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REGIME-SHIFTS, MULTICOINTEGRATION AND FISCAL SUSTAINABILITY: FURTHER EVIDENCE ON POLAND (1999-2015)

ABSTRACT

This paper reassesses the sustainability of fiscal policy in Poland, extending the analysis of Tronzano (forthcoming) to a multicointegration test allowing for regime shifts. The empirical evidence strongly rejects the existence of multicointegration, thus suggesting that Poland's fiscal process is unsustainable in a stochastic environment. In line with my previous research and other recent applied literature on Poland, the main policy implications are twofold. First, a prosecution of the ongoing fiscal consolidation process is needed. Second, the above process should be implemented introducing a systematic response of fiscal policy to contingent disequilibria in public debt.

RIASSUNTO

Cambiamenti di regime, multicointegrazione e sostenibilità della politica fiscale: ulteriore evidenza empirica sulla Polonia (1999-2015)

L'articolo riesamina la sostenibilità della politica fiscale in Polonia, estendendo l'analisi condotta in Tronzano (forthcoming) ad una analisi di multicointegrazione che incorpori la possibilità di cambiamenti di regime. I risultati ottenuti respingono fortemente l'esistenza di multicointegrazione, indicando quindi che la politica fiscale della Polonia non è sostenibile in un contesto stocastico. In linea con mie precedenti analisi empiriche e con altra recente letteratura applicata sulla Polonia, si ottengono due principali implicazioni di politica economica. In primo luogo, è necessaria una prosecuzione dell'attuale processo di consolidamento fiscale. In secondo luogo, questo processo dovrebbe essere condotto introducendo una reazione sistematica della politica fiscale a squilibri imprevisti nella dinamica del debito pubblico.

1.   INTRODUCTION AND MOTIVATION

A large strand of the empirical literature assessing the sustainability of fiscal policies has recently concentrated on Central and Eastern European Countries (CEEC). The reason is straightforward. Most CEEC are new members of the European Union (EU) and plan to join the European Monetary Union (EMU) in the near future. In this perspective, a careful evaluation of fiscal sustainability requirements represents an important issue in order to evaluate the eligibility of these countries for EMU.

The empirical evidence for CEEC countries is remarkably mixed. Focusing on seven individual CEEC, Redzepagic and Llorca (2007) document a positive response of the primary surplus to changes in debt in most countries (i.e. the Baltic States, Slovenia and Slovakia) but not in Poland and in the Czech Republic. Using the same approach on a slightly different group of countries, Stoian and Campeanu (2010) broadly confirm the above results, although suggesting that in a subset of these countries (Latvia, Poland, Romania and Slovakia) severe fiscal adjustments should be made in order to reach long-run fiscal sustainability. Some panel evidence on eight CEEC which are new members of the EU, finally, provides a more favorable outlook. Panel cointegration tests carried out in Llorca and Redzepagic (2008) imply that fiscal policies in these countries are consistent with the intertemporal budget constraint and thus sustainable in the long-run.

In two recent papers (Tronzano, 2017, and forthcoming), I focus on the sustainability of the budget process in Poland, which plays a key role among the group of CEEC given its large weight in terms of population and nominal GDP. The former contribution documents that Poland's fiscal policy is only "weakly" sustainable, due to a significant divergence between public expenditures and government revenues in more recent years. The latter contribution extends the previous analysis in a stochastic environment, applying a single-step multicointegration test to the above fiscal variables. The main conclusion is that fiscal variables are not multicointegrated, thus violating a crucial condition for fiscal sustainability in the presence of a time-varying discount factor.
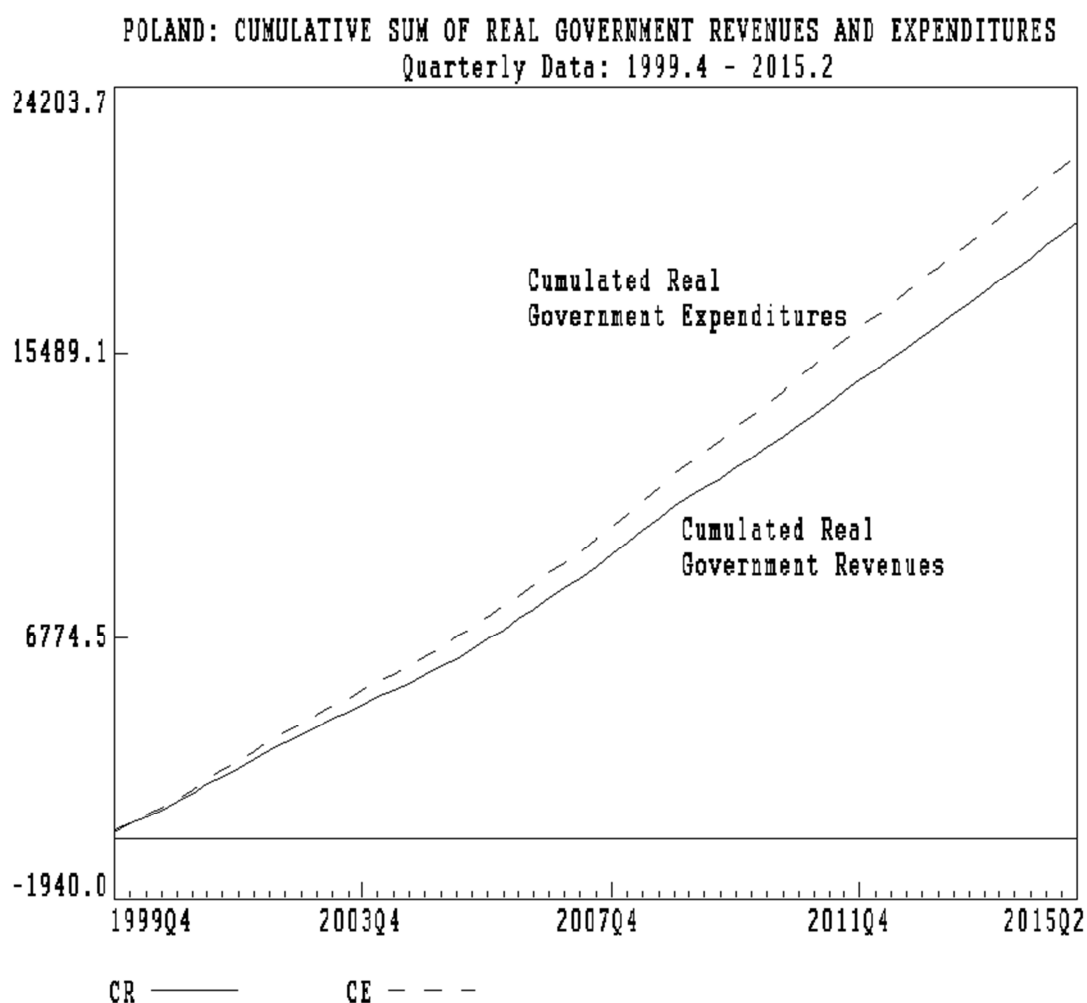
Although the empirical investigation carried out in Tronzano (forthcoming) usefully complements the results from a standard cointegration approach, the multicointegration test implemented in this paper does not allow for a regime-shift in the stock-flow system of fiscal

variables. Yet, the assumption of a stable stock-flow equilibrium relationship might actually be too restrictive in the present context for two main reasons.

First, the standard cointegration approach detects the existence of a long-run equilibrium relationship between revenues and expenditures flows in the presence of a significant structural break towards the end of the sample. As discussed in Tronzano (2017), this structural break can be ascribed to a consistent deterioration in the overall fiscal position of Poland during the latest years.

Second, a visual inspection of cumulated series suggests the possibility of a structural break even in the I(2) system of fiscal variables. Figure 1, reproduced from Tronzano (forthcoming), outlines the pattern of cumulated expenditures and revenues in Poland from 1999Q4 to 2015Q2.

Figure 1

POLAND: CUMULATIVE SUM OF REAL GOVERNMENT REVENUES AND EXPENDITURES
Quarterly Data: 1999.4 - 2015.2

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As observed in this paper:

"while these series are quite close together during the former part of the sample, a significant divergence is apparent during the latter part. Finally, approximately since 2009 onwards, this divergence becomes stronger, possibly suggesting the existence of a regime-shift in this bivariate system of I(2) variables. This last visual evidence represents an interesting research topic for further research" (Tronzano, forthcoming, section 3.1).

Motivated by the above arguments, this paper extends the analysis of Tronzano (forthcoming) applying a multicointegration test allowing for regime shifts to the I(2) system of Polish fiscal variables. This new econometric methodology builds on the standard single-step approach pioneered in Engsted *et al.* (1997) and includes many alternative specifications for deterministic and stochastic regressors. This approach provides therefore a rich testing framework to assess the robustness of previous empirical findings.

The paper is organized as follows. The next section describes the essential features of this econometric framework, discusses the empirical findings, and outlines their policy implications. Section three concludes.

2. A MULTICOINTEGRATION TEST ALLOWING FOR REGIME SHIFTS

2.1 Econometric Framework

This section relies on an econometric methodology developed in Berenguer-Rico and Carrion-I-Silvestre (2011). These authors extend the single-step approach originally proposed in Engsted *et al.* (1997) in order to account for one potential structural break both in the deterministic and in the stochastic part of the stock-flow equilibrium relationship.

Let y_t correspond to real government tax revenues and x_t correspond to real government expenditures (inclusive of interest payments on the stock of outstanding debt). Moreover, let Y_t and X_t correspond to the cumulated values of these fiscal variables, namely: $Y_t = \sum_{j=0}^{t} y_{t-j}$ and $X_t = \sum_{j=0}^{t} x_{t-j}$. Then, in the context of the present empirical investigation, this econometric methodology requires the estimate of the following equation:

$$Y_t = \beta_{00} + \beta_{01} t + \beta_{02} 1(t > T_b) + \beta_{03} (t - T_b) 1(t > T_b) + \alpha t^2 + \quad (1)$$
$$\beta_{11} \Delta X_t + \beta_{12} \Delta X_t 1(t > T_b) + \beta_{21} X_t + \beta_{22} X_t 1(t > T_b) + u_t$$

where, t (t^2) is a linear (quadratic) time trend; $1(\cdot)$ is the usual indicator function, T_b denotes the break point, and u_t represents the residuals from the OLS estimate of equation (1).

The structure of equation (1) is similar to the multicointegration regression estimated in Tronzano (forthcoming)[1]. The new parameters β_{02} and β_{03} capture, respectively, a shift in the level and in the trend of the equilibrium condition. Turning to the stochastic components, the new parameters β_{12} and β_{22} express, respectively, a change in the effect of the "flow" variable (ΔX_t) and of the "stock" variable (X_t) on cumulated government revenues (Y_t).

Focusing on the stochastic properties of the residuals series (u_t), the stock-flow system of fiscal variables described by equation (1) admits various cointegration results.

If u_t is I(2) no long run equilibrium relationship exists. If u_t is I(1), the I(2) variables (Y_t, X_t) cointegrate into an I(1) process, namely $Y_t, X_t \sim CI (2,1)$. This implies that the government keeps revenue and expenditure flows under control, without paying attention to the stock of debt (in this case the stock of debt is I(1)). Finally, if u_t is I(0) multicointegration holds. The I(2) variables cointegrate into a stationary process, namely $Y_t, X_t \sim CI (2,2)$. In this case, not only does the government equilibrate revenue and expenditure flows, but it also intervenes on flow variables whenever some exogenous shock tends to drive debt out of control. The system is now fully cointegrated and the stock of debt is I(0).

In most situations it is likely that two I(2) variables will at least cointegrate at the I(1) level. On this basis, this approach assumes first-level cointegration (i.e. $u_t \sim$ I(1) and Y_t, $X_t \sim$ CI(2,1)) as the null hypothesis. This null is tested against the alternative hypothesis of multicointegration with one structural break (i.e. $u_t \sim$ I(0) and Y_t, $X_t \sim$ CI(2,2), in the presence of one significant structural break in equation (1)).

In order to assess the stochastic properties of u_t, the following ADF-type regression is estimated for each possible break point in the sample:

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[1] More specifically, imposing the restriction $\beta_{02} = \beta_{03} = \beta_{12} = \beta_{22} = 0$, equation (1) collapses to the simpler multicointegration model employed in Tronzano (forthcoming).

$$\Delta u_t = \delta u_{t-1} + \sum_{j=1}^{p} \phi_j \Delta u_{t-j} + \eta_t \tag{2}$$

Denoting with $t_\delta(\lambda)$ the t-ratio ADF statistic testing the null hypothesis that $\delta = 0$ in equation (2), this procedure yields a sequence of ADF-statistics for each possible break point $\lambda \in \Lambda$[2]. The infimum value of this sequence, denoted as:

$$t^*_\delta = \inf_{\lambda \in \Lambda} t_\delta(\lambda)$$

represents the test statistic to assess the existence of multicointegration in the presence of one structural break[3].

The date associated with t^*_δ does not provide, in general, a consistent estimate of the break point (T_b). If multicointegration holds, Berenguer-Rico and Carrion-I-Silvestre (2011) prove that a consistent estimate of the break date can be obtained from the minimization of the sum of squared residuals (SSR) in equation (1) over all possible values of the break fraction (see ibid., Theorem 2, pp. 318-320).

2.2 Results

The results presented in this section are based on the same data set used in Tronzano (2017, and forthcoming). The fiscal variables are total general government expenditures (inclusive of interest payments) and total general government revenues. Both series are expressed in real terms through the GDP deflator. All series are extracted from Thomson Reuters – Datastream and are expressed on a quarterly basis (see Tronzano 2017, and forthcoming, for the exact definition of these series).

The multicointegration model formalized in equation (1) encompasses many alternative specifications which can be derived imposing suitable restrictions on model's parameters. Therefore, in the present section, I focus both on the more general specification represented by

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[2] The break point date is treated as unknown. The break point date may be expressed as $T_b = [\lambda n]$, where n is the sample size, and λ is the break fraction parameter. More specifically, $\lambda \in \Lambda$ where Λ is a closed subset of (0,1), with [·] being the integer part.

[3] The limiting distribution of t^*_δ depends on the particular deterministic specification assumed in equation (1), as well as on the number of I(1) and I(2) stochastic regressors (denoted, respectively, as m_1 and m_2). Critical values of t^*_δ, for various specifications of the underlying model and different values of m_1 and m_2, are tabulated in Berenguer-Rico and Carrion-I-Silvestre (2011) (see Table II, p. 305).

equation (1) and on some relevant nested alternatives for which specific critical values are provided in Berenguer-Rico and Carrion-I-Silvestre (2011).

Table 1 summarizes the alternative regime-shift models used to implement the multicointegration test.

TABLE 1 - *Multicointegration Models with Regime Shifts: Alternative Specifications*

Models	Deterministic Part	Stochastic Part
Model [A]	$\alpha = 0$	$\beta_{12} = \beta_{22} = 0$
Model [B]	$\alpha \neq 0$	$\beta_{12} = \beta_{22} = 0$
Model [C]	$\alpha = 0$	$\beta_{12} = 0 \ ; \ \beta_{22} \neq 0$
Model [D]	$\alpha = 0$	$\beta_{12} \neq 0 \ ; \ \beta_{22} = 0$
Model [E]	$\alpha = 0$	$\beta_{12} \neq 0 \ ; \ \beta_{22} \neq 0$

The coefficients reported in this table refer to the regime-shift multicointegration relationship (equation (1)) which is reproduced below for convenience:

$$Y_t = \beta_{00} + \beta_{01} t + \beta_{02} 1(t > T_b) + \beta_{03} (t - T_b) 1(t > T_b) + \alpha t^2 + \beta_{11} \Delta X_t + \beta_{12} \Delta X_t 1(t > T_b) + \beta_{21} X_t + \beta_{22} X_t 1(t > T_b) + u_t$$

The former two specifications (models [A], [B]) do not assume a structural break in the stochastic regressors ($\beta_{12} = \beta_{22} = 0$). Model [A] includes a constant term and a linear trend as deterministic regressors ($\alpha = 0$), whereas model [B] allows also for a quadratic trend ($\alpha \neq 0$). The remaining specifications (models [C], [D], [E]) allow for one structural break both in the deterministic and in the stochastic regressors. Focusing on stochastic regressors, the regime-shift involves the I(2) variable (X_t) in the case of model [C] ($\beta_{22} \neq 0$), and the I(1) variable (ΔX_t) in the case of model [D] ($\beta_{12} \neq 0$). Model [E], finally, represents the most general specification, with no restrictions on parameters of stochastic regressors ($\beta_{12} \neq 0 \ ; \ \beta_{22} \neq 0$) and one structural break affecting both I(1) and I(2) variables.

Equation (1) was estimated imposing the alternative restrictions on parameters summarized above, defining the different regime-shifts models. Since the potential break point date (T_b) is

treated as unknown, equation (1) in its various specifications was estimated for each possible break point along the sample.

At each iteration, the maximum number of lags to compute $t_\delta(\lambda)$ was set equal to six in equation (2) (p = 6), taking into account the relatively small dimension of the sample. The order of the parametric correction was then selected through the standard Akaike (AIC) and Schwarz (SBC) information criteria.

Table 2 reports the value of the (t^*_δ) statistic for each model.

TABLE 2 - *Multicointegration Tests with Regime Shifts*

Models	$t^*_\delta = \inf t_\delta(\lambda)$	5% C.V.	10% C.V.
Model [A]	-5.396	-6.50	- 6.23
Model [B]	-5.357	-6.96	- 6.64
Model [C]	-5.282	-6.81	-6.49
Model [D]	-5.655	- 6.71	- 6.43
Model [E]	-5.659	- 6.97	- 6.65

$t^*_\delta = \inf t_\delta(\lambda)$ is the multicointegration test statistic developed in Berenguer-Rico and Carrion-I-Silvestre (2011).
Critical values displayed in this table are from Berenguer-Rico and Carrion-I-Silvestre (2011) (Table II, p. 305) and refer to a sample size of 50 observations.
These critical values assume $m_1 = 1$ and $m_2 = 1$, where m_1 and m_2 correspond, respectively, to the number of I(1) and I(2) variables included in the multicointegration regression.

As shown in this table, the values obtained for (t^*_δ) never exceed their corresponding critical values at standard significance levels. This result is robust across all models, namely both for those allowing for one structural break only in deterministic regressors (models [A], [B]), and for more general specifications allowing for one structural break also in stochastic regressors (models [C], [D], [E]).

Overall, the empirical evidence summarized in Table 2 strongly rejects the existence of multicointegration in this system of I(2) fiscal variables. The null hypothesis of cointegration at first-level ($u_t \sim$ I(1)) is never rejected against the alternative hypothesis of multicointegration in

the presence of one structural break in deterministic and stochastic regressors ($u_t \sim I(0)$). These results, therefore, document that Poland's cumulated fiscal variables cointegrate into an I(1) process (i.e. they are CI (2,1)), but not into an I(0) process (i.e. they are not CI (2,2)).

The robustness of these findings was assessed in a slightly different framework where the flow fiscal variable (ΔX_t) is removed from equation (1), thus imposing *a priori* the restriction $\beta_{11} = \beta_{12} = 0$. In formal terms, this means working inside a simple I(2) cointegration framework allowing for structural breaks, instead of the equivalent multicointegration set up considered above. These additional estimates reiterate the existence of non-stationary I(1) residuals for all model's specifications.

It is well known that the absence of multicointegration precludes to obtain consistent estimates of model's parameters (see Haldrup, 1994, Theorem 1, p. 160; Berenguer-Rico and Carrion-I-Silvestre, 2011, Mathematical Appendix, pp. 315-320). It is interesting to observe, however, that all estimated models allowing for a potential structural break in the stock variable (i.e. models [C] and [E] allowing for $\beta_{22} \neq 0$) pinpoint a drastic reduction in comovements of cumulated revenues and expenditures during the final part of the sample.

This result is consistent with the pattern of cumulated fiscal variables reproduced in Figure 1, and with the empirical evidence of Tronzano (2017) documenting a sharp deterioration of Poland's fiscal position in more recent years.

2.3 Discussion and Policy Implications

A major advantage of the multicointegration approach with respect to standard cointegration tests frequently used in the applied literature is that it allows to evaluate the sustainability of fiscal policy in a stochastic environment (see e.g., among others, Leachman *et al.,* 2005, Kia, 2008, Kiran, 2011). In this environment, characterized by the assumption of a time-varying discount factor, particularly adverse economic shocks (i.e. "bad" states of nature) may generate a negative gap between the real growth rate of the economy and the real interest rate, thus invalidating the sustainability of the fiscal process.

In this context, fiscal sustainability requires not only the existence of an equilibrium relationship between "flow" variables (i.e. revenues and expenditures), but also a significant

policy response of the government to prevent a destabilizing pattern in public debt (i.e. an additional "stock-flow" equilibrium relationship).

Thus, differently from the standard cointegration approach, multicointegration tests provide a consistent econometric framework to assess the validity of the intertemporal budget constraint in a stochastic environment.

The main result of this paper is that Poland's fiscal policy is not sustainable in this more complex environment, even allowing for potential structural breaks in deterministic and stochastic variables. Moreover, I show that this result is robust to alternative specifications of the underlying multicointegration regression.

Since the I(2) system of fiscal variables cointegrate into an I(1) process (CI (2,1)), but not into an I(0) process (CI (2,2)), the stock of public debt is I(1). Overall, therefore, notwithstanding the existence of a long-run equilibrium relationship between revenues and expenditures flows, fiscal sustainability criteria are not supported in the present empirical investigation.

The evidence summarized above discloses substantial analogies with my previous applied research on Poland.

The existence of first-order cointegration, namely of a long-run equilibrium relationship between revenues and expenditures flows, corroborates the findings obtained in Tronzano (2017), which document that Poland's fiscal policy is "weakly" sustainable while revenues and expenditures do not tend to drift too far apart in the long-run.

Moreover, the absence of multicointegration in the I(2) system of cumulated fiscal variables reiterates, in the context of a model allowing for regime-shifts, the results obtained in Tronzano (forthcoming) using a standard single-step multicointegration test.

Since the empirical evidence obtained in the present paper is fully consistent with my previous research, the main policy implications outlined in Tronzano (2017, and forthcoming) remain unchanged.

Tronzano (2017) calls for a further consolidation of the ongoing process of fiscal consolidation in Poland, since the persistence of a positive gap between expenditures and revenues flows ("weak" sustainability) might create difficulties for the government in marketing its debt. This policy prescription retains its validity in the present context where, as discussed before, the pattern of cumulated expenditures exhibits a persistent excess over that of cumulated revenues, and

parameters estimates detect a drastic reduction in the comovements of these variables during the final part of the sample.

Turning to Tronzano (forthcoming), the present paper confirms the absence of multicointegration in the context of a more sophisticated econometric framework.

The absence of multicointegration implies that the fiscal process in Poland lacks a systematic policy response mechanism preventing excessive stock-flow disequilibria (and the consequent risk of Ponzi schemes or gambles on public debt, see e.g. Bohn, 1995, Leachman *et al.*, 2005).

In the light of this evidence, another relevant policy prescription is that the Polish government should establish a more robust link between tax and expenditures policies and the evolution of public debt. A closer connection between fiscal policy guidelines and the evolution of public debt is crucial in order to ensure fiscal sustainability in a stochastic environment. Therefore, in line with Tronzano (forthcoming), this paper suggests that the ongoing process of fiscal consolidation should be implemented in the context of explicit targets for medium term debt dynamics, namely in the presence of a systematic reaction of fiscal flows to contingent disequilibria in public debt.

3.   CONCLUDING REMARKS

This paper extends the empirical investigation of Tronzano (forthcoming) reassessing the sustainability of Poland's fiscal policy in a stochastic environment. Differently from my previous contribution, which relies on a standard single-step multicointegration test, this paper implements a more sophisticated econometric framework allowing for structural breaks in deterministic and stochastic regressors. Accounting for potential regime-shifts represents an interesting extension of previous research, in the light of the structural breaks documented in Tronzano (2017) and of a visual inspection of cumulated fiscal variables. The main findings may be summarized as follows.

The null hypothesis of cointegration at first-level is never rejected against the alternative hypothesis of multicointegration in the presence of regime-shifts. This result is robust across all models specifications, and closely in line with the empirical evidence achieved in Tronzano (forthcoming). Overall, this strong result against the existence of multicointegration implies that Poland's fiscal policy is not sustainable in a stochastic environment.

There are two main policy implications to be drawn from the present research.

First, although the evidence points out that revenues and expenditures flows do not tend to drift too far apart (first-order cointegration), a prosecution of the fiscal retrenchment process is needed, given the permanent excess of expenditures over revenues.

Second, since the absence of multicointegration implies the lack of a systematic policy response to excessive stock-flow disequilibria, this fiscal consolidation process should be implemented in the context of explicit targets for medium term debt dynamics. In the absence of multicointegration, the stock of outstanding debt follows an I(1) stochastic process. Introducing a systematic policy response of fiscal flows to excessive debt accumulation drives debt dynamics on a stable equilibrium path, and thus allows meeting fiscal sustainability criteria in a stochastic environment.

These policy prescriptions are consistent with those reached in Tronzano (2017, and forthcoming), but also with some recent results obtained by other authors.

Fiscal policy reaction functions estimated in Redzepagic and Llorca (2007) reveal the lack of a positive response of the primary surplus to changes in debt in Poland; moreover, differently from other CEEC, these authors detect the existence of electoral and partisan fiscal cycles in this country. Using the same approach, Stoian and Campeanu (2010) conclude that sustainable fiscal policies are more difficult to obtain, in Poland, given the lack of a corrective response of the government to public debt shocks, and suggest that severe fiscal adjustments should be made in order to reach fiscal sustainability in the long run.

Overall, therefore, a credible fiscal consolidation along the guidelines indicated above is important in order to allow Poland to relinquish an autonomous monetary and exchange rate policy and join the Euro area in the near future.

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