City University London

DEPARTMENT OF ECONOMICS

School of Social Sciences

Non-linear adjustments in fiscal policy

Gabriella Legrenzi*
University of Cambridge, UK

and

Costas Milas
City University, UK

Abstract

This paper provides evidence that the Italian public finances are sustainable, as the country meets its intertemporal budget constraint. Nevertheless, the burden of correcting budgetary disequilibria is entirely carried by changes in taxes, which can have some detrimental economic effects, rather than changes in government spending or policy mixes. Our non-linear analysis, in particular, shows that taxes adjust more rapidly when deviations from the equilibrium level get larger, and that they are downward inflexible not only with respect to their long-run level, but also during periods of decreasing economic growth. In order to correct the undesirable trend of high fiscal pressure and high public debt in Italy, structural expenditure reforms aiming at a higher degree of government expenditure adjustment are needed. This would also relax the asymmetries reported in the paper.

Keywords: general government expenditure, general government revenues, cointegration, persistence profile, asymmetries.
JEL classification: C32, C51, C52, H20, H50

*Address correspondence to: Dr Gabriella Legrenzi, Department of Land Economy, University of Cambridge, 19 Silver Street, Cambridge CB3 9EP, UK.
Tel: +44 (0) 1223 337147, Fax: +44 (0) 1223 337130 e-mail: GDL22@cam.ac.uk
We have benefited from the comments of Richard Ashley, Clive Granger, Therese McGuire, James Ramsey and Phil Rothman. Any remaining errors are our own.

1. Introduction

The most remarkable feature of Italian public finances is the simultaneous presence of high fiscal pressure and high public debt. The latter rose from around 41% of GDP in the late 1950s to around 124% of GDP in 1994, only to fall to 110% of GDP in 2000, representing the highest value among the EU countries. At the same time, fiscal pressure in Italy is higher than the OECD average; in particular, the taxes to GDP ratio is currently 43.3% for Italy, compared with an OECD average of 37.3% and a European average of 39.9%. Our paper, by proposing the adoption of non-linear error correction models in public finance analysis, provides an explanation of this feature within the revenue-expenditure models.

A detailed analysis of the relationship between the Italian public expenditures and revenues is important for economic policy purposes, as well as for the attainment to the Maastricht and the European Stability and Growth Pact (ESGP) criteria. Indeed, examining the relationship between general government expenditure and revenues can shed some light on the causes and the consequences of fiscal disequilibria.

In particular, we address four main relevant policy questions. First, are the Italian public finances meeting their intertemporal budget constraint? Second, is fiscal adjustment back to equilibrium equally shared by changes in revenues and government spending? Third, is there any evidence of asymmetric and/or non-linear fiscal adjustment back to equilibrium? Fourth, does fiscal adjustment vary with the state of the economy?

Unlike previous work on the revenue-expenditure models, we adopt a non-linear error correction specification, which allows us to test for possible asymmetries and inflexibilities in the use of fiscal instruments. Our proposed approach to the revenue-spending modeling provides a number of interesting findings. The Italian public

finances are sustainable, as there is a long-run relationship between the revenues and government spending shares of GDP. Nevertheless, expenditures will constantly grow at a higher rate than taxes. The burden of correcting budgetary disequilibria is entirely carried by changes in taxes rather than changes in government spending or policy mixes. This supports the spend-and-tax hypothesis, pointing to the need of expenditure reforms, given the distortionary effect of taxes. We also find that taxes adjust more rapidly when deviations from the equilibrium level get larger, as well as some weak evidence of downward inflexibility of taxes, when these are above their long-run level. Further, taxes increase rapidly during periods of accelerating economic growth, but are downward inflexible during periods of decreasing economic growth**.** The policy implication of our findings is that in order to correct the undesirable trend of high fiscal pressure and high public debt, necessary structural expenditure reforms will need to become a priority in the fiscal agenda of the Italian government. These structural reforms, aiming at a higher degree of government expenditure adjustment, would also relax the asymmetries reported in our paper.

The paper is organised as follows. Section 2 discusses the revenue-expenditure theories. Section 3 estimates the long-run model whereas Section 4 reports estimates of the linear, asymmetric and non-linear short-run models. Finally, Section 5 offers some concluding remarks and provides some policy implications of our findings.

2. Tax and spend or spend and tax?

Public finance theory provides three different models of the relationship between general government revenues and expenditure. In particular, according to the "spend-and-tax" hypothesis (SAT), the government raises the necessary finances to cover its expansionary spending (Peacock and Wiseman, 1979). In Friedman's

(1978) analysis, the government spends all the revenues that is politically able to raise, resulting in the "tax-and-spend" model (TAS). The simultaneous model (SIM), closer to the public finance tradition, prescribes instead that a benevolent government will simultaneously set its revenues and expenditures, to maximize a social welfare function (see, e.g. Musgrave 1985). The empirical identification of the correct revenue-expenditure pattern is relevant for policymakers in order to identify the correct strategies to target fiscal disequilibria. Under SAT, a spending restraint is required to reduce public deficits, whereas under TAS, higher taxes will result in raising rather than correcting fiscal deficits. Further, fiscal adjustments based on expenditures (i.e. the TAS model) can induce a more lasting consolidation of the budget and ultimately have an expansionary effect; on the other hand, adjustments based on taxes (i.e. the SAT model) are soon reversed by further deteriorations of the budget and have contractionary effects on the economy (see e.g. Alesina and Perotti 1996, Ardagna 2004).

The empirical testing of TAS versus SAT has been traditionally based on linear models. Restricting our attention to the most recent literature that uses cointegration techniques, Baghestani and McNown (1994) reject both the TAS and SAT hypotheses for the US. Using data for 9 industrialized countries, Koren and Stiassny (1998) find evidence in favor of the SAT hypothesis for Italy, whereas Cheng (1999) rejects the SAT hypothesis for eight Latin American countries.

Non-linear error correction models have not been applied so far in public finance, with the remarkable exception of Sarno (2001), who shows that the US debt to GDP ratio becomes increasingly mean reverting for larger deviations from its equilibrium levels. Based on non-linear error-correction, our work also differs from recent fiscal policy papers. For instance, Giavazzi et al (2000; see also the references cited therein) consider the non-linear response of national savings to

taxation and spending for a panel of OECD and developing economies based on impulse-response analysis.

Our application of non-linear error-correction techniques allows us to derive further policy implications from the revenue-expenditure models. This is done by testing for possible downward (or upward) inflexibility of the fiscal variables along with the possibility of non-linear fiscal adjustment. In particular, we examine whether fiscal authorities react differently to positive and negative deviations of the fiscal variables from the long-run equilibrium level. We also test for possible asymmetries of the fiscal instruments with respect to the state of the economy.

3. The long-run analysis

3.1. Data and empirical methodology

We empirically model the revenue-expenditures patterns of Italy, based on annual Italian data over the period 1957 to 2000. Our use of low frequency data allows us to capture the discretionary changes in budgetary policy, that would be ruled out by higher frequency data (see e.g. Blanchard and Perotti, 2002).

We initially test for cointegration between the GDP shares of government spending and revenues. We express our revenue-expenditure model as GDP shares, given that fiscal policy debates are made in terms of GDP ratios. This is important since all productive activities are the basis for revenues and the government sector is bounded by the size of the aggregate economy (Bohn, 1991). Given that both revenues and spending are highly dependent on aggregate income, our short-run models of Section 4 also allow for additional effects from nominal GDP.

Cointegration involves estimating the Vector Error Correction Model (VECM; see Johansen, 1988) of the form: $\Delta y_t = \Gamma_1 \Delta y_{t-1} + ... + \Gamma_{k-1} \Delta y_{t-k+1} + \alpha \beta' y_{t-1} + \mu + \varepsilon_t, t = 1,...,T$

where $y_t = \left[\frac{T}{GDP}, \frac{G}{GDP}\right]'$, T is the logarithm of nominal general government revenues, G is the logarithm of nominal general government expenditure, and GDP is the log of nominal gross domestic product. ε_t are white noise errors and μ is an intercept. The (p x r) matrix β contains the r cointegrating vectors. The (p x r) matrix α carries the adjustment coefficients in each of the r vectors. We set the lag length k equal to 2 based on the Akaike Information Criterion. The data set is taken from ISTAT, *Annuario Statistico Italiano* (various issues).

Figure 1 plots $\frac{T}{GDP}, \frac{G}{GDP}, \Delta\left(\frac{T}{GDP}\right)$, and $\Delta\left(\frac{G}{GDP}\right)$. Preliminary analysis using the ADF tests suggested that both the revenue and the expenditure series are non-stationary in log-levels. We test for cointegration between revenues and expenditures using Johansen's (1988) maximal eigenvalue (λ-*max*) and trace (λ-*trace*) statistics. To account for our small sample, both tests use a small sample correction (for exact mathematical formulas, see e.g. Doornik and Hendry, 2000, p.282). Both reject the null of no cointegration in favor of one cointegrating vector between revenues and expenditures[1].

We can now test some relevant policy questions, namely: (a) is the budget balanced in the long run? (b) is fiscal adjustment back to equilibrium equally shared by changes in revenues and government spending?, and (c) what is the speed of the process of fiscal consolidation?

Hypotheses (a) and (b) can be tested via a Likelihood Ratio (LR) test, which is distributed as a $\chi^2(1)$ under the null hypotheses of (i) proportionality between revenues

and expenditures and (ii) equal adjustment coefficients, respectively. Both hypotheses are rejected as the LR gives a value of 6.84 (*p*-value = 0.00) for the first one and 8.54 (*p*-value = 0.00) for the second one. In particular, given that the adjustment coefficient on $\frac{G}{GDP}$ is insignificantly different from zero at 1 percent (but not at 5 percent) as the LR test gives a value of 5.33 (*p*-value = 0.02), government share is weakly exogenous in our model. We discuss the implication of this further below. Imposing the above restriction and normalizing with respect to taxes yields the following long-run relationship between the Italian revenues and expenditures (standard error in brackets)[2]:

$\frac{T}{GDP}$ =	0.831 $\frac{G}{GDP}$ (0.067)

Figure 2 plots the deviations from the estimated (restricted) relationship.

3.2. Policy implications of the long-run analysis

What are the economic implications of the above statistical tests? The presence of cointegration points to a stable long-run co-movement of the revenues and expenditure shares of GDP, in the sense that revenues and expenditures do not deviate too much from each other. This is generally interpreted (see, e.g. Trehan and Walsh, 1988, Hakkio and Rush 1991, and Quintos, 1995) as evidence for the

[1] The λ-*max* and λ-*trace* statistics are equal to 15.5 and 19.4, respectively. These are higher than the corresponding 5 percent critical values (i.e. 15.0 and 18.1, respectively). The critical values are taken from MacKinnon et al. (1999).

[2] To check the robustness of the estimated long-run results, we also used the fully modified (semi-parametric) OLS method of Phillips and Hansen (1990) for estimation of a single cointegrating vector when there is endogeneity between the *T*/*GDP* and *G*/*GDP* variables. The Phillips and Hansen (1990) procedure provided almost identical results; in particular, the estimate on *G*/*GDP* was equal to 0.743 (standard error=0.047).

sustainability of fiscal policy, that is, for the ability of the Italian government to meet its intertemporal budget constraint (see e.g. Hamilton and Flavin, 1986). On the other hand, rejection of proportionality provides evidence against sustainability in a strict sense, as government spending will constantly grow at a higher rate than revenues. Therefore, our findings suggest a weak form of sustainability of the Italian public finances, meeting the Quintos (1995) sufficient condition. It should also be pointed out, that this cointegrating equilibrium does not provide evidence in favor of a fiscal discipline in the European Stability and Growth Pact sense; taxes will consistently be lower than expenditures, resulting in a positive long-run deficit. Fiscal consolidation will therefore need to be seriously tackled by the Italian government, in order to attain the ESGP.

Weak exogeneity of government spending implies that the short-run adjustment to correct budgetary disequilibria is done by changes in tax policy rather than changes in government spending or even policy mixes. Government spending is exogeneously decided by the political process, with taxes adjusting consequently. This result provides strong empirical support to the SAT model[3].

The speed of the fiscal consolidation process (question (c) above), can be inferred from the analysis of the impulse response of the cointegrating relationship to system-wide shocks (this is the "persistence profile analysis" in Pesaran and Shin, 1996). From Figure 3, this converges to zero rather slowly with 90 percent of the adjustment completed after 6 years. Deviations from the estimated cointegrating relationship are therefore eliminated very slowly, rendering the process of fiscal consolidation rather slow.

[3] Our result is in line with Koren and Stiassny (1998) for Italy, although they adopt a different empirical specification. Our results also empirically corroborate Alesina and Perotti's (1996) discussion of Italy's fiscal adjustment process.

Slow fiscal adjustment through changes in taxes rather than changes in government spending could be related to public expenditure rigidities, not only due to multi-annual contracts and planning, but also due to strong resistance against expenditure reductions arising both from the demand-side and bureaucratic powers (see OECD, 1997, and Legrenzi and Milas, 2002). The political instability of the country, typically associated with multi party coalition governments[4], renders problematic the achievement of the necessary consensus to politically unpopular spending cuts, favoring therefore the prevalence of the SAT adjustment, rather than a policy mix. The necessary reforms of the welfare state, and of the pensions system in particular, although debated for several years, are very slowly put into place, due to strong public opposition in the form of widespread general strikes (Reviglio, 2001).

Frequent general elections have also undermined the control of public spending for electoral purposes[5], at least until the early 1990s when more prudent policies were put in place in order to meet the Maastricht (1992) convergence criteria (see OECD, 1997). The low level of independence of the Italian Central Bank for most of the sample considered, also resulted in a soft-budget constraint for the central government, favoring expenditure growth (see Koren and Stiassny, 1998).

On the other hand, the SAT adjustment (and tax increases in particular) can be favored by the presence of fiscal illusion arising from the complexity of the Italian fiscal system, therefore resulting in several indirect taxes (see Puviani, 1903, and Wagner, 1976). However, this could undermine the progressivity of the fiscal system enshrined in the Italian Constitution.

[4] For a more detailed analysis of the link between coalition governments and lower fiscal responsibility, see Roubini and Sachs (1989), Grilli et al. (1991) and Alesina and Perotti (1995).

[5] It is interesting to notice that in the time span considered here, Italian political life saw 43 governments and 12 general elections.

Other rigidities that could explain the sluggish rate of convergence towards equilibrium include a plethora of (often) uncoordinated laws[6] that undermine the collection of taxes as well as an inadequate monitoring system of public spending; public management accountability is underdeveloped, therefore hampering the assessment of economic results. For public policies to deliver "value for money", these inefficiencies will need to be seriously tackled by strengthening budgetary institutions and procedures. A related issue (that nevertheless goes beyond the scope of this paper) relies on the effectiveness of large governments to improve on the social welfare of nations. Tanzi and Schuknecht (1997) discuss how pressures for higher spending come from vested interests rather than from the public interest.

A burden of fiscal consolidation entirely carried by taxes has a detrimental impact on the economy due to the distortionary and disincentive effect of taxes. Daveri and Tabellini (2000) identify tax increases on labour and profits as the main cause of declining economic growth and expansion of the shadow economy. This is certainly true for Italy where the black market economy accounted for 25.8% of official GDP in 1994, against 12.4% for the UK, 14.3% for France and 9.4% for the US (see Schneider and Enste, 2000)

Fiscal consolidation based on tax increases alone, can only be short-lived. This is discussed in Alesina and Ardagna (1998) who use a panel of OECD countries to show that spending cuts (primarily on public employment and transfers) can make the fiscal consolidation process successful. Further, Bertola and Drazen (1993) and Sutherland (1997) argue that contrary to the Keynesian wisdom, spending cuts can have an expansionary effect on the economy (via their positive impact on consumers'

[6] As the OECD (1997) study for Italy points out, the number of laws in the early 1990s was estimated at between 100,000 and 150,000 for Italy, compared to 7,000 in France and 6,000 in Germany.

and investors' expectations, and on the labour market). In particular, Ardagna (2004) provides strong empirical evidence on a panel of OECD countries for the "labour market hypothesis" of non-Keynesian effects of spending cuts, operating from the supply-side by lowering the unions' power via cuts in government employment, wage bills and unemployment benefits. These remarks are more than applicable to the high-debt Italian economy, especially in light of Perotti's (1999) OECD panel analysis showing strong evidence of "non-Keynesian" (i.e. expansionary) effects of expenditure shocks at high levels of public debt.

Given that changes in taxes equilibrate the system, the next section explores further the role of asymmetries only along the tax dimension. In particular, we impose weak exogeneity of government spending and examine whether positive versus negative and large versus small disequilibrium deviations have different effects on the short-run behavior of taxes. We also consider possible asymmetries of the tax instrument along the economic cycle.

4. The short-run model

4.1. Linear adjustment

We initially estimate the short-run adjustment of taxes within a linear error correction model, conditional on government spending which is assumed exogenous due to political and other reasons mentioned above. The OLS estimates of the parsimonious linear error-correction model are reported in Table 1(i).

The error-correction coefficient suggests that 14 percent of the disequilibrium error is corrected within a year by changes in taxes. Further, short-run increases in government expenditure have a positive effect on taxes. On the other hand, lagged

$\Delta\left(\frac{G}{GDP}\right)$ and $\Delta\left(\frac{T}{GDP}\right)$ regressors turn out to be insignificant. Overall, our short-run estimates provide further empirical support for the SAT model[7].

To account for the possibility of European Monetary Union effects, we also tried a dummy variable, taking the value of 1 from 1993 (when the Maastricht Treaty was agreed) onwards and 0 elsewhere. The dummy variable turned out to be statistically insignificant, implying that the adjustment of the Italian public finances did not take place through structural changes in the revenue-expenditure patterns. This result is particularly important, considered together with the positive long-run deficit, emphasizing the need for more structural reforms in the Italian public finances[8].

To capture the effects of economic and accelerating economic growth we also considered current and lagged values of ΔGDP and $\Delta^2 GDP$ as extra regressors. We found some significant effect from $\Delta^2 GDP_{t-1}$ only in the non-linear error correction model reported in the following section. This result has to do with the complexity of the relationship among revenues, expenditures, and income, that can only be partially captured by a multivariate econometric model. In particular, together with Keynesian multiplier and Wagner's law effects, a decreasing economic growth triggers the generous system of automatic stabilizers for the Italian welfare state. For this reason, we consider below possible asymmetries of tax policy with respect to the state of the economy.

[7] As our results suggest a feedback from $\Delta(G/GDP)$ to the $\Delta(T/GDP)$ model, we avoid reference to Granger causality running from spending on taxes. The latter would suggest a feedback from lags of $\Delta(G/GDP)$ rather than $\Delta(G/GDP)$ itself on taxes.

[8] Italy qualified to the European Monetary Union despite failing the debt criterion. Economic adjustment was mainly driven by changes in monetary policy. In 1997, a "European tax" was imposed on private households, as a one-off measure, and some "budgetary gimmicks" were used in order to qualify for the deficit criterion (see e.g. Reviglio, 2001).

4.2. Asymmetric and non-linear adjustment

We now examine how the fiscal authorities use tax policy in order to correct budgetary disequilibria by estimating asymmetric and non-linear error correction models. [9] [10]

The asymmetric error correction model is obtained by taking the deviations of the cointegrating vector CV_{t-1} around its mean value, and partitioning them into their positive and negative components (denoted by CV^{+}_{t-1} and CV^{-}_{t-1}, respectively). Results for the parsimonious asymmetric error-correction model are reported in Table 1(ii). The results indicate that the speed of adjustment varies depending on whether the estimated relationship is above or below its equilibrium. The point estimates suggest that when taxes are lower than equilibrium, they increase rapidly. On the other hand, when taxes are higher than equilibrium, they fall slowly. Nevertheless, equality of the coefficients on CV^{+}_{t-1} and CV^{-}_{t-1} is not rejected based on an F-test (*p*-value= 0.78). Hence, in economic terms our results point to downward inflexibility of taxes. Nevertheless, in terms of statistical tests, these results are not clear-cut.

To obtain the non-linear error correction model, we add to the linear model of Table 1(i) the squared and cubed values of the error-correction regressor, that is, CV^{2}_{t-1} and CV^{3}_{t-1}. This type of non-linearity allows for a faster adjustment when deviations from the equilibrium level get larger. Results for the parsimonious non-linear error correction are reported in Table 1(iii). The *p*-value of the F test for the statistical significance of the CV^{3}_{t-1} regressor is equal to 0.02, indicating (at the 5 percent level of statistical significance) that adjustment back to equilibrium is stronger for large disequilibrium

[9] Before estimating asymmetric and non-linear models, we tested and found significant non-linearities in the residuals of the linear error correction model using the Brock, Dechert and Sheinkman (BDS, 1996) test statistic. The test is also discussed in Escribano (2004).

[10] Asymmetric and non-linear error correction models have been introduced by Escribano (1986). See also Granger and Lee (1989), Escribano and Granger (1998), Escribano and Pfann (1998), Escribano and Aparicio (1999), Escribano (2002), and Escribano and Mira (2002), amongst others.

deviations. On the other hand, the *p*-value of the F test for the joint significance of the CV^2_{t-1} and CV^3_{t-1} regressors is equal to 0.06, which is significant only at the 10 percent level. We also report a weak positive effect on taxes from lagged accelerating economic growth, possibly capturing the built-in progressivity of the fiscal system. We return to this issue more in detail below.

Figure 4a and Figure 4b plot the asymmetric and non-linear adjustments against the cointegrating vector, respectively. Figure 4a provides evidence of asymmetric adjustment of taxes; deviations above equilibrium are corrected more slowly than deviations below equilibrium. On the other hand, we notice from Figure 4b that once disequilibrium deviations get larger, adjustment back to equilibrium becomes stronger.

To assess further the differences amongst the estimated models, we take a closer look at the contribution of the error correction terms to changes in the tax share of GDP. To do this, we plot in Figure 5 the values of the error correction components of the linear, asymmetric and non-linear equations across time. The linear and asymmetric error correction effects are fairly similar. This is not surprising given the weak evidence of asymmetric adjustment reported in Table 1(ii). On the other hand, the non-linear model error corrects strongly relative to the linear and asymmetric models. This is particularly true (i) during periods of "macroeconomic stress" associated with the oil price shocks of the mid and late 1970s when taxes adjusted downwards to provide some tax relief, and (ii) in 1997, when taxes adjusted upwards following the imposition of a one-off "European tax" bill in an attempt to help Italy satisfy the Maastricht fiscal criterion.

The presence of these asymmetries suggests the opportunity of analyzing further the behavior of taxes in different phases of the economic cycle. In particular, we investigate the possibility of asymmetric effects from accelerating and decreasing economic growth on taxes, given the weak positive effect from lagged accelerating

growth ($\Delta^2 GDP_{t-1}$) on taxes reported in Table 1(iii). For this purpose, we partition $\Delta^2 GDP_{t-1}$ into its positive and negative components (denoted by $\Delta^2 GDP^+_{t-1}$ and $\Delta^2 GDP^-_{t-1}$, respectively). Then we re-estimate the non-linear model of Table 1(iii) where we replace $\Delta^2 GDP_{t-1}$ with $\Delta^2 GDP^+_{t-1}$ and $\Delta^2 GDP^-_{t-1}$ as separate regressors. The coefficient on $\Delta^2 GDP^+_{t-1}$ is estimated at 0.403 (t-ratio = 1.20). The coefficient on $\Delta^2 GDP^-_{t-1}$ is estimated at 0.087 (t-ratio = 0.16) whereas the estimates of the remaining regressors are almost identical to those of Table 1(iii). GDP symmetry is not rejected based on an F-test (F=0.40, *p*-value = 0.52). On the other hand, the *joint* hypothesis of symmetric GDP effects and linear error correction adjustment (in terms of zero effects from CV^2_{t-1} and CV^3_{t-1}) is rejected at 10 percent (F=2.86, *p*-value= 0.07). Hence, there is some evidence of downward inflexibility of taxes during periods of decreasing economic growth as the coefficient on $\Delta^2 GDP^-_{t-1}$ is four times lower than the coefficient on $\Delta^2 GDP^+_{t-1,}$ which in turn is statistically insignificant. We believe that this result deserves more attention and possibly further analysis in the direction of planning an adequate strategy of tax-smoothing (although the latter is further constrained by the high level of public debt).

Figure 6 plots the time varying contribution of the linear and asymmetric GDP effects on taxes. Compared with linear GDP effects, asymmetries along the economic cycle reveal higher tax increases during “good times” due to the progressivity of the fiscal system, but lower tax reductions during “bad times”.

5. Conclusions

This paper provides an empirical analysis of the Italian public finances between 1957 and 2000. We find a long-run relationship between the government spending share of GDP and the revenues share of GDP resulting in a positive deficit. Short-run

adjustment to correct budgetary disequilibria is done entirely by changes in taxes, rather than spending cuts or policy mixes. This finding supports the spend-and-tax hypothesis. The persistence profile analysis suggests a sluggish rate of convergence towards equilibrium. This could be related to the existence of a complicated budgetary system that adds to the sluggishness in the collection of taxes and undermines the effective monitoring of public spending. We also find that taxes adjust more rapidly when deviations from the equilibrium level get larger. Further, there is some weak evidence of downward inflexibility of taxes during periods of decreasing economic growth and during periods where taxes are above their long-run level with government expenditure.

Taking into account that taxation carries the burden of correcting budgetary disequilibria, a simplified structure of the tax system, despite offsetting fiscal illusion effects, would increase the speed with which deviations from the estimated long-run spending - revenues relation are eliminated. Nevertheless, progress towards fiscal consolidation cannot rely solely on tax pressure due to possible distortionary effects arising from the downward inflexibility of taxes. This is also discussed in Alesina and Perotti (1995) who argue that successful fiscal adjustment in OECD countries results from spending cuts rather than tax increases. A higher degree of government expenditure adjustment would also relax the asymmetries reported in our paper.

Our work can be extended in several ways. Teräsvirta (1998) pointed out that non-linear models with quadratic and cubic error correction terms are first-order approximations to smooth transition autoregression models, where the transition mechanism between different regimes is driven by the disequilibrium error. In the context of our public finance model, it would be interesting to estimate a two-regime smooth transition model where adjustment takes place in every period but the speed of the adjustment as well as the impact of the lagged values of expenditure and taxes

vary conditional on whether disequilibrium deviations from the expenditure/taxes relationship are large or small.

It would also be interesting to examine whether non-linear adjustment can be elevated into a stylized fact, by considering tax and government spending adjustment in other countries, as well as at a local government level. If it can, then non-linearities in taxes and spending might be incorporated into existing non-linear models of fiscal policy (see e.g. Giavazzi et al., 2000). We intend to address these issues in future research.

References

Alesina, A. and S. Ardagna (1998). Fiscal adjustments. Why they can be expansionary. *Economic Policy*, 13, 489-545.

Alesina, A. and R. Perotti (1995). Fiscal expansions and adjustments in OECD countries. *Economic Policy*, 10, 207-248.

Alesina, A. and R. Perotti (1996). Fiscal Adjustments in OECD countries: composition and macroeconomic effects. *NBER Working Paper* 5730, August 1996.

Ardagna, S. (2004). Fiscal stabilizations: When do they work and why. *European Economic Review* (forthcoming).

Baghestani, H. and R. McNown (1994). Do revenues or expenditures respond to budgetary disequilibria?. *Southern Economic Journal*, 61, 311-322.

Bertola, G. and A. Drazen (1993). Trigger points and budget cuts: explaining the effects of fiscal austerity. *American Economic Review*, 83, 11-26.

Blanchard, O. and R. Perotti (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *Quarterly Journal of Economics*, 117, 1329-1368.

Bohn H. (1991). Budget balance through revenue or spending adjustments? Some historical evidence for the United States. *Journal of Monetary Economics,* 27, 333-359.

Brennan G. and J.M. Buchanan (1980). *The Power to Tax. Analytical Foundations of a Fiscal Constitution*. Liberty Fund, Indianapolis.

Brock, W.A., W. Dechert and J. Scheinkman (1996). A test for independence based on the correlation dimension. *Econometric Reviews*, 15, 197-235.

Cheng, B.S. (1999). Causality between taxes and expenditures: evidence from Latin American countries. *Journal of Economics and Finance*, 23, 184-192.

Daveri, F. and G. Tabellini (2000). Unemployment, growth and taxation in industrial countries. *Economic Policy*, 15, 48-104.

Doornik, J.A. and D.F. Hendry (2000). Modelling Dynamic Systems Using PcGive, Volume II, Timberlake Consultants Ltd.

Escribano, A. (1986). Identification and modelling of economic relationships in a growing economy. PhD thesis, University of California, San Diego.

Escribano, A. (2004). Non-linear error correction: the case of money demand in the U.K. (1878-2000). *Macroeconomic Dynamics*, 8, February issue.

Escribano, A. and F. Aparicio (1999). Cointegration: linearity, nonlinearity, outliers and structural breaks in Dahiya, S.B. (ed), *The Current State of Economic Science*, Spellbound Publications, Vol 1, 383-407.

Escribano, A. and C.W.J. Granger (1998). Investigating the relationship between gold and silver prices. *Journal of Forecasting*, 17, 81-107.

Escribano, A. and S. Mira (2002). Non-linear error correction models. *Journal of Time Series Analysis*, 23, 509-522.

Escribano, A. and G.A. Pfann (1998). Nonlinear error correction, asymmetric adjustment and cointegration. *Economic Modelling*, 15, 197-216.

Friedman, M. (1978). The limitations of tax limitation. *Policy Review* (Summer), 7-14.

Giavazzi, F., T. Jappelli and M. Pagano (2000). Searching for non-linear effects of fiscal policy: evidence from industrial and developing countries. *European Economic Review*, 44, 1259-1289.

Granger, C.W.J. and T.H. Lee (1989). Investigation of production, sales and inventory relationships using multicointegration and non-symmetric error correction models. *Journal of Applied Econometrics*, 4, S145-S159.

Grilli, V., D. Masciandaro and G. Tabellini (1991). Political and Monetary Institutions and Public Financial Policies in Industrial Countries, *Economic Policy*, 6, 342-92.

Hakkio, G. and M. Rush (1991). Is the budget deficit too large?. *Economic Inquiry*, 29, 429-445.

Hamilton, J. and M. Flavin (1986). On the limitations of government borrowing: a framework for empirical testing. *American Economic Review*, 76, 808-819.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12, 231-254.

Koren, S. and A. Stiassny (1998). Tax and spend, or spend and tax? An international study. *Journal of Policy Modeling*, 20, 163-191.

Legrenzi, G. and C. Milas (2002). A multivariate approach to the growth of governments. *Public Finance Review*, 30, 56-76.

MacKinnon, J.G., A.A. Haug and L. Michelis (1999). Numerical distribution functions of likelihood ratio tests for cointegration. *Journal of Applied Econometrics*, 14, 563-577.

Musgrave, R.A. (1985). A Brief History of Fiscal Doctrine, in Auerbach A.J. and Feldstein M (eds.) Handbook of Public Economics, North Holland.

OECD (1997, 2002). Economic surveys: Italy, Paris.

Peacock, A.T. and J. Wiseman (1979). Approaches to the analysis of government expenditures growth. *Public Finance Quarterly*, 7, 3-23.

Perotti R. (1999). Fiscal policy in good times and bad. *Quarterly Journal of Economics*, 114, 1399-1436.

Pesaran, M.H. and Y.S. Shin (1996). Cointegration and speed of convergence to equilibrium. *Journal of Econometrics*, 71, 117-143.

Phillips, P.C.B. and B.E. Hansen (1990). Statistical inference in instrumental variables regressions with I(1) processes. *Review of Economic Studies*, 57, 99-125.

Puviani, A. (1903). Teoria dell'illusione finanziaria, Sandron.

Quintos, C.E. (1995). Sustainability of the deficit process with structural shifts. *Journal of Business & Economic Statistics*, 13, 409-417.

Reviglio, F. (2001). Budgetary Transparency for Public expenditure Control. IMF Working Paper 01/8.

Roubini, N. and J. Sachs (1989). Political and economic determinants of budget deficits in the industrial democracies. *European Economic Review*, 33, 903-33.

Sarno, L. (2001). The behavior of US public debt: a nonlinear perspective. *Economics Letters*, 74, 119-125.

Schneider F. and D.H. Enste (2000). Shadow economies: size, causes and consequences. *Journal of Economic Literature*, 38, 77-114.

Sutherland, A. (1997). Fiscal crises and aggregate demand: can high public debt reverse the effects of fiscal policy?, *Journal of Public Economics*, 65, 147-162.

Tanzi V. and L. Schuknecht (1997). Reconsidering the fiscal role of government: the international perspective. *American Economic Review*, *Papers and Proceedings,* 87, 164-168.

Teräsvirta, T. (1998). Comment on "The demand for broad money in the United Kingdom, 1878-1993" by Ericsson, N.R., D.F. Hendry and K.M. Prestwich, *Scandinavian Journal of Economics*, 100, 325-328.

Trehan, B. and C. Walsh (1988). Common trends, the government budget constraint, and revenue smoothing. *Journal of Economic Dynamics and Control,* 12, 425-444.

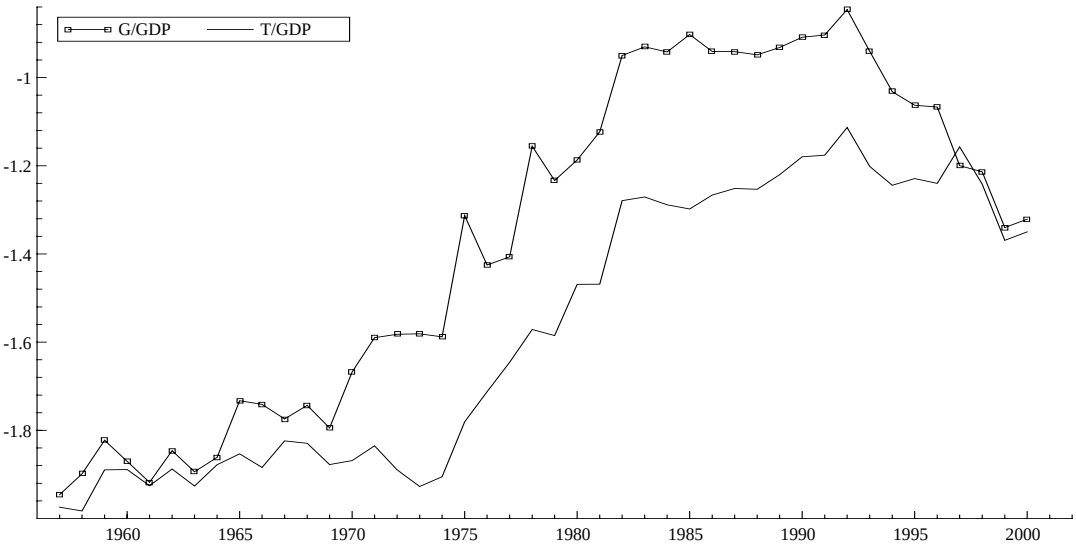
Wagner, R.E. (1976). Revenue structure, fiscal illusion, and budgetary choice. *Public Choice*, 25, 45-61.

Table 1: OLS estimates of alternative error correction models for $\Delta\left(\frac{T}{GDP}\right)$

	(i)	(ii)	(iii)
	Linear model	Asymmetric model	Non-linear model
Constant	0.008 (1.163)	0.004 (0.272)	0.012 (1.039)
$\Delta\left(\frac{G}{GDP}\right)_t$	0.390 (4.609)	0.393 (4.553)	0.450 (5.296)
CV_{t-1}	-0.137 (-2.533)	-	0.097 (0.880)
CV^2_{t-1}	-	-	-0.079 (-0.172)
CV^3_{t-1}	-	-	-7.287 (-2.412)
CV^+_{t-1}	-	-0.105 (-0.824)	-
CV^-_{t-1}	-	-0.172 (-1.230)	-
$\Delta^2 GDP_{t-1}$	-	-	0.234 (1.641)
Diagnostics			
Regression s.e.	0.047	0.047	0.044
$\overline{R^2}$	0.418	0.419	0.513
F*ar*	0.42 [0.66]	0.48 [0.61]	0.67 [0.51]
F*arch*	0.08 [0.76]	0.03 [0.86]	0.74 [0.39]
χ^2*nd*	4.58 [0.10]	1.11 [0.37]	5.47 [0.06]
F test of equal CV^+_{t-1} and CV^-_{t-1} effects	-	0.07 [0.78]	-
F test of zero effect from CV^3_{t-1}	-	-	5.85 [0.02]
F test of zero effects from CV^2_{t-1} and CV^3_{t-1}	-	-	3.03 [0.06]

Notes: T-ratios in parentheses. F*ar* is the Lagrange Multiplier F-test for 2nd order serial correlation. F*arch* is the 1st order ARCH F-test. χ^2*nd* is a Chi-square test for normality. Numbers in square brackets are the *p*-values of the tests. $\overline{R^2}$ is the adjusted coefficient of determination. CV = *T* / *GDP* – 0.831 *G* / *GDP*, in mean corrected form.

Figure 1: Plots of the log-levels and the first differences of the series



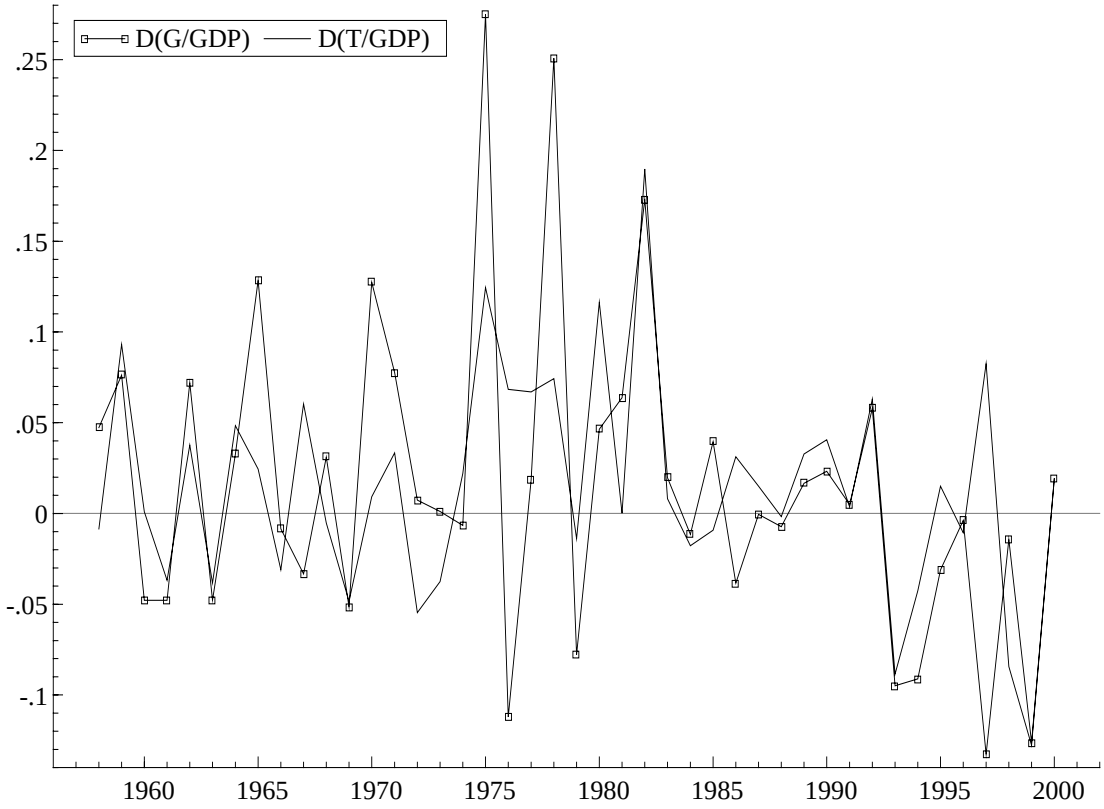


Figure 2: Long-run relationship: CV = *T* / *GDP* – 0.831 *G* / *GDP*

Figure 3: Persistence profile of the cointegrating vector to system-wide shocks

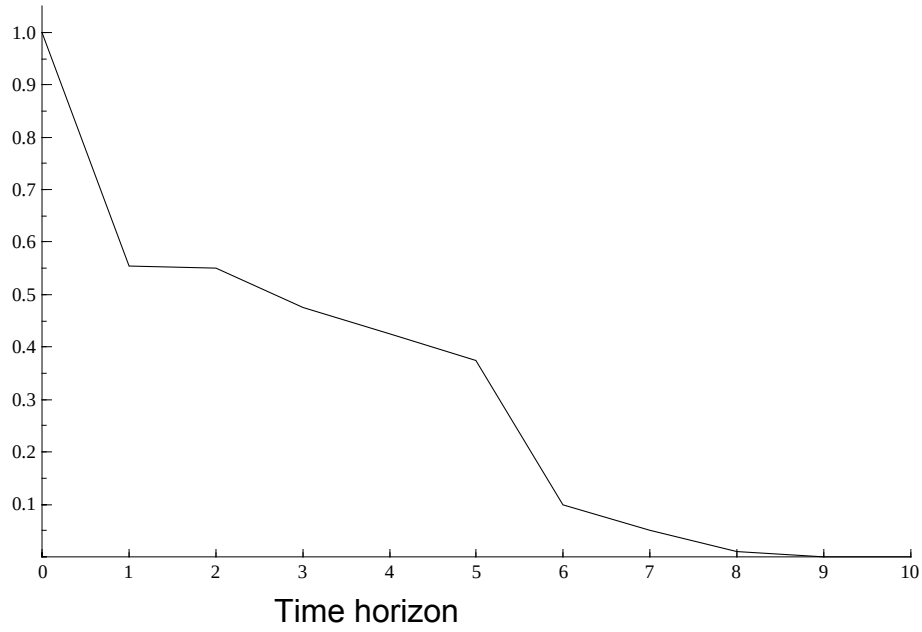
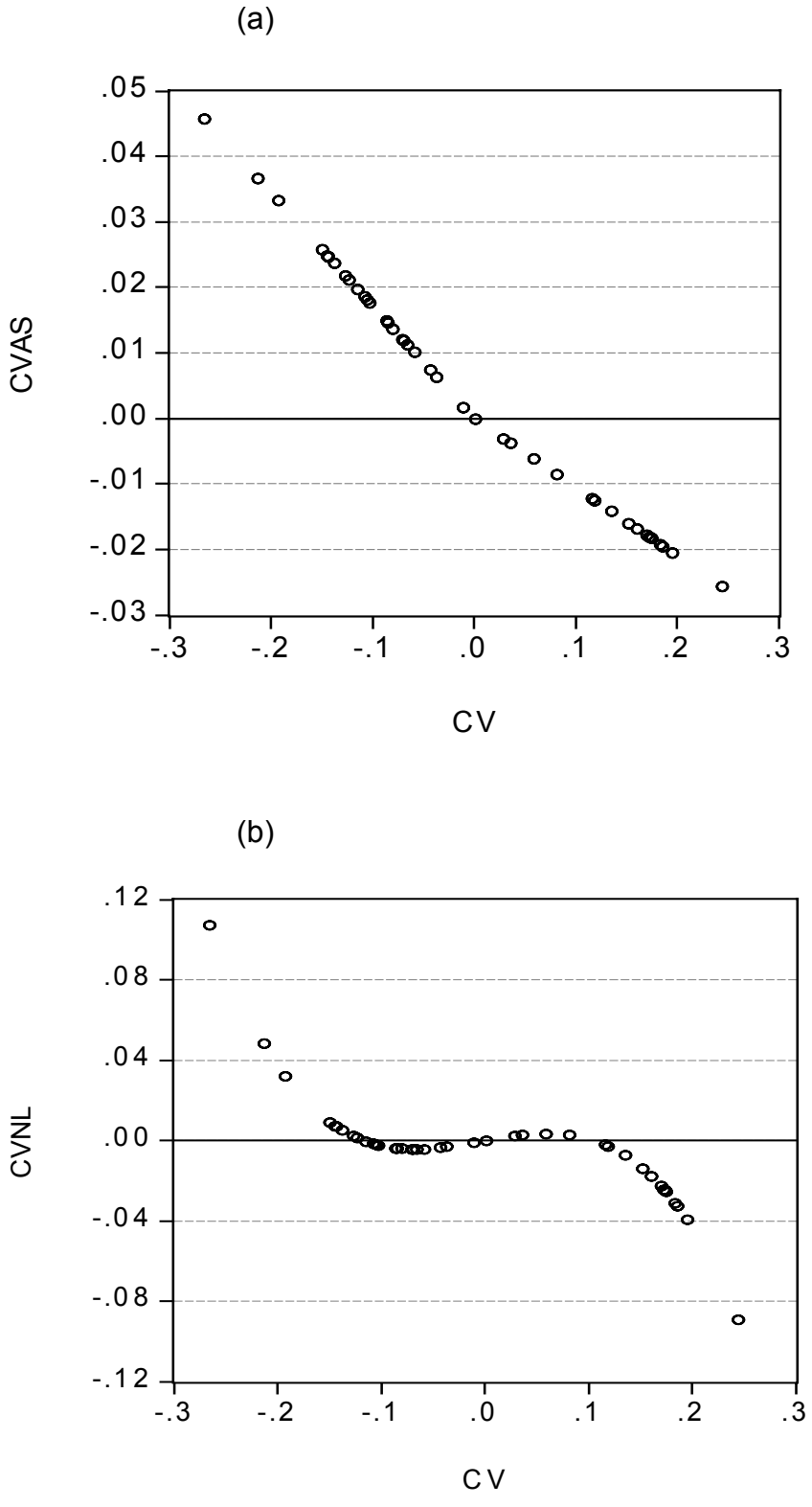
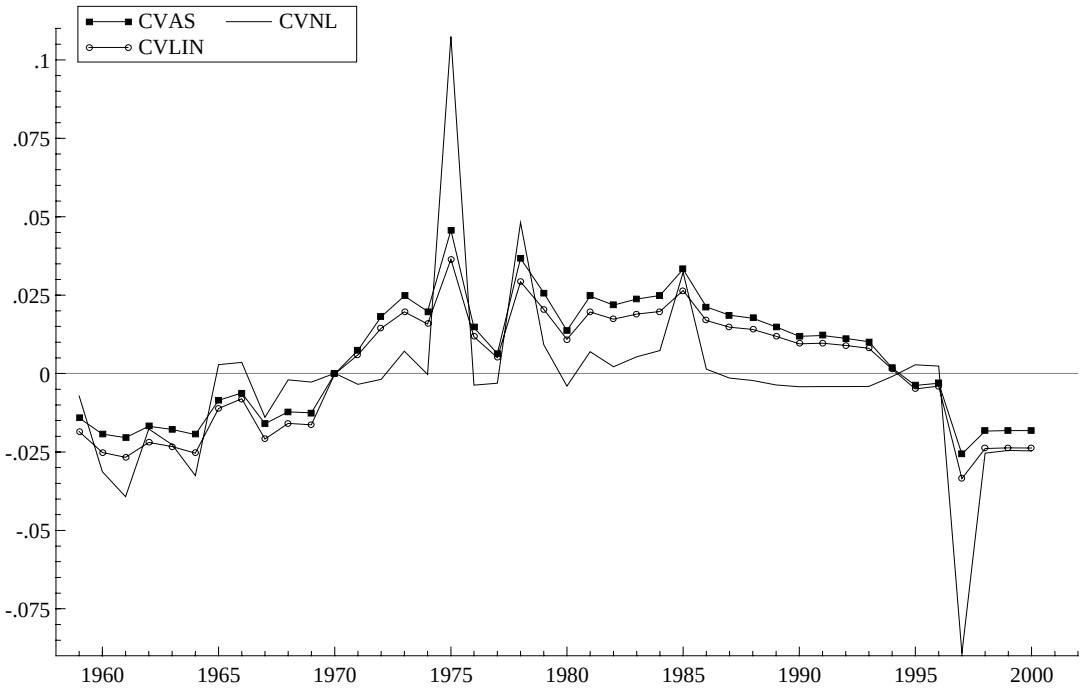


Figure 4: Asymmetric and non-linear adjustment



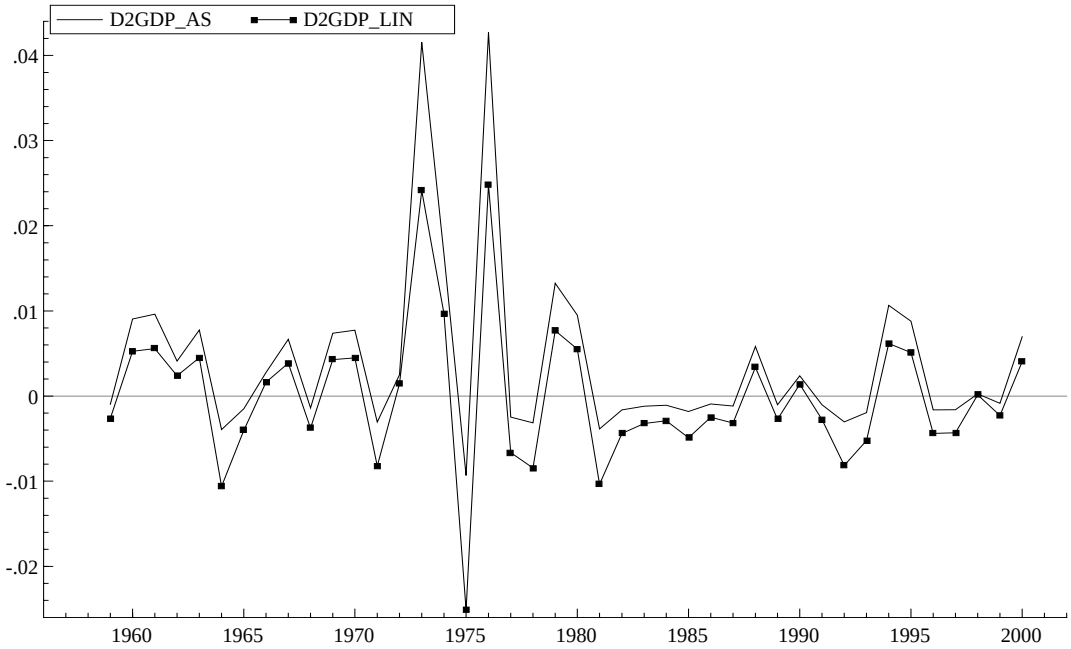
Notes: CVAS = $-0.105CV^{+}$ $-0.172CV^{-}$, CVNL = $0.097CV - 0.079CV^{2} - 7.287CV^{3}$.

Figure 5: Error correction components of the linear, asymmetric and non-linear models for $\Delta\left(\frac{T}{GDP}\right)$



Notes: CVAS = $-0.105CV^{+}$ $-0.172CV^{-}$, CVNL = $0.097CV - 0.079CV^{2} - 7.287CV^{3}$, CVLIN = $-0.137CV$

Figure 6: Linear and asymmetric GDP effects on taxes



Notes: D2GDP_AS = $0.403\Delta^{2}GDP^{+}$ $+0.087\Delta^{2}GDP^{-}$, D2GDP_LIN = $0.234\Delta^{2}GDP$.