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Adjusting the U.S. Fiscal Policy for Asset Prices: Evidence from a TVP-MS Framework

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Abstract

This paper tests for nonlinear effects of asset prices on the US fiscal policy. By modeling government spending and taxes as time-varying transition probability (TVTP) Markovian processes, we find that taxes significantly adjust in a nonlinear fashion to asset prices. In particular, taxes respond to housing and (to a smaller extent) to stock prices changes during normal times. However, at periods characterized by high financial volatility, government taxation only counteracts stock market developments (and not the dynamics of the housing sector). As for government spending, it is neutral vis-a-vis the asset market cycles. We conclude that, correcting the fiscal balance and, notably, the revenue side for time-varying effects of asset prices provides a more accurate assessment of the fiscal stance and its sustainability.

Keywords: Fiscal policy, asset prices, time-varying transition probability Markov process.
JEL: E37, E52.

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1. Introduction

The recent global crisis has highlighted the importance of fiscal policy as a stabilizing tool, in particular, at times of severe economic downturns (Agnello and Nerlich, 2010; Castro, 2010; Agnello and Schuknecht, 2011). Indeed, when the financial turmoil started to exhibit its harmest impact on the economy, many governments actively implemented expansionary measures and substantial fiscal packages.

While helping to prevent another "Great Depression", these interventions also posed major challenges for policymakers, as their impact on the fiscal stance quickly led to well-grounded doubts about the long-term sustainability of debt path, as reflected in the performance of government bond yields that followed (Schuknecht et al., 2009) or the lack of business cycle synchronization (Rafiq and Mallick, 2008).

Perhaps more striking from a research point of view, the 2008-2009 financial turmoil has renewed the interest of academics and policymakers on the linkages between fiscal policy and asset markets (Afonso and Sousa, 2011, 2012; Agnello and Sousa, 2011, 2012; Agnello et al., 2011). However, these works have typically relied on the assumption that there is either: (i) a linear relationship between the policy instrument and the dynamics of the economic variables of interest; or (ii) a nonlinear relationship that characterizes sudden changes in fiscal policy associated with events such as a financial crisis, but also imposes fixed (exogenous) transition probabilities across the different states of the economy.

In the current work, we argue that the fiscal policy developments that emerge in response to asset market changes may be better described by means of a time-varying transition probability (TVTP) Markov-switching model.

First, the estimated state variable (such as asset wealth or asset prices) quite often exhibits a strong correlation with the business cycle. As a result, it is natural to assume that the state is endogenous.

Second, the effects of fiscal policy over the business cycle are likely to be different depending on whether the economy is expanding/contracting moderately or facing a severe recession or a period of exuberant growth. Putting it differently, the impact of fiscal policy should be non-monotonic.

Third, the fiscal policy instruments respond in a nonlinear fashion to the dynamics of the private sector, which is reflected, among others, in asset markets. This can be explained by the fact that fiscal policy affects agents' confidence, their expectations and, ultimately, their decisions.

Fourth, doubts about the effectiveness of policy interventions rely on the recognition that there is a stochastic shift of fiscal regimes that can identified as active or passive, Keynesian or Ricardian, low or high debt-to-GDP ratio, low or high financial distress. More specifically, there is uncertainty regarding the policy instrument that responds to the macroeconomic environment, as well as the magnitude of the reaction. The nature of the fiscal adjustment also depends on features that are outside the control of governments such as adjustment costs, credit and liquidity constraints, informational limitations, leverage effects and market imperfections. Similarly, given that financial crises happen occasionally and suddenly, governments may find it hard to implement fixed-regime rules.

As a result, rather than mapping the evidence of a nonlinear behaviour of fiscal policy into regimes that are defined ex-ante in accordance with a prior belief – as in the case of a Markov-switching model -, we adopt a more flexible approach whereby economic agents make a probabilistic inference regarding the future policy rule and the state of the economy to take decisions. In this context, reaction functions that can be associated with smoother (thereby, less frequent) regime switches are more prone to stabilize the economy and to provide a better understanding of how the fiscal authority responds to asset market developments.

We show that changes in asset prices lead to significant adjustment of the revenue-side of fiscal policy, especially, during normal time, where taxes respond to both housing and stock prices. In contrast, during periods of high volatility in the financial markets, fiscal policy is used as a stabilizing tool but only in response to the dynamics of the stock market. That is, at times of financial distress, the developments of the housing sector do not seem to be taken into account by governments.

In what concerns the government spending, we find that it is neutral with respect to asset markets, that is, the spending-side of fiscal policy is acyclical vis-a-vis the dynamics of housing and stock prices.

Finally, we show that one can assess more accurately the behavior of the fiscal stance and its long-term sustainability from the perspective of the path for government debt, by accounting for the asset market cycles.

The rest of the paper is organized as following. Section two presents the related literature. Section three describes the empirical methodology. Section four provides an overview of the data and discusses the results. Section five concludes and highlights the major policy implications.

2. Review of literature

The 2008-2009 financial turmoil has emphasized the need for a better understanding of the relationship between economic policy and asset markets (Castro, 2010, 2011; Sousa, 2010, 2012; Agnello and Sousa, 2011, 2012).

Some authors have stressed that taxation should account not only for the business cycle, but also for the asset price cycle (Jaeger and Schuknecht, 2007; Morris and Schucknecht, 2007; Tujula and Wolswijk, 2007). Similarly, addressing the occurrence of financial and banking crises matters for a more precise assessment of the fiscal stance (Schuknecht and Eschenbanch, 2004).

Darrat (1988), Tavares and Valkanov (2001) and Arin et al. (2009) argue that fiscal policy has a significant impact on bond yields and stock market returns. Hallett (2008) and Hallett and Lewis (2008) mention the importance of long-term sustainability of public finances, while Ardagna (2009) shows that sounder fiscal policies typically have a positive effect on stock prices. Heim (2010) uncovers a negative link between government deficits and private spending as a result of the credit shortage that is induced by the increase in public debt.

More recently, Afonso and Sousa (2011) use a fully simultaneous system of equations and data for Germany, Italy, UK and US and find that positive fiscal policy shocks lead to a rise in the variability of asset prices. Agnello and Sousa (2011) find that fiscal policy is particularly effective during severe housing busts. Agnello et al. (2011) estimate fiscal policy rules with the aim of understanding the government's response to both financial and housing wealth developments. The authors use three econometric methodologies (a fully simultaneous system approach, a smooth-transition regression and a Markov-switching model) and find that nonlinearity is important. In particular, fiscal policy becomes expansionary in the context of a rise in financial stress, thereby, partially offsetting the decline in wealth. Along the same lines, Jawadi et al. (2011) assess the macroeconomic impact of fiscal policy and estimate fiscal policy rules in the BRICs, and show that while government spending shocks have strong Keynesian effects, tax hikes are harmful for output. In addition, considerations about commodity prices, economic growth, exchange rate and inflation are responsible for the existence of nonlinearities in the fiscal policy reaction function. Tagkalakis (2011a) notes that fiscal buffers may be built to reflect the concerns about debt sustainability contained in asset prices. As a result, the conduction of fiscal policy might be conditional on the "state" of the world. For instance, a consolidation program is more likely to be successful when the fiscal stance is unsound or the economic conditions deteriorate (Tagkalakis, 2011b). Afonso and Sousa (2012) use a Bayesian Structural Vector Autoregression approach and show that fiscal policy shocks have a mixed impact on housing prices and a temporary effect on stock prices. Agnello and Sousa (2012) argue that when governments attempt to mitigate stock price developments, they may de-stabilize housing markets.

3. Methodology

3.1. A Time-Varying Probability Markov-Switching Model

We test for nonlinear effects of asset prices developments on the US fiscal policy stance within a Time-Varying Probability Markov-Switching (TVP-MS) framework. The basic idea behind Markov-switching modeling strategy is that many economic series might obey to different economic regimes associated with events such as financial crises (Jeanne and Masson, 2000; Cerra and Saxena, 2005; Hamilton, 2005) or abrupt changes in economic 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).

The main assumption behind such models consists of imposing fixed transition probabilities (FTP) governing the move between different states. This assumption is relaxed in the seminal work by Filardo (1994) which allows for time-varying transition probabilities (TVTP) in a Markov switching autoregressive model. Such probabilities are modelled as functions of certain conditioning (transitional) variables, which are found to be statistically (and economically) relevant to explain the regime switches (Filardo and Gordon, 1998; Layton and Smith, 2007; Kim et al., 2008). These aspects of TVTP models make them particularly attractive for our purposes. We therefore model tax and spending rules as follows:

$$\Delta lnF_t = \alpha_0(s_t) + \alpha_1(s_t)\Delta lnF_{1t-1} + \alpha_2\Delta lnY_{2t-1} + \alpha_3\Delta lnB_{3t-1} + \alpha_4(s_t)\Delta lnHP_{4t-1} + \alpha_5(s_t)\Delta lnSP_{5t-1} + \varepsilon_t(s_t) \quad (1)$$

where the fiscal policy instrument (F_t), either taxes (T_t) or government expenditure (S_t), is regressed on its lagged values, the lagged values of the GDP growth rate (ΔY_t) and debt to GDP ratio (ΔB_t) as conventionally done in the standard fiscal policy rule. Then, we augment the model specification by accounting for the effects of housing prices (HP_t) and stock prices (SP_t) on fiscal items. All variables are expressed in stationary terms.

Given a limited number of degrees of freedom, we keep the model as parsimonious as possible by considering only one lag for each independent variable. We also note that, as our final aim is to investigate whether fiscal policy reacts differently to housing and stock prices over different regimes, we consider that the coefficients associated to asset prices (besides those associated to the constant and obviously the lagged dependent variable) are allowed to switch between two different states, i.e. $s_t \in \{1,2\}$. By contrast, we assume the relation between the fiscal policy indicators, output growth and public debt is always linear.

The observation of either regime 1 or 2 at time t depends upon the realizations of an unobservable Markov chain, that is $\mathrm{s_t}$ is conditioned by $\mathrm{s_{t-1}, s_{t-2}, \cdots, s_{t-k}}$. At any time $\tau < t$, the regime that will be observed at time t is unknown with certainty. Thus, we introduce a probability P of occurrence of $\mathrm{s_t}$ given the past regimes. Assuming, for purpose of simplicity, that $\mathrm{s_t}$ is a first-order Markov-switching process, we define $P\{s_t/s_{t-1}, s_{t-2}, \cdots, s_{t-k}\} = P\{s_t \,/\, s_{t-1}\}$. We further assume that the transition from one regime to the other depends upon a set of "transition" variables described by a vector $\mathrm{z_t}$ so that, $P\{s_t \,/\, s_{t-1}\} = P\{s_t/s_{t-1}, z_t\}$. The transition probabilities are defined as follows:

$$\begin{cases} p_{11}(z_t) = \frac{\exp(a_1+b_1 z_t)}{1+\exp(a_1+b_1 z_t)}, \quad p_{22}(z_t) = \frac{\exp(a_2+b_2 z_t)}{1+\exp(a_2+b_2 z_t)} \\ p_{12}(z_t) = 1 - p_{11}(z_t), p_{21}(z_t) = 1 - p_2(z_t) \end{cases} \tag{2}$$

where $p_{ij}(z_t)$ is the probability of moving from regime i to regime j conditional on the dynamics of the transition variables. $\mathrm{b_1} > 0\ (< 0)$ indicates that, on average, a positive change in the set of variables in $\mathrm{z_t}$ decreases (increases) the likelihood of a transition from regime 1 to regime 2. Similarly, $\mathrm{b_2} > 0\ (< 0)$ indicates that, on average, a positive change in the set of variables in $\mathrm{z_t}$ increases (decreases) the likelihood of a transition from regime 2 to regime 1. As pointed out the beginning of this section, one advantage of this formalization over the standard Markov-switching model is that the transition probabilities are time-varying because they vary with respect to z_t .

3.2. Estimation and methodological issues

The model is estimated via maximum likelihood (henceforth ML). We define the following vectors: $\Omega_t = (\mathbf{X}_t, z_{t-k})$ is the vector of observed independent variables and transition variables up to period t. Besides, $\xi_t = (y_t, y_{t-1}, \ldots, y_1)$ is the vector of the historical values of an endogenous variable. Denoted θ the vector of parameters to estimate, the conditional likelihood function of the observed data ξ_t is defined as

$$L(\theta) = \prod_{t=1}^{T} f(y_t/\Omega_t, \xi_{t-1}; \theta) \tag{3}$$

where
$$f(y_t/\Omega_t, \xi_{t-1}; \theta) = \sum_i \sum_j f(y_t/s_t = i, s_{t-1} = j, \Omega_t, \xi_{t-1}; \theta) \times P(s_t = i, s_{t-1} = j/\Omega_t, \xi_{t-1}; \theta) \tag{4}$$

The weighting probability is computed recursively by applying Bayes's rule and finally one gets:

$$P(s_t = i/s_{t-1} = j, z_t)P(s_{t-1} = j/\Omega_t, \xi_{t-1}; \theta) = P_{ij}(z_t)P(s_{t-1} = j/\Omega_t, \xi_{t-1}; \theta) \tag{5}$$

We also have

$$P(s_t = i \quad /\Omega_{t+1}, \xi_t; \theta) = P(s_t = i \quad /\Omega_t, \xi_t; \theta) \frac{1}{f(y_t/\Omega_t, \xi_{t-1}; \theta)} \sum_j f(y_t/s_t = i, s_{t-1} = j, \Omega_t, \xi_{t-1}; \theta) \times P(s_t = i, s_{t-1} = j/\Omega_t, \xi_{t-1}; \theta) \tag{6}$$

To complete the recursion defined by the equations (5) and (6), we need the regime-dependent conditional density functions

$$f(y_t/s_t = 1, s_{t-1} = j, \Omega_t, \xi_{t-1}; \theta) = \frac{\phi\left(\frac{y_t - x_t'\beta_1}{\sigma_1}\right)\Phi(a_j + z_t'b_j)}{\sigma_1 P_{1j}(z_t)} \tag{7a}$$

$$f(y_t/s_t = 2, s_{t-1} = j, \Omega_t, \xi_{t-1}; \theta) = \frac{\phi\left(\frac{y_t - x_t'\beta_2}{\sigma_2}\right)\Phi(a_j + z_t'b_j)}{\sigma_2 P_{2j}(z_t)} \tag{7b}$$

The parameters of the TVPMS model are thus jointly estimated with ML methods for mixtures of Gaussian distributions. As compared with other estimators (for instance, the EM algorithm or the Gibbs sampler),[1] the ML estimator has the advantage of computational ease. As shown by Kiefer (1978), if the errors are distributed as a normal law, then the ML yields consistent and asymptotically efficient estimates. Further, the inverse of the matrix of second partial derivatives of the likelihood function at the true parameter values is a consistent estimate of the asymptotic variance-covariance matrix of the parameter values.

3.3. Adjusting fiscal aggregates for asset prices

When fiscal policy stance is under investigation, cyclically-adjusted indicators (i.e. fiscal indicators corrected for the effects of business cycle) represent a useful benchmark to evaluate the direction of fiscal policy and ultimately, in the assessment of long-term fiscal sustainability.

Apart from the well-known measurement problems of such structural indicators mainly related to the high degree of uncertainty intrinsic in statistical smoothing techniques used to extract the cyclical component of budgetary categories (Canova, 1998; Jaeger and Schuknecht, 2007; Darby and Melitz, 2008), they might also be subject to the so-called omitted variables bias. This occurs when economic factors which significantly influence the dynamic of fiscal positions do not enter the computation of their corresponding structural component. As a result, estimate of structural balance (which is calculated as the difference between structural revenues and structural expenditure) is distorted and leads to an inaccurate view of the fiscal stance. This 'bias' could be particularly sizable when structural indicators are not corrected for the effects of asset prices. In fact, a number of papers (Agnello and Sousa, 2011; Tagkalakis, 2011a) use a panel approach to show that, in industrialized countries, government primary balance is significantly driven by housing and stock prices. At country level, this evidence emerges particularly for the US which has experienced sharp fluctuations of financial markets during the last two decades (Agnello et al., 2011).

Similarly to Kanda (2010) and Bornhost et al. (2011), a simple approach to adjust fiscal positions for the effects of the business and asset cycles consists of the

[1] See Diebold et al. (1994) and Filardo and Gordon (1998).

following steps. First, we take exponents of both sides of equation (1) to eliminate natural logs and express all the explanatory variables in levels, say M. Second, we employ an HP filtering technique to extract their corresponding structural part (M^*). Finally, we use the elasticities ($\hat{\alpha}_i$) as obtained from the TVP-MS models to calculate the so-called structural component of taxes and expenditures:

$$F_t^* = F_t \left(\frac{F_{1t-1}^*}{F_{1t-1}}\right) \prod_{i=2}^{5} \left(\frac{M_{it-1}^*}{M_{it-1}}\right)^{\hat{\alpha}_i(\cdot)} \left(\frac{M_{it-2}^*}{M_{it-2}}\right)^{-\hat{\alpha}_i(\cdot)} \quad (8)$$

where F_t^* denotes either the structural component of taxes (T_t) or thje structural component of government expenditure (S_t) while the index i refers to the number of independent variables M (excluding the constant) in equation (1).

4. Data and empirical results

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 expressed in difference of natural logarithms, seasonally adjusted and measured at constant prices unless stated otherwise. The data are available for: 1968:q1-2008:q4. The set of variables considered in the econometric methodologies is as follows. First, series of the primary government spending (S_t) and the government revenues (T_t), are retrieved from the Bureau of Economic Analysis, NIPA Table 3.2. As the macroeconomic variables, the real GDP series (Y_t) is provided by the Bureau of Economic Analysis, NIPA Table 1.1.5 (line 1) while the government debt series (B_t) is downloaded from the Federal Reserve Bank of St Louis database (FRED). In what concerns asset markets data, housing prices are measured using two sources: (a) the U.S. Census and (b) the House Price Index computed by the Office of Federal Housing Enterprise Oversight (OFHEO).

4.2 Evidence from the linear model

We start by presenting and discussing the evidence from the preliminary estimation of the linear fiscal rules augmented with housing and stock prices. For comparative purposes estimates of the fiscal rules without asset prices components are also reported. Results are summarized in Table 1. Columns 1-2 display the results for taxes while columns 3-4 refer to the government spending rule. All the specifications point to an important countercyclical response: an increase in output raises the taxation and reduce the primary spending. As concerns the response of fiscal policy to government debt, our results support the existence of a stabilizing effect mainly on the revenues side: when government debt grows, taxes significantly increase while expenditure declines.

Turning to the response of fiscal measures to asset prices (see columns 2 and 4) the empirical findings show that taxes are strongly affected in a positive and significant way, with housing prices exerting the strongest impact (the coefficients associated to housing and stock prices are 0.33 and 0.10, respectively). In contrast, there is no evidence of a 'linear' response of primary spending to asset markets.

[INSERT TABLE 1 HERE.]

4.3 Evidence from the TVP-MS model

In this section we assess whether fiscal policy is affected in a nonlinear fashion by changes in asset prices. The results from the estimation of the two-regime TVP-MS model are reported in Table 2. A first key preliminary step in modeling TVP-MS consists of testing linearity against the Markov-switching type non-linearity. In principle, the classical approach to testing is the likelihood ratio (LR) test under the null hypothesis of linearity against the alternative standard hypothesis of two-regimes MS model. However, the construction of such tests is complicated because, in the context of Markov switching models, standard regularity conditions for likelihood based inference are violated. In particular, as noted by Hansen (1996a) under the null hypothesis of linearity, some parameters are not identified and scores are identically zero. As a result, the asymptotic distribution of the relevant LR test statistic does not possess the standard χ^2-distribution and a simulation exercise must be carried out to calculate critical values. To that end, following Di Sanzo (2009), we have used a bootstrap re-sampling scheme to approximate the distribution of the test statistic under the null of linearity.[2] As discussed by the author, this approach outperforms alternative methods as proposed by

[2] Specifically, the approach consists of the following steps: (a) the LR statistic is calculated by using the actual data Y; (b) we generate a large number (1000) of artificial series (Y^*) by randomly drawing with replacement from the original data set; (c) we estimate the linear and MS models for each artificial series and calculate the corresponding test statistics (LR^*); and (d) once we get the empirical distribution of LR^* and its critical values, we perform the test based on the computed value of the LR statistic.

Hansen (1992, 1996b) and Carrasco and Hu (2004). The bootstrap-based linearity tests are reported at the bottom of Table 2 and suggest that the TVP-MS specification represents a good description of the behavior of fiscal authorities when the fiscal policy instrument is the taxation (the linearity test statistic is significant at 5% of confidence). By contrast, government spending doesn't react to asset prices movements in a linear fashion.

After testing several variables (e.g. financial and housing wealth, financial stress index, inflation etc.) that may influence the probability to switch between the two regimes, the "aggregate wealth" has been chosen as transition variable. This means that taxes are supposed to react differently to asset prices depending on the wealth developments. However, it is interesting to note that, from a theoretical point of view, this latter assumption is also consistent with the existing literature that views fiscal policy rules as designed to target national wealth (Blake et al., 1998; Lossani and Tirelli, 1994). Under these circumstances, nonlinear models that account for the "state" of asset wealth may be useful to arrive at a more accurate assessment of fiscal policy stance.

[INSERT TABLE 2 HERE.]

Looking at the TVP-MS estimates for the tax rule, we note that, fiscal policy behaves in a counter-cyclical manner, i.e. an increase (reduction) in taxes is associated to output rises (decline). Estimates also support the existence of a debt stabilizing motive. Such results are in accordance with theoretical expectations and in line with the evidence found for the linear framework.

Turning now to the nonlinear reaction of taxes to asset markets, the empirical findings show the 'size' of the tax adjustment to asset prices during the two regimes is significantly influenced by wealth developments. In particular, during 'normal' time (regime 2) characterized by low volatility (0.01), taxes are highly persistent (Afonso et al., 2010) and significantly adjust to housing and (to a lesser extent) stock prices. Such evidence is qualitatively the same as for the linear model. By contrast, during periods characterized by high uncertainly (0.04) and sharp fluctuations in aggregate wealth (regime 1), tax changes are not correlated to their past developments (i.e. low degree of persistence) and, most importantly, they are solely driven by stock market developments. A visual inspection of Figures 1 and 2 suggests that regime 1 broadly captures periods of financial volatility mainly driven by high uncertainly in the stock markets. In this context, our results indicate that the US fiscal policymaker tends to target stock prices and strongly counteract their evolution, i.e. increasing (reducing) taxes (e.g. taxes on capital gains) in response to sharp increases (declines) in stock prices.

[INSERT FIGURE 1 HERE.]

[INSERT FIGURE 2 HERE.]

This evidence supports our intuition about the opportunity to adjust government revenues for asset prices movements as to arrive at a more precise characterization of fiscal developments and is similar in spirit with the work of Bouthevillain and Dufrénot (2010). This is also confirmed by Figure 3. It depicts the structural component of fiscal revenues (in annualized growth terms) as computed using equation (8) and based on the estimates of the TVP-MS model and of the linear model specification augmented for asset prices. We note that controlling for the time-varying effects of asset prices is particularly important. In fact, without accounting for such effects, as in the case of the linear specification (where the impact of asset prices is assumed to be constant over the time), we underestimate (on average) the influence of asset prices on taxation during normal times (regime 2) and overestimate it during periods of financial volatility (regime 1). This 'bias' might cause a misperception of the structural fiscal balance, as computed by netting out fiscal positions (revenues and expenditure) of cyclical and asset prices effects and, therefore lead to an inaccurate assessment of the fiscal stance and/or fiscal sustainability.

[INSERT FIGURE 3 HERE.]

5. Conclusions

This paper tests for nonlinear effects of asset prices on the US fiscal policy. More speficially, we model government spending and taxes as time-varying transition probability (TVTP) Markovian processes. We find that, during normal times, taxes adjust in a significantly nonlinear way vis-a-vis asset prices. In contrast, during periods of substantial financial distress, taxes respond only to stock prices. In what concerns government spending, we show that fiscal policy is neutral with respect to asset market cycles. Finally, we show that, correcting the revenue side of fiscal policy for the time-varying effects of asset prices provides a more accurate assessment of the fiscal stance and its sustainability. From a policy perspective, the current paper shows that fiscal policy can play a major stabilizing role at times of financial distress. Therefore, it can be quite successful at counteracting major downfalls in the stock markets and, thereby, at promoting the economic recovery.

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List of Tables

Table 1: Linear Models.

	Taxes		Primary Spending	
	(1)	(2)	(3)	(4)
Constant	-0.013***	-0.007	0.029***	0.028***
	[-2.52]	[-1.53]	[6.37]	[6.02]
Lagged Output	0.809***	0.422***	-0.385***	-0.326***
	[4.34]	[2.35]	[-3.69]	[-2.59]
Lagged Dependent var.	0.413***	0.413***	0.51***	0.504***
	[6.50]	[6.50]	[7.60]	[7.48]
Lagged Public Debt	0.112***	0.142***	-0.043	-0.04
	[2.30]	[2.79]	[-1.17]	[-0.95]
Lagged Housing Prices	-	0.333***	-	-0.018
		[3.87]		[-0.27]
Lagged Stock Prices	-	0.098***	-	-0.015
		[5.56]		[-1.09]
R-square	0.62	0.69	0.42	0.43
Log-Likelihood	291.06	308.53	340.01	340.64

Note: ***,**,* statistical significance at 1%, 5% and 10%. t-values in square brackets.

Table 2: TVP-MS Models.

	Taxes	Primary Spending
Non-Switching parameters		
Lagged Output	0.326***	-0.151
	[2.64]	[-1.58]
Lagged Public Debt	0.112***	-0.038
	[3.14]	[-1.33]
Switching parameters		
Regime 1 (S=1)		
Constant	-0.0027	0.01***
	[-0.76]	[4.91]
Lagged Dependent var.	0.047	0.62***
	[0.53]	[9.46]
Lagged Housing Prices	0.031	-0.014
	[0.31]	[-0.52]
Lagged Stock Prices	0.124***	-0.014***
	[5.27]	[-2.35]
σ_1	0.040***	0.016***
	[10.09]	[13.28]
Regime 2 (S=2)		
Constant	0.00097	0.015***
	[0.46]	[3.05]
Lagged Dependent var.	0.51***	0.375***
	[5.23]	[2.41]
Lagged Housing Prices	0.153***	-0.087
	[3.12]	[-0.77]
Lagged Stock Prices	0.018***	-0.025
	[2.13]	[-1.22]
σ_2	0.015***	0.039***
	[10.82]	[6.37]
Transition function		
Transition variable/par.	Aggregate Wealth	Aggregate Wealth
a_1	2.073***	3.73***
	[2.15]	[4.33]
a_2	2.283***	3.29***
	[3.80]	[2.32]
b_1	-5.064	5.53
	[-0.31]	[0.27]
b_2	40.42***	-25.71
	[2.13]	[-0.90]
Linearity tests		
Statistics and (p-value)	5.367**	-0.924
	(0.05)	(0.629)

Note: ***,**,* statistical significance at 1%, 5% and 10%. t-values in square brackets. p-values in parenthesis.

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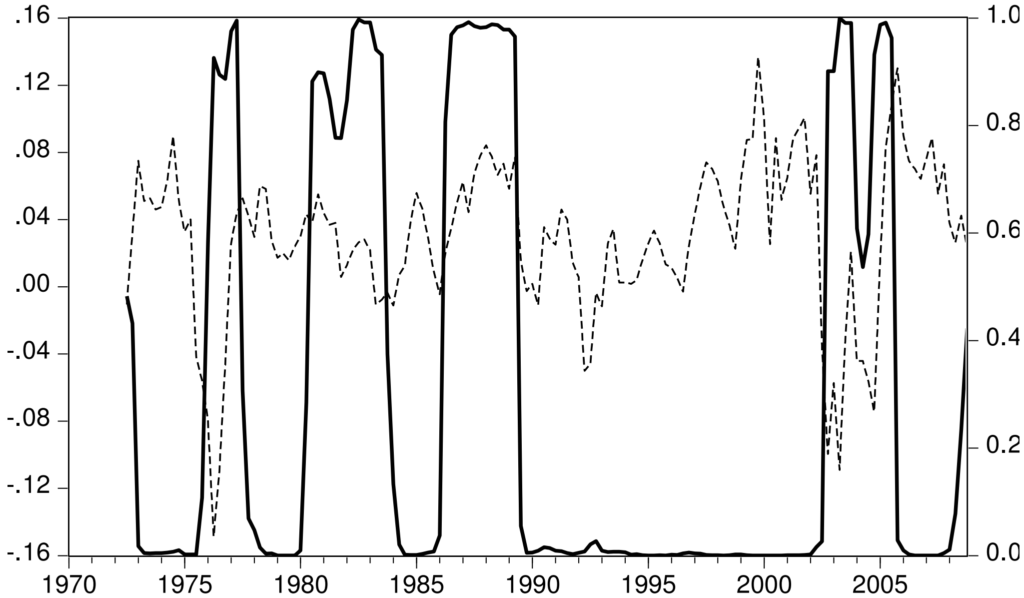
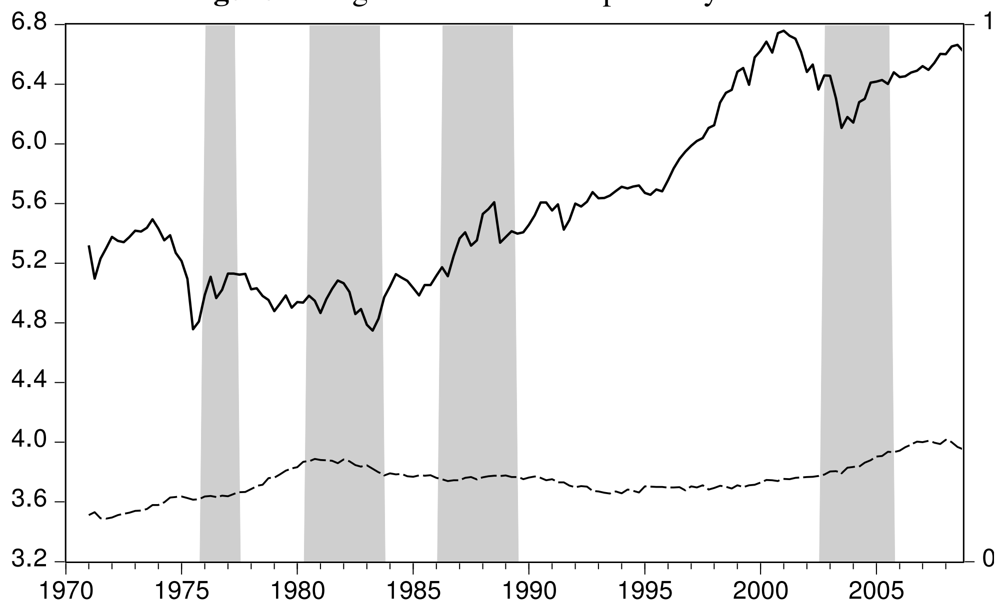
Figure 1: Smoothed probabilities of regime one and wealth growth rate.



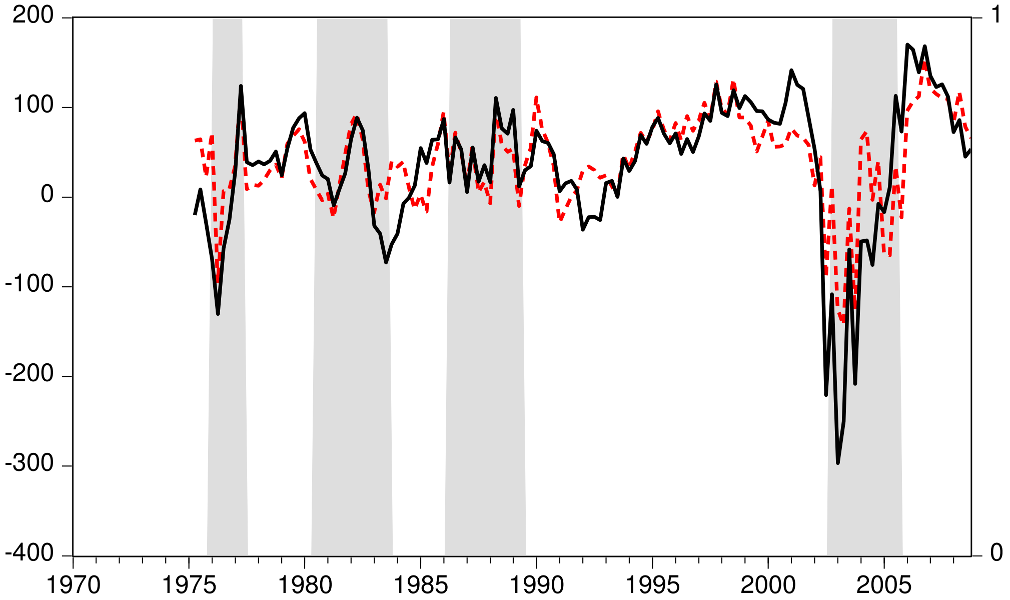
Note: Smoothed probabilities of regime one (bold) and transition variable (dotted)

Figure 2: Regime one and asset prices dynamics.



Note: Regime one (bars), stock prices index (bold) and housing prices index (dotted)

Figure 3: Structural components (revenues).



Note: Annualized growth rate of structural revenues from TVP-MS model (black line) and from the asset prices augmented linear model (dotted red line).

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