known as falsificationism (McCall, 2008). The main argument put forward by Popper is that theories derived on the basis of observation and experiments should have a tentative rather than a permanent character; that is, in the presence of better-quality or more accurate data theories that were once considered to hold in all cases, just might have to change (McCall, 2008). It is because of his conviction that evidence cannot really establish the truth of any
theory that Popper maintains that researchers had better focus on the rejection of falsified theories instead of trying to accept true ones (Hoover, 2005).

Popper's philosophy is closely related to the present study as, according to Hoover (2005), Popper's work has raised concerns that are typically associated with the discipline of Economics, such as, when should a theory be rejected as false? (or to make the analogy: what are the critical values that bound the rejection or non-rejection of some hypothesis?) and what is the best theory (or model) to employ in order to test a phenomenon? Nonetheless, part of the criticism of Popperian philosophy lies in the fact that Popper has not provided an extensive framework to explicitly address these questions (Hoover, 2005).

Before we conclude our discussion of the evolution of positivism, it is worth noting that Lakatos (1922-1974) provides an interesting critical account of Popper's falsificationism. According to Lakatos (1970) Popper's suggestion that falsified theories should be rejected is not really helpful given that most theories are in fact more or less falsified. Instead, Lakatos (1970) in his work Methodology of scientific research programmes is concerned with the assessment of specific research programmes in virtue of their contribution to knowledge. In effect, these research programmes comprise a set of propositions that could be regarded as the extension of some theory and after the empirical exercise takes place research programmes are ordered on the basis of what they manage to explain (i.e. innovations, contribution to resolving existing issues) or fail to explain (i.e. same problems re-appear) (Lakatos, 1970). It is obvious that under the scheme proposed by Lakatos (1970) heavy emphasis is placed upon the contribution of each particular research project to the understanding of social phenomena.

Turning to positivism's opposing doctrine; that is, the doctrine of interpretivism, Bryman (2012) highlights that this doctrine entails mainly the views of researchers who have been
critical of the idea that social sciences can be examined by applications employed in natural sciences. According to Bryman (2012) the sharp contrast between positivism and interpretivism lies within the differing objectives of each approach. In particular, positivism places heavy emphasis on the description of human behaviour (e.g. when condition X occurs then individual A responds by closing their eyes) as opposed to interpretivism which concentrates on the empathic understanding of human behaviour (e.g. why does individual A close their eyes every time condition X occurs?) (Bryman, 2012; Saunders et al., 2012).

The main philosophy underpinning the doctrine of interpretivism is that of phenomenology whose main exponent has been Alfred Schultz (1899-1959) whose work in turn has been greatly influenced by Max Webber (Bryman, 2012). In the words of Bogdan and Taylor (1975) cited in Bryman (2012, p. 30) ‘the phenomenologist views human behaviour... as a product of how people interpret the world... In order to grasp the meanings of a person's behaviour the phenomenologist attempts to see things from that person's point of view’.

Bryman (2012) suggests that the effort made by the researcher to interpret human behaviour is indicative of an inductive approach (usually adopted by the interpretivism position); however the author also stresses the fact that admittedly there have been interconnections between different epistemological approaches and that certain positions are not necessarily followed by specific epistemological practices. In testament to this, Saunders et al. (2012), Grix (2002), as well as, Marsh and Furlong (2002) maintain that in any research project the choice between positivism and interpretivism is not always clear and it is also possible to have some combination of the two.

4.2.3 Methodology, research methods and data

To reiterate a point made above, it would be rather arbitrary to suggest a direct relationship between ontology, epistemology and methodology; however, Grix (2002) argues that a
researcher's methodological approach should reflect their ontological and epistemological arguments. According to Guba (1990) these three positions constitute the research paradigm which, in turn, should guide the research methods approach employed in a particular study.

The latter view accords with Kuhn's (1970) original use of the term paradigm, which pertained to 'a cluster of beliefs' held by the researchers that greatly affects the object and the method of study. In line with Blaikie (2000) we define research methods simply as the specific techniques and procedures implemented by the researcher in order to collect and process data (e.g. questionnaires, interviews, secondary data from reports, databases etc.).

Essentially, to choose a methodology is to choose a research strategy (Grix, 2002). Bryman (2012) highlights two predominant research strategies; namely, quantitative research and qualitative research. According to Teddlie and Burke-Johnson (2010) positivism has been important for the emergence of quantitative research, while interpretivism for the emergence of qualitative research. In particular, Bryman (2012) suggests that quantitative research can be construed as a strategy that:

- emphasizes quantification as regards data collection and data processing,
- puts heavy emphasis on testing theories by adopting a deductive approach,
- follows a rather objectivist path and
- subscribes to a rather positivist view.

By contrast (Bryman, 2012), a qualitative approach usually entails the following:

- generating new theories based on inductive reasoning and also
- an inclination towards the constructionism path and the interpretivism doctrine. Great emphasis is placed on understanding individuals' behaviour.
These statements are illustrated in figure 3.2.

![Research strategies](image)

**Figure 4.2:** Research strategies.  
[Adapted from: Bryman (2012)]

 Nonetheless, Bryman (2012) argues that the distinction is not always clear as in many cases qualitative research has been utilised in order to test (rather than generate) a hypothesis, while quantitative research has been utilised to inform our understanding of human behaviour (rather than just adhere to a typical cause and effect approach). Such a combinational strategy is usually referred to as the *mixed methods strategy* (Burke-Johnson et al., 2007; Bryman, 2012). Reverting to our earlier discussion in the first section of this chapter, we could argue that the mixed method approach bridges the gap between Plato’s *put a rational theory to the empirical test* doctrine and Protagoras’s *investigate individual behaviour* counterargument (Burke-Johnson et al., 2007).

The framework in which data are analysed is called *research design* (Bryman, 2012). Saunders et al. (2012) outline a series of frequently adopted research designs including experimental research designs (along with their variations such as natural or quasi-experiments), surveys, case studies, as well as, comparative studies among others. The experimental design is very typical in the quantitative framework (Bryman, 2012). It is also very closely related to this present study.
According to Bryman (2012) and Saunders et al. (2012) any experiment entails the investigation of the relationship between a dependent and an independent variable where the researcher is able to manipulate the independent variable in order to deduce some form of causality (e.g. consider a laboratory experiment). Nonetheless, laboratory experiments are not feasible when it comes to the investigation of social reality and therefore variants of the experimental approach (such as quasi-experiments or natural experiments) have emerged (Ryan et al., 2002; Bryman, 2012). The analysis of these types of experiments are not to the present purpose; however, it is worth noting that their setting does not involve a deliberate manipulation of the variables of study. What is very interesting though - especially for the quantitative framework - is to investigate whether the proposed research design ensures the main criteria typically adopted to the effect of assessing the quality of a particular research project; that is, reliability and validity (Collis and Hussey, 2003). Reliability is associated with the consistency of the empirical findings while validity concerns the integrity of the empirical findings and breaks down into internal validity (i.e. can we make sure that the causality implied by the findings is actually true?) and external validity (i.e. can we proceed to generalisations based on our findings?).

Authors such as Collis and Hussey (2003) and Saunders et al. (2012) argue that although deductive studies of the positivism persuasion are relatively reliable due to the fact that they focus on techniques that facilitate the replication of the results, they might suffer from low validity due to inconsistent datasets. It is therefore of cardinal importance to choose high-quality data and to develop the theoretical framework underpinning the issue of interest without considering the data in the first place.\textsuperscript{31}

\textsuperscript{31} For a detailed analysis in connection with the various limitations that datasets impose on research projects the reader is directed to the work of Spanos (1999).
4.3 Adopted research paradigm and research methods

4.3.1 Philosophy

The ontological position of the study maintains that the nature of social reality exhibits certain objective features that researchers seek to investigate and explain (objectivism). On general principles this is a deductive study, that follows the positivism doctrine, in the sense that specific theoretical considerations in the domain of monetary policy have lead to the deduction of a number of related hypotheses which in turn become the subject of empirical examination. To put it differently, the research hypotheses - that can be deduced not only from the related theory, but also from the existing literature in the field - take precedence over the collection of the relevant data and the implementation of the appropriate econometric techniques. Inductiveness (i.e. moving from the data to theory) is employed only in the sense that empirical findings are compared to previous studies, but this is considerably different from developing a new or re-establishing an existing theory or even a strand of literature.

In this regard, our study conforms to the basic concessions of the typical quantitative study examined in the previous section. The adopted methodology is the quantitative methodology of econometrics while the datasets employed exclusively consist of secondary data collected from trustworthy databases. Finally, the research design of the study resembles that of a quasi-experiment, given that we have no direct influence over the explanatory variables included in the models.

It is worth mentioning that the econometric methods employed in this study make a great effort to bring economic theory into service at least as far as the formulation of the specific econometric models are concerned. The relations among the variables incorporated in this study conform to a great extent to commonly shared theoretical arguments and in this respect,
this study should not be characterised just as an attempt of the *naive empiricism* persuasion (see Bryman, 2012). In particular, the SVAR models employed in this study are assumed to reflect economic theory to some degree in their structure (Pagan, 2003; Dungey and Pagan, 2008).

As has been mentioned already in previous chapters and as will be discussed in greater detail in the section that follows, macroeconometric modelling has traditionally been torn between theoretically coherent (e.g. DSGE) and empirically coherent (e.g. unstructured VAR) models (see figure 4.3). According to Pagan (2003) the inherent desire of any researcher is to come up with a model that incorporates theoretical assumptions and produces empirical results that conform to widely accepted theoretical priors. We regard SVAR modelling to be lying somewhere along the line that connects the two aforementioned extremes. On no account however, could we argue that SVAR models are theoretically coherent.

**Figure 4.3:** The trade-off between theoretical and empirical coherence.
[Adapted from Pagan (2003)]

On a final note, Bryman (2012) puts forward the argument that on many occasions theory can be either only latent or implicit in the literature and thus, literature may in fact serve as the very underlying theory in a research effort. This may not hold exactly in our case,
nonetheless, previous research in the field plays a key role, as most of the innovation brought about by this study arises from an extensive investigation of the existing literature and the subsequent detection of either relatively neglected, inconsistent or under-researched topics.

4.3.2 Econometrics

Having established the philosophical **positioning** of the present text we turn to the methodology of econometrics in order to provide a short historical overview of the methodology's **inter-temporal** evolution and to outline some of its most essential functions and applications. Highlighting the framework within which the methodology of econometrics purports to decipher the perplexing nature of real economic activity, will not only assist with identifying potential opportunities in terms of types of questions that could be answered, but also, it will allow the elucidation of possible limitations, usually associated with the true relation between economic theory on one hand and empirical analysis on the other; that is, the very question of how research can move from theory to data (Hoover, 2005). Also in Hoover (2005) we encounter - in support of the foregone analysis - the argument that the main philosophical framework of any econometric study is in fact positivism or some variation of positivism regardless of whether inferences are drawn using a deductive (theory driven) or an inductive (data driven) approach.

It would be instructive though before we move on with our analysis to begin our overview by providing some definition. Econometrics as a separate field goes as far back as the establishment of the Econometric Society in 1933 (Hoover, 2005). In Frisch (1933) cited in Hoover (2005, p.4) we find that econometrics is defined as **economic theory in its relation to statistics and mathematics**, while the main issue at hand (for econometricians to solve) is the unification of theoretical and empirical approaches to economic predicaments.

Authors such as Cartwright (1999) and Heckman (2000) argue that econometrics is (or at
least it should be) more than just applications of statistics to economic issues. This is because from the standpoint of econometrics, statistical results need to have some degree of economic interpretation (Stock and Watson, 2001). The effort of econometricians to distinguish between correlation and causation, the so-called *identification problem*, in order to make inferences regarding the issue under investigation is the main reason why econometrics is regarded as being different from statistics (Cartwright, 1989; Cartwright, 1999; Heckman, 2000; Stock and Watson, 2001).

Turning back to the evolution of econometrics, Hoover (2005) outlines four main functions or roles for econometrics as a field within the discipline of economics:

- Econometrics is used to test a new theoretical proposition / assumption (theory strictly takes precedence over evidence).
- Econometrics is used to measure an existing theoretical argument (theory strictly takes precedence over evidence).
- Econometrics is used to predict values (this function could either be based on some *a priori* theoretical considerations or take the form of a simple atheoretical exercise).
- Econometrics is used to characterise either a relationship among variables or a phenomenon (this function emphasises data collection as a means to inform theory).

Be all this as it may, a matter yet open to question concerns the nature of the relationship between *evidence* on one hand and *theory* on the other32 (Hoover, 2005). On the basis that theory and data are not directly *commensurable* Stigum (2003) opines that one needs to shrink the distance between these two concepts mainly by establishing principles which promote the *mapping* between theoretical variables (e.g. national income, inflation rate, short-term interest rates) and statistically measurable variables, such as industrial production,

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32 The reader is also directed to our previous discussion about the evolution of the logical positivism doctrine.
the consumer price index or the repo-rate. The latter, are usually employed in econometric models as approximations of the former.

Furthermore, Hoover (2005) explains that although initially economic data were regarded unfit to be analysed by probabilistic models - mainly because raw economic data for their most part do not exhibit normality and also because controlled experiments are not an option in social sciences - econometricians embarked on the development of models that aimed at bringing together economic datasets and probabilistic approaches.

According to Haalvemo (1943) cited in Hoover (2005, p.19-20) the objective of any econometric model is to identify the \textit{data-generating process} which is the result of a complex economic system. It follows that the complex relations among actual economic variables can only be treated indirectly by econometric models and that only correctly specified econometric models may approximate such relations sufficiently and essentially facilitate the resolving of the identification issue mentioned earlier in this text (Hoover, 2005).

Nonetheless, we should not argue in favour of the view that econometric methodologies are identical to statistical methodologies as not all economists hold the conviction that all of the information about the true relation among the variables of interest lies exclusively within the data (Granger, 2001). Econometric models should not just be \textit{data driven} in line with typical statistical models, but rather, they should comply to specific theoretical assumptions (Spanos, 1999). Spanos (1999) further advocates that econometric models should be a combination of some statistical model and economic theory and should be employed in order to put specific theoretical considerations to the test.

In Spanos (1995) we learn about the \textit{probabilistic reduction} approach to econometric research, according to which true theories entail that variables employed in a model exhibit certain properties (e.g. they are independent and identically distributed). It is therefore only
when the statistical source of error is ruled out (e.g. by employing the appropriate misspecification tests) that the researcher is able to bring theory and data together and proceed to generalisations\textsuperscript{33} (Spanos, 2010). In addition, Spanos (2010) puts forward the argument that although research in the field of applied econometrics has significantly grown over the last years most studies suffer from *statistical inadequacy* (i.e. when the description of the evidence provided in support of a particular theoretical consideration is not statistically sufficient - misspecification) and *substantive inadequacy* (i.e. when the data-generating process appears to be the result of a different mechanism than the one proposed by the theory under investigation).

By all accounts, in Spanos (2010) *robustness* is placed at the heart of econometric modelling as a means to address the identification issue. The *general-to-specific\textsuperscript{34} approach* introduced by Hendry (1993) may very well constitute a realisation of the probabilistic reduction approach to econometric modelling.

According to Hoover (2005) main econometric methodologies include:

- The Cowles Commission approach (where identification is attempted through the imposition of appropriate theoretical restrictions that take the form of exogenous variables incorporated to some - but not to all - equations of the model).
- Vector Autoregressive - VAR models (where all variables are considered to be endogenous and identification is attempted through the Choleski decomposition approach).
- Structural Vector Autoregressive - SVAR models (where again, all variables are

\textsuperscript{33} The reader is also directed to our previous discussion about internal and external validity.

\textsuperscript{34} Hendry (1993) opines that researchers should begin their analysis by a broader and more general model and then by gradually removing insignificant variables they should reach a final version of the model that is trustworthy and facilitates generalisations.
regarded as being endogenous and identification is attempted through the imposition of appropriate restrictions on the coefficients of the model).

- The London School of Economics (LSE) approach (this is closely related to Hendry's (1993) general-to-specific modelling strategy and usually entails the rigorous statistical testing of competing model-specifications in order to obtain the one that is able to survive a specific set of tests. According to Hoover (2005) it has been criticised as a mere data-mining process that leaves statistical results largely un-interpretable).

- Calibration approaches such as Dynamic Stochastic General Equilibrium - DSGE models (where the basis of analysis is always some theoretical model and researchers - drawing mainly from experience and common sense - assign specific values\textsuperscript{35} to important parameters incorporated to the model. The next step is to validate the model through simulations. Finally, an investigation of whether patterns of covariance exhibited by the simulated data are also present in the actual data takes place and if this is indeed the case, then the model is appropriate to explain the evolution of macroeconomic indicators and policy decisions over time).

Analysing each of these methodologies in depth is not to the present purpose. In addition, each econometric method employed in this study will be analysed in the subsequent sections of chapter 6.

In retrospect, certain traditional channels associated with the variables of interest constitute the theoretical framework which this study puts to the test by employing very specific methods of the broader methodology of econometrics and appropriate datasets. Chapter 5 presents the relevant time series data employed by the econometric models of the thesis.

\textsuperscript{35} As opposed to estimating these values from systems of equations as in the Cowles Commission approach.
This chapter introduces the time series data employed in the study. Regarding the variables of interest, three of the essays use monthly data while one uses quarterly data. The use of quarterly data in one of the essays is mainly dictated by the fact that the fiscal policy variable which is included in the relevant model cannot be approximated by any other monthly equivalent. Initially, we begin by providing general information regarding the period of study and the functional form of the variables. In turn, we provide graphs illustrating the trend line of each series over the period of study and tables regarding their descriptive statistics. Finally, on the basis that we are dealing with time series data we are particularly interested in the stationarity of the data. To this end, we provide results for unit roots tests both before and after the transformation of the variables.


5.1 The general framework and key definitions

This study purports to explore potential linkages between monetary policy and housing and financial prices. One of the main concerns of the study is to investigate these potential relationships within the framework of inflation targeting monetary policy. Given that the BoE has actively adopted an inflation targeting monetary policy regime in 1992, the period of study comprises information from the beginning of 1992 and until a more recent date; that is, the end of 2012.

Our second essay (i.e. section 6.2) involves the inclusion of a fiscal policy variable in the model (i.e. Government spending). Unfortunately, it is not easy to find a monthly proxy for Government spending and therefore variables concerning this model have been collected in a quarterly frequency. In this regard, we have three essays that employ monthly data for the period January 1992 to December 2012 and one essay that employs quarterly data from the first quarter of 1992 to the fourth quarter of 2012.

The choice of variables satisfies our concerns with respect to each working assumption under investigation. On no account may we claim though, that this is an exhaustive list of variables or that important variables that could further elucidate the relationships in question have not been left out of this study. We consider this thesis to merely be the beginning of our research endeavours regarding the specific areas of study.

As far as the monthly variables are concerned, sections 6.1, 6.3 and 6.4 employ all or only some of the following variables:

- Domestic income approximated by the industrial production index. Industrial production is often used as the monthly approximation of quarterly GDP which in turn is the natural realisation of domestic income.
A monetary policy instrument approximated by the 1-month interbank rate. As already mentioned in this study within the framework of inflation targeting monetary policy, attention is drawn to short-term interest rates. Another popular choice for this would be the libor rate; however, we decided not to include the libor due to the recent debate over its potential manipulation.

Demand for money, approximated by the monetary aggregate M2. This category includes the narrow definition of money (i.e. mainly banknotes and coins), as well as, liquid deposits. We find this category sufficient for the purpose of our study. Please note that in the VAR model specification, M2 is used in order to capture demand for money (which can be construed as demand for money in circulation and deposits).

The inflation rate approximated by the consumer prices index. The CPI is used in order to produce real time series for the variables of interest. In our study, \( CPI = 100 \) in 2005.

Crude oil prices approximated by Brent crude oil prices. Brent oil is probably the most popular type of crude oil. According to Maghyereh (2004) approximately 60% of the daily crude oil transactions are associated with the type of Brent. As an important input of production, oil price changes may trigger positive or negative economic developments depending on the nature of the country under investigation (i.e. net oil exporting or net oil importing country) and the origin of the price change (i.e. supply-side, demand-side etc.). Especially in VAR models it is also used to represent global economic conditions.

Financial prices approximated by the FTSE all-share index. An approximation for financial prices. For the time being we are not involved in a study concentrated on specific industries and therefore an all-share index is appropriate to act as a variable that quickly responds to economic developments.
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- Housing prices approximated by the Halifax housing index. An approximation for country-average housing prices. For the time being we are interested in average national prices and not in region-specific information. On the basis that the UK is a country with sharp regional contrasts in real estate prices, future modelling approaches could also comprise region-specific housing indices.

- Households' consumption approximated by the UK consumer confidence index. An approximation for households' consumption. Other variables such as retail sales have also been used as a monthly proxy for this variable but we believe that a confidence index is a better starting point for investigating issues revolving around households' consumption. It is understandable that future work should also involve the investigation of other proxies.

Some of the aforementioned time series were also collected on a quarterly basis in order to facilitate the analysis of section 6.2. Additional variables in connection with section 6.2 include:

- Domestic income approximated by the Gross Domestic Product. Employed here as the standard measure of domestic income.

- Fiscal policy, approximated by Government spending. There are not many empirical studies incorporating fiscal variables. Most of these studies however, use Government spending as a proxy for fiscal policies. Variables such as budget deficit or tax revenue have also been employed by some of the existing empirical studies. In any case part of our future work in this area includes testing more than just one approximation.

- Global demand approximated by Kilian's (2009) economic activity index. It is an alternative way to represent global economic conditions. Constructed by Lutz Kilian

---

this measure is predicated upon a global index of *dry cargo single voyage freight rates* and goes as far back as 1968.

All variables are seasonally adjusted. Non index-variables are constant at 2005 prices. The effect of inflation has also been removed from the short-term interbank rate. Most importantly, given that our study involves time series data, we account for *stationarity* as suggested - among others - by Brooks (2007); that is, by taking the logarithmic differences of the time series. In this regard, all estimations presented in this study (i.e. on all four empirical essays) are based on the logarithmic difference of the series, regardless of whether the analysis involves monthly or quarterly data; and also, regardless of whether this is explicitly stated during the analysis of the results or not (i.e. while discussing the results for financial prices for example, we refrain from restating the whole time that financial prices are in fact stock market returns). In other words, all inferences made about the variables of interest are based on the logarithmic difference transformation.

Also important to note is that for two of the time series, the rate of change has been computed instead of the logarithmic difference. This was necessary as the way both the Consumer Confidence Index and the Global Economic Activity Index are constructed, implies that these series incorporate negative values and thus the calculation of logarithms is not possible. On the basis that the rate of change and the logarithmic difference are different ways to approach the same outcome, we overcome this problem by calculating their respective rates of return.

It is worth noting that in some cases there are some extreme observations (outliers) affecting the skewness of the probability distribution of the time series under investigation. Once these outliers have been identified researchers are generally faced with the option to either include or exclude (or even correct - if possible) these outliers (see *inter alia*, Mazzocchi, 2012). The choice is predicated upon the specific objectives of the study. Even more so, assuming that
the cause of these extreme values is unknown -therefore forbidding any option for correction - researchers can either dismiss or keep these values. In this particular study the choice is to retain outliers and this is in line with our intention to allow the datasets to reflect actual although not recurrent or frequent economic conditions.

It is understood that the choice to retain extreme values has a direct impact on the normality of the distribution of the time series under investigation. Furthermore, it is understood that we have to be very cautious in drawing inferences from unit root tests that are performed on datasets which contain extreme values (see inter alia Lucas, 1995). In addition, there may be cases where the distributions of the original datasets (i.e. time series in levels, before the logarithmic-difference transformation) appear to be drawn from a bimodal or a multimodal distribution which could also distort our results. Effectively, in this study we hold on to the assumption that we draw data from a normal sampling distribution and that any deviations from normality are sample-specific. In this regard and as long as the employed models are able to capture the inter-temporal behaviour of the relations they aim to portray we relegate normality issues to a secondary level. On no occasion though, can we lightly dismiss the implications stemming from the current sample and therefore part of future work should also include an expansion of the period of study, as well as, the employment of non-parametric approaches.

Results regarding the stationarity of the time series employed in this study - before and after the transformation - are presented in the following sections.
5.2 Monthly time series

In conducting econometric analysis and making inferences on average, it is essential to initially make the necessary transformations so as ensure similar expected values across different samples. In time series analysis this translates to similar expected values across different sample periods. Time series exhibit upward or downward trends and only on a rare occasion will real world macroeconomic or financial data follow a random walk (i.e. when the trend line does not exhibit a discernible pattern).

Figure 5.2.1: Brent Oil Price (Jan-1992 Dec-2012).

Notes: Constant at 2005 prices. Price per barrel in £. Time series in levels.
[Source: Thomson Reuters Datastream]

Figure 5.2.1 illustrates the trend line for Brent oil price (i.e. before the transformation of the data). Obviously, as time passes, this series exhibits an upward trend. Also this series does not even revolve around a non-zero mean which basically implies that depending on the sample period expected values will be different. This implies that the results we would obtain by performing any sort of econometric test - in order to throw light upon particular relationships among variables of interest - would be spurious and misleading.

Descriptive statistics and the histogram of the series are given by figure 5.2.2. The p-value of the Jarque-Bera statistic is below all conventional statistical significance levels implying that
we can reject the null hypothesis of a normal distribution. We do not expect the series in the model to be normally distributed - in fact, not even after the transformation of the series takes place - however, we proceed with the logarithmic difference transformation to secure that the functional form of our variables is such that allows the derivation of trustworthy conclusions in connection with the relationships under investigation.

Figure 5.2.2: Brent Oil Price (Jan-1992 Dec-2012). Histogram and descriptive statistics.

Notes: Time series in levels. Results obtained using the EViews econometric software.

According to Hill et al. (2008) a stationary time series entails constant mean and variance across samples, while the covariance of the series \( s \) periods ahead is equal to the covariance of the series \( s \) periods back. More formally:

\[
E(y_t) = \mu \quad \text{(constant mean)}
\]

\[
\text{var}(y_t) = \sigma^2 \quad \text{(constant variance)}
\]

\[
\text{cov}(y_t, y_{t-s}) = \text{cov}(y_t, y_{t+s}) = \gamma_s \quad \text{(covariance depends on \( s \) not on \( t \)).}
\]

The argument in favour of stationary time series is that they exhibit the property of \textit{mean reversion}; that is, they fluctuate around a constant mean. By securing that the series reverts to a fixed mean value after a shock we can proceed with econometric estimation.

It is worth noting, that although non-stationary series might produce significant results, these results should not be regarded as valid and trustworthy as estimation will be biased and the
distributions of $t$-statistics will neither be $t$ nor close to normal. Useful transformations regarding the stationarity issue include differencing and de-trending (see among others Hill et al., 2008). In economic and financial literature the attention is typically drawn to returns (e.g. of stock prices) and growth rates (e.g. of domestic income or the rate of return of inflation) and therefore it is very popular to employ the logarithmic difference transformation. This transformation will improve the distribution of the employed time series (i.e. close to normal) and will also produce stationary variables. Figure 5.2.3 illustrates the rate of return for crude oil prices. Apparently after the transformation takes place the new series revolves around a zero mean (i.e. it deviates for a while but then at some point reverts back to the constant average value).

![Figure 5.2.3: Log-difference of Brent Oil Price (Jan-1992 Dec-2012).](image)

Comparing the results obtained between figure 5.2.2 and 5.2.4 we can see that the transformation has indeed improved the distribution of the series (although again we don't have normality).

One of the most popular ways to test for stationarity is by the Augmented Dickey-Fuller (ADF) test. The exposition of this test is not to the present purpose of this study\(^{37}\); however it

\(^{37}\) For a detailed analysis of the test the reader is directed to the work of Brooks (2007) and Hill et al. (2008) among others.
is important to note that this test comes in several variations depending on whether the series under investigation exhibits a deterministic trend or and revolves around a non-zero mean. The trends followed by a time series can either be deterministic (i.e. the time series increases or decreases by a fixed amount at every time point $t$) or stochastic (i.e. the time series resembles a random walk process) and the ADF test considers these issues before producing a decision with respect to the stationarity of the series.

Figure 5.2.4: Log-difference of Brent Oil Price (Jan-1992 Dec-2012). Histogram and descriptive statistics.
Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.

Figure 5.2.5: UK Monetary Aggregate M2 (Jan-1992 Dec-2012).
Notes: Constant at 2005 prices. Million £. Time series in levels.
[Source: Thomson Reuters Datastream]
Figure 5.2.6: UK Monetary Aggregate M2 (Jan-1992 Dec-2012). Histogram and descriptive statistics.

Notes: Time series in levels. Results obtained using the EViews econometric software.

Results for the ADF tests regarding both the original and the transformed data are given by tables 5.2.1 and 5.2.2 respectively.

Having established the main issues revolving around the time series employed in this study and also having stressed the necessity for the inclusion of a stationary version of datasets involved, in the pages that follow we present the trend line, the histograms and the basic statistics for all monthly variables included in our models, both before and after the transformation.

Figure 5.2.7: Log-difference of UK Monetary Aggregate M2 (Jan-1992 Dec-2012).
Figure 5.2.8: Log-difference of UK Monetary Aggregate M2 (Jan-1992 Dec-2012). Histogram and descriptive statistics. Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.

Figure 5.2.9: UK Industrial Production Index (Jan-1992 Dec-2012). Notes: Constant at 2005 prices. Time series in levels. [Source: Thomson Reuters Datastream]

Figure 5.2.10: UK Industrial Production Index (Jan-1992 Dec-2012). Histogram and descriptive statistics. Notes: Time series in levels. Results obtained using the EViews econometric software.
Figure 5.2.11: Log-difference of UK Industrial Production Index (Jan-1992 Dec-2012).

Figure 5.2.12: Log-difference of UK Industrial Production Index (Jan-1992 Dec-2012). Histogram and descriptive statistics. Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.

Figure 5.2.13: UK CPI-Inflation (Jan-1992 Dec-2012). Notes: 2005 = 100. Time series in levels. [Source: Thomson Reuters Datastream]
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Figure 5.2.14: UK CPI-Inflation (Jan-1992 Dec-2012). Histogram and descriptive statistics.
Notes: Time series in levels. Results obtained using the EViews econometric software.

Figure 5.2.15: Log-difference of UK CPI-Inflation (Jan-1992 Dec-2012).

Figure 5.2.16: Log-difference of UK CPI-Inflation (Jan-1992 Dec-2012). Histogram and descriptive statistics.
Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.
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Figure 5.2.17: FTSE All-Share Index (Jan-1992 Dec-2012).
Notes: Time series in levels.
[Source: Thomson Reuters Datastream]

Figure 5.2.18: FTSE All-Share Index (Jan-1992 Dec-2012). Histogram and descriptive statistics.
Notes: Time series in levels. Results obtained using the EViews econometric software.

Figure 5.2.19: Log-difference of FTSE All-Share Index (Jan-1992 Dec-2012).
**Figure 5.2.20:** Log-difference of FTSE All-Share Index (Jan-1992 Dec-2012). Histogram and descriptive statistics. *Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.*

**Figure 5.2.21:** Halifax Index (Jan-1992 Dec-2012).  
*Notes: Time series in levels.*  
[Source: Thomson Reuters Datastream]

**Figure 5.2.22:** Halifax Index (Jan-1992 Dec-2012). Histogram and descriptive statistics.  
*Notes: Time series in levels. Results obtained using the EViews econometric software.*
Figure 5.2.23: Log-difference of Halifax Index (Jan-1992 Dec-2012).

Figure 5.2.24: Log-difference of Halifax Index (Jan-1992 Dec-2012). Histogram and descriptive statistics.
Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.

Figure 5.2.25: Interbank Rate (Jan-1992 Dec-2012).
Notes: Time series in levels.
[Source: Thomson Reuters Datastream]
Figure 5.2.26: Interbank Rate (Jan-1992 Dec-2012). Histogram and descriptive statistics.

Notes: Time series in levels. Results obtained using the EViews econometric software.

Figure 5.2.27: Log-difference of Interbank Rate (Jan-1992 Dec-2012).

Figure 5.2.28: Log-difference of Interbank Rate (Jan-1992 Dec-2012). Histogram and descriptive statistics.

Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.
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Figure 5.2.29: Consumer Confidence Index (Jan-1992 Dec-2012).
Notes: Time series in levels.
[Source: Thomson Reuters Datastream]

Figure 5.2.30: Consumer Confidence Index (Jan-1992 Dec-2012). Histogram and descriptive statistics.
Notes: Time series in levels. Results obtained using the EViews econometric software.

Series: Confidence Index (levels)
Sample: Jan-1992 Dec-2012
Observations 252

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-9.071429</td>
</tr>
<tr>
<td>Median</td>
<td>-6.350000</td>
</tr>
<tr>
<td>Maximum</td>
<td>7.100000</td>
</tr>
<tr>
<td>Minimum</td>
<td>-38.20000</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>8.526872</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.664844</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.665779</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>19.80887</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000050</td>
</tr>
</tbody>
</table>

Figure 5.2.31: Rate of return of the Consumer Confidence Index (Jan-1992 Dec-2012).
Notes: Series involves the rate of change of the variable.
Finally the results from the ADF tests for both original and transformed series are given by tables 5.2.1 and 5.2.2 respectively.

The null hypothesis of the ADF test is always that the series is integrated or has a unit root (i.e. that the series is not stationary).

In table 5.2.1 we can see that the p-values produced by the ADF test for the original series imply that the null hypothesis of non-stationarity cannot be rejected.

On the other hand, table 5.2.2 shows that the p-values obtained, after the transformation, for each of the series under investigation imply that the null hypothesis of non-stationarity can be rejected.

These results come in support of our previous arguments regarding the employment of the logarithmic difference transformation.
Table 5.2.1: Augmented Dickey-Fuller Unit Root Test 1.

<table>
<thead>
<tr>
<th>Series Name</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI-Inflation</td>
<td>-0.7907</td>
<td>0.3727</td>
</tr>
<tr>
<td>Industrial Production Index</td>
<td>-1.3227</td>
<td>0.8799</td>
</tr>
<tr>
<td>Monetary Aggregate (M2)</td>
<td>-1.4853</td>
<td>0.8322</td>
</tr>
<tr>
<td>FTSE All-Share Index</td>
<td>-2.3341</td>
<td>0.4136</td>
</tr>
<tr>
<td>Halifax Index</td>
<td>-2.6007</td>
<td>0.2805</td>
</tr>
<tr>
<td>Interbank Rate</td>
<td>-2.2200</td>
<td>0.1998</td>
</tr>
<tr>
<td>Consumer Confidence Index</td>
<td>-2.7453</td>
<td>0.2194</td>
</tr>
<tr>
<td>Brent Oil Price</td>
<td>-2.9054</td>
<td>0.1626</td>
</tr>
</tbody>
</table>

Notes: Monthly time series in levels. Null hypothesis: The series has a unit root.

Table 5.2.2: Augmented Dickey-Fuller Unit Root Test 2.

<table>
<thead>
<tr>
<th>Series Name</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI-Inflation</td>
<td>-8.8433</td>
<td>0.0000</td>
</tr>
<tr>
<td>Industrial Production Index</td>
<td>-20.0226</td>
<td>0.0000</td>
</tr>
<tr>
<td>Monetary Aggregate (M2)</td>
<td>-16.8898</td>
<td>0.0000</td>
</tr>
<tr>
<td>FTSE All-Share Index</td>
<td>-16.5668</td>
<td>0.0000</td>
</tr>
<tr>
<td>Halifax Index</td>
<td>-2.2107</td>
<td>0.0264</td>
</tr>
<tr>
<td>Interbank Rate</td>
<td>-4.7761</td>
<td>0.0001</td>
</tr>
<tr>
<td>Consumer Confidence Index</td>
<td>-7.6286</td>
<td>0.0000</td>
</tr>
<tr>
<td>Brent Oil Price</td>
<td>-5.8555</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Notes: Monthly time series in logarithmic difference. Null hypothesis: The series has a unit root.
5.3 **Quarterly time series**

As already mentioned in the first section of this chapter, part of our study involves quarterly series. All of the arguments around stationarity apply to quarterly series as well. Section 5.2 comprises a number of variables for which both monthly and quarterly data have been collected. The additional variables that have not yet been introduced are Government spending (i.e. the fiscal policy variable), GDP and Global Economic Activity (GEA). Please note that although GEA appears to be normally distributed in levels (figure 5.3.10) we still proceed with the calculation of the series’ rate of change as the results from the ADF test 3 (table 5.3.1) suggest that the series in levels is non-stationary.

![Figure 5.3.1: Government Spending (Q1 1992 Q4 2012).](image)

*Notes: Constant at 2005 prices. Time series in levels. Million £.*

[Source: Thomson Reuters Datastream]

![Figure 5.3.2: Government Spending (Q1 1992 Q4 2012). Histogram and descriptive statistics.](image)

*Notes: Time series in levels. Results obtained using the EViews econometric software.*
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Figure 5.3.3: Log-difference of Government Spending (Q1 1992 Q42012).

Figure 5.3.4: Log-difference of Government Spending (Q1 1992 Q42012). Histogram and descriptive statistics.

Notes: Time series in logarithmic difference. Results obtained using the EViews econometric software.

Figure 5.3.5: GDP (Q1 1992 Q42012).

Notes: Constant at 2005 prices. Time series in levels. Million £.

[Source: Thomson Reuters Datastream]
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Figure 5.3.6: GDP (Q1 1992 Q4 2012). Histogram and descriptive statistics.

*Notes:* Time series in levels. Results obtained using the EViews econometric software.

Figure 5.3.7: Log-difference of GDP (Q1 1992 Q4 2012) (Jan-1992 Dec-2012).

Figure 5.3.8: Log-difference of GDP (Q1 1992 Q4 2012). Histogram and descriptive statistics.

*Notes:* Time series in logarithmic difference. Results obtained using the EViews econometric software.
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Figure 5.3.9: GEA (Q1 1992 Q42012).
Notes: Time series in levels.
[Source: Lutz Kilian (2009)]

Figure 5.3.10: GEA (Q1 1992 Q42012). Histogram and descriptive statistics.
Notes: Time series in levels. Results obtained using the EViews econometric software.

Figure 5.3.11: Rate of Return of the GEA (Q1 1992 Q42012).
Notes: Series involves the rate of change of the variable.
Figure 5.3.12: Rate of Return of the GEA (Q1 1992 Q4 2012). Histogram and descriptive statistics.

Notes: Rate of change. Results obtained using the EViews econometric software.

Finally results from the ADF tests for both original and transformed series are given by tables 5.3.1 and 5.3.2 respectively. As before, time series in levels appear to be non-stationary whereas time series in logarithmic difference appear to be stationary.

Table 5.3.1: Augmented Dickey-Fuller Unit Root Test 3.

<table>
<thead>
<tr>
<th>Series Name</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Domestic Product (GDP)</td>
<td>0.9490</td>
<td>0.9998</td>
</tr>
<tr>
<td>Government Spending</td>
<td>-2.1697</td>
<td>0.4990</td>
</tr>
<tr>
<td>Global Economic Activity (GEA)</td>
<td>-2.2027</td>
<td>0.4816</td>
</tr>
</tbody>
</table>

Notes: Quarterly time series in logarithmic difference. Null hypothesis: The series has a unit root.

Table 5.3.2: Augmented Dickey-Fuller Unit Root Test 4.

<table>
<thead>
<tr>
<th>Series Name</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Domestic Product (GDP)</td>
<td>-9.1117</td>
<td>0.0000</td>
</tr>
<tr>
<td>Government Spending</td>
<td>-3.7620</td>
<td>0.0239</td>
</tr>
<tr>
<td>Global Economic Activity (GEA)</td>
<td>-8.5662</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Notes: Quarterly time series in logarithmic difference. Null hypothesis: The series has a unit root.
Chapter 5: Data description

Chapter 5 provided a thorough analysis regarding both the monthly and the quarterly time series datasets employed in this study. Most importantly it provided information regarding the relevant transformations which bolster the reliability and the validity of our empirical findings. We then turn to chapter 6 which is devoted to the presentation and the discussion of our empirical findings.
This chapter presents four essays on the macroeconometric modelling with reference to the UK economy. In this regard, there are four distinct sections each one corresponding to a separate working assumption. What is common in all four cases is that the linkages between monetary policy, housing and financial prices remain at the heart of our attention. The first two essays share the same method (although applied to a different economic setup) and therefore section one shoulders the additional burden to illustrate the method. By contrast, sections three and four entail entirely different modelling approaches and therefore the relevant econometric methods are described independently in each of these sections.

Very succinctly, the first essay emphasises the potential effects of monetary policy on housing and financial wealth, the second essay involves the interaction between monetary and fiscal policy, the third essay makes inferences regarding the potential states of both housing and financial markets, whereas the last one investigates the time-varying correlation between monetary policy and housing (or) financial prices. As will be suggested in the upcoming analysis, literature has remained relatively silent when it comes to the investigation of the housing market per se or to the interaction between the housing market and the financial market (or) the formulation of monetary policy - and this greatly reflects the main contribution of this section and of the thesis as a whole. The essays presented in this chapter merely constitute an effort to further elucidate the interactions between the variables of interest and potentially inform policy and practice.
6.1 Asset prices & the wealth channel of monetary policy

In this section we develop a Structural Vector Autoregressive (SVAR) model for the UK economy aiming to trace monetary policy effects on households’ consumption indirectly via the wealth channel. Wealth is disaggregated into housing and financial wealth, approximated by housing prices and stock market prices respectively. However, a proxy for UK households’ consumption is also included in the model to trace direct effects as well. Our attention is also drawn to the specific relationship between housing and financial prices; that is, an area that has been greatly neglected by the literature. Furthermore and in the framework of inflation targeting, contractionary monetary policy in the UK is described as a positive innovation in the economy’s short-term interest rates. At one end of the scale, we provide evidence that contractionary monetary policy exerts negative effects mainly on housing prices. Housing prices react rather quickly; a fact suggestive of their ability to act as transmitters of these innovations into the broader economy. The stock market remains rather unaffected which could be indicative of the level of transparency and confidence ascribed to the inflation targeting central bank. At the other end of the spectrum, results indicate that although the central bank does not target asset markets directly, there is important feedback informing policy decision making coming from both markets. In addition, findings suggest that the stock market responds immediately to innovations in the housing market; however, the effect is relatively transitory. Finally, we verify that there is indeed a link between financial wealth and households' consumption. The effects of innovations in housing prices on households' consumption though are not clear. In all cases, a justification is provided.

6.1.1 Econometric method and modelling

The Vector Autoregressive (VAR) methodology was introduced by Sims (1980) to mainly address the issue of conducting macroeconomic policy by employing very complex structural
equation models (i.e. models of the Cowles Commission persuasion such as dynamic simultaneous equations models) that usually provided very complicated results. In assessing VAR models, Cooley and Leroy (1985), Bernanke (1986), as well as, Stock and Watson (2001) took the view that although VAR models are able to provide useful statistically significant results; they typically fail to distinguish between correlation and causation, a problem known as the identification problem in economics (Sims, 1980; 1986). To the effect that the identification problem was accounted for, Sims (1980) employed the Choleski decomposition approach, a process which ensures that the error term in each regression equation is not correlated with the corresponding error of all preceding equations (i.e. orthogonalisation).

Authors such as Cooley and Leroy (1985), Bernanke (1986), Kim and Roubini (2000), as well as, Stock and Watson (2001) among many others, put forward the argument that the Choleski decomposition approach produces results that are order-dependent since a lower-triangle coefficient matrix is implied. Bernanke (1986) maintains that this approach leads to a subjective orthogonalisation of the error terms which makes very specific assumptions in connection with the workings of real economic life. Furthermore, it is argued that under the Choleski decomposition framework only one shock can be investigated each time (Kim and Roubini, 2000; Elbourne, 2008). In response, Structural Vector Autoregressive (SVAR) models were proposed by Sims (1986). Initial examples of this methodology can be found in the work of Blanchard and Watson (1986) and Bernanke (1986). SVAR models draw from the corresponding economic theory and in this regard they incorporate a priori information allowing for contemporaneous interdependence among the variables under investigation. In contrast with Cholesky-based or unstructured VAR models, SVAR models allow for non-recursive structures implying that results are not order-dependent and also that more than one shock can be examined. To the effect that SVAR models allow correlations to be interpreted
causally, specific identifying restrictions that rely on economic theory must be brought into service. In the pages that follow, we proceed initially with the description of the method - presenting the main features and explaining most of the key concepts and definitions related to VAR models in general - and then we turn to the development of a specific SVAR model.

According to Sims (1980) VAR models can be used either for the forecasting of economic variables or for the investigation of economic shocks. On general principles, any VAR model is a system of equations where all variables are considered to be endogenous (i.e. determined within the system). Equation 6.1.1 describes the simple bivariate case:

\[ y_{1,t} = \beta_{10} + \beta_{11}y_{1,t-1} + \cdots + \beta_{1k}y_{1,t-k} + \delta_{11}y_{2,t-1} + \cdots + \delta_{1k}y_{2,t-k} + e_{1t} \]
\[ y_{2,t} = \beta_{20} + \beta_{21}y_{2,t-1} + \cdots + \beta_{2k}y_{2,t-k} + \delta_{21}y_{1,t-1} + \cdots + \delta_{2k}y_{1,t-k} + e_{2t}, \]

(6.1.1)

where, \( y_{1t} \) and \( y_{2t} \) are both stationary variables and \( e_{it} \) are white noise error terms, all with an expected value equal to zero (\( E(e_{it}) = 0 \)). These error terms represent movements in the variables that cannot be explained within the model and can broadly be attributed to impacts of exogenous shocks / innovations. Obviously, we cannot assign any specific economic interpretation on these disturbance terms as they merely represent an aggregation of potential exogenous factors that affect the model. To put it simple, we cannot be specific as to what affects our model exogenously. Equation 6.1.1 further implies that for the bivariate case, term \( i \) assumes values between 1 and 2 \( (i = 1,2) \).

It follows that the covariance between the error terms in these two equations should also be zero \( (E(e_{1t}e_{2t}) = 0) \). Furthermore, this bivariate example assumes \( k \) lags of each variable. This implies that we are working with a VAR model of order \( k \). In practice, the optimal lag-length is determined by information criteria, such as the Akaike (AIC), the Schwarz (SC), as well as, the Hannan-Quinn (HQ) information criterion (Brooks, 2007).
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Assuming that \( k = 1 \) we can rewrite the bivariate VAR presented in 6.1.1 in its matrix form:

\[
\begin{bmatrix}
    y_{1,t} \\
    y_{2,t}
\end{bmatrix} =
\begin{bmatrix}
    \beta_{10} \\
    \beta_{20}
\end{bmatrix} +
\begin{bmatrix}
    \beta_{11} & \delta_{11} \\
    \delta_{21} & \beta_{21}
\end{bmatrix}
\begin{bmatrix}
    y_{1,t-1} \\
    y_{2,t-1}
\end{bmatrix} +
\begin{bmatrix}
    e_{1,t} \\
    e_{2,t}
\end{bmatrix} .
\] (6.1.2)

Finally, we can rewrite 6.1.2 in the more compact and convenient way:

\[
y_t = \beta_0 + B_1 y_{t-1} + e_t .
\] (6.1.3)

This is the model expressed in its reduced form; that is, all endogenous variables of the model are on the LHS of each equation and there is no feedback coming from these endogenous variables to the RHS of the equations which comprises all exogenous or predetermined variables (i.e. variables that are known at time \( t \)). This implies that all of the equations included in the system comprise an identical set of determining variables. Transforming any system of equations into its reduced form is very important because it facilitates the employment of the ordinary least squares (OLS) optimisation method.

According to BoE (2000) when movements in the endogenous variables of a VAR model are assumed to reflect effects from exogenous shocks / innovations\(^{38}\) related to the endogenous variables of the model, then the VAR model can be very useful for the investigation of these shocks. In this regard, we no longer refer to some vague aggregation of exogenous shocks but we make an effort to decompose the innovations' effects by assigning real economic meaning to specific shocks that affect the system. In the shell of a nut, VAR models try to answer the question of what would the path assumed by all endogenous variables of the system be if there was a shock today related to variable \( y_1 \)? What would the same path be if there was a relevant shock related to variable \( y_2 \)? It follows that if VAR models try to make inferences regarding the future course of the endogenous variables based on current shocks, we will have to also incorporate contemporaneous terms into our model. In other words,

\(^{38}\) ...as opposed to reflecting direct impacts from one variable to another... (Gottschalk, 2001)
variable $y_1$ must have some immediate impact on variable $y_2$ and vice versa. Therefore, assuming now that contemporaneous terms are included in the model (i.e. we make the assumption that term $y_{2t}$ can be found at the RHS of the $y_{1t}$ equation and term $y_{1t}$ can be found at the RHS of the $y_{2t}$ equation respectively) 6.1.2 takes the following form:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \delta_{11} \\ \delta_{21} & \beta_{21} \end{bmatrix} \times \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} \delta_{12} \\ 0 \end{bmatrix} \times \begin{bmatrix} y_{1,t} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix}.$$  

(6.1.4)

As will be explained shortly, it would be appropriate to start working towards computing the reduced form of this model. To this end, we first take all contemporaneous terms to the LHS of the equation to get:

$$\begin{bmatrix} -\delta_{12} & 0 \\ 0 & -\delta_{22} \end{bmatrix} \times \begin{bmatrix} y_{2,t} \\ y_{1,t} \end{bmatrix} + \begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \delta_{11} \\ \delta_{21} & \beta_{21} \end{bmatrix} \times \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix}.$$  

(6.1.5)

We can then rewrite this:

$$\begin{bmatrix} y_{1,t} - \delta_{12}y_{2,t} \\ -\delta_{22}y_{1,t} + y_{2,t} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \delta_{11} \\ \delta_{21} & \beta_{21} \end{bmatrix} \times \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix}.$$  

(6.1.6)

And then:

$$\begin{bmatrix} 1 & -\delta_{12} \\ -\delta_{22} & 1 \end{bmatrix} \times \begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \delta_{11} \\ \delta_{21} & \beta_{21} \end{bmatrix} \times \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix}.$$  

(6.1.7)

We can rewrite 6.1.7 in a compact way:

$$G y_t = \beta_0 + B_1 y_{t-1} + e_t,$$  

(6.1.8)

where $G$ is the contemporaneous matrix. The variance-covariance matrix of innovations in 6.1.8 is given by:

$$\Sigma_e = \begin{bmatrix} \sigma_{y_1}^2 & \sigma_{y_1,y_2} \\ \sigma_{y_1,y_2} & \sigma_{y_2}^2 \end{bmatrix},$$  

(6.1.9)

where $\sigma_{y_1}^2$ denotes the variance of the $y_1$ innovations, $\sigma_{y_2}^2$ stands for the variance of innovations in $y_2$ and $\sigma_{y_1,y_2}$ is the respective covariance between the innovations of the two
variables. As evident in 6.1.9 innovations are directly related to both endogenous variables of our bivariate example. We call these shocks \textit{structural} and we maintain that we cannot assign any specific economic interpretation to these yet, at least not until we solve for the reduced form of the model and find the \textit{reduced form} errors (see \textit{inter alia} Gottschalk, 2001; Brooks, 2007; Enders, 2009).

Provided that $G$ has an inverse matrix, then the second step towards calculating the reduced form model in the presence of contemporaneous terms is to multiply each side of the equation by $G^{-1}$. Consequently we get the following equation:

$$y_t = G^{-1}\beta_0 + G^{-1}B_1y_{t-1} + G^{-1}e_t .$$

(6.1.10)

Finally, we can rewrite 6.1.10 in a more convenient way:

$$y_t = G_0 + G^*y_{t-1} + u_t .$$

(6.1.11)

For the general case of a $k$-order VAR, equation 6.1.11 becomes:

$$y_t = G_0 + \sum_{i=1}^{k} G^*y_{t-i} + u_t .$$

(6.1.12)

Or, using the lag operator\(^{39}\) and - for the sake of simplicity - omitting the constant parameters vector, we can rewrite 6.1.12 as:

$$y_t = G^*(L)y_t + u_t ,$$

(6.1.13)

and the variance-covariance matrix of the reduced form innovations is given by:

$$\Sigma_u = G^{-1}\Sigma_e G^{-1} .$$

(6.1.14)

Note that the quadratic formulation of equation 6.1.14 (i.e. a formulation of the persuasion: $\Phi = X\Lambda X^T$) implies that the covariance matrix $\Sigma_u$ is \textit{positive definite} and therefore variances will always be positive (as these are supposed to be) while the covariance will be identical

\(^{39}\) The lag polynomial takes the general form: $G^*(L) = G_1L + G_2L^2 + \cdots + G_kL^k$ (Gottschalk, 2001)
regardless of which series is primarily considered (Brooks, 2007).

Also note that \( u_t = G^{-1}e_t \) implying that:

\[
e_t = Gu_t . \tag{6.1.15}
\]

Equation 6.1.15 is very important as it implies that the exogenous / structural shocks can be construed as a function of the product of the reduced form innovations and the contemporaneous matrix. According to BoE (2000) the value of a VAR model is that it can recover structural innovations from the reduced form errors by imposing the appropriate restrictions on the contemporaneous matrix. To put it more simply, by employing the contemporaneous matrix and the reduced form disturbances vector we can assign true economic meaning to exogenous / structural shocks that are related to the endogenous variables of our model (i.e. we move from a vague description of exogenous shocks as discussed earlier to a more specific one). In order to facilitate this process, certain restrictions must be considered in connection with the variance covariance matrix and the contemporaneous matrix (see inter alia Sims, 1980; Blanchard and Quah, 1989; King et al., 1992; Gali, 1992).

In order to explain the reasons that make necessary to impose restrictions on \( G \), we need to carry on with our analysis. The next step is to compute the moving average representation of 6.1.13. By so doing, we eventually get to re-parameterise the system in order to express the endogenous variables of vector \( y_t \) as a function of both current and past reduced form innovations. Assuming that the polynomial \( I - G^*(L) \) is invertible, we achieve this transformation by inverting the autoregressive representation in 6.1.13. The moving average representation of the system is then given by:

\[
y_t = (I - G^*(L))^{-1}u_t . \tag{6.1.16}
\]
or by setting: 

$$(I - G^*(L))^{-1} = C(L)$$

6.16 becomes:

$$y_t = C(L)u_t.$$  \hspace{1cm} (6.1.17)

The model in its final form implies that each of the variables is expressed as a function of current and past reduced form innovations and not as a function of the variables' past values. The parameters included in $C(L)$ represent the response of the endogenous variables to a 1-unit innovation in one of the reduced form disturbances each time. This is true as $C(L)$ can be decomposed even further in order to give:

$$y_t = C_0u_t + C_1u_{t-1} + C_2u_{t-2} + \cdots + C_ku_{t-k}.$$ \hspace{1cm} (6.1.18)

In other words, $C_t$ are matrices of parameters that determine the current and past ($t = 1 \ldots k$) effects of the reduced form disturbances on the endogenous variables of the model. In fact this is how we derive the impulse response functions (IRFs) of the endogenous variables of the model which is, as we will discuss shortly, perhaps the most important feature of VAR models. Diagrammatically, the impulse response function process is presented in figure 6.1.1.

In order to explain the information presented in figure 6.1.1 we recall the bivariate case. Assuming for example a shock ($u_t$) in variable $y_2$ at time $t$, and holding innovations in $y_1$ constant, the relevant / appropriate parameter in matrix $C_1$ of equation 6.1.18 will inform us of the response of the variable $y_1$ at time $t + 1$ to a 1-unit innovation in , the relevant / appropriate parameter in matrix $C_2$ will inform us of the response of the variable $y_1$ at time $t + 2$, and so on. In this regard we are able to derive the impulse response functions of the model. Note that in order to appropriately assess the effect of each 1-unit reduced form innovation to each endogenous variable in our model we make the assumption that there is no other innovation following the initial, from any of the variables in the model.

\footnote{For a detailed analysis of these transformations the reader is directed to the work of Hamilton (1994) and Amisano and Giannini (1997).}
The first problem relating to the analysis above is that these impulse response functions are still devoid of economic context (Gottschalk, 2001). To be more explicit, it is true that we have solved for the reduced form of the model and we have obtained the reduced form disturbances; however the latter merely constitute a linear representation of the structural disturbances. To put it simply, what we know so far is how the endogenous variables of the model respond to innovations in a linear representation of the actual structural shocks and not to innovations in the structural shocks per se. To the effect that we can accomplish the latter, a useful transformation is presented in Gottschalk (2001).

Given that $u_t = G^{-1}e_t$ implying that $e_t = Gu_t$, equation 6.1.17 can be re-written as:

$$y_t = C(l)G^{-1}e_t.$$  \hspace{1cm} (6.1.19)
Then, by setting $C^*(L) = C(L)G^{-1}$ we have:

$$y_t = C^*(L)e_t .$$

(6.1.20)

This implies that the relevant / appropriate parameters within the $C_t$ matrices will provide information regarding the response of the model's endogenous variables to impulses of the model's structural innovations.

The second problem is that in order to calculate matrix $C^*$ we need to know beforehand the exact elements included in the contemporaneous matrix $G$. The solution to this problem is directly related to the various restrictions that are required to be imposed to the system, especially with respect to the variance-covariance matrix $\Sigma_e$ and the contemporaneous matrix $G$. The multitude of the restrictions will thus determine the final form of matrix $G$. In effect, the modeller determines the restrictions that are imposed on the contemporaneous matrix $G$ and then matrix $G$ is used to compute matrix $C^*$ (i.e. the IRFs of the system).

According to Sims (1980), in order for structural innovations to be interpreted as true economic phenomena certain assumptions must be made. In effect, these assumptions entail imposing certain restrictions. By imposing restrictions on the $G$ matrix the modeller determines which variable affects which other variable at time $t = 0$. Furthermore, by imposing restrictions on the $\Sigma_e$ matrix the modeller makes sure that the innovations are uncorrelated. In turn and on the basis of the foregone analysis, the VAR model will produce the relevant IRFs which may then be interpreted in terms of economic theory.

Before we present a relevant example it would be instructive to refer to the restrictions that are necessary for the system to be identified. As already mentioned, VAR models - contrary to models of the Cowles Commission persuasion - do not concentrate on the direct relationships among the variables included in the system, but rather, they collect information
in connection with the shocks that drive movements in the variables of the system and then proceed with making inferences regarding co-movements between the variables (i.e. by producing the IRFs) (BoE, 2000). In this respect, structural innovations in VAR models are not treated as minor influences on the underlying equations of the system which exist for example due to the omission of unimportant explanatory variables that have no economic meaning. Structural innovations in VAR models explain the development of the system. In this regard, Sims (1980) explicates that there are two main restrictions that have to be imposed when it comes to a VAR system; that is, the orthogonality restriction and the normalisation restriction. Both restrictions refer to the variance-covariance matrix $\Sigma_e$.

The orthogonality restriction implies that the off-diagonal elements of matrix $\Sigma_e$ are equal to zero. According to Sims (1980) this will guarantee that structural shocks are uncorrelated. This will also facilitate our effort to investigate each shock to the system independently. The normalisation restriction implies that the elements of the main diagonal of matrix $\Sigma_e$ could equal 1. This restriction also stands to reason as the diagonal elements of matrix $\Sigma_e$ correspond to the variances of the structural innovations and IRFs in VAR models are computed on the basis of a one-standard deviation shock to each one of the structural disturbances. Considering for example the bivariate case, after all of these restrictions are imposed, matrix $\Sigma_e$ takes the following form:

$$\Sigma_e = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I.$$  \hspace{1cm} (6.1.21)

It is worth noting that - contrary to models such as the dynamic simultaneous equations models - VAR models, because of the emphasis they put on innovations, impose restrictions on matrix $\Sigma_e$. However, another important issue when it comes to building a model is that the robustness of the results depends on whether there exists a unique solution to the model. In order to tackle this so called identification problem in econometrics (i.e. that different structural models have the same reduced form ruling out any implications regarding causation
among the variables of interest), we have to make sure that we have imposed a sufficient minimum number of restrictions - including restrictions on the contemporaneous matrix $G$. So far we have imposed 3 restrictions (i.e. 2 restrictions regarding the variances and 1 regarding the covariance of matrix $\Sigma_e$).

In general, the exact identification of a VAR system is accomplished when $n^2$ restrictions are imposed on a model of $n$ variables (BoE, 2000). Obviously, for the bivariate VAR model, we need 4 restrictions overall. Having already imposed 3, we need one more. This will be imposed on the contemporaneous matrix $G$. To illustrate how restrictions are imposed on the contemporaneous matrix we use the following example:

As already mentioned, the focal point of any VAR model is the relationship presented in equation 6.1.15. We quote Gottschalk (2001, p. 20-21) who emphasises that "... in SVAR models the dynamic relationships in the economy are modelled as a relationship between shocks (i.e. structural shocks and reduced form errors)". The identification of the structural shocks that hit the VAR system is possible through this relationship. In this regard, we rewrite 6.1.15 in its full matrix form:

$$
\begin{pmatrix}
1 & -\delta_{12} \\
-\delta_{21} & 1
\end{pmatrix}
\begin{bmatrix}
u_{y_{1,t}} \\
u_{y_{2,t}}
\end{bmatrix}
= 
\begin{bmatrix}
\epsilon_{y_{1,t}} \\
\epsilon_{y_{2,t}}
\end{bmatrix},
$$

and then we restrict the term $-\delta_{12}$ to equal zero, that is:

$$
\begin{pmatrix}
1 & 0 \\
-\delta_{22} & 1
\end{pmatrix}
\begin{bmatrix}
u_{y_{1,t}} \\
u_{y_{2,t}}
\end{bmatrix}
= 
\begin{bmatrix}
\epsilon_{y_{1,t}} \\
\epsilon_{y_{2,t}}
\end{bmatrix}.
$$

This restriction basically implies that we allow for contemporaneous causality to run from the $y_2$ error term ($u_{y_{2,t}}$) to the $y_1$ error term ($u_{y_{1,t}}$) but not the other way around. This entails, that any structural innovation ($\epsilon_{y_{2,t}}$) related to variable $y_2$, will have a contemporaneous impact on the reduced form error of variable $y_2$ but not on the respective error of variable $y_1$. 
The latter, will only be influenced by the reduced form error of variable $y_2$ at a later stage. It follows that the outcome of this process will be given by the IRFs.

As a final note with respect to restrictions of VAR models, Sims (1980) had originally suggested that a considerable amount of restrictions could be warranted by setting all upper off-diagonal elements of the contemporaneous matrix equal to zero. We quote from the BoE (2000, p. 122) that "This approach, which is known as the Choleski decomposition, implies that the contemporaneous interactions between the exogenous shocks and the endogenous variables are characterised by a Wold (1938) causal chain". To re-iterate a point made in the beginning of this section, VAR models which incorporate this structure are being widely criticised as they result in a lower-triangular $G$ matrix which clearly suggests a very specific ordering of the variables. This very specific ordering can be rather binding when more than just one exogenous shocks needs to be investigated (see inter alia Kim and Roubini, 2000).

Due to this shortcoming, various authors (see for example Sims, 1986; Bernanke, 1986; as well as, Blanchard and Quah, 1989) turned to the development of the so-called Structural VAR models (SVARs) whose restrictions are mainly based on generally accepted theoretical priors (especially with respect to the possibility of an actual contemporaneous impact of an exogenous shock on any of the endogenous variables). In this respect, SVAR models are the least atheoretical version of models within the VAR family; however, they also incorporate atheoretical restrictions to the effect that some of the underlying relationships can be tested purely empirically (Cooley and Dwyer, 1998).

An interesting critique of VAR models can be found in the work of Bernanke et al. (2005) who mainly centre their criticism around the fact that models of this persuasion (i) typically include a limited number of variables (in fact, only on a rare occasion will VAR models which comprise more than 8 equations be encountered in the literature) and (ii) usually
incorporate arbitrarily chosen approximations of actual economic phenomena. However, as explicitly mentioned in chapter 2 of this study, VAR models are still considered to be a very important tool especially when it comes to investigating the transmission mechanism of the effects of monetary policy on the economy.

One final issue regarding the VAR modelling approach has to do with the estimated coefficients of the variables obtained after the model is ran. According to Sims (1980) it is difficult to interpret VAR coefficient estimates mainly due to their large number. As Kusczczak and Murray (1987) explicate, it is very common for the signs of VAR model coefficients to contradict each other due to the number of lagged terms and the corresponding dimensionality of the problem at hand.

On top of that, although Granger causality tests could facilitate making inferences about the potential direction of causality between the variables of interest, they could not disclose any additional information neither with regard to the sign nor with regard the duration of the effect. Pertaining to this issue authors such as Funke (1990), Lutkepohl and Poskitt (1991), Henriques and Sadorsky (2008), as well as, Jarocinski (2010) among many others turn their focus to the resulting IRFs. According to BoE (2000), after a VAR model is identified, the researcher can then start collecting information for the variables of interest by investigating the IRFs and their corresponding forecast-error variance decompositions (FEVDs). In this regard, we present tables with the results only for the contemporary coefficients of the two VAR models presented in this study and we further refrain from trying to directly interpret the estimated parameters. Instead, we also concentrate on IRFs and FEVDs. After all, as mentioned before, the focal point of VAR models is the relationship between structural / exogenous innovations and reduced form errors and not the relationship between the

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41 To provide an analogy, the SVAR model that we develop in this section approximates gross domestic income by the industrial production index. This is a common approach; however, it stresses the necessity for the parsimonious VAR models to depend on approximations of actual variables.
variables per se.

Turning to our model, we examine the dynamic relationship among monetary policy developments, asset prices and households’ consumption for the UK economy employing a new SVAR framework. In particular, our model incorporates eight macroeconomic and financial variables. As notation is relatively important in this chapter we outline each endogenous variable included in the model along with its proxy-variable and the corresponding notation.

- Domestic income approximated by the industrial production index \((i_p_t)\)
- A monetary policy instrument approximated by the 1-month interbank rate \((r_t)\)
- Demand for money, approximated by the monetary aggregate M2 \((M_t)\)
- The inflation rate approximated by the consumer prices index \((\pi_t)\)
- Crude oil prices approximated by Brent crude oil prices \((oil_t)\)
- Financial prices approximated by the FTSE all-share index \((sp_t)\)
- Housing prices approximated by the Halifax housing index \((hp_t)\)
- Households' consumption approximated by UK consumer confidence index \((hcon_t)\)

The first four variables are typically included in most monetary policy studies (see among others: Kim and Roubini, 2000; Sims and Zha, 2006; Bjornland and Jacobsen, 2010). It is very common in VAR models to incorporate both a monetary aggregate and an interest rate variable in order to capture the dynamics between the demand for money (approximated by the monetary aggregate variable) and monetary policy decision making (approximated by the short-term interest rate). Oil prices serve as an indicator providing useful feedback regarding developments in the level of global prices which inevitably affect domestic monetary policy.

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42 According to Hamilton (1994) these are mere non-linear transformations of the IRFs which show how much of the percentage of the variation in any of the variables of the model can be attributed to the variation in any other variable.
decisions (Kim and Roubini, 2000).

We further include stock market prices and housing market prices - as sufficient approximations of financial and housing wealth respectively – in order to account for monetary policy effects on UK households’ wealth. Finally, households’ consumption is introduced, to consider the effects of all identified shocks on UK consumption. It is worth noting that in our model’s framework we consider both stock and housing prices to the effect that we shed new light on the linkages between monetary policy developments, households’ wealth and consumption. The Akaike information criterion (AIC) has qualified a model of order 2. In this regard, the structural representation of a VAR model of order 2 takes the form:

\[
Gy_t = \beta_0 + \sum_{i=1}^{2} B_i y_{t-i} + e_t .
\] (6.1.24)

Where in our model, \(y_t\) is an 8×1 vector of endogenous variables observed at time \(t\) whose joint behavior constitutes the focal point of our study. The dimensionality of vector \(y_t\) is typically small (comprises only eight macroeconomic variables and in the framework of our model \(y_t\) takes the general form:

\[
y_t = [oil_t, ip_t, \pi_t, M_t, r_t, sp_t, hp_t, hcon_t] .
\] (6.1.25)

In addition, \(G\) represents the 8x8 contemporaneous matrix, \(B_i\) are the 8×8 autoregressive coefficient matrices, and \(e_t\) is an 8×1 vector of structural disturbances, assumed to have zero covariance and be serially uncorrelated (white-noise). In this regard, we consider the covariance matrix of the structural disturbances to be diagonal (orthogonality restriction) and to take the following form:
The variance-covariance matrix is also considered to be normalized. In effect, structural disturbances included in vector \( \mathbf{e}_t \) represent impulses (or) fluctuations, whereas \( \mathbf{B}_i \) matrices capture the dynamic propagation mechanism through which impulses affect the economy (Bernanke, 1986; Blanchard and Watson, 1986). Estimating the dynamic behavior of vector \( \mathbf{y}_t \) can be a cumbersome task because equation 6.1.24 has many unknown parameters. Blanchard and Watson (1986) have shown that a computational simplification in estimating equations such as 6.1.24 can be achieved if no restrictions are imposed on the \( \mathbf{B}_i \) matrices. Instead, restrictions can be imposed on the contemporaneous matrix \( \mathbf{G} \). We can then proceed by producing the reduced form of the model. In order to get the reduced form of our structural model (6.1.24) we multiply both sides by \( \mathbf{G}_0^{-1} \) in order to obtain the following:

\[
\mathbf{y}_t = \mathbf{g}_0 + \sum_{i=1}^{2} \mathbf{G}^*_i \mathbf{y}_{t-i} + \mathbf{u}_t ,
\]  

(6.1.27)

where, \( \mathbf{g}_0 = \mathbf{G}^{-1} \mathbf{b}_0 \), \( \mathbf{G}^*_i = \mathbf{G}^{-1} \mathbf{B}_i \), and \( \mathbf{u}_t = \mathbf{G}^{-1} \mathbf{e}_t \), implying that \( \mathbf{e}_t = \mathbf{G} \mathbf{u}_t \). As already mentioned, the SVAR model concentrates on this particular relationship between the reduced and the structural form errors. In effect, the dynamic relationships among various economic variables in the framework of the SVAR approach are modelled as a relationship between shocks (Gottschalk, 2001). The reduced form errors \( \mathbf{u}_t \) are linear combinations of the structural errors \( \mathbf{e}_t \) and their covariance matrix is given by 6.1.14.

\[
\Sigma_e = \begin{bmatrix}
\sigma_1^2 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \sigma_2^2 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \sigma_3^2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & \sigma_4^2 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \sigma_5^2 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \sigma_6^2 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \sigma_7^2
\end{bmatrix}.
\]  

(6.1.26)
Given that: \( e_t = Gu_t \) the structural disturbances can be derived by imposing suitable restrictions on the contemporaneous matrix \( G \). In particular, we impose the following short-run restrictions\(^{43}\):

\[
\begin{bmatrix}
e_{oil} \\
e_{ip} \\
e_\pi \\
e_{M} \\
e_r \\
e_{sp} \\
e_{h} \\
e_{hcon}
\end{bmatrix}_{1,t} =
\begin{bmatrix}
a_{11} & a_{12} & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{21} & a_{22} & a_{23} & 0 & 0 & 0 & 0 & 0 \\
a_{31} & a_{32} & a_{33} & a_{34} & 0 & 0 & 0 & 0 \\
a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & 0 & 0 & a_{48} \\
a_{51} & 0 & a_{53} & a_{54} & a_{55} & 0 & 0 & 0 \\
0 & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & a_{67} & 0 \\
0 & 0 & a_{73} & a_{74} & 0 & 0 & a_{77} & 0 \\
0 & a_{82} & 0 & 0 & a_{86} & a_{87} & a_{88}
\end{bmatrix}
\begin{bmatrix}
u_{oil} \\
u_{ip} \\
u_\pi \\
u_M \\
u_r \\
u_{sp} \\
u_h \\
u_{hcon}
\end{bmatrix}_{t} ,
\]  

(6.1.28)

where \((\theta_{oil})\) represents an oil price shock, \((\theta_{ip})\) represents a real domestic income shock, \((\theta_\pi)\) an inflationary shock, \((\theta_M)\) a shock in the demand for money, \((\theta_r)\) represents a shock in monetary policy, \((\theta_{sp})\) a financial prices shock, \((\theta_h)\) a housing prices shock and finally \((\theta_{hcon})\) represents a shock in UK households’ consumption. All shocks are considered to be positive shocks (i.e. we assume a positive one-standard deviation shock). On the other hand, unexpected movements of each variable (reduced form errors) with respect to: \(oil_t, ip_t, \pi_t, M_t, r_t, sp_t, h_t, hcon_t\) are given by the \(u_t\) vector.

The focal point of our analysis is the relationship between monetary policy innovations, households’ wealth and consumption for the UK economy. In this respect and despite the fact that our model explicitly identifies more than one shock in the economy, heavy emphasis is put mainly upon the shocks that help with the interpretation of the aforementioned relationship.

Initially, we consider an oil price shock \((\theta_{oil})\). Although this shock triggers a succession of events in our model, we take this to be entirely exogenously determined and thus we do not

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\(^{43}\) To keep things as simple as possible, we have dropped the negative signs from the contemporaneous parameters of interest (in contrast with 6.1.22), we have allowed the parameters of the main diagonal of matrix \(G\) to assume values different than 1 and we have also added the Greek letter theta (\(\theta\)) to denote an exogenous / structural innovation.
anticipate any of the remaining variables included in the model to have any contemporaneous effects on oil prices; implying that, coefficients $a_{12}, a_{13}, a_{14}, a_{15}, a_{16}, a_{17}$ and $a_{18}$ will all be equal to zero. To better illustrate this point, consider the following example: coefficient $a_{42}$, is set to zero simply because we make the statement that we do not allow causality to run contemporaneously from $(u_t^{ip})$ to $(u_t^{oil})$. The reverse, however, is assumed to be true, that is; contemporaneous causality running from $(u_t^{oil})$ to $(u_t^{ip})$ when innovations in the economy are triggered by $(\theta p_t)$, and thus coefficient $a_{21} \neq 0$. Along a similar vein, inflationary shocks $(\theta \pi_t)$ trigger a new succession of events in the economy. In accordance with Kim and Roubini (2000), Elbourne (2008), as well as, Bjorland and Leitemo (2009), we allow for developments in $\pi_t$ to be contemporaneously affected by respective movements in oil$_t$ and $\theta ip_t$. Hence, coefficients $a_{31}, a_{32} \neq 0$.

Monetary policy in the UK in the framework of our model is described by the two equations comprising both the shock in demand for money $(\theta M_t)$ and the shock in the monetary policy rule $(\theta r_t)$. In identifying monetary policy in SVAR models, researchers are usually faced with two puzzling characteristics, namely; the liquidity and the price puzzle. (Sims and Zha, 1999; Leeper and Zha, 2003; Sims and Zha, 2006; Sousa, 2010;). The former, is evident when contractionary policy cannot lead to higher interest rates. The latter, implies that contractionary monetary policy is unable to generate a decline in the price-level. In line with Kim and Roubini (2000), we account for the liquidity puzzle by distinguishing between a money demand shock and a monetary policy shock. Furthermore, by incorporating the world price of oil as what Sims and Zha (1999; 2006) describe as an information variable we further account for the price puzzle. According to Sousa (2010) distinguishing between two components of monetary policy, namely money demand (described by innovations in the monetary aggregate $M_t$) and the monetary policy rule (portrayed by innovations in the short-
term interest rate \((r_t)\) significantly affects our understanding of the monetary policy transmission mechanism. In line with Kim and Roubini (2000) and Elbourne (2008) we allow for innovations in demand for money \((u^M_t)\) to be contemporaneously affected by \((u^p_t)\), \((u^\pi_t)\), \((u^c_t)\), as well as, by households’ consumption \((u^{hcon}_t)\). Therefore, coefficients \(a_{42}, a_{43}, a_{45}\) and \(a_{48}\) are different from zero.

Following the work of Sims (1986), Kim and Roubini (2000), Leeper and Roush (2003), Sims and Zha (2006), as well as, Elbourne (2008) we make the reasonable assumption that monetary policy does not respond contemporaneously to changes in the level of inflation as data is assumed not to be contemporaneously available. This in turn implies, that our model predicates on the assumption that the BOE sets the repo rate based on feedback obtained from developments in the global level of prices \((u^{alt}_t)\) and the current level of demand for money \((u^M_t)\). This assumption, accords with the underlying framework of the empirical work of Kim and Roubini (2000), Sims and Zha (2006), as well as, Sousa (2010). It follows that, coefficients \(a_{51}\) and \(a_{54}\) will be different from zero.

The financial sector on the other hand, reacts contemporaneously to innovations in all other variables of our model. In other words, stock markets are assumed to contain relevant information on agents’ expectations regarding the course of economic activity and inflation (Bjornland and Leitemo, 2009; Sousa 2010). We only assume a lag before innovations in the global level of prices and in consumption propagate the stock market, implying that coefficients \(a_{61}\) and \(a_{68}\) will be equal to zero. Following the work of Elbourne (2008) and Bjornland and Leitemo (2009) we allow for \((u^M_t)\) and \((u^\pi_t)\) to affect housing prices contemporaneously. In this regard, monetary policy decisions affect housing wealth only with a lag, implying that \(a_{75} = 0\). In addition, we assume that there is no contemporaneous feedback between housing prices and financial prices (i.e. \(a_{76} = 0\)). Finally, in setting
restrictions related to households’ consumption we follow Ludvigson, Steindel and Lettau (2002) who strongly suggest that consumption reacts contemporaneously to changes in asset wealth. Our study explicitly distinguishes between financial and housing wealth and in this respect $a_{82}, a_{86}, a_{87} \neq 0$ while $a_{81}, a_{83}, a_{84}, a_{85} = 0$.

In this section, our main contribution is the development of a new structural VAR model that incorporates both financial and housing wealth approximations to investigate monetary policy effects on UK households’ consumption. Contrary to previous studies we restrict housing prices from responding immediately to monetary policy innovations. The structure of our model also suggests that the stock market receives no contemporaneous feedback from rises in the global price of oil. We further allow for contemporaneous effects between the two assets; however, and in contrast with most other studies associated with the consumption-wealth channel of monetary policy, we incorporate both financial and housing prices into the same model and thus we obtain a first approximation regarding their specific relationship.

Furthermore, despite the fact that there is a wealth of literature regarding the relationship among monetary policy innovations, asset wealth and consumption, only few authors clearly distinguish between financial and housing wealth and very few incorporate both types of wealth in one single econometric model and examine their distinct effects under the prism of monetary policy developments. According to Sousa (2010) little attention has been given to the wealth effect that derives from monetary policy decisions on consumption.

6.1.2 Empirical results and discussion

The purpose of this section is to produce the IRFs and the FEVDs of the model presented above in order to investigate how structural innovations in the variables of interest (i.e. the monetary policy instrument, housing and financial prices) affect the endogenous variables of
our system\textsuperscript{44}. Although, within the framework of our model, more shocks can be identified (i.e. an inflation rate shock or a domestic income shock) these remain at large uninterpreted as they do not constitute main priorities of the study.

Table 6.1.1: Contemporaneous coefficients.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Coefficient value</th>
<th>p-value</th>
<th>Coefficient</th>
<th>Coefficient value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_{11}$</td>
<td>0.0766 ***</td>
<td>(0.0000)</td>
<td>$\alpha_{62}$</td>
<td>-0.4561</td>
<td>(0.1904)</td>
</tr>
<tr>
<td>$\alpha_{21}$</td>
<td>-0.0044</td>
<td>(0.5262)</td>
<td>$\alpha_{63}$</td>
<td>-5.5354 ***</td>
<td>(0.0009)</td>
</tr>
<tr>
<td>$\alpha_{22}$</td>
<td>0.0084 ***</td>
<td>(0.0000)</td>
<td>$\alpha_{64}$</td>
<td>0.1573</td>
<td>(0.1273)</td>
</tr>
<tr>
<td>$\alpha_{31}$</td>
<td>-0.0075 ***</td>
<td>(0.0000)</td>
<td>$\alpha_{65}$</td>
<td>0.1290 **</td>
<td>(0.0127)</td>
</tr>
<tr>
<td>$\alpha_{32}$</td>
<td>0.0220 *</td>
<td>(0.0698)</td>
<td>$\alpha_{66}$</td>
<td>0.0447 ***</td>
<td>(0.0000)</td>
</tr>
<tr>
<td>$\alpha_{33}$</td>
<td>0.0016 ***</td>
<td>(0.0000)</td>
<td>$\alpha_{67}$</td>
<td>-0.6669 ***</td>
<td>(0.0089)</td>
</tr>
<tr>
<td>$\alpha_{42}$</td>
<td>-1.9419</td>
<td>(0.1004)</td>
<td>$\alpha_{73}$</td>
<td>0.4143</td>
<td>(0.3169)</td>
</tr>
<tr>
<td>$\alpha_{43}$</td>
<td>1.0745</td>
<td>(0.6903)</td>
<td>$\alpha_{74}$</td>
<td>-0.0198</td>
<td>(0.4295)</td>
</tr>
<tr>
<td>$\alpha_{44}$</td>
<td>0.0723 *</td>
<td>(0.0571)</td>
<td>$\alpha_{77}$</td>
<td>0.0111 ***</td>
<td>(0.0000)</td>
</tr>
<tr>
<td>$\alpha_{45}$</td>
<td>1.1060</td>
<td>(0.1310)</td>
<td>$\alpha_{82}$</td>
<td>18.4930</td>
<td>(0.1226)</td>
</tr>
<tr>
<td>$\alpha_{46}$</td>
<td>-0.0020</td>
<td>(0.5235)</td>
<td>$\alpha_{96}$</td>
<td>-3.6198 *</td>
<td>(0.0993)</td>
</tr>
<tr>
<td>$\alpha_{51}$</td>
<td>-0.2777 **</td>
<td>(0.0223)</td>
<td>$\alpha_{97}$</td>
<td>-5.4454</td>
<td>(0.5490)</td>
</tr>
<tr>
<td>$\alpha_{52}$</td>
<td>-3.4204 **</td>
<td>(0.0139)</td>
<td>$\alpha_{88}$</td>
<td>-1.5824 ***</td>
<td>(0.0000)</td>
</tr>
<tr>
<td>$\alpha_{55}$</td>
<td>0.0999 ***</td>
<td>(0.0021)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: p-values in parentheses, p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

All variables are stationary, seasonally adjusted, constant at 2005 prices and they all have been transmuted into logarithmic differences, while the frequency of the data is monthly and the period of study ranges from January 1992 to December 2012. A more detailed analysis of the datasets employed by this section can be found in chapter 5 of the thesis.

Table 6.1.1 illustrates the contemporaneous coefficients of the model. As mentioned before, it is not really constructive to directly interpret these coefficients and therefore we concentrate on simply pertaining to any statistically significant contemporaneous relationships captured by the model. In this regard, our findings can verify that there is indeed a contemporaneous relationship between the monetary policy instrument and the stock market (as suggested by the value of coefficient $\alpha_{65}$). Furthermore, there is also a contemporaneous relationship

\textsuperscript{44} Estimations of both IRFs and FEVDs were performed in EViews ver. 7.0 econometrics software.
between the housing and the financial market (as suggested by coefficient $a_{67}$). Finally, there appears to be a contemporaneous impact of the stock market on households' consumption (as suggested by coefficient $a_{86}$). However, the main focus of this section is on the IRFs of the model.

Figure 6.1.2 summarizes the estimated response of the domestic variables of interest to contractionary monetary policy (i.e. the response to a positive one-standard-deviation monetary policy shock) as this is realized by an increase in the policy instrument. The dashed lines represent the upper and lower one-standard-error bands. On general principles, we are satisfied with the ability of our model to produce theoretically coherent results.

In particular, according to the definition of contractionary monetary policy, a tighter monetary policy stance is typically associated with an increase in interest rates or a decrease in monetary aggregates. Panel (a) in figure 6.1.2 suggests that monetary contraction indeed increases the opportunity cost of holding money and therefore an increase in the short-term interest rates of the economy is observed. The information illustrated in panel (a) is a good indication that our model is successful in addressing the liquidity puzzle. At the same time contractionary monetary policy exerts negative effects on demand for money - evident in our model through a decline in the monetary aggregate which is illustrated in panel (c).

As far as the effects on inflation are concerned, results could take two alternative explanations. As evident in panel (b) the central estimate implies that inflation is expected to decline in the longer run (i.e. after about 2 months have passed). However, error bounds in panel (b) are not very clear. From a theoretical perspective, there can be an explanation both for the central estimate and for the unclear error bounds. If we focus on the central estimate and assume that this is in fact true, then we could argue that the delay in the response of inflation could be attributed to the price puzzle.
Figure 6.1.2: Estimated accumulated (12-periods ahead) IRFs to a monetary policy shock.

Note: Responses are estimated on the basis of a positive one-standard-deviation shock in the monetary policy instrument. Lines with symbols stand for the upper and lower one standard error bands.

Pertaining to the price puzzle this can be explained by the fact that domestic inflation receives feedback not only from domestic variables but also from exogenous factors (as Sims and Zha, 1999; Kim and Roubini, 2000 and Sims and Zha, 2006 have suggested). Following Kim and Roubini (2000) the price puzzle issue is accommodated in our model with the inclusion of global oil prices. In addition, Bjornland and Jacobsen (2010), Ravenna and Walsh (2006), as
well as, Chowdhury et al. (2006) take the view that the price puzzle can be explained by the fact that a substantial part of the increase in corporate borrowing can be passed on to consumers implying an increase in the overall level of prices. Nonetheless, the view that there is a lagged effect of monetary policy on macroeconomic activity has been suggested by many authors including Mankiw (2001) who particularly maintains that contractionary monetary policy typically leads to a gradual decline in inflation. By all accounts, our model suggests that with a short delay, the level of prices in the economy falls and this decline appears to be persistent over the medium-run.

If on the other hand, we concentrate on the error bounds which practically suggest that there is no response from inflation, then the answer could lay in the monetary policy regime. In particular, Boivin and Giannoni (2006) also using a VAR model for the US economy report quite similar results (both in terms of estimates and error bounds) and put forward the argument that if there is a systematic approach to monetary policy formulation (i.e. frequent reviews and timely responses) which is basically the cornerstone of an inflation targeting regime, then a potential response not only from inflation but also from output to a sudden policy change, could result to negligible responses from both variables. The advantages of a systematic monetary policy have been underscored by authors such as Clarida et al. (2000), Cogley and Sargent (2001, 2005), as well as, Boivin (2005).

Be all this as it may, both explanations imply that UK monetary policy can have the desired impact on inflation levels. It is understandable that further study is required to the effect that the aforementioned relationship is adequately elucidated. This chapter however, provides a considerable amount of evidence suggesting that the inflation targeting monetary policy regime has in fact lent a new perspective to the process of understanding the workings of real economic activity.
In panel (d) of figure 6.1.2, we further observe that unexpected rises in the monetary policy instrument cause a gradual reduction on domestic income (although error bounds are such that prevent us from making a really strong case). The previous analysis regarding the error bounds provided for inflation also applies here.

It is also evident that housing prices fall immediately after the adoption of a tighter monetary policy stance and this decline is persistent throughout the remainder of the projection period. This is presented in panel (f). The stock market on the other hand has a positive - yet almost negligible - response. This could be interpreted on the basis of a successfully implemented inflation targeting monetary policy which renders macroeconomic expectations relatively tranquil, removing any surprise element from affecting stock market developments (see *inter alia* Sims, 2003). Further evidence in favour of this argument is provided in section 6.4 of this chapter. For the time being we maintain that monetary policy developments have a strong and prolonged effect on housing prices thus highlighting the importance of this market in better understanding the monetary policy transmission mechanism. Focusing on the effects on housing prices, our results are consistent with the analysis of both Elbourne (2008) and Bjornland and Jacobsen (2010). Findings regarding the impact of contractionary monetary policy on stock market prices challenge the empirical evidence provided by Bredin *et al.* (2007) who suggest that, at an aggregate level, a change in the monetary policy stance is conducive to a significant negative effect on FTSE returns.

Overall, results indicate that housing prices appear to be more sensitive to monetary policy developments and to respond rather quickly to these developments, implying they could potentially act as transmitters of monetary policy shocks in the economy. This outcome is in line with Iacoviello and Minetti (2008) and Bjornland and Jacobsen (2010), who proponent that housing prices react swiftly to monetary policy developments and appear to be very
sensitive to monetary policy innovations. Finally, the impact of an unexpected monetary policy shock appears to have negligible effects on households' consumption.

Turning to unexpected innovations in the housing market we concentrate on figure 6.1.3. We observe that a housing prices shock is almost immediately followed by an increase in the short-term interest rate of the economy as suggested by panel (a). We quote Elbourne (2008) who voices the opinion that this could be seen as a response in anticipation of higher prices. We also provide evidence of a persistent response from inflation. Our findings are similar to Elbourne (2008); however, they differ from Bjornland and Jacobsen (2010) who in analysing the effects of the housing market in the UK economy suggest only a temporary increase in both interest rates and inflation. With reference to the response of financial prices to developments in the housing market, in panel (e) of figure 6.1.3 we observe that housing market innovations cause a simultaneous positive response to stock market prices which is however immediately followed by a sharp decline. This is an interesting finding as stock markets appear to be able to capture rather swiftly innovations in the housing market.

We further observe that the central estimate of the stock market response to a housing prices shock is positive despite the decline. On top of that, we provide evidence that positive developments in the housing market are followed by a positive response of households’ consumption. However the effect soon becomes negative. Apparently, the error bounds in panel (g) do not really help us make a good case and therefore this effect deserves further study. Recall also, that innovations are orthogonal and in this respect we cannot combine the information provided by the panels; that is, we cannot argue that the impact is the result of a somewhat delayed (i.e. not simultaneous) response of interest rates - as suggested by panel (a) - which allows households to benefit from the increase in housing prices but only until higher interest rates appear in the economy.
In any event and in connection with the relationship between housing wealth and consumption it is worth recalling an excellent point raised by Cambell and Cocco (2007) who argue that although it is tempting to directly associate higher housing prices to increased levels of consumption, sometimes the link is not very clear. In particular, Cambell and Cocco (2007) suggest that if a household is to enjoy higher consumption levels when housing prices increase then it would inevitably have to enjoy less housing services.

Figure 6.1.3: Estimated accumulated (12-periods ahead) IRFs to a housing prices shock.

*Note: Responses are estimated on the basis of a positive one-standard-deviation housing prices shock. Lines with symbols stand for the upper and lower one standard error bands.*
In addition, an increase in housing wealth does not necessarily mean more consumption today as it could potentially lead to a smoother allocation of consumption over the years (see *inter alia* Lustig and van Nieuwerburg 2005).

Finally, we provide evidence of a positive impact of a shock in the housing market on demand for money and domestic income. Findings are presented in panels (c) and (d) of figure 6.1.3 respectively. These results both stand to reason as properties in the light of higher housing prices are worth more implying that their owners can use their properties as a collateral and apply for a loan. In short, both of these findings are in line with the arguments presented in the work of Bjornland and Jacobsen (2008) and Bjornland and Jacobsen (2010) concerning the housing market.

Turning to positive innovations in the financial market, these are immediately followed by an increase in the short-term interest rates of the economy, as this can be seen in panel (a) of figure 6.1.4. Furthermore, according to the information provided by panel (f) we can argue in favour of a positive impact of stock market innovations on the housing market which lasts for at least two months. As evidenced in panel (f) the effect remains positive on average over a period of 12 months; however, after the second month error bounds prevent us from making a really strong case.

On all accounts though, our empirical findings suggest that there is indeed a link between housing and financial prices. This finding, along with the one previously reported regarding the impact of the housing market on stock prices, is in line with Sousa (2010) who in conducting a study on the US and the Euro area monetary policy, housing and financial wealth, puts forward the argument that linkages between the housing and the financial market have substantially increased over the years.
Sousa (2010) further highlights the fact that considering the implications followed by developments in both markets when analyzing the predictability of asset returns is becoming increasingly imperative.

Figure 6.1.4: Estimated accumulated (12-periods ahead) IRFs to a financial prices shock.

Note: Responses are estimated on the basis of a positive one-standard-deviation financial prices shock. Lines with symbols stand for the upper and lower one standard error bands.

In any case, additional research is required in order to better understand the specific relationship between stock market prices and housing prices. Augmenting the current setup /
modelling approach or considering alternative approaches in order to improve our understanding regarding the aforementioned relationship is part of future study.

Evidence relating to a financial prices innovation further suggests that inflation, demand for money, domestic income, as well as, households' consumption all rise following the shock. We consider this evidence to adhere to the theoretical framework of our study which sees financial prices as an important component of wealth with direct implications for households' consumption. Considering both housing and financial shocks, our empirical findings reveal that the link between financial housing shocks and households' consumption is relatively more straightforward.

Thus far we have employed the IRFs in order to assess the responsiveness of the endogenous variables of interest to unexpected exogenous shocks - related to these variables - that hit the system. An additional interesting feature of VAR models is the forecast error variance decomposition functions (FEVDs). These functions decompose the variance of the system over a forecast period (for consistency we choose a forecast period of 12 months) in the sense that they provide the proportion of changes in a particular variable that can be attributed to each of the other variables included in the system. We quote Brooks (2007, p.342) who argues that "Variance decompositions determine how much of the s-step ahead forecast error variance of a given variable is explained by innovations to each explanatory variable for s=1,2,...".

Figure 6.1.5 illustrates the variance decomposition of changes in the monetary policy instrument (i.e. the short-term interest rate) over a forecast period of 12 months. Therefore, by employing the FEVDs we aim to trace the proportion of the variance in the monetary policy instrument that can be attributed to unexpected shocks related to the endogenous variables of the model.
Although in practice it is typical for most of the variation to be attributed to innovations in the variable itself (Brooks, 2007) in figure 6.1.5 we see that most of the variance in the monetary policy instrument comes from unexpected innovations in the demand for money.

![Figure 6.1.5: Estimated (12-periods ahead) FEVDs for the monetary policy instrument.](image)

*Note: The contribution of each factor is given as a percentage (%).*

This could reflect developments regarding the credit conditions in the market or other factors that affect demand for money in general. There is a proportion of variance stemming from housing and financial prices - see panels (e) and (f) respectively, and this fact prompts back the question of whether central banks should target asset markets in order to subdue potential
bubbles. Despite the fact that Cobham (2013) argues that BoE does not target asset markets, our findings however suggest that there is some degree (even small) of involvement of these markets in the setting of monetary policy.

In partial support of our findings, Bjornland and Jacobsen (2010) also argue in favour of a key role that housing prices play in the setting of UK monetary policy. Bjornland and Leitemo (2009), further provide evidence that the stock market is very important as far as the formulation of the US monetary policy concerned. However, the US is not explicitly inflation targeting in its monetary policy. A reconciliation is perhaps provided by Vickers (2000, p.16) who argues that as far as the UK monetary policy is concerned "Asset prices (merely) inform judgments about inflation prospects". Furthermore, Vickers (1998) and Bean (2003b) among many others put forward the argument that the UK monetary policy is not really one-dimensional as income considerations and low output volatility always accompany inflation considerations. The latter argument could explain the evidence illustrated in panel (d).

As far as the contribution of a shock in inflation is concerned, in panel (b) we can see that this is relatively low. The moderate contribution of an unexpected shock in inflation can be explained by the fact that under an inflation targeting monetary policy regime the emphasis is placed in anchoring agents' expectations regarding the long-term prospect of inflation. In fact, authors such as Svensson (1997), Bernanke et al. (1999), Bean (2003b), as well as, Kuttner and Posen (2011) among others have argued in favour of a flexible inflation targeting strategy. In this framework, positive or negative deviations from the target in the short-run are allowed implying that monetary policy can be less aggressive to support - for example - economic growth or recovery at times of recession.

Results regarding the variance decomposition of both asset markets support Brook's (2007) account that the biggest proportion of variation can be attributed to innovations in the
endogenous variable itself.

This is evident in panels (d) and (e) of figures 6.1.6 and 6.1.7 respectively. Note that surprise innovations in the monetary policy instrument have a relatively low contribution compared to other factors such as demand for money or domestic income. This finding - evident in panel (a) of both figures - could also be interpreted on the basis of anchored expectations regarding long-run inflation. Agents are therefore reassured and innovations in both markets are determined mainly by other factors (see *inter alia* Sims, 2003).

**Figure 6.1.6:** Estimated (12-periods ahead) FEVDs for the housing market.

*Note: The contribution of each factor is given as a percentage (%).*
As expected, demand for money and income innovations - presented in panels (c) and (d) respectively in both figures - also play a key role in both markets. Turning to the specific relationship between housing and financial prices we can see - panel (g) of figure 6.1.6 - that innovations in the stock market appear to explain a very low proportion of the variation in the housing market.

Despite the fact that the effect is non-trivial, we cannot really go beyond the mere realisation that there indeed seems to be a link. Perhaps part of future work could investigate the effects...
of specific industrial stock market indices in order to produce better results. Looking at panel (f) of figure 6.1.7 though, we can see that innovations in the housing market can explain a relatively large proportion of the variation in financial prices. Earlier on, while presenting the IRFs of the model, we showed that innovations in the housing market are immediately followed by a positive response from the stock market to (figure 6.1.3). Coupled with the results that we get from the FEVDs we can argue that there is indeed evidence supportive of Sousa (2010) who advocates in favour of the existence of a strong link between the two markets. According to our findings though, the effects exerted from the housing market on the stock market appear to be larger and more clear - than the other way around.

In retrospect, this section introduces a new SVAR model for the UK economy in an effort to trace out linkages between unexpected monetary policy decision making and housing or financial prices. We further make the concession that housing and financial prices are sufficient approximations of housing and financial wealth respectively and this bears certain implications regarding the existence of an *indirect* link between monetary policy decision making and households' consumption. The latter is also included in the model in order to capture the potential *direct* link between itself and unsystematic monetary policy. As a final concern, we collect any information derived by the model regarding the specific link between housing and financial prices, as we maintain that this is an under-researched area which deserves greater attention.

We find that unsystematic monetary policy has a negative impact on housing prices which can be construed as the result of a worsening of credit conditions in the economy. By contrast, we do not find significant evidence that innovations in monetary policy have a profound impact on the stock market. This can also be explained by the fact that within an inflation targeting monetary policy regime the interest is turned from the policy instrument to
the long-term level of inflation. The differences in the two markets can be attributed to the unique characteristics of the housing market in the UK. It is worth noting though, that according to these findings, it is the housing market that could act as a transmitter of monetary policy in the UK economy rather than the stock market. The central direction of the effect of monetary policy innovations on inflation, as this is illustrated in the relevant IRF, implies that inflation will start declining two months after the shock. We provide two alternative explanations for this. First, assuming that the central tendency provided by the IRF is in fact corresponding to reality, then the delay in the response can be attributed to the so called price puzzle. Alternatively, if we emphasize the error bounds, which imply that there is actually no response from inflation, then the answer can be found in the suggestion that a successful inflation targeting monetary policy which considers many potential exogenous disturbances during its formulation (i.e. there is a more systematic / consistent approach towards the development of monetary policy), could potentially lead to negligible responses from both inflation and output in the event of an actual monetary policy shock. The latter argument implies however, that both inflation and output are at satisfying levels right before the monetary shock takes place. Neither interpretation though suggests that UK monetary policy is not successful in controlling the inflation rate.

Other important findings include that a shock in either market has a positive impact on the monetary policy instrument. This is also supported by the relevant FEVDs which illustrate that a considerable proportion of the variance in short-term interest rates can be attributed to innovations in both the housing and the financial market.

As some authors have suggested, although BoE does not directly target asset prices, markets such as the ones included in our study are broadly used to inform the strategy of the policy authority (i.e. systematic approach to monetary policy). Also prominent among our results is the fact that there is an immediate positive (and yet transitory) response from the stock
market to innovations in the housing market. In this regard, financial prices could act as a transmitter / leading indicator of housing prices shocks in the economy. However, the reverse in not clear. FEVDs analysis suggests that innovations in the housing market do in fact explain a larger proportion of stock market variance as opposed to the respective proportion of housing market variance explained by the stock market.

Finally, we provide evidence of a direct positive link between stock market innovations and households' consumption. This evidence comes in testament to the suggestion that there is a link between financial wealth and consumption. Unfortunately results are not terribly clear as far as the effect of housing innovations on households’ consumption. Although the central estimate implies a positive (yet very transitory) response, error bounds suggest that in fact there is no response. The no response scenario could be attributed to specific patterns of consumer behaviour that render the link between the housing market and consumption vague.

Furthermore, a sub-sample analysis considering various different periods in support of the robustness of the results can be found in appendix A. Apparently, the accumulated responses relating to all variables of interest appear to follow a similar trend most of the times, while results are not qualitatively different.

A promising area for future work in this line of research would be to improve the identification scheme of the model in order to describe more efficiently the complex relationship between the housing and the financial market. This could be achieved by testing various definitions with respect to housing and financial wealth (implying the inclusion of alternative variables) and perhaps consider different modelling approaches in tandem with a VAR model.
6.2 The response of asset prices to monetary & fiscal policy shocks

In this section we develop a new SVAR model of the UK economy in order to further elucidate the relationship between monetary policy and asset prices in the presence of fiscal policy. The motivation underpinning this particular line of research lies on the fact that the contribution of fiscal policy to developments in asset markets has been rather neglected by researchers. Moreover, current literature has also overlooked the interaction of monetary and fiscal policies and their respective combined impact on asset prices. Employing an SVAR framework, we are able to investigate this relation thereby shedding some additional light on the thread that ties together these two policies. We provide evidence that when fiscal policy is present the effects on both the stock and the housing market are different from the individual effects of each policy. Results for the stock market imply an indirect link between fiscal policy and the stock market through monetary policy. On top of that, we show that both demand-side policies are used in a countercyclical manner. Empirical findings also imply a crowding out effect. On the whole, this section stresses the necessity to consider both policies in tandem rather than in isolation.

6.2.1 Econometric method and modelling

Having established most of the key considerations - revolving around VAR modelling - in the previous section, we immediately turn our attention to the model employed in this case. To begin with, our model incorporates the following eight macroeconomic and financial variables. As notation is again relatively important in this chapter, we outline each endogenous variable included in the model along with its proxy-variable and the corresponding notation.

- Domestic income approximated by the Gross Domestic Product ($gdp_t$)
- A monetary policy instrument approximated by the 1-month interbank rate ($r_t$)
• Fiscal policy, approximated by Government spending \( (G_t) \)
• Demand for money, approximated by the monetary aggregate M2 \( (M_t) \)
• The inflation rate approximated by the consumer prices index \( (\pi_t) \)
• Global demand approximated by Kilian's (2009) economic activity index \( (gea_t) \)
• Financial prices approximated by the FTSE all-share index \( (sp_t) \)
• Housing prices approximated by the Halifax housing index \( (hp_t) \)

It is important to note that the data have been collected on a quarterly basis, mainly due to the fact that it is not easy to use a monthly approximation for the fiscal policy variable. That aside, all variables are stationary, seasonally adjusted, constant at 2005 prices and they all have been transmuted into logarithmic differences, while the period of study ranges from January 1992 to December 2012. A more detailed analysis of the datasets employed by this section can be found in chapter 5 of the thesis.

The SVAR model can be adequately described by equations 6.1.24, 6.1.26 and 6.1.27 of the previous section. In addition, both the normality and orthogonality restrictions on the variance-covariance matrix \( \Sigma_e \) apply respectively.

The Akaike information criterion (AIC) has qualified a model of order 2. The vector of endogenous variables takes the form:

\[
y_t = [gea_t, gdp_t, \pi_t, G_t, M_t, r_t, sp_t, hp_t] \ .
\] (6.2.1)

As before, given that: \( e_t = Gu_t \) the structural disturbances can be derived by imposing suitable restrictions on the contemporaneous matrix \( G \). In particular, we impose the short-run restrictions given by 2.2.2. Note that \( (\theta gea_t) \) represents a shock in global economic activity.

Following Hamilton (2009a,b) and Kilian (2009) who explicate that the effect of an oil price shock in the economy greatly depends on the origin of the shock (i.e. it depends on whether
we are dealing with a supply-side, a demand-side or a precautionary shock) we put forward the argument that alternative variables to approximate global demand (which is typically included in VAR models) must be put to the test.

\[
\begin{bmatrix}
    e_{1,t} \\
    e_{2,t} \\
    e_{3,t} \\
    e_{4,t} \\
    e_{5,t} \\
    e_{6,t} \\
    e_{7,t} \\
    e_{8,t}
\end{bmatrix}
\begin{bmatrix}
    \theta_{gea} \\
    \theta_{gdp} \\
    \theta_{\pi} \\
    \theta_{M} \\
    \theta_{r} \\
    \theta_{sp} \\
    \theta_{hp}
\end{bmatrix}
\begin{bmatrix}
    a_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
    a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\
    a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 & 0 \\
    0 & a_{42} & a_{43} & a_{44} & 0 & 0 & 0 & 0 \\
    0 & a_{52} & a_{53} & a_{54} & a_{55} & 0 & 0 & 0 \\
    a_{61} & 0 & 0 & a_{64} & a_{65} & a_{66} & a_{67} & 0 \\
    a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} & a_{78} \\
    0 & 0 & a_{83} & 0 & a_{85} & 0 & 0 & a_{88}
\end{bmatrix}
\begin{bmatrix}
    \theta_{gea} \\
    \theta_{gdp} \\
    \theta_{\pi} \\
    \theta_{M} \\
    \theta_{r} \\
    \theta_{sp} \\
    \theta_{hp} \\
\end{bmatrix}
\end{bmatrix}
\begin{bmatrix}
    \nu_{1,t} \\
    \nu_{2,t} \\
    \nu_{3,t} \\
    \nu_{4,t} \\
    \nu_{5,t} \\
    \nu_{6,t} \\
    \nu_{7,t} \\
    \nu_{8,t}
\end{bmatrix}, \quad (6.2.2)
\]

In this regard, we employ the global economic activity (GEA) index\(^ {45}\) which has a rather more straightforward effect. In turn, (\(\theta gdp_t\)) represents a real domestic income shock, (\(\theta \pi_t\)) an inflationary shock, (\(\theta M_t\)) a shock in the demand for money, (\(\theta r_t\)) represents a shock in monetary policy, (\(\theta sp_t\)) a financial prices shock and (\(\theta hp_t\)) a housing prices shock. Finally, (\(\theta G_t\)) represents a fiscal policy shock. Following Fatas and Mihov (2001), Ardagna (2009), as well as, Afonso and Sousa (2011) we employ Government spending as an appropriate approximation of fiscal policy. Other potential proxies, such as tax revenue or fiscal deficit, have been considered in the past by authors working in this area and in fact, studies such as the one by Afonso and Sousa (2012) use most of these alternatives in different models. Within the framework of our model though, employing tax revenue as a proxy for fiscal policy would add complexity as we would also have to capture the contemporaneous relationship between taxation and economic activity. In line with the innovations’ process of the previous section, we consider all shocks to be positive (i.e. we assume a positive one-standard deviation shock). Furthermore, unexpected movements of each variable (reduced form errors) with respect to: \(gea_t, gdp_t, \pi_t, G_t, M_t, r_t, sp_t, hp_t\) are given by the \(\nu_t\) vector.

\(^{45}\) Developed by Lutz Kilian (2009), the GEA index is based on the dry cargo freight rates and is constructed to capture economic fluctuations in global demand.
Initially, we consider a shock in global economic activity ($\theta g e a_t$). Similarly to an oil price shock, we take this to shock be entirely exogenously determined and thus we do not anticipate any of the remaining variables included in the model to have any contemporaneous effects on oil prices; implying that, coefficients $a_{12}, a_{13}, a_{14}, a_{15}, a_{16}, a_{17}$ and $a_{18}$ will all be equal to zero. We anticipate this global economic activity innovation to infiltrate the economy via triggering a shock in domestic activity (implying that coefficients $a_{21}$ will be different from zero). On the other hand, an inflationary shock ($\theta \pi_t$) is expected to trigger a new succession of events in the economy. In accordance with Kim and Roubini (2000), Elbourne (2008), Bjornland (2008), as well as, Bjorland and Leitemo (2009), we allow for developments in $\pi_t$ to be contemporaneously affected by respective movements in global-demand effects ($\theta g e a_t$ and $\theta g d p_t$). Hence, coefficients $a_{31}, a_{32} \neq 0$.

Fiscal policy is also concerned with inflation and output and therefore we make the assumption that it receives contemporaneous feedback from both relevant variables (implying that coefficients $a_{42}$ and $a_{43}$ will be different from zero). This is in line with Afonso and Sousa (2011). We make the further assumption that a shock in the fiscal policy variable ($\theta G_t$) contemporaneously affects both the short-term interest rate of the economy and demand for money (see inter alia Wyplosz, 1999; Melitz, 2000). It follows that, coefficient $a_{64}$ will be different from zero. By defining that short-term interest rates receive contemporaneous feedback from Government spending implies that we allow for contemporaneous crowding out effects. However, in line with Afonso and Sousa (2011) we also trace lagged crowding out effects by investigating the effects on economic activity (i.e. the response from GDP). Finally, following Bjornland and Leitemo (2009) we allow for a non-permanent effect from the stock market on interest rates (i.e. coefficient $a_{67} \neq 0$).

Monetary policy in the UK in the framework of our model is again described by two
equations which include both the shock in demand for money ($\theta M_t$) and the shock in the monetary policy rule ($\theta r_t$). In line with Kim and Roubini (2000) and Elbourne (2008) we allow for innovations in demand for money ($u_t^M$) to be contemporaneously affected by ($u_t^{gdp}$), ($u_t^P$), as well as, by ($u_t^c$). Therefore, coefficients $a_{52}$, $a_{53}$ and $a_{54}$ are different from zero.

Following the work of Sims (1986), Kim and Roubini (2000), Leeper and Roush (2003), Sims and Zha (2006), as well as, Elbourne (2008) we make the reasonable assumption that monetary policy does not respond contemporaneously to changes in the level of inflation as data is assumed not to be contemporaneously available. This in turn implies, that our model predicates on the assumption that the BOE sets the repo rate based on feedback obtained from developments in the global level of prices ($u_t^{gea}$) and the current level of demand for money ($u_t^M$). This assumption, accords with the underlying framework of the empirical work of Kim and Roubini (2000), Sims and Zha (2006), as well as, Sousa (2010). It follows that, coefficients $a_{61}$ and $a_{65}$ will be different from zero.

The financial sector on the other hand, reacts contemporaneously to innovations in all other variables of our model. In other words, stock markets are assumed to contain relevant information on agents’ expectations regarding the course of economic activity and inflation (Bjornland and Leitemo, 2009; Sousa 2010). It follows that coefficients $a_{71}$, $a_{72}$, $a_{73}$, $a_{74}$, $a_{75}$, $a_{76}$, $a_{77}$ and $a_{78}$ will all be different from zero.

Following the work of Elbourne (2008) and Bjornland and Leitemo (2009) we allow for ($u_t^M$) and ($u_t^P$) to affect housing prices contemporaneously. For consistency, we maintain that both demand-side policies affect housing wealth only with a lag, implying that $a_{94} = 0$ and $a_{86} = 0$. In addition, although we allow for the stock market to be contemporaneously affected by the housing market, we assume that there is no contemporaneous feedback going
the other way around (i.e. $a_{87} = 0$).

According to authors such as Darrat (1988), Afonso and Sousa (2012), as well as, Agnello and Sousa (2013), literature has rather neglected the interaction between the two polices. In this regard and in order to improve our understanding with respect to the relationship between monetary policy and housing or financial assets, we develop a new SVAR model that considers the potentially diverging effects that stem from the inclusion of a fiscal policy variable.

### 6.2.2 Empirical results and discussion

The purpose of this section is to produce the IRFs and the FEVDs of the model presented above in order to investigate how structural innovations in the variables of interest affect the endogenous variables of our system\(^{46}\). Our main concern is to record the effects of both demand-side policies on housing and financial prices. We would also be very interested to see how both policies react to an inflationary shock in order to deduce whether both fiscal and monetary policies are used in a countercyclical manner or not. To re-iterate a point made in the previous section, although, within the framework of our model, more shocks can be identified (i.e. a domestic income shock or a shock in demand for money) these remain at large uninterpreted as they do not constitute main priorities of this section.

Table 6.2.1 illustrates the contemporaneous coefficients of the model. As mentioned before, it is not really constructive to directly interpret these coefficients and therefore we concentrate on simply pertaining to any statistically significant contemporaneous relationships captured by the model. In this regard, our findings can verify that there is indeed a contemporaneous relationship between domestic income and inflation (as suggested by the value of coefficient $a_{32}$). Furthermore, there is also a contemporaneous relationship between domestic income

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\(^{46}\) Estimations of both IRFs and FEVDs were performed in EViews ver. 7.0 econometrics software.
and Government spending (as suggested by coefficient $a_{42}$), as well as, a contemporaneous impact between inflation and Government spending (as suggested by coefficient $a_{43}$). Finally, there appears to be a contemporaneous impact of inflation on the housing market (as suggested by the value of coefficient $a_{83}$). However, the main focus of this section is on the IRFs of the model.

**Table 6.2.1:** Contemporaneous coefficients.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Coefficient value</th>
<th>p-value</th>
<th>Coefficient</th>
<th>Coefficient value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_{11}$</td>
<td>1.9603</td>
<td>***</td>
<td>$a_{45}$</td>
<td>2.5177</td>
<td>(0.4442)</td>
</tr>
<tr>
<td>$a_{21}$</td>
<td>0.0006</td>
<td>(0.2452)</td>
<td>$a_{46}$</td>
<td>0.4734</td>
<td>(0.2755)</td>
</tr>
<tr>
<td>$a_{22}$</td>
<td>0.0096</td>
<td>***</td>
<td>$a_{47}$</td>
<td>-5.2769</td>
<td>(0.2964)</td>
</tr>
<tr>
<td>$a_{31}$</td>
<td>-0.0002</td>
<td>(0.3328)</td>
<td>$a_{71}$</td>
<td>0.0267</td>
<td>(0.4804)</td>
</tr>
<tr>
<td>$a_{32}$</td>
<td>0.3633</td>
<td>***</td>
<td>$a_{72}$</td>
<td>-25.2402</td>
<td>(0.4876)</td>
</tr>
<tr>
<td>$a_{33}$</td>
<td>0.0034</td>
<td>***</td>
<td>$a_{73}$</td>
<td>-40.8979</td>
<td>(0.4972)</td>
</tr>
<tr>
<td>$a_{42}$</td>
<td>0.5312</td>
<td>*</td>
<td>$a_{74}$</td>
<td>0.5396</td>
<td>(0.8510)</td>
</tr>
<tr>
<td>$a_{43}$</td>
<td>3.1936</td>
<td>***</td>
<td>$a_{75}$</td>
<td>0.0832</td>
<td>(0.9743)</td>
</tr>
<tr>
<td>$a_{44}$</td>
<td>0.0194</td>
<td>***</td>
<td>$a_{76}$</td>
<td>3.9236</td>
<td>(0.4968)</td>
</tr>
<tr>
<td>$a_{52}$</td>
<td>-0.4645</td>
<td>(0.2031)</td>
<td>$a_{77}$</td>
<td>0.4814</td>
<td>(0.4769)</td>
</tr>
<tr>
<td>$a_{53}$</td>
<td>1.1365</td>
<td>(0.1577)</td>
<td>$a_{78}$</td>
<td>10.2936</td>
<td>(0.4902)</td>
</tr>
<tr>
<td>$a_{54}$</td>
<td>-0.1105</td>
<td>(0.3753)</td>
<td>$a_{83}$</td>
<td>0.6163</td>
<td>* (0.0834)</td>
</tr>
<tr>
<td>$a_{63}$</td>
<td>0.0217</td>
<td>***</td>
<td>$a_{93}$</td>
<td>0.0026</td>
<td>(0.9713)</td>
</tr>
<tr>
<td>$a_{64}$</td>
<td>-0.0439</td>
<td>(0.4099)</td>
<td>$a_{98}$</td>
<td>0.0144</td>
<td>*** (0.0000)</td>
</tr>
<tr>
<td>$a_{64}$</td>
<td>-5.6885</td>
<td>(0.3729)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: p-values in parentheses. p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

Figure 6.2.1 summarizes the estimated response of the domestic variables of interest to a Fiscal policy shock (i.e. the response to a positive one-standard-deviation fiscal policy shock) as this is realized by an increase in Government spending. The dashed lines represent the upper and lower one-standard-error bands. On general principles, we are satisfied with the ability of our model to produce theoretically coherent results.

Prominent among our results is the negative impact that Government spending innovations exert on the stock market, which is evident in panel (e). This result is in line with authors
such as Akitoby and Stratmann (2008), Ardagna (2009), Agnello and Sousa (2010), Afonso and Sousa (2011, 2012), as well as, Chatziantoniou et al. (2013). Considering the results presented in the previous section, regarding the effect of monetary policy innovations on the stock market (which is largely negligible), it is indeed very interesting that the stock market reacts to fiscal policy news. This outcome is in accordance with the view presented in Afonso and Sousa (2012) that the effects of monetary policy on the UK stock market do not seem to be significant, while innovations in Government spending appear to cause an immediate negative response from the stock market. Therefore, on general principles evidence suggests that stock markets do not favour fiscal expansion (especially if this is the product of additional Government borrowing).

On the other hand, this could be a sign that stock markets do not feel as confident with fiscal policy as they do with monetary policy. According to Pastor and Veronesi’s (2012) review regarding the effects of fiscal policy on the economy of the US, changes in Government policy may actually involve fundamental changes in the economic environment within a country and could result in stock markets being extremely alert when it comes to fiscal policy innovations. Pastor and Veronesi (2012) attribute these concerns to the uncertainty about Government policy which unequivocally accompanies the process of policy making.

On top of that, in panel (b) we see a negative response from the domestic income variable. Following Afonso and Sousa (2011) who report a similar finding for the respective shock, we can interpret this outcome as the sign of a crowding out effect. If this is true then our findings are rather supportive of a Neoclassical approach of crowding out effects rather than a Keynesian approach of aggregate demand stimulus (see inter alia Bernheim, 1989).

Unfortunately, our results regarding the effects of Government spending innovations on the interest rate of the economy are not very clear, as evident in panel (d), and therefore we cannot deduce whether this crowding out effect could have a more permanent nature. To this
end, in making future endeavours related to this section we should also consider employing a longer-term interest rate in our analysis by developing the appropriate model.

Finally, as illustrated in panel (f), there is no significant impact of Government spending innovations on the housing market.

\[\text{Figure 6.2.1: Estimated accumulated (8-periods ahead) IRFs to a fiscal policy shock.}\]

Note: Responses are estimated on the basis of a positive one-standard-deviation shock in the fiscal policy variable. Lines with symbols stand for the upper and lower one standard error bands.

Not much research has been done on this relationship; however, Afonso and Sousa (2011) report that housing prices respond positively to a Government spending shock but only after 4 quarters have passed during which they decline. This is not captured by our model, in our opinion though, this relationship deserves further study by considering perhaps alternative approximations for the fiscal policy variable.
Most of the effects of monetary policy on the variables of interest have been analysed in the previous section, implying that in this section we will concentrate on potential differences between the relevant outcomes.

Before we proceed with our analysis, it would be instructive to recall that the evidence presented by table 6.1.2 suggested a negative response from housing prices and a rather negligible response from the stock market to a monetary policy shock. Undoubtedly, the VAR model of the previous section had a different identification scheme and employed slightly different variables; however, we would like to see what would the result be in the case that we employed the quarterly variables in a model without fiscal policy.

To this end, we develop a second (in this section) SVAR model - which excludes the fiscal policy variable - and impose the restrictions presented in equation 6.2.3.

\[
\begin{bmatrix}
\varepsilon_{t,1} \\
\varepsilon_{t,2} \\
\varepsilon_{t,3} \\
\varepsilon_{t,4} \\
\varepsilon_{t,5} \\
\varepsilon_{t,6} \\
\varepsilon_{t,7}
\end{bmatrix}
= \begin{bmatrix}
a_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 \\
a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 \\
a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 & 0 \\
a_{51} & 0 & 0 & a_{54} & a_{55} & a_{56} & 0 \\
a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & a_{67} \\
0 & 0 & a_{73} & a_{74} & 0 & 0 & a_{77}
\end{bmatrix}
\begin{bmatrix}
u_{t,1} \\
u_{t,2} \\
u_{t,3} \\
u_{t,4} \\
u_{t,5} \\
u_{t,6} \\
u_{t,7}
\end{bmatrix}.
\]  

(6.2.3)

It is not in the interests of this section to analyse the entire model; however concentrating on the effects of monetary policy innovations on housing and financial prices entails a twofold benefit. First, we provide additional evidence that the estimations presented in the first section of this chapter are robust. Second, it facilitates our investigation regarding potential differing results obtained in the presence of the fiscal variable.

The results from the alternative (i.e. the fiscal exclusive) model with respect to the effect of a shock in the monetary policy variable on both housing and financial market is illustrated in
figure 6.2.2. Results appear to be similar to those of section 6.1, implying that even under the new SVAR structure which employs quarterly frequencies and slightly different variables and identification scheme, a monetary policy shock has a negative impact on the housing market and no impact on the stock market. With reference to these innovations, the same analysis applies in this section as well. Results are shown in figure 6.2.3.

Interestingly enough though, if we turn our attention back to the fiscal inclusive model (i.e. the model given by equation 6.2.2) we notice two important differences. First, in the presence of fiscal policy, we find that there is a negative effect of monetary policy innovations on the stock market. Second the effect of the monetary policy shock on the housing market becomes negligible.

![Figure 6.2.2: Fiscal-exclusive model. Estimated accumulated (8-periods ahead) IRFs to a monetary policy shock when fiscal policy is not included in the model.](image)

Note: Responses are estimated on the basis of a positive one-standard-deviation shock in the monetary policy instrument. Lines with symbols stand for the upper and lower one standard error bands.

A negative response from the stock market to an innovation in the monetary policy variable in the presence of fiscal policy has also been reported by Chatziantoniou et al. (2013). We consider this to be a great contribution towards further elucidating the interaction between these two policies. This finding suggests that Government spending may affect the UK stock
market both directly and indirectly through monetary policy. In addition, authors such as Jansen et al. (2008) maintain that the effects of monetary policy innovations on the stock market varies with the underlying fiscal policy stance.

Evidence regarding the response from the housing market suggests that monetary policy innovations have no effect on housing prices in the presence of fiscal policy.

Figure 6.2.3: Fiscal-inclusive model. Estimated accumulated (8-periods ahead) IRFs to a monetary policy shock.

Note: Responses are estimated on the basis of a positive one-standard-deviation shock in the monetary policy instrument. Lines with symbols stand for the upper and lower one standard error bands.

According to Afonso and Sousa (2012) empirical research regarding the effects of fiscal policy on the housing market is still at an infantile level and so is empirical research that considers the interaction between monetary and fiscal policy.

It is therefore understood that further research is required which should consider the
formulation of alternative models and identification schemes, testing as many variables as possible.

Another very interesting finding is related to the response from both policies in the event of a shock in inflation. In particular, focusing on figure 6.2.4 we see that assuming a positive one-standard-deviation shock in inflation, both policies react counter cyclically.

To be more explicit, in panel (a) of figure 6.2.4 we can see that when inflation goes up then the response on behalf of the fiscal policy is fiscal consolidation. This is reflected in the reduction of Government spending.

**Figure 6.2.4:** Fiscal-inclusive model. Countercyclical policies. Estimated accumulated (8-periods ahead) IRFs to a shock in inflation.

*Note:* Responses are estimated on the basis of a positive one-standard-deviation shock in the monetary policy instrument. Lines with symbols stand for the upper and lower one standard error bands.
On the other hand, in panel (b) of figure 6.2.4 we see that the response from monetary policy to a respective shock is an increase in the monetary policy instrument.

**Figure 6.2.5**: Fiscal-inclusive model. Estimated (8-periods ahead) FEVDs for monetary policy.
*Note: The contribution of each factor is given as a percentage (%).*

Demand for money, illustrated in panel (c) will also decline, largely reflecting the increased opportunity cost of holding money. Empirical evidence regarding the countercyclical manner in which UK monetary and fiscal policies are employed with respect to an inflationary shock is also provided in Chatziantoniou et al. (2013).
Turning to the FEVDs of the fiscal policy inclusive model, we concentrate on the decomposition of the same endogenous variables as in the previous section. Interestingly enough, by looking at figure 6.2.5 we see that variations in the monetary policy variable are mainly driven by the main priorities of the monetary policy authority; namely, inflation and output (Bean, 2003b).

![Figure 6.2.6: Fiscal-inclusive model. Estimated (8-periods ahead) FEVDs for the housing market.](image)

*Note: The contribution of each factor is given as a percentage (%).*

This could be attributed to the fact that including the fiscal policy variable allows us to see a
more realistic reflection of BoE’s monetary policy. On top of that, monetary policy also receives non-trivial feedback from both asset markets, demand for money and the fiscal policy variable itself.

### Figure 6.2.7: Fiscal-inclusive model. Estimated (8-periods ahead) FEVDs for the stock market.

*Note: The contribution of each factor is given as a percentage (%).*

Turning to variations in the housing market, these receive most of their feedback from innovations in the housing variable itself. This is evident in panel (g) of figure 6.2.6. As far as the relationship between housing and financial prices is concerned we see that with some lag
variations in housing prices are affected by innovations in the stock market. Unfortunately this model does not provide any additional useful information regarding the specific relationship between the two asset markets.

Finally, in figure 6.2.7 we observe that variation in the stock market (i.e. in the presence of fiscal policy) mainly receives feedback from monetary policy. This is illustrated in panel (e) of figure 6.2.7. This result simply verifies what was previously reported; that in the presence of fiscal policy the effect of monetary policy on the stock market becomes significant. In particular, IRFs of this section show that the effect is indeed negative.

In retrospect, this section develops a new SVAR model of the UK economy aiming to put together monetary and fiscal policy, as well as, housing and financial prices. To some extent empirical results are enlightening and improve our understanding regarding the under-researched relationship between monetary and fiscal policy.

In particular, there are four main points rising from the analysis. First, in contrast with innovations in the monetary policy instrument, innovations in Government spending appear to exert a direct negative effect on the UK stock market. This result stresses not only the importance of Government policy but also agents' uncertainty regarding Government policy. Second, by concentrating on the effects of a fiscal policy shock on domestic income we provide evidence in support of the Neoclassical theory of crowding out effects. Results stand to reason especially when Government spending is financed by additional debt. Third, with the aid of an auxiliary SVAR model we show that the effects of monetary policy on the stock market in the presence of fiscal policy become significantly negative. This could also be interpreted as an indirect channel between fiscal policy and the stock market. Fourth, both policies seem to be acting counter cyclically in the event of an inflationary shock. In order to fully comprehend the countercyclical nature of the interaction between these policies, more
variables, as well as, different sources of shocks must be considered.

On the gloomy side, although we do find that in the presence of a fiscal policy variable the effects of both monetary and fiscal policies on the housing market become negligible, we cannot really provide any useful or additional information regarding either the housing market alone or the complex interaction between the housing and the stock market.

Furthermore, a sub-sample analysis considering various different periods in support of the robustness of the results can be found in appendix B. Apparently, the accumulated responses relating to all variables of interest appear to follow a similar trend most of the times, while results are not qualitatively different.

Future study in this area of research should include the development of models that consider more than just one approximation of fiscal policy, long term interest rates that could potentially capture the longer-term or the transitory nature of the crowding out effects, as well as, the investigation of alternative identification schemes that could potentially provide more enlightening results.
6.3 Asset prices & regime-switching: The role of monetary policy

This section is centred around regime-switching modelling which has become a rather popular approach in terms of identifying structural breaks in time series. In this regard, analysis is primarily focused on both detecting potential regimes for housing and financial prices and calculating the probabilities of transition between one regime and another for both assets. In turn, using standard probit regression techniques we investigate the potential impact of the monetary policy instrument on the tendency (probability) of asset prices to move towards one state / regime or another. To the effect that we are able to extract the effect of the short-term interest rate on the said probability in an applicable manner, we also include a set of control variables such as the price of crude oil. In so doing, we contribute towards the development of time series macroeconometric models that endeavour to provide predictive information associated with the regime-switching of asset prices. Results indicate that the current monetary policy stance provides valuable information relating to the transition of asset prices between a low and a high regime; indicating that our model has some degree of forecasting power and could be employed in policy analysis.

6.3.1 Econometric method and modelling

It has been argued by many authors (see inter alia Cerra, 2005; Hamilton, 2005; Sims and Zha, 2006) that many economic and financial time series do not move smoothly over time but rather exhibit sudden changes in their behaviour, especially at times of abrupt policy changes or at times of recession. Past research has specifically investigated the performance of financial data in the light of abrupt fundamental changes, in order to highlight how these changes are in turn reflected on asset prices (Ang and Bekaert, 2002; Ang and Timmermann, 2011; Guidolin and Hyde, 2012).

According to Piger (2009) an appropriate way of modelling this behaviour is by non-linear
time series regime-switching models. Piger (2009) argues that these models are developed on the basis that some stochastic process generates the need for a shift of regime and that the inclusion of this randomness allows for model-based forecasts with regard to future regimes. According to Hamilton (2008), Markov regime-switching econometric models have recently been very popular while their introduction goes as far back as the empirical work of Goldfeld and Quandt (1973), Cosslett and Lee (1985), as well as, Hamilton (1989). Piger (2009) in a detailed investigation of the role of regime-switching models, further provides a thorough list of contributors. Indicatively we quote Beaudry and Koop (1993), Pesaran and Potter (1997), Kim et al. (2003), as well as, Sims and Zha (2006). Examples of applications of these models include modelling and identifying the various stages of business cycles, identifying regime shifts of inflation and interest rates, as well as, identifying lags in the response of growth to monetary policy decision making (Piger, 2009).

In a detailed analysis of Markov chain processes Bertsekas and Tsitsiklis (2008) describe a Markov chain as the transition of a system from one state to another on the basis that the new state is not just a simple function of the old state, but rather, a function of the old state along with some stochastic element which reflects the randomness (sudden character) of the process. At this point, and for the interests of simplicity and brevity, it would be instructive to make the following assumptions: First, that there is a finite number of potential new regimes (i.e. we assume a discrete state space); and second, that time is also discrete. In this way, Bertsekas and Tsitsiklis (2008) explain that transitions of the system from one regime to another are constrained to occur only at discrete points in time. It is also important to note that remaining at the same regime is also considered to be a transition option (Bertsekas and Tsitsiklis, 2008). In order to measure the likelihood of moving from one state to another, or to simply remain at the current state, we need to assign transition probabilities. It stands to reason that transition probabilities are conditional probabilities on the basis that we are
looking for the probability that the system will migrate to state (j) given that it currently is at state (i). Formally this is given by equation 6.3.1.

\[ p_{ij} = P(s_t = j | s_{t-1} = i) , \tag{6.3.1} \]

where \((s_t)\) represents the state \((i, j)\) of the system at time \((t)\) and so on.

Therefore it is obvious that the evolution of the system can be abundantly portrayed by the system's own transition probabilities (Piger, 2009). Piger (2009) further explains that according to what has been known as the Markov property we can ignore the path that our system followed before it reached state \((i)\). What happened in the past of the process; that is, what happened before the system arrived at state \((i)\) has absolutely no bearing on the calculation of the transition probability \(p_{ij}\). This is formally described by equation 6.3.2.

\[ p_{ij} = P(s_t = j | s_{t-1} = i) = P(s_t = j, s_{t-2} = q, ...) . \tag{6.3.2} \]

In effect, given that a Markov chain is a random process, we can only employ a Markov regime-switching model in order to make probabilistic predictions regarding the future state of the system.

Furthermore, Piger (2009) underscores a strong assumption made by the Markov chain approach; that is, that the process in equation 6.3.2 indicates a total probability. This stands to reasons of course given that each time the system can only be in one of the available alternative states. For an N-State Markov chain this implies:

\[ \sum_{i=1}^{N} p_{ij} = 1 . \tag{6.3.3} \]

This can be shown schematically in figure 6.3.1. In particular, assuming a 2-State Markov process (e.g. with 2 states; namely, 0 and 1) where:

- \(p_{00}\) is the transition probability that the system will remain at state 0
• $1 - p_{00}$ is the transition probability that the system will move from state 0 to state 1
• $p_{11}$ is the transition probability that the system will remain at state 1
• $1 - p_{11}$ is the transition probability that the system will move from state 1 to state 0
• and 0' and 1' represent the potential future regimes

then when the system is at state (0), the probability that it will remain at state (0); that is, $p_{00}$, and the probability that it will move to state (1); that is, $1 - p_{00}$ should be equal to 1.

**Figure 6.3.1:** A basic 2-State Markov regime-switching process and the corresponding probability transition matrix.

Similarly, when the system is at state (1) the probability that it will remain at state (1); that is, $p_{11}$ and the probability that it will move to state (0); that is, $1 - p_{11}$ should also be equal to 1.

In other words, the transition probability assumes values within the interval $0 \leq p_{ij} \leq 1$ and the sum of all the transition probabilities for each $p_{ij}$ should equal 1.

Furthermore, the various transition probabilities can be conveniently summarised in the 2x2 *transition probability matrix* which is also presented in figure 6.3.1. A more formal way to present the transition probabilities matrix for an N-State Markov chain would be the following (Brooks, 2007; Perlin, 2012):
where for example $P_{00}$ is the probability to remain at state (0), whereas $P_{0N}$ is the probability to move from state (0) to state (N). Perlin (2012) further posits that these transition probabilities are usually assumed to be constant overtime.

Turning to the question of how the system moves from one state to another, in Brooks (2007) we find that first we have to define a row vector of current state probabilities:

$$
\pi_t = (\pi_1 \quad \pi_2 \quad \ldots \quad \pi_N) .
$$

(6.3.5)

It can be shown (Hamilton, 1989) that given $\pi_t$ (where $\pi_t$ is the probability that the time series of study $y_t$ currently is at a certain state) and $P$, the probability that $y_t$ will be at a certain state in the next period is given by:

$$
\pi_t = \pi_{t-1}P .
$$

(6.3.6)

Furthermore according to Hamilton (1989) the same probability for (k) periods into the future is given by:

$$
\pi_t = \pi_{t-1}P^k .
$$

(6.3.7)

It is worth noting that current and future state probabilities are unconditional probabilities (Brooks, 2007). Therefore, an initial observation could be that the calculation of the transition probabilities matrix is a cardinal issue in Markov chain analysis.

In order to take the foregone analysis one step further, we make the assumption that we have 2 potential states (i.e. $s_t = 0$ and $s_t = 1$), in which case a basic regime switching model can be written as (Perlin, 2012):

$$
y_t = \mu_0 + \varepsilon_{t,0}, \quad \varepsilon_{t,0}\sim N(0, \sigma_0^2)
$$

(6.3.8)

$$
y_t = \mu_1 + \varepsilon_{t,1}, \quad \varepsilon_{t,1}\sim N(0, \sigma_1^2)
$$

(6.3.9)
where, $y_t$ is the time series under investigation (within the framework of this study, this will be either the financial or the housing prices), $\mu_0$ is the conditional mean of one of the series - each time - under regime (0), $\mu_1$ is the conditional mean of each series under regime (1), $\sigma_0$ is the standard deviation under regime (0) and $\sigma_1$ is the standard deviation under regime (1). Both variable $s_t$ and the $\varepsilon_t$ follow a normal distribution with zero mean and variance equal to $\sigma^2$. Note that depending on the value of $s_t$ we get different values for both $\mu$ and $\sigma^2$. The number of the potential values that both $\mu$ and $\sigma^2$ can assume is equal to the number (N) of states. In this case the number of states is equal to 2. The descriptive statistics of the specific time series and their corresponding functional forms employed in this section have been thoroughly presented in chapter 5 of the thesis.

As previously mentioned, regime switching models are a useful way to model the non-linear behaviour of time series. The structure of the model as given by (6.3.8) and (6.3.9) implies that the difference between the two regimes is a mean and volatility shift (excluding any autoregressive change). On top of that, it is understood that $s_t$ is a latent variable that can only be observed through the behaviour of $y_t$ and that the regimes have been arbitrarily defined (Hamilton, 2008). According to Hamilton (1989) the transition between the various regimes is a stochastic first-order Markov process which implies that the state at time (t); that is, $s_t = 0$ (or) 1 depends only on the previous state; that is, $s_{t-1} = 0$ (or) 1 (Hamilton, 1989).

To make a connection with what was mentioned earlier, the value of $s_t$ depends on certain transition probabilities (i.e. $p_{00}$ and $p_{11}$ for the 2-State case).

Given that the variable $s_t$ can only be observed through the behaviour of $y_t$, Hamilton (2008) maintains that in order to appropriately describe the probability law relating to $y_t$ we have to calculate all the necessary parameters for both regimes, which in this case include, the average level of the series, the variance of the Gaussian innovation $\varepsilon_t$, as well as, the
transition probabilities (i.e. \( p_{00} \) and \( p_{11} \) for the 2-State case). In the 2-State case the problem takes the following form:

\[
\begin{bmatrix}
\pi(s_t = 0) \\
\pi(s_t = 1)
\end{bmatrix} =
\begin{bmatrix}
p_{00} & 1 - p_{11} \\
1 - p_{00} & p_{11}
\end{bmatrix}
\begin{bmatrix}
\pi(s_{t-1} = 0) \\
\pi(s_{t-1} = 1)
\end{bmatrix}.
\] (6.3.10)

Regime switching models are non-linear models and their estimation cannot be performed by using the OLS optimisation method (Brooks, 2007). As shown by Hamilton (1989) all of the population parameters of the model in (6.3.8) and (6.3.9) along with the transition probabilities in (6.3.10) can be estimated by maximum likelihood approaches and appropriate logarithms.

The presentation of this particular method is beyond the scope of the thesis; however, the main idea behind the method is to form a log-likelihood function and then find the values that maximise it\(^{47}\). Piger (2009) illustrates that a general form (which applies to our case as well) of the log-likelihood function to be maximised in the case of regime switching models could be the following:

\[
l(\boldsymbol{\theta}) = \sum_{t=1}^{T} l_t(\boldsymbol{\theta}),
\] (6.3.11)

where, \( \boldsymbol{\theta} \) is a row vector of population parameters:

\[
\boldsymbol{\theta} = [p_{00}, \ p_{11}, \ \mu_0, \ \mu_1, \ \sigma_0^2, \ \sigma_1^2].
\] (6.3.12)

These values are then regarded as the most likely values to be assumed by the parameters in question (Brooks, 2007; Hill et al., 2008). Once the results are obtained we can then make specific inferences regarding the transition of the system from one regime to another.

\[^{47}\text{Maximum likelihood calculations in our model are based on the feasible sequential quadratic programming (SQPF) algorithm introduced by Lawrence and Tits (2001) which is provided by the Ox-Metrics software.}\]
6.3.2 Empirical results and discussion

The purpose of this section is to investigate whether monetary policy (approximated by a short-term interest rate; that is, the interbank rate), CPI-inflation, Brent crude-oil prices, as well as, growth (as the latter is approximated by the industrial production index) can provide any predictive information regarding the state which both UK housing and financial prices are more likely to be in. Housing and financial prices are approximated by the Halifax housing prices index and the FTSE all-share index, respectively. Needless to say that our main concern is the impact stemming from the monetary policy variable. All variables have been transmuted into logarithmic differences, while the frequency of the data is monthly and the period of study ranges from January 1992 to December 2012. A more detailed analysis of the datasets employed by this section can be found in chapter 5 of the present thesis.

The first step towards answering our research question is the identification of the relevant alternative regimes for both types of assets. To this end, we go ahead with the simplifying assumption that there exists a relatively fundamental two-states Markov process which can sufficiently describe the workings of real economic activity in both individual markets.

The idea that stock markets move between two alternative states (i.e. from a bullish to a bearish regime or vice versa) is not quite new. Authors such as Turner et al. (1989), Schaller and Norden (1997), Maheu and McCurdy (2000), Ismail and Isa (2008), as well as, Chen (2010) provide clear evidence of the existence of two regimes for the stock market; namely, a bullish (i.e. low volatility and high returns) regime and a bearish (i.e. high volatility and low returns) regime. On top of that, the importance - for the stock market - of monetary policy in general and interest rates in particular has been thoroughly investigated by authors such as Thorbecke (1997), Mishkin (2001), as well as, Rigobon and Sack (2003) among others. Evidence related to all these studies suggests that contractionary monetary policy could potentially lead to lower stock market returns. However, as explicitly mentioned in Bernanke
and Kuttner (2003) and Sims (2003) we should be very careful in deciphering the potential impact of monetary policy decisions on the stock market because the latter is rather unlikely to respond to already anticipated policy decisions (where anticipated decisions are in a sense the cornerstone of the inflation targeting strategy).

In turn, the idea that housing prices switch between regimes of different degrees of volatility has been suggested by authors such as Hall et al. (1997) and Tsai et al. (2010). Hall et al. (1997) in particular, have argued that high volatile and unstable regimes could provide fertile ground for the development of bubbles in the UK housing market.

In addition, the importance of interest rates for housing prices movements has been argued by many authors, including Lastrapes (2002), Iacoviello and Minetti (2003), as well as, McQuinn and O'Reilly (2008). Most of these studies concentrate on the positive impact on housing prices that typically follows the adoption of low interest rates. Himmelberg et al. (2003) further maintain that - considering the credit channel of monetary policy - housing markets characterised by relative inelastic supply, tend to be much more influenced by changes in interest rates than others.

It would be important to note at this point that although deciding upon the number of regimes can be dictated by the framework of study (in our study the distinction between high volatile and low volatile stock or housing market appears to qualify a 2-state framework), statistical tests have also been developed in order to determine the number of regimes directly from the data (see *inter alia*, Ang and Bekaert, 1998; Garcia, 1998; Laurini and Portugal, 2004; Ang and Timmermann, 2011). Ang and Timmermann (2011) further argue that very frequently the decision regarding the appropriate number of regimes is not at all based on econometric tests; especially as in most cases these tests do not follow standard distributions. One of these statistical approaches is the log-likelihood ratio (LR) test.
The results we obtain from this test\textsuperscript{48} verify that describing both markets using two regimes is better than describing the markets using just one single state. In addition, as far as the stock market is concerned, two regimes appear to be better than three. Apparently, statistical results regarding the housing market suggest that a model with three regimes could be a better fit than a model comprising only two regimes. In the analysis that follows we provide further evidence suggesting that alternative models for the housing market - comprising a greater number of regimes – should also be employed, in order to capture the abrupt decline in housing prices especially between the period 2007 and 2009. This is indeed part of future work; however, at the present framework of high or low volatile stock and housing markets we proceed with our analysis attempting a two-state description of both markets.

On a final note in this short overview of the related literature, Nneji et al. (2013) who conduct a similar study for the US housing market, put forward the argument that - as far as housing markets are concerned - little research has been conducted with respect to their cyclicality. In this regard, this section contributes to the relevant field of research by elucidating factors that could potentially explain UK housing prices movements. As already mentioned, following Chen (2007) and Kurov (2010) we employ a simple mean-variance autoregressive Markov regime switching model of order zero (MS-AR(0)) for both markets. This model is adequately described by equations 6.3.8 and 6.3.9. In addition, we deviate from Hamilton (1989) and the problem at hand - as the latter was described by equation 6.3.10 - and in line with Chen (2007) and Nneji et al. (2013) we assume a fixed transition probabilities (FTP) setup, instead of a time-varying (TVTP) one\textsuperscript{49}. This basically entails that the transition

\textsuperscript{48} The LR test for the stock market considering 2 instead of 1 regimes implies $\chi^2(165.12, 4)$ and $p$-value=0. At the same time considering 3 instead of 2 regimes implies $\chi^2(8.25, 8)$ and $p$-value=0.409. For the housing market, considering 2 instead of 1 regimes we get $\chi^2(77.51, 4)$ and $p$-value=0. At the same time, considering 3 instead of 2 regimes implies $\chi^2(56.18,8)$ and $p$-value=0. On general principles, within the framework of the LR test, a significant coefficient implies that a model that comprises a higher number of regimes is potentially better.

\textsuperscript{49} A time varying transition probabilities framework that would allow making linkages between the transition probabilities and other macroeconomic or financial variables is not considered in this study it is however an interesting area for future research.
probabilities matrix remains fixed over time, facilitating the investigation of the actual factors (i.e. monetary policy decisions, economic growth etc.) that can predict the state of each market. To put it more simple, we investigate the possibility to know beforehand the time and the reason why a regime-shift is likely to occur and not the reason that makes the transition probabilities change over time in general. Furthermore, in both markets, we test for the strength / validity of our regimes-classification by applying Ang and Bekaert's (2002) regime classification measure (RCM). This is given by the following formula:

\[
RCM = 400 \sum_{t=1}^{T} p_t (1 - p_t),
\]

(6.3.13)

where \( p_t = p(s_t | \Omega_T) \) and \( \Omega_T \) is the information set corresponding to the entire sample employed in the models.

**Table 6.3.1: Markov regime switching model for the stock market.**

<table>
<thead>
<tr>
<th>MS-AR(0) for financial prices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mu_0 )</td>
<td>-0.006453</td>
</tr>
<tr>
<td>( \mu_1 )</td>
<td>0.013875***</td>
</tr>
<tr>
<td>( \sigma_0 )</td>
<td>0.062900***</td>
</tr>
<tr>
<td>( \sigma_1 )</td>
<td>0.021419***</td>
</tr>
<tr>
<td>( \rho_{00} )</td>
<td>0.899063***</td>
</tr>
<tr>
<td>( \rho_{11} )</td>
<td>0.902890***</td>
</tr>
<tr>
<td><strong>RCM</strong></td>
<td>34.58</td>
</tr>
</tbody>
</table>

Notes: p-values in parentheses. p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote \( p < 0.01 \), \( p < 0.05 \), and \( p < 0.1 \) respectively.

The RCM assumes values between 0 and 100 and lower values consistently entail successful classification / identification of the corresponding regimes.
As far as the financial market is concerned, results are presented in table 6.3.1. Our model clearly identifies two distinct regimes; that is, regime 0, which is characterised by low / negative returns $\mu_0$ and high volatility $\sigma_0$ and regime 1, which is characterised by higher returns $\mu_1$ and lower volatility $\sigma_1$. The coefficient for $\mu_0$ is not statistically significant; however, it assumes the appropriate sign. The RCM value is relatively low. These results indicate that we may proceed with our model and get a first rough approximation of the differing states assumed by the UK stock market. The corresponding transition probabilities matrix is then given by:

$$\begin{bmatrix} p_{00} & 1 - p_{11} \\ 1 - p_{00} & p_{11} \end{bmatrix} = \begin{bmatrix} 0.899063 & 0.097110 \\ 0.100940 & 0.902890 \end{bmatrix}. \quad (6.3.14)$$

Apparently, the probability to stay in each regime is quite high (i.e. 89.9063% chance to stay at the high volatile regime and 90.2890% chance to stay at the low volatility regime) implying quite persistent regimes. The chance for the stock market to move from the low return - high volatility regime to the high return - low volatility regime is merely greater than 10%; while the probability for the reverse event to occur is just a bit less than 10%.

In line with Chen (2007) and Nneji et al. (2013) we can use the following formula in order to be more precise regarding the expected duration ($ED$) of each regime:

$$ED = \frac{1}{(1-p_{ii})}. \quad (6.3.15)$$

In this case, the expected duration of regime 0 will be approximately equal to 9.9 months, while the expected duration of regime 1 will be approximately equal to 10.3 months. Roughly speaking, this can be interpreted in the sense that we would expect the bullish regime to last longer than the bearish regime before the switch.

As far as the housing market is concerned, results are presented in table 6.3.2. In particular, our model clearly identifies two distinct regimes; that is, regime 0, which is characterised by
positive changes in housing prices $\mu_0$ and positive volatility $\sigma_0$ and regime 1, which is characterised by higher positive changes in housing prices $\mu_1$ and even higher volatility $\sigma_1$.

These results adhere to the empirical evidence presented in the work of Hall et al. (1997) and Tsai et al. (2010) who distinguish between the various regimes of the UK housing market in terms of the degree of volatility in the market. Also recall that according to Hall et al. (1997) highly volatile periods of the UK housing market can be linked to very high housing prices.

Table 6.3.2: Markov regime switching model for the housing market.

<table>
<thead>
<tr>
<th></th>
<th>MS-AR(0) for housing prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_0$</td>
<td>0.002614** (0.042)</td>
</tr>
<tr>
<td>$\mu_1$</td>
<td>0.004762</td>
</tr>
<tr>
<td>$\sigma_0$</td>
<td>0.007018*** (0.000)</td>
</tr>
<tr>
<td>$\sigma_1$</td>
<td>0.016369*** (0.000)</td>
</tr>
<tr>
<td>$\rho_{00}$</td>
<td>0.931860*** (0.000)</td>
</tr>
<tr>
<td>$\rho_{11}$</td>
<td>0.915203*** (0.000)</td>
</tr>
<tr>
<td>RCM</td>
<td>10.82</td>
</tr>
</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

The corresponding transition probabilities matrix is given by:

$$
\begin{bmatrix}
    p_{00} & 1 - p_{11} \\
    1 - p_{00} & p_{11}
\end{bmatrix} = \begin{bmatrix}
    0.931860 & 0.084797 \\
    0.068136 & 0.915200
\end{bmatrix}.
$$

(6.3.16)

The RCM value as an indication of successful classification of the potential regimes is quite satisfactory. The coefficient for $\mu_1$ is not statistically significant. As in the previous case, results indicate that we may proceed with our model in order to have a first impression of the regime switching process in this particular market.

Similarly to the stock market case, the probability to stay in each regime is quite high (i.e.
93.1860% chance to stay at the low volatility regime and 91.5200% chance to stay at the high volatility regime) implying quite persistent regimes. The chance for the housing market to move from the higher volatility regime to the lower volatility regime is approximately 8.5%; while the probability for the reverse event to occur is approximately 6.8%. As far as the expected duration of each regime is concerned, the expected duration of regime 0 will be approximately equal to 14.7 months, while the expected duration of regime 1 will be approximately equal to 11.8 months.

**Figure 6.3.2:** A Financial and housing prices regimes and their corresponding probabilities.

Roughly speaking, this can be interpreted in the sense that we would expect the relatively more stable regime to last longer than the unstable regime before the switch. Figure 6.3.2
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illustrates the smoothed probabilities of the estimated regimes for both markets. In short, following Chen (2007) we simply take 0.5 as the cut-off point between the two regimes and when for one of the two alternative regimes (e.g. for regime $S_t = 0$) the probability assumes a value less than 0.5 then the stock market will more likely be a bear market, whereas a value of less than 0.5 for the housing market (again for $S_t = 0$) would imply that the housing market is a relatively stable one.

Furthermore, panels (a) and (b) correspond to the stock market while panels (c) and (d) correspond to the housing market. Obviously, panel (a) is the mirror image of panel (b) and panel (c) is the mirror image of panel (d). In order to investigate the alternative regimes assumed by the markets of interest throughout the period of study and get a more complete picture we will have to bring into service the changes in both markets. This materialises in figures 6.3.3 and 6.3.4. In these figures we have chosen one of the two alternative regimes corresponding to the markets of interest$^{50}$ and we have added the path of the percentage changes in both assets prices. The practical use of incorporating growth paths for both housing and financial prices in the regime switching charts is to check whether any dominant states - with reference to the period of study - can be identified.

Starting with the stock market, we concentrate on figure 6.3.3. Evidently, stock market prices grew at a relatively stable pace until around 1997 when a high volatile regime is indeed verified by our results. On general principles, the period between 1997 and 2000 was quite volatile for the stock markets, as it was marked by the contagious US banking-sector turmoil and the dot-com bubble. Consequently, regime 0; that is, the high volatility regime, was the dominant regime for that period. From then on, the growth path of stock market prices was relatively stable (with only a few exceptions) until the outbreak of the Great Recession; that

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$^{50}$ In particular, for both markets we have arbitrarily chosen the high volatility regime; that is, (regime 0 or $S_t = 0$) for the stock market and (regime 1 or $S_t = 1$) for the housing market.
is, the global financial crisis which began in August 2007 in the aftermath of the housing bubble in the United States. This increased volatility in stock market returns is captured by our findings which clearly recognize the dominance of a high volatility regime for a period between late 2007 and late 2009, while it is also obvious that stock market returns go back to a stable path sometime during 2010. It is only then, when regime 1 (i.e. that is the low volatility regime for the stock market) becomes the dominant regime in the market. In this regard and as far as the stock market is concerned, we are satisfied with the empirical findings of our model in terms of the latter adequately describing the probabilities of two distinct states which could help delineate the market and better explain stock market developments.

Turning to the housing market, figure 6.3.4 illustrates the probabilities for the housing market to be in one of the two regimes based on the chart for the high volatility regime (i.e. regime 1 or $S_t = 1$). It is evident from figure 6.3.4 that the growth path for housing prices was relatively stable until early 1999. Our empirical findings can verify this by providing a very low (close to zero) probability for the market to be in regime 1 throughout this particular period. The period between late 1990s and 2005 is generally regarded as a period in which housing prices in the UK rose considerably and authors such as Bone and O'Reilly (2010) and Morley and Thomas (2011) raise the question of whether this unprecedented hike in housing prices could be attributed to factors other than just the adoption of an expansionary policy approach, such as, the development of a some speculative bubble in the market. As evident in figure 6.3.4, despite the fact that the housing market remains very volatile throughout the period between 1999-2005, the percentage change in housing prices remains relatively high compared to respective changes of previous periods. Authors such as Kuezel and Bjørnbak (2008) and Bone and O'Reilly (2010) put heavy emphasis on the fact that UK housing prices
Figure 6.3.3: Regime dominance for the stock market in relation to stock market returns.
- almost throughout the period that began after the crisis of the early 1990s and ended with the credit crunch in late 2007 - rose at a rate faster than the rate of inflation.

From then onwards, the market remains very volatile, however it is difficult to identify a dominant regime, although the prevalence of regime 1 for the period between 2007-2009 (i.e. the peak of the Great Recession) is probably the most straightforward case. In particular, pertaining to the period that began after the outbreak of the crisis, our findings for the period between 2007-2009 verify that the market has a very strong probability to remain at the high volatility regime. However, it appears that in the UK housing market unprecedented hikes are then followed by unprecedented declines. More particularly, there is definitely a persistent downward adjustment in housing prices starting in 2005 and holding for almost throughout the peak-years of the crisis, while at times (e.g. the period between January 2010 and January 2011, or the period between July 2011 and July 2012) the housing market growth rate volatility becomes really big. Overall, our findings suggest that the 2-state Markov model performs very well until the year 2005, wherein it appears to provide some unclear results for the period afterwards. It is worth noting that authors such as Nneji et al. (2013) who argue in favour of a bubble in the US housing market that burst right before the beginning of the financial meltdown in 2007, further opine that this has led to a meltdown in the mortgage market as well. Considering the evidence provided by Nneji et al. (2013) we arrive at the conclusion that both the US and the UK housing markets have behaved in a similar way. To be more explicit, it appears that both markets initially experienced a persistent hike during the years right before the crisis and then suffered unprecedented shrinking in the years that followed the crisis. One of the main arguments put forward in this section is that it may very well be that the volatility of UK housing prices has acquired new features over the past few years; that is, in analysing the volatility of recent years we have to consider the large drops in housing prices. On a final note in connection with the housing market, as will be shown
Figure 6.3.4: Regime dominance for the housing market in relation to housing market growth rates.
shortly, one of the main contributions of this section compared to similar studies (see for example Tsai et al., 2010 and Nneji et al., 2013 who among others have investigated regime switches in the UK and the US housing market respectively) is the fact that we make an effort to identify potential factors that could help predict the future state of the market by considering changes not only in the monetary policy variable (in our case the short-term interest rate) but also in other potential sources of influence (control variables).

In this regard, we turn to testing the ability of our model to make forecasts regarding the future state / regime of each market. In effect, having established the classification of the divergent regimes in both housing and financial markets, the next step is to identify the factors that significantly affect the probability of each market to be in any of the two alternative regimes. Needless to say that the focal point of this task is the effect of the monetary policy instrument. The control variables we employ alongside the monetary policy approximation in order to put our assumptions to the test are the main variables that have been employed for the most part of this study and include oil prices, the inflation rate, housing and financial prices, as well as, industrial production. It should be noted, that all variables have been converted to logarithmic differences and that each market is being investigated independently. We also include the lagged smoothed probability itself. Furthermore, we proceed with this analysis by adding one control variable at a time in order to discern any specific incremental power.

In order to achieve this we have to use - for each market - a probit model which entails a binary specification for the dependent variable under investigation. As far as the stock market is concerned, the dependent variable will be the probability for the market to remain at the high volatility regime (i.e. $S_t = 0$). Similarly, as regards the housing market, the dependent variable will again be the probability for the market to remain at a high volatility regime. For the housing market this is regime 1 or $S_t = 1$. 
In both cases, if the probability of staying at the high volatility regime is greater than 0.5 then the dependent variable of the probit model assumes the value of 1. On the other hand, if the probability of being at the high volatility regime is less than 0.5 then the dependent variable of the probit model assumes the value of 0. For each market, the new binary series is constructed by considering all probabilities that correspond to the high volatility regime throughout the period of study. The intended outcome of this exercise is to discern whether the behaviour of certain factors could have an impact such that each of the markets moves towards or away from the high volatility regime. This is very important especially when it comes to monetary policy decision making, as the monetary authority would be rather keen on knowing whether the short-term interest rate instrument could be used in order to lead any of these markets away from an unstable and towards a more stable state. Initially, we turn our attention to the stock market. Results are shown in table 6.3.3.

The optimum lag length for our probit model was based on the Akaike Information Criterion (AIC) although it is worth noting that results differ neither substantially nor qualitatively from those of the contemporaneous or the one-period lag case. Apparently, monetary policy has a key role to play as in all cases it assumes a positive and statistically significant coefficient implying that any rise in the short-term interest rate policy instrument increases the probability that the stock market will remain at the unstable (i.e. bearish) regime. This outcome is in line with Chen (2007) who conducted a similar study for the US stock market. Most importantly, this finding has obvious implications for monetary policy as during periods of high uncertainty in the stock market, the central bank may decide to lower short-term interest rates and thus help the market follow a more stable path. The lagged smooth probability also appears to be important in determining the adopted state. Finally, housing prices appear to be important only in some cases only.
Table 6.3.3: Factors that affect \( p(S_t = 0) \) for the stock market between the period 1992:1-2012:12.

<table>
<thead>
<tr>
<th>Dependent variable: The probability that the stock market remains at the high volatile regime ( [p(S_t = 0)] )</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
<th>Equation 4</th>
<th>Equation 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term interest rate</td>
<td>7.5179 ** 0.0296</td>
<td>8.0866 ** 0.0183</td>
<td>8.6767 ** 0.0143</td>
<td>8.4378 ** 0.0137</td>
<td>8.4685 ** 0.0135</td>
</tr>
<tr>
<td>Other control variables:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( [p(S_t = 0)]_{t-1} )</td>
<td>3.2457 *** 0.0000</td>
<td>3.3424 *** 0.0000</td>
<td>3.4018 *** 0.0000</td>
<td>3.4457 *** 0.0000</td>
<td>3.4443 *** 0.0000</td>
</tr>
<tr>
<td>Housing prices</td>
<td>-18.0517 0.1325</td>
<td>-21.6821 * 0.0814</td>
<td>-21.6754 * 0.0702</td>
<td>-21.6089 * 0.0705</td>
<td>-21.6089 * 0.0705</td>
</tr>
<tr>
<td>Inflation</td>
<td>-86.8650 0.1415</td>
<td>-14.8371 0.3523</td>
<td>-14.8371 0.3523</td>
<td>-14.8557 0.3526</td>
<td>-14.8557 0.3526</td>
</tr>
<tr>
<td>Industrial production</td>
<td>-1.6347 *** 0.0000</td>
<td>-1.5862 *** 0.0000</td>
<td>-1.3912 *** 0.0000</td>
<td>-1.3959 *** 0.0000</td>
<td>-1.3959 *** 0.0000</td>
</tr>
<tr>
<td>Oil</td>
<td>-1.6347 *** 0.0000</td>
<td>-1.5862 *** 0.0000</td>
<td>-1.3912 *** 0.0000</td>
<td>-1.3959 *** 0.0000</td>
<td>-1.3959 *** 0.0000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.7000</td>
<td>0.7075</td>
<td>0.7128</td>
<td>0.7152</td>
<td>0.7153</td>
</tr>
</tbody>
</table>

Notes: \( p \)-values in parentheses. \( p \)-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote \( p < 0.01 \), \( p < 0.05 \), and \( p < 0.1 \) respectively. \( S_t = 0 \) is the high volatility regime for the stock market.

Table 6.3.4: Factors that affect \( p(S_t = 1) \) for the housing market between the period 1992:1-2001:12.

<table>
<thead>
<tr>
<th>Dependent variable: The probability that the housing market remains at the high volatile regime ( [p(S_t = 1)] )</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
<th>Equation 4</th>
<th>Equation 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term interest rate</td>
<td>6.4068 ** 0.0233</td>
<td>6.4778 ** 0.0223</td>
<td>7.1846 ** 0.0161</td>
<td>7.3413 ** 0.0246</td>
<td>5.8652 * 0.0829</td>
</tr>
<tr>
<td>Other control variables:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( [p(S_t = 1)]_{t-1} )</td>
<td>3.1475 *** 0.0000</td>
<td>3.1428 *** 0.0000</td>
<td>3.1541 *** 0.0000</td>
<td>3.2052 *** 0.0000</td>
<td>3.3581 *** 0.0000</td>
</tr>
<tr>
<td>Financial prices</td>
<td>1.2440 0.6057</td>
<td>1.7059 0.4428</td>
<td>1.7319 0.4788</td>
<td>1.7620 0.5985</td>
<td>1.7620 0.5985</td>
</tr>
<tr>
<td>Inflation</td>
<td>-117.4186 * 0.0747</td>
<td>-112.7620 * 0.0858</td>
<td>-99.3409 0.1808</td>
<td>-29.3408 0.1199</td>
<td>-29.3408 0.1199</td>
</tr>
<tr>
<td>Industrial production</td>
<td>22.6990 * 0.0869</td>
<td>-2.9613 * 0.0938</td>
<td>29.3408 0.1199</td>
<td>29.3408 0.1199</td>
<td>29.3408 0.1199</td>
</tr>
<tr>
<td>Oil</td>
<td>-1.6717 *** 0.0000</td>
<td>-1.6735 *** 0.0000</td>
<td>-1.4166 *** 0.0000</td>
<td>-1.4731 *** 0.0000</td>
<td>-1.5198 *** 0.0000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.6835</td>
<td>0.6841</td>
<td>0.6922</td>
<td>0.6972</td>
<td>0.7141</td>
</tr>
</tbody>
</table>

Notes: \( p \)-values in parentheses. \( p \)-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote \( p < 0.01 \), \( p < 0.05 \), and \( p < 0.1 \) respectively. \( S_t = 1 \) is the high volatility regime for the housing market.
Turning to the housing market, results are given by table 6.3.4. To begin with, the AIC has qualified a three-period lags binary model for this case as well. Contrary to the evidence provided by Nneji et al. (2013) for the US housing market, our findings suggest that monetary policy can greatly affect the probability that the UK housing market will remain at the unstable regime. The monetary policy variable again assumes positive and significant coefficients implying that, as in the case of the stock market, monetary policy may lead the market to a more stable regime by lowering its short-term policy instrument. The lagged smooth probability also appears to be important in determining the adopted state. The coefficient for inflation is negative and significant (in most cases) implying that rises in inflation increase the probability that the housing market will move away from the unstable regime. This particular result is rather vague as on one hand, rises in inflation could be seen as a signal of future downturns (as suggested by Brunnermeier and Julliard, 2008) implying further turmoil, while on the other hand, inflation always works in favour of the borrower, implying good news for the mortgage market. On all accounts, this result deserves further study. Finally, we do get a first indication regarding the importance of oil in the framework of this study. In particular, rises in the price of oil result in a higher probability for the housing market to remain at the unstable regime. When it comes to understanding the effects of oil prices, perhaps a more complex framework\textsuperscript{51} - one that considers the likely origins (i.e. demand-side or supply side) of the shocks or the current status of the country under investigation with respect to oil (i.e. net oil-importer or net oil-exporter) - would be more appropriate; however, in line with Filis and Chatziantoniou (2013) - who point out that in recent years the UK has in fact turned into a net oil-importing country - we interpret this finding as one of the consequences of the negative effects of a positive oil price shock on the economy of an oil-importing country. We do however maintain that the effects of oil should

\textsuperscript{51} Such as the one suggested by Kilian (2009) or the one suggested by Hamilton (2009).
be further investigated and this is also suggested by the results we obtain and present in appendix C where in the framework of two arbitrarily chosen periods for which we choose to repeat the exercise we cannot capture any significant effects of oil. The effects of monetary policy though appear to always be significant.

In retrospect, this section provides evidence in favour of the existence of two distinct regimes for each of the UK housing and the UK financial market. On general principles results indicate that our models have some degree of predictive power and therefore, out-of-sample forecasts provide a fertile ground for future work. Empirical findings in this section suggest that developments in monetary policy could possibly affect the probability that either the housing or the stock market remain at (or leave from) the unstable and highly volatile regime. Findings further suggest that additional modelling efforts are required in order to better describe the downward spiral of housing prices concerning the period beginning in 2005. For example, following Nneji et al. (2013) who conduct a regime switch analysis for the US housing market - which appears to bare great resemblance to the UK housing market - future work could entail the development of regime switching models fit to accommodate more than just two potential regimes. Finally, further study should also incorporate a thorough analysis regarding the contribution of both inflation and oil prices to the propensity of the market to remain at one of the alternative states.
6.4 Correlation patterns between asset prices & monetary policy

This section is devoted to a different type of non-linear models; that is, *volatility models* which primarily purport to portray volatility behaviour and identify correlation patterns between the series of study. In particular, we employ a specific type of multivariate generalised autoregressive conditionally heteroskedastic (MGARCH) model in order to make inferences regarding volatility spillovers between asset prices and monetary policy and identify the evolution of correlation between; financial prices and monetary policy, as well as, housing prices and monetary policy. In addition, using control variables we run a series of regressions to investigate whether the identified correlation patterns are indeed persistent. We provide empirical evidence in favour of a *time-varying* behaviour of the correlation between both assets and monetary policy. On top of that, the identified correlation pattern does not appear to be affected by many of the control variables employed in the analysis.

6.4.1 Econometric method and modelling

Volatility is a very important concept for various aspects of economic and financial life and has a key role to play in modelling the workings of economic activity. The concept of volatility has been widely used in the areas of macroeconomics and finance. Many studies regarding the course of essential macroeconomic indicators, or the existence of business cycle synchronisations, or the forecasting of financial assets' returns have considered volatility issues. In effect, research related to volatility goes back quite a few years, in the beginning of the 1980s. Indicatively we quote the seminal research of Engle (1982) on inflation in the United Kingdom and Bernanke (1983) on output growth and economic activity in the United States, as well as, the early work of Bollerslev et al. (1988) and Ding et al. (1993) on volatility and stock market returns.

Hill et al. (2008) among others explicate that a series is generally considered to be volatile
when its values change rapidly throughout a certain period of time. Investigating the historical variance of a time series could lead to very useful conclusions. Brooks (2007) supports the view that one of the most simple and relatively useful ways to account for volatility and produce volatility forecasts for the periods ahead is to observe the historical variance of the time series. Brooks (2007) further reports that it is rather customary in finance to describe volatility as the historical variance or standard deviation of stock prices' returns and to use it as a rough estimate of the risk involved in an investment.

Volatility models such as the autoregressive conditionally heteroskedastic (ARCH) model introduced by Engle (1982) though, concentrate on conditional volatility. To be more explicit, this family of models does not take for granted one of the main assumptions of the classical linear regression model - that is, that the variance of the error term is constant - and purports to describe the way in which the variance of errors evolves over time. Contrary to historical or unconditional volatility which is assumed to remain constant, conditional volatility - according to Engle (1982) and Bollerslev (1986) among others - changes over time as a function of disturbances from the past. In particular, it has been observed that volatility occurs in clusters; that is, periods of large (small) positive or negative changes are followed by periods of large (small) positive or negative changes. To quote Brooks (2007, p.446) 'abusing the terminology slightly, it could be stated that volatility is autocorrelated'.

In this framework, the conditional variance of the error term (usually denoted by $h_t$) is given by:

$$h_t = \text{var}(u_t | u_{t-1}, u_{t-2}, \ldots) = E[(u_t - E(u_t))^2 | u_{t-1}, u_{t-2}, \ldots], \quad (6.4.1)$$

and further assuming that - on average - prediction errors are equal to zero (i.e. $E(u_t) = 0$), we have:

$$h_t = \text{var}(u_t | u_{t-1}, u_{t-2}, \ldots) = E[u_t^2 | u_{t-1}, u_{t-2}, \ldots]. \quad (6.4.2)$$
Equation (6.4.2) states that the conditional variance of an error term - whose expected value is equal to zero - can be modelled as the *conditional mean* of the error term *squared*. In practice, the ARCH specification *models* conditional volatility as a function of errors, implying that the variance of the error term depends on past values of squared errors. The simplest form of an ARCH model; that is, the form of an ARCH(1) model can take the general form:

\[
y_t = b_1 + b_2 x_{2t} + b_3 x_{3t} + \cdots + b_m x_{mt} + u_t \quad \text{where } u_t \sim N(0, h_t) \quad (6.4.3)
\]

\[
h_t = a_0 + a_1 u_{t-1}^2, \quad (6.4.4)
\]

implying that the conditional variance depends on the immediately previous value of the squared innovation (i.e. one lagged squared error). Also note, that any model of this sort typically comprises two equations; one equation for the conditional mean corresponding to the evolution of the time series of interest (e.g. equation 6.4.3) and one equation for the conditional variance (e.g. equation 6.4.4). Hill et al. (2008) put forward the argument that producing conditional forecasts can be much more efficient than producing unconditional ones, on the basis that the former rely on the latest available information.

A major issue with conditional volatility modelling is the fact that it should always (i.e. for any point in time) be positive (see *inter alia* Brooks, 2007; Hill et al., 2008). It would be counter-intuitive to develop a model which is based on the fact that autocorrelation is indeed present and then end up with negative values of $h_t$.

Looking at the right hand side of equation (6.4.4) for example, it is easy to ensure positive values for the error term $u_{t-1}^2$ as the latter is squared. However, a meaningful outcome from the model would further require that both coefficients $a_0$ and $a_1$ are positive. Related to that is the fact that ARCH models have been criticised for being way far from *parsimonious* and this begs the question of how easy it would be to secure a positive value of $h_t$ in a model that
consists of too many coefficients. This fact, along with the realisation that it is indeed very difficult to identify the appropriate lag length for the conditional volatility equation, eventually led researchers to seek new specifications in order to accommodate these problems.

In this regard, a new type of model was developed; namely, the generalised autoregressive conditionally heteroskedastic (GARCH) model, which is regarded as being much more parsimonious and safe (in terms of non-negative \( h_t \) results) than its predecessor the ARCH model (Brooks, 2007). The GARCH model was developed by Bollerslev (1986) and Taylor (1986) independently.

The standard representation of the conditional variance component of a GARCH \((p,q)\) model usually takes the following general form:

\[
 h_t = a_0 + \sum_{i=1}^{q} a_i u_{t-i}^2 + \sum_{j=1}^{p} b_j h_{t-j} , \tag{6.4.5}
\]

where \( h_t \) is the conditional variance of the error term of the time series which is dependent on a long-term average value \( a_0 \), on information regarding the previous variance of its squared errors \( a_i u_{t-i}^2 \), as well as, on own fitted past values \( b_j h_{t-j} \). To put this differently, this equation defines that the current conditional variance of a time series is conditional not only on \((q)\) previous lags of squared errors (as implied by the standard ARCH representation) but also, on \((p)\) previous lags of itself.

It is worth noting that both ARCH and GARCH specifications are linear in mean but non-linear in variance - as opposed to the classical linear regression models which can be estimated by the OLS methodology (Brooks, 2007; Hill et al., 2008). In addition, any

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52 This issue is originally discussed in Engle (1982) who further proposes a solution based on an arbitrarily chosen linearly declining lag length.
GARCH model can be extended to a GARCH\((p, q)\) version, implying that the current conditional variance depends upon \((p)\) own lags and \((q)\) lags of the squared error term; however, a GARCH\((1,1)\) model is considered to be sufficient enough to capture the conditional volatility within the datasets employed (Brooks, 2007). Brooks (2007) further argues that it is not very common to encounter GARCH models of higher order in the academic literature.

However, when the volatility of one variable is affected by the volatility attributed to shocks to another variable then a multivariate representation is required. Apparently, many multivariate representations have been proposed\(^{53}\) (see among others Bollerslev et al., 1988; Kroner and Ng, 1998; Engle and Kroner, 1995, Silvennoinen and Teräsvirta, 2009). This section focuses on an MGARCH\((p, q)\)-BEKK (named after its developers; that is, Yoshi Baba, Robert F. Engle, Ken Kroner and Dennis Kraft).

MGARCH\((p, q)\)-BEKK models have been criticised for their multidimensionality and their computational complexity and have often been compared to Dynamic Conditional Correlation (DCC) models; the latter assumed to exhibit a relatively less complicated structure (see *inter alia* Engle, 2002; Caporin and McAleer, 2008; Caporin and McAleer 2012; Chevallier, 2012). However, in a comparative study Caporin and McAleer (2012) specifically point out that BEKK models can definitely be used not only for estimations of conditional variances but also for *consistent* estimations of dynamic conditional correlations; while at the same time, assuming identical mean innovations feeding into the divergent conditional variance specifications, these authors show that BEKK models in fact, perform relatively better.

The conditional variance component of an MGARCH\((p, q)\)-BEKK model usually takes the

\(^{53}\) These representations include for example Dynamic Conditional Correlation (DCC) models, Constant Conditional Correlation (CCC) models and BEKK models.
The following general form\(^5\) (see *inter alia* Engle and Kroner, 1995):

\[
H_t = C'C + \sum_{k=1}^{K} C'_{1k} x_t x'_t C_{1k} + \sum_{k=1}^{K} \sum_{i=1}^{q} A'_{ik} u_{t-i} u'_{t-i} A_{ik} + \sum_{k=1}^{K} \sum_{i=1}^{P} B'_{ik} H_{t-i} B_{ik}. \tag{6.4.6}
\]

A simpler version of the model is given by Engle and Kroner (1995). In effect, the authors present an MGARCH(1,1)-BEKK of the general form:

\[
H_t = C'C + A'_{11} u_{t-1} u'_{t-1} A_{11} + B'_{11} H_{t-1} B_{11}, \tag{6.4.7}
\]

where \(H_t\) is a \(n \times n\) conditional variance-covariance matrix, \(c_{ij}\) are the elements of matrix \(C\) (i.e. a \(n \times n\) matrix of constant parameters), \(a_{ij}\) are the elements of the \(n \times n\) matrix \(A\) which captures spillover effects in the innovations from one variable to the other and \(b_{ij}\) are the elements of the \(n \times n\) matrix \(B\) which captures the persistence of conditional volatility between the chosen variables. Also note that \(C\) is a lower or upper - depending on the specification of the model - triangular matrix with \((n(n+1))/2\) parameters and \(A\) and \(B\) are \(n \times n\) matrices with \(n^2\) parameters each\(^5\) (Engle and Kroner, 1995).

Existing empirical research in the field has suggested various shorter alternative parameterisations of the conditional variance-covariance matrix \(H_t\) including among others the diagonal or the scalar MGARCH\((p, q)\)-BEKK model (see for example Sadorsky, 2012).

Equation (6.4.7) presents the full version of the MGARCH(1,1)-BEKK model and this is the version of the model that we employ in this section in order to model conditional variances and covariances.

Having computed the \(H_t\) matrix the last step would then be to compute the conditional (time-

\(^5\) This version of the model further includes exogenous influences (e.g. volatility inducing events such as a major slump in the economy, or effects coming from distant markets) determined in equation (6.4.6) by the term \(\sum_{k=1}^{K} C'_{1k} x_t x'_t C_{1k}\). Following Engle and Kroner (1995) the assumption of exogenous influences is dropped at both the MGARCH(1,1)-BEKK version and the matrix-representation of the model.

\(^5\) In all cases, \(n\) stands for the number of variables employed by a specific BEKK model.
varying) correlation between the variables of interest. As will be shown below, this can be easily achieved by dividing (standardising) the conditional covariance of the said variables by the square root of the product of their conditional variances.

In order to get a better understanding of an MGARCH(1,1)-BEKK model, we illustrate its matrix-representation for the bivariate case (Engle and Kroner, 1995):

\[
H_t = CC' + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \times \begin{bmatrix} u_{1t-1}^2 & u_{1t-1}u_{2t-1} \\ u_{2t-1}u_{1t-1} & u_{2t-1}^2 \end{bmatrix} \times \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} \\ b_{21} \end{bmatrix} \begin{bmatrix} b_{12} \\ b_{22} \end{bmatrix}' 
\]

\[
\times \begin{bmatrix} h_{11t-1} & h_{12t-1} \\ h_{21t-1} & h_{22t-1} \end{bmatrix} \times \begin{bmatrix} b_{11} \\ b_{21} \end{bmatrix} \begin{bmatrix} b_{12} \\ b_{22} \end{bmatrix}
\]

Note that the quadratic\(^{56}\) formulation of the model (i.e. a formulation of the persuasion: \(\Phi = X\Lambda X'\)) implies that the covariance matrices are positive definite and therefore variances will always be positive (as these are supposed to be) while the covariance between two series will be identical regardless of which series is primarily considered (Brooks, 2007).

However, before we proceed with the description of the modelling approach employed in this section, it would be instructive to outline the expected outcomes from the model. To begin with, as previously mentioned, any volatility model of this persuasion consists of two components; one equation referring to the conditional mean of the series and another equation referring to its conditional variance. As far as the mean equation of the model is concerned, expected results include the identification of potential significant mean returns spillovers not only among the variables of interest, but also, within each variable in terms of impact deriving from its own lagged values. Turning to the conditional variance equation, on one hand, significant parameters in the \(H_t\) matrix could be a first indication of the presence

\(^{56}\) Authors such as Brooks (2007) and Greene (2012) emphasise the importance of a positive definite matrix from the mathematics perspective. In particular, a positive definite matrix is expected not only to have just positive elements on its main diagonal, but also, to be symmetrical about its main diagonal. Understandably, this is very convenient in the case of a variance-covariance matrix. According to Engle and Kroner (1995) within the framework of an MGARCH(p,q)-BEKK model this issue of positive definiteness is being successfully accommodated.
of strong volatility effects. Decomposing the $H_t$ matrix as in (6.4.7) the information provided by the conditional variance equation of the model is associated with the effects of own (lagged) and cross-variable innovations (i.e. the information that stems from matrix $A$), as well as, the effects of own and cross-variable volatility persistence (i.e. the information that stems from matrix $B$) with regard to the series of interest. Finally, on the basis that variances and covariances are calculated we can derive the dynamic correlation between the variables of interest.

The main focus of this section is to produce evidence regarding the intertemporal evolution of the correlation between the monetary policy variable and financial prices, as well as, the monetary policy variable and housing prices. The descriptive statistics of the specific time series and their corresponding functional forms employed in this section have been thoroughly presented in chapter 5 of the thesis. In this regard, we proceed with the development of two models; one in order to investigate the dynamic correlation between monetary policy and financial prices and another one in order to investigate the dynamic correlation between monetary policy and housing prices. The first step of the process is to estimate the mean equations in order to recover the error terms which will then be used in the conditional volatility equation.

The generic form of the conditional mean equations employed in this study is given by:

$$G(L)\gamma_t = u_t,$$  \hspace{1cm} (6.4.9)

where $(u_t | \Omega_{t-1} \sim N(0, H_t)$) implying that $u_t$ is a vector of innovations given the amount of available information at time $t - 1$ (usually denoted as: $\Omega_{t-1}$) and its conditional variance-covariance matrix $H_t$. In each model there are two time series and therefore $\gamma_t = [\gamma_{1t}, \gamma_{2t}]$. In addition, $G_t$ is a $n \times n$ matrix where the elements of its main diagonal represent each variable's own mean returns spillovers, as opposed to the off diagonal
elements which represent cross-variable mean returns spillovers. The lag operator is given by \((L)\). In both models, the Akaike Information Criterion (AIC) qualifies a structure that considers information up to four months in the past (i.e. for both models \(L\) corresponds to a lag length equal to 4). Incorporating lagged values into our models allows for the removal of any autocorrelation effects in the standardised residuals. It is also important to note, that each conditional mean equation - in both models - further comprises the conditional variance of each respective variable under investigation. Despite the fact that this latter modelling approach results into some sort of deviation from the generic form of the conditional mean equation, as this is given by 6.4.9, it accounts for volatility effects and provides further insight into the relationship between the variables of interest. The particular results of this approach are given by tables 6.4.3 for the first model and table 6.4.7 for the second model. In retrospect, the structure of the conditional mean equations (regarding both models) fundamentally adheres to a typical vector autoregressive (VAR) structure of order four. However, as will be shown shortly, the AIC has qualified very specific relationships among the variables of interest.

In turn, under the MGARCH(1,1)-BEKK framework, the conditional variance-covariance matrix \(H_t\) - which is associated with the vector of innovations \(u_t\) - is given by 6.4.7 and 6.4.8. In order to obtain the estimated values for the parameters of the model we have to optimise a log-likelihood function. The log-likelihood function that is typically employed in the presence of a MGARCH\((p,q)\)-BEKK model takes the following general form\(^{57}\) (see inter alia Kearney and Patton, 2000; Brooks, 2007; Antonakakis and Badinger, 2011):

\[
\ell(\theta) = -\frac{kn}{2} + \ln(2\pi) - \frac{1}{2} \sum_{t=1}^{k} (\ln|H_t(\theta)| + \epsilon_t(\theta)'H_t(\theta)^{-1}\epsilon_t(\theta)),
\]

\(^{57}\) The optimisation of the log-likelihood function is performed by the employment of the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm available in the *Estima* RATS econometric software.
where, \( k \) is the number of observations and \( n \) is the number of variables included in the specification of the model and \( \vartheta \) is a vector of parameters (in particular the parameters included in matrices \( C, A \) and \( B \)) to be estimated. As aforementioned, on the basis that each model is responsible for the investigation of 2 variables, matrix \( C \) is expected to have a total number of \( \left( \frac{n(n+1)}{2} \right) \) or 3 parameters to be estimated, whereas matrices \( A \) and \( B \) are expected to have a total number of \( n^2 \) or 4 parameters each.

Finally, the conditional correlation (\( \rho \)) between the variables of interest (e.g. \( x_1 \) and \( x_2 \)) can be estimated by the following generic formula:

\[
\rho_{x_1,x_2,t} = \frac{H_{x_1,t}H_{x_2,t}}{\sqrt{H_{x_1,t}H_{x_2,t}}} .
\]

6.4.2 Empirical results and discussion

The purpose of this section is to estimate the conditional (time-varying) correlation between a monetary policy variable (approximated by a short-term interest rate; that is, the interbank rate) and housing and financial prices - as the latter are approximated by the Halifax housing prices index and the FTSE all-share index, respectively. In addition, all variables have been transmuted into logarithmic differences. The frequency of the data is monthly and the period of study ranges from January 1992 to December 2012. Particular details regarding the datasets can be found in chapter 5 of the present thesis. At a secondary level, using regression analysis, this section investigates whether other exogenous factors significantly contribute to changes in the conditional correlation which is estimated for the pertinent variables of each model.

Starting with the first model, we concentrate on the relationship between the monetary policy variable and financial prices. The conditional mean equation resembles the generic form of a
The typical conditional mean equation as the latter is given by 6.4.9. On the basis of the AIC, a certain quasi-VAR structure - to describe the relation between these two variables - is qualified, which, in particular, suggests that the return of financial prices is a function of:

- the percentage change in the short-term interest rate,
- the conditional variance of financial prices, and
- the conditional variance of the short-term interest rate

whereas, the percentage change of the short-term interest rate is considered to be a function of:

- the percentage change in the short-term interest rate itself
- the conditional variance of financial prices, and
- the conditional variance of the short-term interest rate itself.

In both equations, information is being traced back to a period of up to four lags.

As far as the conditional variance equations are concerned, it should be clear by now that the MGARCH(1,1)-BEKK model which is presented in 6.4.7 and 6.4.8 is in fact the structure which is considered to be the most appropriate for the estimation of both the conditional variance matrix $H_t$ and the time-varying correlations $\rho_{x_1,x_2,t}$. The coefficients of the conditional mean equations for the first model of this section are given by table 6.4.1.

Table 6.4.1 illustrates the results for the conditional mean equation. Apparently, we cannot report any significant cross variable mean spillovers apart from a lagged positive effect stemming from the percentage change in short-term interest rates at $t=3$. This result basically implies that previous (3 months in the past) percentage changes in the short-term interest rate have a positive (0.0818) impact on stock market returns.

On general principles, it is expected that the relationship between interest rates and stock market returns is a negative one as higher interest rates are typically associated with increased
cost of capital and therefore smaller future cash inflows (see *inter alia* Mishkin, 2001; Bjornland and Leitemo, 2009); however, a positive impact could perhaps be explained on the basis of the existence of a rather *indirect* as opposed to a *direct* relationship between interest rate changes and stock market returns, which is predicated upon inflationary expectations within the framework of an inflation targeting monetary policy regime.

**Table 6.4.1**: Conditional mean coefficients of model 1.

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Financial prices</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>21.8625**</td>
<td>-34.1534</td>
</tr>
<tr>
<td>Interest rate ( r_1 )</td>
<td>-0.0822</td>
<td>0.1135**</td>
</tr>
<tr>
<td>Interest rate ( r_2 )</td>
<td>-0.0027</td>
<td>0.2565***</td>
</tr>
<tr>
<td>Interest rate ( r_3 )</td>
<td>0.0818*</td>
<td>0.0386</td>
</tr>
<tr>
<td>Interest rate ( r_4 )</td>
<td>0.0185</td>
<td>0.0725**</td>
</tr>
<tr>
<td>Financial prices volatility</td>
<td>-0.0087**</td>
<td>0.0231**</td>
</tr>
<tr>
<td>Interest rate volatility</td>
<td>0.0047**</td>
<td>-0.0178***</td>
</tr>
</tbody>
</table>

*Notes: p-values in parentheses. p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote \( p < 0.01 \), \( p < 0.05 \), and \( p < 0.1 \) respectively.*

To be more explicit, under an inflation targeting regime it is the actual and the expected levels of inflation that matter the most for economic developments; implying that issues relating to interest rate and money growth changes are relegated to a secondary level (Sims, 2003). In this regard, an increase in the level of the monetary policy variable could be perceived as a positive signal from market participants in the sense that the monetary policy authority is consistently responding to its main task which is to successfully control inflation in the economy. In testament to this, Li et al. (2010) in analysing the effects of monetary policy on the stock markets of Canada (one of the first countries to adopt an explicit inflation
target in 1991) and the United States (a country which has not set an explicit inflation target) document that rises in the monetary policy instrument interest rate are far more greater in magnitude and more time-persistent in the US than they are in Canada. On the whole, these suggestions appear to be in line with authors such as Bean (2003), Lomax (2004), as well as, King (2012) who broadly argue that the adoption of an explicit inflation targeting by the Government and the pursuit of this target by an independent monetary policy authority can actually bolster confidence and lead to better macroeconomic results.

Turning to the conditional mean equation related to the monetary policy variable, it is not surprising that percentage changes in interest rates in the past have a statistically significant impact on current changes. Again, this might be related to a consistent implementation of the inflation targeting monetary policy strategy.

As mentioned earlier in this section, in order to provide as much information as possible regarding the variables of interest we also include volatility effects on the estimation of the percentage change of the variables of the model. It is understood that this is not an exhausting approach in terms of incorporating every potential alternative structure into the model; however, it is an interesting way to provide further insight on and to have a rough first approximation of the potential effects of volatility on the growth rates of the variables included in the model. The results of this approach are also given by table 6.4.1.

With reference to the first conditional mean equation concerning financial prices, table 6.4.1 reports that the conditional variance of financial prices has a statistically significant negative impact (-0.0087) on stock market returns, an outcome which apparently stands to reason (as volatile markets tend to be less of a rational choice for investors) and is in line with past and recent literature related to the field (see inter alia Poon and Granger, 2003; Leroy, 2013). Also, there is a positive impact (0.0047) of interest rate volatility on financial prices. We
maintain that the positive relationship between interest rate changes and stock market returns is due to a more credible inflation targeting monetary policy. Removing the element of surprise from the monetary policy decision making process, greatly affects the results we obtain regarding the impact of monetary policy in the volatility observed in the stock market (Bomfim, 2003).

With regard to the second conditional mean equation, financial volatility appears to have a statistically significant positive impact on interest rates (0.0231) whereas interest rate volatility has a significant negative (-0.0178) impact on its own changes. The positive effect of financial prices on interest rates has been reported by authors such as Rigobon and Sack (2003); however it is important to note that the positive reaction does not necessarily mean that the central bank is targeting stock market prices in order to narrow the possibility of the development of a bubble in the stock market. To re-iterate an issue brought forward earlier in this study, it is still a matter open to question whether monetary policy should respond or not to rises in asset prices (see inter alia Bernanke and Gertler, 2001; Wadhwani, 2008; Blanchard et al., 2010; Allen and Rogoff, 2011).

As far as the BoE is concerned Cobham (2013) documents that the MPC has long maintained that the bank does not target asset prices and that the policy reaction on asset prices movements is limited to the extent that the latter pose a threat to the overall level of inflation (i.e. because of the financial wealth effect). In this spirit, the reaction of monetary policy to asset prices in general can be considered as a systematic response on behalf of the central bank, which fashions the level of the instrument interest rate after having taken into account the wider macroeconomic conditions that may or may not be directly related to developments in the particular market (Rigobon and Sack, 2003).

Finally, the negative impact of interest rate volatility on the percentage change in the level of
the monetary policy variable could be related to the relatively unstable and turbulent period of analysis, a period characterised by consecutive and repeated declines in interest rates - especially after the most recent financial crisis of 2007.

Table 6.4.2: Conditional variance coefficients from the MGARCH(1,1)-BEKK specification for model 1.

<table>
<thead>
<tr>
<th></th>
<th>Financial prices</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial prices</td>
<td>0.0398 (0.4583)</td>
<td>-0.2927*** (0.0000)</td>
</tr>
<tr>
<td>Interest rate</td>
<td>-0.4746*** (0.0000)</td>
<td>0.5792*** (0.0000)</td>
</tr>
<tr>
<td>Financial prices</td>
<td>0.3382*** (0.0000)</td>
<td>0.3771*** (0.0000)</td>
</tr>
<tr>
<td>Interest rate</td>
<td>0.4953*** (0.0000)</td>
<td>0.5683*** (0.0000)</td>
</tr>
</tbody>
</table>

Notes: p-values in parentheses. ***, ** and * denote p < 0.01, p < 0.05, and p < 0.1 respectively. p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. 'Innovations' represents the ARCH effect and refers to matrix $A$ of equation 6.4.7, whereas 'persistence' represents the GARCH component and refers to matrix $B$ of equation 6.4.7.

Turning to the more specific results obtained from the first model of this section we concentrate on the information provided by table 6.4.2. As mentioned earlier in this section, according to the MGARCH(1,1)-BEKK specification, the conditional volatility of the time series of interest can be modelled as a function of squared lagged innovations (i.e. the ARCH effect) and own lagged values or persistence (i.e. the GARCH effect). The ARCH effect results correspond to matrix $A$ of equations 6.4.7 and 6.4.8 whereas the GARCH effect results correspond to matrix $B$ of the same equations. Furthermore, in a VAR framework apart from own-variable spillovers we can also identify cross-variable spillovers. The idea here is to effectively capture the forces behind financial and interest rate volatility.

As evident in table 6.4.2 almost all results are statistically significant implying the strong presence of both ARCH and GARCH effects.
In connection with ARCH effects, own innovation spillovers appear to be significant only in the case of the monetary policy variable. In particular, we observe that past interest rate innovations have a strong positive impact (0.5792) on the current volatility of interest rate changes. There is also a negative impact (-0.2927) on the current volatility of the change in the monetary policy variable deriving from past innovations of stock market returns; however, this impact is relatively weaker. As far as the volatility of financial prices is concerned, there is a positive - yet not statistically significant - impact (0.0398) from past innovations in stock market returns, as well as, a significant negative impact (-0.4746) deriving from past innovations in interest rate changes. On the whole, interest rate innovations (shocks) appear to have a key role to play for the volatility of both stock market returns and interest rate changes.

Regarding GARCH effects, we observe that both past own-variable and cross-variable volatility spillovers are important for explaining the current volatility in stock market returns and interest rate changes. In particular, the current volatility in stock market returns is positively influenced by its own lagged volatility (0.3382) and by the past volatility in interest rate changes (0.4953). Apparently, in the case of stock market returns, the cross-variable spillover effect is greater. Turning to the current volatility in interest rate changes, past own-variable volatility appears to have a greater impact (0.5683) as opposed to the respective effect deriving from the past volatility in stock market returns (0.3771).

In turn, the time-varying correlations pertaining to the monetary policy variable and financial prices are illustrated in figure 6.4.1 together with their 90% confidence intervals. As shown in this figure, the time-varying correlation between financial prices and the short-term interest rate is very volatile throughout the period of study, and assumes both negative and positive values. In addition, the correlation between these two variables appears to be stronger during
Figure 6.4.1: Conditional correlations between interest rate changes and stock market returns for the period 1992-2012.

Note: Shading areas correspond to recessions, as the latter have been identified by the National Bureau of Economic Research (NBER)
turbulent times - as this is evidenced by the values reported for the correlation for three standard periods of global recession (as the latter have been determined by the National Bureau of Economic Research and depicted as three distinct shading areas on figure 6.4.1).

It is also evident that the correlation between these two variables - be it negative or positive - has in effect become stronger, on average, after the outbreak of the 2007 financial crisis. In light of our previous analysis regarding the defining impact of inflation targeting monetary policy on the economy and the capital markets, this finding could be explained on the basis that during turbulent times the implemented macroeconomic policies are questioned and therefore news regarding developments in interest rates may have a rather direct impact on the stock market. Finally, we cannot argue that the time-varying correlations presented in figure 6.4.1 follow any particular positive or negative trend.

On the whole, we put forward the argument that this section has so far provided clear evidence regarding the fact that the relation between financial prices and interest rates is not as straightforward as was perhaps initially thought. Future work could further incorporate the employment of a policy uncertainty index which could perhaps help improve our understanding even further.

Finally, in an effort to explain the factors that determine the intertemporal evolution of these time-varying correlations we run a series of regressions including exogenous factors such as a one period lag of time-varying correlation, oil prices, industrial production, as well as, housing prices. All variables employed have been presented in chapter 5 of the thesis. Furthermore, all variables have been transformed into logarithmic differences. The results are given by table 6.4.3 below.
Table 6.4.3: Regression analysis coefficients for model 1.

<table>
<thead>
<tr>
<th>Independent variables:</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying correlation t-1</td>
<td>0.3927*** (0.0000)</td>
<td>0.3918*** (0.0000)</td>
<td>0.3897*** (0.0000)</td>
</tr>
<tr>
<td>Oil prices</td>
<td>0.9201* (0.0503)</td>
<td>0.913* (0.0536)</td>
<td>0.9231* (0.0508)</td>
</tr>
<tr>
<td>Industrial production</td>
<td>0.7989 (0.8430)</td>
<td>0.8608 (0.8319)</td>
<td>-1.7567 (0.6600)</td>
</tr>
<tr>
<td>Housing prices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0946*** (0.0072)</td>
<td>-0.0946*** (0.0074)</td>
<td>-0.0887** (0.0205)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.1669</td>
<td>0.1669</td>
<td>0.1681</td>
</tr>
</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

According to the first regression equation, both correlation of the previous period and oil prices appear to have a positive statistically significant impact on the time-varying correlation between financial prices and the monetary policy variable, suggesting that both of these factors drive correlation into higher positive values. This result may very well stand to reason as, on general principles, oil prices tend to introduce inflationary pressures into the economy thus triggering contractionary monetary policy. In addition, a positive impact of oil prices on stock market returns could be explained in the event of an aggregate-demand oil price shock.

As explained in chapter 3 of the thesis, the outcome of an increase in the price of oil may differ remarkably depending on the origin of this positive shock. It would be very interesting - and this could also be considered as part of future research - to incorporate in our analysis the distinction between the various types of oil price shocks as this has been suggested by Hamilton (2009) and Kilian (2009). Similarly to what was mentioned in the previous section though, results regarding the effects of oil prices should not be regarded as something more
than just a first indication and this is also suggested by the results we obtain and present in appendix D where in the framework of two arbitrarily chosen periods for which we choose to repeat the exercise the effects of oil are not always significant.

The second equation in table 6.4.3 involves adding industrial production to the list of explanatory variables, whereas the third equation involves further adding housing prices as a potential factor to explain the evolution of correlation over time. Neither of these variables though, appears to have any statistical significant impact on the relationship under investigation. Part of future research could also include identifying additional variables to help us elucidate even further the factors that affect the time-varying correlations between stock market returns and short-term interest rates.

Turning to the second model of this section, we concentrate on the relationship between the monetary policy variable and housing prices. The AIC qualifies a standard VAR specification of order four for the relevant conditional mean equations. In this VAR(4) framework, the percentage changes in housing prices are assumed to be a function of:

- the percentage change in their own lagged values
- the percentage change in the short-term interest rate
- the conditional variance of housing prices, and
- the conditional variance of the short-term interest rate

whereas, the percentage changes in the short-term interest rate are regarded as a function of:

- the percentage change in their own lagged values
- the percentage change in housing prices
- the conditional variance of housing prices, and
- the conditional variance of the short-term interest rate
In both equations, information is being traced back to a period of up to four lags.

In line with the first model, both the conditional variance matrix \( H_t \) and the time-varying correlations \( \rho_{x_{t-1}x_{t-2}} \) are estimated based on the MGARCH(1,1)-BEKK specification presented in equations 6.4.7 and 6.4.8.

The coefficients of the conditional mean equations for the second model of this section are given by tables 6.4.4.

**Table 6.4.4:** Conditional mean coefficients of model 2.

<table>
<thead>
<tr>
<th>Dependent variable: Housing prices</th>
<th>Dependent variable: Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.2861</td>
</tr>
<tr>
<td>Housing prices ( t^{-1} )</td>
<td>0.0583</td>
</tr>
<tr>
<td>Housing prices ( t^{-2} )</td>
<td>0.1987***</td>
</tr>
<tr>
<td>Housing prices ( t^{-3} )</td>
<td>0.2443***</td>
</tr>
<tr>
<td>Housing prices ( t^{-4} )</td>
<td>0.2768***</td>
</tr>
<tr>
<td>Interest rate ( t^{-1} )</td>
<td>-0.0051</td>
</tr>
<tr>
<td>Interest rate ( t^{-2} )</td>
<td>-0.0419***</td>
</tr>
<tr>
<td>Interest rate ( t^{-3} )</td>
<td>0.0075</td>
</tr>
<tr>
<td>Interest rate ( t^{-4} )</td>
<td>-0.0222**</td>
</tr>
<tr>
<td>Housing prices volatility</td>
<td>-0.008</td>
</tr>
<tr>
<td>Interest rate volatility</td>
<td>(-3E-05)**</td>
</tr>
</tbody>
</table>

Notes: \( p \)-values in parentheses. \( p \)-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote \( p < 0.01 \), \( p < 0.05 \), and \( p < 0.1 \) respectively.

The information provided by table 6.4.4 suggests that percentage changes in housing prices are positively influenced by respective changes in housing prices of the past and negatively influenced by previous changes in the short-term interest rate of the economy. As mentioned earlier in this study (see inter alia Whitehead and Williams, 2011; ONS, 2013a) low interest rates typically entail lower cost of borrowing money to buy a property - justifying the negative sign in the relation between housing prices and the interest rate (in particular, see the
statistically significant coefficients: -0.0419 and -0.0222). Similar results have also been reported for the UK from authors such as Iacoviello and Minetti (2003), Giuliodori (2005), as well as, Narayan and Narayan (2011).

Table 6.4.4 further provides information regarding a positive effect of the change in housing prices on the short-term interest rate of the economy (i.e. coefficients: 0.5287, 0.3446, as well as, 0.4314). Up to a certain extent, this finding reflects the reaction of the central bank within an inflation targeting monetary policy setting.

However, in order to re-iterate a point mentioned above, this relation should not be regarded as an effort on behalf of the central bank to directly target asset prices. Stephens (2012) in a detailed analysis of the factors that could potentially subdue high prices and volatility in UK housing prices, argues in favour of primarily sector-specific measures (as opposed to the economy-wide interest rate decisions) such as imposing limits to mortgage lending or property taxes to home-owners.

On a final note, findings presented in table 6.4.4 further suggest that there is a significant relationship (not too clear as far as its direction is concerned; yet positive for its most part - in particular, see coefficients: -0.2393, 0.1807, 0.1583, as well as, 0.0879) between changes in interest rates in the past and current changes. A positive statistically significant relation between previous and the current rate of change in the monetary policy variable is also the finding of the previous model (see table 6.4.1).

With regard to volatility spillovers, findings presented in table 6.4.4 suggest that the conditional volatility of interest rates has a negative and significant effect on housing prices. Again, if high interest rate volatility is related to frequent adjustments on behalf of the monetary policy authority in order to successfully accommodate macroeconomic issues related to achieving the inflation target then it should be welcome by market agents.
However, the housing market is very different from the stock market in many ways - in general - and in terms of immediately reflecting positive changes in the economy - in particular. To be more explicit, by authors such as Bjornland (2008) and Bernanke and Kuttner we briefly recall the views put forward (2005) - presented in chapter 3 of the study - who explain that asset prices react rather more quickly to monetary policy developments and can therefore act as transmitters of such developments in the economy as opposed to other types of assets. In this regard, we strongly believe that this particular relation deserves further investigation. An alternative possible explanation regarding the negative impact of interest rate volatility on housing prices might be the fact that high volatility in interest rates could be conducive to negative expectations regarding the future lending rates in the economy (this is particularly true for mortgage loans structured on the basis of variable interest rates) resulting in agents reluctant to acquire a loan and thus to lower demand for properties and lower housing prices. However, all of these suggestions are put forward with the highest caution as the UK housing market exhibits many unique characteristics (a pronounced lack of supply being its first and foremost) implying that any results concerning the housing market may be quite difficult to interpret.

Turning to the more specific results obtained from the second model of this section, we concentrate on the information provided by table 6.4.5. The MGARCH(1,1)-BEKK specification is identical to that of the first model, with the only difference being housing prices replacing financial prices. In this respect, our aim this time is to effectively capture the forces behind housing and interest rate volatility. As evident in table 6.4.5 our results imply strong ARCH effects, both own and cross-variable, and some own-variable GARCH effects.

In connection with ARCH effects, both own-variable and cross-variable innovations appear to be important for the current volatility of both housing prices and interest rates. In
particular, past housing prices innovations appear to have a positive and significant (0.2791) impact on the current volatility of housing prices, whereas past interest rates innovations have a negative and significant (-0.7664) effect on the current volatility of housing prices. Apparently the impact deriving from interest rate innovations is stronger.

On the other hand, the current volatility of the monetary policy variable receives positive and significant (0.0194) feedback from the volatility in housing prices (suggesting that housing prices should be considered in the formulation of monetary policy-making decisions). In addition, current volatility in the short-term interest rate can also be explained by its own volatility in the past (see coefficient: 1.0967).

Turning to GARCH effects, it is evident that only own-variable volatility spillovers are significant in explaining the current volatility of both housing prices and interest rates.

**Table 6.4.5:** Conditional variance coefficients from the MGARCH(1,1)-BEKK specification for model 2.

<table>
<thead>
<tr>
<th></th>
<th>Housing prices</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing prices innovations</td>
<td>0.2791***</td>
<td>0.0194**</td>
</tr>
<tr>
<td>Interest rate innovations</td>
<td>-0.7664**</td>
<td>1.0967***</td>
</tr>
<tr>
<td>Housing prices persistence</td>
<td>0.8982***</td>
<td>0.0091</td>
</tr>
<tr>
<td>Interest rate persistence</td>
<td>0.4158</td>
<td>0.1873**</td>
</tr>
</tbody>
</table>

Notes: p-values in parentheses. ***, ** and * denote p < 0.01 , p < 0.05 , and p < 0.1 respectively. p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. 'Innovations' represents the ARCH effect and refers to matrix A of equation 6.4.7, whereas 'persistence' represents the GARCH component and refers to matrix B of equation 6.4.7.

More particularly, past volatility of housing prices appears to have a positive and significant (0.8982) effect on the current conditional variance of housing prices, while at the same time,
past interest rate volatility has a positive and significant (0.1873) impact on the current conditional volatility of the monetary policy variable.

In turn, the time-varying correlations pertaining to the monetary policy variable and housing prices are illustrated in figure 6.4.2 together with their 90% confidence intervals. As shown in this figure, the time-varying correlation between housing prices and the short-term interest rate is very volatile throughout the period of study, and assumes both negative and positive values. In addition, the correlation between these two variables appears to be stronger during turbulent times - as this is evidenced by the values reported for the correlation for three standard periods of global recession (as the latter have been determined by the National Bureau of Economic Research and depicted as three distinct shading areas on figure 6.4.2). Similarly to the case of the time-varying correlations between financial prices and the short-term interest rate, it is also evident that the correlation between housing prices and the short-term interest rate - be it negative or positive - has achieved its peak values after the outbreak of the 2007 financial crisis.

Finally, we cannot argue that the time-varying correlations presented in figure 6.4.2 follow any particular positive or negative trend. In effect, results show that housing prices in the UK are indeed very volatile, perhaps more volatile than we would expect given their particular features.

On a final note, authors such as Tsatsaronis and Zhu (2004) and Mishkin (2007), put forward the argument that housing prices tend to be more volatile in countries with a high ratio of mortgage loans based on variable rates. In supplement to this, authors such as Miles (2004) and Becker et al. (2012) report that most mortgage loans in the UK have indeed been offered on the basis of some variable rate.
Figure 6.4.2: Conditional correlations between interest rate changes and housing market returns for the period 1992-2012.

Note: Shading areas correspond to recessions, as the latter have been identified by the National Bureau of Economic Research (NBER)
Finally, in an effort to explain the factors that determine the intertemporal evolution of these time-varying correlations we run a series of regressions including exogenous factors such as a one period lag of time-varying correlation, oil prices, industrial production, as well as, financial prices. All variables employed have been presented in chapter 5 of the thesis. Furthermore, all variables have been transformed into logarithmic differences. The results are given by table 6.4.6 below.

Unfortunately, none of the equations employed appears to have produced statistically significant coefficients; suggesting that overall, we should perhaps employ alternative explanatory variables in order to approach this specific research hypothesis. Part of future research will inevitably be linked to this endeavour as well.

Table 6.4.6: Regression analysis coefficients for model 2.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying correlation t-1</td>
<td>-0.0472 (0.6133)</td>
<td>-0.0314 (0.7401)</td>
<td>-0.0322 (0.7354)</td>
</tr>
<tr>
<td>Oil prices</td>
<td>-0.1107 (0.7814)</td>
<td>-0.15 (0.7039)</td>
<td>-0.1876 (0.6357)</td>
</tr>
<tr>
<td>Industrial production</td>
<td>4.0096 (0.2265)</td>
<td>4.3973 (0.2273)</td>
<td></td>
</tr>
<tr>
<td>Financial prices</td>
<td></td>
<td>0.3868 (0.5273)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.3228*** (0.0000)</td>
<td>0.3182*** (0.0000)</td>
<td>0.317*** (0.0000)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0026</td>
<td>0.0095</td>
<td>0.0110</td>
</tr>
</tbody>
</table>

Notes: p-values in parentheses. p-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, *** , ** and * denote p < 0.01 , p < 0.05 , and p < 0.1 respectively.

In retrospect, this section provides evidence relating to both the conditional time-varying correlation between financial prices and the monetary policy variable, and the conditional
time-varying correlation between housing prices and the monetary policy variable. In both cases the correlation appears to fluctuate considerably over time and to assume both positive and negative values. It is also evident that the correlation between these two pairs of variables becomes stronger during turbulent periods. In addition, no particular trend can be identified, either positive or negative.

As far as the first relation is concerned, potential explanations regarding the observed patterns of correlation can be traced in the interpretation of the important role of the inflation targeting regime. On top of that, the price of oil provides significant feedback to this relationship. Turning to the specific relation between housing prices and the monetary policy variable, potential explanations can be traced in the link between monetary policy decisions and the cost of borrowing, as well as, to the unique characteristics of the UK housing market. Future work relating to this section should focus on enhancing the model with more relevant variables to capture perhaps issues related to policy uncertainty, cost of borrowing, as well as, demand and supply side oil price shocks.

Finally, it would be instructive at this point to note that the time-varying correlation approach employed to measure the inter-temporal relation between the variables of interest actually measures the linear association between these variables. It has been argued (see inter alia, Granger and Lin, 1994; Maasoumi and Racine, 2002) that when nonlinearities are present in the employed datasets then linear approaches are not perhaps the ideal approach. Given that for the most part financial time series appear to be non-linear (see inter alia, Brooks, 2007) it would be interesting to also adopt alternative approaches in order to investigate the said association. In particular, a promising method could be the non-linear correlation measure based on mutual information (see among others, Granger and Lin, 1994; Darbellay and Wuertz; 2000; Hassani et al. 2010). The particulars of this method are not to the present
purpose of this study; however, it should be noted that this approach is able to capture nonlinearities and does not require making any further assumptions regarding the type of distribution followed by the datasets under investigation. In this regard, future work could also be directed towards these avenues.
This study involves the development of four macroeconometric essays in order to provide further insight into the relationship between UK inflation monetary policy and housing or financial markets. Each essay predicates upon a specific working assumption and purports to answer a specific question. Regarding the specific econometric methods employed, the first essay develops a structural VAR model aiming to capture the wealth effect of UK monetary policy on consumption, the second essay develops a structural VAR model to account for the interaction between monetary and fiscal policy, the third essay develops a Markov regime switching model for each asset market to mainly identify potential regimes that both markets may find themselves in, whereas the fourth essay develops two MGARCH(1,1)-BEKK models in order to determine the time-varying correlation between monetary policy and housing prices, as well as, between monetary policy and financial prices. The contribution of this study is strongly related to the investigation of the evolving nature of the aforementioned relationships in the light of inflation targeting monetary policy. In addition, the econometric methods employed in the study help some under-researched relations come on stage.

This chapter concludes the study. Initially, an overview of the main results is presented, not only with respect to each individual essay, but also, in terms of a general observation that emerges from the analysis regarding developments in both asset markets in the light of inflation targeting monetary policy. In turn, we provide an account of potential limitations related to the study, as well as, suggestions / intentions regarding future work.
7.1 Main findings of the study

7.1.1 Empirical findings related to each individual study

As far as the first essay is concerned, the investigation of whether there exists a wealth channel of monetary policy in the UK has provided us with valuable insight regarding the specific relationship between monetary policy innovations and financial or housing markets. In particular, we provide evidence that traditional transmission mechanisms which implied a direct negative effect of monetary policy decisions on financial prices are no longer valid under the inflation targeting monetary policy regime. Results show that monetary policy shocks have a direct negative effect only on housing prices. We also provide evidence that there exists a positive (yet rather transitory) effect of housing prices on financial prices. Evidence further suggests that a large proportion of the variation in stock market prices can be explained by changes in the housing market. Both markets have a non-trivial role to play with respect to informing monetary policy. Finally, although positive developments in the stock markets do have an impact on households' consumption, we cannot argue in favour of the existence of a clear wealth channel of monetary policy that affects households' consumption.

Turning to the second essay, we observe that the inclusion of a fiscal policy variable reinstates the negative effect of monetary policy on the stock market. By employing two different SVAR models (and also by considering the results from the SVAR model of the previous section) we believe that our findings are indicative of an indirect channel between fiscal policy and the stock market through monetary policy. We also provide evidence of a crowding out effect in the UK and that both policies react in a countercyclical way with respect to inflation. Unfortunately, this model is very silent in terms of providing any useful or significant information regarding the effects on the responses of the housing market.
In the third essay initially we identify potential regimes for both asset markets and then we argue in favour of the predictability of our model by testing factors that could potentially explain what drives asset markets to change regimes. The classification of the regimes distinguishes between a high and a low volatility regime. Results are more clear as far as the stock market is concerned. By contrast, the idea that there can be only two regimes for the housing market seems to hold until a couple of years before the outburst of the recent financial meltdown. Similar studies for other countries suggest that a 3-state Markov regime switching model for the housing market would be more appropriate. Be all this as it may, we provide evidence that rises in interest rates help both asset markets remain at the high volatility regime. Furthermore, oil prices also contribute towards the tendency of housing prices to remain at the high volatility regime.

The main outcome from the fourth essay is that the time-varying correlation between monetary policy and the housing or the financial market may assume both positive and negative values, does not exhibit any particular trend and becomes stronger during turbulent times. We also provide evidence that interest rate volatility is positively perceived by financial prices and negatively perceived by housing prices. Furthermore, there is no evidence that changes in the interest rates *per se* have a negative impact on the stock market (we can only identify a significant positive effect with a 3-month lag). The reverse is true for the housing market (we find significant negative effects of changes in the interest rates on housing prices). Finally, oil prices lead the time-varying correlation between monetary policy and the stock market to higher positive values.

7.1.2 Synthesis

On the basis of the results obtained from each individual study we could arrive at two important conclusions. The first one relates to the specific relationship between UK monetary policy and the stock market. According to evidence provided in section 6.1 there is no
significant impact of monetary policy innovations on stock market returns. This can be viewed as a reasonable outcome considering that the adopted monetary policy regime promotes confidence in the economy and helps anchor expectations regarding future inflation. The stock market appears unaffected by innovations in monetary policy and this is also evident in section 6.4 where stock market returns respond positively to interest rate volatility. The stock market salutes changes in interest rates as part of a well organised plan on behalf of the monetary policy authority to keep the economy on an even keel. However, in section 6.4 we find that during turbulent times the correlation between the monetary policy instrument and the stock market becomes stronger. In other words, when the conditions in the economy are such that the confidence of the public in macroeconomic policies is tested then there may be a closer (and significant) link between monetary policy decision making and stock market developments. This is verified by the evidence provided in section 6.3 according to which, when the stock market is already at a high volatility regime then rises in the interest rates will push the stock market to remain in this high volatility regime. In section 6.2 we provide evidence that fiscal policy has both a direct and an indirect negative effect on the stock market. Government policy decision making plays a key role in shaping current economic conditions. Positive innovations in Government spending are punished by the stock market as factors that contribute to financial instability.

Turning to the housing market, this appears to be exclusively affected by monetary policy. According to evidence presented in section 6.1, monetary policy innovations immediately have a negative effect on the housing market. In section 6.4 we also find that interest rate volatility negatively affects the housing market. In turn, section 3 implies that when the housing market is at a high volatility regime rises in the monetary policy instrument will push the housing market to remain at that regime. By contrast, we cannot provide any evidence
regarding a significant negative effect (direct or indirect) from fiscal policy innovations to the housing market.

Apparently the empirical evidence provided in this study is important to decision makers, scholars and investors in both the stock and the housing market. We argue in favour of the consideration of both fiscal and monetary policies in the formulation of macroeconomic decisions and the analysis of the effects of each policy on asset markets. Policy makers, should be aware that the effects of their decision making differs depending on whether both polices are being considered in tandem or not. Investors in the stock market should consider the interaction of both demand-side policies before deciding upon investments. By contrast, investors in the housing market and home owners should always consider that a key factor that determines the level of housing prices (and potentially their ability to enjoy higher levels of consumption based on home-collateralised loans) is indeed monetary policy and the current level of the interest rate. In particular, chapter 3 introduced us to the various channels through which both monetary and fiscal policy decisions affect asset markets. Traditional transmission mechanisms suggest that innovations in monetary policy have a non-trivial impact on both asset markets. Although this study provides evidence against the direct traditional link between monetary policy and the stock market, we find that these effects greatly depend on the broader economic conditions (which are largely affected and determined by fiscal policy). If therefore, there is indeed a link between the two macroeconomic policies (as suggested by this study) then this information is very useful to both investors and firms. Recall for example the impact of interest rate changes on the net worth of a business or on its ability to raise funds. Investors on the other hand, need this information in order to make the necessary portfolio adjustments and protect their investments against unexpected changes in macroeconomic policy. On top of that, households which according to traditional monetary policy channels can be affected on the
basis of higher / lower cost of borrowing and are thus expected to consume less / more of their housing wealth, could find the evidence provided in this study useful - especially in connection with their future consumption and investment decisions. This study also provides useful information for policy makers. On one hand, we provide evidence relating to the various sources which inform the monetary policy instrument, while on the other, considering the argument in favour of an interaction between the two macroeconomic policies and the differing outcomes which this interaction entails, policy makers could potentially accomplish more effective policy decisions. Policy makers should also consider the effects of increased oil prices which according to our findings have a key role to play regarding the behaviour of the variables of interest. The transmission mechanisms between innovations in the price of oil and monetary policy have also been presented in chapter 3 of this study.
7.2 Limitations of the study and future work

The empirical findings presented in this study have a value of their own and overall we are satisfied with the information provided by the adopted econometric methods. The analysis of the results at the discussion section of each essay, as well as, the composition of some of the outcomes presented in different essays reveal that we are able to capture important developments and relations regarding the variables of interest.

We maintain that this is the beginning of a wider set of efforts regarding the investigation of the relevant linkages. It is understandable that although results on all four essays appear to make specific suggestions regarding the thread that weaves together our key variables, further research is required to bolster the validity of the outcomes of this study even further.

As far as the methods per se are concerned, the main limitations of this study revolve around the difficulty to incorporate as many equations to the VAR model as we would have liked. The structure of a typical VAR model amounts to a maximum of 8 equations implying that only a given number of relationships can be investigated by each model.

Furthermore, the incorporation of a fiscal policy variable generally entails a low frequency of data. Given the relatively constrained period of our study, the use of quarterly data has an immediate impact on the number of observations available for running the models and making inferences. Alternative fiscal policy approximations entail even lower frequencies rendering the comparison of different approaches very difficult.

In addition, there are various more complicated definitions for both housing and financial wealth. However, the adoption of these definitions would complicate the identification scheme of our model leading to a model with more arbitrary constraints. In their current
structure, the arbitrary constraints employed in the SVAR models of the study are kept to a minimum.

Another limitation concerns the adoption of only two potential regimes for the housing market. It appears that a 3-state Markov process would describe the market more sufficiently especially after 2005. This limitation pertains to computational difficulties and weighs on the author's shoulders.

With reference to future work, all above mentioned concerns should be accommodated in order to have a complete picture of the forces that drive the relations of interest. We need to develop models to account for more than just one approximation of fiscal policy and just a single definition for housing and financial wealth respectively. A third potential regime for the housing market is required to capture the steep decline in housing prices right before and right after the financial crisis of 2007. It would also be very interesting to test the effects of oil prices - both within the framework of a regime switching and a multivariate GARCH model - considering though, the origin of the shock in the price of oil. In addition, the inclusion of a longer-term interest rate in a VAR model could provide us with better insight in connection with the duration of potential crowding out effects.

Finally, we need to improve our econometric methods (or use different approaches) in order to improve the results we get with regard to the specific interaction between housing and financial prices. In this direction it would be interesting to develop an MGARCH model and estimate their time-varying volatility. It is understandable that the relationship between monetary policy developments and housing and financial markets can be a wide topic and in this regard there are quite a few assumptions that could be put to the test. Working towards a link between the results we get from empirically coherent models and the theoretical considerations provided by DSGE models would be the ideal next step for this study.
APPENDICES
A1. Accumulated responses of all variables of interest to a monetary policy shock

Figure A.1.1: Accumulated response of domestic income to a shock in monetary policy. Different lines correspond to different periods.

Figure A.1.2: Accumulated response of inflation to a shock in monetary policy. Different lines correspond to different periods.
Figure A.1.3: Accumulated response of demand for money to a shock in monetary policy. Different lines correspond to different periods.

Figure A.1.4: Accumulated response of the short-term interest rate to a shock in monetary policy. Different lines correspond to different periods.

Figure A.1.5: Accumulated response of the stock market to a shock in monetary policy. Different lines correspond to different periods.
Figure A.1.6: Accumulated response of the housing market to a shock in monetary policy. Different lines correspond to different periods.

Figure A.1.7: Accumulated response of households' consumption to a shock in monetary policy. Different lines correspond to different periods.
A2. ACCUMULATED RESPONSES OF ALL VARIABLES OF INTEREST TO A HOUSING PRICES SHOCK

Figure A.2.1: Accumulated response of domestic income to a shock in housing prices. Different lines correspond to different periods.

Figure A.2.2: Accumulated response of inflation to a shock in housing prices. Different lines correspond to different periods.
Figure A.2.3: Accumulated response of demand for money to a shock in housing prices. Different lines correspond to different periods.

Figure A.2.4: Accumulated response of the short-term interest rate to a shock in housing prices. Different lines correspond to different periods.

Figure A.2.5: Accumulated response of the stock market to a shock in housing prices. Different lines correspond to different periods.
Figure A.2.6: Accumulated response of the housing market to a shock in housing prices. Different lines correspond to different periods.

Figure A.2.7: Accumulated response of households’ consumption to a shock in housing prices. Different lines correspond to different periods.
A3. ACCUMULATED RESPONSES OF ALL VARIABLES OF INTEREST TO A FINANCIAL PRICES SHOCK

Figure A.3.1: Accumulated response of domestic income to a shock in financial prices. Different lines correspond to different periods.

Figure A.3.2: Accumulated response of inflation to a shock in financial prices. Different lines correspond to different periods.
Figure A.3.3: Accumulated response of demand for money to a shock in financial prices. Different lines correspond to different periods.

Figure A.3.4: Accumulated response of the short-term interest rate to a shock in financial prices. Different lines correspond to different periods.

Figure A.3.5: Accumulated response of the stock market to a shock in financial prices. Different lines correspond to different periods.
Figure A.3.6: Accumulated response of the housing market to a shock in financial prices. Different lines correspond to different periods.

Figure A.3.7: Accumulated response of households' consumption to a shock in financial prices. Different lines correspond to different periods.
APPENDIX B
B1. ACCUMULATED RESPONSES OF ALL VARIABLES OF INTEREST TO A FISCAL POLICY SHOCK

Figure B.1.1: Accumulated response of Government spending to a fiscal policy shock. Different lines correspond to different periods.

Figure B.1.2: Accumulated response of domestic income to a fiscal policy shock. Different lines correspond to different periods.
Appendix B

Figure B.1.3: Accumulated response of demand for money to a fiscal policy shock. Different lines correspond to different periods.

Figure B.1.4: Accumulated response of the short-term interest rate to a fiscal policy shock. Different lines correspond to different periods.

Figure B.1.5: Accumulated response of the stock market to a fiscal policy shock. Different lines correspond to different periods.
Appendix B

Figure B.1.6: Accumulated response of the housing market to a fiscal policy shock. Different lines correspond to different periods.

B2. ACCUMULATED RESPONSES OF THE STOCK AND THE HOUSING MARKET TO A MONETARY POLICY SHOCK WITHIN THE FISCAL-EXCLUSIVE FRAMEWORK

Figure B.2.1: Accumulated response of the stock market to a monetary policy shock. Different lines correspond to different periods.
Figure B.2.2: Accumulated response of the housing market to a monetary policy shock. Different lines correspond to different periods.

B3. ACCUMULATED RESPONSES OF ALL VARIABLES OF INTEREST TO A MONETARY POLICY SHOCK WITHIN THE FISCAL-INCLUSIVE FRAMEWORK

Figure B.3.1: Accumulated response of Government spending to a monetary policy shock. Different lines correspond to different periods.
Figure B.3.2: Accumulated response of domestic income to a monetary policy shock. Different lines correspond to different periods.

Figure B.3.3: Accumulated response of demand for money to a monetary policy shock. Different lines correspond to different periods.

Figure B.3.4: Accumulated response of the short-term interest rate to a monetary policy shock. Different lines correspond to different periods.
Figure B.3.5: Accumulated response of the stock market to a monetary policy shock. Different lines correspond to different periods.

Figure B.3.6: Accumulated response of the housing market to a monetary policy shock. Different lines correspond to different periods.
**B4. Evidence of Counter-Cyclical Monetary and Fiscal Policy to an Inflationary Shock within the Fiscal-Inclusive Framework**

![Graph](image)

**Figure B.4.1:** Accumulated response of Government spending to a shock in inflation. Different lines correspond to different periods.

![Graph](image)

**Figure B.4.2:** Accumulated response of demand for money to a shock in inflation. Different lines correspond to different periods.
Figure B.4.3: Accumulated response of the short-term interest rate to a shock in inflation. Different lines correspond to different periods.
APPENDIX C
Table C.1: Factors that affect $p(S_t = 0)$ for the stock market between the period 1992:1 2001:12.

<table>
<thead>
<tr>
<th>Dependent variable: The probability that the stock market remains at the high volatile regime [$p(S_t = 0)$]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equation 1</strong></td>
</tr>
<tr>
<td>Short-term interest rate</td>
</tr>
<tr>
<td>Other control variables:</td>
</tr>
<tr>
<td>$[p(S_t = 0)]_{t-1}$</td>
</tr>
<tr>
<td>Housing prices</td>
</tr>
<tr>
<td>Inflation</td>
</tr>
<tr>
<td>Industrial production</td>
</tr>
<tr>
<td>Oil</td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>R-squared</td>
</tr>
</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively. $S_t = 0$ is the high volatility regime for the stock market.

Table C.2: Factors that affect $p(S_t = 0)$ for the stock market between the period 2002:1 2012:12.

<table>
<thead>
<tr>
<th>Dependent variable: The probability that the stock market remains at the high volatile regime [$p(S_t = 0)$]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equation 1</strong></td>
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<td>Short-term interest rate</td>
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</tr>
<tr>
<td>$[p(S_t = 0)]_{t-1}$</td>
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<tr>
<td>R-squared</td>
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</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively. $S_t = 0$ is the high volatility regime for the stock market.
Table C.3: Factors that affect $p(S_t = 1)$ for the housing market between the period 1992:1 2001:12.

<table>
<thead>
<tr>
<th>Dependent variable: The probability that the housing market remains at the high volatile regime [$p(S_t = 1)$]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equation 1</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Short-term interest rate</td>
</tr>
<tr>
<td>Other control variables:</td>
</tr>
<tr>
<td>$[p(S_t = 1)]_t$</td>
</tr>
<tr>
<td>Financial prices</td>
</tr>
<tr>
<td>Inflation</td>
</tr>
<tr>
<td>Industrial production</td>
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<tr>
<td>Oil</td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>R-squared</td>
</tr>
</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively. $S_t = 1$ is the high volatility regime for the housing market.

Table C.4: Factors that affect $p(S_t = 1)$ for the housing market between the period 2002:1 2012:12.

<table>
<thead>
<tr>
<th>Dependent variable: The probability that the housing market remains at the high volatile regime [$p(S_t = 1)$]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equation 1</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Short-term interest rate</td>
</tr>
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<td>Other control variables:</td>
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<td>$[p(S_t = 1)]_t$</td>
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<td>Constant</td>
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<tr>
<td>R-squared</td>
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</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively. $S_t = 1$ is the high volatility regime for the housing market.
Table D.1: Time-varying correlation between monetary policy and the stock market for the period 1992:1 to 2001:12.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying correlation</td>
<td>0.3589 **</td>
<td>0.0009</td>
<td>0.3705 **</td>
</tr>
<tr>
<td>Oil prices</td>
<td>0.3609 *</td>
<td>0.0894</td>
<td>0.3415</td>
</tr>
<tr>
<td>Industrial production</td>
<td>-2.0793</td>
<td>-0.2254</td>
<td>-2.0520</td>
</tr>
<tr>
<td>Housing prices</td>
<td>2.0230 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0717 **</td>
<td>0.0018</td>
<td>-0.0683 **</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.141692</td>
<td>0.148456</td>
<td>0.157193</td>
</tr>
</tbody>
</table>

Notes: *p*-values in parentheses. *p*-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

Table D.2: Time-varying correlation between monetary policy and the stock market for the period 2002:1 to 2012:12.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying correlation</td>
<td>0.4620 **</td>
<td>0.0001</td>
<td>0.4619 **</td>
</tr>
<tr>
<td>Oil prices</td>
<td>0.1044</td>
<td>0.7270</td>
<td>0.1593</td>
</tr>
<tr>
<td>Industrial production</td>
<td>-2.6505</td>
<td>-2.4895</td>
<td>-2.4895</td>
</tr>
<tr>
<td>Housing prices</td>
<td>-1.1193</td>
<td>0.3291</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0336</td>
<td>0.2279</td>
<td>-0.0355</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.21982</td>
<td>0.225085</td>
<td>0.227223</td>
</tr>
</tbody>
</table>

Notes: *p*-values in parentheses. *p*-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.
Table D.3: Time-varying correlation between monetary policy and the housing market for the period 1992:1 to 2001:12.

<table>
<thead>
<tr>
<th>Independent variables:</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying correlation</td>
<td>-0.1490 0.2861</td>
<td>-0.1513 0.2886</td>
<td>-0.1518 0.2930</td>
</tr>
<tr>
<td>Oil prices</td>
<td>-0.2591 0.3432</td>
<td>-0.2530 0.3786</td>
<td>-0.2502 0.3853</td>
</tr>
<tr>
<td>Industrial production</td>
<td>0.6558 0.7005</td>
<td>0.5693 0.7295</td>
<td></td>
</tr>
<tr>
<td>Financial prices</td>
<td>0.1955 *** 0.0000</td>
<td>0.1953 *** 0.0000</td>
<td>0.1970 *** 0.0000</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.1848 0.6457</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.034728 0.035843</td>
<td>0.037535</td>
<td></td>
</tr>
</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

Table D.4: Time-varying correlation between monetary policy and the housing market for the period 2002:1 to 2012:12.

<table>
<thead>
<tr>
<th>Independent variables:</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying correlation</td>
<td>-0.1102 0.5281</td>
<td>-0.1099 0.5300</td>
<td>-0.1082 0.5407</td>
</tr>
<tr>
<td>Oil prices</td>
<td>0.2602 0.2149</td>
<td>0.2574 0.2383</td>
<td>0.2931 0.1694</td>
</tr>
<tr>
<td>Industrial production</td>
<td>0.1374 0.9323</td>
<td>0.2571 0.8775</td>
<td></td>
</tr>
<tr>
<td>Financial prices</td>
<td>0.1175 *** 0.0001</td>
<td>0.1176 *** 0.0001</td>
<td>0.1170 *** 0.0001</td>
</tr>
<tr>
<td>Constant</td>
<td>0.023115 0.02314</td>
<td>0.031453</td>
<td></td>
</tr>
</tbody>
</table>

Notes: $p$-values in parentheses. $p$-values are calculated on the basis of both autocorrelation and heteroskedasticity-robust standard errors. In addition, ***, ** and * denote $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.
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