"Analysing one policy at a time is like dancing a tango solo: it's a lot easier, but it is incomplete and ultimately unfulfilling" (Leeper, 1993)

The policy tango: rules-based evidence on policy interaction

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ABSTRACT

This paper seriously tests the effects of policy interaction on systematic policy behaviour. We basically translate simple monetary policy rules into simple fiscal policy rules. We test strategic interaction also directly by inclusion of reactions to the other authority's policy instrument. We infer more precise estimates of both the Federal Reserve and the Administration's reaction coefficients by adopting a system GMM approach. Our results qualify existing evidence on systematic policy. First, policymakers do dance a tango. Fiscal and monetary have separated tasks in stabilising output and inflation. The combination of passive fiscal policy and active monetary policy is consistent with a determinate equilibrium. Changes in policy regimes can be interpreted in terms of an 'unpleasant fiscal arithmetic'.

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1. Introduction

Newspaper articles rarely discuss economic issues without reference to the policy stance of both monetary and fiscal authorities. The US 'twin deficit' is hardly ever mentioned without the fiscal boost of the Bush Administration and the accompanying loose policy of the Federal Reserve. Over the last decade, the impotence of monetary policy to get Japan out of the economic slump has repeatedly given rise to calls for fiscal expansion. And the gradual dismantling of the Stability and Growth Pact (SGP) reveals tensions on the right policy balance in a heterogeneous EMU. At the same time, central bankers seem to take special interest in taming fiscal profligacy, while politicians regularly forewarn of stringent monetary conditions.[3] This may be part of the policy game, in which either the fiscal or monetary authority tries to manoeuvre policy settings in its favour. But central bankers may also be aware of the constraints that unsustainability of public finances imposes on monetary policy in the longer term.

Few economists would also disregard the policy mix in a colloquial debate on current macroeconomic topics. Nevertheless, the predominant view in economic theory is to consider either fiscal or monetary policy in isolation. Recently, the interaction between fiscal and monetary policy has been put front stage again with the 'Fiscal Theory of the Price Level' (FTPL). Its main contention is that if fiscal policy is set such that it does not satisfy the intertemporal government budget constraint for all possible price paths, then it is not monetary policy – but fiscal policy – that eventually determines prices (Leeper, 1991; Sims, 1994; Woodford, 1998). Such an 'active' fiscal policy does not result in a determinate economic equilibrium then if monetary policy is 'actively' combating inflation.[4] The implications and the underlying assumptions of this theory have not gone unchallenged, and its validity is a fiercely debated issue.[5] But the FTPL has certainly refocused attention on the interaction between both fiscal and monetary policy. The analysis has also gone beyond the link provided by the sustainability of public finances. The New Keynesian workhorse model for the analysis of monetary stabilisation policies has been extended now to fiscal policy. As both policies react to – and have an effect on – current economic conditions, interaction of fiscal and monetary policy naturally occurs also in the short term. Interestingly, these DSGE models have also revived interest in the public finance approach towards the joint determination of policies (Lucas and Stokey, 1983). Recent analysis marries these Ramsey type of models to New Keynesian models with more realistic features of fiscal policy so as to arrive at an optimal characterisation of both policies (Correia et al., 2001; Schmitt-Grohé and Uribe, 2004a,b; Siu, 2004). These results carry relevant insights in the systematic setting of both fiscal and monetary policy. The discussion about economic policy is now firmly framed in a 'policy rules' context. In contrast to monetary policy, thinking about fiscal policy in terms of policy rules has been less common in academic discussions than in practical policy debates. Actually, the recent rise in public debt in most industrialised

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[3] "*Greenspan urges reinstating budget rules*" AP 12/02/2004; "*Trichet wirbt für den Stabilitätspakt*", FAZ 21/11/2003; *"I think that we are credible enough for people to believe that we will deliver what we promise to deliver. And now it is the turn of the governments to do the same thing"* (Duisenberg, 05/06/2003, ECB Press Conference).

[4] We use the 'active' versus 'passive' terminology of Leeper (1991).

[5] The analysis of the FTPL was already preluded in Blinder and Solow (1973) and Sargent and Wallace (1981), who stressed the wealth effects and monetary financing of deficits respectively. The FTPL scenario has not been deemed realistic by some of the vocal contenders of the theory. Buiter (2002) ardently criticises the existence of equilibria that may never be attained in reality. MacCallum (2003) and Niepelt (2004) criticise the 'bubble' solution of the model which requires the public to hold non-redeemable debt. For a favourable reading of the FTPL, see Woodford (2001) or Cochrane (1999, 2001). In our opinion, the FTPL provides an encompassing theory of the diverse studies on policy interaction.

countries (Figure 1) comes somewhat as a surprise after rules-bound policies came into vogue in the nineties. Even if the Gramm-Rudman-Hollings Act never officially applied, the Clinton Administration nevertheless governed a substantial reduction of public debt. The EU governments enshrined public debt and deficit targets in the Treaty of Maastricht and strengthened these provisions with the SGP.

Despite the recent theoretical advances, the incorporation of both fiscal and monetary in an empirical analysis of systematic policy behaviour is still missing, however. Monetary Taylor rules that express the setting of the interest rate as a reaction function of inflation and output have enjoyed enormous empirical interest. The heterogeneous nature of fiscal policy has impeded a straightforward extension, even if estimates of fiscal policy rules are implicit in diverse strands of the empirical literature. The objective of this paper is to take stock of the literature on policy interaction, and to empirically analyse fiscal and monetary policy instrument rules. We examine how the common properties of policy rules alter when interaction is accounted for. We characterise policy regimes that depart from the usual assumption of dichotomy between fiscal and monetary policy.

The structure of the paper is as follows. In section 2, we discuss the consequences of interaction for systematic fiscal and monetary policy. This outlines the arguments for the derivation of the empirical policy rules. A concise overview of the empirical literature on systematic fiscal policy leads us to recast a test for debt sustainability à la Bohn (1998) in terms of a fiscal policy rule. A common specification for the monetary ‘Taylor’ rule is taken from the New Keynesian theoretical shelf. Specification and methodology are adjusted accordingly in section 3. Essentially, we follow traditions in the monetary policy literature in presenting rules in which the policy instrument is gradually adjusted to its target level. The methodology then consists in simultaneously estimating the system of non-linear policy rules using GMM. As such, we correct for the endogeneity of policies in determining output and inflation and can infer more precise estimates when policy interaction really matters. In addition, we develop a test for strategic policy interaction by allowing for direct reactions to the other policymaker's instrument.

The standard results undergo some changes when fiscal and monetary policies are jointly modelled. The estimation of the each policy rule in isolation confirms some of the conventional findings in the literature. Fiscal policies are sustainable (Bohn, 1998); monetary policy has switched to a more activist policy against inflation since 1980 (Clarida et al., 2000). The system estimates discussed in section 4 also reveal that the Federal Reserve and the Administration are dancing a tango. To further paraphrase Leeper (1993), the entire US macroeconomic history is consistent with determinacy through a combination of passive fiscal and active monetary policies. Fiscal and monetary policy have clearly separated tasks. Fiscal policy stabilises output, while monetary policy in turn stabilises prices. But the analysis of the consolidated US government shows that regime shifts are important in accounting for the evolution of policies over time. The common finding of a shift in monetary policy needs to be reconsidered given the evidence for major changes in fiscal policy. We explain the evidence of active monetary and passive fiscal policy in terms of an ‘unpleasant fiscal arithmetic’ (King, 1998) in which tight monetary policy raises the debt burden for the Treasury. An extensive robustness analysis, both in methodology and specification confirm these insights. Conclusions follow in section 5.

2. Sustainability of public debt and policy rules

2.1. Indeterminacy and policy regimes

In contrast to more casual discussions on macroeconomic policy, most economists nowadays have a framework in mind in which fiscal and monetary policy have clearly separable tasks. Monetary policy can deliver stable economic conditions – also in the short-term – as long as it is guided by the aim of price stability in the long term. Fiscal policy ought to be dedicated to long-term allocative and redistributive tasks instead. The role for discretionary policy is limited, as its flexible use is hindered by political constraints. Automatic stabilisers built in the fiscal system can nonetheless provide timely intertemporal smoothing in the short term. This division of policy tasks, which is perhaps most clearly stated by Taylor (1993, 2000), goes back at least to the proposals of Friedman (1948) for setting immediate post-war US economic policies.[6] This view is firmly cast in terms of systematic rules-based policies nowadays. Nonetheless, the possibility of occasional interaction between monetary and fiscal policy is not entirely excluded. During exceptional events, gains from the joint setting of policies have usually been recognised. The typical examples are a liquidity trap or external crises in which monetary policy alone is insufficient for furthering economic stability. It has been much less acknowledged that rules-based policies also have important reciprocal effects – even under normal economic circumstances – that may overturn the usual policy advice for either fiscal or monetary authorities separately.

This is perhaps best illustrated by means of a monetary policy rule. An instrument rule as in (1) in which the central bank adjusts a short-term interest in response to inflation and output has been popularised by Taylor (1993).

$$i_t = \alpha + \beta \pi_t + \gamma y_t \qquad (1)$$

Such a feedback rule is not only believed to be a good empirical description of central bank behaviour. It is also a useful framework for thinking on systematic policy setting. This has passed by now the time-inconsistency issue of uncommitted central bank decisions. Monetary policy rules close a variety of fully fledged DSGE economic models based on microeconomic foundations and characterised by nominal rigidities, and can be shown to be optimal in a variety of macroeconomic models (Giannoni and Woodford, 2003a). Simple rules seem to be as good as optimal rules in bringing about aggregate economic stability. The consensus recommendation to monetary authorities that emerges from this literature is that of reacting sufficiently strongly to expectations of future inflation. In terms of a monetary rule as (1), this implies that the coefficient <beta> be larger than unity (<beta>). By ‘actively’ combating inflation, the possibility is ruled out that self-fulfilling inflation expectations build up. The propagation of fundamental shocks would indeed not be uniquely determined in case the central bank is soft on inflation. Moreover, stationary equilibria and business cycle fluctuations exist that would be driven by sunspot shocks. Forward-looking agents anticipate that a central bank that follows the ‘Taylor principle’ keeps real interest rates positive in the face of economic fluctuations, and thereby stabilises aggregate demand and hence inflation. This insight has not gone unchallenged, however, and there are serious doubts about the general validity of strong anti-inflationary policies. Equally plausible assumptions may lead to widely diverging qualitative outcomes. There are a variety of ways in which the policy choice of the central bank can

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[6] Okun (1972) discusses the *“fiscal-monetary partnership”*.

lead to nominal indeterminacy. Slight changes in the assumptions on consumer preferences or technology underlying the basic New Keynesian models can easily disturb seemingly firm conclusions (Carlstrom and Fürst, 2001). More elaborate monetary models that include capital (Benhabib and Eusepi, 2004) or real balances (Benhabib et al., 2001a) immediately launches many plausible channels for having multiple equilibria: by affecting marginal decisions of agents, monetary policy directly impinges on the pricing conditions of firms and thus aggregate supply in addition to the conventional aggregate demand channel.[7]

By opening up many different ways for policy to be wrong, this questions the possibility at all of designing robust monetary policy strategies. Guaranteeing determinacy seems to call for very specific modifications of the model or a need to impose further parameter restrictions. Fortunately, this pessimistic view on determinacy is not entirely warranted. In general, a credible commitment to reverse policy in the future is usually sufficient to restore determinacy.[8] A particular role has been attributed to fiscal policy in this regard. The debate spurred by the dispute on the FTPL has led to a reconsideration of the channels of interaction between fiscal and monetary policy. There is a wider variety of also unconventional policy approaches to guarantee price stability.

It has placed the focus again on fiscal sustainability and on the policy mix in determining macroeconomic outcomes. Basically, the argument of the FTPL hinges on the interpretation of the intertemporal government budget constraint as a value equation rather than as a constraint. As the budget equation does not constrain behaviour of economic agents any longer, models of fiscal policy consequently need to be closed in very much the same way as models of monetary policy are closed. I.e., with a rule describing the policymaker's behaviour. In this case, the rule links the instrument to the stock variable. We have a fiscal rule that expresses the surplus as a function of debt B_t, as in (2),

$$s_t = \phi B_t + \varepsilon_t \quad , \tag{2}$$

and where $\phi = 0$ would imply an 'active' or 'non-Ricardian' policy that disregards developments in debt.[9] According to the FTPL, the eventual responsibility for the price level is always in the hands of the fiscal authority. This does not only work out in the long-term but has moreover some major implications for the policy mix of systematic fiscal and monetary policy in the short-term too. Optimal monetary policy rules need not conform to the standard properties derived under the dichotomy assumption anymore. In particular, under non-Ricardian regimes the properties of policy rules need to be reversed to ensure determinacy (Leeper, 1991; Sims, 1994; Woodford, 1998). If fiscal policy is sufficiently reactive to debt (the so-called 'passive' policy or $\phi > 0$ in (2)) then the budget constraint will be satisfied for all price paths. Monetary policy retains the ability to control prices in this Ricardian environment. As long as monetary policy is 'active' and follows the Taylor principle, a

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[7] Another type of indeterminacy problems arise if equilibrium cycles of any periodicity (Benhabib et al., 2002b). The fiscal policies usually considered for restoring determinacy of the economy do not take effect in this case.

[8] In general, Lubik and Marzo (2006) argue that a central bank that is strongly aggressive on inflation, but gives some attention to output too can achieve equilibrium determinacy for a very wide range of parameters, as long as it smoothes interest rates. Davig and Leeper (2005b) show that the Taylor principle need not be followed at all times in order for monetary policy to be active. Short-term deviations from commitment to the Taylor rule are compatible with determinate economic outcomes if private agents believe the central bank will revert to a tougher anti-inflationary policy stance with some probability.

[9] In the terminology of Leeper (1991) or Woodford (2001) respectively.

determinate equilibrium will result. However, if fiscal policy is exogenously determined ('active' policy), it will necessarily select the price path for the economy. This may still result in a determinate equilibrium, but only if monetary policy does not pin down the price level itself. The classical result of Sargent and Wallace (1975) that associates an interest rate peg with indeterminacy of the price level need not hold anymore. Generally speaking, for determinacy and uniqueness of the equilibrium, it is necessary that at least one policy maker sets it control variable actively; while for fiscal solvency, at least one authority set its instrument passively (Leeper, 1991). Policy rules need not conform anymore to the standard results under Ricardian fiscal policies.[10]

While a combination of active interest rate policy and passive fiscal policy (or vice versa) is generally compatible with determinacy, the stylised FTPL model entails rather strict restrictions on the parameters of the policy rule. Some modifications of the baseline FTPL model do not have the dire prediction that fiscal policy need be set as an exogenous sequence of primary surpluses to have an interest rate peg compatible with determinacy. A feedback effect of fiscal variables on economic outcomes is sufficient for having determinate outcomes in which fiscal policy determines prices, regardless of the exogeneity or endogeneity of fiscal policy. The determinacy result holds only for certain blends of policy rule parameters in this case.[11] The prime example is distortionary taxation. Leeper and Yun (2005) show that the fiscalist view of price determination does not hinge on the existence of lump sum taxes only. The feedback of the stock of public debt on future taxation decisions has non-trivial economic consequences. Interest rate hikes aiming at lowering inflation simultaneously raise interest payments on outstanding debt. To the extent that this entails higher future taxation and triggers adverse economic effects, the tax base shrinks and productions costs rise such that inflation may well end up higher. This is particularly pronounced under a balanced budget, and requires a moderately active monetary policy (Linnemann, 2005).[12] If deficits are allowed for, this effect is moderated but fiscal policy ought not to be too passive to shield the economy from the negative supply-side output effects. Leith and Wren-Lewis (2000) develop similar arguments for reducing the degree of passiveness of fiscal policy.

Canzoneri and Diba (2005) consider another feedback channel of public debt. They argue that nominal government bonds are a close substitute to money holdings. By providing arbitrarily small transaction services, total outstanding debt directly affects consumption. As a consequence, interaction between fiscal and monetary policy naturally arises from the effects of interest rate changes on interest payments. A more passive fiscal policy requires a more aggressive monetary policy reaction so as to hold steady total interest payments. Likewise, monetary responses to inflation need be less hard-hitting as inflation erodes already the real value of debt (Schabert, 2004). Bénassy (2005) breaks the link in an overlapping generations model. The wealth effects of public debt make an interest peg compatible with nominal determinacy.

Accompanying monetary policy rules with an adequate fiscal prescription is less straightforward in 'crisis' situations in which the need for fiscal and monetary interaction is more acute (Taylor, 2000).

[10] Schmitt-Grohé and Uribe (2000) analyse the consequences of passive fiscal policies under several monetary regimes. While an interest rate peg always produces nominal indeterminacy, a money growth peg gives determinacy. A Taylor rule only results in determinate equilibria for intermediate values of the inflation coefficient, as interest rates directly impinge on intertemporal trade-offs. For a related analysis, see Von Thadden (2004).

[11] Schabert and Von Thadden (2006) argue that the region of possible indeterminacies enlarges by having non-neutral effects of both monetary and fiscal policies.

[12] Schmitt-Grohé and Uribe (1997) show that balanced budgets can create real instability by making expectations of future income tax increases self-fulfilling.

A first ‘crisis’ situation occurs when active monetary policy subsides into an indeterminate equilibrium. Monetary policy is then ineffective in stimulating the economy. Liquidity traps can arise as an unintended consequence of globally active interest rules (Benhabib et al., 2001b). Usually, only the local uniqueness of the economic equilibrium attained by pursuing active Taylor rules is examined. As interest rates are bound from below, another (indeterminate) equilibrium necessarily exists in which monetary policy need be passive. Convergence to this equilibrium with decelerating inflation and output dynamics cannot be excluded. Further reductions in interest rates to incite future inflation are not possible, however. Monetary policy can only become potent again and credibly promise to inflate the economy if monetary policy is made sufficiently history dependent (Eggertson and Woodford, 2003). A fiscal package can also restore determinacy: by making fiscal policy respond to lower inflation by running unsustainable policies avoids this liquidity trap situation (Benhabib et al., 2002a; Woodford, 2003). Unsustainable fiscal policies would eventually make an inflationary bail-out inevitable. Eggertson and Woodford (2004) consider an alternative possibility for optimal fiscal policy to reduce the distortions from interest rates reaching the zero bound. Due to the negative supply side effects of taxes, temporary rises in tax rates can produce inflation so as to prepare the ground for an economic boom in the future. In external ‘crisis’ situations in contrast, some monetary regimes may render fiscal policies unsustainable. Favero and Giavazzi (2004) illustrate the possibility of interest rate hikes under an inflation targeting regime leading to snowballing debt service, possibly threatening default (Loyo, 1999; Uribe, 2002).

2.2. Policy games and policy rules

Fiscal policy has certainly not been considered only as an appendix to salvage the determinacy properties of models of monetary policy. The variety of approaches that has been used for analysing the joint determination of fiscal and monetary policy is best understood from the Ramsey ‘public finance’ perspective on optimal taxation (Ramsey, 1927). In this approach, the government’s problem is that of selecting the least disruptive combination of inflation and taxation that maximises the representative agent’s welfare for financing a given level of public spending (Lucas and Stokey, 1983; Chari et al., 1991). Unanticipated inflation can be used as a lump-sum tax to redeem nominal non-state contingent public debt. This approach has recently been popularised by marrying it to the growing class of DSGE models with nominal price rigidities and imperfect competition (Schmitt-Grohé and Uribe, 2004a,b). As these have been mainly used to analyse monetary policy, fiscal policy often takes a very simple specification: the government has access to lump-sum taxes to finance its budget, and is able to implement a subsidy that eliminates the market distortions due to monopoly power in product and factor markets. Optimal monetary policy has an interest in price stability so as to minimise the costs of inflation associated with nominal rigidities.

Recent extensions have introduced distortionary taxation and dispose of the fiscal subsidy. Benigno and Woodford (2003) characterise time-invariant optimal monetary and fiscal policy targeting rules, the commitment to which implements the welfare-maximising equilibrium. A relevant joint decision problem for both authorities arises as both policies can minimise the cumulative distortion in output that is caused by distortionary taxation and sticky prices. Both fiscal and monetary policymakers intend to maximise welfare by stabilising inflation and the resulting output gap. Both policies necessarily respond to both targets. Fiscal policy needs to contribute to the traditional monetary task of inflation stabilisation, as tax rates affect real marginal costs (and hence prices). Monetary policy needs to take account of alternative price and interest rate paths on the government budget constraint.[13] With two policy instruments (taxation and interest rates) and two targets (inflation and output gap), many joint policy settings are possible.[14] Benigno and Woodford (2003) derive robustly optimal targeting rules for either authority under the dual assumption that the central bank takes the evolution of public debt as given, whereas fiscal policy leaves output determination to the central bank.[15] The inflation targeting rule is then of the 'flexible' type in that it includes a relevant reaction to output (Svensson, 1997). This can accordingly be rewritten as an instrument rule that can implement this targeting objective has the interest rate set as a reaction function to output and inflation (Woodford, 2003). The targeting rule for fiscal policy has debt being set in function of future real output and – generally speaking – future fiscal conditions. As instrument or targeting rules are equivalent representations of optimal policy, we choose to specify a fiscal instrument rule in terms of the underlying policy variables: output, inflation and debt. These rules form the basis for the empirical specification of the policy rules in section 4.

The Ramsey approach proceeds on some stylised assumptions on policy setting. The government jointly sets monetary and fiscal instruments – as a benevolent social planner – and is assumed to commit to these policies. Since fiscal and monetary policy have been given to separate authorities, it is probably more realistic to leave the assumption of cooperative policy setting. It has often been argued that fiscal and monetary policy are on conflict course, or that both have been caught in a bad policy mix (Nordhaus, 1994). If the central bank and the treasury are separate entities, we need to determine the sequence of actions by each policymaker and the discretionary character of each policy. Both policymakers have an incentive to exploit their own instrument to move the output gap closer to the optimal level now, given rise to a monetary inflation or a fiscal spending bias (Adam and Billi, 2005).

The consequences of committing to rules based policy have been well understood for central bankers in alleviating the inflationary bias from time inconsistent policies (Kydland and Prescott, 1977). A variety of solutions to time-inconsistent policies, ranging from commitment to contractual delegation, have been proposed. The ramifications of policy discretion are less obvious once fiscal policy enters the analysis. This has most commonly analysed in the static framework of Alesina and Tabellini (1987). Monetary policy chooses inflation, and the government has an exogenously given target for spending. The mechanism behind interaction is that the central bank's choice on inflation determines seigniorage income from the government. If too much additional finance from distortionary taxation is needed to balance the budget, total welfare may well decrease. This makes it desirable to have some discipline enhancing fiscal institutions, which can take the form of commitment or deficit rules, but are conditional on the form of interaction (Castellani and Debrun, 2001).

This analysis does not allow for any strategic moves between policymakers. Timing of the policy setting matters. Sargent and Wallace (1981) already argued that it would be sufficient to give monetary policy to an independent and conservative central bank to avoid the unpleasant monetary consequences of fiscal insolvency. Leadership by one of both policymakers would indeed avoid the non-cooperative races that are associated with the Nash equilibrium whenever there is no

[13] This does not seem to involve a decisive trade-off between fiscal or monetary policy, however. Even for small degrees of price stickiness, optimal inflation volatility is near zero and government debt and tax rates follow a near random walk (Schmitt-Grohé and Uribe, 2004a).

[14] Correia et al. (2001) show that fiscal policy should be optimally set as if prices were flexible, and leave monetary policy to run counter to the market distortion of rigid prices.

[15] The robustness of the rule pertains to the specification of the exogenous shock processes (Giannoni and Woodford, 2003a).

agreement on the policy objectives and both policies are discretionary (Dixit and Lambertini, 2003a). This is not a surprising result, given that Stackelberg equilibria are usually Pareto superior to Nash outcomes. But giving a first-mover advantage to one authority does not necessarily avoid 'leadership battles'. Fiscal discretion may destroy monetary commitment (Dixit and Lambertini, 2003a). Commitment to a monetary rule is not sufficient to reduce the inflation bias as the ensuing fiscal reaction reduces output. Only if monetary policy incorporates the consequences of its actions on the distortions of fiscal policy, can its decisions bind. Adam and Billi (2005) find a similar result. Monetary discretion does not undo fiscal commitment, however, but results in an inflation bias that can be undone by tighter fiscal policy. Dixit and Lambertini (2003a,b) further show that the cooperative equilibrium can be replicated if both policymakers agree on the economic objectives, or if they separate tasks of stabilising each one objective.[16] The outcome can be substantially improved by giving monetary policy in the hands of a sufficiently conservative central bank. This eliminates the inflation bias, and to some extent also the spending bias (Adam and Billi, 2005). The conclusions of these game-theoretic models remain rather stylised. They do not carry immediate implications for empirically testable policy parameters. Even though a split of policy tasks is not necessarily welfare superior to other – more coordinated – settings of monetary and fiscal policy, the arguments of this literature have been at the base for granting independence to central banks and putting constraints on fiscal policies. But apart from institutional design, this does not fill in detailed practical policy proposals (MacCallum, 1999).

2.3. Testing policy rules and policy interaction

Starting with the simple rule for setting interest rates proposed by Taylor (1993), both the theoretical and empirical analysis of monetary policy rules has become a true research industry. The *leitmotiv* of the empirical analysis has been the validity of the Taylor principle by which central banks should not accommodate changes in the price level (Clarida et al., 2000). In contrast, the discussion of fiscal policy rules has mostly been normative and limited to simple rules with practical policy implications. Proposals of balanced budget rules, a golden rule, deficit or debt target values,… have been discussed extensively in the literature criticising the SGP, for example. However, there is no comprehensive framework to analyse fiscal policy rules. It is therefore useful to set some terminology for characterising fiscal policy. By definition, we can decompose the overall indicator s_t of fiscal stance[17] into a structural – or cyclically adjusted $s_{s,t}$ – and a cyclical part (εy_t) as in (3):

$$s_t = s_{s,t} + \varepsilon y_t, \tag{3}$$

with ε the elasticity of the fiscal indicator with respect to output. We can attribute fiscal policy to discretionary policy ($s_{s,t}$) or automatic stabilisers (εy_t) respectively. With a fiscal rule in contrast, we express the indicator s_t as a function $f(\cdot)$ of cyclical (y_t) and some other variables collected in X_t, as in (4):

[16] Hughes Hallett (2004) sees some advantages of fiscal leadership that focuses on long-term allocation and provides short-term automatic stabilisers, and an independent central bank that focuses on short-term price stability. This separation entails an implicit coordination of policies.

[17] It is irrelevant for the specification whether this indicator is a deficit or a surplus, but the notation in terms of surpluses s_t is more common in the literature.

$$s_t = f(y_t, X_t; \xi) + \varepsilon_t \qquad (4)$$

We associate cyclical reactions of fiscal policy with both automatic stabilisers and the systematic cyclical reactions of discretionary policy, conditional upon the reaction to variables X_t, and subject to a possible policy shift ξ. The non-systematic part is the true 'policy shock' (ε_t).[18]

The empirical analysis of fiscal policy behaviour has been rather varied. This reflects the inherent heterogeneity of the budget both in its setting (composition of revenues versus expenditures) and in its effects on economic agents. The latter aspect also adds a distinct political flavour.[19] In addition, fiscal policy is subject to an intertemporal budget constraint. It has therefore hardly carried the normative policy prescriptions of the monetary Taylor rule. Data constraints have also limited a thorough analysis. Few papers indeed test fiscal policy rules as such. Much of the analysis is limited to gauging the cyclical sensitivity of some fiscal policy indicator in (4). Taylor (2000) himself suggests and estimates simple fiscal policy rules for the USA by regressing the structural and the cyclical surplus on the output gap. His results indicate a countercyclical reaction elasticity of 0.45 in the total surplus. This number is close to the presumed 0.50 elasticity of automatic stabilisers as calculated by the OECD, and suggests there has been little discretionary intervention by the US Administration. Auerbach (2002) instead finds a stronger systematic response of discretionary policy to both the cycle and past fiscal imbalances over the last decade. Other studies assess the cyclical properties of fiscal policy in a European or OECD sample, either on a country-by-country or panel basis. The main finding is probably the slight countercyclicality of the budget. Fatas and Mihov (2001) relate growth ratios of different fiscal variables on output growth, but find that EU governments regularly undo automatic stabilisers.[20]

These results do not have any structural interpretation, however, and cannot characterise systematic policy behaviour. Not only do cyclical fluctuations explain an important part of the variation in fiscal variables because of the workings of the automatic stabilisers. Except under the hypothesis of Ricardian equivalence, these fluctuations may be determined by the fiscal variable too. If fiscal policy has indeed real effects, then the variables will be correlated with the error terms in the policy rule. Applying OLS leads to biased and inconsistent estimates and the degree of stabilisation would be overestimated consequently. This suggests instrumental estimation to correct for the endogeneity of output. Viren (2001, 2002) demonstrates how much the cyclical sensitivity of the budget is reduced for a pool of EU states. Lane (2003) examines cyclical properties of different government budget

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[18] Structural policy ($s_{s,t}$) is reflected both in this shock and any systematic cyclical reaction beyond that provided by the automatic stabilisers.

[19] We recognise the importance of these institutional and political variables. While there is evidence for politically coloured swings in deficit, sustainability of fiscal policy is rather subject to stronger political agreement. We take these political settings henceforth as given in our analysis.

[20] The assessment of fiscal policy is also related to the literature on income smoothing and inter/intra national risksharing. Arreaza et al. (1999) do not use a regression-based measure of cyclicality but examine the various channels of income smoothing on the basis of the different categories of national income. In a panel of OECD and EU countries, they find a strong effect (up to 36%) of countercyclical government consumption and transfers – but not of taxes – upon income. These effects are largely symmetric over the cycle, with transfers being much more significant in recessions. No trade-off with debt is apparent. Another strand of the literature to which the analysis of cyclical fiscal policy is related, is the relationship between government size and output volatility. Some papers obtain estimates of budget elasticities by examining changes in government size. According to Hercowitz and Strawczynski (1999), countercyclical budgetary reactions in recessions and the acyclicality of the deficit during booms are responsible for the rise in the government spending ratio in OECD countries.

components. The regression of these categories on output growth shows that cyclicality varies substantially. Ballabriga and Martinez-Mongay (2003) estimate non-linear fiscal policy rules for EU countries. Fiscal policy is found to be only weakly countercyclical. Galí and Perotti (2003) estimate systematic discretionary policy in EMU countries before and after the introduction of the Maastricht rules, but do not find evidence of reduced countercyclical reactions. This correctly labels as a fiscal policy rule the estimation of this reaction function.

Most of the empirical analysis disregards fiscal sustainability that is deemed central to policy interaction. Tests for the sustainability of government finances can also be considered sort of fiscal rules, however. Bohn (1998) – although driven by other motivations than testing the FTPL – proofs that a positive reaction of the primary surplus to the debt to GDP ratio in (2) is a robust sufficient condition for fiscal sustainability.[21] In his specification, the term χ_t contains other relevant variables upon which the primary surplus can be conditioned. In the empirical counterpart to (2), Bohn (1998) models χ_t by conditioning on permanent and cyclical components of fiscal policy.

Another interpretation of the fiscal rule in (2) bears on the FTPL. The same positivity restriction on [illegible] implies a passive or Ricardian policy that guarantees fiscal solvency and hence renders monetary policy autonomous in determining prices. However, these short-term reactions may not be distinguishable as FTPL reactions in the longer term (Canzoneri et al., 2003).[22] Moreover, the interpretation of the fiscal rule is not complete without a description of monetary policy.

The empirical examination of the relevance of policy interaction is still at an infant stage. As under standard assumptions policy interaction does not matter for macroeconomic outcomes, both policies have predominantly been studied in isolation. Interaction poses some hard problems in the identification of both policies jointly. The main reason is probably that the chief contention of the FTPL literature is not directly empirically testable. There are no identifying restrictions that allow distinguishing the intertemporal government budget constraint as a value equation or as a constraint, for this equilibrium relation necessarily holds. This casts some doubt also on the validity of direct univariate or cointegration tests for sustainability.[23] In addition, both policies have a relevant stabilisation role to the same cyclical conditions. Finally, there are also direct policy games between policy makers that further blur the identification of the policy responses.

Most of the evidence for policy interaction has been predicated on the existence of a combination of policy regimes that do not need to satisfy the usual dichotomy of Ricardian fiscal policies and autonomous monetary policy. Some narrative accounts document periods in which US policy was believed to be in an ‘active’ monetary/’passive’ fiscal regime. Woodford (2001) and Hetzel and Leach (2001) characterise the Fed-Treasury Accord between 1940 and 1951 as evidence for the plausibility of the FTPL, for example.[24]

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[21] Under the additional assumptions that the process is stationary and ergodic, and that χ_t is bounded as a share of GDP.

[22] Actually, the lack of a stable feedback would be consistent with a non-sustainable policy but also with a data set that contains insufficient variation in the fiscal series for identifying sustainability.

[23]For some attempts to directly test the FTPL in a VAR context, see Cochrane (1998), Canzoneri et al. (2001), Woodford (2001) and Sala (2004).

[24] For a more general history on post-war fiscal policies in the US, see in particular Stein (1996).

Usually, the arguments are conditioned on the existence of a fixed policy regime. From the evidence of passive monetary policy in the seventies, it then follows that fiscal policy is necessarily active, on the grounds that the economy needed to satisfy a determinate equilibrium (Woodford, 1998). By a similar argument, the evidence for a shift in fiscal policy from a debt-stabilising regime to a period in which the accumulation of liabilities is ignored would have consequences for the behaviour of monetary policy. Structural breaks in fiscal policy have not been so well documented. A range of eligible breakdates has been suggested in the literature, mostly based on ad-hoc arguments. Narrative studies on the effects of fiscal policy use major US defence spending increases as the Korean, Vietnam or the Cold War to identify fiscal shocks (Ramey and Shapiro, 1998). According to Taylor (2000), 1984 saw a major change in systematic policy under the Reagan Administration. A common turning point for European fiscal policymakers is supposed to be the Treaty of Maastricht (Wyplosz, 2002; Galí and Perotti, 2003).

A few papers explicitly model continuous regime changes in fiscal and monetary policy behaviour. Davig and Leeper (2005a) estimate regime switching rules for a standard Taylor rule and a less common tax rule.[25] Fiscal policy is argued to set tax revenues as a function of cyclical conditions, debt and spending. The (positive) reaction to debt determines whether policy can be considered passive or not. They find that monetary and fiscal policies change between states of active and passive fiscal policy. Favero and Monacelli (2003) model the same Markov switching process on a monetary rule, and a fiscal rule that is expressed in terms of the primary surplus and moreover allows for some interest rate smoothing. Except for the large tax cut under the Ford Administration, they characterise only the period 1995-2001 as one of passive debt stabilising fiscal policy. Fiscal policy is countercyclical over the whole sample. Monetary policy is found to be passive before 1980. Loyo (1999) characterises different policy regimes for Brazil.
These results do not have as a consequence that the economy evolves into zones with a combination of only passive or only active policies that would imply indeterminate or non-existent equilibria respectively. The argument of Davig and Leeper (2005a) for finding a determinate equilibrium over the entire sample is that agents form expectations on the probability distribution of policy rules, such that all combinations of regimes are compatible with equilibrium.[26] Both studies derive the change in policy regime in isolation taking as given the behaviour of the other policymaker. Their estimation does not impose the cross-restrictions that any theory of policy interaction would imply for the joint process of policy rules.[27] This might result in finding combinations of policy regimes that need not correspond to true 'interactive' switches. In this respect, the question of Davig and Leeper (2005a) as to what causes policy changes is not limited to policy having a stochastic component. Changes in one policy regime might correlate with changes in the other policy maker's regime.

[25] See Greiner et al. (2005) for the estimation of time-varying fiscal rules.
[26] A similar problem arises from the results of Lubik and Schorfheide (2004) that monetary policy could not deliver a determinate equilibrium before 1979. They construct a likelihood function of a DSGE model of monetary policy for the indeterminacy region, and can quantify the importance of determinacy and indeterminacy regions in the parameter space.
[27] Other strategies for inferring on policy interaction are still based on univariate analyses of fiscal policy. Favero and Monacelli (2003) add a fiscal rule to a VAR-augmented Taylor rule. This results in an improved fit for inflation in periods of fiscal indiscipline. Conversely, Galí and Perotti (2003) insert a monetary policy shock into their fiscal rule and find that fiscal policy is a significant yet unimportant substitute to shocks to monetary policy. Another more informal way to assess policy interaction is based on a descriptive correlation analysis of both fiscal and monetary policy shocks, either within or between countries. See Bruneau and DeBandt (2003) for evidence in the SVAR context, or Ballabriga and Martinez-Mongay (2003) in the policy rule literature.

Clearly, it is somehow inappropriate to infer on fiscal or monetary policy rules in isolation. If policy interaction indeed matters, the inclusion of fiscal or monetary policy setting improves upon the inference of each policy studied in isolation. Even if there is a clear methodological improvement (Favero, 2003), the strategy of simultaneously estimating a system of fiscal and monetary reaction functions has seen only a few applications. Both policies are set in function of cyclical conditions. In addition, a direct reaction of either fiscal or monetary policy to the other policy maker's instrument is introduced. This is considered a test for the substitutability or complementarity of economic policies. Mélitz (2002) estimates such a system of fiscal and monetary reaction functions. Automatic stabilisation seems much weaker than what previous studies find for a pool of OECD countries. Fiscal policy still reacts in a stabilising way to the debt burden. There is also evidence of policy substitutability: fiscal and monetary policies tend to offset each other. Wyplosz (1999) includes some additional explanatory variables but results for the panel of EMU countries are similar. Fiscal policy reacts in a similarly small stabilising way to the gap and inflation. Debt dynamics are kept under control. While the European central banks react in the standard accommodating way to inflation and the output gap, no reaction to fiscal policy is detected as such. Conversely, fiscal policy is a strategic substitute to monetary policy, albeit the effect is small. Von Hagen et al. (2001) look into the pre-EMU fiscal consolidations, and estimate a small model consisting of fiscal spending and tax rules and output growth. Fiscal policy tends to loosen when monetary policy tightens, while monetary policy is set as a complement. The 'Maastricht effect' they detect consists mainly of a rise in average primary surpluses at the cost of less countercyclical responses. Favero (2003) constructs a small structural model. A system of equations for inflation, the output gap, the policy reaction functions and debt interest payments is set up. Identifying restrictions are imposed in order to separate systematic from non-systematic policies. The SUR-estimation of this system for four large EMU-countries confirms prior evidence on fiscal policy behaviour: (a) a combination of countercyclical revenues and procyclical expenditures induces weak systematic fiscal stabilisation effects; (b) fiscal policy maintains solvency, be it through lower expenditures or increased revenues; and (c) the interest rate channel on interest payment burden is important. Besides, deviations by fiscal authorities from this systematic behaviour do not change the behaviour of monetary policy. Muscatelli et al. (2004) partly estimate (with GMM) and calibrate a small New Keynesian model that consists of a Phillips curve and IS demand equation, jointly with monetary and fiscal spending and tax rules for the US. The results do not differ greatly from conventional estimates of policy rules estimated in isolation. The rules are rather persistent. Monetary policy is quite active with respect to output as well as inflation. Fiscal policy is debt stabilising on both spending and revenue sides of the budget.

The connection to policy interaction in these studies has not been explicitly made. We build on this work by providing a more rigorous specification of a fiscal rule that derives from optimising behaviour from both fiscal and monetary policymakers. We accordingly propose a methodology that takes policy interaction seriously.

3. Methodology

We closely follow Clarida et al. (1998) in presenting the empirical specification of a fiscal and a monetary instrument rule. The fiscal rule provides a sufficient solvency test on public debt, while conditioning upon cyclical responses and policy interaction. A standard monetary rule is appended to the fiscal rule. This specification then gives testable conditions that allow using a Generalised Method of Moments (GMM) procedure to identify the reaction coefficients in both rules.

3.1. The fiscal policy rule

We can write a reaction function of fiscal policy to cyclical conditions and to public debt in the form of an instrument rule as follows,[28]

$$s_t^* = \bar{s} + \beta_y (y_t^{e,n} - y^*) + \beta_b (B_t - B^*) \tag{5}$$

The fiscal policy maker sets its desired value for the policy instrument s_t^* at some long-term level $\bar{s}$. This could correspond to a 'golden rule' deficit which allows for investment expenditures to be financed by issuing debt, for example. Another reason for an average positive deficit is the existence of a political deficit bias. The ideal value s_t^* at time t fluctuates – as in the definition equation (3) – in response to expected deviations of output $y_t^{e,n}$ some n periods ahead, around the target value y^* for the fiscal authority. The output response β_y not only captures the automatic stabilisation responses of some spending and revenue categories. It also includes any systematic discretionary intervention of the government to cyclical conditions. From (3), if the government just let the automatic stabilisers work over the cycle, then $\beta_y = \alpha$. Next to this response, the government attaches some direct weight β_b on sustainable public finances by maintaining deviations of debt B_t from steady-state long-term level for debt B^* under control. Hence, in contrast to the test suggested by Bohn (1998), we model explicitly the χ_t term in (2) and identify it as a 'fiscal rule'.[29]

Applying the definition equation (3) to (5), and under the assumption that the government sets its fiscal instrument consistent with its output level target y^*, we obtain an expression for the structural instrument of the fiscal authorities $s_{s,t}^*$

$$s_{s,t}^* = \bar{s}_s + (\beta_y - \alpha)(y_t^{e,n} - y^*) + \beta_b (B_t - B^*) \tag{6}$$

This shows that the structural deficit comprises a structural long term part $\bar{s}_s$, but is also determined by any inflation or debt bias the government may have. The output bias will be reinforced only if the discretionary cyclical reaction is stronger than that of the automatic stabilisers ($\beta_y > \alpha$).

It has been argued in the monetary policy rule literature that interest rate smoothing is a realistic description of central bank behaviour. Persistence in a fiscal reaction function seems even more natural as the budgetary process involves lengthy parliamentary processes and sunk decisions. The

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[28] For simplicity, we assume a linear reaction function, which arises as a reduced form rule from the policy maker's quadratic loss function over target variables subject to a (linear) Phillips curve economy. This is also the approximation used by Benigno and Woodford (2003). The coefficients β_y, β_π and β_b are themselves functions of the reaction coefficients to economic shocks and the preferences of the government.

[29] Ignoring the modelling of these components risks creating omitted variable problems, at least if not both s_t and B_t are non-stationary, in which case estimates would be super-consistent.

fiscal instrument thus adjusts only gradually to its target level:

$$s_t = \rho s_{t-1} + (1-\rho) s_t^* + \varepsilon_{s,t}, \tag{7}$$

with $0 \leq \rho \leq 1$ the degree of persistence. Introducing smoothing gives us the following empirical specification of a fiscal policy rule:

$$s_t = \rho s_{t-1} + (1-\rho)(\beta_0 + \beta_y x_{t|t-1} + \beta_b B_{t-1}) + \varepsilon_{s,t}. \tag{8}$$

where the output gap is given by $x_t = y_t - \hat{y}$. In this rule, β_0 equals $\bar{s} - \beta_y (y^* - \hat{y})$ and represents the long-term fiscal indicator adjusted for the deviation between the government's output target and potential output $\hat{y}$. The error term in (8) is now composed of an exogenous i.i.d. disturbance representing shocks to fiscal policy and the forecast error on output and debt.[30]

We test (8) as our baseline fiscal policy rule. This specification is not complete once accounting for the interaction with monetary policy, however. A general fiscal policy reaction function (5) can be modelled along the arguments of Benigno and Woodford (2003) by rewriting their optimal target criterion for public debt also in terms of future inflation. The inclusion of a response to inflation deviations from target follows from distortionary taxation having real supply side effects. Fiscal policy needs to consider stabilisation of projections of inflation too in this case (Benigno and Woodford, 2003). Simultaneously, there is an effect of inflation developments on the real burden of interest payments. This effect may be quite large given the issuance of public debt in nominal terms, even if the conventional seigniorage contribution to the government's budget is negligible (Woodford, 2001).[31] If the fiscal authority targets inflation π at some k periods ahead around a target value π^*, then similar derivations as above give the following testable policy rule:

$$s_t = \rho s_{t-1} + (1-\rho)(\beta_0 + \beta_y x_{t|t-1} + \beta_\pi \pi_{t+k|t} + \beta_b B_{t-1}) + \varepsilon_{s,t}. \tag{9}$$

Let us now assume that the fiscal instrument is the actual surplus ratio. Key interest usually focuses on β_y, which reflects the systematic cyclical properties of fiscal policy. If systematic fiscal policy just 'lets the automatic stabilisers work', then $\beta_y = \varepsilon$ and the structural deficit s_s is constant at its long-term level $\bar{s}_s$ *ceteris paribus*. A positive coefficient $\beta_y > \varepsilon$ indicates additional discretionary intervention, while $\beta_y < \varepsilon$ procyclically magnifies the output gap. The important caveat in the further analysis is that only systematic policy behaviour in β_y can be detected. Drawing on some recent work at the OECD on calculating cyclically adjusted balances (Girouard and André, 2005), we may

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[30] That is, $\varepsilon_{s,t} \equiv \epsilon_t - (1-\rho)\beta_y (x_{t|t-1} - x_t^{e,n}) - (1-\rho)\beta_b B_t$.

[31] The inflation tax on nominal bonds may be large if governments have large nominal outstanding debt. This effect works through real interest payments. This will generally depend on the maturity structure and the composition of public debt. Further reasons for reactions of budget variables to inflation are the non-indexation of tax brackets and the Olivera-Tanzi effect. These effects are not expected to determine real tax revenues in industrialised economies featuring low to moderate inflation, however. For some literature on these effects and the difficulties in correcting conventional deficits for inflation, see Tanzi et al. (1988).
One additional argument for inflation stabilisation has its roots in the Optimum Currency Area literature and is highly relevant to monetary union. With asymmetric shocks or diverging inflation preferences, national fiscal policy makers may assume the role of monetary policy in stabilising inflation.

envisage a value for the aggregate cyclical budget elasticity ε of 0.50 in most countries.

Debt sustainability has commonly been inferred from a positive coefficient β_b. The magnitude of the response is of minor importance: as long as a stabilising response to public debt comes about on average, this is sufficient for sustainability (Canzoneri et al., 2001). A similar condition implies that fiscal policy is 'passive'. In the framework of the FTPL, this means monetary is having complete control over prices. Active fiscal policy that would disregard the evolution of public debt would constrain monetary policy.

Finally, in (9) we can also test the significance of inflation as an independent policy target for fiscal policy. The sign of the response is unclear a priori. We rather expect β_π to be positive if the government is concerned about economic stabilisation. Apart from this, the non-indexation of tax brackets mechanically raises revenues, while incomplete indexation reduces spending.

3.2. The monetary policy rule

Having set out the specification of the fiscal policy rule at length, the derivation of a monetary policy reaction function amenable to empirical analysis follows along similar lines. We basically adopt the same forward-looking instrument rule as in Clarida et al. (1998). The central bank has an objective for its instrument, the nominal short term interest rate i^*,

$$i_t^* = \bar{i} + \beta\left(\pi_t^{e,m} - \hat{\pi}\right) + \gamma\left(y_t^{e,l} - \hat{y}\right) \qquad (10)$$

which is set in function of both expected inflation and output gap, some m and l periods ahead, relative to their target values.[32] Such an instrument rule arises in a number of models of monetary policy (Giannoni and Woodford, 2003b). The justification for the inclusion of inflation and output in the target criterion of the central bank is somewhat different in the presence of fiscal policy however. Next to the economic stabilisation motives, the central bank needs to take into account the consequences of its actions on the government budget constraint (Benigno and Woodford, 2003). Alternative choices on inflation and interest rate setting impinge on the real burden of interest payments, which through distortionary taxation feed back on economic conditions.

Rewriting (10) for the *ex ante* real interest rate r_t^* gives:

$$r_t^* = \bar{r} + (\beta - 1)\left(\pi_t^{e,m} - \hat{\pi}\right) + \gamma\left(y_t^{e,l} - \hat{y}\right) \qquad (11)$$

with $\bar{r}$ the long-term equilibrium real interest rate. Adding target rate smoothing, a non-linear expression for monetary instrument setting is then obtained:

$$i_t = \rho i_{t-1} + (1-\rho)\left[\alpha + \beta \pi_{t+m} + \gamma x_{t+l}\right] + \varepsilon_{i,t} \qquad (12)$$

where $0 < \rho < 1$ measures the degree of persistence, α is $\bar{i} - \beta\hat{\pi}$ indicates the long-term inflation adjusted real interest rate. This is the baseline monetary rule that we test in section 4. Such a rule yields the standard insight that non-accommodative monetary policy is inflation stabilising if $\beta > 1$. Hence, monetary policy can avoid self-fulfilling inflationary paths and indeterminate

[32]These targets – $\hat{\pi}$ and $\hat{y}$ – may differ from those of the fiscal authority's (π^* and y^*).

equilibria by adhering to a sufficiently strong reaction to inflation. This characterises ‘active’ monetary policy. Monetary policy is output accommodating if [illegible]$_y$ [illegible] 0.

3.3. Tango solo o doble?

This interpretation of the policy rule coefficients proceeds on each single equation in isolation. Policy interaction probably alters the sign and magnitude of the reaction coefficients in both policy rules. This concerns in first instance the degree of ‘activism’ or ‘passivity’ of either fiscal policy (with regard to debt) and monetary policy (with respect to inflation). Interaction also matters for inference on the cyclical properties of each policy. When both policies respond contemporaneously, either fiscal or monetary policy may bear more of the brunt of stabilisation. By estimating both policy rules (8) and (12) jointly in a system, we can test if taking interaction into account matters or not for the usual inference on each rule separately. Are empirical studies right in studying both policies separately (the ‘tango solo’ assumption) or can indeed more be said about the ‘tango doble’ of the central bank and the treasury together?

Before probing into the benefits of the system approach, it is worth considering at this stage an alternative interpretation of both policy rules as reaction functions. The optimal policy rules derived in theory are usually based on the assumption of benevolent policymakers that jointly decide on welfare maximising policymaking. We characterise policy rules just as a reasonable empirical description of policy, or a guideline to think about theory. The estimates of the coefficients in the policy rules reflect the equilibrium structure of the game between fiscal and monetary authorities. This might be the outcome of joint decision-making, but both authorities can behave in a non-cooperative way as well. This leads the policymaker to react to the decisions of the other policymaker. As discussed in section 2.3, this leads either to a Nash equilibrium or a situation in which one of the authorities assumes (Stackelberg) leadership.

The identification of a reaction function is not unfamiliar to the readers of the empirical Industrial Organisation literature. Interest focuses on uncovering the nature of strategic interaction between firms on the basis of their price and quantity decisions. The degree of positive mark-up of a firm’s prices over marginal cost characterises the market structure of a certain industry. Apart from the problem of identifying the unobservable marginal cost, the main difficulty is how to estimate a static or dynamic decision rule for a firm without imposing too many constraints on the spillover across firms. Strategic games inevitably involve a set of continuous choices on price or quantity that are correlated in some industry. Modelling these cross-sectional dependencies is not straightforward without assuming some further structure for the game or the market (Bresnahan, 1989).

This is most easily illustrated with an example of estimating market power in industries that produce differentiated goods. Usually, studies approximate the whole matrix of cross-demand elasticities on the closely substitutable goods to infer on the effect of price or quantity changes on a firm’s behaviour. Bresnahan and Baker (1988) instead estimate the slope of the residual demand curve for a firm. This reflects the own price elasticity to changes in a firm’s production. The endogeneity of the own price is controlled for via instrumental variables that shift the own firm’s production schedule, while the simultaneous supply response of all other firms in the industry is taken care of via a system approach. Under perfect competition, the slope of residual demand is flat. A wide variety of

imperfectly competitive market structures is compatible with the alternative hypothesis of a negative elasticity.[33] This points at one difficulty with this approach: only the behavioural equation is estimated, and not the structural parameters that are associated with a particular market structure. This questions the stability of market behaviour once big changes in the industry occur, such as entry or exit of firms for example (Pinkse et al., 2002; Pinkse and Slade, 2005). Alternatively, one might test the parameters on restrictions that derive from some more specific models, as in Bajari et al. (2004).
Another disadvantage of this approach is the static nature of the game: all decisions are one-shot. There are no dynamic effects of a firm's choices on the future behaviour of competing firms and the structure of the market. Pinkse and Slade (2005) develop estimators for dynamic decision rules, and model time and cross-sectional dependence on the basis of spatial analysis.[34][35]

Can this framework be extended to policy games? The choices of either fiscal or monetary authorities does not appear in the ex post observed data, and does not provide a directly testable hypothesis (Hughes Hallett, 1984; Basar and Oldser, 1999). Similar to firms, each policy maker has an instrument that it can set so as to affect the economic conditions to which the other player responds. As both policymakers pursue the same targets, there must be important indirect reactions of monetary policy to systematic fiscal policy setting, and vice versa. For fiscal or monetary policymakers, we condition on factors that move policy decisions along the other policymaker's reaction function. In order to control for any endogeneity in policy decisions, we estimate both rules with IV-techniques. We further follow Bresnahan and Baker (1988) by estimating the system of policy rules, and believe this is sufficient to identify the equilibrium response to the other policymaker.[36] As we have no clear theoretical structure to guide us on the structure of the game, this semi-structural approach is to be preferred.

But in contrast to firms, each player has a different instrument that also constrains directly the way the other player can set its instrument. For firms, strategic interaction follows from any residual reaction of own prices to quantities. However, the direct interaction is less obviously tested in policy games. In theoretical models, as discussed in section 2.2, strategic interaction between policymakers mostly evolves as a stylised stage game. When a Nash equilibrium is adopted, policies are set contemporaneously in a one-shot game. Other models assume fiscal or monetary policy to have a first-mover advantage. The fiscal and monetary instrument rules in (9) and (12) are optimal once allowing for interaction of monetary and fiscal policy, but the parameters will be convolutions of these optimal reactions as well as any strategic reactions.

It has been usual to test strategic interaction by including a direct reaction to the other policymaker's instrument in the policy rule. The literature has considered this strategic setting of policy in isolation (Hughes Hallett, 2004), but usually proceeds on system estimates.[37] As we specify a full model of policy interaction, and thereby condition on any systematic policy responses of the other policymaker, we will identify the competitive use of policy instruments as a strategic reaction.

[33] Bresnahan and Baker (1988) study the competitive behaviour of major US brewers with this approach.
[34] They examine continuous and discrete choice estimators for a dynamic game of price and advertising competition.
[35] The spatial methodology is analogous for modelling cross-border spillovers. See Brückner (2003) for an overview.
[36] Note that we have used the same set of instrumental variables for both fiscal and monetary policy rules. It is less obvious that there are exogenous economic variables that shift only fiscal policy or monetary policy decisions.
[37] See also section 2.3.

Given that the fiscal rule conditions on cyclical variability, the effect of inflation and any effect of interest payments, we isolate the direct interaction with monetary policy by adding interest rates to the fiscal rule. We get the following specification (13):

$$s_t = \rho s_{t-1} + (1-\rho)(\beta_0 + \beta_y x_{t-1} + \beta_\pi \pi_{t-1} + \beta_i i_t + \beta_b B_t) + \varepsilon_{s,t}. \qquad (13)$$

We label monetary policy either as a strategic substitute $(\beta_i < 0)$ or complement $(\beta_i > 0)$.[38] Vice versa, we can control for the independent effect of fiscal policy on interest rates. In the augmented monetary rule (14),

$$i_t = \rho i_{t-1} + (1-\rho)(\gamma_0 + \gamma_\pi \pi_{t+n} + \gamma_y x_{t-1} + \gamma_s s_t) + \varepsilon_{i,t} \qquad (14)$$

a significant systematic response implies that monetary policy is non-autonomous (Woodford, 2001). Important for this analysis is the sign of γ_s: this shows whether monetary policy has acted as a substitute $(\gamma_s < 0)$ or was set complementary to fiscal policy $(\gamma_s > 0)$.

A combination of these results makes it possible to infer on the nature of the policy game as well. In a Stackelberg situation, the follower does not expect a further change after it has set policy and the leader takes into account this reaction. This makes both policy instruments complements in the reaction function of the leader, but substitutes in the reaction function of the follower (Hughes Hallett, 2004). Our system tests make possible a more precise inference on these coefficients.

3.4. Methodology

Under rational expectations, shocks to systematic policy behaviour should be unrelated to external information at time t. Let z_t be a vector of variables that contain this external information. The system (15) defines a set of orthogonality conditions

$$\begin{cases} E_t\{[s_t - \rho s_{t-1} - (1-\rho)(\beta_0 + \beta_y y_{t-1} + \beta_\pi \pi_{t-1} + \beta_b B_t + \beta_i i_t)] z_t\} = 0 \\ E_t\{[i_t - \rho i_{t-1} - (1-\rho)(\gamma_0 + \gamma_\pi \pi_{t+n} + \gamma_y y_{t-1} + \gamma_s s_t)] z_t\} = 0 \end{cases} \qquad (15a\text{-}b)$$

that imply testable conditions such that the system consisting of equations (15a) and (15b) can be estimated with GMM. This corrects for the endogeneity problem referred to above. If systematic policy has indeed real effects then output and inflation will be correlated with the error terms in both policy rules. Applying SUR leads to biased and inconsistent estimates and the degree of stabilisation would be overestimated consequently. GMM moreover allows identifying the equilibrium responses of reaction functions.

GMM estimation is attractive for several reasons. The estimates are strongly consistent and asymptotically normal. It does not require strong assumptions about exogenous variables, and the need for modelling an entire system of variables is implicitly relegated to the choice of the instrumental variables. GMM involves a minimal set of prior assumptions, but nonetheless suffers

[38] This goes beyond the inclusion of a term responding to variations in the interest saved on the monetary base, as the literature on dynamically optimal fiscal policy would suggest. For its small size, seigniorage is unlikely to matter for the validity of the conclusions anyhow (Woodford, 2001).

from several flaws, even in relatively large samples (Fuhrer and Rudebusch, 2004). Coefficients are generally biased, statistically insignificant and economically implausible (Fuhrer et al., 1995). A first cause is the poor quality of the instruments. We test the validity of the overidentifying restrictions through the J-test. In particular, when the overidentifying restrictions are valid, policy makers react systematically to all relevant and available information. The non-rejection of this null means explanatory variables have been omitted, leading to a violation of the orthogonality conditions. When the instrument set contains variables that belong to the true model, but have erroneously been omitted from the specification, this introduces a bias in the GMM estimates (Rudd and Whelan, 2005). Even if instruments seem highly relevant, poor exogeneity for at least one regressor can still bias all the estimates. This is further exacerbated by the inclusion of insufficient lags in the instrumental variables, when there is strong serial correlation in the variables in the model. This particularly holds for specifications in which a smoothing term is rightly included. In order to avoid potential estimation bias in small samples, only a small number of overidentifying restrictions is therefore imposed. Moreover, we use variables dated one year back ($t-1$ for yearly data, $t-4$ for quarterly data) or earlier but exclude lags of the policy variables or objectives.

The interpretation of the J-test also provides a neat way to assess the importance of the additional policy targets we include in the rule. We compute the J-test with some of the explanatory variables included among the instrumental variables instead.[39]

The J-test does not consider a specific alternative, and it is likely to have low power in assessing the validity of the instrument set. Unfortunately, the problems of instrumental variables are not limited to their exogeneity.

Instrumental variables may also be irrelevant or weak: the partial correlation between these instruments and the endogenous variables is low. In non-linear models as GMM, this has also been called a problem of weak identification. The moment conditions are satisfied not only for the true coefficient parameter, but for other parameter constellations as well. Weak identification causes GMM to break down such that standard inference cannot be used anymore and this regardless of the size of the sample. Slight changes in the set of instruments or in sample length that produce widely different coefficient estimates are symptomatic of weak instruments. Formal tests are based on the concentration parameter that measures the correlation between variables and instruments. Staiger and Stock (1997) propose the F-statistic on the relevance of the instruments in the first stage regression. A value smaller that 10 is seen as an indication of weak instruments, but a rejection of null does not mean the problem can be thereafter ignored. We therefore compute in addition an F-test on the first stage regression for each of the endogenous right hand side variables $F^1_{[illegible]}$. This is not entirely correct, as the F-test applies to the case of a linear specification with a single endogenous regressor. The test cannot be straightforwardly extended to n regressors unfortunately.[40] If weak instruments have been detected, a few fully or partially robust procedures are available for correcting the inference on the estimates. There are fewer methods that practitioners can use to detect and cure problems with weak instruments in non-linear models, however.[41] The only formal test for detecting underidentification is an F-test analogue by Wright (2003). Fully robust tests on coefficients are a non-linear extensions of the Anderson-Rubin test and the conditional score and LR tests of Kleibergen (2002) and Moreira (2003), while partially robust

[39]This holds in particular for the interaction terms.
[40] See Cragg and Donald (1993) or Stock and Yogo (2001) on this matter.
[41] See Stock et al. (2002) for a review.

tests are the continuous-updating estimator (Hansen et al., 1996) and generalized empirical likelihood estimator (Smith, 1997). We are likely to encounter weak identification in estimating a New Keynesian model. Mavroeidis (2004) discusses the various sources of weak identification in monetary policy models, and methods for identifying true policy parameters. Weak identification in the estimation of forward-looking monetary policy rules is problematic when inflation is firmly under control of the central bank. Intuitively, the variation in inflation due to exogenous events is small relative to unpredictable shocks in policy. This exacerbates the weak correlation problem. Such problems are diminished as we explicitly consider the specification of a system of policy rules.

A second problem of GMM relates to the non-linearity of the policy rule.[42] An even more serious problem is the sensitivity of GMM to the normalisation imposed upon the orthogonality conditions. (Fuhrer et al., 1995). In order to exclude such arbitrary results, the estimations are therefore run on alternative normalisations of specification (15). We can already anticipate that the results are nearly identical, and do not discuss this further.

There is another problem with moments estimators that we can discard. The policy rule may not provide a fully correct moment condition. As we base the specification of both fiscal and monetary rules on theoretical foundations, this is not a problem. However, binding constraints on the optimisation problem underlying the derivation of the rules may blur estimation results. Deficit rules may indeed have constrained policy makers in some countries, but we do not see this as too limiting. Nevertheless, the insights derive from a DSGE model that has become the workhorse model for the analysis of monetary policy. This implies there are cross-equation restrictions imposed upon the parameters of a corresponding empirical VAR model. Many of the applications of the model depend on its interpretation as a whole system (Henry and Pagan, 2004; Lubik and Schorfheide, 2004; Lindé, 2005).[43] Curiously, each of the basic building blocks of the New Keynesian model (Euler-IS equation, Phillips-AS curve and the policy rule) has been analysed individually, and focused on the observable part of the reduced form of the system. Single equation IV estimation does not provide efficient estimators then: the instruments insufficiently capture the remaining part of the model. It also creates some bias in GMM estimation. Monte Carlo evidence on the properties of New Keynesian Phillips curves by Lindé (2005) suggest that GMM tends to find too much inertia, owing to the inertia in the underlying variables, and are likely to change with variations in the monetary regimes. In other words, the procedure does not uncover 'deep' parameters. Full information procedures instead find the true parameters, even when the model is severely misspecified and the measurement error is not normally distributed. Maximum likelihood estimates in particular seem superior in terms of significance and unbiasedness of the parameters in comparison to most other single equation methods, and are dynamically stable (Fuhrer et al., 1995). The necessity of distributional assumptions and a complete specification of the stochastic environment seems less demanding for FIML than originally believed (Hansen, 1982; Tauchen, 1986). We will use FIML estimation of the policy rules as a robustness check.

This may also yield some benefits from estimating the fiscal and monetary policy rules in a system. The economic arguments for a system approach are obvious. Estimated policy rules are reduced

[42] We control in particular for residual autocorrelation, and include additional smoothing lags if necessary.
[43] There are also two dangers of using single equation policy rules. The shocks from these equations can be related to either fundamental or sunspot shocks (Beyer and Farmer, 2004). Carrillo and Fève (2005) show that using single equation parameters in the original model from which it has been derived can result in indeterminacy.

form equations. In absence of a completely specified model, the results are uninformative of policy issues that involve structural parameters or that require a structural interpretation (Lucas, 1976). The implications of the New Keynesian model should be considered from a system-wide perspective (Henry and Pagan, 2004). The empirical literature on policy reaction functions has so far largely neglected the stance of fiscal respectively monetary policy that emerges as crucial in recent theoretical New Keynesian models. By appending fiscal policy to the usual monetary rule, we make an important step in the direction of recovering structural policy estimates.[44] Shocks to both policies are likely contemporaneously correlated (Favero, 2003). This not only follows from the specification of the target objectives of both policy makers. If we replace the reaction to expected target variables $X_t^{e,n}$ by their realised values X_{t+n} for both policymakers, the error in each will have a common component $X_t^{e,n} - X_t$ and are hence correlated in both rules by definition (Henry and Pagan, 2004). Joint estimation then allows a more precise estimation of systematic policy reaction coefficients. Information on the policymaker's settings is useful in constructing estimates for the other policy authority. Nevertheless, a misspecification in one part of the model will spillover to all the coefficient estimates. We check some alternative specifications of the basic forward looking version of the monetary Taylor rule, as well as different specifications for fiscal policy.

Undoubtedly, this approach is subject to the usual criticism on some ad hoc identifying restrictions. The system of rules imposes quite some 'incredible' restrictions. This relates in particular to the timing of policy reactions. Even if the basic specification of the policy rules is derived from a consistent theoretical framework, we base the choice on the ability to adjust policy and the frequency of our data sample. Already for the monetary policy rule, different suggestions have been made in the literature. We choose a simple forward-looking version as in Clarida et al. (1998). This specification is standard in the empirical literature. The standard approach to modelling inflation expectations (to replace expected by realised inflation) is in practice implemented by assuming that the expectation errors are uncorrelated with the instrumental variables. Even for lagged values this will generally lead to inconsistent estimates, as information lags are unknown and serial correlation is large.[45]

It is unlikely that fiscal policy is as forward looking as monetary policy in adjusting its instruments. The budget is usually set on an annual basis, even if within-the-year adjustments are not uncommon. However, as the fiscal impact of output runs mainly through automatic stabilisers, we include the contemporaneous output gap ($n = 0$). Our choice of contemporaneous inflation is motivated by its tax effect on fiscal receipts and debt deflation ($k = 0$). Also, we choose to lag the measure of debt by one year, even if this may be too rapid if unsustainability is not immediately apparent.

When considering strategic interactions, the policy timing is even more challenging. Theoretical models provide little guidance in this respect. The fiscal authority is usually considered as the natural Stackelberg leader. We proceed under a practical (Stackelberg like) assumption on the nature of the policy game: fiscal policy is infrequently set whereas monetary policy is a 'swing' variable that may anticipate fiscal actions instantaneously (Debelle and Fischer, 1997). Under such regime, reactions

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[44] However, our policy reaction functions remain reduced form equations whose coefficients are convolutions of policymakers' targets and preferences and parameters describing economic structure. Only an explicit solution and estimation of the policymaker's optimization problem would give an insight in deep policy parameters. See Dennis (2004) for an application to monetary policy.

[45] Adam and Padula (2002) and Palovvita (2003) use survey data on inflation forecasts instead.

of fiscal policy to the central bank rate are backward-looking, but monetary reactions to fiscal policy are contemporaneous.

3.5. Policy instruments and targets: some definitions

Henceforth, we consider the primary surplus ratio to potential output as the fiscal instrument. This choice is a logical consequence of our specification of the fiscal policy rule. First, we are interested in characterising actual fiscal policy behaviour rather than in describing the setting of discretionary policy. The distinction between discretionary and cyclical fiscal policy is of minor importance. Moreover, as neither structural deficit nor automatic stabilisers are directly observable, we avoid contentious choices on the method of cyclical adjustment. Second, a spurious relationship between the overall deficit and monetary policy may arise if a monetary tightening – resulting in higher interest payments – induces compensations in other components of the budget. The primary category corrects for this effect. Third, actual output is endogenous with respect to the policy instrument. Potential GDP filters out this effect. We decompose the primary surplus into government consumption – excluding net interest payments on outstanding debt – and total tax revenues in a more detailed analysis of the budget. As the monetary policy instrument, we follow the standard choice in the literature of a nominal short-term interest rate directly influenced by the central bank.

The policy target variables for both fiscal and monetary policy makers are taken to be the GDP deflator and a simple mechanical output gap measure (HP-filter). General government debt is consolidated across different government levels, and expressed as a ratio to potential GDP.[46] As the interaction variable, we use the policy instrument of the other authority. In the set of instrumental variables we include lags of the target output and debt variables. In addition, domestic and international monetary conditions are used, as are supply side factors.[47] All fiscal and economic data are in ratios; inflation and nominal interest rates are in percentages.

3.6. Procedure

In the following section 4, we pay particular attention to the derivation of the fiscal rule and consider in detail the modelling of a robust specification for fiscal policy behaviour. We then continue analysing jointly US fiscal and monetary policy. We start documenting baseline specifications of fiscal and monetary policy rules separately, in which a more common monetary policy rule is taken from the literature, and then augment the rules for the effects of inflation and strategic interaction. This prepares the ground for combining both specifications in the system analysis.
Technically, the estimation procedure is conducted in the following steps.[48] In first instance, the

[46] An alternative that controls for economic growth and real interest rates is the debt-stabilising debt ratio (Artis and Marcellino, 1998; Favero and Monacelli, 2005). As we explicitly model monetary policy this has less sense in our specification.
[47] The former include lags of a broad money aggregate, a commodity price index, the yield, a foreign interest rate and the exchange rate to the DEM or the yen. The latter include lagged NAIRU or unit labour costs.
[48] We proceed under the assumption that all variables in the policy rules are stationary. Appropriate data transformations are applied to that end, but the unit root hypothesis cannot always be rejected. By construction, the output gap satisfies this assumption, yet for some of the main variables (the fiscal indicator and the debt ratio in particular), the ADF test does not always reject a unit root and the KPSS confirms this result.

linear target rule in (8) and (12) is estimated with OLS.[49] For the single equation estimates, these initial coefficient estimates are consequently used for input in non-linear 2SLS and GMM estimates of the policy rule. For the system estimates, the initial OLS coefficients are updated with SUR estimation and are then used as starting values for 3SLS estimation of both reaction functions, with a sufficient number of instrumental variables. These first step estimates are then used to construct an optimal weighting matrix and to start off the iteration procedure for GMM. Perturbation of the initial estimates – and especially those of the persistence parameters – performs robustness checks on the coefficient estimates.

4. Policy interaction: revisiting fiscal and monetary policy

We now turn to the joint examination of fiscal and monetary policy for the US consolidated government over the period 1960-2001. We first bring to bear on fiscal policy the terminology and testing machinery that has been applied to monetary policy rules. The analysis of fiscal policy entails its specific problems in terms of specification and testing. Second, we discuss the impact of a common monetary policy on fiscal policy behaviour. The following sections document the properties fiscal and monetary policy rules before going into the system estimation of both rules.

4.1. Data

The monetary, fiscal and economic data come from a variety of sources. For the budget and economic series, we draw upon the NIPA accounts; public debt and monetary data derive from the FRED II database (Table 1). Data are available on a quarterly basis and this intermediate choice of data frequency somehow reflects a trade-off in the joint modelling of monetary and fiscal policy. Monetary decisions are usually taken at a much higher frequency. Given the rather high degree of interest rate smoothing found in the literature on Taylor rules, this measure is probably not too coarse. In contrast, fiscal policy is legislatively set at an annual frequency. Discretionary in-year revisions are not unusual, but most cyclical responses of automatic stabilisers are direct. The synchronised relation of the budget can be seen in Figure 2a, which plots the primary surplus to various measures of the output gap. This cyclicality mainly comes from government revenues that display a much larger variability than expenditures (Figure 2b). A few dramatic spikes are associated to the tax cuts in 1975 of the Ford Administration or post-2001 under the Bush Administration. The size of government is on a slight trend decline. The persistence in most of the fiscal series makes it actually difficult to reject a unit root (Table 2). On the basis of present value tests of the budget constraint, the sustainability of US public finances can be questioned given the finding of a non-stationary primary surplus and debt following an I(2) process. This is the consequence of both spending and revenues being integrated, and is also reflected in net interest payments being an I(2) process. Both the ADF and KPSS tests confirm this result.[50]

Monetary policy displays the usual observation that real interest rates are usually negative before 1980, but except for some periods of economic crisis in which the Federal Reserve strongly reduced

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[49] That is, we estimate separately $s_t = \alpha_0 + \alpha_y x_{t-n} + \alpha_b B_t + \varepsilon_{s,t}$. and $i_t = \beta_0 + \beta_\pi \pi_{t+m} + \beta_y x_{t+l} + \varepsilon_{i,t}$.

[50] Any measure of the output gap is stationary.

the Federal Funds rate (1991 or 2001) real rates have been constantly positive (Figure 3). This marks the so-called Volcker-Greenspan shift in monetary policy, and the adherence to the Taylor principle. Interest rates and inflation cannot be rejected to contain a unit root. With the ADF test, the rejection of stationary interest rates is weak though. Similarly, CPI based inflation cannot be rejected to be integrated of order two (Table 2).

In the next paragraphs, we first discuss in detail a fiscal rule for the US Treasury, discussing some robustness checks and looking into decomposition in spending and revenues. We then reestimate a monetary rule for the US Federal Reserve. We then jointly estimate both rules to infer on policy interaction.

4.2. A fiscal rule for the Treasury

The results of the estimation of a baseline fiscal rule (8) over the period 1960-2001 are in Table 3. US fiscal policy is geared at stabilising debt, and quite strongly so. The reaction β_b to past debt developments is in line with the strong debt response found by Bohn (1998, 2005).[51] This is all the more surprising given that our estimates are structural. The GMM estimates also confirm another conventional result of a significant cyclical stabilisation effect, and the coefficient β_y cannot be rejected to equal 0.50. For comparison, we have also reported the OLS estimates β_y^{OLS} and β_b^{OLS} on the linear fiscal rule (5) here; this demonstrates the downward bias of estimators that do not account for the endogeneity of fiscal policy The US Administration gradually adjusts the primary surplus over time, but smoothing is not much more important than for monetary policy. We cannot give a structural interpretation to the average surplus ratio β_0 without making assumptions on the inflation and output targets of the government, but is seems that on average, the various US administrations ran a deficit of about 4.80% of GDP.

The J-test shows that the overidentifying restrictions are valid. Although the first-stage F-tests on the instruments do not indicate to a problem of weak instruments, we nevertheless find that slight changes in the specification of the baseline rule (8) can result in rather different outcomes for the reaction coefficients.[52] This relates in particular to the timing of the target variables in the rule. Public debt has to be defined at a sufficient number of lags in order for the other estimates not to be biased. Only a reaction to the contemporaneous output gap results in a reasonable cyclical reaction of the budget. Doing so, also results in finding quite some residual autocorrelation that is not salvaged by the inclusion of additional smoothing lags.

There is also quite some evidence on instability in the baseline surplus rule. Table 3 reports Andrews-Ploberger tests for a breakdate in each of the coefficients of the policy rule, its residual variance (σ^2_ε) or for all coefficients contemporaneously (β). We estimate the breakdate by least squares, and test significance with the sup-Quandt LR test. This procedure delivers a unique break associated with the largest test statistic over the trimmed sample.[53] Significant breaks are detected

[51] Our conclusion of sustainability is consistent with most evidence in the literature that derives fiscal rules or estimates Markov switching models on US federal government debt (Davig, 2004).
[52] Results not reported.
[53] Using an optimal trimming percentage of 15%.

in all coefficients separately. The break in the average surplus and the reaction to public debt in 1995 dominate the change in the cyclical responses of the budget, which is located in 1991:1. There is seemingly no relevant shift in the volatility by which the surplus ratio is used. Nevertheless, we modify the test so as to account for subsample variability in the way suggested by Stock and Watson (2003). In particular, the corrected test searches for a break in the coefficients of the model, conditional upon and controlling for a potential change in the residual variance before and after the initial breakdate in the coefficients. Accordingly, it scales down periods of greater turbulence and magnifies relatively small policy shifts in calmer periods. We implement the Andrews-Quandt version of the test on all coefficients in the policy rule. This makes the results in Table 4 differ slightly from those of the Andrews-Ploberger version in Table 3. As before, we do not find a relevant break for the volatility of policy. Accordingly, we can place the break in the fourth quarter of 1995 but the shift might have occurred anywhere in the period 1993:3 to 1998:1. This generalised shift in fiscal policy in the nineties is also endorsed by the exponential and average Quandt-Andrews LR tests; Figure 4 plots the LR test statistics and critical values: the period of the break extends nearly over the entire nineties.

It is nevertheless hard to find changes in cyclical and debt responses from a model of continuous regime change. We recursively estimate the linear target fiscal rule with GMM, disregarding thereby any changes in the smoothing parameter. Figure 5 shows the coefficient estimate and the 95% confidence interval of progressively adding data points. The instability in the nineties is now less evident. On the contrary, cyclical responses seem to have become much stronger since 1980 (a result also found by Taylor (2000) and Auerbach (2002)), whereas the debt stabilising response is gradually weakening over time to become only positive again in the nineties. A probable change in the smoothing properties of fiscal policy may be responsible for that.

A plot of the standardised residuals of the baseline rule (Figure 6, upper panel) gives some further insight into the reasons for the instability of fiscal policy. There are only a few pronounced shocks to fiscal policy that are mostly associated with tax policy. Following Blanchard and Simon (2001), we plot the smoothed volatility of the policy shocks. The tax cut of 1975 actually initiates a period of quite some volatility in fiscal policy that finishes only in 1980 (Figure 6, lower panel). The gradual decline in policy volatility reaches a dip around 1995, but shoots up again at the time of the large tax cut of 2001. The instability of the nineties is due to a less pronounced use of fiscal policy, and with an unusual focus on the reduction of public debt.

This does not imply that fiscal policy had not been stabilising debt before 1995. Estimating the baseline fiscal rule over the subsample 1960-1995 shows that fiscal policy was only slightly less passive and responsive to the cycle (Table 3). We else replicate the results for the full sample.
This made us also wonder to the conduct of fiscal policy over other subsamples. Analysis of monetary policy has proceeded on the post-1980 sample during which interest rates are believed to be set in an active way by the Federal Reserve (the so-called 'Volcker-Greenspan shift'). Might the switch from passive monetary policy under Burns-Miller to a more activist strategy under Volcker-Greenspan have brought along a change in the behaviour of fiscal policy? We estimate the fiscal rule separately over the period 1960-1979 and 1980-2001; also with a view to the later analysis of monetary policy. Fiscal policy is actually active over the first sample: there is no significant response to past fiscal imbalances. This concords with the argument of Woodford (1998) that a combination of

active fiscal/passive monetary policy was needed for economic determinacy over this period. Fiscal policy is also much less inertial and only responsive to the cycle. In the second period, in contrast, fiscal is very strongly responsive both to public debt and to the cycle,[54] but not very volatile in changing the primary surplus. This again supports a 'passive/active' combination of fiscal and monetary policies that is consistent with determinacy.

4.2.1. Some robustness checks

We first want to check the validity of the GMM-approach. Following the discussion of the merits of maximum likelihood approaches in section 3.4, we reestimate the baseline fiscal rule with FIML (Table 5). The main result remains largely unchanged: the stabilisation of public debt is a significant target of the US Treasury, and the size of the reaction coefficient γ_b is similar to the one for GMM. Fiscal policy is more inertial, however, and the cyclical elasticity of the budget is larger than unity.

These results hold up quite well for the NIPA definition of the output gap; the cyclical and debt response over the total are only slightly weaker and significant than for the HP filter measure (Table 6). The difference between both cyclical measures is not very pronounced (see Figure 2a). The same cannot be said of the theoretical output gap that we derived as in Gali et al. (2001). None of the coefficients is significant, nor do they display the expected sign. One reason why this measure may be less successful in capturing the cycle is that the labour share is a less perfect approximation to true marginal cost. With fiscal policy, the distortionary effect of taxation on the gap measure need to be included as well (Gali et al., 2005).

One may hypothesise that the unusually strong reaction to public debt in the period 1995-2001 is due to a sense of urgency in the US Treasury that fiscal consolidation has become unavoidable as public finances get out of control. A specification of the fiscal rule that allows for non-linear reactions to the debt ratio does not track the evolution of the primary surplus very well (Table 7). Both debt and cyclical responses are non-significant over the entire sample period. Only if we consider the second sample period does the inclusion of the squared debt ratio result in significant coefficient estimates, but the responses to debt go in the wrong direction. The reaction becomes significantly negative at much higher debt ratios, and is only weakly positive at lower rates. The non-linear specification probably tracks the response to debt rather well.

Finally, we reconsider some of the evidence on a discretionary measure of fiscal policy. We have filtered out cyclical movements in net lending with a HP-filter. Any cyclical response is not significant anymore: there is no procyclical tendency in US fiscal policies. In comparison to the baseline rule, the debt response is now even stronger (Table 8).

4.2.2. The budgetary effects of inflation

An optimal fiscal rule that accounts for interaction would have the Treasury also respond to inflation. Stabilisation of prices is a deliberate strategy of the fiscal authority; but we cannot exclude that inflation affects real revenues (tax bracket effects, for example) or spending (incomplete indexation).

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[54] That the coefficient γ_y equals 0.50 is still not rejected though at the 5% level.

If we estimate a specification as in (9), we find that inflation further reduces the surplus. Whether this is due to lower tax revenues or increased spending will be examined in section 4.2.4. Debt responses are not significant now, but the cyclical response is as strong as in the baseline case (Table 9). There are some remarkable differences over the subsamples, however. We still characterise the first subsample 1960-1979 as being of 'active' fiscal policy: in fact, something stronger holds. Fiscal policy did not just ignore debt accumulation, but even responded to higher debt with significantly higher deficits. At the same time, higher inflation incited a loosening of the budget. This might not necessarily have been incompatible with the sustainability of public debt. Higher inflation over the period 1960-1979 deflated real interest payments on outstanding debt. In the period of active monetary policy, fiscal policy turns passive again, but not significantly so. The effect of inflation is not significant anymore. That both inflation and debt are insignificant is strongly rejected by an F-test on both coefficients, however. The cyclical responsiveness of the budget raises a lot, but is rather imprecisely pinned down.[55]

4.2.3. Strategic interaction with the Federal Reserve

We then include the nominal Federal Funds rate into the baseline rule as a test for strategic policy actions. Fiscal policy is found to be a substitute to fiscal policy, as a monetary tightening induces a lower primary surplus ($\square_i$ $\square$ 0)(Table 10, upper panel). Over neither of the subsamples is the effect of monetary policy significant, and neither are the conclusions on the conduct of fiscal policy in each subperiod altered. Interestingly, the break associated with the interest rate coefficient $\square_i$ is located in 1995. This suggests that the break in fiscal policy is primarily related to the debt payments channel. There are a few problems that arise with this specification, however. First, the response of debt is insignificant over the entire sample period. Higher interest payments probably substitute out for other budget categories. Second, instead of finding the usual cyclical stabilisation response, this effect is now entirely insignificant and even displays the 'wrong' sign. It then seems as if including the interest rate as a distinct target variable does not separate out the strategic interaction effect, as the systematic setting of monetary policy is only incompletely modelled via the instrumental variables. But does interaction really matter? Might the inclusion of the policy instrument not just absorb the effects of some other variables? Formal exclusion F-tests on the interaction term with public debt never revealed its insignificance ($\square$ $\square_i$, $\square_b$ $\square$ $\square$ 0 in Table 10). The tighter link between interest rates and debt is only not rejected for the period 1980-2001, however. This suggests that the higher interest payments did not constrain fiscal policy over the period 1960-1979 by much.

Policy substitutability does not necessarily mean that both policies have constantly been on conflict course (Buti et al., 2001). Both policies can still be relatively tight (or loose) to each other. We therefore consider as an alternative measure of policy interaction the deviation from the normalised value of the Federal Funds rate (Table 10, lower panel). This never results in a significant effect of monetary policy, and moreover does not affect the other conclusions of the baseline fiscal rule.[56]

What happens to the results of the inflation-augmented fiscal rule when we additionally include the nominal Federal Funds rate? Table 11 reports the results of the specification (9) with inflation as an

[55] Even a tiny change in inflation with a large fiscal shock may have a big impact on the change in public debt.
[56] Another suggestion is to use an external SVAR policy equation residual (Gali and Perotti, 2003).

additional target: nearly identical results hold as for the rule without inflation. The latter is variable is not significant, but the combined effect of either nominal interest rates or inflation with public debt is never rejected to be significant. This again suggests that it is through real interest payments that monetary policy has an important effect on fiscal variables.

4.2.4. Tax and spending rules

As in Davig and Leeper (2005a) we specify a tax rule in terms of cyclical and debt reactions. In contrast, we do not set taxes in terms of government spending directly, but decompose the primary surplus into separate spending and tax rules. The instrument of government spending is government consumption, hence excluding net interest payments or government transfers. As for the tax instrument rule, all tax revenues are included in our measure. We estimate each rule separately by GMM.

Spending is not cyclical, but quite strongly stabilises debt (Table 12). This is the net effect of two different subperiods, however. On the one hand, active fiscal policy in the 1960-1979 sample goes together with significant countercyclical responses in the budget. Government spending is strongly procyclical in the Volcker-Greenspan era, on the other hand, but focuses also more strongly on the stabilisation of public debt. A structural break in the government spending rule is detected earlier than the surplus rule would suggest, and is exclusively related to the reaction coefficient on public debt. The cyclical response does not undergo significant changes. A plot of the Andrews-Quandt test statistics in Figure 7 shows that the instability of fiscal policy is located around two peaks in the nineties that are significant for each of the supremum, exponential and average version of the Andrews-Quandt test. A recursive estimate of the spending rule shows the tendency for fiscal policy to become procyclical over the nineties; the debt response is significant in the seventies and again in the nineties, but not relevant in the eighties (Figure 8). Large discretionary changes in government consumption are not common; there is no obvious outlier in the plot of standardised residuals of the spending rule (Figure 9). The volatility in spending movements tapers off near the end of the sample, but there are periods of somewhat heightened changeability such as the mid-eighties (associated with the military build-up of the Reagan period).

The augmented rule that also includes inflation does not result in a reasonable specification. None of the coefficients is significant. The same result holds for the specification with interest rates. There is not an impact of monetary policy setting on government spending.

If we then turn to the tax rule (Table 13), the strong cyclical responses of total revenues are immediately apparent. There is a weakly significant response to debt, making tax policy passive over the entire sample. There is a significant break in this response in 1975, linked to the large tax cut of the Ford Administration.[57] These Andrews-Ploberger tests give rather different indications than the Andrews-Quandt test in Table 4 and Figure 7. The latter test locates the break in the tax rule, for either the basic or the corrected version in the early nineties. It is also quite precisely located in a few quarters around the start of the Clinton Administration. The volatility in the changes of spending seems to have undergone significant changes at the end of the eighties already. The change in the reaction coefficients in the tax rule extends for a larger couple of years, but abruptly ends in 1995. This heralds the start of the unusual period of debt consolidation in the US. This shift causes some

[57] The 1991 break in the cyclical response also explains the break in the primary surplus rule (Table 3).

problems in the estimation of the tax rule. While for the first subsample, we find that tax policies are hardly cyclical but still passive, we fail to make converge the empirical model on the subsample 1980-2001.

We can only infer on the changes over this period with some continuous estimates. Recursive estimates of the target tax rule show that cyclical responses of total revenues jumped after 1980, a result also found by Taylor (2000) or Auerbach (2002). On the other hand, the debt response declines over time, and is hardly significant over the entire Volcker-Greenspan era (Figure 8). The plot of the smoothed volatility of the residuals $\varepsilon_{s,t}$ of the tax rule shows the gradual damping out of changes in fiscal policy; an even stronger reduction in the volatility starts in 1995 up to the reversal of the first tax cuts under the Bush Administration (Figure 9). Two events dominate the history of US tax policies, the strong tax cuts of 1975 and 2001. As a consequence, most of the results for the tax rule can be put over from the surplus rule, indicating the larger variation in tax than spending policies. The significantly negative effects of inflation on the primary surplus are mainly explained by the negative effects on tax revenues. This has also the effect of making tax policies active: a higher debt ratio even induces lower tax intake now. The cyclical responses in the augmented tax rule are otherwise unchanged. The tax rule for strategic interaction suffers from the same flaws as the surplus rule: interest rates absorb all of the significant debt and output responses.

The passivity of fiscal policy is due to a combination of government spending and revenues reacting to developments in public debt; but over the period 1960-1979, we find that spending causes fiscal policy to be active. This is consistent with determinate economic equilibrium if monetary policy were passive over the same period. We now turn to an examination of the behaviour of the Federal Reserve.

4.3. A monetary rule for the Federal Reserve

We consider a common Taylor rule as in (12) that includes a forward looking reaction to inflation developments (at four quarters), but includes the current output gap. If we estimate this conventional specification over the sample 1960-2001, the Federal Reserve is seen as reacting much more to cyclical conditions β_y than to inflation β_π (Table 14). Even though the reaction is significant, the Taylor Principle is rejected. This is a combination of two different periods, however. Before 1980, the output response is much larger than the response to inflation, even if the anti-inflationary stance can not be said to be accommodating. The reaction coefficient is smaller than unity, but the Taylor Principle is nonetheless not rejected. This switches to a much more activist policy that downgrades the importance of output stabilisation after 1980, and takes a tougher stance towards inflation. As a consequence, the Taylor Principle is clearly satisfied over the Volcker-Greenspan period, and corroborates some of the classical results in the monetary policy literature (Clarida et al., 2000).

We believe that the importance of the policy shift should not be overstated, however. There is no strong evidence for a structural break in the monetary policy rule. While the Andrews-Ploberger tests on each single coefficient confirm the existence of a break around the period that coincided with the monetary targeting initiated under chairman Volcker, the existence of a break in the entire rule is rejected. The same finding holds for the Andrews-Quandt test. There is some weak evidence for a change in the volatility of monetary policy around 1994 (Table 15). This confirms the findings of a less radical shift in monetary policy than is apparent from the data, and is commonly taken for granted (Sims and Zha, 2004). Only if a correction for the change in residual volatility is made, do we find a significant and precisely estimated structural break in the policy rule in 1980:4. The instability in monetary policy is indeed asymmetrically distributed over the sample. The recursive plot of the Andrews-Quandt LR test statistics indicates instability over the late seventies, running through the period of monetary targeting, but this quite strongly decays afterwards (Figure 10). A similar inference can be made from the plot of the smoothed volatility of the standardised residuals: the peak in policy reactiveness is associated with the interest rate hikes in 1980 (Figure 11). It is interesting to see that around the mid-seventies, monetary policy has already attempted to react more vigorously to inflation but refrained from increasing rates by too much. Between 1976 and 1980, monetary policy is becoming much more inertial. This ‘wait and see’ attitude over this period is explained by Orphanides (2003) as a mistaken action to imperfectly measured output. A recursive regression of the linear target rule for the Federal Funds rate reveals that it may indeed be the decline in the output response that marks the transition to the Volcker-Greenspan period (Figure 12). Except for the initial monetary targeting, there is little evidence that monetary policy has become much more activist on inflation, The Taylor Principle is not satisfied, but can also not be rejected over the entire 1980-2001 period. A final remark then on the smoothing: monetary policy has not been more inertial under passive than under active monetary policies.

4.3.1. Some robustness checks

The main results do not always hold up well for a Taylor rule that is defined in terms of some for different definitions of the state variables, however (Table 17).[58] If we replace the GDP deflator with the CPI based inflation rate, the switch from an output targeting to an actively inflation combating is more pronounced than before. But using the official NIPA output gap measure instead of the HP-filter based one, results in a specification that has as a significant state variable only the inflation response under the active regime. Using a combination of the NIPA output gap and CPI inflation results in finding an active monetary policy both over the entire sample and any of the subsamples. That the Taylor Principle holds throughout is a consequence of the reaction to the output gap being insignificant in this case.

Clarida et al. (2000) also examine a Taylor rule in which the central bank reacts to future cyclical conditions, which would be more consistent with a reaction to future expectations of inflation. When we include the HP filtered output gap one quarter ahead, we would confirm their findings of a rather tough anti-inflationary stance since 1980. However, there is an equally large, albeit only weakly significant, response to this cyclical measure. A Taylor rule that has the instrument set in response to accelerations in the output gap is found to track the record of the Federal Reserve rather well. Giannoni and Woodford (2003a) derive such a specification as an optimal and robust instrument rule. We find an overall passive monetary policy, with a rather pronounced cyclical response, but these results are not always very significant.

For the same reasons as given above, we reestimate the baseline rule with FIML. This even strengthens the previous findings of the switch from a passive to a more active monetary policy

[58] The specification is rather robust to the inclusion of additional smoothing lags to resolve any problems of residual autocorrelation (Table 16).

(Table 18). But whereas the increase in the inflation response rather large, the decline in the output reaction is much less pronounced.

4.3.2. Strategic interaction with the US Treasury

There is hardly any evidence for a strategic move of monetary policy vis-à-vis the Treasury (Table 19). The response of interest rates to fiscal policy is positive, but not significant. Fiscal policy also absorbs much of the cyclical response in interest rates. Instead, only the reaction to inflation is significant in each subsample. This suggests that, conditional upon any systematic reactions of automatic stabilisers to the cycle, monetary policy assumes a relatively less important role in output stabilisation. A baseline Taylor rule augmented for the primary surplus ratio is not a very reasonable specification, though. For probably much the same reasons as why the interest rate does not capture very well strategic interaction, instrumenting the surplus does not result in a good model for systematic fiscal policy. If we consider this result in combination with the finding of substitutability in the fiscal rule, this suggests that fiscal policy conditions its actions on changes in monetary policy, but not vice versa. It does not make the Federal Reserve the Stackelberg leader in the policy game with the US Treasury. For this to hold, monetary policy actions would need to be a complement to changes in fiscal policy (Hughes Hallett, 1984).[59]

4.4. The policy tango of Fed and Treasury

4.4.1. Baseline result

We now take both the baseline fiscal and monetary rule, and estimate both with system GMM. Not much changes in the coefficients of the baseline fiscal rule (Table 20). The primary surplus reacts strongly to the debt ratio, indicating a passive fiscal policy over the entire span of data. The cyclical reaction nearly coincides with the true budget elasticity (0.51). The average (inflation and output adjusted) deficits stands at about 5% of potential GDP. The conclusions on the monetary rule do modify, however. In particular, there is no significant cyclical response anymore, but the Federal Reserve follows an active anti-inflationary stance.[60] This strengthens the intuition from the monetary policy rule that was augmented with the primary surplus ratio. As monetary policy takes into account the systematic countercyclical reactions of fiscal policy through the automatic stabilisers, the Federal Reserve needs to counter less on cyclical conditions itself. The policy tasks of US Treasury and Federal Reserve to focus on output versus price stabilisation respectively seem well separated. In the model of Dixit and Lambertini (2003a,b), this would exactly be the allocation of policy tasks that is socially optimal and feasible. It does not imply that policies do not act together. Even though a plot of the standardised residuals of each rule does not show any strong comovements (Figure 13), the correlation between shocks to the monetary and fiscal rule is not high but still significant ($\gamma_{s,i}$ =0.22).[61] This combination of active fiscal and active monetary policy is also consistent with a determinate economic equilibrium over the entire sample. The standard insight of US monetary

[59] Responses to deviations from the normalised primary surplus ratio do not result in a well-specified Taylor rule.

[60] Structural estimation of the policy objective function in Dennis (2004) shows that an output stabilization objective does not enter significantly into the considerations of the Federal Reserve.

[61] Figure 13 displays the classical plot for the monetary policy shock. The break is associated with the period of monetary targeting. For fiscal policy, the breaks in 1975 and 2001 are mainly related to the tax cuts of the Ford and Bush Administration.

policy causing the Great Inflation of the seventies, and being inconsistent with equilibrium determinacy certainly needs to be reconsidered in light of this evidence.

The result is also robust to modifications to the estimation method. We estimate all the structural parameters in the system (15) with FIML, which may have superior properties in terms of biasedness and significance. FIML has been a more common approach in the estimation of systems in open economy models.[62] We find that both policies are still active, but also become more responsive to the cycle (Table 20).

The separation of policy tasks of the Treasury and the Federal Reserve is perhaps not as strong as we find here. The baseline rules only have as a joint target variable the economic cycle. Benigno and Woodford (2003) argue that under policy interaction, also fiscal policy needs to concern itself with the stabilisation of inflation. We thus augment the baseline fiscal rule with inflation (Table 21). Over the entire sample, there is only a significant cyclical response of the primary surplus left but no reaction to the debt ratio. The inference with respect to the monetary rule is unaltered.

4.4.2. Regime switches

The reaction function estimates in the baseline rules are most likely a convolution of different regimes. The literature on either monetary or fiscal policy, or their interaction, has attributed quite some attention to characterising different regimes for policy because of its consequences for the determinacy of the economic equilibrium. *Pro memoria*, we have put the Andrews-Ploberger breakdates on the coefficients of both policy rules in Table 20. The usual route taken in the empirical analysis is to consider regime changes for each policy separately and consequently examine the effects on the joint equilibrium (Davig and Leeper, 2005a; Favero and Monacelli, 2005). In that case, there are of course plenty of ways of looking at the effects of imposing a particular breakdate on the model. We consider dividing the subsample into the classical pre- and post-1980 shift in monetary policy that we have maintained so far. This unsettles some of the previous evidence. That monetary policy becomes active over the entire sample once systematic fiscal policy setting is taken into account, already suggested that the inference on policies in isolation can easily be overturned. And indeed, while we find both policies consistent with determinacy over the entire sample, this is not the case for each of the subperiods. Fiscal policy would still pay attention to past fiscal imbalances as from 1980 onwards, but monetary policy changes from an active to a more passive stance in the Volcker-Greenspan period. Neither of the two combinations would then be consistent with determinacy. In both periods, the output stabilisation motive is stronger than the inflation target, but both decline in importance.[63] The causes of this change are less obvious, but the larger cyclical responses of the budget look as if the budget started to play a larger role in stabilising the economy relative to monetary policy. Monetary policy bore the brunt of economic stabilisation in the period 1960-1979 in contrast. The correlation $\gamma_{s,i}$ between both shocks remains equally high and significant over both samples, still indicating modest comovements of both policies. Despite the claim that monetary policy has played a more important – if not the prime – role in reducing macroeconomic volatility over the past two decades, and is also considered the most adequate tool

[62] See Ghironi (2000), Bergin (2003) or Giordani (2004) for an application to New Keynesian open economy models; Dennis (2004) for estimating monetary policy objective functions.
[63] While the inflation target coefficient does not satisfy the Taylor Principle, it is nevertheless not rejected either.

for stabilisation (Taylor, 2000), we find that fiscal policy has substantially eased the task of the Federal Reserve by focusing both on debt developments and the cycle. This statement is of course conditional on the type of shocks hitting the economy: automatic stabilisers are particularly adequate in the face of demand shocks that have been found to dominate the US economy (Giannone et al., 2002; Stock and Watson, 2003). In our view, fiscal policy should nevertheless be included in an account of macroeconomic evolutions, and in an evaluation of the 'good luck' versus 'good policy' hypothesis.

Estimation of a system of rules in which fiscal policy also reacts to inflation gives some further support for this insight. When we estimate (15) over the subperiods, the primary surplus destabilises debt and gets looser when inflation increases, apart from the usual cyclical responses (Table 21). Simultaneously, monetary policy responds more strongly to the cycle even though the Taylor principle continues to be satisfied. From 1984 onwards,[64] the inflationary effects on the budget become even stronger, as is the cyclical response but the debt response is insignificant. This passive policy is consistent with a passive monetary policy that only weakly responds to the cycle.[65] This corroborates our hypothesis that by reacting more vigorously to the cycle, fiscal policy managed to stabilise contemporaneously inflation. This might have eased the task of the Federal Reserve. However, it does not fully explain the significant cyclical response of interest rates.

For the same reason that we argue fiscal policy should be included in the analysis, we remain a bit critical towards imposing the break in monetary policy as the only relevant change. The fiscal regime is as relevant for the analysis. More probably, the effects a regime change entails some consequences for the conduct of the other policymaker. An evaluation of the structural breaks in either monetary or fiscal rules in section 4.2 and 4.3 does not reveal a clear synchronisation of regime changes. This is also not what would be expected from a single equation analysis: we get only a partial understanding of the mutual effects of policy changes. This raises a subtle point. The question of Davig and Leeper (2005a) as to what causes policy changes is not limited to policy having a stochastic component. Once interaction is taken seriously, changes in one policy regime might correlate with changes in the other policy maker's regime. Policy prescriptions that are made in isolation might then also have repercussions on changes for the other policy maker. This might make findings of combinations of active/active or passive/passive policy regimes still compatible with determinacy. Any combination of fiscal and monetary regimes could be consistent with a rational expectations equilibrium, if policymakers adjust their policies over time to changes in the behaviour of the other policymaker. Following the arguments of Leeper and Zha (2003) and Davig et al. (2004),[66] as long as an adjustment in fiscal or monetary is expected with some probability, this is sufficient to make the equilibrium determinate and have implications for the real effects of policy.[67]

It is less obvious how to handle policy switches in a system analysis, however. At one extreme end stands the single equation analysis; at the other extreme the analysis of structural breaks in a

[64] The model failed to converge when the period of monetary targeting was included.
[65] Note also that both policies display significant comovements in the first subsample, but not anymore after 1984.
[66] They consider policy interventions as a sequence of realizations of policy variables. Agents hold some beliefs on changes in policy regimes and accordingly attach a probability distribution to various policy rules. Davig et al. (2004) compute these probabilities by estimating a Markov switching model on fiscal and monetary policy rules separately.
[67] That indeterminacy of equilibria can explain real world phenomena has long been acknowledged (Benhabib and Farmer, 2000). Testing this hypothesis empirically has been more challenging. Lubik and Schorfheide (2004) construct a likelihood function of a DSGE model of monetary policy for the indeterminacy region. They can quantify the importance of determinacy and indeterminacy regions of the parameter space. They find that before 1979, US monetary policy was inconsistent with determinacy.

system. This considers total instability in the DGP of the empirical model, but does not associate the break to the underlying structural parameters (Boivin and Giannoni, 2003; Stock and Watson, 2003). Hence, we cannot characterise a break in the regime of either monetary or fiscal policy but only get an overall indication of parameter instability. We have estimated a VAR with the policy instruments and the target variables of the baseline rules. We follow Bai et al. (1998) in constructing a sequential Quandt-Andrews likelihood ratio test based on a VAR representation of X_t. The breakdate is the supremum value of this recursively generated series. Following Stock and Watson (2003), we scale the series by the change in residual variance before and after the initially estimated breakdate. Applying this heteroskedasticity correction more correctly locates the break if the data series did not only change its first, but also its second moments. We consider a single breakdate only. The optimal breakdate search concentrates on the central 60% of the sample, thereby leaving too few degrees of freedom for examining multiple breaks on the subsamples. The confidence interval around this break indicates (Bai, 1997) how precisely we can locate the structural break. Finally, we set the lag length of the VAR model to four, which should be sufficient for quarterly data. Applying this to the VAR, we find a significant break in the first quarter of 1989 (Table 22). The change in the volatility is relatively minor, as both the homoskedastic and heteroskedastic version locate the structural shift in the same period. There is only a slight sign that volatility over the eighties was stronger, as the heteroskedasticity corrected version has the confidence interval narrower by about one year.

How do we interpret this result? Does the vicinity to the breakdate in monetary policy imply that the shift in interest rate setting has been relatively more important? Not necessarily so, but we suggest another interpretation here of the effects of the change in monetary that unravel over time. The consequences of fiscal inaction in the face of growing debt that eventually entail monetising by the central bank of the government's current and expected liabilities is the logic underlying the 'unpleasant monetary arithmetic'. We believe that an opposite 'unpleasant fiscal arithmetic' better characterises the interaction of fiscal and monetary policy that took place over the eighties. As the Federal Reserve became more active and oriented towards stabilising inflation, real interest rates became positive (Figure 3). We leave in the middle whether fiscal policy under the Reagan Administration attempted to revert the ensuing economic crisis from 1982 to 1984.[68] It is certain that debt started to accumulate at a growing rate over the eighties (Figure 1). As the US Treasury started to realise that the loose fiscal stance might threaten sustainability of fiscal policies, shy moves towards budget consolidation were taken first under the Bush Administration (1988-1992) and more strongly so with the tax hikes implemented by the first Clinton Administration. In combination with a monetary policy that gained credibility for its anti-inflationary stance interest rates fall substantially. The gradual move towards more passive fiscal policy is not inconsistent with stronger cyclical stabilisation. The evidence in section 4.2 on the declining volatility in fiscal policy, and structural breaks in fiscal policy occurring around 1992-1995 are consistent with this interpretation.[69] According to this interpretation, monetary policy has the capacity for coercing fiscal policy into a passive stance.

One problem with this sequential interpretation is that active and passive policies are concepts that are valid in the long term (Canzoneri et al., 2001). In that case, we do identify properly the reaction function estimates, but these hold on average over the sample period. GMM is not sufficient to take account of the endogeneity of inflation and debt. The future consolidation of debt might already have

[68] And hence explains some of the discretionary expansion that has taken place in that period.
[69] Favero and Monacelli (2003) find fiscal policy to change stance in 1987.

induced expectations of lower inflation long before the passive fiscal policy was implemented. The finding of active monetary policy before the shift in fiscal policy does not have a causal explanation. The entire expected path of fiscal and monetary policies matters. Our interpretation of the results holds only under a Ricardian assumption.

4.4.3. Strategic interaction

Such a reading of the recent US macroeconomic evolution is corroborated by our finding of strategic games between fiscal and monetary policy. As we control for the systematic policy setting via instrumented system estimation, we consider the addition of the other policymaker's instrument as a test for strategic interaction. Our results, reported in Table 23 show that in reaction to a tightening in monetary policy, fiscal policy loosens its stance. In particular, an increase in the interest rates by the Federal Reserve of 1%, for example, provokes a loosening of the primary surplus of about 0.38 per cent of potential GDP. As in the analysis of the fiscal reaction function in a single equation framework (Table 10), interest rates are also the only variable to which the budget reacts in a significant way. In contrast, monetary policy does not react significantly to the primary surplus. Inflation is now the only relevant target variable to which the Federal Reserve reacts. The combination of monetary policy choosing independently of fiscal policy its targets (next to any cyclical or inflation responses) and fiscal policy reacting as a substitute to monetary policy is more consistent with a leadership role of the Federal Reserve. Changes in interest rates by the Federal Reserve have budgetary implications to which the US Treasury responds by loosening policy. This does not imply a deliberate attempt to undo any cyclical effects of monetary policy. This reaction is captured by the cyclical reaction coefficient θ_y: its insignificance indeed suggests that the movements of automatic stabilisers and interest rates are not synchronised. Economic shocks that already trigger an automatic change in the budget may still await recognition, reaction and transmission of a change in monetary stance. If there is a strategic association between fiscal and monetary policies, substitutability of the primary surplus probably implies that rising interest payments are only partially offset with cutting other budget items.

The specification that has reactions to the deviations from the normalised policy instrument makes both policies weak complements. This would lead to a more benign view on joint US policymaking. Both Federal Reserve and US Treasury cooperate on achieving similar aims, but fiscal policy reacts to the cycle only. A counterintuitive procyclical response of monetary policy is found in this specification, however.

4.4.4. Spending and tax rules

We explore further the finding of an active/active or passive/passive combination of policy regimes by looking into more detail in the composition of changes in the fiscal stance. This makes us infer as to whether government spending or revenues is used to pay off debt. Moreover, the primary surplus confounds some of the adjustments in either spending or tax revenues (Davig and Leeper, 2005a). Taking this into account should make the inference more precise.

We examine first whether it is the spending or tax rule that determines the change in monetary policy regime from active to passive over the subperiods. We add each fiscal rule separately to the Taylor

rule. We then see that the changes in both spending and revenue patterns drive the switch from an active to a more passive fiscal policy stance. In particular, government consumption completely disregarded the evolution of past fiscal imbalances. Higher public debt did not curb spending; quite on the contrary, strong responses to the economic cycle went hand in hand with a further expansion of the budget (Table 24). Tax revenues were used to keep the debt consequences of this expansion under control. This came at the expense of a cyclical reaction of taxes (Table 25). The switch to a more passive stance is in the first place given in by weak replies of the budget to either the cycle or outstanding debt. Tax revenues become much more responsive to the cycle, and this also explains the countercyclicality of the primary surplus. No significant response to debt is detected, however. Appending only a spending to the monetary rule does not result in a reasonable description of the behaviour of the Federal Reserve. It is the description of tax revenues that results in a monetary policy rule that changes from an active to a passive stance over the two subperiods.
It is also tax revenues that are set as the significant strategic substitute to changes in interest rates. One might have expected that increases in the interest rate enlarge tax bases for capital taxation and hence result in higher revenues (Perotti, 2005). The result we find here is rather strong, and has the US Treasury decide on deliberate tax cuts when the Federal Reserve tightens. Spending in contrast diminishes when the Federal Reserve implements a monetary tightening. Finally, adding inflation to the fiscal rule only results in significant revenue declines but does not affect spending.

Even if tax revenues dominate the variability in fiscal series, it is hard to arrive at a good characterisation of either policy. We therefore look into an extended system (16), in which the surplus rule has been decoupled into a spending and a tax rule:

$$
\begin{cases}
E_t\left[\tau_t - \rho_\tau \tau_{t-1} - (1-\rho_\tau)\left(\psi_{\tau,0} + \psi_{\tau,y} y_{t+n} + \psi_{\tau,\pi} \pi_{t+k} + \psi_{\tau,b} B_t + \psi_{\tau,i} i_t\right) \mid z_t\right] = 0 \\
E_t\left[g_t - \rho_g g_{t-1} - (1-\rho_g)\left(\psi_{g,0} + \psi_{g,y} y_{t+n} + \psi_{g,\pi} \pi_{t+k} + \psi_{g,b} B_t + \psi_{g,i} i_t\right) \mid z_t\right] = 0 \\
E_t\left[i_t - \rho_i i_{t-1} - (1-\rho_i)\left(\phi_0 + \phi_\pi \pi_{t+m} + \phi_y y_{t+l} + \phi_s s_t\right) \mid z_t\right] = 0
\end{cases}
\qquad \text{(16a-c)}
$$

We follow the same GMM procedure as before for estimating jointly all three policy rules.
The results do not indicate any significant reactions of policymakers to target variables, and we could read this as evidence for a combination of active fiscal and passive monetary policy (Table 26). The finding of insignificant responses is more likely due to some overlapping regimes over which we estimate all the rules. If we split the sample again according to the classical Burns-Miller/Volcker-Greenspan shift for monetary policy, then only over the subperiod 1960-1979 does the model (16) characterise the combination of an active fiscal and passive monetary policy rather well. Active fiscal policy is a combination of spending exceeding revenue responses to the increase in public debt. Both fiscal instruments are also quite cyclical. At the same time, monetary policy gives quite some attention to cyclical conditions too, but much less to inflation (albeit the Taylor Principle cannot be rejected). It is much more difficult to arrive at a good model for the period 1980-2001. The coefficients are in line with an active fiscal policy that curbs spending and raises tax revenues. Monetary policy pays strong attention to inflation and much less to output. These coefficients are hardly significant. It is hard to find an explanation as to why the significance of the results differs so strongly across the subsamples. The J-test indicates that the overidentifying restrictions are valid and even more strongly so for the Volcker-Greenspan period. We cannot exclude the existence of weak instruments, however. This would be especially problematic for GMM estimation in case policy has been able to keep its target variables under stricter control (Mavroeidis, 2004, Nason and Smith,

2005). It has been argued that the shift to an active monetary regime has indeed given a stronger lever to monetary policy. Strong interventions are not necessary as expectations of private agents have settled on rules-based monetary policy (Clarida et al., 2000). Another view is that the Volcker-Greenspan period is characterised by additional instability. There may have been other shifts over this period. The period of strong budget consolidation from 1995 till 2001 is the prime candidate of course. A simple plot of the standardised residuals of (16) does not give much support to this hypothesis (Figure 14). Apart from the large tax cut in 2001, large shifts in spending or revenues do not appear over the nineties. It also shows the dominance of revenue shocks in fiscal policy: shocks to government spending have been minor. Moreover, their variability declines over time.

Finally, we find that except for the correlation of spending and revenue shocks ($\gamma_{g,t}$), there are no significant contemporaneous comovements in monetary policy and either spending ($\gamma_{g,i}$) or revenues ($\gamma_{t,i}$) anymore. Notice also the large increase in spending and revenue targets, taking into account that these are unadjusted for any changes in the inflation and output targets of each authority.

These findings are only slightly less robust to the estimation methodology. Table 27 reports the reaction coefficient estimates from FIML estimation. While the coefficients do not undergo major changes, the standard errors improve markedly and especially so over the second part of the sample (Fuhrer and Moore, 1995). We confirm the finding of a passive monetary policy, while it is less obvious that fiscal policy has followed a passive or active stance. Revenue and spending responses go in the opposite directions, but are not significantly different. In contrast, the debt stabilising responses of both spending and revenues are weakly significant since 1980 and both contribute to the stabilisation of public debt. Tax revenues are also countercyclical. For monetary policy, more clear-cut evidence for a tougher anti-inflationary stance is found. The Taylor Principle is fulfilled, and only minor attention is given to the output gap. Both fiscal and monetary policy display some strong small but significant comovements.

5. Conclusion

While there is substantial practical interest in the joint setting of fiscal and monetary policy, the predominant view in economic theory is still to analyse each policy in isolation. This can have dire consequences, especially as the generality of the Taylor principle by which active monetary policy alone is sufficient to stabilise the economy is increasingly being questioned. Fiscal policy may play a useful role in bringing about economic determinacy, and not only in crisis situations in which monetary policy is impotent in affecting economic activity. This view is most articulate in the Fiscal Theory of the Price Level: generally speaking, for determinacy and uniqueness of the equilibrium, it is necessary that at least one policy maker sets it control variable actively; while for fiscal solvency, at least one authority set its instrument passively (Leeper, 1991). When the government budget constraint is only a value equation, models of fiscal policy need be closed with a fiscal rule. The specification of this rule looks very much like the debt rule suggested by Bohn (1998) to test sustainability of public finances. The reassessment of the channels of interaction between fiscal and monetary policy has also put the focus on the policy mix in determining macroeconomic outcomes. Recent extensions marry the Ramsey type analysis of the optimal characterisation of policies to DSGE models that allow for a relevant stabilisation role for both fiscal and monetary policy. In these models, variations in interest rates and inflation directly affect the real debt burden; while tax rates in turn impinge on pricing decisions. If both policies are set according to rules, the next step is to jointly empirically analyse fiscal and monetary policy rules. This is the main contribution of this paper. In particular, following arguments in Benigno and Woodford (2003), we allow both policy makers too react to the output gap and inflation. For fiscal policy, we also add a debt stabilisation motive. Moreover, we allow each policy instrument to have an independent direct effect on the other policy maker's systematic policy decisions. This may be seen as a test of strategic policy interaction. We follow traditions in the monetary policy literature by estimating rules with gradual adjustment by GMM.

We then estimate the system of both policy rules by system GMM to characterise the policy tango of the US Treasury and the Federal Reserve since 1960. The estimation of the each policy rule in isolation confirms some of the classical findings in the literature. Fiscal policies are sustainable (Bohn, 1998); monetary policy has switched to a more activist policy against inflation since 1980 (Clarida et al., 2000). We find the importance of this shift in policy to be relatively minor, but instead find a more relevant change in fiscal policy. The attention to public debt is an unusual phenomenon that is limited to the period 1995-2001. If we condition our results on the more conventional shift in monetary policy that is associated with the Volcker-Greenspan period, the combination of fiscal and monetary policy is consistent with determinacy for each period. Taking policy interaction into account gives a deeper insight into and modifies these standard results. The entire US macroeconomic history is consistent with determinacy through a combination of passive fiscal and active monetary policies. Fiscal and monetary policy have clearly separated tasks. Fiscal policy stabilises output, while monetary policy in turn stabilises prices. This allocation of policies breaks down over subsamples: active fiscal policy and passive monetary policy ensure determinacy for the Burns-Miller period; the inverse combination of passive fiscal and active monetary policy holds in the Volcker-Greenspan era. This combination of policies is nevertheless only found when we have a more detailed model that contains a spending and tax rule, next to the Taylor rule. We believe that the change in the monetary regime should be reconsidered given the evidence for changes in fiscal policy. We find some evidence on breaks in policies of the consolidated government. We give accordingly an interpretation in terms of the ‘unpleasant fiscal arithmetic’. The debt consolidation of the late eighties and nineties is the consequence of a more active monetary policy stance that raises real interest rates while keeping inflation under control. The burden of real interest payments urges fiscal measures to contain the unsustainability of public finances. This is not inconsistent with our finding of strategic interaction between the Federal Reserve and the US Treasury. Fiscal actions follow the decisions by the monetary authority, but not vice versa, giving monetary policy some leading edge over macroeconomic policy.

This work is only a first step at characterising rules based policies for both fiscal and monetary policy makers. The direct translation of the theoretical work on monetary and fiscal policy rules needs further empirical validation. A stricter correspondence of theoretical to empirical concepts would help in validating the models of interaction. To cite just two fiscal examples. First, future deficits may matter more for monetary policy makers than current realised values, as these capture latent inflationary pressures. As in Celasun et al. (2004), budget forecasts may aid in tracking inflation developments. Second, the reaction of public debt to interest payments depends on the maturity and composition of public debt. Debt structure varies across countries, depending also on the monetary

regime in place. For that reason, a refinement of the debt measure would give more precise results on policy interaction.
We did not always find a robust ordering of either the GMM or FIML estimates of the system of rules, and this needs closer examination. Also, the estimates may suffer from a problem of weak instruments. The derivation of robust estimation techniques for non-linear systems may overturn some of the results, but this holds with respect to the current analysis of monetary policy too (Mavroeidis, 2004). Finally, the characterisation of the joint process of fiscal and monetary policy and the mutual consequences of switches in regimes need to be better understood. Our analysis is limited to finding combinations of policy regimes that need not correspond to truly ‘interactive’ policy shifts. In this respect, the question of Davig and Leeper (2005a) as to what causes policy changes is not limited to policy having a stochastic component. Changes in one policy regime might correlate with changes in the other policy maker’s regime. This may be an interesting way to proceed on the analysis of the interaction of fiscal and monetary policy.

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TABLES

Table 1. Data.

data series		*source*
government consumption		BEA, NIPA
government transfers (paid)		
government investment		
net interest payments		
government revenues		
government transfers (received)		
public debt		FRED II
GDP		BEA, NIPA
potential GDP		
output gap	%	
GDP deflator	%	
core CPI deflator	%	BLS
Federal Funds rate (end of period)	%	Federal Reserve
interest rate at 5 years	%	FRED II
interest rate at 10 years	%	
interest rate at 20 years	%	
exchange rate USD/DEM		IMF/IFS
exchange rate USD/YEN		
interest rate Germany	%	
interest rate Japan	%	
money stock M2		
commodity price index		CRB
unit labour cost		BLS
NAIRU	%	

data construction		*transformation*
primary surplus ratio	% of potential GDP	revenues – consumption – investment –
government spending	% of potential GDP	government consumption
government revenue	% of potential GDP	direct taxes + indirect taxes + transfers
output gap	% of potential GDP	BEA, NIPA
	% of potential GDP	HP filter[(a)]
	deviation from log mean	marginal cost based
	first difference	BEA, NIPA
inflation	% growth yoy	CPI deflator
	% growth yoy	GDP deflator
public debt	% of potential GDP	

Notes: (a) HP filter, smoothing parameter on quarterly data λ = 1600 (Ravn and Uhlig, 2002).

Table 2. Unit root tests.[(a)]

Test	level				first difference			
	ADF[(b)]		KPSS		ADF[(b)]		KPSS	
	μ	τ	μ	τ	μ	τ	μ	τ
primary surplus ratio	-2.29	-2.42	***2.13	**2.03	***-5.30	***-5.39	0.31	***0.22
expenditure ratio	-0.76	-2.54	***1.17	0.08	***-15.61	***-15.63	0.14	0.10
revenues ratio	-2.41	*-3.15	***0.75	*0.13	***-7.41	***-7.41	0.05	0.04
cyclically adjusted primary surplus ratio	-2.33	-2.32	0.19	**0.17	***-14.26	***-14.21	0.08	0.07
output gap HP	***-3.55	**-3.63	**0.54	***0.37	***-3.55	**-3.59	0.04	0.03
output gap NIPA	***-3.55	**-3.63	*0.35	***0.37	***-3.55	**-3.59	0.02	0.02
inflation (CPI)	-2.15	-2.70	**0.59	***0.37	-2.32	-2.42	0.12	0.04
inflation (GDP deflator)	-2.04	-2.44	***0.37	***0.31	***-4.15	***-4.40	0.12	0.04
interest rate	**-2.91	-2.88	**0.57	***0.57	***-3.89	***-4.13	0.19	0.03
public debt	-1.90	-2.42	**0.56	0.26	-2.58	-2.62	0.31	***0.22
net interest payments ratio	-1.03	0.92	***6.85	***2.03	-1.15	-1.56	**0.50	***0.36

Notes: (a) table entries are test statistics; */ **/ *** indicates the null hypothesis is rejected at 10, 5 and 1% significance level respectively; the optimal lag order is determined by the Bayesian Information Criterion (BIC), with a maximum of 16 lags; (b) μ for level stationarity, τ for trend stationarity.

Table 3. Fiscal policy rule, GMM, baseline estimate.

	ρ	β_0	β_y	β_π	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	$[\beta_\pi,\beta_b=0]$	$[\beta_i,\beta_b=0]$	$[\beta_y=.50]$
1960:1-2001:4	0.68	-4.81	0.43	-	0.14	-	0.68	0.47	1.39	0.87	0.00	0.00	-	-	-	-	0.65
	(.00)	(.00)	(.01)		(.00)		$[\sigma]$	$[\beta]$			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1995:3	1991:1		1995:4		1995:4	1995: 2			0.45	0.06	-	-			
		(.00)	(.00)		(.00)		(.99)	(.00)			(.00)	(.00)					
1960:1-1995:2	0.63	-2.97	0.51	-	0.08	-	0.67	0.68	1.50	0.77	0.00	0.00	-	-	-	-	0.94
	(.00)	(.30)	(.07)		(.44)						β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
											0.45	0.00	-	-			
											(.00)	(.85)					
1960:1-1979:4	0.53	1.39	0.54	-	-0.06	-	0.64	0.47	1.63	0.77	0.00	0.00	-	-	-	-	0.54
	(.00)	(.23)	(.00)		(.17)		$[\sigma]$	$[\beta]$			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1968:2	1968:2		1968:2		1976: 1	1968:4			0.46	0.05	-	-			
		(.00)	(.00)		(.00)		(.78)	(.00)			(.00)	(.00)					
1980:1-2001:4	0.93	-19.65	3.04	-	0.50	-	0.61	0.83	2.08	0.94	0.00	0.00	-	-	-	-	0.09
	(.00)	(.00)	(.04)		(.00)		$[\sigma]$	$[\beta]$			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1995:2	1996:2		1996:2		1997:4	1995:2			0.47	0.09	-	-			
		(.00)	(.01)		(.00)		(.99)	(.00)			(.00)	(.00)					

Notes: (a) estimation of policy rule; p-values in brackets; σ is standard error of estimate; J the p-value for J-test for overidentifying restrictions (Hansen, 1982); dw the Durbin Watson test statistic; $F_\cdot^1$ the F-test on the significance of the instrumental variables in the first-stage regression; [•] are p-values for the F-tests on coefficients; $\beta_\cdot^{OLS}$ are the OLS coefficients of a linear OLS regression of the policy rule (p-values in brackets); dates indicate the sup Andrews-Ploberger breakdate for the corresponding coefficient, $[\beta]$ is the breakdate for all coefficients, and $[\sigma]$ for the residual variance.

Table 4. Breakdate tests on fiscal policy rule.[(a)]

Rule	Initial break in coefficients		Break in residual variance		Corrected break in coefficients[(b)]	
baseline fiscal policy rule						
	***1995:4	[1993:3 , 1998:1]	1975:2	-	***1995:4	[1993:3 , 1998:1]
spending rule						
	***1991:4	[1991:2 , 1992:2]	***1975:2	[- ; -]	***1991:4	[1991:2 , 1992:2]
tax rule						
	***1992:1	[1991:3 , 1992:3]	***1987:4	[1987:1 , 1989:3]	***1992:1	[1991:3 , 1992:3]

Notes: (a) a ** denotes significance of the breakdate at 5%; (b) breakdate is the heteroskedasticity corrected sup Quandt-Andrews breakdate (Stock and Watson, 2003), years in brackets are the confidence interval at 33% (Bai, 1997); [-; -] indicates this interval exceeds the sample.

Table 5. Fiscal policy rule, FIML, baseline estimate.[(a)]

	ρ	β_0	β_y	β_γ	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_γ^1	F_i^1	β_y^{OLS}	$\beta_i,\beta_b \to 0$	$\beta_y \to$ [illegible]50
1960:1-2001:4	0.85	-4.14	1.04	-	0.11	-	0.38	-	1.94	0.88	-	-	-	-	0.00	-	0.00
	(.00)	(.01)	(.00)		(.02)												

Notes: (a) see notes to Table 3.

Table 6. Fiscal policy rule, GMM, various output gap definitions.[(a)]

	ρ	β_0	β_y	β_γ	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_γ^1	F_i^1	$\beta_\gamma,\beta_b \to$ [illegible]0	$\beta_i,\beta_b \to$ [illegible]0	$\beta_y \to$ [illegible]50
gap NIPA	0.65	-3.28	0.23	-	0.10	-	0.73	0.48	1.23	0.85	0.00	0.00	-	-	-	-	0.01
	(.00)	(.03)	(.03)		(.03)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_γ^{OLS}	β_i^{OLS}			
1960:1-2001:4		1995:1	1990:3	-	1995:1	-	1996:2	1995: 1			0.38	0.05	-	-			
		(.00)	(.00)		(.00)		(.99)	(.00)			(.00)	(.00)					
marginal cost gap	0.80	4.25	-1.73	-	-0.09	-	1.88	0.39	1.52	0.85	0.00	0.00	-	-	-	-	0.01
	(.00)	(.40)	(.06)		(.49)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_γ^{OLS}	β_i^{OLS}			
1960:1-2001:4		1995:4	1995:4	-	1995:4	-	1991:2	1995: 4			-0.08	0.05	-	-			
		(.00)	(.00)		(.00)		(.99)	(.00)			(.40)	(.00)					

Notes: (a) see notes to Table 3.

Table 7. Fiscal policy rule, GMM, non-linear debt.[(a)]

	ρ	β_0	β_y	β_π	β_b	β_b^2	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	$\beta_y, \beta_b = 0$	$\beta_i, \beta_b = 0$	$\beta_y = 0.50$
1960:1-2001:4	0.67	-2.89	0.36	-	0.00	-0.00	0.72	0.28	1.26	0.85	0.00	0.00	-	-	-	-	0.51
	(.00)	(.28)	(.10)		(.43)	(.60)	$[\sigma_\varepsilon]$	$[\beta]$			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_b^2 OLS			
		1995:2	1991:1	-	1995:2		1995:4	1995: 2			0.51	0.00	-	0.00			
		(.00)	(.00)		(.00)		(.99)	(.00)			(.00)	(.99)		(.45)			
1960:1-1979:4	0.93	-14.62	2.83	-	0.01	-0.00	0.62	0.83	2.07	0.94	0.00	0.00	-	-	-	-	0.13
	(.00)	(.12)	(.07)		(.92)	(.61)	$[\sigma_\varepsilon]$	$[\beta]$			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_b^2 OLS			
		1968:3	1968:2	-	1968:4		1976:1	1968:2			0.45	0.00	-	0.00			
		(.00)	(.00)		(.00)		(.74)	(.00)			(.00)	(.13)		(.30)			
1980:1-2001:4	0.42	-4.95	0.60	-	0.01	-0.00	0.64	0.55	1.49	0.77	0.00	0.00	-	-	-	-	0.21
	(.00)	(.06)	(.00)		(.05)	(.03)	$[\sigma_\varepsilon]$	$[\beta]$			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_b^2 OLS			
		1996:3	1990:3	-	1995:2		1998:1	1995:2			0.51	0.00	-	0.00			
		(.00)	(.04)		(.00)		(.99)	(.00)			(.00)	(.78)		(.78)			

Notes: (a) see notes to Table 3.

Table 8. Fiscal policy rule, GMM, cyclically adjusted primary net lending ratio.[(a)]

	ρ	β_0	β_y	β_π	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	$\beta_y, \beta_b = 0$	$\beta_i, \beta_b = 0$	$\beta_y = 0.50$
1960:1-2001:4	0.97	-11.51	0.25	-	0.36	-	0.06	0.54	1.05	0.99	0.00	0.00	-	-	-	-	0.29
	(.00)	(.00)	(.29)		(.00)						β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
											0.07	0.05	-	-			
											(.21)	(.00)					

Notes: (a) see notes to Table 3.

Table 9. Fiscal policy rule, GMM, inflation (GDP deflator).[(a)]

	ρ	β_0	β_y	β_π	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	$\beta_\pi, \beta_b = 0$	$\beta_i, \beta_b = 0$	$\beta_y = 0.50$
1960:1-2001:4	0.72	-1.32	0.48	-0.15	0.06	-	0.67	0.26	2.01	0.88	0.00	0.00	0.00	-	0.03	-	0.92
	(.00)	(.68)	(.01)	(.42)	(.40)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1995:2	1991:1	1995:4	1995:4	-	1995: 4	1995:1			0.50	0.04	-0.07	-			
		(.00)	(0.01	(.00)	(.00)		(.99)	(.00)			(.00)	(.02)	(.20)				
1960:1-1979:4	0.59	7.73	0.58	-0.29	-0.24	-	1.34	0.48	1.73	0.77	0.00	0.00	0.00	-	0.06	-	0.32
	(.00)	(.03)	(.00)	(.02)	(.03)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1968:2	1968:2	1968:2	1968:2	-	1976: 1	1968:2			0.46	0.06	0.03	-			
		(.00)	(.00)	(.00)	(.00)		(.80)	(.00)			(.00)	(.01)	(.54)				
1980:1-2001:4	0.93	-19.31	3.00	-0.02	0.49	-	0.62	0.83	2.05	0.94	0.00	0.00	0.00	-	0.00	-	0.38
	(.00)	(.47)	(.29)	(.99)	(.32)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1996:2	1991:1	1996:3	1996:3	-	1997: 4	1995:1			0.53	0.04	-0.29	-			
		(.00)	(.01)	(.00)	(.00)		(.99)	(.00)			(.00)	(.26)	(.05)				

Notes: (a) see notes to Table 3.

Table 10. Fiscal policy rule, GMM, strategic interaction.[(a)]

	ρ	β_0	β_y	β_η	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_η^1	F_i^1	$\beta_y, \beta_\eta = 0$	$\beta_i, \beta_b = 0$	$\beta_y = 50$
	0.76	2.10	-0.18	-	0.03	-0.42	1.88	0.41	1.55	0.85	0.00	0.00	-	0.00	-	0.01	0.02
interest rate	(.00)	(.44)	(.53)		(.67)	(.01)	$[\sigma]$	$[J]$			β_y^{OLS}	β_b^{OLS}	β_η^{OLS}	β_i^{OLS}			
1960:1-2001:4		1995:2	1991:1	-	1995:4	1995:2	1995:4	1995: 1			0.43	-	0.04	-0.10			
		(.00)	(.02)		(.00)	(.00)	(.99)	(.00)			(.00)		(.02)	(.02)			
	0.65	5.31	0.29	-	-0.15	-0.22	1.34	0.52	1.78	0.74	0.00	0.00	-	0.00	-	0.19	0.02
interest rate	(.00)	(.09)	(.00)		(.07)	(.14)	$[\sigma]$	$[J]$			β_y^{OLS}	β_b^{OLS}	β_η^{OLS}	β_i^{OLS}			
1960:1-1979:4		1968:2	1968:2	-	1968:2	1968:2	1976: 1	1968: 4			0.45	-	0.04	-0.03			
		(.00)	(.00)		(.00)	(.02)	(.71)	(.01)			(.00)		(.07)	(.68)			
	0.93	-8.28	2.93	-	0.33	-0.63	2.44	0.86	1.98	0.93	0.00	0.00	-	0.00	-	0.01	0.15
interest rate	(.00)	(.68)	(.08)		(.29)	(.58)	$[\sigma]$	$[J]$			β_y^{OLS}	β_b^{OLS}	β_η^{OLS}	β_i^{OLS}			
1980:1-2001:4		1995:2	1991:1	-	1996:3	1993:3	1999: 4	1993:2			0.45	-	0.07	-0.05			
		(.00)	(.01)		(.00)	(.00)	(.99)	(.00)			(.01)		(.18)	(.68)			
deviation	0.59	-3.77	0.39	-	0.10	0.00	0.82	0.33	1.83	0.81	0.00	0.00	-	0.07	-	0.03	0.40
interest rate	(.00)	(.00)	(.00)		(.01)	(.39)	$[\sigma]$	$[J]$			β_y^{OLS}	β_b^{OLS}	β_η^{OLS}	β_i^{OLS}			
1960:1-2001:4		1995:4	1991:1	-	1995:4	1982:3	1995:4	1995: 2			0.49	0.06	-	0.00			
		(.00)	(.00)		(.00)	(.00)	(.99)	(.00)			(.00)	(.00)		(.70)			
deviation	0.49	1.21	0.64	-	-0.07	0.00	0.81	0.58	1.57	0.63	0.00	0.00	-	0.74	-	0.41	0.20
interest rate	(.00)	(.43)	(.00)		(.26)	(.18)	$[\sigma]$	$[J]$			β_y^{OLS}	β_b^{OLS}	β_η^{OLS}	β_i^{OLS}			
1960:1-1979:4		1968:2	1968:2	-	1968:2	1967:2	1976:1	1968:4			0.46	0.05	-	0.00			
		(.00)	(.00)		(.00)	(.00)	(.99)	(.00)			(.00)	(.00)		(.22)			
deviation	0.93	-15.04	2.97	-	0.39	0.00	0.61	084	2.02	0.94	0.00	0.00	-	0.00	-	0.00	0.13
interest rate	(.00)	(.08)	(.07)		(.07)	(.44)	$[\sigma]$	$[J]$			β_y^{OLS}	β_b^{OLS}	β_η^{OLS}	β_i^{OLS}			
1980:1-2001:4		1995;2	1991:4	-	1996:2	1995:1	1997:4	1995: 2			0.43	0.08	-	-0.00			
		(.00)	(.01)		(.00)	(.00)	(.99)	(.00)			(.00)	(.00)		(.02)			

Notes: (a) see notes to Table 3.

Table 11. Fiscal policy rule, GMM, all variables.[(a)]

	ρ	β_0	β_y	β_π	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	$\beta_\pi,\beta_b=0$	$\beta_i,\beta_b=0$	$\beta_y=.50$
1960:1-2001:4	0.74	0.79	-0.27	0.04	0.13	-0.41	0.74	0.43	1.45	0.84	0.00	0.00	0.00	0.00	0.04	0.01	0.00
	(.00)	(.86)	(.34)	(.65)	(.60)	(.02)	[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1995:4	1991:1	1995:4	1995:4	1995:2	1995:4	1992:4			0.42	0.05	0.08	-0.12			
		(.00)	(.02)	(.00)	(.00)	(.00)	(.99)	(.00)			(.00)	(.02)	(.31)	(.01)			

Notes: (a) see notes to Table 3.

Table 12. Fiscal policy rule, GMM, total spending.[(a)]

	ρ	β_0	β_y	β_π	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	[illegible]	[illegible]	[illegible]
	0.94	24.31	0.02	-	-0.20	-	0.29	0.73	2.20	0.96	0.00	0.00	-	-	-	-	0.10
1960:1-2001:4	(.00)	(.00)	(.96)		(.00)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1992:4	1981:3	-	1992:4	-	1969:3	1992:4			0.03	-0.08	-	-			
		(.00)	(.19)		(.00)		(.06)	(.99)			(.69)	(.00)					
	0.80	8.46	-0.43	-	0.38	-	0.52	0.92	2.42		0.00	0.00	-	-	-	-	0.00
1960:1-1979:4	(.00)	(.00)	(.00)		(.00)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1970:3	1969:3	-	1972:2	-	1969:4	1972:2			-0.05	0.04	-	-			
		(.00)	(.00)		(.00)		(.56)	(.00)			(.39)	(.00)					
	0.91	29.14	0.88	-	-0.28	-	0.22	0.54	2.21	0.98	0.00	0.00	-	-	-	-	0.05
1980:1-2001:4	(.00)	(.00)	(.00)		(.00)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1993:3	1990:3	-	1993:2	-	1997:4	1993:2			0.14	-0.10	-	-			
		(.00)	(.10)		(.00)		(.99)	(.00)			(.11)	(.00)					
inflation	0.96	19.09	-0.03	0.19	-0.08	-	0.29	0.36	0.29	0.96	0.00	0.00	0.00	-	0.13	-	0.20
	(.00)	(.01)	(.94)	(.67)	(.56)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
1960:1-2001:4		1992:4	1981:3	1993:4	1992:4		1995:4	1988:1			-0.11	-0.18	-	-			
		(.00)	(.10)	(.00)	(.00)		(.34)	(.00)			(.00)	(.00)					
strategic interaction	0.97	11.84	1.29	-	-0.05	0.94	0.29	0.41	2.28	0.96	0.00	0.00	-	0.00	-	0.34	0.60
	(.00)	(.41)	(.40)		(.75)	(.45)	[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
1960:1-2001:4		1992:4	1969:3	-	1992:4	1992:4	1995:4	1992:4			-0.07	-0.10	-	-0.17			
		(.00)	(.47)		(.00)	(.00)	(.99)	(.00)			(.24)	(.00)		(.00)			

Notes: (a) see notes to Table 3.

Table 13. Fiscal policy rule, GMM, total revenues.[(a)]

	ρ	β_0	β_y	β_π	β_b	β_i	σ	J	dw	$\bar{R}^2$	F_y^1	F_b^1	F_π^1	F_i^1	$(\beta_\pi, \beta_b)=0$	$(\beta_i, \beta_b)=0$	$\beta_y=.50$
	0.87	12.37	1.54	-	0.15	-	0.63	0.28	1.88	0.86	0.00	0.00	-	-	-	-	0.07
1960:1-2001:4	(.00)	(.00)	(.01)		(.12)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1975:1	1991:2	-	1975:1	-	1970:2	1975:1			0.51	-0.02	-	-			
		(.00)	(.00)		(.00)		(.06)	(.00)			(.00)	(.17)					
	0.68	12.62	-0.00	-	0.21	-	0.77	0.81	1.47	0.77	0.00	0.00	-	-	-	-	0.00
1960:1-1979:4	(.00)	(.00)	(.98)		(.00)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
		1974:4	1977:1	-	1974:4		1968:2	1968:2			0.42	0.09	-	-			
		(.00)	(.01)		(.00)		(.99)	(.00)			(.00)	(.00)					
1980:1-2001:4		no convergence															
	0.84	29.70	1.13	-1.00	-0.20	-	0.61	0.29	1.97	0.86	0.00	0.00	0.00	0.08	0.03	-	0.08
inflation	(.00)	(.00)	(.00)	(.01)	(.08)		[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
1960:1-2001:4		1974:4	1975:1	1970:4	1975:1	-	1970:4	1974: 3			0.53	-0.07	-0.25	-			
		(.00)	(.00)	(.00)	(.00)		(.12)	(.00)			(.00)	(.00)	(.00)				
strategic	0.78	22.21	0.00	-	0.01	-0.63	0.66	0.68	1.81	0.84	0.00	0.00	-	0.00	0.00		0.01
interaction	(.00)	(.00)	(.98)		(.80)	(.00)	[illegible]	[illegible]			β_y^{OLS}	β_b^{OLS}	β_π^{OLS}	β_i^{OLS}			
1960:1-2001:4		1975:1	1991:4	-	1975:1	1970:4	1970:4	1975:1			0.36	-0.07	-	-0.25			
		(.00)	(.00)		(.00)	(.00)	(.45)	(.00)			(.00)	(.00)		(.00)			

Notes: (a) see notes to Table 3.

Table 14. Monetary policy rule, GMM, baseline estimate.[(a)]

	e	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	J	dw	R^2	$F^1_{[illegible]}$	F^1_y	F^1_i
1960:1-2001:4	0.85	4.21	2.73	0.47	-	1.03	0.53	1.75	0.89	0.00	0.00	-
	(.00)	(.00)	(.00)	(.00)		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
		1979:3	1983:4	1980:3	-	1986:1	1980:3		0.03	0.33	0.87	-
		(.00)	(.00)	(.00)		(.15)	(.73)			(.00)	(.00)	
1960:1-1979:4	0.87	2.86	2.18	0.82	-	0.76	0.71	1.73	0.88	0.00	0.00	-
	(.00)	(.12)	(.03)	(.01)		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
		1979:3	1983:4	1980:3	-	1969:1	1970:4		0.56	0.46	0.74	-
		(.00)	(.00)	(.00)		(.15)	(.73)			(.00)	(.00)	
1980:1-2001:4	0.84	2.00	1.38	2.13	-	0.85	0.36	1.63	0.92	0.00	0.00	-
	(.00)	(.16)	(.05)	(.00)		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
		1986:2	1983:4	1990:4	-	1994:2	1986:2		0.05	0.17	1.63	-
		(.00)	(.00)	(.00)		(.15)	(.73)			(.15)	(.00)	

Notes: (a) estimation of monetary policy rule; p-values for coefficients are in brackets; [illegible] is standard error of estimate; J is the p-value for J-test for overidentifying restrictions (Hansen, 1982); dw is the Durbin Watson test statistic; $F^1_{[illegible]}$ is the p-values for the F-test on the significance of the instrumental variables in the first-stage regression; [•] are p-values for F-tests on coefficients; [illegible]^{OLS} are the OLS coefficients of a linear OLS regression of the policy rule (p-values in brackets); dates indicate the breakdate and p-values for the corresponding coefficient, [illegible] is the Andrews-Ploberger breakdate for all coefficients, and [illegible] for the residual variance.

Table 15. Breakdate tests on baseline monetary policy rule.[(a)]

Rule	Initial break in coefficients[(b)]		Break in residual variance		Corrected break in coefficients	
	1980:4	-	***1994:4	[1994:2 , 1995:2]	***1980:4	[1980:2 , 1981:2]

Notes: (a) a ***/ **/ * denotes significance of the breakdate at 10/ 5/ 1 %; (b) breakdate is the heteroskedasticity corrected sup Quandt-Andrews breakdate (Stock and Watson, 2003), years in brackets are the confidence interval at 33% (Bai, 1997); [-; -] indicates this interval exceeds the sample.

Table 16. Monetary policy rule, GMM, baseline estimate, lag order: smoothing parameter $\rho = \rho_1 + \rho_2$.[(a)]

	ρ	β_0	β_y	β_π	β_s	σ	J	dw	R^2	F^1_π	F^1_y	F^1_i
1960:1-2001:4	0.86	5.04	2.35	0.30	-	1.08	0.55	2.05	0.89	0.00	0.00	-
	(.04)	(.00)	(.00)	(.28)		$[\sigma_\varepsilon]$	$[\varepsilon]$		$\beta_\pi = 1$	β_y^{OLS}	β_π^{OLS}	β_s^{OLS}
		1979:3	1983:4	1980:3	-	1986:4	1980:3		0.01	0.33	087	-
		(.00)	(.00)	(.00)		(.15)	(.73)			(.00)	(.00)	
1960:1-1979:4	0.78	3.05	0.84	0.61	-	0.80	0.87	2.21	0.87	0.00	0.00	-
	(.00)	(.00)	(.02)	(.00)		$[\sigma_\varepsilon]$	$[\varepsilon]$		$\beta_\pi = 1$	β_y^{OLS}	β_π^{OLS}	β_s^{OLS}
		1970:4	1973:2	1970:4	-	1969:1	1970:4		0.06	0.46	0.74	-
		(.00)	(.03)	(.02)		(.99)	(.00)			(.00)	(.00)	
1980:1-2001:4	0.84	2.00	1.38	2.13	-	0.85	0.36	1.63	0.92	0.00	0.00	-
	(.00)	(.16)	(.05)	(.00)		$[\sigma_\varepsilon]$	$[\varepsilon]$		$\beta_\pi = 1$	β_y^{OLS}	β_π^{OLS}	β_s^{OLS}
		1986:2	1983:4	1990:4	-	1994:2	1986:2		0.05	0.17	1.63	-
		(.00)	(.00)	(.00)		(.24)	(.00)			(.19)	(.00)	

Notes: (a) see notes to Table 14; the smoothing coefficient is the sum of the two lags and the corresponding p-value for joint significance.

Table 17. Monetary policy rule, GMM, output gap and inflation.[(a)]

	ρ	β_0	β_y	β_π	β_s	σ	J	dw	R^2	F^1_π	F^1_y	F^1_i	$\beta_\pi = 1$	β_y^{OLS}	β_π^{OLS}	β_s^{OLS}
CPI 60:1-79:4	0.87	4.94	2.40	0.42	-	0.76	0.60	1.76	0.88	0.00	0.00	-	0.04	0.46	0.68	-
	(.00)	(.01)	(.04)	(.14)										(.00)	(.00)	
CPI 80:1-01:4	0.68	0.53	0.45	1.98	-	0.81	0.59	1.40	0.93	0.00	0.00	-	0.00	-0.03	1.54	-
	(.00)	(.56)	(.28)	(.00)										(.77)	(.00)	
NIPA gap 60:1-79:4	0.95	-7.08	3.56	8.88	-	0.88	0.67	1.48	0.85	0.00	0.00	-	0.43	0.29	0.85	-
	(.00)	(.47)	(.37)	(.23)										(.00)	(.00)	
NIPA gap 80:1-01:4	0.81	1.83	-0.23	2.09	-	0.99	0.49	1.23	0.89	0.00	0.00	-	0.82	0.05	1.64	-
	(.00)	(.29)	(.70)	(.02)										(.57)	(.00)	

NIPA gap CPI 60:1-01:4	0.80	3.30	-0.14	0.78	-	1.24	0.40	2.42	0.85	0.00	0.00	-	0.36	-0.09	0.83	-
	(.00)	(.00)	(.77)	(.00)		[illegible]	[illegible]							(0.26	(.00)	
		1980:3	1977:2	1980:3	-	1984:4	1980:3									
		(.00)	(.00)	(.00)		(.19)	(.00)									
NIPA gap CPI 60:1-79:4	0.92	-2.18	8.36	1.65	-	0.87	0.63	2.01	0.85	0.00	0.00	-	0.44	0.22	0.71	-
	(.00)	(.58)	(.21)	(.05)										(.01)	(.00)	
NIPA gap CPI 80:1-01:4	0.53	0.61	0.07	1.95	-	0.88	0.62		0.91	0.00	0.00	-	0.00	-0.07	1.53	-
	(.00)	(.44)	(.64)	(.00)										(.43)	(.00)	
forward gap 60:1-79:4	0.97	0.50	8.40	1.76	-	0.83	0.66	1.68	0.86	0.00	0.00	-	0.74	2.06	0.64	-
	(.00)	(.94)	(.60)	(.49)										(.06)	(.01)	
forward gap 80:1-01:4	0.87	-0.87	3.00	3.18	-	0.80	0.34	1.69	0.93	0.00	0.00	-	0.05	0.13	1.63	-
	(.00)	(.79)	(.10)	(.00)										(.27)	(.00)	
differenced output gap 60:1-01:4	0.87	4.56	4.22	0.48	-	1.36	0.67	2.41	0.82	0.00	0.00	-	0.18	-0.76	0.75	-
	(.00)	(.00)	(.05)	(.23)										(.00)	(.00)	
differenced output gap 60:1-79:4	0.89	4.02	4.09	0.56	-	1.04	0.85	2.03	0.78	0.00	0.01	-	0.28	-0.72	0.66	-
	(.00)	(.21)	(.65)	(.16)										(.00)	(.00)	
differenced output gap 80:1-01:4	0.91	2.87	5.36	1.31	-	0.90	0.73	2.68	0.91	0.00	0.00	-	0.72	-0.01	1.62	-
	(.00)	(.10)	(.20)	(.14)										(.94)	(.00)	

Notes: (a) see notes to Table 14.

Table 18. Monetary policy rule, FIML. [(a)]

	ρ	β_0	β_y	β_π	σ	dw	$\bar{R}^2$	$\beta_\pi=1$
1960:1-2001:4	0.87	2.90	2.36	0.96	0.76	1.86	0.92	0.83
	(.00)	(.06)	(.00)	(.00)				
1960:1-1979:4	0.80	3.10	1.73	0.67	0.78	1.62	0.93	0.07
	(.00)	(.02)	(.00)	(.00)				
1980:1-2001:4	0.74	2.05	1.06	1.52	0.86	1.89	0.93	0.00
	(.00)	(.08)	(.01)	(.00)				

Notes: (a) see notes to Table 14.

Table 19. Monetary policy rule, GMM, strategic interaction. [(a)]

	ρ	β_0	β_y	β_π	β_s	σ	J	dw	$\bar{R}^2$	F^1_π	F^1_y	F^1_i	$\beta_\pi=1$	β_y^{OLS}	β_π^{OLS}	β_s^{OLS}
interest rate	0.88	7.28	1.64	-0.03	-1.20	1.30	0.34	2.14	0.83	0.00	0.00	0.00	0.03	-0.20	0.83	0.26
	(.00)	(.00)	(.24)	(.99)	(.14)	[illegible]	[illegible]							(.04)	(.00)	(.04)
1960:1-2001:4		1979:3	1977:2	1980:3	1981:3	1986:2	1980:3									
		(.00)	(.00)	(.00)	(.00)	(.12)	(.00)									
interest rate	0.73	2.04	0.32	0.77	0.33	0.81	0.71	2.17	0.87	0.00	0.00	0.00	0.06	0.09	0.79	0.77
1960:1-1979:4	(.00)	(.01)	(.11)	(.04)	(.47)									(.25)	(.00)	(.25)
interest rate	0.90	-3.61	-0.79	4.62	0.53	1.16	0.70	1.57	0.85	0.00	0.00	0.00	0.16	0.13	1.64	0.06
1980:1-2001:4	(.00)	(.53)	(.52)	(.08)	(.33)									(.32)	(.00)	(.45)
deviation interest rate	0.92	5.44	3.64	0.23	-0.00	1.08	0.65	2.10	0.89	0.00	0.00	-	0.13	0.15	0.88	0.00
1960:1-2001:4	(.05)	(.01)	(.13)	(.65)	(.62)									(.20)	(.00)	(.35)

Notes: (a) see notes to Table 14.

Table 20. System of fiscal and monetary policy rule, GMM, baseline estimate.[(a)]

	fiscal						*monetary*									
	ρ	β_0	β_y	β_b	R^2	dw	ρ	α_0	α_y	α_π	R^2	dw	*J*	$\sigma_{f,i}$	$\beta_y \to$ 50	α_π 1
1960:1-2001:4	0.64	-5.11	0.51	0.16	0.87	1.21	0.86	1.67	-0.06	1.28	0.87	1.74	0.79	0.22	0.93	0.52
	(.00)	(.00)	(.00)	(.00)	[illegible]	[illegible]	(.05)	(.47)	(.94)	(.00)	[illegible]	[illegible]		(.00)		
		1995:3	1991:1	1995:4	1995:2	1995:4		1980:3	1977:2	1980:3	1980:3	1980:4				
1960:1-1997:4	0.53	2.55	0.43	-0.10	0.75	1.44	0.95	-6.52	2.39	3.12	0.81	0.96	0.87	0.24	0.15	0.60
	(.00)	(.13)	(.00)	(.11)			(.00)	(.09)	(.00)	(.00)				(.00)		
1980:1-2001:4	0.77	-17.36	3.94	0.43	0.94	1.87	0.81	2.99	1.35	0.89	0.91	2.35	0.90	0.22	0.00	0.60
	(.00)	(.00)	(.00)	(.00)			(.00)	(.00)	(.00)	(.00)				(.00)		
FIML 1960:1-2001:4	0.86	-4.13	1.08	0.11	0.88	1.96	0.89	2.68	2.69	1.02	0.92	1.89	0.27	0.28		0.94
	(.00)	(.01)	(.00)	(.02)			(.00)	(.45)	(.00)	(.00)						

Notes: (a) see notes to Table 3 and 14; $\sigma_{f,i}$ indicates the contemporaneous correlation between fiscal and monetary shocks.

Table 21. System of fiscal and monetary policy rule, GMM, inflation.[(a)]

	fiscal							*monetary*									
	ρ	β_0	β_y	β_b	β_π	R^2	dw	ρ	α_0	α_y	α_π	R^2	dw	*J*	$\sigma_{f,i}$	$\beta_y \to$ 50	α_π 1
1960:1-2001:4	0.72	-1.42	0.54	0.67	-0.20	0.88	1.47	0.86	1.51	0.24	1.31	0.87	1.62	0.76	0.20	0.80	0.49
	(.00)	(.03)	(.00)	(.31)	(.23)			(.00)	(.52)	(.77)	(.00)				(.10)		
1960:1-1979:4	0.58	6.89	0.52	-0.21	-0.22	0.78	1.67	0.90	0.24	2.45	1.15	0.87	1.65	0.94	0.18	0.67	0.73
	(.00)	(.02)	(.00)	(.02)	(.04)			(.00)	(.89)	(.15)	(.01)				(.01)		
1984:1-2001:4	0.76	10.71	3.00	-0.01	-2.77	0.92	1.52	0.77	5.89	1.01	-0.13	0.53	1.21	0.92	0.22	0.01	0.00
	(.00)	(.00)	(.00)	(.72)	(.06)			(.00)	(.00)	(.10)	(.72)				(.50)		

Notes: (a) see notes to Table 3 and 14; $\sigma_{f,i}$ indicates the contemporaneous correlation between fiscal and monetary shocks.

Table 22. Stability tests: breakdate in VAR[X_t], 4 lags, 1960:1-2001:4. [(a)]

	QLR-test stat[(a)]	breakdate	confidence interval
homoskedastic	18.58 (0.03)	1989:1	[1986:1; 1992:1]
heteroskedastic	40.14 (0.00)	1989:1	[1987:1; 1992:1]

Notes: (a) the test statistic is the Quandt-Andrews LR version, with p-value in brackets. The breakdate is the heteroskedasticity corrected sup Quandt-Andrews breakdate (Stock and Watson, 2003). The years in brackets are the confidence interval at 33% (Bai, 1997); [-; -] indicates this interval exceeds the sample.

Table 23. System of fiscal and monetary rule, GMM, strategic interaction, 1960:1-2001:4.[(a)]

	fiscal							*monetary*										
	ρ	β_0	β_y	β_b	β_i	R^2	dw	ρ	α_0	α_y	α_π	α_s	R^2	dw	J	$\rho_{s,i}$	$\beta_y \to$ 50	α_π 1
instrument	0.72	1.35	-0.04	0.03	-0.38	0.86	1.41	0.87	2.15	1.06	1.00	8.97	0.88	1.75	0.81	0.45	0.01	0.98
	(.00)	(.53)	(.84)	(.50)	(.00)			(.00)	(.17)	(.28)	(.00)	(.43)				(.00)		
deviation from instrument	0.56	-2.83	0.41	0.09	0.00	0.82	0.85	0.52	2.07	-0.65	1.09	0.01	0.65	0.98	0.93	0.16	0.43	0.52
	(.10)	(.00)	(.00)	(.01)	(.38)			(.07)	(.01)	(.00)	(.00)	(.15)				(.50)		

Notes: (a) see notes to Table 3 and 14; $\rho_{s,i}$ indicates the contemporaneous correlation between fiscal and monetary shocks.

Table 24. System of government spending and monetary rule, GMM. [(a)]

	spending							*monetary*										
	ρ	ϕ_0	ϕ_y	ϕ_b		R^2	*dw*	ρ	ϕ_0	ϕ_y	ϕ_π	ϕ_s	R^2	*dw*	*J*	$\rho_{g,i}$	$\phi_y \to 50$	$\phi_y = 1$
1960:1-2001:4	0.98	31.50	-0.78	-0.41	-	0.96	2.31	0.82	4.19	0.76	0.64	-	0.89	1.96	0.86	-0.16	0.42	0.14
	(.00)	(.04)	(.62)	(.98)				(.00)	(.00)	(.24)	(.04)					(.10)		
1960:1-1979:4	0.89	6.18	-0.43	0.46	-	0.92	2.78	0.90	4.31	3.33	0.32	-	0.88	1.81	0.94	-0.11	0.00	0.14
	(.00)	(.06)	(.01)	(.00)				(.00)	(.12)	(.20)	(.49)					(.80)		
1984:1-2001:4	0.97	12.76	-0.83	0.07	-	0.98	2.10	0.79	4.62	-0.09	0.53	-	0.79	0.95	0.91	-0.06	0.27	0.00
	(.00)	(.02)	(.44)	(.63)				(.00)	(.04)	(.64)	(.04)					(.00)		
inflation	0.98	32.24	-2.53	-0.63	ϕ_π=1.09	0.97	2.38	0.84	3.78	0.86	0.75	-	0.89	1.76	0.79	-0.12	0.85	0.38
	(.00)	(.67)	(.87)	(.83)	(.89)			(.00)	(.00)	(.27)	(.01)					(.24)		
interaction	0.99	29.14	-0.82	-0.19	ϕ_i=-0.69	0.96	2.42	0.78	9.04	0.61	0.79	-0.32	0.89	1.90	0.76	-0.20	0.04	0.24
	(.00)	(.00)	(.21)	(.01)	(.12)			(.00)	(.25)	(.17)	(.00)	(.44)				(.02)		

Notes: (a) see notes to Table 3 and 14; $\rho_{g,i}$ indicates the contemporaneous correlation between fiscal and monetary shocks.

Table 25. System of tax and monetary rule, GMM. [(a)]

	tax							*monetary*										
	ρ	ϕ_0	ϕ_y	ϕ_b		R^2	*dw*	ρ	ϕ_0	ϕ_y	ϕ_π	ϕ_s	R^2	*dw*	*J*	$\rho_{g,i}$	$\phi_y \to 50$	$\phi_y = 1$
1960:1-2001:4	0.84	14.57	2.24	0.06	-	0.85	1.40	0.95	-0.79	6.48	1.25	-	0.90	1.95	0.69	0.20	0.02	0.86
	(.00)	(.00)	(.00)	(.44)				(.00)	(.94)	(.67)	(.39)					(.01)		
1960:1-1979:4	0.62	6.98	0.08	0.41	-	0.77	1.24	0.92	-5.50	-0.13	2.95	-	0.75	0.94	0.91	0.30	0.00	0.48
	(.00)	(.01)	(.51)	(.00)				(.00)	(.57)	(.71)	(.24)					(.00)		
1980:1-2001:4	0.67	20.50	1.71	-0.08	-	0.81	1.14	0.73	3.20	3.69	0.78	-	0.84	0.63	0.93	0.47	0.00	0.51
	(.00)	(.00)	(.00)	(.06)				(.00)	(.00)	(.00)	(.02)					(.00)		
inflation	0.86	32.16	0.86	-0.25	ϕ_π= -1.14	0.86	1.76	0.95	-1.64	1.49	1.79	-	0.88	1.78	0.93	0.25	0.24	0.51
	(.00)	(.00)	(.00)	(.04)	(.01)			(.00)	(.79)	(.62)	(.14)					(.09)		
interaction	0.98	29.14	-0.82	-0.19	ϕ_i= -0.69	0.97	2.42	0.78	9.04	0.61	0.79	-0.32	0.89	1.65	0.01	-0.21	0.04	0.24
	(.00)	(.00)	(.21)	(.01)	(.12)			(.00)	(.25)	(.17)	(.00)	(.44)				(.20)		

Notes: (a) see notes to Table 3 and 14; $\rho_{g,i}$ indicates the contemporaneous correlation between fiscal and monetary shocks.

Table 26. System of government spending, tax and monetary rule, GMM.[a]

	spending / tax						*monetary*									
	ρ	γ_0	γ_y	γ_b	$\bar{R}^2$	dw	ρ	β_0	β_y	β_π	$\bar{R}^2$	dw	J			$\beta_\pi=1$
1960:1-2001:4	0.96	22.49	0.44	-0.11	0.97	2.43	0.94	5.45	4.28	0.37	0.89	1.97	22.38	$\rho_{g,t}$	0.15 (.04)	0.93
	(.00)	(.15)	(.64)	(.84)			(.00)	(.90)	(.64)	(.96)				$\rho_{g,i}$	-0.21 (.14)	
	0.91	16.93	1.28	0.06	0.89	2.03								$\rho_{t,i}$	0.21 (.27)	
	(.00)	(.59)	(.04)	(.96)												
1960:1-1979:4	0.92	5.92	-0.31	0.47	0.95	2.87	0.72	1.63	1.54	0.85	0.88	1.61	1.07	$\rho_{g,t}$	0.10 (.06)	0.00
	(.00)	(.36)	(.16)	(.02)			(.00)	(.16)	(.01)	(.00)				$\rho_{g,i}$	-0.18 (.17)	
	0.64	10.28	0.49	0.32	0.87	1.68								$\rho_{t,i}$	0.19 (.30)	
	(.00)	(.00)	(.08)	(.00)												
1980:1-2001:4	0.97	26.33	0.90	-0.19	0.95	2.49	0.84	2.78	0.53	1.30	0.90	2.09	234. 28	$\rho_{g,t}$	0.07 (.02)	0.97
	(.01)	(.81)	(.91)	(.95)			(.21)	(.96)	(.92)	(.88)				$\rho_{g,i}$	-0.17 (.15)	
	0.81	14.01	0.73	0.11	0.90	2.20								$\rho_{t,i}$	0.30 (.21)	
	(.64)	(.79)	(.62)	(.94)												

Notes: (a) see notes to Table 3 and 14; $\rho_{g,t}$ indicates the contemporaneous correlation between spending and revenue shocks, $\rho_{g,i}$ between spending and monetary shocks and $\rho_{t,i}$ between revenue and monetary shocks.

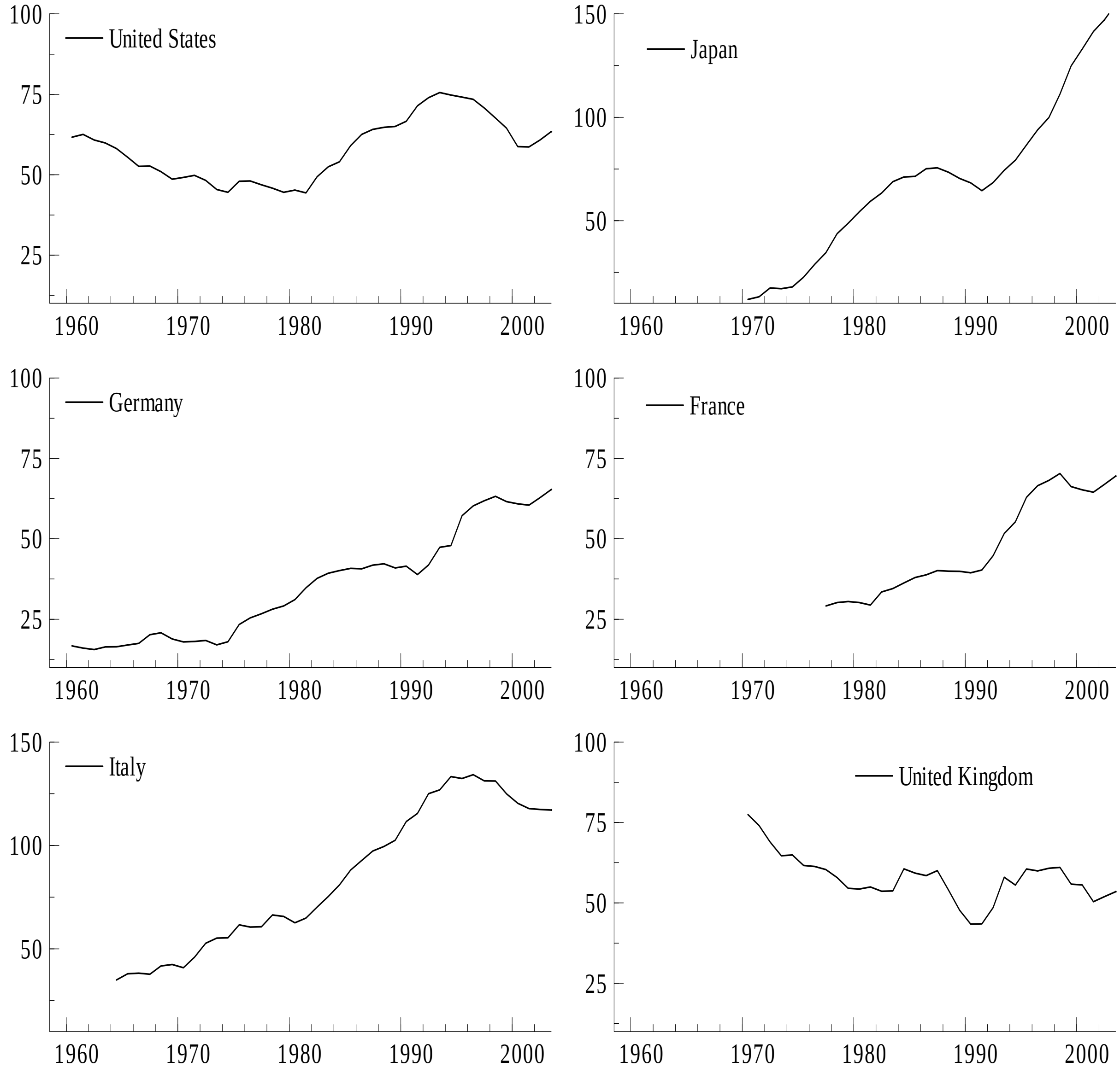
Table 27. System of government spending, tax and monetary rule, FIML. [(a)]

	spending / tax						*monetary*									
	ρ	β_0	β_y	β_b	$\bar{R}^2$	dw	ρ	α_0	α_y	α_π	$\bar{R}^2$	dw	J			$p_{\gamma=1}$
1960:1-2001:4	0.98	19.68	0.63	-0.03	0.97	2.32	0.89	2.68	2.84	1.02	0.92	1.90	0.01	$\rho_{g,t}$	0.13 (.13)	0.94
	(.00)	(.00)	(.43)	(.81)			(.00)	(.82)	(.00)	(.00)				$\rho_{g,i}$	-0.17 (.04)	
	0.90	16.12	1.54	0.07	0.90	1.57								$\rho_{t,i}$	0.21 (.07)	
	(.00)	(.00)	(.00)	(.28)												
1960:1-1979:4	0.93	13.38	0.16	0.12	0.93	2.34	0.80	3.00	1.74	0.69	0.93	1.62	0.02	$\rho_{g,t}$	0.14 (.15)	0.19
	(.00)	(.00)	(.66)	(.09)			(.00)	(.06)	(.02)	(.00)				$\rho_{g,i}$	-0.23 (.06)	
	0.77	14.92	0.84	0.15	0.86	1.83								$\rho_{t,i}$	0.12 (.10)	
	(.00)	(.00)	(.00)	(.01)												
1980:1-2001:4	0.95	24.61	0.66	-0.16	0.95	2.44	0.76	2.13	1.13	1.49	0.92	1.92	0.01	$\rho_{g,t}$	0.05 (.09)	0.03
	(.00)	(.00)	(.24)	(.09)			(.00)	(.13)	(.08)	(.00)				$\rho_{g,i}$	-0.14 (.03)	
	0.84	14.49	1.14	0.09	0.89	2.12								$\rho_{t,i}$	0.29 (.08)	
	(.00)	(.00)	(.00)	(.15)												

Notes: (a) see notes to Table 3 and 14; $\rho_{g,t}$ indicates the contemporaneous correlation between spending and revenue shocks, $\rho_{g,i}$ between spending and monetary shocks and $\rho_{t,i}$ between revenue and monetary shocks.

FIGURES

Figure 1. Public debt ratio to GDP (%).



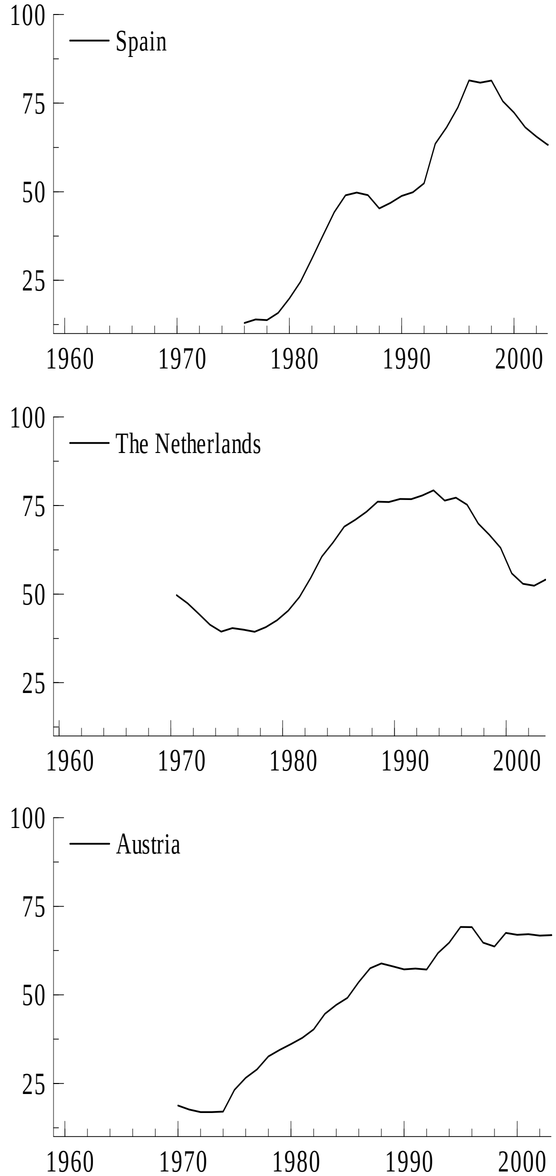

Spain
The Netherlands
Austria
100
75
50
25
1960
1970
1980
1990
2000

Figure 2a. Output gap and primary surplus ratio (% of potential GDP), United States.

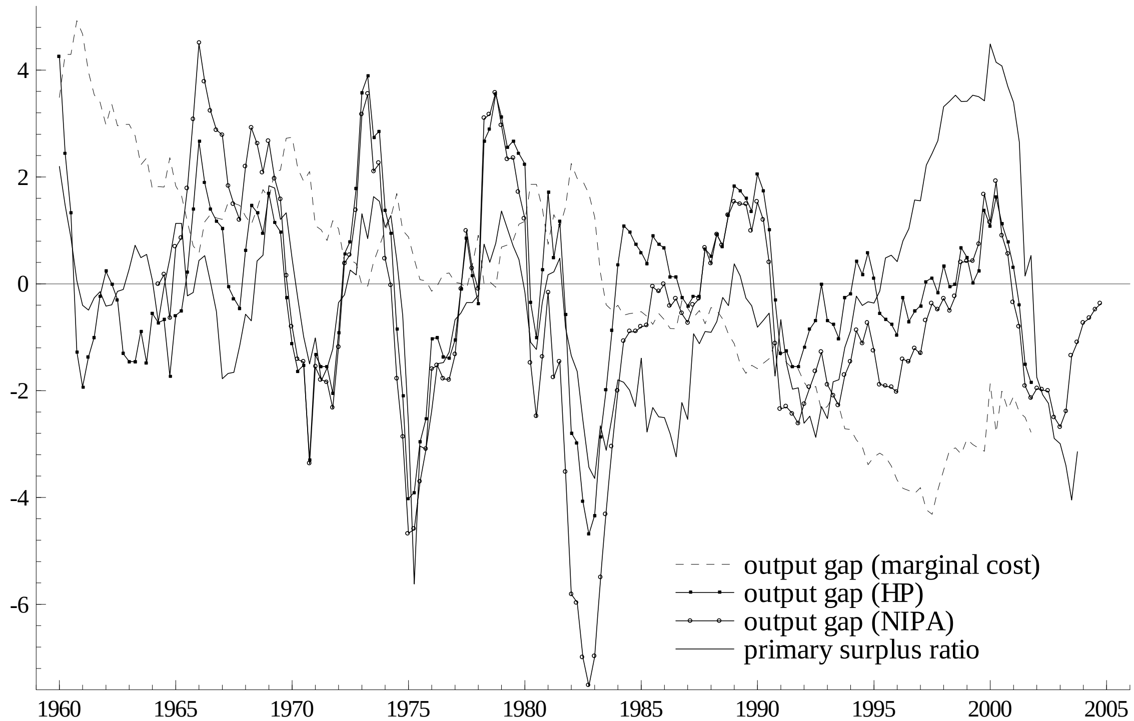


Figure 2b. Spending and revenue ratio (% of GDP), United States.

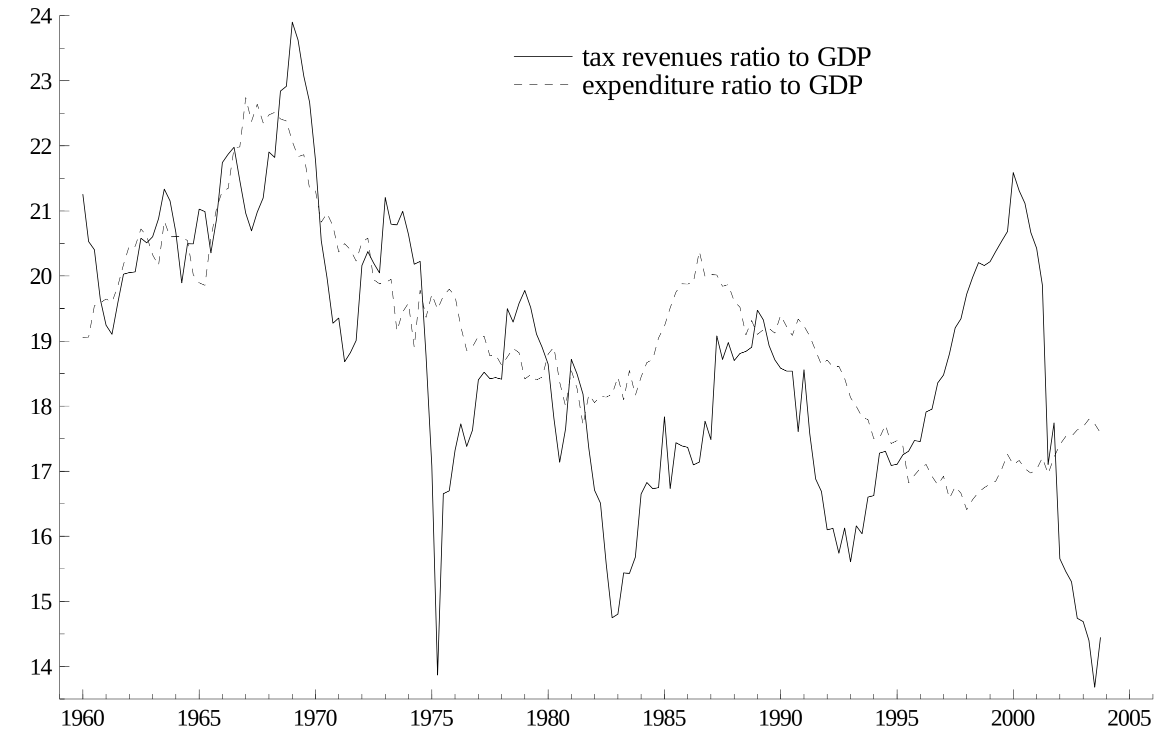


Figure 3. Federal Funds rate and inflation, United States.

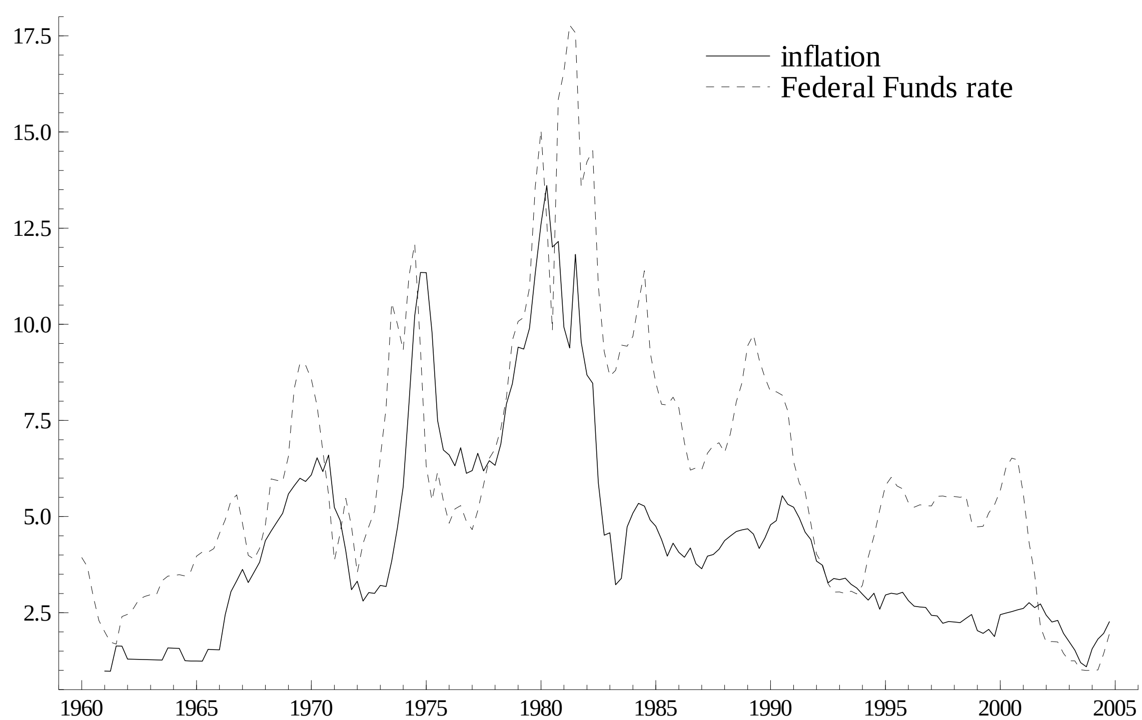
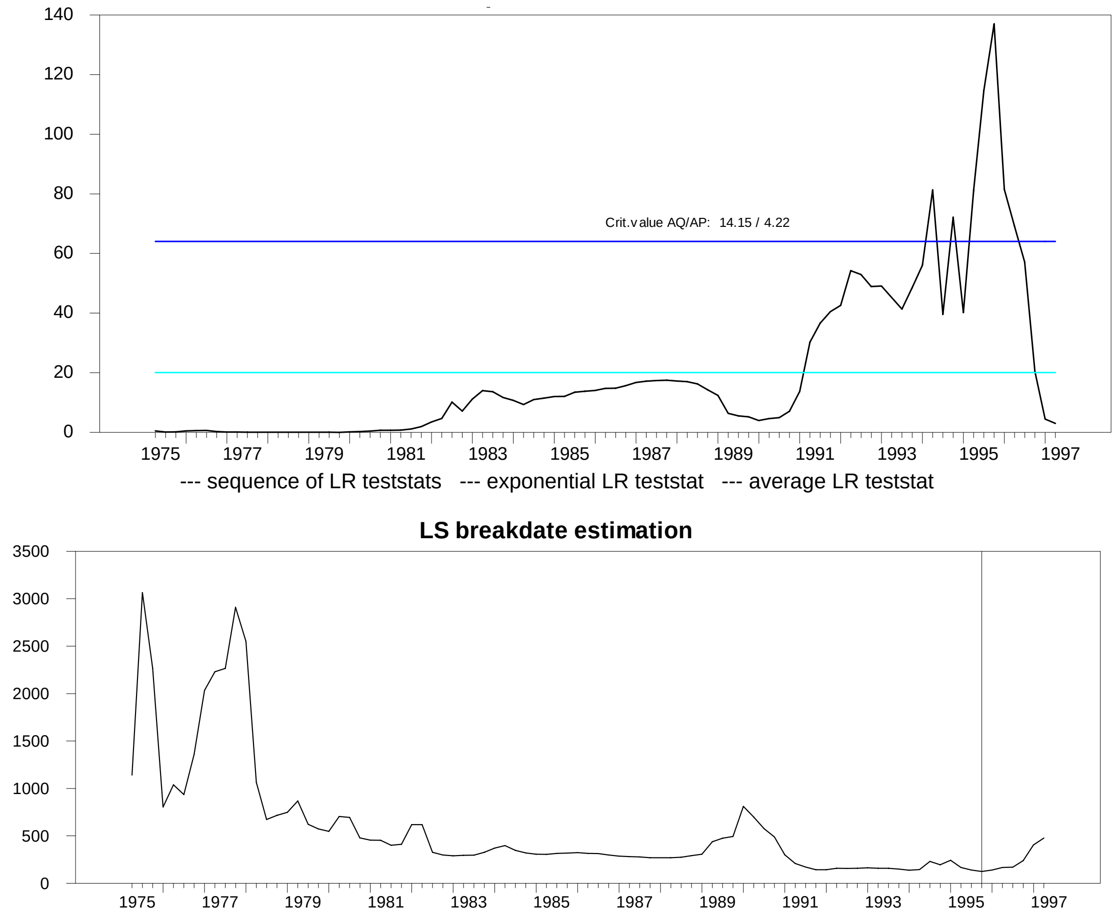


Figure 4. Recursive Quandt LR test-statistics, and least squares breakdate estimation.[(a)]



Notes: (a) critical values for exponential and average Andrews-Quandt test indicated in graph; the vertical grid line indicates the estimated break date.

Figure 5. Recursive regression of fiscal policy rule: coefficient and 95% confidence interval.

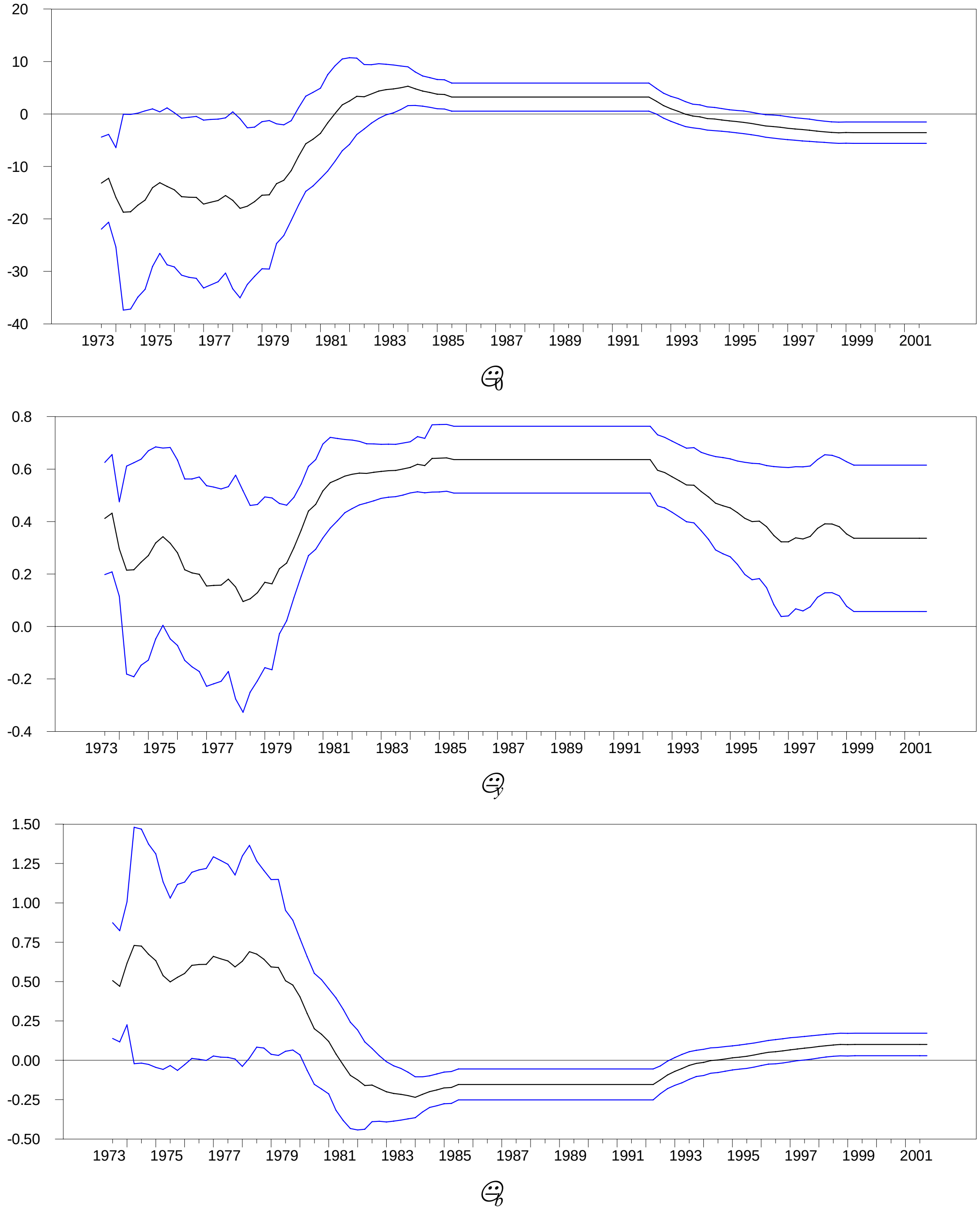


Figure 6. Fiscal policy rule: shocks (smoothed volatility with 20 quarters rolling window).

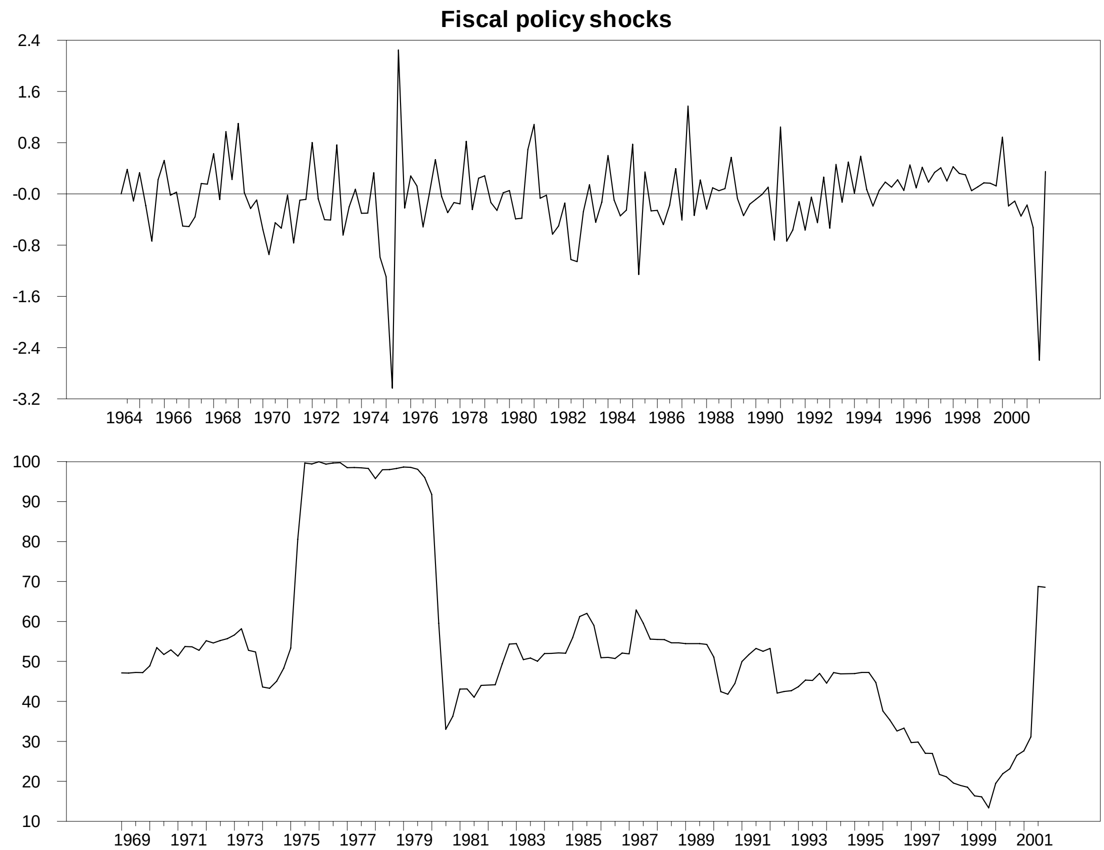
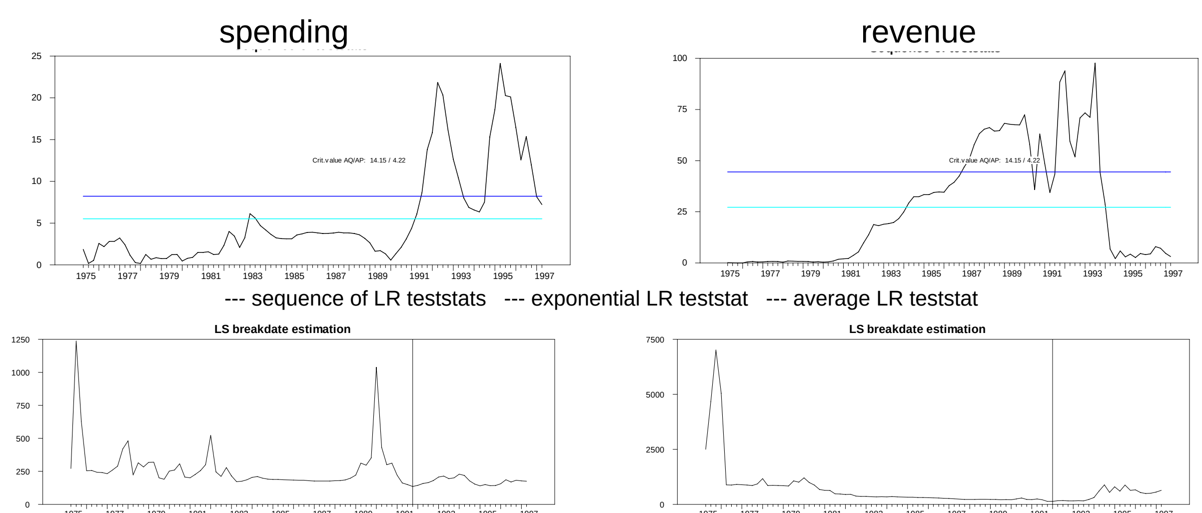


Figure 7. Recursive Quandt LR test-statistics.



Notes: (a) critical values for Andrews-Quandt test indicated in graph; vertical grid line indicates the breakdate.

Figure 8. Recursive regression of spending and revenue rule: coefficient and 95% confidence interval.

spending | revenue

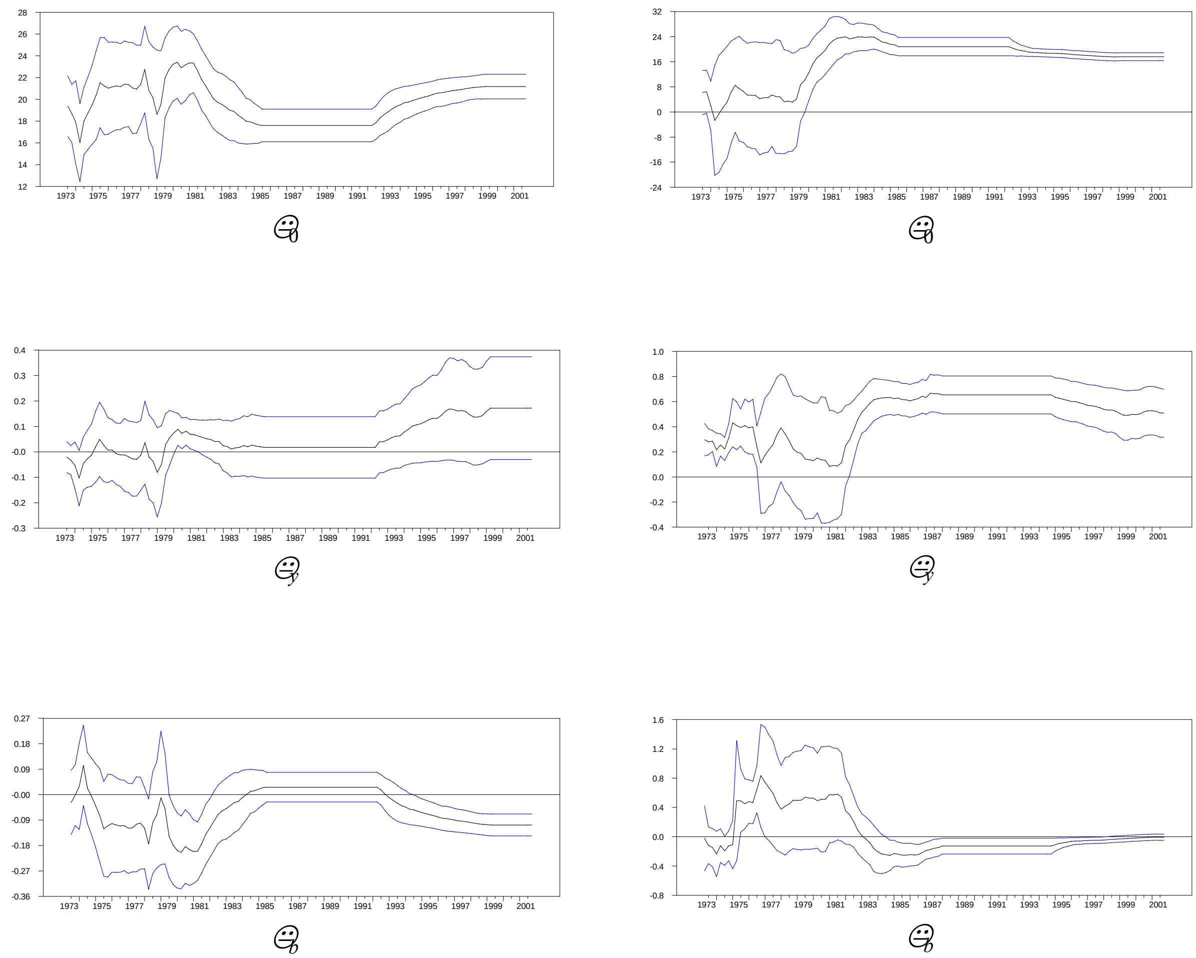


Figure 9. Fiscal spending and revenues rule: shocks, and smoothed volatility of shocks with 20 quarters rolling window.

spending ratio | revenue ratio

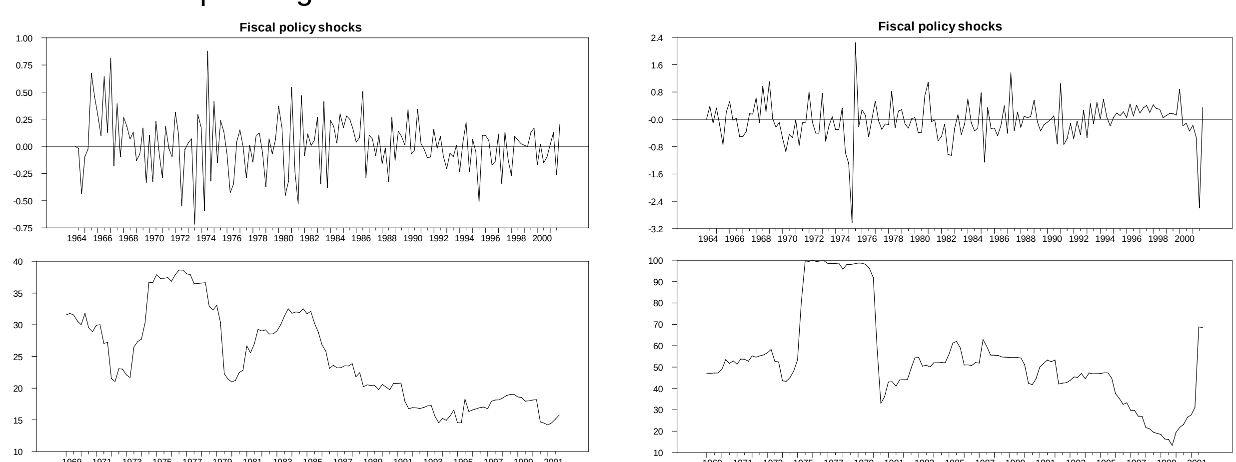
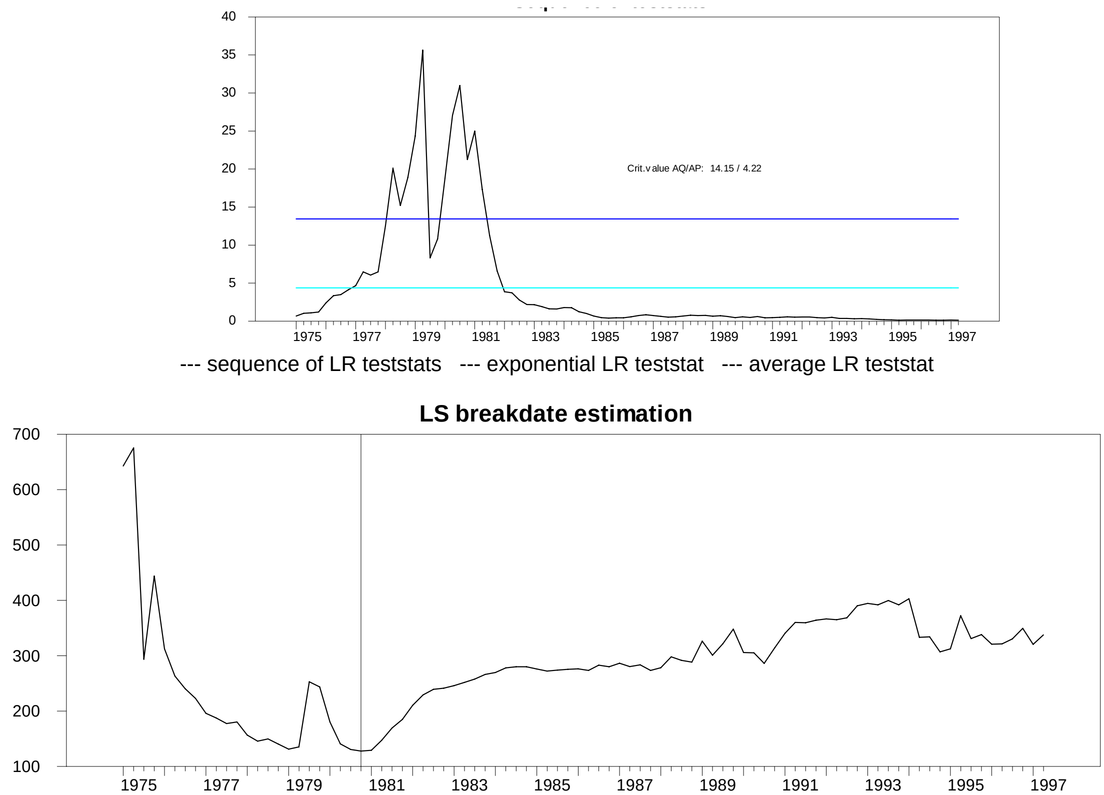


Figure 10. Recursive Quandt LR test-statistics.



Notes: (a) critical values for Andrews-Quandt test indicated in graph.

Figure 11. Monetary policy rule: shocks, and smoothed volatility of shocks (20 quarter rolling window).

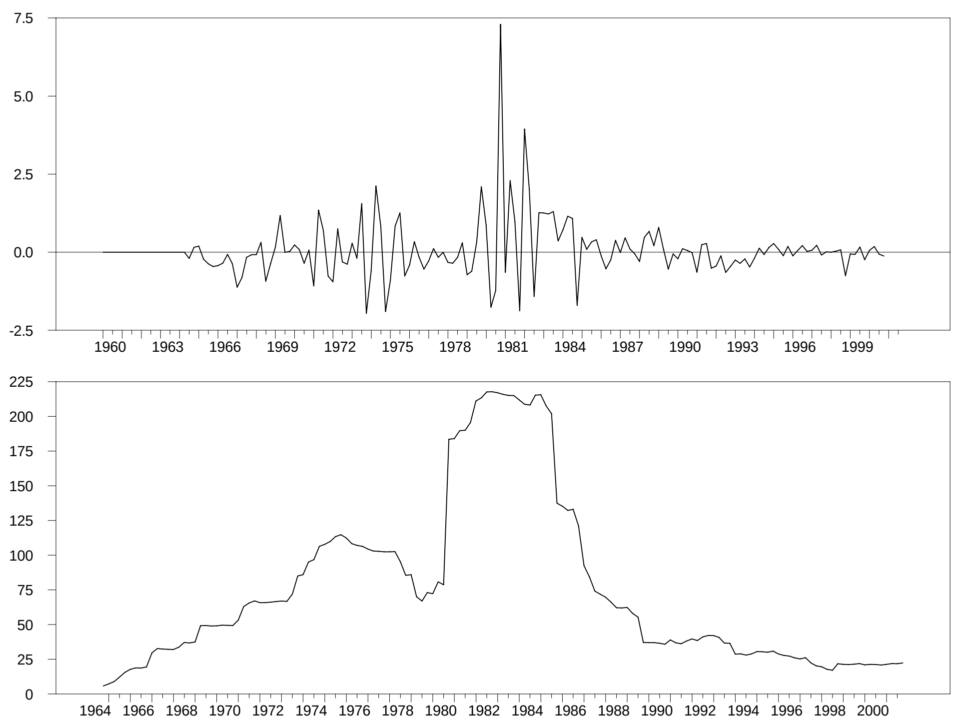


Figure 12. Recursive regression of monetary policy rule: coefficient and 95% confidence interval.

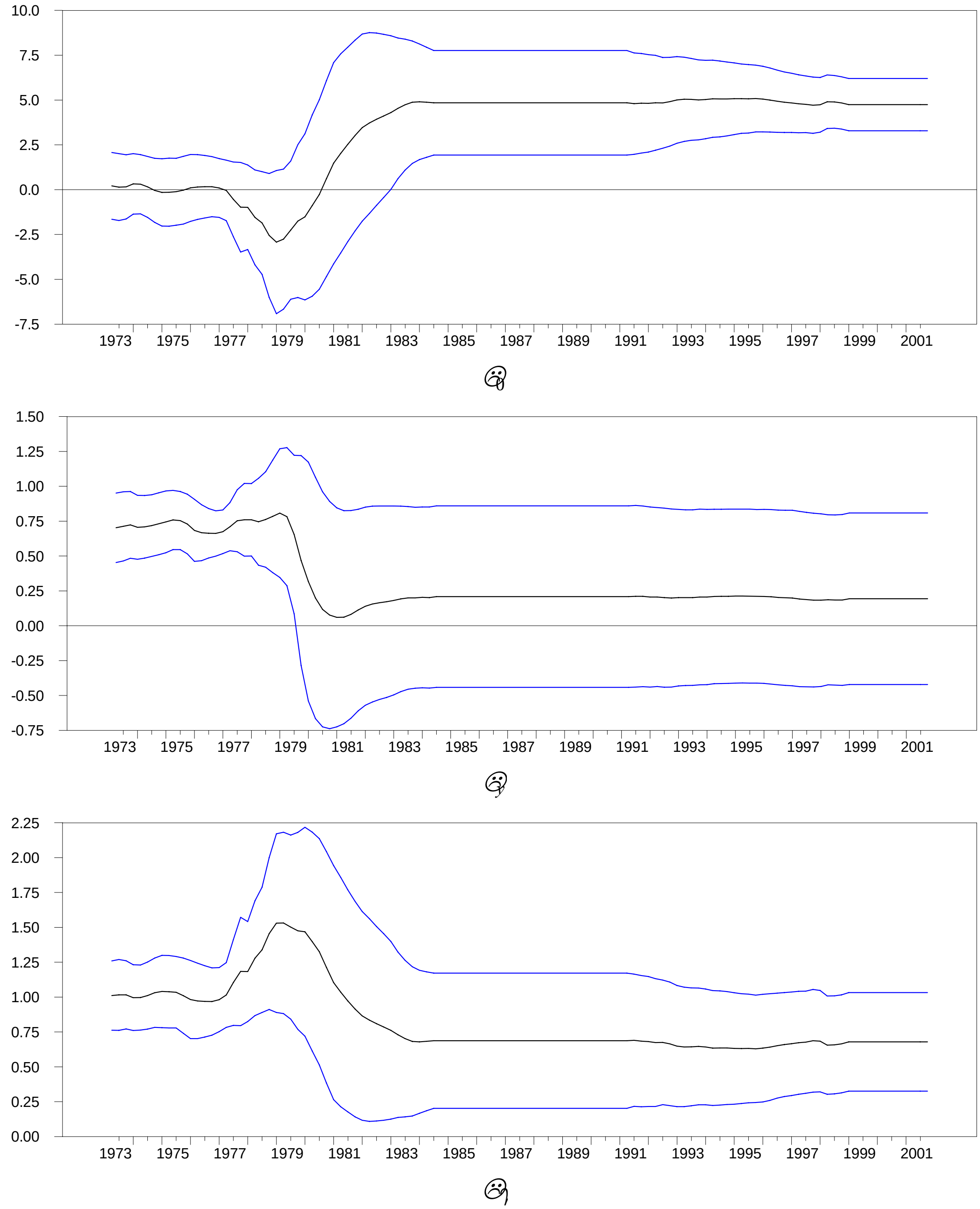
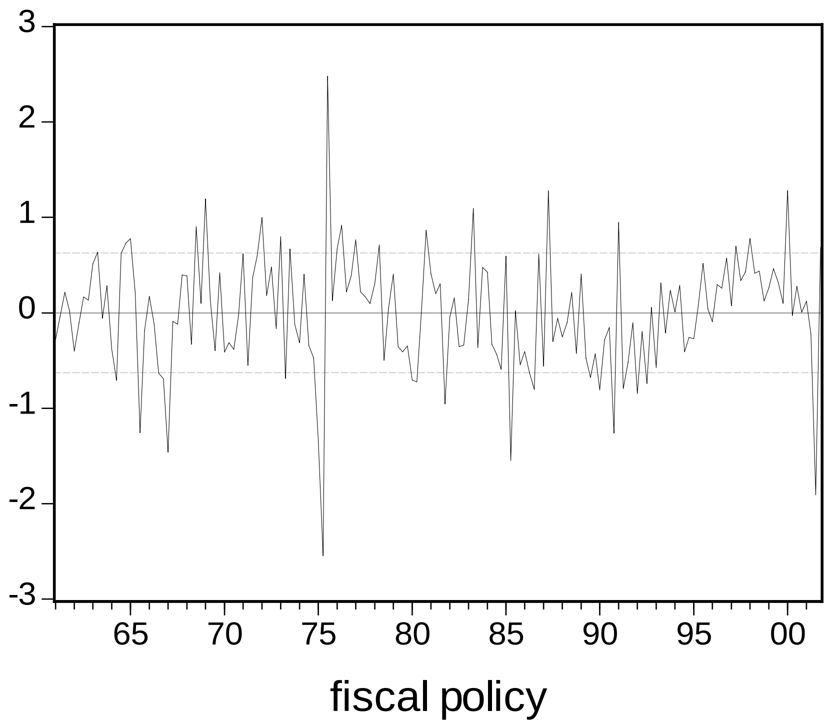


Figure 13. Fiscal and monetary policy shocks (primary surplus and Federal Funds rate).



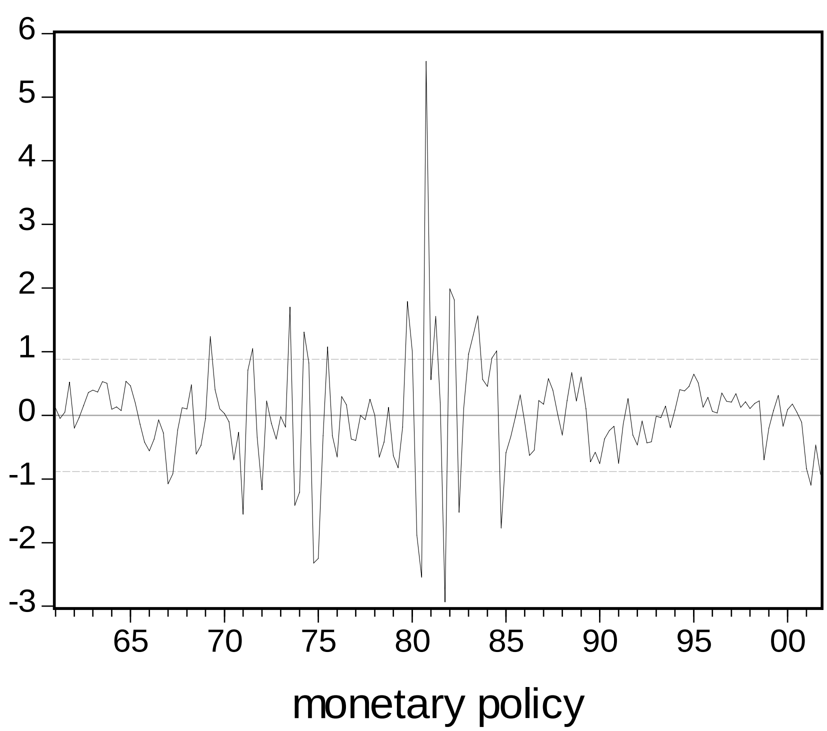


Figure 14. Fiscal and monetary policy shocks (primary spending, revenues and Federal Funds rate).