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The Quest for a Fiscal Rule: Italy, 1861-1998

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ABSTRACT

The Italian fiscal history is characterised by a number of fiscal consolidations. In this paper we characterise fiscal policy in terms of non-linear deterministic processes. We find that government spending and taxes can be described as being non-linear trend stationary processes instead of unit roots. A long run equilibrium relationship - a non-linear co-trend - does exist between the two series, fulfilling the intertemporal government budget constraint. We interpret this result as evidence of a long run fiscal rule that different policy makers have adopted, putting public finance in balance.

JEL Classification nos.: E620, H62, N100.

Keywords: taxes, government expenditure, intertemporal government budget constraint, non-linear trend stationarity, non-linear co-trending.

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1. Introduction

Italy has contemporary and historically high level of public deficit and debt. Economic historians have discussed the circumstances of this high level and the policies that from time to time have been implemented to ensure fiscal sustainability. Marongiu (1986a, b) introduced the notion of a fiscal rule that the Right established during its governments (1861-1876) and that subsequently the Left breached. The fiscal rule was to balance the public budget, and the instrument was an increase in taxes. Zamagni (1998) concluded her reconstruction of the government debt series arguing that a strong increase in debt has been related to exceptional circumstances, and that fiscal authorities were always able to implement fast fiscal consolidations. Implicitly, she assumed the existence of a fiscal rule, and gave a narrative account for its existence.

In this paper we look for the existence of a long-run fiscal rule, that is a deterministic process that several fiscal authorise over time have implemented in order to keep the government deficit sustainable. In particular, we consider the issue of the inter-temporal government budget constraint that has been extensively analysed in a stochastic environment via the unit root and cointegration approach. In our approach, for processes that are stationary about non-linear deterministic time trends (government spending and taxes), non-linear co-trending is the phenomenon whereby one or more linear combinations of the time series are stationary about a linear trend and a constant, and hence have common non-linear deterministic time trends (Bierens, 2000).

The paper is organised as follows: section 2 reviews issues in fiscal sustainability and surveys previous empirical results. Section 3 presents the Italian fiscal history. Sections 4 and 5 discuss the empirical methodology used here and the results, respectively. Conclusions are drawn in the final section.

2. Fiscal sustainability: theory and empirics

As individuals, governments face an inter-temporal budget constraint (IGBC). Accordingly, they can run a large deficit for a short to medium term, but in the long run it is assumed that they cannot play a Ponzi game. If the government issues one-

period debt, the real value of the outstanding debt b_t, in the discrete-time version, evolves according to:

$$b_{t+1} = (1+r)b_t + g_t - \tau_t - s_t, \tag{1}$$

where r is the real, constant interest rate, g_t is the real government expenditures net of interest, τ_t is real tax revenues, $s_t = (M_{t+1} - M_t)/P_t$ equals real revenue from seigniorage when M_t is the nominal supply of high powered money, and P_t is the price level. Taking the expected values of (1) and solving through iterations, we obtain the IGBC:

$$b_t = -E_t \sum_{j=0} (1+r)^{-(j+1)} (g_{t+j} - \tau_{t+j} - s_{t+j}) + \lim_{j\to\infty} E_t (1+r)^{-(j+1)} b_{t+j+1}, \tag{2}$$

where E(.) denotes the expectation operator conditional to information at time t. From the second term of the right-hand side of eq. (2), we impose the transversality condition:

$$\lim_{j\to\infty} E_t (1+r)^{-(j+1)} b_{t+j+1} = 0. \tag{3}$$

The government budget constraint is fulfilled, or in other words, fiscal policy is sustainable in the long run, if the present value of government spending equals the present value of taxes. The analysis of this issue has been carried out using cointegration. The rationale is that if revenue and government spending are non-stationary series, and if they are cointegrated, i.e. there is a linear combination of the two series which is stationary (Engle and Granger, 1987), they do not drift apart and then the government obeys to its inter-temporal budget constraint. However, this is only a necessary but not sufficient condition, since the cointegrating vector should be (1, -1) to ensure that taxes match government spending. Another method (Hamilton and Flavin, 1986) looks at the stationary properties of the stock of public debt. If the debt series is stationary, the debt is sustainable, otherwise the IGBC is not fulfilled. An

important issue is whether or not interest payments should be included in the constraint. McCallum (1984) argued that a constant, positive deficit (excluding interest payments) could not be financed entirely by bond sales; however, a constant positive deficit inclusive of interest payments can. Although most studies take this approach, Trehan and Walsh (1988) show that the IGBC implies that government expenditure inclusive of interest, tax receipts and seigniorage be cointegrated. However, the condition is in fact stronger, requiring that the deficit inclusive of interest be stationary.

Although many studies support the sustainability of government debt, the results are controversial. For the periods 1960-1981 and 1890-1986 Hamilton and Flavin (1986) and Trehan and Walsh (1988), respectively, found that US data was consistent with the IGBC. However, the first period is too short to obtain reliable results when testing for cointegration.[1]

Bohn (1998) argued that wartime and cyclic fluctuations can obscure the relationship between primary surplus and debt. Therefore, univariate regression of the first on the second would not detect a significant correlation between the two: even if it is impossible to reject a unit root, this test leads to inconsistent and misleading results. For 1916-1995 he found that the primary surplus was an increasing function of the debt-to-GDP ratio. In addition, when one controls for wartime and cyclic fluctuations, an autoregressive model shows that the debt-to-GDP ratio is mean-reverting. Under weak conditions, a positive (at least linear) response of primary surpluses to the debt-to-GDP ratio implies that the IGBC is satisfied.

In a number of more recent papers, the stability of the IGBC is tested in face of possible changes in fiscal policy. Using US data from 1947(2) to 1992(3), Quintos (1995) found a major breakpoint in 1980(4) by applying the Hansen parameter stability test. She showed that revenues and expenditure inclusive of interest are cointegrated in the pre-break period, but are not cointegrated in the post-break period. The evidence supports strong sustainability in the pre-break periods, but only weak sustainability in the post-break period.[2] Martin (2000) applied an integrated cointegration/structural

[1] Hakkio and Rush (1991) obtained similar results.

[2] Strong sustainability means that the IGBC holds, and the undiscounted debt process B_t, is $I(1)$. Weak sustainability means that the constraint holds, but that B_t is exploding at a rate lower than the growth rate of the economy. This situation is consistent with sustainability, but may turn into a default situation.

methodology, allowing for multiple shifts in level and slope parameters. The inferential approach is Bayesian, with rests based on Markow chain Monte Carlo posterior simulators. Strong long-run sustainability was found, with three breaks endogenously determined in the first quarters of 1975, 1985, and 1987, over the same time-span used as in Quintos (1995). However, these changes were small and almost offset each other, implying fulfilment of the IGBC over the whole period.[3]

3. An overview of the Italian fiscal policy

In this Section we briefly sketch some historical facts about fiscal policy to give an idea behind the data of the different arrangements occurred in the period under analysis.

After unification in 1861, fiscal policy was expansionary. The need to fund the unification of the new State through infrastructure and the nationalisation of railways, the obligation of repaying the debt issued by the Kingdom of Piedmont during the war for unification, and a new war of independence with Austria in 1866 put pressure on the budget policy. In this situation public debt grew until 80% of the GDP and the first fiscal consolidation took place through the increase in taxes.

During the ruling years of the Left (1876-1896), public budget was used to fund investments in railways, iron industry, and military industry. Taxes were not increased accordingly and a surge in government deficit occurred.[4] However, this deficit was not funded through seigniorage, because Italy returned to the Gold Standard in 1883. This decision was not deflationary: it caused a strong inflow of foreign investments, which helped industrial development. The Gold Standard was again abandoned during the economic crisis in 1887-1895, when both government deficit and debt increased because of the active fiscal policy. During the Giolitti period (1901-1913) there was a positive interaction between fiscal consolidation and business cycle. Government expenditure was almost constant, while taxes grew in real terms; therefore both were

[3] Similar results are obtained by Haug (1995), with respect to policy changes during Reagan and Bush administrations.

[4] Marongiu (1986b) describe the change in fiscal policy from the Right to the Left as a shift from 'rules to emergency'. A more balanced judgement should consider that during the governments of the Left, the World economy suffered from a strong deflation.

reduced with respect to GDP, but the former at a faster rate. Together with a reduction in international interest rates, and in particular of the spread of the Italian ones with respect to those of other major countries, this situation made it possible the second fiscal consolidation in 1906, in which bondholders were allowed to choose either to exchange their bonds in a perpetuity yielding a 3.75% interest rate or getting repaid at the par value. Only 6% of bondholders decided of being refunded and this voluntary conversion was successful because the government gained credibility against financial markets and savers.

From 1914 onwards, there are three major episodes of fiscal deficits: before and during the two World Wars, and at the end of the period of increasing fiscal expansion post-1960. During the World War I military expenditure raised at almost 50% of the GDP and in 1920 public debt was over 120% of the GDP. During the Fascist regime there were two episodes of fiscal consolidation. The minor one took place in 1922-1926 through a strong reduction in government expenditure, a high rate of inflation that reduced the real value of the government debt, and a remission of debt from the US and the UK. This resulted in a return to the gold standard at an overvalued exchange rate (the so-called *quota 90*) that, in the light of rising fiscal deficits and military expenditure, could only be defended through the imposition of capital controls and trade barriers in later years. In addition, there was a compulsory switching of all government bonds with a residual duration of less than seven years into 5% nine-year bonds in the second and more important fiscal consolidation of the Fascist government. While the first consolidation was obtained by raising taxes, the second was achieved through credibility of the government and voluntary switching from bond-holders; the third one was made possible by the authoritarianism of the regime.

The financial needs of Word War II were quite demanding because of the isolation of the Italian government. There was an attempt at funding government expenditure through forced government bond at a low interest rate, but the government debt to GDP ratio skyrocketed again. In 1941 Bank of Italy increased its funding leading to an increase in inflation that reduced the above ratio to a quarter. However, until 1947 the inflation rate was about 100% per year. Fiscal consolidation was mainly achieved through the inflation-tax.

In the post-World War II period, Italy joined the Bretton Woods system and, as in many other developed economies, monetary policy continued to be dominated by the stance of fiscal policy, with the stabilisation of interest rates as the main objective. In the 1970s the increase in government expenditure was devoted to the expansion of the Welfare State. However, an increase in government debt did not occur because while the primary deficit increased, the debt service decreased because the real interest rate was lower than the rate of growth of the economy. Interest rates were exceptionally low because of restrictions that prevented the diversification abroad of the financial wealth. When these constraints were removed the interest rates increased together with the government debt. The pattern follows that of the high-inflation OECD countries from the mid-1960s to the early 1980s, with rising deficits leading to higher inflation.

The fiscal dominance of monetary policy was only broken in the early 1980s, when the Bank of Italy gradually acquired greater independence in setting monetary policy, and did so independently of fiscal considerations. In addition, in 1978 the entry in the European Exchange Rate System imposed an additional constraint on monetary policy, namely on inflation. In 1979 the so-called divorce between the Treasury and the Bank of Italy took the form of the removal of the obligation on the part of the Bank to buy unsold Treasury Bills at auctions. In the 1990s the objective of both fiscal and monetary policies has been to achieve inflation convergence with the Euro-area and exchange rate stability to fulfil the Maastricht criteria. A reduction of the debt over GDP ratio was achieved through a reduction in government expenditure, in particular public employees and pension schemes, and an increase in taxes to obtain a substantial primary surplus.

4. Empirical methodology and data

The first stage of this work is to establish whether the series are non-linear trend stationary. This is done in two ways: first we apply a battery of tests in which the unit root hypothesis is either the null or the alternative, tested against stationarity or trend stationarity, as appropriate. Conflicting results of these tests may be interpreted as the possibility of the series being stationary around a non-linear deterministic trend. Next we apply four tests developed by Bierens (1997) in which the null of a unit root with

drift process is tested against non-linear trend stationarity. After the data generating process has been assessed and specified in terms of non-linear trend stationarity, we implement the Bierens (2000) co-trending test.

Cushman (2002) systematises the tests proposed by Bierens (1997), based on the Dickey-Fuller model augmented with orthogonal Chebishev polynomials:

$$\Delta z_t = \alpha z_{t-1} + \sum_{i=1}^{p} \phi_i \Delta z_{t-i} + \sum_{j=p}^{m} \theta_j P_{j,t} + \varepsilon_t \,, \tag{4}$$

where $P_{0,\,t}$ to $P_{m,\,t}$ are Chebishev polynomials, $P_{0,\,t}$ equals 1, $P_{1,\,t}$ is equivalent to a linear trend, and $P_{2,\,t}$ through $P_{m,\,t}$ are cosine functions. We use four tests from this model:

1. $\hat{t}(m)$, the t-statistic on the estimated coefficient $\hat{\alpha}$;
2. $\hat{A} = n\hat{\alpha} / \left| 1 - \sum_{i=1}^{p} \hat{\phi}_i \right|$;[5]
3. $\hat{F}(m)$, joint F test on $\hat{\alpha}$ and the coefficients of non-constant Chebishev polynomials;
4. $\widetilde{T}(m)$, non-parametric joint test on $\hat{\alpha}$ and the coefficients of non-linear Chebishev polynomials.

The null of these tests is unit root with drift, while the alternative is linear or non-linear deterministic trend stationarity. In particular, right-side rejections for the $\hat{t}(m)$, $\hat{A}$, and $\widetilde{T}(m)$ tests indicate non-linear trend stationarity, whereas left-side rejections are ambiguous, since the process can be mean stationary, trend stationary or non-linear trend stationary. The $\hat{F}(m)$ test is one sided and right-side rejections lead to non-linear trend stationary.

Once we have determined that the series are stationary around a non-linear trend, we can investigate whether they have non-linear trends in common. Bierens (2000) develops a test similar to the search for common stochastic trends and cointegration for

[5] Bierens (1997) specifies this test without taking the absolute value. This modification is made in Bierens (2005) because, under H_1, $\hat{\phi}$ can be negative.

unit root series, a relationship called non-linear co-trending.[6] As put by Cushman (2002), the test is based on the eigenvalues of matrices constructed from partial sum of the variables. It is nonparametric since the non-linear trends and serial correlation processes do not need to be specified. The test statistic is λ_r for $r = 1$ through k, where r is the number of co-trending vectors under the null, and k is the number of variables. The alternative hypothesis is that there are $r - 1$ co-trending vectors. The test procedure also gives estimates for the co-trending vector parameters. Let y_t denote a demeaned and de-linear-trended vector of variables, and define:

$$\hat{M}_1 = (1/n)\sum_{t=1}^{n} \hat{F}(t/n)\hat{F}(t/n)^T , \tag{5}$$

where $\hat{F}(x) = (1/n)\sum_{t=1}^{nx} y_t$ if $x \in [n^{-1},1]$, $\hat{F}(x) = 0$ if $x \in [0,n^{-1}]$, and

$$\hat{M}_2 = (1/n)\sum_{j=s}^{n}\left((1/s)\sum_{j=0}^{s-1} y_{t-j}\right)\times\left((1/s)\sum_{j=0}^{s-1} y_{t-j}\right)^T . \tag{6}$$

Then solve:

$$\left|\hat{M}_1 - \lambda\hat{M}_2\right| = 0 . \tag{7}$$

Taking the ordered solutions of (7), the test statistics are calculated as $n^{1-\alpha}\hat{\lambda}_r$. s, the order of nonparametric serial correlation correction is equal to n^{α}, with $\alpha = 0.05$ which is the rate of convergence of the partial sum that embodies the serial correlation correction.

This analysis is applied to Italian annual data from 1861 to 1998. Expenditure (*LGOV*) is defined as the log of sum of total budget outlays less interest payments on debt, calculated as a ratio to GDP. The average tax rate (*LTAX*) is the log of the ratio of government revenue to GDP. Data for GDP, debt, interest payment on outstanding debt are from Fratianni and Spinelli (2001). Government expenditure and taxes are from Spinelli and Fratianni (1991) for the period 1861-1980, and from Istat (various

[6] Related work on co-breaking is developed by Clements and Hendry (1999, ch. 9). They define co-breaking as the removal of deterministic shifts using linear combinations of variables. It is introduced, for example, to analyse cointegration between series with different order of integration. Also relevant is recent work on non-linear cointegration, as surveyed by Dufrenot and Mignon (2002).

years) for the remaining period. All the original data is in nominal terms. Figure 1 shows non-logarithmic data for these variables and government debt.

[Figure 1 about here]

5. Empirical results

In this Section we present the results of our estimations. We then apply a battery of non-linear trend stationarity tests. Having shown that the series are non-linear trend stationary, we then test for the existence of common long-run behaviour between government expenditure and taxes. All the estimations have been carried out using Bierens software *EasyReg International*.

5.1 Non-linear trend stationarity tests

When implementing the Bierens non-linear trend stationarity test, one faces the decision to determine p, the order of lagged first difference of the stochastic part of the time series, and m, the order of the Chebishev time polynomials. One can use different criteria in determining p, for example the AIC or the sequential test proposed by Ng and Perron (1995). We opted for the former method, which is more appropriate for simulating the actual value of the test size, though the other results in lower size distortion. The issue of choosing m is more difficult, since there is no explicit criterion to determine it. If m is too low, a non-linear trend may not be detected, which determines a lack of power. If m is too large, superfluous parameters are estimated, which may cause lack of power. We perform the four tests outlined above for all the values of m from 2 to 20. Nonetheless, the tests show substantial size distortion, their assessment has to be done by simulating p-values by estimating an autoregressive first difference model (with lag order determined by AIC). Using the estimated parameters and sampling from the rescaled residuals of the estimated model, 1,000 new first difference series were generated, using the first $p + 1$ actual values to initialise. Errors were drawn from the normal distribution with zero mean and variances the squared OLS residuals.

For government spending (Table 1) we find an area of right-sided rejections of the null of unit root in the range of m included between 8 and 11, with all the tests

leading to rejection for m = 9 and 10. For the *LTAX* variable (Table 2) we find about the same range for m. These results overall suggest non-linear trend stationarity for both variables, and our conclusion is to set m = 9 to both series as possible common non-linear trend.

[Table 1 and 2 about here]

Figures 2 and 3 show the fit of the model for government expenditure and taxes, respectively.[7] The autoregressive part of the model (p) was set equal to 1 for *LTAX* and 2 for *LGOV*, according to the AIC.

[Figures 2 and 3 about here]

5.2 Co-trending test

Now we turn to the non-linear co-trending test. The parameter α was set equal to 0.5, and the test was conducted on the de-trended variables, since Figures 2 and 3 show an upward trend of the two variables. The corresponding generalized eigenvectors of $\hat{M}_1$ with respect to $\hat{M}_2$ are:

$$\begin{matrix} 1 & -0.232 \leftarrow \text{LGOV} \\ -0.284 & 1 \leftarrow \text{LTAX} \end{matrix} \qquad (12)$$

When the hypothesis of r co-trending vectors was tested against the alternative of r - 1 co-trending vectors, yielded the results summarized in Table 3, which tells us that there exists one co-trending vector. This standardised vector H = (1, 0.336) is determined according to a λ-max test statistic equal to 0.05 with 10% and 5% critical values respectively equal to 0.120 and 0.150, under the null that there exists a co-trending vector x satisfying $x = Hy$, where y is an arbitrary conformable vector.

[7] Note that in these figures the values of the variables are standardised, whereas in Figure 1 they are the actual values.

We can write $F(x) = Q_2Q_2'F(x)$, where Q_2 is the matrix of orthogonal eigenvectors of $\hat{M}_1$ corresponding to the positive eigenvalues. The vector $Q_2'F(x)$ can be interpreted as the vector of common cumulative non-linear trends. Similarly, $F'(x) = Q_2Q_2'F'(x)$, where Q_2 is the matrix of orthogonal eigenvectors of $\hat{M}_2$ corresponding to the positive eigenvalues. The vector $Q_2'F'(x)$ can be interpreted as the vector of common non-linear trends. Figure 4 and 5 plots the estimated $F(x)$ and $F'(x)$ components for both *LGOV* and *LTAX*, standardised between –1 and 1. They appear rather synchronised, confirming that government receipts and outlays are linked via a common non-linear trend.

[Figures 4 and 5 about here]

Finally, these estimates allow us to write:

Common nonlinear trend =
0.8547 x Component of F'(x) corresponding to *LGOV*
0.5189 x Component of F'(x) corresponding to *LTAX* (13)

Nonlinear trend in *LGOV* = 0.8547 x Common nonlinear trend (14)

Nonlinear trend in *LTAX* = 0.5189 x Common nonlinear trend (15)

Figure 6 plots the co-trending relationships between the variables.

[Figures 6 about here]

5. Conclusions

In this paper we have addressed the issue of the intertemporal government budget constraint applying the notions of non-linear trend stationarity and non-linear co-trending or the two time series involved in this framework: government outlays and receipts. We found that the two series can be represented by non-linear trend stationarity instead of unit root processes, and that a non-linear long-run relationship does exist between them, fulfilling fiscal sustainability. From an economic point of view, it makes sense to think that policy makers (those responsible for fiscal decisions over the long period analysed here) might have acted as if they were guided by specific rules (e.g., do not accumulate too much government debt) in responding to stochastic

fiscal shocks. As long as these shocks are stochastic, we can figure out that responses were stochastic signals too. From time to time there were presumably different attitudes to respond to fiscal signals, because fiscal authorities do change over time. Therefore, the non-linear trend relationships uncovered here constitute a mixture of stochastic and deterministic components in the making of fiscal policy.

This interpretation makes sense from an historical point of view: as discussed in section 3, Italy experienced five major episodes of fiscal consolidation that followed periods of raising government expenditure. The first one in the 90s of the nineteen century was obtained by raising taxes, the second in 1906 with a voluntary bond swap that was successful because the government gained credibility against financial markets and savers for its efforts in promoting a sound financial stance. The third event was obtained by the Fascist government in the 30s when there was a compulsory switching of all government bonds with a residual duration of less than seven years into 5% nine-year bonds, together with other protectionist measures. The fourth episode occurred after the World War II and was achieved through skyrocketing inflation that dramatically cut the value of government debt. The latest fiscal consolidation was accomplished again rising taxes and took place in the '90s when Italy joined the Euro. This brief sketch shows how the policy responses were different to different fiscal shocks, still keeping the Italian economy on a fiscally sustainable path. The econometric evidence we report is therefore consistent with of Zamagni (1998), who implicitly assumed a long-run fiscal rule.

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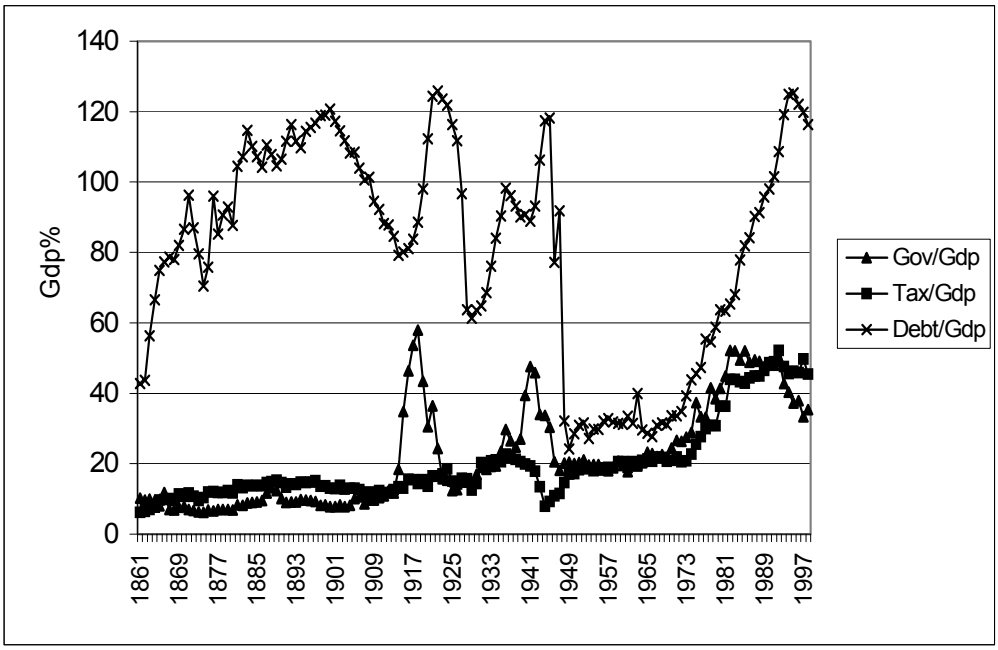
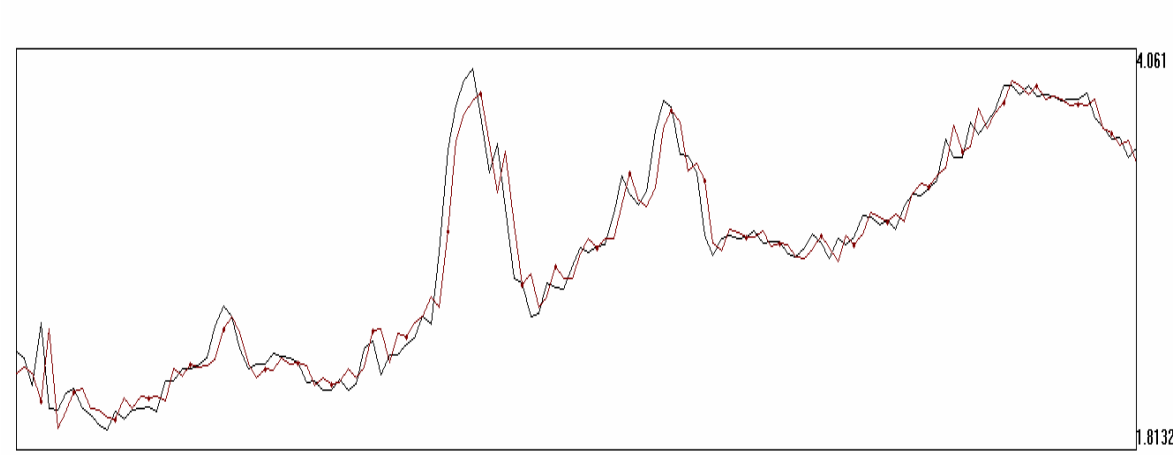
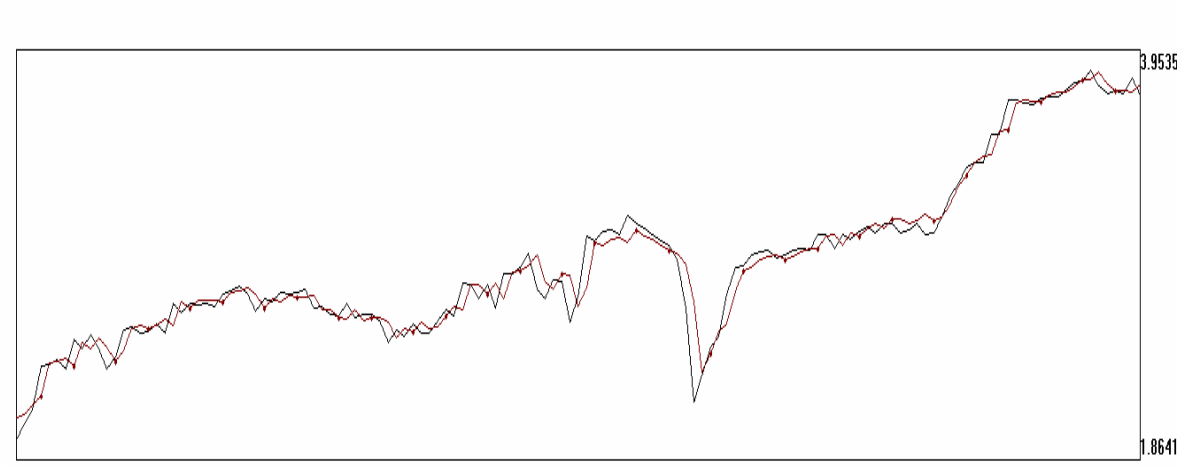


Figure 1 – Italian fiscal aggregates



Dotted line: non-linear model (p = 2, m = 9)
Solid line: LGOV

Fig. 2 – Fit of the non-linear model for government expenditure



Dotted line: non-linear model (p = 1, m = 9)
Solid line: LTAX

Fig. 3 – Fit of the non-linear model for taxes

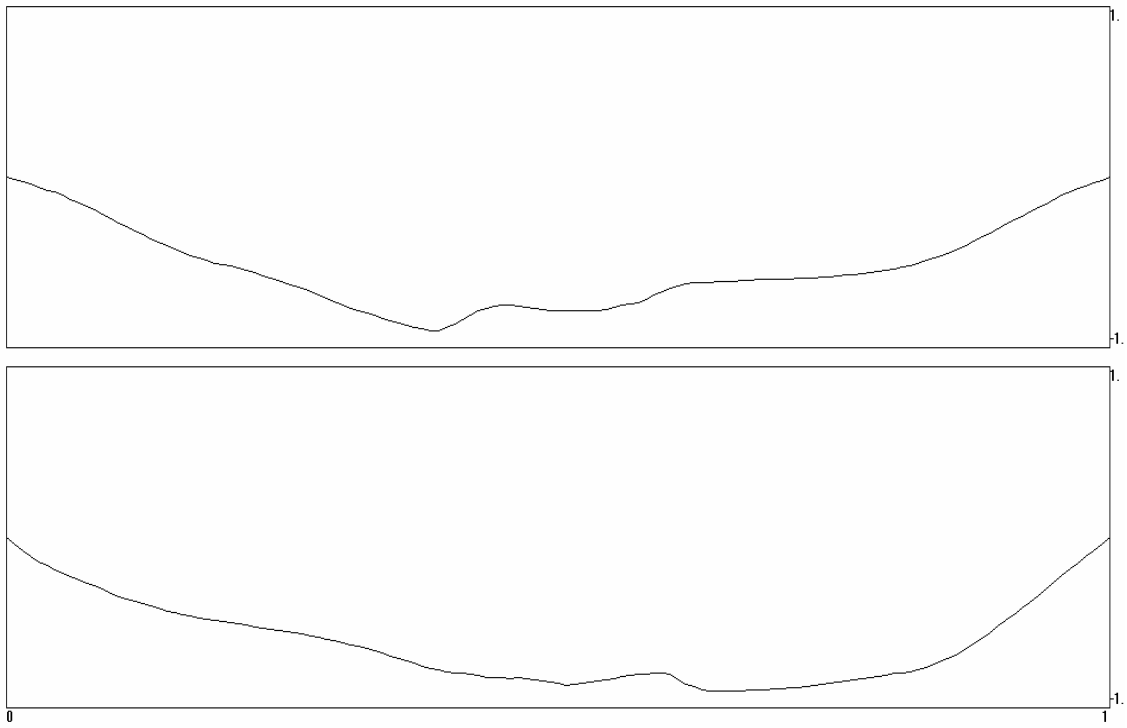


Fig. 4 – Estimated F(x) components for LGOV (above) and LTAX (below)

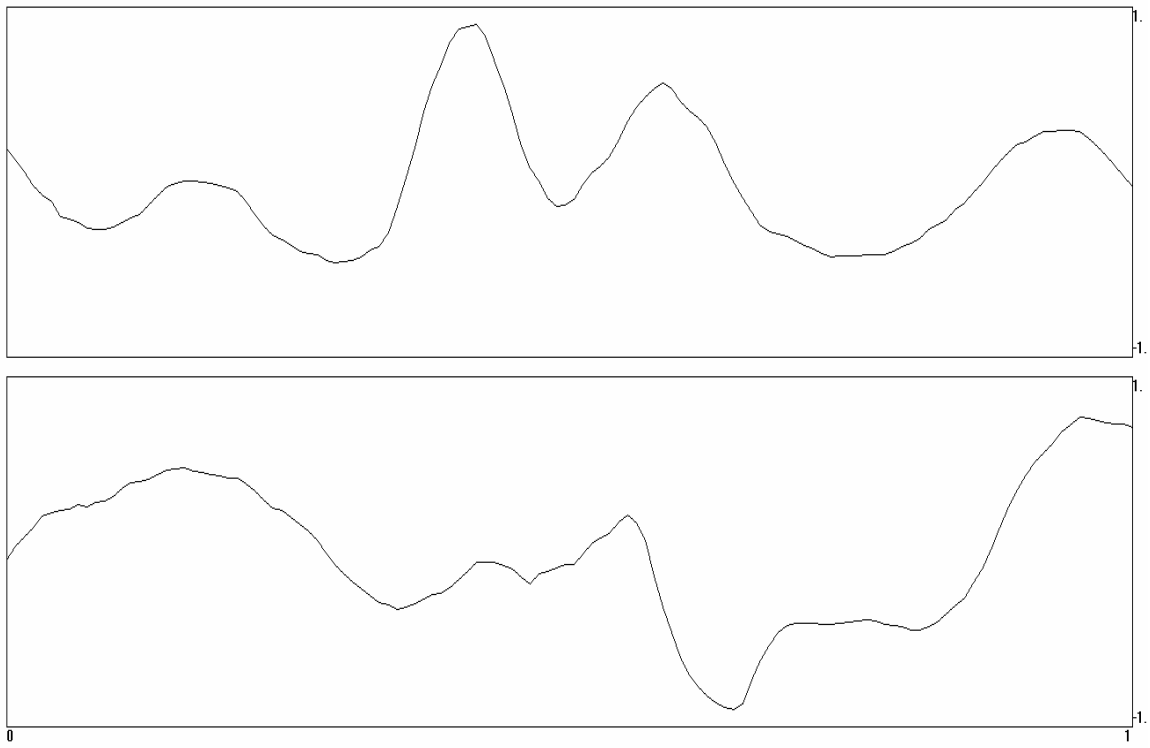
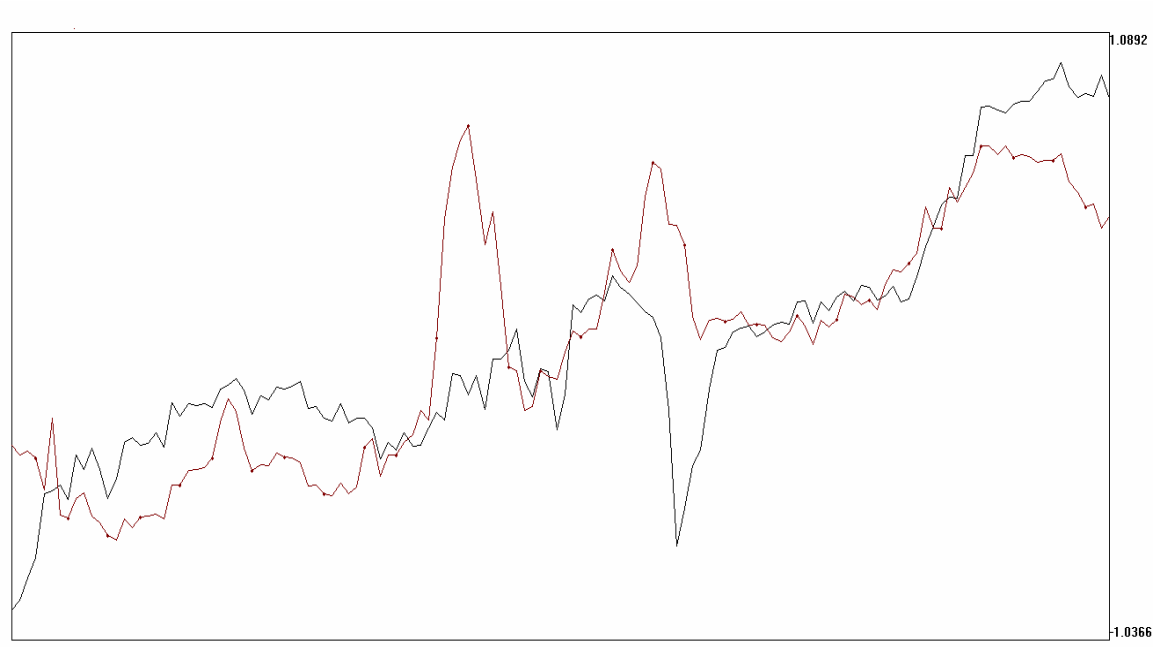
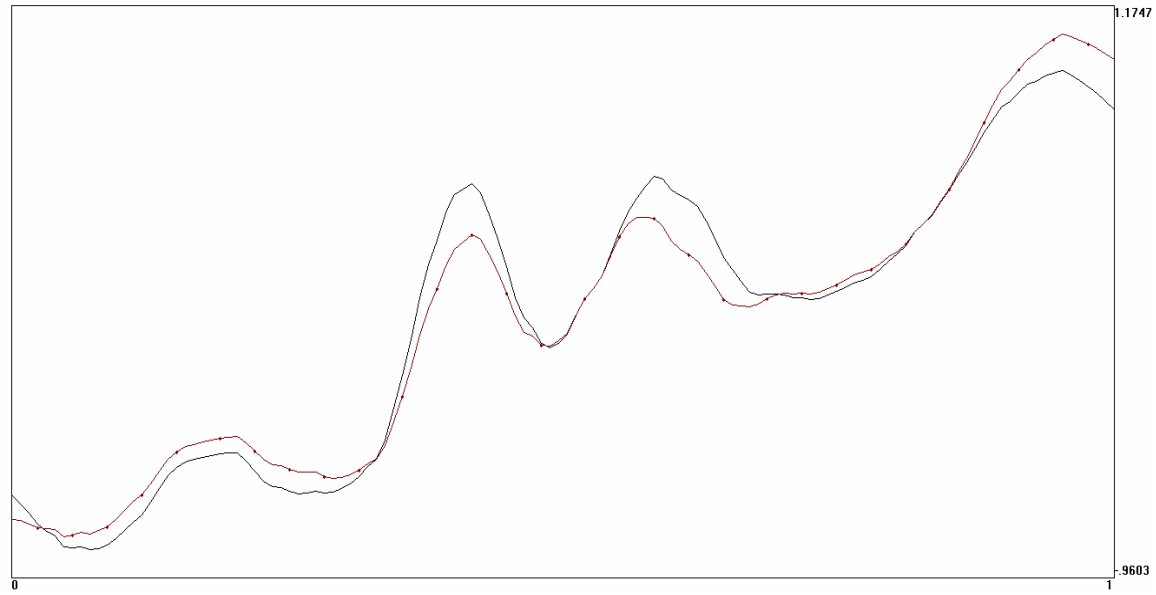


Fig. 5 – Estimated F'(x) components for LGOV (above) and LTAX (below)



Solid line: LTAX
Dotted line: 0.7161 x LGOV



Solid line: component F'(x) corresponding to LGOV
Dotted line: 0.85477 x common trend

Figure 6 – Co-trending relationships

Table 1 – Small sample pretests of the tests of the unit root hypothesis against non-linear trend stationarity for LGOV ($p = 2$)

	2	3	4	5	6	7	8
$\hat{t}_m$	0.162	0.308	0.300	0.392	0.512	0.704	0.371
$\hat{A}$	0.135	0.296	0.359	0.368	0.445	0.678	0.061
$\hat{F}_m$	0.805	0.453	0.528	0.304	0.118	0.043	0.010
$\tilde{T}$		0.150	0.220	0.077	0.084	0.044	0.077
	9	10	11	12	13	14	15
$\hat{t}_m$	0.973	0.985	0.918	0.527	0.629	0.710	0.713
$\hat{A}$	0.981	0.992	0.980	0.425	0.578	0.763	0.681
$\hat{F}_m$	0.975	0.995	0.992	0.097	0.224	0.254	0.257
$\tilde{T}$	0.968	0.986	0.950	0.086	0.427	0.534	0.527
	16	17	18	19	20		
$\hat{t}_m$	0.645	0.814	0.827	0.875	0.928		
$\hat{A}$	0.757	0.796	0.826	0.887	0.931		
$\hat{F}_m$	0.285	0.171	0.112	0.068	0.420		
$\tilde{T}$	0.564	0.525	0.511	0.409	0.381		

Table 2 – Small sample pretests of the tests of the unit root hypothesis against non-linear trend stationarity for LTAX ($p = 1$)

	2	3	4	5	6	7	8
$\hat{t}_m$	0.930	0.720	0.826	0.756	0.610	0.736	0.973
$\hat{A}$	0.929	0.723	0.854	0.709	0.573	0.762	0.994
$\hat{F}_m$	0.024	0.330	0.406	0.467	0.467	0.393	0.978
$\tilde{T}$		0.885	0.869	0.757	0.730	0.754	0.926
	9	10	11	12	13	14	15
$\hat{t}_m$	0.974	0.991	0.733	0.492	0.726	0.740	0.836
$\hat{A}$	0.972	0.941	0.884	0.717	0.755	0.792	0.898
$\hat{F}_m$	0.987	0.986	0.385	0.602	0.423	0.456	0.257
$\tilde{T}$	0.979	0.987	0.088	0.389	0.854	0.816	0.685
	16	17	18	19	20		
$\hat{t}_m$	0.687	0.832	0.621	0.531	0.820		
$\hat{A}$	0.871	0.835	0.804	0.614	0.763		
$\hat{F}_m$	0.370	0.295	0.601	0.615	0.489		
$\tilde{T}$	0.735	0.776	0.822	0.831	0.887		

Table 3 – Test of the number *r* of co-trending vectors

r	Test statistics	10% critical region	5% critical region	Conclusion
1	0.0537	>0.119	>0.151	Accept
2	0.1997	>0.169	>0.203	Reject

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