



Universidade do Minho

Documentos de Trabalho
Working Paper Series

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URL:

<http://www.eeg.uminho.pt/economia/nipe>

* NIPE – *Núcleo de Investigação em Políticas Económicas* – is supported by the Portuguese Foundation for Science and Technology through the *Programa Operacional Ciência, Tecnologia e Inovação* (POCI 2010) of the *Quadro Comunitário de Apoio III*, which is financed by FEDER and Portuguese funds.

How Does Fiscal Policy React to Wealth Composition and Asset Prices?

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Abstract

We assess the response of fiscal policy to developments in asset markets in the US and the UK. We estimate fiscal policy rules augmented with aggregate wealth, wealth composition (i.e. financial and housing wealth) and asset prices (i.e. stock and housing prices) using: (i) a linear framework based on a fully simultaneous system approach; and (ii) two nonlinear specifications that rely on a smooth transition regression (STR) and a Markov-switching (MS) model.

The linear framework suggests that, while primary spending does not seem to react to wealth composition or asset prices, taxes and primary surplus are significantly: (i) cut when financial wealth or stock prices rise; and (ii) raised when housing wealth or housing prices increase.

The smooth transition regression model shows that primary spending and fiscal balance are adjusted in a nonlinear fashion to both wealth and price effects, while the Markov-switching framework highlights the importance of tax cuts (in the US) and spending hikes (in the UK) to offset the decline in wealth during major recessions and financial crises.

Overall, our results provide evidence of a non-stabilizing effect of government debt, a countercyclical policy and a vigilant track of wealth developments by fiscal authorities.

Keywords: *fiscal policy, wealth composition, asset prices.*

JEL Classification: *E37, E52.*

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1 Introduction

The recent financial turmoil brought the linkages between the financial markets, the banking system, the housing sector and the monetary framework to the frontline of policy making. Its dramatic impact on the global economy highlighted the need to complement a quick and targeted response by monetary authorities with a robust implementation of fiscal packages by governments aimed at boosting output.

These unconventional interventions took place in reaction to such an extraordinary event and, despite the consensual view on the withdrawal of such stimulus as the recovery materializes,¹ the uncertainty regarding the economic path and the concerns about long-term (un)sustainability of public finances, on the one hand, and the pressure for avoiding similar episodes in the future, on the other hand, might demand for a more systematic response from fiscal authorities.

The deepening of the crisis was mainly driven by the sharp collapse of asset prices (after several years of boom) and simultaneous destruction of financial and housing wealth. Not surprisingly, we have assisted to an interesting debate on the opportunity to target asset markets in the conduct of economic policies aimed at avoiding the repetition of similar episodes and at reducing the risk of unconventional fiscal and monetary interventions. Therefore, under the ongoing securitization process of the housing and financial sectors which implies the transfer of assets and risk to the private sector, wealth may be considered as a valid complementary target variable entering the policymaking rule.

The dynamics of asset prices and wealth composition is indeed of great importance for financial institutions and homeowners and the empirical evidence suggests that monetary authorities should pay a close attention to those developments. In fact, several papers have emphasized the existing nexus between monetary stability and financial markets stability (Granville and Mallick, 2009; Sousa, 2010a, 2010b; Castro, 2011), the implications for the macroeconomy (Rafiq and Mallick, 2008; Mallick and Mohsin, 2007, 2010) and the role of market segmentation (Blenman, 1991). Booms and busts in stock and housing markets have been widely considered as important events in determining the occurrence of economic crises (Agnello and Nerlich, 2010; Agnello and Schuknecht, 2011) and a number of studies has focused on the appropriateness of the monetary policy strategy in the presence of such episodes (Detken and Smets, 2004) and, in general, on the opportunity to consider asset prices as part of monetary policy goals (Issing, 2009). Similarly, the relationship between monetary policy, macroeconomic variables and wealth has gained a new interest in recent

¹Interestingly, Heim (2010a, 2010b) shows that government deficits crowd out both private consumption and investment. However, while government spending deficits are associated with a complete crowding-out effect (i.e. no net stimulus impact), tax cut deficits result in net negative economic effects. In addition, Heim (2010c) finds that, calculating the effects for recession and non-recession periods and comparing them to models with average crowd out and models without crowd out, one concludes that the magnitude of the crowding-out effects is roughly the same.

times: some authors focused on the importance of contagion effects during financial crises episodes (Blenman, 2004), while others analyzed how wealth effects modify the central bank's reaction function (Sousa, 2009; Castro and Sousa, 2010) and its transmission mechanisms on the components of aggregate demand (Sousa, 2010c).

Despite this, the empirical evidence on the reaction of fiscal authorities to asset markets is still at an early stage. In fact, while the existing studies have typically explored the links between stock and housing prices and fiscal policy (Tagkalakis, 2011; Agnello and Sousa, 2011), our knowledge about the response of governments to the composition of wealth is still incomplete.

The extent to which fiscal policy stabilizes output depends on its ability to influence aggregate demand and, in particular, private consumption. This is, in turn, strongly related to the dynamics of asset markets via the so-called "wealth effects". In fact, it is well known that asset markets react to economic developments and policy decisions, and consumers respond to changes in their wealth composition. The "wealth" channel associated with economic policies characterizes this mechanism: changes in policy measures influence asset values, which, in turn, affect economic activity. As a result, the macroeconomic impact of governments' actions may be amplified through their effects on households' wealth. It is indeed the change in the "aggregate wealth", i.e. the variation in the "price-quantity" set that can make economic agents more prone to adjust their demand patterns and which fiscal authorities may decide to stabilize (via taxation and/or spending measures). This is close in spirit with the idea of "constrained discretion" (Bernanke, 2003): first, the policymaker establishes a strong commitment with its major role (for instance, keeping inflation low and stable in medium and long-run, guaranteeing a high level of employment and sustainable and non-inflationary growth...); second, subject to the condition that the first principle is satisfied, the policymaker should strive to limit cyclical swings in resource utilization (which may be due to undesirable fluctuation in aggregate wealth).

Changes in the composition of the "wealth bundle" may also play an important role in the assessment on the future course of economic developments made by governments. First, housing assets typically have a lower degree of liquidity than financial assets (Pissarides, 1978; Muellbauer and Lattimore, 1999). Second, consumers derive utility from the property right of housing assets (Poterba, 2000), but not from financial assets. Third, financial wealth tends to be more concentrated across income groups than housing wealth (Banks et al., 2004). In fact, in many countries, financial wealth is concentrated in the high-income groups which are often thought to have a lower propensity to consume out of both income and wealth. Fourth, the expected permanency of changes in housing wealth tends to be larger than for financial wealth, i.e. while an increase in housing wealth may be seen as permanent and certain, a rise in financial wealth is generally considered as being short-lived and uncertain (Case et al., 2005). Fifth, investors may incorrectly infer about the

value of housing assets, given that housing assets are less homogenous and less frequently traded than financial assets. Similarly, consumers may be more prone to consume out of directly held stock market wealth than indirectly held stock market holdings (via mutual and pension funds), given that the value of indirect holdings may be more difficult to compute (Sousa, 2008). Finally, one can also consider 'psychological factors' and 'mental accounting' (Shefrin and Thaler, 1988). In this case, different wealth components generate different wealth effects, as some assets are normally appropriate for long-term savings (e.g. real estate) while others are framed for consumption expenditures (e.g. deposits). These arguments give rise to the opportunity for governments to target wealth composition in their policy formulation.

Moreover, there are several reasons that would justify the estimation of a fiscal policy rule augmented with housing and financial wealth vis-a-vis housing and stock prices. For instance, a significant increase in housing prices can lead to a rise in housing wealth and, consequently, boost consumption. In the case of overheating of the economy, a rule targeting asset prices would demand tightening of fiscal policy. However, the increase in housing prices may also trigger a rise in housing costs and generate a drop in housing wealth, whereby consumption spending would be reduced. In this context, the policy response to the dynamics of housing prices would imply an expansionary fiscal policy (e.g. tax reduction). Putting it differently, housing prices could provide an uncertain signal to the fiscal authority. This problem would be avoided if wealth developments were directly tracked: the increase (decrease) in housing wealth would forecast a rise (drop) in future aggregate demand (via the wealth channel) and the fiscal policymaker could react by rising (cutting) taxes and/or cutting (rising) expenditure. Similarly, an increase in stock prices could signal either a rise in market valuation of financial assets that is driven by fundamentals or a potential bubble, in which case, business cycle stabilization would demand different policy measures. On the contrary, a vigilant follow-up of the dynamics of financial wealth would allow governments to foresee market tensions and provide an unequivocal response to them (e.g. via taxation on capital gains).

In this paper, we try to contribute to the literature by estimating fiscal policy rules with the aim of understanding the government's response to both financial and housing wealth developments. Specifically, we compare the formulation of fiscal policy in the context of "asset price" effects (i.e., the reaction of the government to stock and housing prices) and "asset wealth" effects (that is, the response of the fiscal authority to financial and housing wealth). As a result, we estimate linear fiscal policy reaction functions using a fully simultaneous system approach, allowing for simultaneity between the fiscal instrument and a set of macroeconomic variables. In order to account for the effects of asset market developments on the conduction of fiscal policy, we augment the policy rules with variables capturing changes in wealth composition or asset prices.

In addition, we assess the existence of nonlinearity in the fiscal policy reaction function, which

may be relevant for two major reasons. First, Browning and Collado (2001) show that economic agents tend to smooth consumption when wealth fluctuations are large, but are less likely to do so when wealth variation is small given that the cost of adjusting their consumption patterns is not trivial. This suggests that the response of fiscal policy to wealth developments may exhibit nonlinearity. Second, as Tagkalakis (2011) notes, governments could start building up fiscal buffers in reflex of the valuable information provided by the dynamics of asset prices and the concerns about debt sustainability. Thus, while fiscal authorities can exhibit a linear behaviour regarding asset market movements, they may also have asymmetric preferences and assign different weights to negative and positive gaps in wealth, asset prices or even output. More specifically, the conduction of fiscal policy might be conditional on the "state" of the economy in general (for instance, booms versus recessions) and asset markets in particular (for example, whether financial wealth is increasing or falling, if housing wealth is booming or shrinking...). We investigate the importance of such nonlinear description of fiscal policy behaviour by using a Smooth Transition Regression (STR) model and a Markov-Switching (MS) framework. These should help us refining the characterization about the response of governments to specific "states" of asset markets and, therefore, understanding how such wealth dynamics improve the information provided by other economic variables.

The linear framework suggests that, for both the US and the UK, taxes and primary surplus are strongly affected in a negative and significant way by changes in aggregate wealth, but there is little evidence of a response of primary spending to aggregate wealth. Looking at the importance of wealth composition, financial wealth seems to play a stronger role. However, while taxes and primary surplus are reduced when financial wealth increases, a rise in housing wealth impacts positively on them. As for government spending, the existing evidence does not corroborate a significant reaction to financial and housing wealth. In addition, the results show that an increase in stock prices induces a fall in the primary surplus. In contrast, a rise in housing prices has a positive effect on the fiscal stance. The negative relationship between taxation and wealth is consistent with the literature supporting the view that fiscal policy rules can be designed to steer national wealth to its target value (Blake et al., 1998; Lossani and Tirelli, 1994).

The estimation of the nonlinear smooth transition regression model indicates that, for the US, the nonlinear reaction of fiscal policy is felt when the policy instruments are the primary spending and fiscal balance, and are linked with the behaviour of asset markets, in particular, financial wealth and stock prices. In fact, fiscal policy is tightened when: (i) the growth rate of aggregate wealth is above the threshold of 1.4%; (ii) stock prices rise well above 9.8%; and (iii) there is accumulation of financial wealth in which case fiscal policy counterbalances the dynamics of housing wealth. In contrast, for the UK, only the primary surplus exhibits an asymmetric behavior, but this is

conditional on the growth rate of output. In addition, fiscal policy is adjusted in case of a change in financial wealth, but not in housing wealth, and there is evidence supporting a reaction of the fiscal authority to both stock and housing prices.

Finally, the findings provided by the Markov-switching model highlight the nonlinearity of the response of both primary spending and taxes to aggregate wealth, wealth composition and asset prices. In fact, for the US, fiscal policy behaviour significantly changes during periods characterized by sharp corrections of output or even recessions: in a context of economic distress, fiscal policy becomes expansionary, thereby, partially offsetting the decline in wealth. Moreover, fiscal authorities counteract the fall in financial wealth and stock prices, namely, by cutting government taxation. As for the UK, despite neither primary spending nor government revenue significantly react to changes in aggregate wealth, the wealth composition effect is important: primary spending counteracts the fall in both financial and housing wealth, especially, during major recessions and financial crises.

The rest of the paper is organized as follows. Section 2 reviews the existing literature on the linkages between fiscal policy and asset markets. Section 3 presents the estimation methodologies. Section 4 discusses the empirical evidence on the reaction of fiscal policy to wealth composition and asset prices. Finally, Section 5 concludes with the main findings and policy implications.

2 Review of the Literature

The events associated with the 2007-2009 financial turmoil have highlighted the importance of the relationship between economic policy, wealth, financial markets and housing sector (Castro, 2010, 2011; Sousa, 2010a, 2010b; Agnello and Sousa, 2010, 2011). While there has been a large number of studies devoted to the analysis of the reaction of monetary policy to asset price developments (Borio and Lowe, 2002; Bordo and Jeanne, 2002), the research on the behaviour of fiscal policy is far less developed and somewhat lagging.

Understanding the fiscal policy reaction to wealth composition or asset prices emerges as a very important question for two main reasons. First, in light of the recent developments in asset markets, the literature has started to look at the role played by fiscal policy in explaining such dynamics. Second, the theoretical relevance of the linkages between the dynamics of asset prices and the process of wealth accumulation suggests that the performance of a fiscal policy rule accounting for "asset price" and "asset wealth" effects deserves an econometric evaluation.

In this context, we start by describing the recent, but yet limited, developments of the existing literature on that matter.

2.1 Why should one expect a relationship between fiscal policy and stock prices?

The stock market boom of the late nineties and the subsequent burst of the technological bubble generated important changes in the stance of fiscal policy, making it apparent that stock price changes can influence government balances. Despite being typically assessed through the lenses of monetary policy (Bernanke and Kuttner, 2005), the dynamics between economic policy and financial markets is relevant and some recent studies also consider the role of fiscal policy. For this reason, some authors have argued that government revenue should be adjusted for the asset price cycle in addition to the business cycle (Schuknecht and Eschenbanch, 2002; Jaeger and Schuknecht, 2007; Morris and Schuknecht, 2007; Tujula and Wolswijk, 2007) and take into account the occurrence of financial and banking crises (Schuknecht and Eschenbanch, 2004). In fact, financial markets and, in particular, asset prices can affect the government budget via two major mechanisms: (i) the "direct" channel, through certain revenue categories; and (ii) the "indirect" channel, through the feedback effect on real economic activity. In the case of the "direct" channel, an increase in stock prices can have a positive impact on capital gains-losses related taxes, government revenue from households and corporations and turnover taxes (i.e. changes in government revenue via transactions in assets) and, consequently, can influence the fiscal stance. As for the "indirect" channel, higher stock prices can lead to a rise in consumer's confidence and household's wealth, boosting consumption and real economic activity and, thereby, increasing government revenue. In contrast, a sharp correction in stock prices and the design of fiscal stimulus packages can raise costs to governments and, therefore, deteriorate the public finances. Moreover, a greater uncertainty about the long-run sustainability of public finances may lead investors to demand a higher risk premium, thereby, impacting on the relative term spread. This, in turn, can severely deteriorate the fiscal stance in reflex of the increase in costs of (re)financing the debt.

At the empirical level, Darrat (1988) and Arin et al. (2009) show that fiscal policy influences stock market returns. Tavares and Valkanov (2001) argue that fiscal policy can impact financial markets both directly (via bond markets and interest rates) and indirectly (via stock market returns), while Hallett (2008) and Hallett and Lewis (2008) highlight the role of long-term sustainability of public accounts. Blenman (1991) points out that portfolio diversification effects can be important and financial market interdependence might be crucial, in particular, during debt crises. Akitoby and Stratmann (2008) find that, for emerging markets, fiscal adjustments based on the revenue side lower sovereign risk spreads more than spending-based ones. Ardagna (2009) emphasizes that, for OECD countries, fiscal adjustments signalling a sounder fiscal behaviour (such as a reduction in government spending or a substantial fall in government debt) are typically asso-

ciated with increases in stock prices. Arin et al. (2009) investigate the effects of various tax policy innovations on stock market returns and show that indirect taxes have a larger effect on market returns than labor taxes. Heim (2010d) finds a strong negative relationship between government deficits and private consumer and investment spending and shows that the mechanism operates via credit shortages to the private sector that are induced by borrowing-financed government deficits.

2.2 Why should a link between fiscal policy and housing prices exist?

As with stock prices, the linkages between economic policy and housing prices have been typically considered in the context of monetary policy (Aoki et al., 2004; Iacoviello, 2005). However, the dynamics of housing markets can be also influenced by a variety of fiscal measures such as: (i) capital taxes on housing gains, (ii) reduced VAT on home purchases; (iii) tax deductibility of interest payments; (iv) taxation of the imputed rental housing value; and (v) subsidies for first-house purchases. Moreover, sovereign financing needs and fiscal stance can indirectly influence housing prices through the impact on a country's interest rates and mortgage-loans and resources available to home-owners can be crowded-out in case of higher government indebtedness (MacLennan et al., 1999).

In the few studies looking at the interaction between fiscal policy and asset markets, the research has mostly looked at the potential impact of fiscal policy on financial and/or housing prices, rather than assessing the response of fiscal authorities to developments in those markets via the estimation of a policy rule. For instance, Afonso and Sousa (2011a) investigate the macroeconomic effects of fiscal policy using a Bayesian Structural Vector Autoregression approach. Using an identification of fiscal policy shocks based on a recursive scheme and data for Germany, Italy, UK and US, the authors show that government spending shocks, in general, have a small effect on GDP, lead to important "crowding-out" effects, have a varied impact on housing prices and generate a quick fall in stock prices. Afonso and Sousa (2011b) use a fully simultaneous system of equations and the same set of four countries and find that unexpected variation in fiscal policy can substantially increase the variability of housing and stock prices. Agnello and Sousa (2010) use a panel of ten industrialized countries and show that a positive fiscal shock has a negative (although quick and temporary) impact on stock prices and a negative (although gradual and very persistent) effect on housing prices. Consequently, they argue that the attempts of fiscal policy to mitigate stock price developments may severely de-stabilize housing markets. Agnello and Sousa (2011) also point out to significant fiscal multiplier effects, in particular, in the context of severe housing busts, which gives rise to the importance of the implementation of fiscal stimulus packages. Notably, Tagkalakis (2011) provides estimations of fiscal policy reaction functions that look into the links between

financial market movements and fiscal policy outcomes. The author highlights that, although stock prices affect both government revenues and primary spending, the most important effect on fiscal balances is due to changes in housing prices.

2.3 Why should one expect a relationship between fiscal policy and wealth?

As discussed above, the existing studies have typically focused on asset prices, therefore, not targeting the reaction of governments to household's wealth. Generally speaking, the increase in stock or housing prices can influence consumption. However, it is the change in the "price-quantity" bundle, i.e. variation in the wealth counterparts (financial and housing wealth) that can produce substantial variation in personal savings. When the corporate sector does not compensate the change in households' savings, it is then left for the government to allow for a variation in its own savings and, thereby, to smooth the fluctuations in national saving. Blake et al. (1998) and Lossani and Tirelli (1994) argue that fiscal policy accomodates a wealth expansion (e.g cutting taxes on wealth) when its level is below the target value. In contrast, an increase of taxation might have the effect of reducing the incentive to accumulate wealth (e.g. by reducing savings and prompting agents to consume their income) with negative consequences for the economy as a whole. More recently, Tagkalakis (2011) provide a substantial contribution to this key question. The author assesses the links between stock and housing prices and fiscal policy outcomes, namely, by estimating standard fiscal policy reaction functions, augmented with asset price variables. He finds a significant impact on primary balances, in particular, from changes in residential property prices. Similar attempts to tackle this issue lie in the context of monetary policy. Sousa (2010a, 2010b) uses data for the US and the Euro Area and shows that a monetary contraction generates an important (negative) wealth effect, but neglects the existence of possible nonlinear linkages. Castro and Sousa (2010) also suggest that wealth composition is important in the formulation of monetary policy although the reaction to "price" effects is smaller. Additionally, the authors account for the nonlinearity of the relationship between monetary policy and wealth and find that concerns over wealth and its components are stronger once inflation is under control, i.e. below a certain target.

3 Empirical Methodology

3.1 The Fully Simultaneous System of Equations

We estimate the following Structural VAR (SVAR)

$$\underbrace{\Gamma(L)}_{n \times n} \underbrace{X_t}_{n \times 1} = \Gamma_0 X_t + \Gamma_1 X_{t-1} + \dots = c + \varepsilon_t \text{ where } \varepsilon_t | X_s, s < t \sim N(\underline{0}, \Lambda) \quad (1)$$

where $\Gamma(L)$ is a matrix valued polynomial in positive powers of the lag operator L , n is the number of variables in the system, and ε_t is a vector of fundamental economic shocks that span the space of innovations to X_t . The “reduced form” form of (1) can be expressed as

$$\Gamma_0^{-1}\Gamma(L)X_t = B(L)X_t = a + v_t \sim N(\underline{0}, \Sigma) \quad (2)$$

where $\Sigma = \Gamma_0^{-1}\Lambda(\Gamma_0^{-1})'$, the vector $v_t = \Gamma_0^{-1}\varepsilon_t$ contains the innovations of X_t , and Γ_0 pins down the contemporaneous relations among the variables in the system. In what follows we use the normalization $\Lambda = I$.

We do not assume that the government reacts only to variables that are predetermined relative to policy shocks, and assume that there are no predetermined variables with respect to fiscal policy shock. The economy is divided into three sectors: a financial, a public and a production sector. The financial sector – summarized by the financial wealth measure, fw_t (or the stock price index, sp_t) – reacts contemporaneously to all new information, in recognition of the fact that this component of wealth is determined in markets characterized by a continuous auction structure. The public sector – that allows for simultaneous effects – comprises the equations for primary government spending, g_t , and government revenue, t_t , or primary government surplus, gs_t , and links them with the real GDP, y_t , and the government debt, b_t . The production sector consists of the real GDP, y_t , the government debt, b_t , and the housing wealth measure, hw_t (or the housing price index, hp_t). The orthogonalization within this sector is irrelevant to identify fiscal policy shocks correctly. All these variables are not predetermined relative to the fiscal policy shocks but it is assumed that the policy shock can influence them contemporaneously.

Additionally, we adopt an identification of the fiscal policy shocks based on Blanchard and Perotti (2002) and Perotti (2004). This identification scheme consists of two steps: (i) institutional information about taxes and transfers and the timing of tax collections is used to identify the automatic response of taxes and government spending to economic activity, that is, to compute the elasticity of government revenue and spending to macroeconomic variables; and (ii) the fiscal policy shock is then estimated.

While estimating the fiscal policy rule, we consider several specifications, namely, by linking the fiscal policy instrument (i.e. either the primary government spending, g_t , or the government revenue, t_t , or the primary government surplus, gs_t) with the real GDP, y_t , the government debt, b_t , and: (i) aggregate wealth, w_t ; and (ii) financial wealth, fw_t , and housing wealth, hw_t . These different policy reactions allow us to understand how the fiscal authority reacts to wealth composition.

The identifying restrictions on the matrix of contemporaneous effects, Γ_0 , can be defined as:

$$\Gamma_0 = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & 0 & -\zeta_{g,y} \cdot \gamma_{22} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & 0 & \gamma_{33} & -\zeta_{t,y} \cdot \gamma_{33} & \gamma_{35} & \gamma_{36} \\ 0 & 0 & 0 & \gamma_{44} & 0 & 0 \\ 0 & 0 & 0 & \gamma_{54} & \gamma_{55} & 0 \\ 0 & 0 & 0 & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix} \begin{bmatrix} fw_t \\ g_t \\ t_t \\ y_t \\ b_t \\ hw_t \end{bmatrix},$$

where the parameters $\zeta_{g,y}$ and $\zeta_{t,y}$ are the elasticities of, respectively, government spending and government revenue with regards to GDP and can be identified using external information. These are set in accordance with Blanchard and Perotti (2002) and Afonso and Sousa (2011a, 2011b), that is, for both the US and the UK, $\zeta_{g,y} = 0$ and $\zeta_{t,y} = 1.85$.

The identification can be summarized in the following table where “+” indicates non-zero elements and we add a triangular orthogonalization for the production sector that is irrelevant for the identification of the fiscal policy shock.

Sector:						
Variable:	Financial	F Policy	F Policy	Prod y	Prod b	Prod hw
Financial wealth	+	+	+			
Gov. spending	+	+				
Gov. revenue	+		+			
GDP	+		+	+	+	+
Gov. debt	+	+	+		+	+
Housing wealth	+	+	+			+

Then, we assess the adjustment of fiscal policy in the outcome of changes in asset prices. More specifically, we estimate a policy rule that links the fiscal instrument with the real GDP, y_t , the government debt, b_t , the stock price index, sp_t , and the housing price index, hp_t . In this way, we are able to detect whether the government reacts differently to changes in the wealth composition vis-a-vis changes in asset prices. This analysis is crucial as it makes possible to infer about the weights that the fiscal authority puts into asset markets' "quantity" and "price" effects.

Finally, the fully simultaneous identification scheme as defined above implies that the estimates of Γ_0 are obtained via numerical maximization of the integrated likelihood. The probability bands for the impulse-response functions should be constructed by drawing jointly from the posterior distribution of $B(L)$ and Γ_0 . Given that the integrated likelihood is not in the form of any standard probability density function, one cannot draw Γ_0 from it directly to make inference. We solve this problem by: (i) taking draws for Γ_0 using an importance sampling approach that

combines the posterior distribution with the asymptotic distribution of Γ_0 ; and (ii) drawing $B(L)$ from its posterior distribution conditional on Γ_0 . Probability bands are then constructed from the weighted percentiles of the impulse-response functions.

3.2 The Smooth Transition Regression Model

A nonlinear Smooth Transition Regression (STR) model is employed to control for the cases in which fiscal authorities are responding differently to deviations of wealth variables or output from their targets. While allowing for smooth endogenous regime switches, this model is also able to explain when a fiscal authority changes its policy behaviour. Although a few versions have been already applied to study the behaviour of some monetary authorities (Castro and Sousa, 2010; Castro, 2011), we provide the first attempt to control for the presence of a nonlinear reaction of fiscal authorities to wealth composition and asset prices.

A standard STR model for a nonlinear fiscal rule can be defined as follows:

$$FI_t = \psi' z_t + \omega' z_t G(\eta, c, s_t) + \varepsilon_t, \quad t = 1, \dots, T \quad (3)$$

where FI_t denotes the fiscal policy instrument (g_t, t_t, g_{st}) and $z_t = (1, z_{1t}, \dots, z_{kt})$ is a vector of k explanatory variables. The vectors $\psi = (\psi_0, \psi_1, \dots, \psi_k)$ and $\omega = (\omega_0, \omega_1, \dots, \omega_k)$ represent the parameter vectors in the linear and nonlinear parts of the model, respectively. In total, we may have $2(k+1)$ parameters to estimate, but some of these may be zero a priori. The disturbance term is assumed to be independent and identically distributed with zero mean and constant variance, $\varepsilon_t \sim iid(0, \sigma^2)$. The transition function $G(\eta, c, s_t)$ is continuous and bounded between zero and one in the transition variable s_t , that is: as $s_t \rightarrow -\infty$, $G(\eta, c, s_t) \rightarrow 0$; and as $s_t \rightarrow +\infty$, $G(\eta, c, s_t) \rightarrow 1$. s_t , can be an element of z_t or even a linear combination of elements of z_t (or a simple deterministic trend).

We start by considering $G(\eta, c, s_t)$ as a logistic function of order one:

$$G(\eta, c, s_t) = [1 + \exp \{-\eta (s_t - c)\}]^{-1}, \quad \eta > 0. \quad (4)$$

This kind of STR model is called logistic STR model or LSTR1 model. In this case, the transition function is a monotonically increasing function of s_t , where the slope parameter, η , indicates the smoothness of the transition from one regime to another, i.e. it shows how rapid the transition from zero to unity is, as a function of s_t . Finally, the location parameter, c , determines where the transition occurs. Considering this framework, the LSTR1 model can describe relationships that change according to the level of the threshold variable and, consequently, an asymmetric reaction

of the government to, for example, a high and a low debt regime.

The STR model is equivalent to a linear model with stochastic time-varying coefficients and, as so, it can be rewritten as:

$$FI_t = [\psi' + \omega'G(\eta, c, s_t)] z_t + \varepsilon_t \Leftrightarrow FI_t = \lambda' z_t + \varepsilon_t, \quad t = 1, \dots, T. \quad (5)$$

The combined parameters, λ , will fluctuate between ψ and $\psi + \omega$ and change monotonically as a function of s_t . The more the transition variable moves beyond the threshold, the closer $G(\eta, c, s_t)$ will be to one, and the closer λ will be to $\psi + \omega$. Similarly, the further s_t approaches the threshold, c , the closer the transition function will be to zero and the closer λ will be to ψ .

Given that a monotonic transition may not be a satisfactory alternative, we will also consider (and test for) the presence of a non-monotonic transition function. This can be the case where governments consider not a simple point target for the transition variable, but a band or an inner regime where the transition variable is considered to be under control. Consequently, the reaction of the fiscal authority will be different from the situation where transition variable is outside that regime.

We consider the following logistic function of order two:

$$G(\eta, c, s_t) = [1 + \exp \{-\eta(s_t - c_1)(s_t - c_2)\}]^{-1}, \quad \eta > 0, \quad (6)$$

where $c = \{c_1, c_2\}$ and $c_1 \leq c_2$. This transition function is symmetric around $(c_1 + c_2)/2$ and asymmetric, otherwise, and the model becomes linear when $\eta \rightarrow 0$. If $\eta \rightarrow \infty$ and $c_1 \neq c_2$, $G(\eta, c, s_t)$ becomes equal to zero for $c_1 \leq s_t \leq c_2$ and equal to one for other values; when $s_t \rightarrow \pm\infty$, $G(\eta, c, s_t) \rightarrow 1$. This model is called the quadratic logistic STR or LSTR2. If, for example, output (or wealth) is the transition variable, this model allows us to estimate separate lower and upper bands for output (or wealth) growth instead of a simple target value.

In the estimation of the nonlinear model, it is important to test whether the behaviour of fiscal policy in a given country can be really described by a nonlinear rule. This implies testing linearity against the STR model. The null hypothesis of linearity is $H_0 : \eta = 0$ and the alternative hypothesis is $H_1 : \eta > 0$. Neither the LSTR1 model nor the LSTR2 model are defined under the null hypothesis; they are only defined under the alternative. Teräsvirta (1998) and van Dijk et al. (2002) show that this identification problem can be solved by approximating the transition function with a third-order Taylor-series expansion around the null hypothesis. This approximation yields, after some simplifications and re-parameterisations, the following auxiliary regression:

$$FI_t = \beta_0' z_t + \beta_1' \tilde{z}_t s_t + \beta_2' \tilde{z}_t s_t^2 + \beta_3' \tilde{z}_t s_t^3 + \varepsilon_t^*, \quad t = 1, \dots, T, \quad (7)$$

where $\varepsilon_t^* = \varepsilon_t + \omega' z_t R(\eta, c, s_t)$, with the remainder $R(\eta, c, s_t)$, $z_t = (1, \tilde{z}_t)'$, and \tilde{z}_t is a $(k \times 1)$ vector of explanatory variables. Moreover, $\beta_j = \gamma \tilde{\beta}_j$, where $\tilde{\beta}_j$ is a function of ω and c . The null hypothesis of linearity becomes $H_{01} : \beta_1 = \beta_2 = \beta_3 = 0$, against the alternative of $H_{11} : \exists \beta_j \neq 0$, $j = 1, 2, 3$. An LM-test can be used to investigate this hypothesis because, under the null, $\varepsilon_t^* = \varepsilon_t$. The resulting asymptotic distribution is χ^2 with $3k$ degrees of freedom under the null (Teräsvirta, 1998). If linearity is rejected, we can proceed with the estimation of the nonlinear model. However, in this process it is important to select the adequate transition variable. Sometimes, it is clear from the economic theory which one to choose. However, Teräsvirta (1998) argues that if there is no theoretical reason to choose one variable over another to be the threshold variable and if nonlinearity is rejected for more than one transition variable, the variable presenting the lowest p-value for the rejection of linearity should be chosen to be the transition variable.

There is a final question to answer before proceeding with the estimation of the nonlinear model: Which transition function should be employed? The decision between an LSTR1 and an LSTR2 model can be made from the following sequence of null hypotheses based on the auxiliary regression: $H_{02} : \beta_3 = 0$; $H_{03} : \beta_2 = 0 | \beta_3 = 0$; and $H_{04} : \beta_1 = 0 | \beta_3 = \beta_2 = 0$. Granger and Teräsvirta (1993) show that the decision rule works as follows: if the p-value from the rejection of H_{03} is the lowest one, we should choose an LSTR2 model; otherwise, the LSTR1 model should be selected.

3.3 The Markov-Switching Framework

An alternative approach to capture nonlinear aspects of fiscal policy reaction function consists of estimating a Markov-Switching Regression model (MSR). The basic idea behind MS modelling strategy is that many economic series might obey to different economic regimes associated with events such as financial crises (Jeanne and Masson, 2000; Cerra, 2005; Hamilton, 2005) or abrupt changes in government policy (Hamilton, 1988; Davig, 2004; Sims and Zha, 2006). This observation has given rise to the “Markov switching model” formulation proposed in econometrics by Goldfeld and Quandt (1973) and popularized by Hamilton (1989, 1994).

We should note that there are at least two important conceptual differences between MSR and STR models. First, the MSR incorporates less prior information than the STR approach. Indeed, regime probabilities in a MSR model can be interpreted as a transition function that is estimated directly from the data. In contrast, the specification of the transition function in the STR framework requires the choice of a transition variable (which is sometimes a difficult task). Second, the MSR model allows to immediately infer from the data the timing of significant changes in the behavior of

the dependent variables, whereas STR models control for the possibility of abrupt changes occurring when the level of the transition variable is below or above a certain threshold value.

The MSR counterpart of equation (3) can be written as:

$$FI_t = \psi' z_{1t} + \omega(s_t)' z_{2t} + \sigma(s_t) \varepsilon_t, \quad t = 1, \dots, T, \quad (8)$$

where FI_t is the fiscal policy instrument, while z_t denotes the vector of explanatory variables including the intercept.² ψ is the vector of non-switching parameters while ω represents the vector of parameters that vary across different regimes s_t with $s_t \in \{1, \dots, m\}$. We also assume that the variance of the disturbance term is regime-dependent, i.e. $\varepsilon_t | s_t \sim N(0, \sigma^2(s_t))$.

Denoting by p_{ij} the unconditional transition probability that $s_t = i$ when the state at date $(t-1)$ is $s_{t-1} = j$, i.e. $p_{ij} = P\{s_t = i | s_{t-1} = j\}$, the Markov-Switching model assumes that the matrix P of the transition probabilities $[p_{ij}]$ is constant over time and sums up all time-dependence between the states, i.e. $p_{i1} + p_{i2} + \dots + p_{im} = 1$. Under these conditions, the model can be estimated using Maximum-Likelihood Estimator (MLE) and an Expectation-Maximization (EM) algorithm as discussed by Hamilton (1990).

From an analytical point of view, since our final aim is to investigate if fiscal policy is conducted differently towards wealth composition vis-a-vis asset prices and over different regimes, we consider that only the coefficients associated to asset values are regime-switching while the relation between the fiscal policy indicator, FI_t , output, y_t , and public debt, b_t , is assumed to be linear.

Formally, for each fiscal instrument (namely, the primary government spending, g_t , government taxes, t_t , and primary government surplus, gs_t), we estimate the following fiscal reaction functions:

$$FI_t = \psi_1 y_t + \psi_2 b_t + \omega_1(s_t) w_t + \omega_2(s_t) + \sigma(s_t) \varepsilon_t \quad (9)$$

$$FI_t = \psi_1 y_t + \psi_2 b_t + \omega_1(s_t) f w_t + \omega_2(s_t) h w_t + \omega_3(s_t) + \sigma(s_t) \varepsilon_t \quad (10)$$

$$FI_t = \psi_1 y_t + \psi_2 b_t + \omega_1(s_t) s p_t + \omega_2(s_t) h p_t + \omega_3(s_t) + \sigma(s_t) \varepsilon_t \quad (11)$$

where $s_t = \{1, 2\}$. The linear part of the model includes the vector of variables $z_{1t} = [y_t, b_t]$ while the regime-dependent part includes aggregate wealth, w_t and its components (financial wealth, $f w_t$, and housing wealth, $h w_t$) - i.e. equations (9) and (10) - or, alternatively, stock prices, $s p_t$, and housing prices, $h p_t$ - i.e. equation (11). We also assume that the intercepts are regime-dependent.

² A model with no autoregressive elements such as the one represented in equation (8) has been pioneered by Lindgren (1978) and Baum et al. (1980).

4 Does the Fiscal Authority React to Wealth Composition or Asset Prices?

4.1 Data

This Section provides a summary description of the data employed in the empirical analysis. A detailed version can be found in Section A of the Appendix. All variables are in natural logarithms and measured at constant prices unless stated otherwise.

The set of variables considered in the econometric methodologies is as follows. First, we use either the primary government spending, g_t , the government revenue, t_t , or the primary government surplus, gs_t , as the fiscal policy instrument. Second, regarding macroeconomic aggregates, we consider: the real GDP, y_t , and the government debt, b_t . Finally, the variables of interest in the fiscal policy rule are: (1) the aggregate wealth, w_t ; (2) the measure of the financial market (that is, either financial wealth, fw_t , or the stock price index, sp_t); and (3) the measure of the housing market (i.e. either housing wealth, hw_t , or the housing price index, hp_t). The data are available for: 1967:2-2008:4, in the case of the US; and 1975:1-2007:4, for the UK.

4.2 Linear Evidence

We start by presenting and discussing the evidence from the estimation of the linear fiscal rules using the fully simultaneous system approach described in Section 3.1. Tables 1 and 2 summarize the results for the US and the UK, respectively. In particular, they provide information about the coefficient estimates and the asymptotic standard errors computed using a Monte Carlo Importance Sampling algorithm (and based on 50000 draws). Columns 1-3 display the results for the government primary spending rules, Columns 4-6 refer to the tax rules and Columns 7-9 describe the evidence for the primary surplus rules.

Following Blanchard and Perotti (2002) and Afonso and Sousa (2011b), we impose that primary spending does not react to economic activity, which can be seen by the "zero" coefficient associated with output in Columns 1-3. This is also in line with the work of Tagkalakis (2011) who does not find a significant response of primary spending to output gap. On the contrary, taxes respond substantially to the business cycle: Columns 4-6 show that the elasticity of government revenue to output is set to 1.85, in accordance with Blanchard and Perotti (2002) and Afonso and Sousa (2011b). The rules for the fiscal surplus also point to an important countercyclical response: an increase in output rises the primary surplus in all specifications.

Turning to the response of fiscal policy to government debt, our results do not support the existence of a stabilizing effect. In fact, when government debt grows, primary spending increases,

while taxes and primary surplus are reduced.

In what concerns to the reaction of fiscal policy to aggregate wealth (Columns 1, 4 and 7), the empirical findings show that taxes and primary surplus are strongly affected in a negative and significant way (the coefficients associated to aggregate wealth are -27.659 and -22.994, respectively). In contrast, there is little evidence of a response of primary spending to aggregate wealth (the coefficient estimate is -7.618).

When we consider wealth composition in the fiscal rules (Columns 2, 5 and 8), we conclude that financial wealth is the variable that exerts the strongest impact, in particular, for taxes and primary surplus. However, while these policy instruments tend to be lowered when financial wealth increases, in contrast, a rise in housing wealth has a positive impact on them. As for government spending, the existing evidence does not corroborate a significant reaction to financial and housing wealth.

Finally, we look at the effect of disaggregated asset price variables (i.e. stock and housing prices) on fiscal policy (Columns 3, 6 and 9). As can be seen, an increase in stock prices induces a fall in the primary surplus and a rise in government spending. This can be explained by the very small response of taxation to stock prices. On the contrary, both primary spending and taxes respond negatively to a rise in housing prices. However, given that the magnitude of the reaction is similar (-4.578 for government primary spending and -9.187 in the case of taxes), the overall response of primary surplus to housing prices is small, in line with the work of Tagkalakis (2011).

[INSERT TABLE 1 AROUND HERE]

We now look at the evidence for the UK. As before, we restrict the elasticities of primary spending and government taxation to output to be equal to 0 and 1.85, respectively. We do not impose such restriction on the reaction of primary surplus to economic activity. However, as expected, the results show a strong countercyclical response, given that a rise in output increases primary surplus in all policy rules.

In what concerns to the reaction of fiscal policy to government debt, our findings do not suggest a stabilizing effect, as primary spending is raised when government debt increases. However, in contrast with the US, there is little response of taxes to government debt. As a result, the unstabilizing effect of debt on fiscal policy is driven by primary spending.

Turning to the response of fiscal policy to aggregate wealth (Columns 1, 4 and 7), the results confirm that taxes and primary surplus are negatively and strongly affected (the coefficients associated to aggregate wealth are -31.375 and -29.134, respectively). As in the case of the US, we find

little evidence of a response of primary spending to aggregate wealth (the coefficient estimate is 3.718).

When we look at the impact of wealth composition on fiscal policy (Columns 2, 5 and 8), we can see that it is the dynamics of financial wealth that plays a stronger role: both taxes and primary surplus are reduced when financial wealth increases. A similar pattern can be found for housing wealth, although to a smaller scale.

Finally, we analyze the response of the fiscal authority to the dynamics of stock and housing prices (Columns 3, 6 and 9). An increase in stock prices induces a large reduction in taxes and primary surplus, but has virtually no impact on primary spending. In addition, a rise in housing prices has a positive effect on taxes and primary surplus, although the response is relatively small (the coefficients associated to housing prices are 3.759 and 4.042, respectively). This piece of evidence is in sharp contrast with the evidence for the US, where taxation does not react to stock prices, and housing prices have a negative impact on fiscal policy.

[INSERT TABLE 2 AROUND HERE]

Im sum, the linear framework shows that, for both the US and the UK, taxes and primary surplus are strongly affected in a negative and significant way by changes in aggregate wealth, but there is little evidence of a response of primary spending to aggregate wealth. The negative link between government revenue and wealth could be, in part, explained by the fact that housing and financial wealth are typically related to each other, but sometimes they move in opposite directions. For instance, in the US, the equity market fell in the first half of 2000s while the housing market was booming. In contrast, between 2006 and the summer of 2007, the US housing market cooled down while the stock market moved up. This argument seems to be confirmed when we look at the importance of wealth composition. In this case, we find that while taxes and primary surplus are reduced when financial wealth increases, a rise in housing wealth impacts positively on them. Similarly, an increase in stock prices induces a fall in the primary surplus, but a rise in housing prices has a positive effect on the fiscal stance.

From a theoretical point of view, the negative relationship between taxation and wealth also seems consistent with the existing literature that views fiscal policy rules as designed to target national wealth (Blake et al., 1998; Lossani and Tirelli, 1994). Accordingly, fiscal policy could accomodate (counteract) a wealth expansion (contraction) when the wealth level is below (above) its target. Under these circumstances, nonlinear models that account for the "state" of the economy and the "state" of asset wealth may be useful to disentangle the relationship between fiscal policy and wealth dynamics.

4.3 Nonlinear Evidence I

The results from the estimation of the nonlinear STR specifications are analyzed in this section. Table 3 reports the estimations for US, while Table 4 summarizes the findings for the UK.

In the case of the US, nonlinearity is not always present. The linearity tests shown at the bottom of Table 3 (see line H_{01}) only support the existence of nonlinearity (at a level of significance of 5%) when the fiscal policy instruments are the primary spending and the primary surplus, and this explains why the findings for the tax rules are not displayed.

In what concerns to the choice of the transition function, the tests indicate that a LSTR1 model fits better all policy rules (see lines H_{02} , H_{03} and H_{04}). This means that the fiscal authority is more concerned in pursuing a point target than a target range for the respective transition variable. That variable was chosen taking into account the lowest p -value for the rejection of the linear model.

In Columns 1 and 4, aggregate wealth was chosen as the transition variable (given that it presents the lowest p -value for the rejection of the linear model), which means that fiscal policy tends to react differently when wealth is above or below a certain threshold. The results show that output has no significant effect on primary spending, confirming the assumption made in the linear analysis. Hence, primary spending does not react to economic activity.³ However, the primary government surplus is still reacting positively to output growth. It can also be seen that government debt exerts a non-stabilizing effect over fiscal policy. In fact, all regressions show that an increase in debt leads to a rise in primary spending and to a decrease in government surplus, which is in accordance with our theoretical expectations and, once again, in line with the evidence found for the linear framework. We should also notice that the improvement in primary balance when output rises and its deterioration when government debt increases may reflect the dynamics of government revenue along the business cycle and the unstabilizing feedback effect from government debt.

Column 1 also shows that primary spending starts to react to aggregate wealth only when it grows substantially above 1.4%. This means that primary spending will only respond to government debt when wealth is below that threshold; when aggregating wealth grows above that threshold, primary spending will react negatively to further increases in that aggregate. Hence, the systematic response of primary spending to aggregate wealth seems to exhibit a nonlinear pattern. In Column 4, we can see that the reaction of primary surplus to aggregate wealth is also nonlinear, as it only responds (in a positive manner) when the growth rate of wealth is above 1.5%. This is in line with the work of Tagkalakis (2011) who also suggests that financial market variables have a positive and

³We start by estimating the model with all variables in the linear and nonlinear parts, but we only report (and analyze) the results from the best fitting and more parsimonious models. Those are found by sequentially eliminating regressors that are not statistically significant (at least in one of the parts: linear or nonlinear) via the SBIC measure of fit.

significant impact on the fiscal stance.

When we consider wealth composition in the fiscal policy rule (Column 2), we find evidence suggesting that the government adopts a vigilant posture regarding the dynamics of housing wealth: as in the case of aggregate wealth, primary spending is reduced when housing wealth rises. However, fiscal policy does not respond to financial wealth in a significant way, despite the fact that this wealth component is the threshold variable. This shows that the government starts reacting to housing wealth only when the growth rate of financial wealth is positive. Moreover, it gives rise to the idea that changes in wealth composition play a particular role in the conduction of fiscal policy. The results are not substantially different for primary surplus: Column 5 shows that when housing wealth increases primary surplus is increased, but only if financial wealth grows above 3.2%. Hence, fiscal policy reacts to wealth components only when they are growing at a relatively good pace; otherwise, the behaviour of the fiscal authority is dominated by movements in output and government debt.

Turning now to the reaction of fiscal policy to asset prices (Columns 3 and 6), the empirical findings show that stock prices emerge as the transition variable. In particular, the response of fiscal policy is detected only when the growth rate of stock prices lies well above 9.8%. In this case, the dynamics of primary spending are essentially driven by stock prices, for which there is a negative and statistically significant reaction. Regarding the primary government surplus, we observe that an increase in the stock prices generates a rise in the primary balance, especially, when the growth rate of stock prices is above 9.7%.⁴ In contrast, primary spending and government surplus do not seem to respond to movements in housing prices.

Summing up, the smooth transition regression model estimated for the US suggests that both "asset price" and "wealth" effects are relevant for the conduction of the fiscal policy. However, stock prices matter more than financial wealth while housing wealth seems to be more important than housing prices. On the one hand, this probably reflects the easier monitoring of stock prices as they are available on a real-time basis. On the other hand, it can be linked to the fact that housing prices do not always reflect the market value of residential wealth as a result of the heterogeneity of the quality of real estate assets. Therefore, a larger weight is put into housing wealth in the fiscal policy rule.

[INSERT TABLE 3 AROUND HERE]

We now discuss in Table 4 the empirical evidence for the UK. Nonlinearity is found only when the primary surplus is the fiscal policy instrument. In this case, the transition variable has proved

⁴Not surprisingly, the estimated values for the thresholds of both fiscal policy instruments (primary spending and primary government surplus) correspond essentially to the same value.

to be the output and the results show that the fiscal authority reacts to output independently of its growth rate: the primary surplus always responds to increases in output in a positive manner. Nevertheless, we should stress that the magnitude of the impact is substantially larger than the one estimated for the US. Moreover, there is evidence of an unstabilizing effect of government debt on fiscal policy that emerges only when output growth is positive. Hence, contrary to the US, the UK primary surplus reacts in a nonlinear fashion to government debt.

Regarding the effects of aggregate wealth, nonlinearity is still present: the primary surplus improves when wealth increases, but only if the growth rate of output is significantly positive. Finally, when wealth is disaggregated into its major components, the results indicate a different reaction relative to that found for the US: the primary surplus is adjusted in the outcome of a change in financial wealth, but not in housing wealth, possibly reflecting the lagged nature of the impact of this wealth component on the fiscal position. However, increases in financial wealth only improve the fiscal balance when the economy is growing.

Turning to the asset price effects, we find that while fiscal policy reacts to increases in output, no significant response is found towards changes in government debt. However, the fiscal authority seems to place an important role into changes in stock and housing prices, as the primary surplus reacts positively to rises in those variables when output is growing at a significantly positive rate.

[INSERT TABLE 4 AROUND HERE]

4.4 Nonlinear Evidence II

This Section discusses the evidence from the estimation of the Markov-switching models. Tables 5 and 6 describe the findings for the US and the UK, respectively.

Looking at the evidence for the US, Table 5 suggests that the nonlinear specifications represent a good description of the behaviour of fiscal authorities as supported by the LR statistics. Taxes and primary surplus behave in a cyclical way: a rise in the policy instrument is associated with an increase of output. As for primary spending, it is negatively linked to changes in output but the associated coefficient is small in magnitude, which is in accordance with the linear framework and the smooth transition regression model in that this component of fiscal policy does not react to the business cycle. Interestingly, we also find support of an unstabilizing feedback effect from government debt: primary spending (taxes) are lowered (raised) when government debt increases.

In what concerns the response of both primary spending and taxes to aggregate wealth, wealth composition and asset prices, we find that this relationship is strongly nonlinear. On the spending side (Columns 1-3), there is a positive and significant link in regime one. The same evidence holds for taxes (Columns 4-6) during regime two. Given that both regimes tend to overlap, we conclude

that, in general, an increase in wealth and asset prices leads to an increase in government taxation (e.g. via property taxes or taxes on capital gains) and, ultimately, to a rise in government spending (e.g. investment in infrastructure and public services with high returns for growth). In terms of the impact of wealth composition on fiscal policy, we find that while housing wealth is the main driver for primary spending, financial wealth plays a dominant role for taxes, in particular, in regime one. As for the effects of asset prices, our estimates indicate that both stock and housing prices contribute in a relatively similar manner to fiscal policy developments in the two regimes. The results for primary surplus (Columns 7-9) also corroborate these findings: it behaves in cyclical way and debt exerts an unstabilizing effect on fiscal policy. However, governments seem to be relatively neutral vis-a-vis wealth developments in regime two.

[INSERT TABLE 5 AROUND HERE]

The behaviour of fiscal policy significantly changes during periods characterized by sharp downward corrections of output or even recessions. Such episodes are broadly captured by spending models in regime two and by tax rules in regime one (see Figure 1). As for primary spending, we find that, in a context of economic distress, fiscal policy becomes expansionary, which partially offsets the decline in wealth. In particular, the policymaker seems to counteract the decline of financial wealth and stock prices. In line with this expansionary strategy, government taxation is reduced, therefore, further boosting aggregate wealth. More specifically, the fall in financial wealth leads to a cut of taxation in regime two.

[INSERT FIGURE 1 AROUND HERE]

Table 6 summarizes the results for the UK and the LR statistics support the existence of nonlinearity in the fiscal policy rules. The empirical findings also suggest that the UK fiscal policy is countercyclical: a cut (rise) in spending (taxation) is associated with an increase in output. In addition, we find evidence of an unstabilizing feedback effect from government debt, especially, at the level of primary surplus, which is reduced in the outcome of an increase of government debt.

Turning to the reaction of fiscal policy to aggregate wealth, the results show that it is typically neutral. In fact, neither primary spending nor government revenue react in a significant way to changes in aggregate wealth. However, this finding hides a rather weak but statistically significant composition effect. On the spending side, the policymaker seems to slightly counteract the changes in housing wealth during regime two, which identifies the major recessions experienced by the UK in

early eighties and nineties as well as the financial crisis of 2007-2008. It also takes into account the sharp wealth collapse (driven by financial wealth) in the period 2000-2002 and caused by the burst of the technological bubble that led to a dramatic fall in equity markets. In contrast, government spending seems to be positively related to changes in financial wealth and stock prices in regime one. Such regime is characterized by a lower level of spending but also by a higher volatility (especially, in the late seventies and mid eighties) than in the alternative regime two. This, in turn, might be responsible for the low statistical relevance of financial wealth and stock prices in regime two. On the revenue side, there is no evidence of a nonlinear response to the financial wealth component, despite some support for such behaviour regarding housing wealth. In fact, despite the very low growth rate of government revenue in regime one (see the coefficient associated to the intercept terms) which tends to commove very closely with housing wealth, the policymaker helps boosting housing wealth and housing price developments in regime two (as shown in Figure 2). Finally, nonlinear effects are also at work when looking at the primary surplus reaction functions, in particular, during the regime two. In this context, both financial and housing wealth and stock and housing prices negatively impact on the primary surplus. In contrast, fiscal policy does not seem to react to wealth composition and asset prices in regime one, which is characterized by a less sound fiscal stance. Putting it differently, the fiscal authority seems to put some weight on wealth developments only when public finances are relatively under control.

[INSERT TABLE 6 AROUND HERE]

[INSERT FIGURE 2 AROUND HERE]

5 Conclusion

In this work, we analyze the linkages between fiscal policy and asset markets through the lenses of fiscal policy reaction functions. Using quarterly data for the US and the UK, we estimate fiscal policy rules augmented with: *(i)* aggregate wealth; *(ii)* wealth composition (i.e. financial and housing wealth); and *(iii)* asset prices (i.e. stock and housing prices). This allow us to compare the adjustment of fiscal policy to markets' developments in the context of "asset wealth" and "asset price" effects.

We pay close attention to the design of the fiscal policy rule. Specifically, we consider a linear policy reaction function based on a fully simultaneous system of equations. In addition, we investigate the existence of nonlinearity in the response of governments to asset markets using a smooth transition regression framework and a Markov-switching model.

The estimated linear policy rules show that, while primary spending does not react to aggregate wealth, taxes and primary surplus are significantly cut when aggregate wealth rises. In addition, although the spending side does not respond to wealth composition, the revenue side is negatively impacted by financial wealth and positively affected by housing wealth. Similarly, an increase in stock prices induces a fall in the primary surplus, while a rise in housing prices has a positive effect on the fiscal stance.

The results of the estimation of the smooth transition regression model show that, for the US, nonlinearity describes well the dynamics of primary spending and fiscal balance. These policy instruments are adjusted in a nonlinear fashion to: (i) housing wealth, given that it describes the dynamics of housing markets better than housing prices; and (ii) stock prices, for which information is more readily available than financial wealth. As for the UK, the nonlinearity is also found in both "quantity" and "price" effects, although it is conditional on the growth rate of output, that is, those impacts lead to a change in the conduction of fiscal policy only only when output is growing.

Finally, the Markov-switching model emphasizes that, for the US, fiscal policy offsets the decline in wealth during periods of financial distress. Moreover, the fall in financial wealth and stock prices is counteracted by a cut in government taxation. In the case of the UK, it is primary spending that is boosted to compensate for the fall in both financial and housing wealth during major recessions and financial crises.

From a policy perspective, the current paper gives rise to the stabilizing role that fiscal policy can play regarding wealth developments. By continuously tracking the dynamics of aggregate wealth and its major components, governments better forecast future developments in aggregate demand as well as counteract any potential mispricing, that is, deviation from fundamentals in financial and housing markets. In a related piece of research, Castro and Sousa (2010) show that central banks may find it difficult to target wealth composition with the use of a single policy instrument (such as the interest rate). Moreover, the authors find that if the monetary authorities attempt to mitigate undesirable fluctuations in say, financial wealth, they may end up disrupting housing wealth. In this context, our work suggests that fiscal policy can complement the task of central banks. In particular, during periods of severe financial turmoils, a selective choice of monetary and fiscal policy instruments can be quite successful at boosting the economy and stabilizing financial and housing markets.

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Appendix

A Data Description

A.1 US Data

GDP

The source is Bureau of Economic Analysis, NIPA Table 1.1.5, line 1. Data for GDP are quarterly, seasonally adjusted, and comprise the period 1947:1-2008:4.

Price Deflator

All variables were deflated by the CPI, All items less food, shelter, and energy (U.S. city average, 1982-1984=100) ("CUSR0000SA0L12E"). Data are quarterly (computed from monthly series by using end-of-period values), seasonally adjusted, and comprise the period 1967:1-2008:4. The source is the Bureau of Labor Statistics.

Government Spending

The source is Bureau of Economic Analysis, NIPA Table 3.2. Government Spending is defined as primary government expenditure, obtained by subtracting from total Federal Government Current Expenditure (line 39) net interest payments at annual rates (obtained as the difference between line 28 and line 13). Data are quarterly, seasonally adjusted, and comprise the period 1960:1-2008:4.

Government Revenue

The source is Bureau of Economic Analysis, NIPA Table 3.2. Government Revenue is defined as government receipts at annual rates (line 36). Data are quarterly, seasonally adjusted, and comprise the period 1947:1-2008:4.

Government Debt

Debt corresponds to the Federal government debt held by the public. The source is the Federal Reserve Bank of St Louis (series "FYGFDPUN"). Data are quarterly, seasonally adjusted, and comprise the period 1970:1-2008:4.

Aggregate wealth

Aggregate wealth is defined as the net worth of households and nonprofit organizations. Data are quarterly, seasonally adjusted at an annual rate, measured in billions of dollars (2000 prices), in per capita terms and expressed in the logarithmic form. Series comprises the period 1952:2-2008:4. The source of information is Board of Governors of Federal Reserve System, Flow of Funds Accounts, Table B.100, line 41 (series FL152090005.Q).

Financial wealth

Financial wealth is defined as the sum of financial assets (deposits, credit market instruments, corporate equities, mutual fund shares, security credit, life insurance reserves, pension fund reserves, equity in noncorporate business, and miscellaneous assets - line 8 of Table B.100 - series FL154090005.Q) minus financial liabilities (credit market instruments excluding home mortgages, security credit, trade payables, and deferred and unpaid life insurance premiums - line 30 of Table B.100 - series FL154190005.Q). Data are quarterly, seasonally adjusted at an annual rate, measured in billions of dollars (2000 prices), in per capita terms and expressed in the logarithmic form. Series comprises the period 1952:2-2008:4. The source of information is Board of Governors of Federal Reserve System, Flow of Funds Accounts, Table B.100.

Housing wealth

Housing wealth (or home equity) is defined as the value of real estate held by households (line 4 of Table B.100 - series FL155035015.Q) minus home mortgages (line 32 of Table B.100 - series FL153165105.Q). Data are quarterly, seasonally adjusted at an annual rate, measured in billions of dollars (2000 prices), in per capita terms and expressed in the logarithmic form. Series comprises the period 1952:2-2008:4. The source of information is Board of Governors of Federal Reserve System, Flow of Funds Accounts, Table B.100.

Stock Market Index

Stock Market Index corresponds to S&P 500 Composite Price Index (close price adjusted for dividends and splits). Data are quarterly (computed from monthly series by using end-of-period values), and comprise the period 1950:1-2008:4.

Housing Price Index

Housing prices are measured using two sources: (a) the Price Index of New One-Family Houses sold including the Value of Lot provided by the U.S. Census, an index based on houses sold in 1996, available for the period 1963:1-2008:4; and (b) the House Price Index computed by the Office of Federal Housing Enterprise Oversight (OFHEO), available for the period 1975:1-2008:4. Data are quarterly, seasonally adjusted.

Other Housing Market Indicators are provided by the U.S. Census. We use the Median Sales Price of New Homes Sold including land and the New Privately Owned Housing Units Started. The data for the Median Sales Price of New Homes Sold including land are quarterly, seasonally adjusted using Census X12 ARIMA, and comprise the period 1963:1-2008:4. The data for the New Privately Owned Housing Units Started are quarterly (computed by the sum of corresponding monthly values), seasonally adjusted and comprise the period 1959:1-2008:4.

A.2 UK Data

GDP

The source is Office for National Statistics (ONS), series "YBHA". Data for GDP are quarterly, seasonally adjusted, and comprise the period 1955:1-2008:4.

Price Deflator

All variables were deflated by the GDP deflator (series "YBGB"). Data are quarterly, seasonally adjusted, and comprise the period 1955:1-2008:4. The source is the Office for National Statistics.

Government Spending

The source is the Office for National Statistics (ONS), Release Public Sector Accounts. Government Spending is defined as total current expenditures of the Public Sector ESA 95 (series "ANLT") less net investment (series "ANNW"), to which we subtract net interest payments (obtained as the difference between interest and dividends paid to private sector (series "ANLO") and interest and dividends received from the private sector and the Rest of World (series "ANBQ")). We seasonally adjust quarterly data using Census X12 ARIMA, and the series comprise the period 1947:1-2007:4.

Government Revenue

The source is the Office for National Statistics (ONS), Release Public Sector Accounts. Government Revenue is defined as total current receipts of the Public Sector ESA 95 (series "ANBT"). We seasonally adjust quarterly data using Census X12 ARIMA, and the series comprise the period 1947:1-2007:4.

Government Debt

The source is the Office for National Statistics (ONS), Release Public Sector Accounts. Debt is defined as the Public Sector net debt (series “BKQK”). We seasonally adjust quarterly data using Census X12 ARIMA, and the series comprise the period 1962:4-2007:4.

Aggregate wealth

Aggregate wealth is defined as the net worth of households and nonprofit organizations, this is, the sum of financial wealth and housing wealth. Data are quarterly, seasonally adjusted at an annual rate, measured in millions of pounds (2001 prices), in per capita terms and expressed in the logarithmic form. Series comprises the period 1975:1-2008:4. The sources of information are: Fernandez-Corugedo et al. (2007) - provided by the Office for National Statistics (ONS) -, for the period 1975:1-1986:4; and the Office for National Statistics (ONS), for the period 1987:1-2008:4.

Financial wealth

Financial wealth is defined as the net financial wealth of households and nonprofit organizations (NZEA). Data are quarterly, seasonally adjusted at an annual rate, measured in millions of pounds (2001 prices), in per capita terms and expressed in the logarithmic form. Series comprises the period 1970:1-2008:4. The sources of information are: Fernandez-Corugedo et al. (2007) - provided by the Office for National Statistics (ONS) -, for the period 1970:1-1986:4; and the Office for National Statistics (ONS), for the period 1987:1-2008:4.

Housing wealth

Housing wealth is defined as the housing wealth of households and nonprofit organizations and is computed as the sum of tangible assets in the form of residential buildings adjusted by changes in house prices (CGRI), the dwellings (of private sector) of gross fixed capital formation (GGAG) and Council house sales (CTCS). Data are quarterly, seasonally adjusted at an annual rate, measured in millions of pounds (2001 prices), in per capita terms and expressed in the logarithmic form. Series comprises the period 1975:1-2008:4. The sources of information are: Fernandez-Corugedo et al. (2007) - provided by the Office for National Statistics (ONS) -, for the period 1975:1-1986:4; and the Office for National Statistics (ONS), for the period 1987:1-2008:4. For data on house prices, the sources of information are: Office of the Deputy Prime Minister (ODPM), Halifax Plc and the Nationwide Building Society.

Stock Market Index

Stock Market Index corresponds to FTSE-All shares Index. Data are quarterly (computed from monthly series by using end-of-period values), and comprise the period 1975:1-2008:4.

Housing Price Index

Housing Price Index corresponds to Nationwide: All Houses Price Index. Data are quarterly, seasonally adjusted using Census X12 ARIMA, and comprise the period 1955:1-2008:4.

B List of Tables

Table 1: Linear fiscal rule estimated using a fully simultaneous system of equations: US.

	Primary Spending (g)			Taxes (t)			Primary Surplus (gs)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Fiscal instrument	54.605 [3.151]	55.571 [3.172]	36.304 [28.270]	31.301 [4.960]	24.326 [7.981]	41.005 [2.573]	25.494 [3.728]	19.006 [6.154]	14.478 [9.073]
y_t	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	57.907 [9.175]	45.003 [14.765]	75.858 [4.761]	47.163 [6.897]	35.161 [11.384]	26.784 [16.784]
b_t	42.785 [7.871]	47.256 [8.094]	31.217 [25.013]	-16.326 [7.342]	-13.474 [7.627]	-7.545 [7.708]	-35.242 [7.560]	-28.195 [9.224]	-15.412 [12.996]
w_t	-7.618 [5.468]			-27.659 [7.463]			-22.994 [8.467]		
fw_t		-3.900 [4.173]			-33.115 [6.488]			-32.172 [6.717]	
hw_t		-5.911 [3.902]			9.707 [4.127]			11.786 [3.794]	
sp_t			7.931 [6.306]			0.615 [2.418]			-10.577 [2.107]
hpt			-4.578 [7.059]			-9.187 [5.616]			3.514 [6.071]

Note: Coefficient estimates computed using a Monte Carlo Importance Sampling algorithm. Asymptotic standard errors are in square brackets.

Table 2: Linear fiscal rule estimated using a fully simultaneous system of equations: UK.

	Primary Spending (g)			Taxes (t)			Primary Surplus (gs)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Fiscal instrument	55.066 [3.727]	55.488 [3.733]	49.234 [2.608]	27.587 [9.715]	25.549 [14.653]	13.166 [6.085]	24.707 [8.953]	16.484 [11.567]	10.624 [5.085]
y_t	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	51.036 [17.973]	47.266 [27.107]	24.357 [11.258]	45.708 [16.563]	30.496 [21.400]	19.655 [9.408]
b_t	12.765 [4.601]	13.301 [4.610]	18.505 [4.282]	-0.222 [4.585]	0.027 [4.572]	2.083 [4.229]	-7.543 [5.423]	-5.257 [6.011]	-1.639 [4.909]
w_t	3.718 [4.934]			-31.375 [4.603]			-29.134 [5.346]		
fw_t		1.984 [2.702]			-15.624 [2.543]			-15.857 [2.055]	
hw_t		-3.517 [4.386]			-7.752 [4.561]			-4.209 [4.276]	
sp_t			-1.188 [0.919]			-10.689 [0.656]			-10.223 [0.768]
hp_t			0.420 [3.243]			3.759 [3.537]			4.042 [3.475]

Note: Coefficient estimates computed using a Monte Carlo Importance Sampling algorithm. Asymptotic standard errors are in square brackets.

Table 3: Nonlinear fiscal rule estimated using a smooth transition regression model: US.

Part	Primary Spending (g)			Primary Surplus (gs)		
Linear (ψ)	(1)	(2)	(3)	(4)	(5)	(6)
y_t	-0.088 [0.203]	-0.004 [0.197]	-0.169 [0.197]	1.050*** [0.271]	0.945*** [0.270]	1.635*** [0.354]
b_t	0.257*** [0.089]	0.211** [0.092]	0.245** [0.095]	-0.394*** [0.147]	-0.323** [0.152]	-0.348** [0.170]
Nonlinear (ω)						
w_t	-0.412*** [0.127]			1.982*** [0.662]		
fw_t		-0.063 [0.637]			-0.389 [1.401]	
hw_t		-0.422*** [0.161]			0.810*** [0.299]	
sp_t			-0.169*** [0.075]			0.294** [0.134]
hp_t			0.023 [0.298]			-0.198 [0.527]
η	6.82	7.93	9.04	9.65	6.82	9.25
c	0.014*** [0.003]	0.032 [0.053]	0.098*** [0.011]	0.015*** [0.003]	0.032*** [0.007]	0.097*** [0.010]
Adj.R ²	0.153	0.165	0.131	0.198	0.229	0.186
SBIC	-7.661	-7.642	-7.602	-6.510	-6.517	-6.431
H ₀₁	0.007	0.013	0.010	0.045	0.010	0.016
H ₀₂	0.048	0.006	0.055	0.031	0.013	0.010
H ₀₃	0.774	0.085	0.085	0.700	0.027	0.039
H ₀₄	0.371	0.538	0.075	0.051	0.547	0.131
Model	LSTR1	LSTR1	LSTR1	LSTR1	LSTR1	LSTR1
$s_t =$	w_t	fw_t	sp_t	w_t	fw_t	sp_t

Notes: * statistically significant at 10% level; ** at 5% level; *** at 1% level. All variables are in log differences. Standard errors are in square brackets. Adj.R² is the adjusted R² and SBIC is the Schwarz Bayesian Information Criterion. H₀₁ reports the p -value of the linearity test; H₀₂ to H₀₄ report the p -value of the tests used to choose the preferred model.

Table 4: Nonlinear fiscal rule estimated using a smooth transition regression model: UK.

Part	Primary Surplus (gs)		
	(1)	(2)	(3)
Linear (ψ)			
y_t	2.429*** [0.416]	2.440*** [0.418]	0.816*** [0.276]
Nonlinear (ω)			
b_t	-0.824*** [0.292]	-0.853*** [0.290]	-0.378 [0.439]
w_t	0.465*** [0.166]		
fw_t		0.185*** [0.069]	
hw_t		0.294 [0.196]	
sp_t			0.108** [0.050]
hp_t			0.481* [0.284]
η	8.55	4.91	3.48
c	-0.001* [0.001]	-0.001** [0.001]	0.004** [0.002]
Adj.R ²	0.265	0.268	0.111
SBIC	-7.236	-7.204	-6.898
H ₀₁	0.016	0.026	0.004
H ₀₂	0.079	0.043	0.881
H ₀₃	0.777	0.900	0.144
H ₀₄	0.724	0.016	0.009
Model	LSTR1	LSTR1	LSTR1
$s_t =$	y_t	y_t	y_t

Notes: * statistically significant at 10% level; ** at 5% level; *** at 1% level. All variables are in log differences. Standard errors are in square brackets. Adj.R² is the adjusted R² and SBIC is the Schwarz Bayesian Information Criterion. H₀₁ reports the *p-value* of the linearity test; H₀₂ to H₀₄ report the *p-value* of the tests used to choose the preferred model.

Table 5: Nonlinear fiscal rule estimated using a Markov-switching approach: US.

Part	Primary Spending (g)			Taxes (t)			Primary Surplus (gs)		
Linear (ψ)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
y_t	-0.290*** [-3.058]	-0.327*** [-3.548]	-0.362*** [-3.798]	1.187*** [7.855]	1.130*** [6.248]	1.089*** [8.397]	1.604*** [3.096]	1.900*** [8.406]	1.381*** [7.208]
b_t	0.231*** [7.708]	0.253*** [8.138]	0.268*** [8.107]	-0.083*** [-1.953]	-0.081* [-1.811]	-0.026 [-0.623]	-0.332*** [-2.737]	-0.308*** [-4.151]	-0.254*** [-3.001]
Nonlinear (ω)									
<i>Regime 1</i>									
w_t	0.154*** [2.596]	-	-	0.368** [2.337]	-	-	0.508*** [2.913]	-	-
fw_t	-	0.071 [1.415]	-	-	0.301** [2.068]	-	-	0.382*** [2.951]	-
hw_t	-	0.144*** [3.521]	-	-	0.058 [0.612]	-	-	0.052 [0.566]	-
sp_t	-	-	0.028** [2.036]	-	-	0.003 [0.074]	-	-	0.097 [1.147]
hp_t	-	-	0.147** [2.421]	-	-	0.083 [0.305]	-	-	-0.024 [-0.055]
c	0.011*** [2.848]	0.009** [2.404]	0.014*** [3.705]	-0.050*** [-4.437]	-0.049*** [-4.181]	-0.051*** [-4.377]	-0.096*** [-5.055]	-0.105*** [-9.269]	-0.111*** [-5.267]
<i>Regime 2</i>									
w_t	-0.097** [-1.938]	-	-	0.153** [2.442]	-	-	0.126 [1.067]	-	-
fw_t	-	-0.100** [-2.170]	-	-	0.118** [2.184]	-	-	0.128 [1.529]	-
hw_t	-	0.015 [0.500]	-	-	0.062 [1.108]	-	-	-0.104 [-1.509]	-
sp_t	-	-	-0.031** [-1.943]	-	-	0.046*** [3.020]	-	-	0.009 [0.389]
hp_t	-	-	0.124 [1.444]	-	-	0.328*** [4.873]	-	-	0.285** [2.316]
c	0.065*** [16.798]	0.065*** [17.291]	0.0644*** [16.175]	0.006 [1.359]	0.007 [1.415]	0.005 [1.215]	-0.014 [-0.850]	-0.021*** [-3.146]	-0.021*** [-3.009]
$\sigma_1(\times 100)$	0.035*** [6.93]	0.032*** [6.74]	0.035*** [6.88]	0.282*** [4.03]	0.288*** [3.94]	0.368*** [4.08]	0.382*** [4.34]	0.351*** [4.94]	0.706*** [3.46]
$\sigma_2(\times 100)$	0.038*** [4.53]	0.038*** [4.70]	0.036*** [4.63]	0.043*** [7.03]	0.044*** [7.07]	0.378*** [7.04]	0.084*** [3.79]	0.082*** [6.34]	0.117*** [7.08]
p_{12}	0.059** [2.46]	0.061** [2.45]	0.060** [2.45]	0.117** [1.91]	0.117** [1.91]	0.109** [1.94]	0.102** [2.05]	0.094** [2.21]	0.102* [1.62]
p_{21}	0.105** [2.21]	0.098** [2.22]	0.105** [2.22]	0.049** [2.17]	0.048** [2.17]	0.045** [2.22]	0.070** [1.86]	0.067** [2.41]	0.034* [1.88]
LR-Stat.	33.981	37.813	35.253	37.522	37.711	46.518	34.378	35.907	38.167

Notes: * statistically significant at 10% level; ** at 5% level; *** at 1% level. t -values are in square brackets. LR statistics test the null hypothesis of linear versus a non linear model and are constructed as $2(\ln L^* - \ln L)$, where L^* and L represent the unconstrained and the constrained maximum likelihood respectively. These tests are distributed as $\chi^2(r)$ where r is the number of restrictions imposed.

Table 6: Nonlinear fiscal rule estimated using a Markov-switching approach: UK.

Part	Primary Spending (g)			Taxes (t)		Primary Surplus (gs)			
Linear (ψ)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
y_t	-0.512*** [-3.162]	-0.414** [-2.342]	-0.832*** [-4.522]	0.794*** [3.554]	0.713*** [3.938]	0.910*** [4.900]	0.981*** [5.054]	1.001*** [5.155]	1.210*** [6.086]
b_t	-0.022 [-0.559]	-0.041 [-1.232]	-0.126*** [-3.848]	-0.029 [-0.779]	-0.031 [-0.796]	-0.019 [-0.548]	-0.096** [-2.273]	-0.147*** [-2.971]	-0.119*** [-2.787]
Nonlinear (ω)									
<i>Regime 1</i>									
w_t	0.096 [1.475]	-	-	0.055 [0.759]	-	-	0.022 [0.263]	-	-
fw_t	-	0.063* [1.682]	-	-	0.004 [0.128]	-	-	-0.027 [-0.703]	-
hw_t	-	-0.005 [-0.106]	-	-	0.076* [1.630]	-	-	0.008 [0.898]	-
sp_t	-	-	0.047* [1.683]	-	-	-0.025 [-0.910]	-	-	-0.037 [-1.351]
hpt	-	-	0.092 [1.575]	-	-	0.050 [0.843]	-	-	-0.068 [-1.425]
c	0.010* [1.667]	0.010* [1.831]	0.015*** [2.637]	-0.020*** [-4.272]	-0.021*** [-4.860]	-0.019*** [-3.310]	-0.083*** [-14.761]	-0.085*** [-16.175]	-0.092*** [-17.039]
<i>Regime 2</i>									
w_t	-0.049 [-0.842]	-	-	-0.111 [-0.889]	-	-	-0.321*** [-4.300]	-	-
fw_t	-	-0.026 [-1.102]	-	-	-0.005 [-0.118]	-	-	-0.124*** [-3.059]	-
hw_t	-	-0.100* [-1.815]	-	-	-0.137** [-2.238]	-	-	-0.265*** [-4.509]	-
sp_t	-	-	-0.003 [-0.167]	-	-	0.044* [1.889]	-	-	-0.058** [-2.145]
hpt	-	-	0.060 [1.437]	-	-	-0.199*** [-3.330]	-	-	-0.305*** [-5.123]
c	0.072*** [14.582]	0.077*** [14.210]	0.072*** [15.014]	0.032 [4.371]	0.034*** [6.335]	0.026*** [5.415]	0.020*** [3.042]	0.024*** [3.580]	0.009 [1.452]
$\sigma_1(\times 100)$	0.090*** [5.83]	0.091*** [5.97]	0.104*** [5.42]	0.053*** [4.76]	0.081*** [5.97]	0.054*** [4.53]	0.063*** [3.29]	0.060*** [3.47]	0.045*** [3.45]
$\sigma_2(\times 100)$	0.029*** [3.75]	0.023*** [3.54]	0.030*** [4.51]	0.058*** [4.72]	0.021*** [3.71]	0.057*** [5.24]	0.010*** [6.20]	0.095*** [6.19]	0.100*** [6.56]
p_{12}	0.063** [2.08]	0.061** [2.15]	0.073** [1.95]	0.072* [1.75]	0.078*** [2.09]	0.059* [1.64]	0.129** [1.64]	0.128** [2.28]	0.136** [2.25]
p_{21}	0.105** [2.22]	0.109** [2.19]	0.092** [2.21]	0.069** [2.21]	0.073** [1.93]	0.053* [1.59]	0.048** [2.00]	0.046** [1.96]	0.044** [1.98]
LR-Statistics	32.475	32.911	46.36	10.223	20.846	25.386	38.934	42.897	42.783

Notes: * statistically significant at 10% level; ** at 5% level; *** at 1% level. t -values are in square brackets. LR statistics test the null hypothesis of linear versus a non linear model and are constructed as $2(\ln L^* - \ln L)$, where L^* and L represent the unconstrained and the constrained maximum likelihood respectively. These tests are distributed as $\chi^2(r)$ where r is the number of restrictions imposed.

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Figure 1. Markov-switching regimes: US.

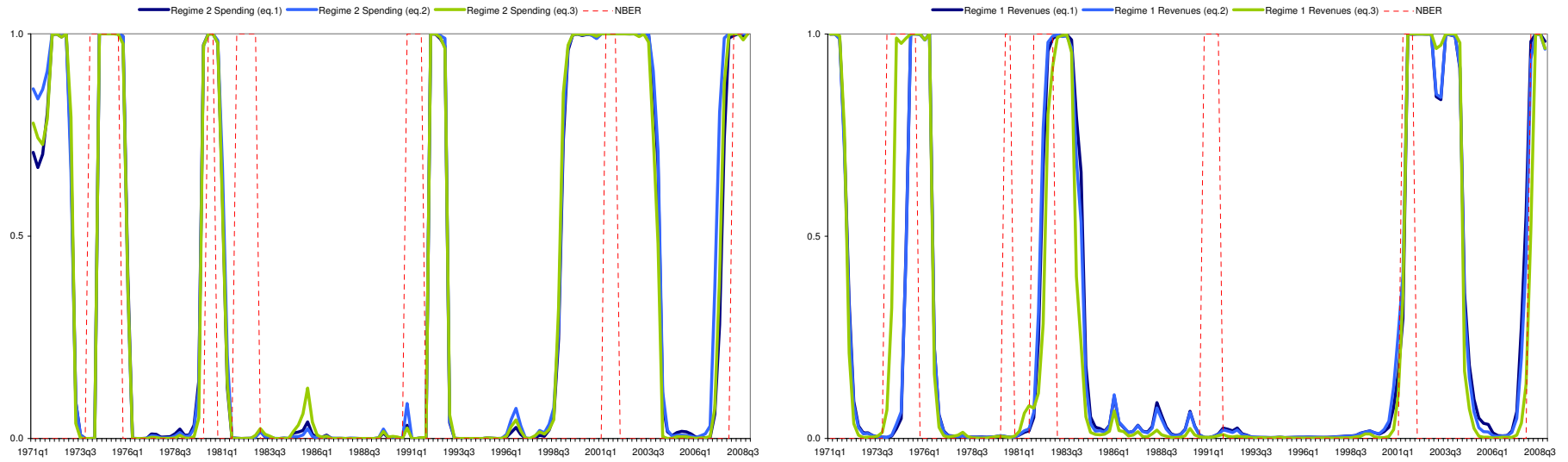
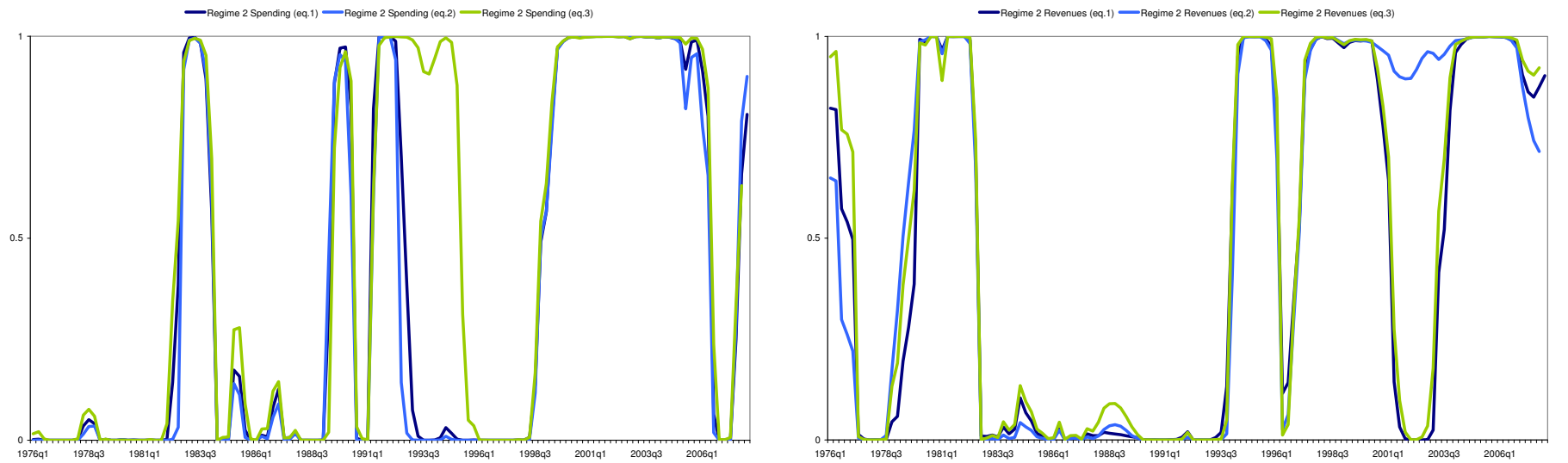


Figure 2. Markov-switching regimes: UK.



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