Analysis of exchange-rate regime effect on growth: Theoretical channels and empirical evidence with panel data

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Abstract

The aim of this paper is to empirically investigate the relationship between exchange-rate regime and economic growth, building on underlying theoretical examination and shortcomings of empirical literature. The natural-rate hypothesis implies that the best that macroeconomic policy can hope to achieve is price stability in the medium-term. An attempt to over-stimulate economy, by expansionary monetary policy or currency devaluation will result in higher rate of inflation, but no increase in real economic growth (Goldstein, 2002). Hence, as a nominal variable, exchange-rate regime might not affect long-run economic growth.

Many studies argue that the linkage between regime and growth exists, but the sign of influence is ambiguous. Theoretically, channels through which regime might influence growth could be distinguished at: i) level of uncertainty imposed by certain regime, which than affects trading and investment decisions; ii) regime as shock absorber; iii) its linkage to productivity growth, which usually interferes with financial development. However, academicians dispute that not only certain regime differently affects growth through these channels, but also no consensus is reached on the sign of inference when one channel is considered (Levy-Yeyati and Sturzenegger, 2002; Ghosh et al. 1997; Eichengreen and Leblang, 2003). Empirical research offers divergent result though. While one group of studies found that a peg stimulates growth, another group concluded the opposite holds; third group concluded no relationship or inconclusive results. The empirical literature is, however,

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criticized because of: measurement error in regimes' classification; appropriateness of growth framework; endogeneity of exchange-rate regime and/or other regressors; Lucas critique – if parameters change when regime switches; sample-selection bias (big- and diversified-enough sample) and survivor bias (excluding high-inflation episodes) (Petreski, 2008).

Applying dynamic system-GMM panel estimation on 169 countries over the period 1976-2006 and addressing all shortcoming of the empirical literature, this paper finds that the exchange-rate regime is not statistically significant in explaining growth. The conclusion is robust to dividing the sample on developing versus advanced countries and considering two sub-periods. In all specifications, the exchange-rate regime does not even approach conventional significance levels. Observation de-facto versus de-jure regime matters neither. No empirical grounds were established that coefficients in the regression suffer the Lucas critique. Hence, the main conclusion is that, as nominal variable, the exchange rate regime does not have explanatory power over growth.

Keywords: exchange-rate regime, economic growth

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1. Introduction

The aim of this paper is to test the relationship between the exchange-rate regime and economic growth. The natural-rate hypothesis implies that the best that macroeconomic policy can hope to achieve is price stability in the medium-term. In terms of exchange-rate policy, the nominal exchange rate can not be used to keep unemployment rate away from its natural level on a sustained basis. Therefore, an attempt to over-stimulate the economy, by expansionary monetary policy or currency devaluation will result in higher rate of inflation, but no increase in real economic growth (Goldstein, 2002). Hence, as a nominal variable, the exchange rate (regime) might not affect the long-run economic growth. However, there is no unambiguous theoretical evidence what impacts the exchange-rate target exhibits on growth.

Many studies argue that the linkage between regime and growth exists, but the sign of the influence is blurred. The channel through which the regime might influence growth is trade, investment and productivity. Theoretical considerations relate the exchange-rate effect on growth to the level of uncertainty imposed by flexible option of the rate. However, while reduced policy uncertainty under a peg promotes an environment which is conductive to production-factor growth, trade and hence to output, such targets do not provide an adjustment mechanism in times of shocks, thus stimulating protectionist behaviour, price distortion signals and therefore misallocation of resources in the economy. Consequently, the relationship remains blurred and requires in-depth empirical investigation.

The empirical research offers divergent result though. While one group of studies found that a pegged exchange rate stimulates growth, while a flexible one does not, another group concluded the opposite holds. Moreover, a third group of studies came up with no effect or inconclusive results. The latter could be due to a measurement error in the exchange-rate regimes' classifications, divergences in measuring exchange-rate uncertainty or sampling errors. A big part of the studies focuses on the parameter of the exchange-rate dummy, but does not appropriately control for other country-characteristics nor apply appropriate growth framework. Also, the issue of endogeneity is not treated at all or inappropriate instruments are repeatedly used. Very few studies disgracedly pay small attention to the capital controls, an issue closely related to the exchange-rate regime and only one study puts the issue in the context of monetary regimes. Overall, the empirical evidence is condemned because of growth-framework, endogeneity, sample-selection bias and the so-called peso problem.

This paper aims to establish the relationship between exchange-rate regime and output (growth and volatility) by considering the theoretical arguments and by accounting for all drawbacks present in the current literature. It investigates data for 169 countries over the period 1976-2006. We find that the exchange rate regime is not significant in explaining output growth. No empirical grounds were established for the coefficients in the regression as suffering from the Lucas critique. Observing two sub-periods or developing countries only led to the same conclusion – the insignificance of the exchange-rate regime. Using the de-facto versus de-jure classification of exchange rates did not matter in that respect. Specifically, although the de-facto classification accounts for the actual behaviour of the exchange rate, including any capital controls and any devaluation or crises episodes, which were all apparent in the developing, including transition, economies during 1990s and early 2000s, the conclusion is the same – the exchange-rate regime does not affect economic growth, no matter the classification, observed time period or level of development of countries. The duration of peg is also not of importance. The duration and developing-countries group was especially considered for the period 1991-2006, with numbers of episodes of devaluation and currency crises, which were expected to have played a role in affecting growth. However, these expectations proved incorrect.

The paper is organized as follows. The next section investigates the theoretical channels through which the exchange-rate regime might affect growth and particularly focuses on how it might affect production factors and hence growth. It then summarizes all studies published on the relationship between exchange-rate regime and growth, focusing on their possible flaws. Section three pursues the empirical strategy, with special focus on the approach toward the issues not captured in the current literature. Section four portrays the data and offers some descriptive statistics. Section five describes the methodology. Section six presents the results and offers discussion. The last section concludes the paper.

2. Theoretical overview and literature review

2.1. Does exchange-rate pegging matter for growth?

A narrow part of the academic literature (Domac *et al.*, 2004b; Levy-Yeyati and Sturzenegger, 2002; Moreno, 2000 and 2001; Edwards and Levy-Yeyati, 2003; Husain *et al.*, 2004; De Grauwe and Schnabl, 2004; Eichengreen and Leblang, 2003; Bailliu *et al.*, 2003) investigates the *exchange-rate regime's effect on economic growth*. However, investigation of the relation between peg and growth has evoked considerably less research, compared to the research on the relation between peg and inflation, "probably due to the fact that nominal variables are typically considered to be unrelated to longer-term growth performance" (Levy-Yeyati and Sturzenegger, 2002, p.2). In that line, Goldstein (2002) argues that the natural-rate hypothesis implies that the best that macroeconomic policy can hope to achieve is price stability in the medium-term. In terms of exchange-rate policy, the nominal exchange rate can not be used to keep unemployment rate away from its natural level on a sustained basis. Therefore, an attempt to over-stimulate the economy, by expansionary monetary policy or currency devaluation will result in higher rate of inflation, but no increase in real economic growth (Barro and Gordon, 1983). Hence, as a nominal variable, the exchange rate (regime) might not affect the long-run economic growth. There is no unambiguous theoretical evidence what impacts the exchange-rate regime exhibits on growth.

Economic theory does not noticeably articulate if and how the exchange-rate regime and particularly the exchange-rate peg affects growth. Instead, arguments typically focus on its impact on investment and international trade. Levy-Yeyati and Sturzenegger (2002) argue that the linkage between regime and economic growth exists, but the sign of the influence is blurred. Advocates of pegs usually highlight that by the reduced *policy uncertainty* and lowered interest-rates variability, this strategy promotes an environment which is conductive to trade, investment and, hence, growth. Gylfason (2000) explains that the macroeconomic stability (certainty) imposed by pegging promotes foreign trade, thus "stimulating economic efficiency and growth over the long haul and restraining inflation, which is also good for growth" (p.176). Fixing the exchange rate may enable faster output growth in the medium and long run by supporting greater openness to international trade. Also, the latter may spur growth by easing technology transfer, thus aiding the productivity growth, and which in turn is boosted by promoting greater openness (Moreno, 2001). De Grauwe and Schnabl (2004) argue that there will be higher output growth under a peg because of two factors: first, the eliminated exchange-rate risk which stimulates the international trade and the international division of labour; second, a credible fix promotes certainty, as argued above, thus lowering the country risk-premium embedded in the interest rate. Low interest rates in turn stimulate consumption, investment and growth.

Nilsson and Nilsson (2000) explore the impact of the exchange-rate regime on exports for developing countries. They argue that for developing countries, export-led growth is the *spiritus movens* for overall development, on one hand, while on the other, developing countries' exporters are severely affected by exchange-rate misalignments and volatility. That is to say, they are additionally harmed as to their market power and thus motivated to change export quality. Brada and Mendez (1988) further deepen this hypothesis. They argue that apologists of pegs assert that flexible rates depress the volume of international trade in two ways: either through the exchange-rate uncertainty for conducting foreign trade, or throughout erecting trade barriers as a reaction to the increased exchange-rate volatility. Likewise, Domac *et al.* (2004b) point out that because of the uncertainty imposed, a floating regime may hamper international trade. However, the same papers emphasize the efficiency of floats in correcting balance of payments disequilibria as their advantage, which in turn will enable internal stability to be achieved quicker.

The preceding notions are related to the exchange-rate risk which stems from allowing the rate to float. This risk is restrained with an exchange-rate target, completely with a currency board or irrevocable peg or considerably with an exchange-rate band or crawling peg/band. Then the relation between an exchange-rate target and trade could be straightforward: a stable macroeconomic environment promotes bilateral trade. However, Viaene and de Vries (1992) argue that such a straightforward assumption of a negative link between uncertainty and trade may not be appropriate, because agents might amplify their incentives to trade more under intensified exchange-rate fluctuations, depending on their risk aversion. Dellas and Zilberfarb (1995) found a significant positive link between exchange-rate variability and trade growth; however they acknowledged that (exporters') risk-aversion matters. Namely, a low level of risk aversion could imply positive effect; nevertheless a developed forward market could be helpful and serve as shock absorbers by supplying a variety of hedging instruments. If exporters are provided with an efficient vehicle for hedging exchange-rate risk such as forward markets, increased exchange-rate volatility could ultimately have positive effects (Bailliu *et al.*, 2003). However, such instruments are unavailable in developing markets. Furthermore, advocates of pegs blame floats for throwing bewilderment at the international market as to the exporters' competitiveness (Grubel, 2000), consequently promoting recourses' misallocation (Gylfason, 2000) and in that manner harming growth.

In line with what has been said for the relationship between regime and trade, Bohm and Funke (2001) suggest that the channel through which the exchange-rate regime influences investment is the level of uncertainty. That is, when the latter is reduced, investment is increased and therefore, new-jobs creation and output (Bohm and Funke, 2001).

The degree to which the concept of uncertainty imposed by the exchange-rate regime is essential, is the concern of the study of Dixit (1989), who states that instability leads to disinvestment or puts off already planned investment. In the same line of thinking, Krugman (1991; cited in Bohm and Funke, 2001) affirms the belief that exchange-rate volatility will "warm up" the reasons for taking on "a 'wait and see' attitude towards both investment and trading decisions" (p.3). In sum, the literature relates the exchange-rate regime to investment via the uncertainty imposed by the former. However, it offers negligible evidence of this relation which could be ascribed to the fact that the decision to invest internationally, or to engage in the international capital flows, is dependent not only on the exchange-rate system and the perception of uncertainty, but on other, probably more real factors as well (Crowley and Lee, 2003).

Bailliu *et al.* (2003) argue that regime's influence on growth could be direct, through the regime's effect on *shock adjustments*, or indirect, through *investment, international trade and financial sector development*. The first effect is channelled by "dampening or amplifying the impact and adjustment to economic shocks" (p.385), thus allowing a flexible rate to enable fast and easy accommodation and absorption of aggregate economic shocks. Consequently, "when the adjustment to shocks is smoother, one would expect the growth to be higher, given that the economy is, on average, operating closer to capacity" (p.385). This could stimulate protectionist behaviour, distorted price signals and therefore misallocation of resources in the economy (Levy-Yeyati and Sturzenegger, 2002). However, Nilsson and Nilsson (2000) argued that exchange-rate volatility under flexible option of the exchange rate could be the one that stimulates erecting trade barriers; hence, the literature is not consensual on this issue. McKinnon and Schnabl (2003), as an example, illustrate that before the Asian crisis of 1997/98 the exchange-rate stability against the US dollar contributed to low inflation and the sound fiscal position. The resulting stable expectations then promoted investment and boosted long-term growth, which has become known as the East Asian miracle. But the miracle came to an end because it was inefficient in absorbing shocks!

Friedman (1953) explains that flexible rates act as absorbers of external shocks; under exchange-rate peg, the adjustment is channelled through the change in the relative price level. But, in a world of Keynesian prices, the adjustment is slow, thus creating an excessive burden in the economy and ultimately harming growth. Furthermore, under perfect (or at least high) capital mobility, interest rates changes produce high costs for the economy, in attempts to defend a peg when the currency is under attack. Fisher (2001), in that regards, explains that in modern times, free capital across borders makes pegs unsustainable, leading to severe recessions in times of crisis.

The indirect effects for the relationship between exchange-rate regime and trade and investment mentioned by Bailliu *et al.* (2003) were established above. In general, the lower the uncertainty warranted by pegging the currency, the higher the trade and investment. However, the more risk averse the traders, the more will trade when the exchange rate is volatile. Moreover, the peg does not provide a buffer mechanism when shock hits the economy. The buffer could be nevertheless found in the level of development of the financial system. The latter is closely related to peg's effect on productivity growth. Ghosh *et al.* (1997), Garofalo (2005) and Collins (1996) all deal with the relationship between the peg and growth. The first paper argues that a peg enhances investments, but a float produces faster productivity growth. Reverting to the production function and specifically to the Solow model of growth, output growth could be promoted if one of the *production factors (labour and capital) or the total factor productivity*, or all three, increase. Therefore, if there is considerable evidence that an exchange-rate target promotes investment, then the lower output under a peg has to be associated with slower productivity growth. Moreover, a part of the spurred productivity growth under more flexible option of the exchange rate is associated with faster growth of the international trade.

The peg's impact on productivity growth is especially emphasised in emerging markets, where credit markets appear to be thin. However, the ultimate effect of the peg channelled through productivity growth remains unclear. For instance, Aghion *et al.* (2005) argue that an aggregate external shock, under a peg, transmits into real activity and causes a higher share of the firms in the economy to experience credit constraints, given the under-developed financial market. Suppose that producers can decide whether to invest in short-run capital or in a long-term productivity-enhancing venture. Typically, the long-term productivity-enhancing investment creates higher need for liquidity in order to face medium-term idiosyncratic liquidity shocks, the latter mainly stemming from the aggregate shock that hit the economy. With perfect credit markets, the necessary liquidity is always supplied, but this is no longer the case when credit markets are imperfect. The liquidity shock is only financed when the firm has enough profits, because only profitable firms can borrow enough to cover their liquidity costs. A negative aggregate shock, by making all firms less profitable, makes it less likely that the liquidity needs of any of them will be met. As a result, a fraction of the potentially productivity-enhancing long-term investments will go to waste, with obvious consequences for growth. A main implication is that firms in countries with better financial markets will deal better with the aggregate shock, and therefore will tend to go more for long-term investments, which in turn should generate higher aggregate growth, while the shock in developing markets will result in distorting real activity and lower productivity growth.

In conclusion there are some theoretical channels through which the exchange rate regime affects growth: i) uncertainty imposed in the economy and its effect on investment and trade; ii) shock-adjustment mechanism, the level of financial development and their interference with productivity growth. However, directions in which the regime may impinge on productivity, investment, trade and thus, on the output growth are ambiguous. Hence, the relationship between the exchange-rate regime and growth becomes an empirical issue and is further debated in the next sections.

2.2. Evaluating the empirical evidence of the growth effects of exchange-rate regimes

Since economic theory does not reveal clear foundations for the relationship between the exchange-rate target and economic growth, the issue becomes empirical. However, the few published empirical studies have also indicated divergent results. These are summarized in table 1 at the end of this section and reviewed as the section proceeds. The methodological approach of the studies is the criterion through which these are examined in this section.

Two classic papers, Baxter and Stockman (1989) and Mundell (1995) compare growth between the two periods: the period of the fixed exchange rate system and the one under the generalized floating in the US and four other regions. The first study concluded that exchange-rate arrangements do have little effect on the key macroeconomic variables. The second found that the former period of fixed rates achieved better performance in all respects, including the real per capita growth. However, the simple comparison does not proceed with an econometric analysis which would discover significant causal relationships. Ghosh *et al.* (1997) provides a descriptive analysis (means and standard-deviation comparisons across regimes) of the growth performance under alternative regimes in 145 IMF-member countries for 30 years after 1960 and found a slightly higher GDP growth under a float (1.7% under floating compared to 1.4% under a peg). The study concludes that as investment rates contributed two percentage points of GDP, then the lower output growth under a peg must be a result of a slow productivity growth. Higher productivity growth under a float also supported the growth of external trade. However, the evidence is not overwhelming. Surprisingly, growth appeared to be the highest (2%) under an intermediate regime (soft pegs of managed float). Switching to a floating regime resulted to improved growth by 1 percentage points (p.p.) in three years. Moreno (2000; 2001) in his two studies, also using descriptive statistics, measured how the regime (actual behaviour) affected GDP growth and volatility on a sample of 98 developing countries and East-Asian countries, respectively, over the period 1974-1999. His work supports the view that real growth used to be higher under a peg by 1.1 p.p. and 3 p.p, respectively. The difference is robust to excluding the periods of currency crises preceded by a peg and excluding the top 1% high-inflation episodes. However, Moreno accounts for the so-called survivor bias (excludes sharp devaluation episodes which could be attributed to policies adopted while pegging) and finds that the growth difference between regimes significantly narrows. Both studies do not provide sufficient evidence that growth is a causal effect of the exchange-rate regime; in addition, as the growth of investment and output are opposite under certain regimes, the study prescribes the result on productivity, which is the residual. However, there are no any figures to confirm neither this nor an explanation of how the exchange-rate regime effect might be channelled to productivity.

Levy-Yeyati and Sturzenegger (2002) examined the issue with a sample of 183 countries in the post-Breton-Woods era (1974-2000), using a pooled regression, estimated by OLS applied to annual data. The study presents a minimal-growth framework, necessary to examine the exchange-rate regime effect on growth, and consistent with both the neoclassical and endogenous-growth models: the growth being a function of state and control variables. The former accounts for initial conditions and belong to the neoclassical framework; the latter capture differences in steady-state levels across countries. In an endogenous-growth model, an economy is assumed to always be in its steady state, and therefore the explanatory variables capture differences in steady-state growth rates. The specification can be used to explain either what determines differences in transitional growth rates across countries as they converge to their respective steady states (consistent with a neoclassical framework), or what determines differences in steady-state growth rates across countries (consistent with an endogenous-growth framework). We will return to the growth framework in sections 4 to 6. Levy-Yeyati and Sturzenegger (2002) used the variables listed in table 1; population variable controls for the size of the economy, as the choice of exchange-rate regime is expected to be related to size. Specifically, the study tests the effect of hard pegs, explaining that conventional pegs (which might exhibit flexibility to limited extent) may fall short of credibility and thus making the strong commitment under hard pegs necessary. Findings for developing countries are that a peg is likely to be associated with slower growth; however, the conclusion does not hold for industrial countries. Edwards and Levy-Yeyati (2003) and Husain *et al.* (2004) use the same growth specification as in Levy-Yeyati and Sturzenegger (2002) to investigate the same issue. The first study investigated the period 1973-2000 over 183-country sample and using de-facto classification. It found that countries with fixed exchange-rate regimes have had a lower rate of per-capita growth ranging between 0.66 and 0.85 p.p. per year, than compared with a flexible regime. The second study investigated the period 1970-1999 over 158-country sample using de-jure exchange-rate regimes and found that neither pegs harm growth nor flexible rates support growth. Husain *et al.*'s (2004) study is very weak on robustness checks.

Because of possible simultaneity between growth performance and the exchange-rate regime, Levy-Yeyati and Sturzenegger (2002) use a feasible generalized two-stage IV estimator. As instrument, they use the predicted value of the exchange-rate dummy from a formerly estimated logit model, whereby country's economic size, land area, island dummy, level of reserves and a regional exchange-rate dummy are used as regressors. Yet, the authors point out that endogeneity, if found to exist, might be weaker for growth than for inflation in respect to exchange-rate regime, due to the general inconclusiveness of the channels through which exchange-rate regime might influence growth. The findings strengthen the negative causation originating from the peg to growth, i.e. the relationship is robust to estimation allowing for the endogeneity. However, the regressors entering the logit regression might directly enter the growth regression and will simultaneously allow for correction of potential endogeneity of the other growth determinants. The latter is not assumed to be the case. The other two studies, although aware of the issue, do not allow for endogeneity in their empirical work.

The hypothesis that exchange-rate regime affects growth is investigated by Garofalo (2005) for the case of Italy over the period 1861-1998, with the same variables as in Levy-Yeyati and Sturzenegger (2002). The study used the OLS technique to estimate the specified regression and results indicate that Italy experienced the highest growth rates under some form of intermediate regime. To correct the potential endogeneity bias stemming from the direction of the link between growth and peg, Garofalo (2005) utilized two-stage IV estimation with heteroskedasticity consistent standard errors and the estimation suggested that pegging slows growth rather than low growth suggests imposing a peg.

Dubas *et al.* (2005) regress per capita growth on a set of growth control variables (listed in table 1) and a set of exchange-rate dummies for 180 countries in the period 1960-2002. The study utilizes random-effects panel estimation and finds that the highest growth rates are associated with de-facto fixers, which experience, on average, 1% faster growth than de-facto floaters. The conclusion is statistically significant for the non-industrial countries only. The same conclusion applies when the exchange-rate dummies are replaced with an indicator for the exchange-rate stability. However, the study does not report the coefficients on the control variables, which is important for considering if the growth model is suitable for such analysis; also, there are no robustness checks which might confirm the stability of the obtained coefficients, at least for the variables of interest. However, the study makes a pioneering approach to the issue if the distinction between de-jure and de-facto exchange-rate regime matters for growth. The evidence that such distinction matters for industrialized countries is scarce, but some important insights for non-industrial economies are found: countries that de-jure float, but de-facto peg are estimated to grow at 1.12% above countries that de-facto and de-jure float; countries that de-jure and de-facto peg are estimated to grow at 0.64% above countries that de-facto and de-jure float. In conclusion, countries displaying fear of floating experience significantly higher per-capita growth. The study does not take into account the sample-selection problem by not reporting whether these results could be assigned to the exchange-rate regime itself or to some other factors. Namely, the sample might be biased towards countries that have experienced currency crises, which would have led to severe economic outcomes. The latter in turn, burrs the relationship regime – growth. Moreover, the stud does not treat the potential endogeneity bias.

Huang and Malhorta (2004) examine the relationship between exchange-rate regime and growth by paying attention on two aspects: exchange-rate-regime classification and differentiation between developing and developed economies. They augment earlier approaches with the classification issue and achieve firm de-facto classification of exchange-rate regimes. In addition, the differentiation of the level of development should help in demystifying if financially underdeveloped economies need a credible anchor, whereas the latter does not matter for developed economies. The study uses 12 developing Asian countries and 18 advanced European economies over the period 1976-2001. No special cautions are considered when constructing the sample. It utilizes descriptive statistics and regression variables as presented in table 1; some of the minimally-needed variables for credible regression are missing, which might lead to omission variables bias and, hence, further proliferation of the endogeneity bias, because those could also interfere with the exchange-rate dummy (like inflation, population or the political indicator). Findings suggest that the exchange-rate regime matters for developing economies: fixed and managed floating regimes outperform the others in terms of growth. However, for advanced economies, no significant regularity is discovered. Albeit the study makes considerable effort to highlight the importance of the proper classification of regimes and models advanced versus developing economies in separate regressions, still some criticism remains. The growth framework used is weak: the independent variables included do not coincide with the conventional persuasion of what basically determines growth. No diagnostics checking is offered and the R-squared is very low. Robustness checks are also weak and endogeneity seems to be further proliferated instead of being corrected.

The study of Bleaney and Francisco (2007) also pays attention to the regime classification. It utilizes de-facto classification carried out by previous studies, including 91 developing countries over the period 1984-2001. They regress the growth rate on its lagged value, exchange-rate dummies and time dummies and exclude high inflation-periods. Findings are that pegs are associated by significantly slower growth than soft pegs or floats. However, no theory-consistent growth framework is applied; there are many insignificant variables, suggesting that the specification might suffer from high level of colinearity; endogeneity is not considered; robustness checks are not offered. It could be argued, the study cannot see the forest from the trees: it pays to much attention on the classification schemes and too little to other important issues.

A different approach that opts to address the problems that undermine the robustness of the previous findings is carried out by Domac *et al.* (2004b). At an outset, they accentuate that the effect of the regime on growth could not be independently revealed if macroeconomic fundamentals and institutional arrangements are not considered. Also, the study criticises previously mentioned studies (and, essentially all studies published on the topic) for their failure to capture the change in regression parameters when the exchange-rate regime switches and hence to reflect the Lucas critique. In addition, as the sample-selection problem is not addressed in these earlier studies (since the choice of the exchange-rate regime depends on macro-fundamentals and is not random), Domac *et al.* (2004b) argue that the error term in a standard equation would be correlated with the regime choice and thus parameters would be biased. Addressing this issue, thus will address the endogeneity problem.

They trial several investigations of the link investigated in this section, but their findings are inconclusive. However, the technique applied deserves some attention since it is alone in the literature to address the outlined issues. Namely, the study analyses the relationship between exchange-rate regime and growth with a *switching regression technique*, by a specifying separate regression for each regime:

$$Y_i = X_i B_1 + u_{1i} \quad \text{if} \quad \nu_i < Z_i \gamma + \alpha_1 ; \quad i = 1....I_1 \tag{1}$$

$$Y_i = X_i B_2 + u_{2i} \quad \text{if} \quad Z_i \gamma + \alpha_1 < \nu_i < Z_i \gamma + \alpha_2 ; \quad i = 1....I_2 \tag{2}$$

$$Y_i = X_i B_3 + u_{3i} \quad \text{if} \quad \nu_i > Z_i \gamma + \alpha_2 ; \quad i = 1....I_2 \tag{3}$$

Where u_{ij} is i.i.d. N~(0,σ_j); v_{ij} is i.i.d. N~(0,1); cov(u_{ij};ν_j)=σ_{jv}; j=1,2,3; α_1, α_2, and γ are parameters which are obtained by ordered-probit approach. Equations (1)-(3) correspond to different regimes. The same set of independent variables is employed in each equation in order to test the equality of parameters across regimes.

The regime is determined by the realization of normally distributed random variable ν_j which is not observable. However, the expected value of u_{ij}, given the value of ν_j, could be derived with appropriate density and cumulative normal distribution functions. Given that, the ultimate equations are as follows:

$$Y_i = X_i B_1 - \sigma_{1v} h_{1i} + e_{1i} \tag{4}$$

$$Y_i = X_i B_2 - \sigma_{2v} h_{2i} + e_{2i} \tag{5}$$

$$Y_i = X_i B_3 - \sigma_{3v} h_{3i} + e_{3i} \tag{6}$$

The X_i matrix includes: fiscal balance; the change in liberalization index; inflation and other initial factors (as specified in table 1). The most important test in this estimation is the one that tests the hypothesis of no different output outcomes and variances among different regimes (H_0: $B_1 = B_2 = B_3 = 0; \sigma_{1v} = \sigma_{2v} = \sigma_{3v} = 0$) against the alternative hypotheses that all these differ from zero. Based on the empirical results, the study does end up with the inference that there is no particular exchange-rate regime being superior to another in terms of growth performance. However, the study suggests that there is an association between exchange-rate regime and growth but the strength of the coefficient is found to be different under different exchange-rate arrangements. Nonetheless, the low explanatory power of the regression does not offer firm conclusions about the link between exchange-rate regime and growth.

The technique pursued by Domac *et al.* (2004b) is rare in the exchange-rate regime literature. However, in terms of robustness of results, it provides sufficient superiority over techniques which employ exchange-rate dummies in reduced-form equations. In particular, as the authors emphasize, these coefficient estimates for the exchange-rate dummy variable are intended to reveal the effect of the applied exchange-rate regime on growth. But, in times of regime switch, the coefficients associated with policy variables also change – an aspect mentioned at the very beginning of this study and referred to as the Lucas critique. In light of this, the approach of Domac *et al.* (2004b) is superior over the other approaches as it models each regime in a separate regression allowing for time-variant estimates of the effect of the independent variables. While this technique directly addresses the sample-selection problem (the biasness of the regime choice), by a modelling of the different regimes in separate equations, it also addresses the endogeneity issue by specifying constant covariance between the error term in the structural equation and the normally distributed random variable whose realization determines the exchange-rate regime. Nevertheless, some caution in interpreting the results are needed: the study uses de-jure classification, a short time period (less than 10 years for the majority of countries in the 1990s) and 22 transition countries. Hence, albeit the results might be applicable for transition economies, the exchange-rate-regime effect on growth in general remains ambiguous.

De Grauwe and Schnabl (2004) carried out a growth-model investigation of 10 CEE countries for the period 1994-2002. To the standard set of variables explaining growth (ehich, however, lack the initial conditions; see table 1), they added a measure of exchange-rate stability. The endogeneity issue (but not the sample-selection one) is removed by utilizing GMM technique; GMM uses a full set of valid lags of all endogenous and exogenous variables as instruments. The technique however is superior to Domac *et al.*'s (2004b) as it may create more effective instruments. In this study, the real growth of EU and the dummy for the Russian crises are assumed to be exogenous, while all the others are endogenous. Additional variables (like openness, export concentration to EU and a measure for the volatility of the official reserves) could be used as instrumental variables. Without attempting an exhaustive explanation of results, this study suggests that the exchange-rate pegging promotes growth in the CEE countries, the results being more significant than studies that use all-country samples.

Considering the endogeneity problem when investigating the effect of the exchange-rate regime on growth, Eichengreen and Leblang (2003) investigated the issue on a sample of 21 countries over the period 1880-1997. They use instrumental variables and dynamic panel estimators which contain internal instruments to eliminate bias arising from possible endogeneity of the independent variables. The independent variables used are given in table 1; averages over 5-year period are used; however, some of the standard-growth-regression variables are still missing. The study advances the issue of the inclusion of the economy in the global capital markets, approximating it by a dummy variable for capital controls. However, the study is problematic in another way: it uses long period within which the international monetary environment has been subject to considerable change: the effect of the generalized pegging under Bretton Woods and that of pegging today on growth might be different (due to capital restrictions, say). Also, the sample could be biased towards countries that use a flexible or floating rate but are developed because of other reasons. The overall finding is that pegged economies perform worse than compared to flexible-rate ones by 5.2 to 8.6 p.p. per annum in terms of per capita growth. Nevertheless, these findings seem considerably high; in that line, the results are not robust.

Distinct from previous studies, Bailliu *et al.*'s (2003) research turns the focus from the exchange-rate regime to another important aspect of the story, that is, the *monetary-policy framework* applied along with the exchange-rate regime. They accentuate their belief that the exchange-rate anchor is a monetary anchor simultaneously, thus providing firm grounds for appropriate assessment of the link regime-growth. On the other hand, intermediate and floating regimes might be associated with weak monetary regimes which will reflect upon the mentioned relationship. Explicitly, Bailliu *et al.* (2003) assessed the impact of regime on growth on a panel data set of 60 countries over period 1973-1998 using the dynamic GMM technique in order to correct the endogeneity bias and the correlation between the unobserved country-specific effects and the explanatory variables. The variables included are those identified in the other studies; these are averaged over 5-year period. The exchange-rate regime is averaged as well, grouped into pegged, intermediate and floating regime, but then augmented with the monetary regime: pegged; intermediate without anchor; intermediate with anchor; floating without anchor; floating with anchor. However, averaging the exchange-rate regime might hide valuable information about regime switches, hence blurring the ultimate objective and findings of the study. Bailliu *et al.* (2003) found that if a regime is accompanied by a monetary policy anchor, it “exert[s] a positive influence on economic growth”, regardless of its type (Bailliu *et al.*, 2003, p.398). On the contrary, when there is no monetary anchor, a regime other than peg destructs growth. At this point, the study is very ambiguous, nevertheless. In general, the exchange-rate anchoring is a monetary-policy framework by itself and thus the study is unclear on these issues. If the exchange rate is pegged, than itself is an anchor. If it is not (managed float, say), than an inflation target will enhance growth. On balance, peg supports growth, the effect of a flexible regime is dependent on the monetary anchor. This is however odd and asks for further empirical investigation. Moreover, some of the implicit targeters (defined in this study as no-anchors) use several indicators for controlling inflation and thus might be more efficient in their endeavour.

The next table summarizes the studies above.

Table 1. Summary-table of the empirical research of the exchange-rate regime effect on growth

Study	Data and sample	ER classification	Model	Technique	Endogeneity	Result (Peg and Growth)	Other problems
Baxter and Stockman (1989)	1946-1984; 49 countries	Only sub-periods of general fixing and general floating considered	Descriptive analysis	Averages and standard deviations	-	NO EFFECT No systematic relationship between real aggregates and exchange rate system	Unconditional analysis
Mundell (1995)	1947-1993; US, Japan, Canada, EC, other Europe	Only sub-periods of general fixing and general floating considered	Descriptive analysis	Average growth rates between two sub-periods	-	POSITIVE Considerable higher growth under generalized pegging	Unconditional analysis
Ghosh *et al.* (1997)	1960-1990; 145 countries	De-jure supplemented by categorizing non-floating regimes by the frequency of the parity changes	Descriptive analysis	Means and standard deviations comparison across ERRs	-	INCONCLUSIVE Slightly higher growth under a exchange-rate floating regime; Growth the highest under soft peg or managed float	Unconditional analysis; no evidence of whether ERR affects productivity; causal relationships and the effect on productivity only assumed
Moreno (2000 and 2001)	1974-1999; 98 developing countries East-Asia countries	De-facto classification	Descriptive analysis	Means and standard deviations comparison across ERRs	-	POSITIVE Higher growth under a peg by 1,1 p.p and 3 p.p respectively in both studies. The difference narrows when survivor bias considered	Unconditional analysis
Levy-Yeyati and Sturzenegger (2002)	1974-2000; 183 countries	De-facto	Pooled regression; Real growth = f (inv/GDP; ToT; GC; political instability; initial per capita GDP; population; openness; secondary enrolment; regional dummies and exchange-rate dummies)	OLS	2SLS to correct for endogeneity; Logit model estimated and predicted values used as instruments	NEGATIVE NO RELATION Slower growth under a peg for developing countries; No association for developed countries	

Edwards and Levy-Yeyati (2003)	1974-2000; 183 countries	De-facto	Pooled regression; Real growth = f (inv/GDP; GC; political instability; initial per capita GDP; population; openness; secondary enrolment; regional dummies and exchange-rate dummies)	FGLS	Not treated	NEGATIVE Lower growth under fixed regime then compared to flexible	
Husain *et al.* (2004)	1970-1999; 158 countries	De-jure	Pooled regression; Real growth = f(investment ratio; trade openness; terms of trade growth; average years of schooling; tax ratio; government balance; initial income/US income; population growth; population size; exchange rate dummies)	Fixed effects panel	Lagged values of the exchange-rate dummy used as an instrument	INCONCLUSIVE Pegs do not harm growth, but flexible rates do not deliver growth rates	Weak robustness checks; Classification issues
Garofalo (2005)	1861-1998; Italy	De-facto	Simple regression; Real growth = f (inv/GDP; ToT; GC; political instability; initial per capita GDP; population; openness; secondary enrolment; regional dummies and exchange-rate dummies)	OLS	2SLS to correct for endogeneity; Logit model estimated and predicted values used as instruments	INCONCLUSIVE Highest growth under soft peg or managed float	Weak robustness checks
Dubas *et al.* (2005)	1960-2002; 180 countries	De-facto versus de-jure especially considered	Random-effects panel regression; Real per capita growth = f(initial year GDP; initial year population; population growth; investment to GDP; secondary education attainment; a political indicator of civil liberties; trade openness; terms of trade; dummies for transitional economies; regional dummies for Latin America and Africa; time-specific dummies; exchange-rate dummies)	Random-effects estimation	Not treated	POSITIVE De-facto fixers, on average, have 1% higher growth than de-facto floaters; de-jure floaters - de-facto fixers grow at 1,12% above de-facto and de-jure floaters. Conclusions significant for non-industrialized economies only.	No robustness or diagnostics checking. Other variables not reported if in line with theory.
Huang and Malhorta (2004)	1976-2001; 12 developing and 18 developed countries	De-facto	Panel regression; Per capita growth = f(Financial crisis; Openness; Government consumption; Initial GDP; Fertility rate; Secondary school enrolment ratio; exchange-rate dummies)	OLS	Not treated	INCONCLUSIVE NO RELATION For developing economies, fixed and managed float outperform the others in terms of growth; for developed economies, no relationship revealed	Weak growth-framework; no robustness checks
Bleaney and Francisco (2007)	1984-2001; 91 developing countries	De-facto	Growth = f(growth[-1]; exchange-rate dummies; time dummies)	OLS	Not treated	NEGATIVE Growth is slower under more rigid exchange-rate regime	Very weak growth specification; no robustness checks

Domac *et al.* (2004b)	10 years (1990s, different period for each country); 22 transition countries	De-jure	Growth = f (budget balance, lagged liberalization index, inflation, years under communism, share of industry, urbanization, share of CMEA trade)	Switching regression technique	Address endogeneity "through the assumption of constant covariance between the error term in the structural equation and the normally distributed random variable whose realization determines the exchange rate regime".	INCONCLUSIVE There is an association ERR-growth, but the strength is different for different ERRs	Weak growth specification. Small period and small sample; does not account for de-facto exchange-rate behaviour.
De Grauwe and Schnabl (2004)	1994-2002; 10 CEE countries	De-facto	Real growth = f(inv/GDP, export, fiscal balance/GDP, short-term capital flows/GDP, real growth of EU-15, ER dummy)	GLS	Not treated	POSITIVE ER peg does not reduce economic growth	Weak growth specification. Short time period and small sample
Eichengreen and Leblang (2003)	1880-1997; 21 countries	De-jure	Real per capita growth = f(Per capita income as a share of US income; primary and secondary enrolment rates; capital controls and exchange-rate dummy)	Dynamic GMM and IV estimators	The technique generates internal instruments, but they also run probit model of the exchange-rate dummy to obtain fitted values, which are then used as instruments.	NEGATIVE More flexible exchange rates associated with faster growth	Weak growth specification. De-jure classification and sample selection; weak robustness
Bailliu *et al.* (2003)	1973-1998; 60 countries	De-jure and de-facto, but the latter more important in terms of findings	Real per capita growth = f(initial growth; investment-to-GDP; secondary schooling; real government share of GDP; trade-to-GDP; M2-to-GDP; private sector credit-to-GDP; domestic credit-to-GDP; gross private capital flows-to-GDP; exchange-rate dummies)	Dynamic GMM	Internal lags generated by the technique itself.	POSITIVE ERR exercised by any monetary anchor positively affects growth; otherwise, ERR other then peg destructs growth	Weak on robustness check

The review of the studies above found that whereas one group of studies found that a pegged exchange rate stimulates growth, while a flexible one does not, another group concluded the opposite holds. Moreover, a third group of studies came up with no effect or inconclusive results. The latter could be due to a measurement error in the exchange-rate regimes' classifications (Levy-Yeyati and Sturzenegger, 2002), divergences in measuring exchange-rate uncertainty (Du and Zhu, 2001) or sampling bias (Huang and Malhorta, 2004). A great part of the studies focuses on the parameter of the exchange-rate dummy, but do not appropriately control for other country characteristics nor apply appropriate growth framework (Bleaney and Francisco, 2007). Also, the issue of endogeneity is not treated at all or inappropriate instruments are repeatedly used (Huang and Malhorta, 2004; Bleaney and Francisco, 2007), whereas all published studies on the topic, except one, do not treat the Lucas critique al all. Very few studies pay attention to the capital controls, an issue closely related to the exchange-rate regime and only one study puts the issue in the context of monetary regimes. Du and Zhu (2001) add that results from many empirical studies differ among counties when the same method of examination is applied and even for the same country at different points of time.

Concluding this section, an overall critique of the literature examining the relationship between exchange-rate regime and growth is offered by Goldstein (2002), whose assertion might be helpful: as a nominal variable, the exchange rate (regime) does not affect the long-run economic growth. In addition, the empirical evidence is condemned because of growth framework, endogeneity bias, classification issue and changing parameters under regime switch. Moreover, in the majority of studies, parameters in the regressions are time-invariant which might be problematic, because conditions on the world capital market changed, especially since the end of the Breton-Woods system.

3. Background of the empirical analysis

3.1. Empirical issues for modelling

Previous sections portrayed the theoretical background of the issue to be empirically examined here – the relationship between the exchange-rate regime and output. Although the possible channels through which the relationship may work were established, still there is no agreement on whether and how the exchange-rate regime affects growth. Empirical research has also come to no conclusion. This section briefly reviews problems with previous research, with the objective being to resolve/account for these issues in the empirical analysis that follows in this study.

Firstly, the investigation of the relationship between exchange-rate regime and output depends on the growth-modelling framework employed. The growth equation needs to reflect recent advances in the literature, considering new insights from the neoclassical and endogenous-growth theories. More importantly, the growth equation should encompass macroeconomic fundamentals and institutional arrangements. Also, important concepts related to exchange-rate regime, like capital controls, need to be considered. A country with the same exchange-rate rigidity, but differences in capital controls might have different results in terms of growth. Once the theoretical background of the growth equation is justified, it can be augmented by measures of exchange-rate regime. Robustness checks should confirm the soundness of the growth framework.

Secondly and equally importantly, the specified modelling framework should reflect the Lucas critique. Specifically, it has been argued in section 2 and by Domac *et al.* (2004) that when the exchange-rate regime changes, the coefficients in the growth regression are not invariant to this switch. Addressing the Lucas critique requires capturing this change. A brief discussion of the Lucas critique is offered in section 3.3.

Third, a measurement issue emerges in such an analysis. The classification of exchange-rate regimes matters. Broader discussion is offered in section 3.4, but this study does not opt for developing its own classification of exchange-rate regimes.

Potential endogeneity is an important concern. Discussing inflation, Levy-Yeyati and Sturzenegger (2001) argued that countries with a peg constrain inflation, but also countries with low inflation might decide to peg the exchange rate in order to maintain the macroeconomic stability achieved. Thus, the estimated coefficient in front of the exchange-rate dummy in a standard money-demand equation might suffer endogeneity bias. The same applies to the relationship between exchange-rate regime and growth, although the argument is possibly weaker. The modelling framework needs also to address this issue. Endogeneity will be treated within the methodological section below.

Some studies also report other problems when modelling this relationship. For instance, Moreno (2000) accounts for the so-called *survivor bias*; the term referring to a situation whereby, for instance, high-inflation episodes appear under a floating regime. For example, assume that high inflation caused the peg which preceded the floating regime to fail. However, it is inappropriate to attribute (inflation) performance during such episodes to the floating regime itself. This, though, might be corrected by excluding sharp-devaluation episodes which could have been attributed to policies pursued under the peg. Bleaney and Francisco (2007) exclude high-inflation episodes which might be also a result of incorrect policies while pegging. The latter has been more generally described as the *peso problem*, related to the episodes of severe economic stress that can lead to peg exit. Finally, the *sample-selection bias* needs to be addressed. Previous studies usually fail to construct unbiased sample given the question of interest. Some studies (table 1) consider only developing countries which more often have rigid exchange rates or face problems not related to exchange-rate policy. The negative impact of the peg on growth in such instances is likely to be biased and does not discover the real picture. Some other samples do not differentiate between countries that experienced severe exchange-rate crises and those with long-lasting stable regimes. These issues could be resolved by considering a large sample, but the distinction between developing and advanced economies must be made (section 2).

All studies on the relationship between exchange-rate regime and growth (reviewed in table 1) do not treat some or all of the issues mentioned above. This study will address or try to address these issues in its empirical framework, which is considered to be its main contribution to the existing literature.

3.2. Growth theory

Understanding what determines growth has been long disputed among academicians and policymakers. Higher growth is beneficial for the overall economic welfare of the country, so that knowing the factors that determine it becomes an imperative in order to know how to boost or contain it. The root of this concern goes back to the classical period (Hume, 1742; Tucker, 1776; Smith, 1776), which provided many of the basic ingredients that appear in modern theories of economic growth, such as competitive behaviour, equilibrium dynamics, diminishing returns and its relation to capital accumulation, the importance of population growth rate, “the effects of technological progress in the forms of increased specialization of labour and discoveries of new goods and methods of production, and the role of monopoly power as an incentive for technological advance” (Barro and Sala-i-Martin, 2004, p.9). However, there is at the present no straightforward and simple answer to the specification of growth determinants, with growth theory constantly evolving. This section presents, in a condensed manner, the stream of thought about economic growth in order to build the context in which the effect of the exchange-rate regime on growth will be analysed. The objective is not an in-depth analysis of growth theory; a comprehensive and advanced reading on economic growth is Barro and Sala-i-Martin (2004).

Neo-classical economic growth

To begin with, classical economists mainly focused on capital accumulation, but disregarded the role of technology, until the revolutionary work of Solow (1956, 1957) and Swan (1956) was published. A significant development in growth theory was made by Solow who developed a formal model, in the neoclassical tradition, that describes the path of important economic variables over time, such as per capita output and capital. Two key features of the conceptual structure of neoclassical growth theory are important. First, it is based on “the production function approach to the analysis of economic growth” (Thirlwall, 2005, p.140). That is to say, it is based on an aggregate production function which expresses the relationship between aggregate output, on the one hand, and stocks of inputs and their productivity, on the other. Second, the neoclassical model is designed to show the long-run equilibrium growth rate with all resource inputs fully employed and returns to capital and labour equal to their marginal productivity. The main outcome of this model is that the growth rate declines as the economy evolves toward its steady state, where income, capital and consumption per capita grow at a constant rate. This implies that countries with low levels of capital grow faster than rich countries, and so their per capita income level will converge towards the level of rich countries. The main assumptions behind the Solow growth model are perfect competition, homogeneous product, homogeneous capital, constant returns to scale, perfect substitutability between capital and labour, and diminishing marginal productivity of labour and capital (Barro and Sala-i-Martin, 2004). As a result of the last assumption, economies starting with lower levels of initial capital stock are expected to experience higher returns to capital and are therefore expected to grow faster than rich countries and to converge towards the leader country’s level of income.

In the Solow model, the driving force of output growth in the short and medium run is physical capital accumulation determined by the saving rate. In the long run, per capita output growth is entirely determined by technological progress, which is assumed to be *exogenous* in the model. In this theory, technology is treated as a public good, i.e. it is available to everyone free of charge. The neoclassical growth model predicts that, in the long run, countries reach their steady states. Countries that own the same technology and population growth rate are expected eventually to converge to the same steady-state growth rate, although their steady-state levels of income do not necessarily have to be same. Thus, if technology is assumed to be a public good, all countries are expected to attain the same steady-state growth rate in the long run.

Models based on Solow ideas have been the point of departure for most of the empirical analysis on economic growth. Some decades later, empirical research (Mankiw *et al.,* 1992) acknowledged the role of human capital (educational attainment and the health of workers) to be equally important as the role of the physical capital. This research established the so-called augmented Solow model. However, since the Solow model by construction does not explain the engine of economic growth (technological progress), it assumes away what it actually tries to explain: "we end up with a model of growth that explains everything but long-run growth, an obviously unsatisfactory situation" (Barro and Sala-i-Martin, 2004, p.11). Thus, an alternative to the neoclassical model was developed – the endogenous growth theory which is next discussed.

Endogenous growth

The difficulty in including endogenous technological progress in neoclassical growth theory, while at the same time preserving the perfect competition assumption, led to the modification of neoclassical growth theory by Romer (1986; 1990; 1994), Lucas (1988), Rebelo (1991) and others, who developed the 'new' endogenous growth theory by making technological progress *endogenous* to the model. In practice, the shift towards endogenous growth has been accomplished through retaining the production function approach and the general equilibrium framework, but modifying the assumptions about the nature of the production function and relaxing assumptions of perfect competition which underpin the old neoclassical model. Most critically, in endogenous growth theory, the assumption of perfect competition was replaced by imperfect competition and increasing returns to scale, which allow for the generation of new ideas. One can view endogenous growth theory as an extension to the Solow model, combining elements of the earlier growth theory with the assumptions of increasing returns; elements of imperfect competition; and some of the microeconomic research on science, R&D, and technological change (Hands, 2001).

There are now a variety of sophisticated endogenous growth theories in which innovation increases product variety or product quality and also considers the effects of general purpose technologies which constitute radical technological breakthroughs (see Aghion and Howitt, 1998; and Verspagen, 2004, for reviews). But these models generally make the above-mentioned assumptions to ensure a steady-state growth rate and although they may have a separate sector for education or R&D, they continue to work with an aggregate production function.

Although the new growth theories which seek to endogenize technical change are sometimes seen as the major alternative to the old neoclassical growth theories, there are a number of other alternatives (reviewed in Gore, 2007), which go further by rejecting the production function approach and general equilibrium framework. These are briefly reviewed in turn.

Alternative growth approaches

These theories reject the aggregate production function approach in three different ways – focusing on *institutions, structure and demand*. The first alternative theory (Nelson and Winter, 1974; 1982) relates economic growth to the institutions within which their actions are embedded and the economic capabilities of agents (firms). This approach has been developed as a critique of the micro-foundations of the neoclassical growth framework.

The second major alternative growth theory (Ocampo, 2005) rejects the production function approach through interrelating economic growth and the sectoral structure of production. Instead of "viewing the growing economy as an inflating balloon, in which added factors of production and steady flows of technological change smoothly increase aggregate GDP", growth is seen as a dynamic process in which some sectors surge ahead and others fall behind "as part of a continuous transformation of production structures" (p.8).

The third alternative growth theory (Setterfield, 2002; Blecker, 2002) rejects the production function approach because it explains growth solely in terms of supply factors of production and their productivity and ignores the role of demand in this process. Theories of demand-led growth recognize that at any point in time, the level of utilization of productive resources may vary according to demand conditions. Moreover, they are founded on the view that both factor accumulation and technological progress are ultimately demand-determined.

Growth theories and empirical analysis

Turning to empirical analysis, the following generic form of a growth model is used in the literature:

$$g_{i,t} = X_{i,t}\gamma + Z_{i,t}\pi + \varepsilon_{i,t} \qquad (7)$$

where $g_{i,t}$ is real per capita growth in economy i over period t. Following the growth theories presented above, Barro and Sala-i-Martin (2004) suggest that real per capita GDP growth should be related to two groups of variables: initial levels of some variables, denoted $X_{i,t}$ (like the GDP itself or variables for schooling and health) and the population level or growth rate; and control variables, denoted $Z_{i,t}$, which will reflect policy actions, institutional setting or other country characteristics. The inclusion of initial values of some variables date back to Solow-Swan and Ramsey models which predict that, for a given value of these variables, an increase of initial per capita GDP or initial human capital per person, would reduce growth. That is, a richer economy tends to grow slower and vice versa. However, each economy has its own steady state, as determined by the control variables; the so-called steady-state level of output per "effective" worker (Barro and Sala-i-Martin, 2004, p.517). For given values of the state (initial) variables, a change in control variables (say, a change in government consumption) might hence impinge on growth.

A fundamental problem in growth empirics is which variables to include in the model. This is a result of what Brock and Durlauf (2001) call "the open-ended theory"; namely, a causal relationship between one variable and growth, suggested by one theory, does not exclude the relationship between another variable and growth, suggested by another theory. The literature (Durlauf and Quah, 1999) suggested over 90 variables as potential determinants of growth. However, the primary purpose of the empirical investigation in this study is not to make contribution to growth theory or empirics, but rather to acknowledge if and how the exchange-rate regime affects output. For that purpose, a minimally-specified growth model will be a tool for tackling this linkage, which will be sufficient to explore one-variable effects on growth. Yet again, the growth framework is not chosen randomly and it dovetails within the considerations specified in this section and as the text proceeds.

At an outset, the growth function is specified with the expected sign of the relationship being in parenthesis:

Per capita GDP growth = f(initial GDP(-); average years of schooling(+); 1/(life expectancy at age 1)(-); government consumption/GDP(-); trade openness(+); inflation rate(-); investment/GDP(+); fertility rate(-); democracy index(+); population(?); rule of law index(+); exchange-rate regime(?); regional/country specific/time dummies) (8)

As mentioned above and as suggested by the classical growth theory (reviewed in Barro and Sala-i-Martin; 2004), the initial level of per capita GDP should enter the regression in a log-form, so that the coefficient will represent the rate of convergence of the economy. In addition, the other initial variables are here measured as commonly in the literature by the average years of school attainment (as a proxy for the human capital – education) and the life expectancy (as a proxy for the human capital – health).

The list of control variables comes from classical growth theory, endogenous growth theory and the theory that explains growth by institutional factors. The list is: trade openness; the ratio of the government consumption to GDP; an indicator of the maintenance of the rule of law; an indicator of the democracy; the log of the total fertility rate; the ratio of real gross domestic investment to real GDP and the inflation rate.

One sub-group of these variables is *policy variables*. For instance, government consumption is assumed not to contribute to productivity directly, but as entailing distortion to private decisions. Moreover, such distortions can reflect the governmental activities themselves. Hence, a higher value of the government consumption leads to a lower steady-state level of output and to a lower growth, ceteris paribus. Explanatory variables also include a measure of the international openness (exports plus imports to GDP) which also reflects some government policies, like tariff and trade restrictions, on the international trade. The inflation rate is included as a measure of macroeconomic stability. Fiscal variables could also be included as a proxy for macro-stability and the exchange rate. In the same line of thinking, the exchange-rate regime can be considered as a policy variable. Barro and Sala-i-Martin (2004) do not directly account for the exchange-rate regime (that is not their primary interest), but nevertheless this could be included in the list of policy variables, since altering the exchange-rate regime, or passing from ERT to IT, would be considered as a policy action aimed at certain macroeconomic goals (like preserving price stability and/or supporting the real economy and/or isolating the economy from shocks from abroad). Hence, our model, policy variables will include the exchange-rate regime, since this is our primary concern.

In the neoclassical growth model, the fertility rate exhibits a negative effect on growth, since higher fertility entails more resources devoted to the raising of children and, hence, lowers growth. The effect of the saving rate in the neoclassical model is accounted for through the investment-GDP ratio. Barro and Sala-i-Martin (2004) attempt to isolate the effect on the saving rate on growth, rather than the reverse, by using lagged values (lagged investment ratio) as instruments in order to account for the endogeneity problem (this is further discussed in a section 3.4).

Another sub-group of variables reflects the institutional setup. As a measure for the institutional setting two indicators are used, one measures the rule of law, which reflects the argument that by enhanced property rights, investment and growth incentives are supported. The second indicator is the democracy index in the sense of electoral rights and it is usually included along with a square term, which suggests that democratization is expected to enhance growth for countries that are not very democratic, but to retard growth for countries that have already achieved a substantial amount of democracy. Nevertheless, the effect of democracy on growth might be ambiguous, because some models that stress the incentive of electoral majorities to use their political power to transfer resources from rich minority groups found a negative effect. Democracy, on the other hand, could be productive as a mechanism for government to commit itself not to confiscate the capital accumulated by the private sector (Barro and Sala-i-Martin, 2004).

The final variable reflects shocks hitting the economy. The terms-of-trade variable (ToT) is included through its interaction with the trade openness. Changes in the ToT measure the effect of changes in international policies (including financial crises) on the income position of the domestic residents. Higher export prices will induce an increased inflow from abroad and will improve the income position at home, and vice versa. Hence, the ToT exogenously affects the position of each individual country. A positive movement of the ToT variable (higher export prices, lower import prices) would increase domestic purchasing power, consumption and hence, growth. However, following the discussion in Petreski (forthcoming), the ToT are not related to the steady-state position, and these are usually argued in relation to output volatility.

In conclusion, following the mainstream growth-theory literature, as basic ingredients of the growth function should be considered: initial level of GDP; human capital (average years of schooling and life expectancy); government consumption/GDP; domestic investment/GDP; fertility rate; inflation rate; rule of law and democracy index; trade openness; and changes in the ToT. Finally, what is of particular interest of this study, the growth equation would include a measure of the exchange-rate regimes, as a policy variable, in a manner that is described further in the Data section below.

3.3. The Lucas critique – A revisit

The Lucas (1976) critique of econometric policy evaluation argues that it is inappropriate to estimate econometric models of the economy in which endogenous variables appear as unrestricted functions of exogenous or predetermined variables. In Lucas own words, "[E]ven to obtain the decision rules…, we have to attribute to individuals some view of the behaviour of the future values of variables of concern to them. … To assume stability of [the exogenous or predetermined variables] under alternative policy rules is thus to assume that agents' views about the behaviour of shocks to the system are invariant under changes in the true behaviour of these shocks" (p.111). Instead, expectations about future policy actions should be considered and affect current decision-making; this view revived and brought into prominence the theory of rational expectations. He argues that expectations about the future are highly important to economic decisions made by households and firms today. But, contrary to adaptive expectations, rational expectations are genuinely forward-looking (Li, 2004). The rational expectations hypothesis means that agents exploit available information without making the systematic mistakes implied by earlier theories. Expectations are formed by constantly updating and reinterpreting this information.

The objective of this study is not to explore the Lucas critique *per se,* but instead to take it into consideration. As argued in the preceding sections, changing the exchange-rate or monetary regime (rule), implies that model's parameters might change as a result of the arguments of Lucas. The econometric work pursued in this study thus needs to incorporate the Lucas critique.

3.4. Exchange-rate regimes classification

Two influential articles in the literature (Reinhart and Rogoff, 2004; Levy-Yeyati and Sturzenegger, 2005) consider an issue that has been ever since treated as trivial: the classification of exchange-rate regimes. Namely, the majority of studies employ the classification schemes by the IMF which are based on what countries report and not on the actual behaviour of the exchange rate. In practice, by law, a country could pursue pegged regime, but in practice could allow certain flexibility, in order to, say, support the real economy. This is only one example; other combinations are also possible. Reinhart and Rogoff (2004) (hereafter RR) made a pioneering inroad into this issue by measuring the actual behaviour of the nominal exchange rate. Moreover, in their study they account for the existence of dual foreign-exchange markets and for related factors, like exchange controls and currency reforms. By applying the classifying algorithm (p.14 in their study), they identify 14 options for exchange-rate regime, applied to 227 countries[2] for the period 1940-2006. This fine-tune classification is then generalized into 5 groups (fixed, limited-flexible, flexible, free-floating and free-falling). The following fine groups were identified:

Table 2. Classification categories of the exchange-rate regimes, according to Reinhart and Rogoff (2004)

Classification category	Number assigned to the category (fine)	Number assigned to the category (coarse)
No separate legal tender	1	1
Pre-announced peg or currency board arrangement	2	1
Pre-announced horizontal band that is narrower than or equal to ±2%	3	1
De facto peg	4	1
Pre-announced crawling peg	5	2
Pre-announced crawling band that is narrower than or equal to ±2%	6	2
De facto crawling peg	7	2
De facto crawling band that is narrower than or equal to ±2%	8	2
Pre-announced crawling band that is wider than ±2%	9	3
De facto crawling band that is narrower than or equal to ±5%	10	3
Moving band that is narrower than or equal to ±2% (i.e., allows for both appreciation and depreciation over time)	11	3
Managed floating	12	3
Freely floating	13	4
Freely falling (includes hyper-float)	OTHER	OTHER
Dual market in which parallel market data is missing	OTHER	OTHER

Source: Reinhart and Rogoff (2004)

Note: By contrast to the common crawling bands, a non-crawling band refers to the relatively few cases that allow for both a sustained appreciation and depreciation of the exchange rate over time. While the degree of exchange-rate variability in these cases is modest at higher frequencies (i.e., monthly), lower frequency symmetric adjustment is allowed for.

Although very influential and prominent, this procedure does not account for the behaviour of foreign-exchange reserves, which could be considered as its main drawback. This is due to the notion that under a peg, reserves exhibit increased volatility; the lower the exchange-rate rigidity, the lower the need for foreign-exchange intervention. However, the authors dispute this drawback by emphasizing the widespread switch from intervention based on reserves to intervention based on interest-rate changes; however, data on the latter are also

[2] However, some of those are already non-existent.

difficult to obtain. On the other hand, although measures of capital controls have not been directly accounted for, authors argue that data show that the dual market premium becomes insignificant with capital market integration and hence could be considered as a measure for the "size" of the capital controls imposed. Hence, the latter are implicitly taken into account when de-facto classifying the exchange-rate regimes. This also accounts for that a country with the same exchange-rate rigidity, but differences in capital controls might have different results in terms of growth.

The other important paper, by Levy-Yeyati and Sturzenegger (2005) (hereafter LYS), utilizes cluster analysis (p.4) in order to de-facto classify regimes for 119 countries over the period 1974-2004[3]. Before forming clusters of similar regimes, authors use three measures to define the regime: nominal exchange-rate changes; volatility of nominal exchange-rate changes; and the volatility of international reserves. The idea behind this is that countries with a volatile nominal rate and stable reserves are classified as floaters, while those with stable nominal rate and volatile reserves as fixers. Although the approach considers foreign-exchange reserves behaviour into the classification of exchange-rate regimes, it does not account for the existence of capital controls or currency reforms. The approach of LYS identifies four regimes (flexible, dirty float, crawling peg and fixed) and one "inconclusive" group, which, compared to the RR approach, is a small number of identified groups. A drawback of this method is that countries which do not exhibit considerable volatility in either variable are classified as inconclusive. While the authors present a solid theoretical argument for the inconclusive group, it decreases the size and the variance of the data which might reduce its usefulness in regression. Moreover, classification is to an extent vague, since it does not make the difference between dirty float and crawling peg extremely accurate. On the other hand, having in mind that RR account for capital controls (which might be of crucial interest when measuring the macroeconomic effect of a particular exchange-rate regime – see section 2 and Petreski, forthcoming); use 14 and 5 categories of de-facto regimes, respectively; come up with an exhaustive set of data, in terms of time-span and country-coverage; and the idea that the purpose of this study is not to de-facto classify the exchange rate regimes; the empirical part will continue by using RR de-facto classification, as specified in Table 2.

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[3] However, data are missing for a lot of years. On the other hand, in the RR classification, the missing fields are related to a non-existence of the state in that period or similar reason.

For the sake of comparison with the previous literature, the empirical part will also present the results from de-jure classification, as specified by the IMF, which classifies the exchange-rate regime on: fixed, limited flexibility, managed float and free float.

4. Data and descriptive statistics

4.1. Data issues

We matched the countries of RR classification (227) with the IMF member states (185) and obtained data for 169 countries, which gives a sufficient country-set in order to account for the sample-selection bias. The empirical investigation will deal with the post-Bretton-Woods monetary/exchange-rate era, hence covering the period 1976-2006. The variables used and their sources are fully described in Appendix A. The provider for the majority of the data is the IMF; educational-attainment and life-expectancy variables are obtained from the World Bank; the fertility rate is obtained from the United Nations; the democracy index and the index of civil liberties are provided by Freedom House, which, as a source, might be contested, but no alternative is presently available.

For the definitions of the growth-regression variables, we follow Barro and Sala-i-Martin (2004) and section 3.2. An exception is the variable measuring the rule of law; this variable could be obtained with considerably high monetary cost and since it is not of our primary interest, we do not include it.

In order to account for the Lucas critique as described in section 3.3, we use interaction terms of all independent variables with the dummies representing the exchange-rate regimes. In such specification, the significance of the estimated coefficients in front of the interaction terms will indicate if and how parameters change when the exchange-rate regime switches.

In order to account for the survivor bias (the peso problem), as defined in section 3.1, we will exclude the high-inflationary episodes. Some studies and textbooks (Federal Reserve Bank of Boston, 2008; Baumol and Blinder, 2006; Poulson, 1994) define high inflation as within the range of 30-50% per year. Hence, we will exclude all years where the inflation rate exceeds 30%. In order to account for the monetary integration in Europe (the common currency and the ERM-2 as its predecessor), we exclude 12 countries in the period 1991-

2006[4]; this is done because the common currency in Europe might follow different pattern in terms of growth as compared to a country that unilaterally adopted an other-country currency (as Montenegro or Ecuador). We define regional dummies, which along all remaining dummies are described in Appendix A and follow from the discussion in the preceding sections.

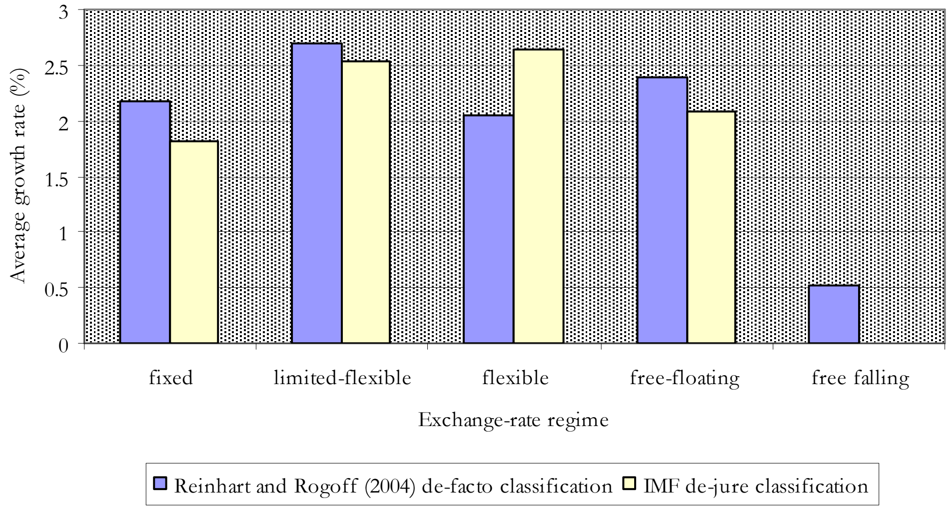
4.2. Descriptive analysis

This section portrays a simple descriptive analysis of growth performance under alternative exchange-rate regimes and classifications. We present the outcomes for the two regime classifications: de-facto (RR) and de-jure (IMF). This analysis does not discover causal relationships and its aim is not to do so, but rather to build expectations about the issues treated herein.

The growth rates by the RR classification (Appendix B and Table B.1) span from 2.1% in the flexible-regime category to 2.7% in the limited-flexibility category (free-falling category excluded). While the growth rate in the IMF classification spans from 1.8% for fixers to 2.6% for flexible regimes. Table B.1 and Figure 1 suggest that, nevertheless, it could not be inferred that certain exchange-rate regime is superior over another in terms of output growth, particularly within the de-facto classification.

[4] However, with minor adjustments in terms of when did those joined or left ERM-2.

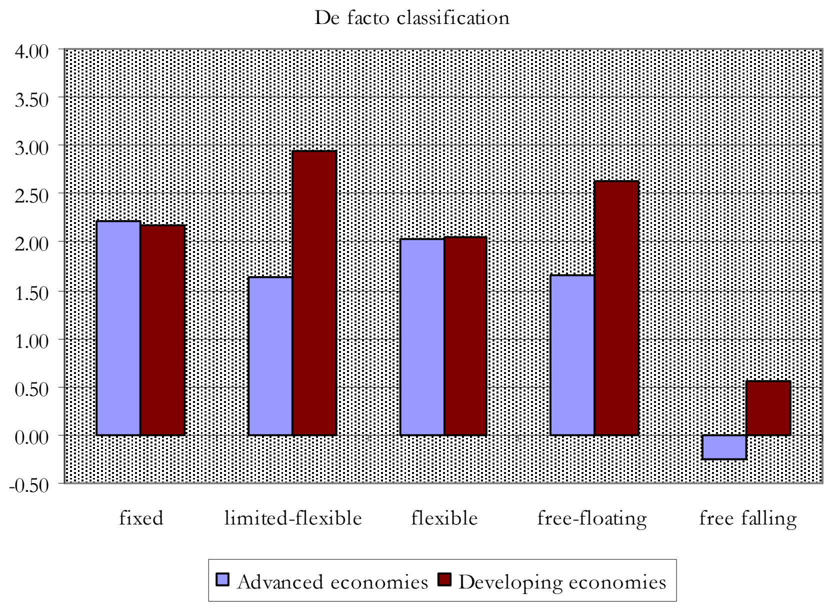
Figure 1. Growth performance under different exchange-rate regimes and under two classification schemes (averages 1976-2006)

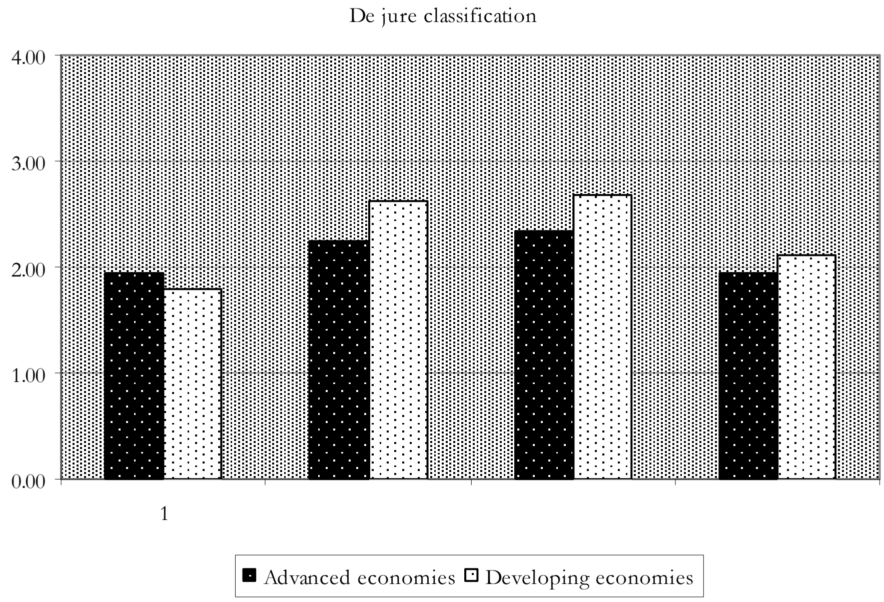


A different picture emerges when the exchange-rate regimes are put in the context of the level of development of the countries in the sample. The latter are observed on advanced and developing economies, according to the specification in Appendix A. Table B.2 and Figure 2 (upper panel) suggest that within de-facto (RR) classification, there are apparent differences: the growth rate of advanced economies does not considerably vary across exchange-rate regimes, although it is the highest under fixed regime; for the developing economies, the variance gets larger: considerably low growth is experienced by flexible-rate countries, followed by fixers. The highest growth is observed with limited-flexible-regime countries.

The de-jure (IMF) classification in Figure 2 (lower panel) portrays different picture. Growth-differences among exchange-rate regimes are again not considerable for advanced economies, similar as in the RR classification. However, for developing economies, fixers exhibit considerably low average growth, the flexible-rate countries being the best in terms of growth., but still similar to limited-flexible-rate ones This conclusion of the comparative analysis is expected, having on mind that larger differences are apparent between exchange-rate policy pursued and the one reported to the IMF within the developing-economies group. This observation strengthens the need to rely on the de-facto classification, as argued in section 3.4.

Figure 2. Growth performance under different exchange-rate regimes, depending on countries' level of development (averages 1976-2006)





In conclusion, the descriptive analysis of growth performance under alternative exchange-rate regimes points to no straightforward expectation for the causation between exchange-rate regime and growth. Nevertheless, the level of development of the economy and the exchange-rare-regime classification appear to make considerable differences and this should be accounted for further in the empirical investigation.

5. Methodology

5.1. Addressing endogeneity

The preceding sections discussed how the outlined issues will be addressed within the empirical investigation in this study. What remains to be addressed is the endogeneity problem. An explanatory variable is said to be endogenous if it is correlated with the error term. Endogeneity bias might arise because of omitted variables, measurement error, simultaneity or the presence of a lagged dependent variable (Wooldridge, 2002). The first three of these are discussed in the current sub-section and the latter in the following sub-section.

Endogeneity because of omitted variables appears when there is a need to control for variables, but these are not included in the empirical model, either because they are unavailable or because they are unintentionally left out of the analysis. The estimates will be biased if the excluded variable is correlated with included variables. In the estimations in this study the variable of most concern is the exchange rate regime. Section 2 suggested that the number of variables which are assumed to be highly correlated to the exchange-rate regime are very few: inflation, trade volume, investment and population. These variables are included in the growth regression and consequently, there are no theoretical grounds to expect that endogeneity bias could arise because of omitting a variable that might be correlated to the exchange-rate-regime dummies.

Endogeneity because of measurement error arises when we want to measure the effect of the exchange-rate regime over growth but we do have an imperfect measure of the exchange-rate regime. The error term would suffer endogeneity bias because it will contain the measurement error as well. Section (3.4) discussed the issue of the measurement of the exchange-rate regime and we do not expect endogeneity bias because of measurement error.

Endogeneity because of simultaneity arises when at least one of the explanatory variables is determined simultaneously along with the dependent variable. The literature suggests that the relationship between exchange-rate regime and growth might be simultaneous. Thus this type of endogeneity might be present in the overall growth regression and hence needs to be taken account of in estimation.

The exchange-rate literature is not agreed over its effect on growth nor does the growth literature associate its choice to growth performance. Hence, Levy-Yeyati and Sturzenegger (2001) believe that this problem should be relatively minor. Eichengreen and

Leblang (2003), however, run a probit regression whereby they regress the choice to peg on a set of explanatory variables: trade openness; country size; inflation; GDP per capita; and some political indicators. They find that the majority of these variables are significant in terms of affecting the probability to choose a fixed exchange-rate regime. In consequence, the study suggests that the exchange-rate regime should be treated as endogenous and the failure to do that "is likely to confound efforts to identify the impact of the exchange-rate regime on growth" (p.810).

Consequently, as endogeneity, arising mainly because of simultaneity, is/might be of concern within the growth- and exchange-rate literature, it will be considerably treated in this study. The next section discusses both the final possible source of endogeneity and the estimation technique which will be used to address the problem.

5.2. Instrumental-variables and dynamic panel techniques

Endogeneity, as defined in section 5.1, causes inconsistency of the usual OLS estimates and requires the use of instrumental variables to correct it. An instrumental variable (IV) is the one which is highly correlated with the regressor (which is assumed to be endogenous), but is not correlated with the error term (Wooldridge, 2007). Two general[5] IV estimation techniques were developed to correct the endogeneity bias: two-stage least squares (2SLS) and the generalized method of moments (GMM) techniques. In the 2SLS technique at the first stage, new endogenous variables (so-called, instruments) are created to substitute the original ones and then, in the second stage, the regression is computed by OLS, but using the newly created variables, which are not correlated with the error term (i.e. are exogenous). In GMM estimation, the information contained into the population moment restrictions is used as instruments (Hall, 2005). In addition to the two general IV methods, Hausman and Taylor (1981) developed, and Amemiya and MaCurdy (1986) advanced, an IV estimator, applicable to panel data only, based on the random-effects model. Namely, in RE model, regressors are assumed to be uncorrelated with the individual-specific error; the Hausman-Taylor estimator allows some of the regressors to be correlated with the individual-country effect, but not with the idiosyncratic error. However, the former is still a source of endogeneity bias and requires

[5] By "general", we mean techniques applicable in all fields of econometrics where endogeneity might be a problem, including panel econometrics.

an IV correction. Still, 2SLS and GMM estimates, on the one hand, and Hausman-Taylor, on the other, are not directly comparable, because they correct endogeneity emulating from different sources (Greene, 2003). The three IV estimators (2SLS, GMM and Hausman-Taylor) are important in panel context; nevertheless a large strand of the panel literature focuses on endogeneity bias stemming from the inclusion of the lagged dependent variable as a regressor.

The revitalization of the interest in long-run growth, its treatment as being a dynamic process (Islam, 1995) and the availability of macroeconomic data for large panels of countries and time spans, has raised the interest in estimating dynamic panel models (See: Barro and Sala-i-Martin, 2004; Mankiw *et al.*, 1992; Fisher, 1993; Levine and Renelt, 1992; and others). Judson and Owen (1996) argue that the utilization of panel data is appropriate because it allows the identification of country-specific effects that control for missing or unobserved variables. The term "dynamic", in econometrics, refers to adding the lagged dependent variable as a regressor in the equation (Baltagi, 2008). Furthermore, Bond *et al*. (2001) argue that the right-hand-side variables in a standard growth regression are "typically endogenous" (p.1) and hence suggest GMM estimation of growth model within dynamic context. A dynamic fixed-effects model could be specified as follows (Lokshin, 2006):

$$y_{i,t} = y_{i,t}\gamma + x_{i,t}\beta + \eta_i + \varepsilon_{i,t} \qquad (9)$$

whereby, the dependent variable, $y_{i,t}$, is determined by its one-period lag, $y_{i,t-1}$, an exogenous regressor, $x_{i,t}$, which is assumed not to be correlated with the error term $\varepsilon_{i,t}$, an unobserved individual effect (the so-called, unobserved heterogeneity), η_i, and a random error, $\varepsilon_{i,t} \sim \mathrm{N}(0,\sigma_\varepsilon^2), \sigma_\varepsilon^2 > 0$. Judson and Owen argue that the fixed-effects model is preferred in macroeconomics because of two reasons: the unobserved individual effect, representing country characteristics, is highly likely to be correlated with the other regressors; and it is fairly likely that a macro-panel will not represent a *random* sample from a large number of countries, but rather the majority of countries of interest.

Since the model contains the lagged dependent variable, the least squares dummy variable (LSDV) estimator produces biased coefficients (Behr, 2003). Namely, since the dependent variable is included as a regressor with one lag, the latter will be correlated with the error term, rendering estimated coefficients biased (Sevestre and Trognon, 1985). Nickel (1981) shows, however, that when there are no exogenous regressors, the LSDV estimator's bias approaches zero as the time dimension approaches infinity. However, Judson and Owen (1996) found that even when T is as large as 30, the bias could span up to 20% of the coefficient's true value. The effort to account for this bias resulted in two classes of estimators: bias-corrected (BC) and instrumental-variables (IV) estimators (Behr, 2003).

Two practical questions arise in applied econometrics: i) which estimator/technique to proceed with; ii) how large should T be for the bias to vanish? From the viewpoint of this study, since we have only 31 years of data use LSDV does not seem appropriate, given the findings reported above. However, the first question asks for more attention. Before we have a look at the results of several Monte Carlo analyses, we briefly review the different estimators within the BC and IV groups, which is simultaneously the chronology of the dynamic-panel developments.

Following the investigation of the bias by Nikel (1981), Kiviet (1995) suggested a direct BC method, whereby a formula for the LSDV bias is subtracted from the estimated LSDV coefficients. Based on this, Hansen (2001) suggested an alternative BC method, with a two-step procedure where residuals from the first-step consistent estimator are used in the second-step calculation of the bias. Everaert and Pozzi (2007) further developed the BC approach, with an iterative bootstrap procedure. The general idea behind the correction procedures is to take advantage of the variance which is much smaller under LSDV than compared to IV estimators (Behr, 2003). Because of this, it is found that BC methods perform well, i.e. produce more efficient estimates than IV estimators (Judson and Owen, 1996; Lokshin, 2006). However, they rely on the assumption of the other regressors being exogenous (Behr, 2003) and cannot be applied to unbalanced panels (Judson and Owen, 1996; Roodman, 2008b). These drawbacks are directly applicable to the case of this study (with an unbalanced panel data set and a model with possibly endogenous regressors).

The use of instrumentation methods, mentioned at the beginning of the section, removes the endogeneity bias resulting from the correlation between the regressor and the error term (Wooldridge, 2007). Anderson and Hsiao (1981) and (1982) were the pioneers in proposing use of the GMM procedure within a dynamic context; they differenced equation 9 in order remove the fixed effects in the error term which are correlated with the lagged dependent variable; however, the difference of the lagged dependent variable will still be correlated with the error term and, hence, should be instrumented. These researchers proposed using the second lag of the dependent variable ($y_{i,t-2}$) or the lagged difference

($y_{i,t-2} - y_{i,t-3}$) as instruments of $\Delta y_{i,t-1}$, because those are expected to be uncorrelated to the error term. Arellano (1989); Arellano and Bond (1991); and Kiviet (1995) analysed the properties of the two instruments suggested by Anderson and Hsiao and found that the "level" instrument has smaller variance and is, hence, superior to the "differenced" one.

Arellano and Bond (1991) suggested exploiting an enlarged set of instruments; namely, all available lagged values of the dependent variable and the lagged values of the exogenous regressors. A possible drawback of this, so called, difference-GMM estimator, is that by enlarging the number of periods, the number of instruments gets considerably larger. Moreover, instruments could be weak, because they use information contained in differences only (Ahn and Schmidt, 1995) and because they do not account for the differenced structure of the residual disturbances (Baltagi, 2008). Ahn and Schmidt (1995), Arellano and Bover (1995), and Blundell and Bond (1998) consequently suggested using additional information contained in levels, which should result in more efficient estimator, known as a system-GMM estimator. This augments the difference-GMM by simultaneously estimating in differences and levels, the two equations being distinctly instrumented (Roodman, 2008b). In the system-GMM estimator, both predetermined and endogenous variables in first differences are instrumented with suitable lags of their own levels (used by Arellano-Bond); and predetermined and endogenous variables in levels are instrumented with suitable lags of their own first differences. As a consequence, the system-GMM estimator should produce more efficient estimates and, hence, outperform the difference-GMM estimator. All Arellano-Bond, Arellano-Bover and Blundell-Bond estimators can be estimated as one- or two-step procedures; the one-step estimator makes use of a covariance matrix that accounts for autocorrelation, while the two-step estimator uses the residuals from the first step to estimate the covariance matrix.

Nevertheless, when either difference- and system-GMM are applied, a problem arises: increasing the number of instruments adds efficiency but adds bias as well. The problem has been acknowledged in the literature (Roodman, 2008b; Tauchen, 1986; Altonji and Segal, 1996; Andersen and Sørensen, 1996; Ziliak, 1997; Bowsher, 2002; and others). For instance, Windmeijer (2005) found that when the number of instruments is reduced from 28 to 13, the average bias reduces by 40%. Similar results were obtained by Ziliak (1997) and Tauchen (1986). It is inherent that the number of instruments gets larger as the number of endogenous and predetermined variables increases and as T grows. Moreover, the researcher can add external instruments. However, "the overall count [of instruments] is typically quadratic in T"

(Roodman, 2008b, p.6) and this makes asymptotic inference of the estimators and the specification tests misleading. Moreover, the asymptotics could be even doubled – the bias rises as both T and N grow (Arellano, 2003b).

The development of the dynamic-GMM panel techniques in recent years established that both difference- and system-GMM panels can generate moment conditions prolifically (Roodman, 2008b). A crucial assumption for the validity of GMM is that generated instruments are exogenous, i.e. do not correlate with the error term. Sargan and Hansen-J tests have been designed to detect violation of this assumption, but there is no formal test to check how many instruments should be cut (Ruud, 2000). Sargan and Hansen-J set the null as "instruments are valid", which is the assumption that we want to support. However, the Hansen-J test grows weaker with more moment conditions and a p-value of 1 is a classic sign of instrument proliferation, because it points out that the test does not detect the problem. Sargan/Hansen tests can be also used to test the validity of subsets of instrument, through the difference-in-Sargan specification. Roodman (2008b) suggests combining two ways to cut instruments: collapsing them and/or limiting lag length. Using simulation, he found that the problem of too many instruments becomes apparent when T>15; also, the bias slightly increased when both collapsing and lag-limiting commands were used (from 0.03 to 0.05), but strangely lessened as T went from 5 to 20.

There are two great additional advantages of the GMM estimator in addition to those already discussed (Verbeek, 2000): i) it does not require distributional assumptions, like normality; and ii) it can allow for heteroskedasticity of unknown form. The first feature means that normality is not an assumption that should be a subject of diagnostic testing, while the potential heteroskedasticity can be allowed for by estimating "robust" parameters. However, if the errors are serially correlated, than these will not be independent of the instruments; the GMM estimator, hence, requires no (second-order) serial correlation in the error term of the differenced equation (Arellano and Bover, 1995). Moreover, the above-mentioned Sargan and Hansen-J tests (Roodman, 2006b; Baltagi, 2008) test if instruments are uncorrelated with the error term, i.e. it checks for over-identifying restrictions in the model.

An early trial to evaluate the different dynamic-panel estimators has been made by Judson and Owen (1996). However, the study was done when the system-GMM estimator was in its launch-phase and it is thus not included in the analysis. This Monte Carlo study shows that OLS definitely generates significant bias, even when T gets large. The bias is lessened, but still spans up to 20% under LSDV estimator even when T=30, but the estimator does not become more efficient. In any case, LSDV was acknowledged to be inappropriate in many cases, among which is this study. To account for the computation difficulty of including too many instruments in the difference-GMM estimator, Judson and Owen (1996) restrict the number of instruments to a maximum of eight; vary T from 10 to 30 and N from 20 to 100. The one-step difference-GMM estimator is found to outperform the two-step in terms of producing a smaller bias and a lower standard deviation of the estimates. When compared to all dynamic-panel estimators, difference-GMM again shows superiority when N is large. “[F]or a sufficiently large N and T, the differences in efficiency and bias of the different techniques become quite small” (p.12), suggesting that the estimators improve as T gets larger (up to 100 periods). Albeit, results suggest that the Anderson-Hsiao estimator produces the lowest average bias and lower bias as T gets larger. Therefore, “a reasonable strategy … for panels with larger time dimension [would be to] use the Anderson-Hsiao estimator” (p.12). On the other hand, the Monte Carlo study by Arellano and Bond (1991) (N=100, T=7) showed that the difference-GMM estimator has negligible finite sample bias and substantially smaller variance than the Anderson-Hsiao estimator. However, the estimated standard error of the two-step estimator was found to suffer downward bias, which is attributed to the estimation of the weight matrix (Windmeijer, 2005). Hence a correction has been proposed, based on a Taylor-series expansion that accounts for the estimation of the weighted matrix[6].

Behr (2003) conducted Monte Carlo analysis which includes the system-GMM Blundell-Bond estimator. When N=100, T=10, the Anderson-Hsiao estimator is found to be unbiased but rather inefficient because of the large standard deviation. The system-GMM estimator is found to be unbiased and the most efficient. The same conclusion holds, although both estimators improve, when N=1000, T=10. If predetermined endogenous variables are used, then the system-GMM is again found to be superior. A drawback of the simulation is that it does not enlarge the number of periods in order to observe how these estimators perform, but rather focuses on the cross-section dimension. Changes in the number of periods are examined in Harris and Matyas (2004) who found that both difference- and system-GMM estimator suffer bias when sample is small and the number of instruments very large. They found that the bias is reduced as T gets larger.

[6] And a Roodman’s (2008a) xtabond2 command implements this correction.

In summary, the evidence of the Monte Carlo studies is not overwhelming, but they tend to suggest that the least biased and the most efficient estimator is the system-GMM. The biasness is further lowered by increasing T, which is of particular importance in this study. The number of instruments, however, matters in terms of the trade-off between biasness and efficiency: limiting instruments slightly increases biasness, although efficiency as well, and makes computation less cumbersome. Consequently, next we estimate growth regression within the system-GMM framework.

6. Results and discussion

6.1. Exchange-rate regime and output growth

Taking into account what was proposed in section 3.2, the growth regression is:

$$GROWTH_{i,t} = \alpha_0 + \delta\, GROWTH_{i,t-1} + \beta_j X_i + \gamma_j Z_{i,t} + \tau_j N_{i,t} + \kappa_j INT_{i,t} + \psi_j LAG_{i,t-1} + \vartheta_j T_{i,t} + \varepsilon_{i,t} \qquad (10)$$

The coefficients are specified according to the groups of variables, as follows:

- δ is for the lagged dependent variable;
- βs for predetermined variables $X_i = (LGDP75; LIFE1)$;
- γs for endogenous variables $Z_i = (EDUC; GCGDP; TO; INF; INVGDP; LFERTIL; DEM; RRx / IMFx)$;
- τs for exogenous variables $N_i = (LPOPUL; EURER; SURVIVOR; LATCAR; SAHAR)$. Dummies for Sub-Saharan Africa and Latin America and the Caribbean enter as routinely suggested in the growth literature;
- κs for interaction terms of exchange-rate regime dummies with all policy variables $(GCGDP; TO; INF; INVGDP; DEM)$, including variables which are objects of policy actions $(EDUC; FERTIL)$. Interaction terms are added in order to reflect the Lucas critique (see section 3.3). We believe that interacting policy variables may be sufficient to capture the possible parameters-change, according to Lucas (1976);

- ψs for one-lag regressors from the policy variables $(GCGDP; TO; INF; INVGDP)$ and from the two object-policy variables $(EDUC; FERTIL)$. This is because of Bond *et al.*'s (2001) and Roodman's (2008a) argument that the right-hand-side variables in a standard growth regression are dynamic as well, which means the process of adjustment to changes in these factors may depend on the passage of time;
- φs for time dummies, which, according to Sarafidis *et al.* (2006) and Roodman (2008a) is always suggested as a wise strategy to remove any global time-related shocks from the errors.

Variables are as defined in Appendix A. We estimate this regression for 169 countries and 31 periods. One of the exchange-rate dummies is dropped to represent the base and is indicated as "omitted category" in Tables 5, 6 and 8. The log of the average GDP per capita (1970-74) enters as external instrument to correct potential measurement error in GDP per capita in 1975.

We utilize system-GMM dynamic panel estimation, according to the discussion in 3.2. Bond *et al.* (2001) argue that utilizing system-GMM approach in a growth framework has at least four advantages: i) it produces estimates not biased by omitted variables (like the initial efficiency); ii) produces estimates which are consistent even in presence of measurement error; iii) accounts for the endogenous right-hand-side variables (like investment in growth-context); and iv) exploits an assumption about the initial conditions to obtain moment conditions that remain informative even for persistent series (i.e. series that contain unit root, like the output). In their empirical work, Bond *et al.* (2001) found that the difference-GMM in growth models is seriously biased, due to the high degree of persistence of output and the resulting weak instruments. On the other hand, they found the system-GMM to be unbiased and consistent when some of the series contains a unit root. Hence, this study discards the earlier recommendation by Caselli *et al.* (1996) to use differenced-GMM estimator for empirical growth models.

Nevertheless, although system-GMM is found to be unbiased and consistent when some of the series are persistent, no solution has been offered when variables cointegrate, i.e. when they are all I(1), but a linear combination of those is I(0). We add this caution following the recent work of Pesaran and Smith (1995) and Pesaran *et al.* (1997, 1999) who treat the non-stationarity and cointegration properties of the underlying data-generating process.

Though, the system might cointegrate only if all variables contain a unit root. Table 3 presents the results from two panel unit-root tests proposed by Maddala and Wu (1999) and Pesaran (2003), respectively. The first, so-called Fisher's test combines the p-values from N independent unit-root tests and assumes that all series are non-stationary under the null hypothesis. Pesaran's test applies to heterogeneous panels with cross-section dependence and it is based on the mean of individual Dickey-Fuller (or Augmented DF) t-statistics of each unit in the panel. Null hypothesis also assumes that all series are non-stationary. To eliminate the cross dependence, the standard DF (or ADF) regressions are augmented with the cross-section averages of lagged levels and first-differences of the individual series.

Table 3. Panel unit-root tests (growth regression)

	Maddala and Wu (1999)		Pesaran (2003)	
	Constant	*Constant and trend*	*Constant*	*Constant and trend*
Real per capita GDP growth	1540.38***	1370.20 ***	-15.53***	-10.90***
Inflation	1410.18***	1265.26***	-13.05***	-13.14***
Trade openness	499.14***	459.84***	-0.77	-2.85***
Government consumption to GDP	617.53***	559.70***	-0.99	0.38
Investment to GDP	702.35***	742.97***	-3.84***	-4.52***
Democracy index	565.71***	527.91***	No obs	No obs
Log of population	140.79	754.03***	9.44	6.74
Δ Log of population	1156.57***	968.74***	-11.96***	-4.96***

Note: Numbers represent Chi2 statistics or t-statistics. *, ** and *** indicate that the null of unit root is rejected at 10, 5 and 1% level of significance, respectively.
Regressions for testing unit roots include one lag to eliminate possible autocorrelation.

The results suggest that there are little empirical grounds for being concerned that the variables are non-stationary. As expected, the only non-stationary variable is population, where both tests indicate a presence of unit root; hence, we use the first difference, reflecting population growth. Pesaran's test indicates unit root in the government-consumption variable, but this is not the case with the Fisher's test. Considering those findings, we proceed with the system-GMM estimation, as explained above.

We use both the lag-limiting and collapse commands available under Roodman's (2008a) xtabond2 command to reduce the number of instruments. These methods are important in reducing the number of instruments, whose number otherwise will be enormous because of the number of regressors and the large T. Lag-limits are set so that the number of instruments does not exceed the number of cross sections and/or to get good Hansen's statistics (p-value above 0.25, but below values near unity)[7].

We start with equation 10; Hansen's test for over-identification and Arellano-Bond test for serial correlation suggest an appropriate specification. We conduct F-tests, to check if interaction terms, group-by-group, are jointly significant; these suggest that the null that the effect of the policy variables do not change when regime switches could not be rejected for all exchange-rate regimes and, in consequence, there is no evidence for the Lucas critique. We remove those interactions and get the estimates where the Hansen test (p=0.739) suggests all the instruments are valid, while Arellano-Bond-AR(2) (p=0.396) suggests no evidence of serial correlation in the errors. However, observing the coefficients, majority of those are insignificant at conventional levels. A possible explanation is that including the current and lagged value of each variable might give rise to multicollinearity. The F-test for the joint significance of the lagged independent variables is insignificant (p=0.3352). Without lagged values, indeed some of the variables improve in terms of the statistical significance, which suggests that the suspicion of multicollinearity may be justified. The regression is well specified (p(AR2)=0.860; p(Hansen)=0.646) and this is our final specification. The Wald tests (p=0.000) suggests that all the right-hand-side regressors are jointly highly significant in explaining growth. Observed individually, some of the regressors are statistically significant, some are not, but all of them have the expected sign and magnitude. The lagged dependent variable has the expected positive coefficient of 0.158, which is below one and is in line with the literature (Roodman, 2008a), pointing to a stable dynamic process. The convergence rate estimates that if country's initial GDP level is lower by 1%, the economy will, on average, grow faster by 2.47 percentage points, which could be expected and is in line with other findings (Barro and Sala-i-Martin, 2004), but the coefficient lacks statistical significance. All other regressors have the expected sign and magnitude, although only inflation, fertility rate, trade openness and, in some specifications, government consumption and investment, are significant at conventional levels. Table 4 compares the system-GMM estimate of the lagged dependent variable with the FE one (which is, on average, downward biased) and with the OLS one (which is, on average, upward biased). Our finding is within the range given by FE and OLS estimators (Bond *et al.,* 2001; Roodman, 2008a) which supports its validity.

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[7] Our general principle in all specification was to expand the number of instruments until Hansen's p-value deteriorates, i.e. approaches 0.25 or unity.

Table 4. Comparison statistics of System-GMM with OLS and FE in terms of the estimated coefficient on the lagged dependent variable (RR classification)

	FE	OLS	System-GMM
Growth(-1)	0.118	0.232	**0.158**
AR(1) (p-value)	0.000	0.607	**0.000**
AR(2) (p-value)	-	-	**0.860**
Hansen (p-value)	**-**	**-**	**0.646**

The variable of main interest – the de-facto *exchange-rate regime*, is statistically insignificant at conventional levels, although the signs suggest that de-facto fixers deliver the best growth performance. The insignificance of the de-facto exchange-rate regime in explaining growth is confirmed by the F-test of the joint effect of the regimes (p=0.1720). Hence, the main conclusion is that the de-facto exchange-rate regime is not significant in explaining growth. The results are confirmed if the specification is applied to developing countries only, reducing the sample to 139 countries[8]. In these specifications also the de-facto exchange-rate regime did not come close to conventional significance levels. Columns (5) and (6) of Table 5 present the estimates for two distinct sub-periods: 1976-1990 and 1991-2006. The intuition behind this division is to capture the early post-socialism period (past 1991), when transition countries experienced accelerating inflation and nearly all of them subsequently established a form of fixed exchange rate. The de-facto regime again is insignificant at conventional levels in both periods, although coefficients in the overall regression slightly differ between the two periods. Finally, column (7) distinguishes de-facto regimes between advanced, developing and transition economies for the period 1991-2006, but finds no different results.

Table 6 advances the issue by considering peg duration. Some studies and findings mentioned in section 2, argued that a peg delivers early benefits since it curbs inflation, but long pegs strangle growth. To check for this, we make an arbitrary cut-off of the pegs duration at: pegs up to 5 years, pegs longer than 5 but shorter than 10 years, and pegs longer than 10 years. All specifications are diagnostically valid. However, signs, magnitudes and significance, and hence, conclusions are similar to those in Table 5. De-facto exchange-rate regime and its duration are not significant in explaining growth, no matter the level of development of countries or the observed sub-periods.

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[8] We do not run a regression for advanced-countries group because they comprise a sample of 30 countries, so that N=T. In this case, it could be argued that dynamic system-GMM is not the best estimator. Refer to section 3.4.2.

Table 5. Growth regression under RR (de-facto) classification of exchange-rate regimes

Dependent variable: *Real per capita GDP growth*	**FE**	**OLS**	**System-GMM**	**Developing countries**	**Sub-periods**		**1991-2006 – Lev. of devel.**
					1976-1990	**1991-2006**	
	(1)	(2)	(3)	(4)	(5)	**(6)**	**(7)**
Real per capita GDP growth(-1)	0.118***	0.232***	**0.157*****	0.163**	0.167	0.295***	0.298***
Initial GDP in 1975	-	-0.192	**-2.469**	-0.455	3.875	-1.945	-1.551
Life expectancy at birth (inverse)	-	-0.422	**33.276**	14.424	10.707	-6.976	-11.084
Inflation	-0.383	0.158	**-2.649**	-3.367**	4.820	3.107	2.673
Average years of schooling	-	-0.062	**2.254**	1.925**	-2.650	0.037	-1.047
Log of fertility rate	0.119	0.00078	**-11.978****	4.153	-6.831	-0.394	-0.544
Trade openness	4.771***	1.961***	**8.272****	12.880***	7.384	0.210	1.327
Government consumption to GDP	-23.068***	-7.453***	**13.436**	18.389	13.807	0.561	8.085
Investment to GDP	-0.032	0.014	**0.775***	0.870	-0.446	0.196	-0.122
Democracy index	-0.091	-0.058	**-0.786**	-1.162	-3.666	-0.229	-0.537
Democracy index squared	0.005	-0.015	**0.073**	0.155	0.492	0.028	0.023
Fixed ERR	*1.206**	*0.106*	***2.317***	*-1.564*	*0.415*	*1.160*	*3.382*
Limited flexible ERR	*0.446*	*0.312*	***-0.183***	*-3.004*	*2.572*	*-0.355*	*-0.918*
Flexible ERR	*0.022*	*0.149*	***1.134***	*-0.110*	*-1.090*	*0.025*	*0.303*
Free floating ERR	*Omitted cat*	*Omitted cat*	***Omitted cat***	*Omitted cat*	*Omitted cat*	*Omitted cat*	*Omitted cat*
Other cat. (dual market / free fal.)	*-2.073****	*-1.766****	***0.124***	*-1.543*	*-3.670*	*-2.672*	*-2.804*
Δ Log of population	-87.489***	-65.394***	**-0.075**	-117.391	-99.67	-80.729	-89.059**
Dummy for the Euro zone	-0.716	-0.782**	**-1.788**	-	-2.081	-1.865	-5.153
Dummy for survivor bias	0.580	0.931	**1.641**	1.504	-	-0.438	0.0067
Dummy for Latin A. and Caribbean	-	-0.765**	**3.698***	-0.147	-0.102	-0.414	-0.059
Dummy for Sub-Saharan Africa	-	-0.240	**-2.704**	-5.159	-0.757	1.288	2.794
Fixed ERR in Transition countries							-0.480
Lim-flex ERR in Transition countries							3.786
Flexible ERR in Transition countries							4.079
Fixed ERR in Developing countries							-3.852
Lim-flex ERR in Developing countries							1.307
Flexible ERR in Developing countries							0.478
Wald test (p-value)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
AR(2) (p-value)	**-**	**-**	**0.860**	**0.539**	**0.565**	**0.901**	**0.838**
No instruments	**-**	**-**	**54**	**52**	**36**	**48**	**56**
Hansen (p-value)	**-**	**-**	**0.646**	**0.662**	**0.617**	**0.308**	**0.505**
Difference in Hansen (p-value)			**0.572**	**0.746**	**0.684**	**0.365**	**0.454**

Notes: *, ** and *** refer to a significance level of 10, 5 and 1%, respectively. All regressions are two-step system GMM. The Windmeijer (2005) corrected standard errors are reported in parentheses.

The specification for the period 1991-2006 uses the initial level of real per capita GDP in 1990. The level in 1989 is used as instrument to correct for possible measurement error. Life expectancy at birth refers to 1990.

Table 6. Growth regression under RR (de-facto) classification of exchange-rate regimes – peg's duration

Dependent variable: *Real per capita GDP growth*	**FE** (1)	**OLS** (2)	**System-GMM** (3)	**Developing countries** (4)	**Sub-periods** **1976-1990** (5)	**1991-2006** **(6)**	**1991-2006 – Lev. of devel.** **(7)**
Real per capita GDP growth(-1)	0.118***	0.224***	**0.159****	0.136**	0.119*	0.287***	0.276***
Initial GDP in 1975	-	-0.317*	**-2.033**	-4.603	8.889	-2.350	-1.280
Life expectancy at birth (inverse)	-	-0.537	**21.952**	14.598	41.597	-9.795	-11.856
Inflation	-0.373	-0.012	**-1.877**	-4.138*	7.036	3.219	3.302
Average years of schooling	-	-0.048	**1.562***	2.491*	2.889	0.124	-0.316
Log of fertility rate	0.101	0.068	**-8.247***	1.691	16.845	2.389	3.621
Trade openness	4.816***	2.049***	**8.771*****	13.059***	23.764	-0.644	-0.198
Government consumption to GDP	-23.198***	-7.113***	**3.538**	24.247	84.155	8.310	9.374
Investment to GDP	-0.03	0.016	**0.601***	0.784	2.817	0.149	-0.069
Democracy index	-0.088	-0.092	**-0.180**	-0.2	5.125	-0.722	-0.363
Democracy index squared	0.0049	-0.01	**0.017**	0.023	0.604	0.073	0.001
Fixed ERR under 5 years	*1.154**	*0.975***	***1.506***	*-3.937*	*10.984*	*0.102*	*-1.878*
Fixed ERR 5 to 10 years	*1.405**	*0.557*	***1.458***	*-7.544*	*9.135*	*-1.848*	*-5.512*
Fixed ERR over 10 years	*1.312*	*-0.449*	***0.251***	*-16.384*	*9.978*	*-2.137*	*-5.956*
Limited flexible ERR	*0.461*	*0.304*	***-0.801***	*-3.410*	*9.488*	*-1.071*	*-4.856*
Flexible ERR	*0.040*	*0.131*	***0.332***	*-0.068*	*9.472*	*-0.433*	*-2.172*
Free floating ERR	*Omitted cat*	*Omitted cat*	***Omitted cat***	*Omitted cat*	*Omitted cat*	*Omitted cat*	*Omitted cat*
Other cat. (dual market / free fal.)	*-2.068****	*-1.724****	***-0.934***	*-1.074*	*10.613*	*-2.996*	*-3.995*
Δ Log of population	-87.631***	-66.026***	**-31.845**	-70.086	218.957	-93.556**	-92.09**
Dummy for the Euro zone	-0.768	-0.836**	**-1.423**	-	4.284	-0.037	1.35
Dummy for survivor bias	0.598	0.848	**0.939**	1.504	-	-0.714	-0.796
Dummy for Latin A. and Caribbean	-	-0.681**	**2.652**	3.018	6.681	-1.149	-1.427
Dummy for Sub-Saharan Africa	-	-0.128	**-1.651**	-1.380	5.112	1.004	1.921
Fixed ERR 5 in Transition countries							3.044
Fixed ERR (5-10) in Transition countries							7.698
Fixed ERR 10 in Transition countries							7.325
Fixed ERR 5 in Developing countries							5.338
Fixed ERR (5-10) in Developing countries							4.238
Fixed ERR 10 in Developing countries							1.621
Wald test (p-value)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
AR(2) (p-value)	**-**	**-**	**0.939**	**0.536**	**0.519**	**0.802**	**0.921**
No instruments	**-**	**-**	**58**	**50**	**40**	**52**	**60**
Hansen (p-value)	**-**	**-**	**0.693**	**0.740**	**0.439**	**0.440**	**0.637**
Difference in Hansen (p-value)			**0.738**	**0.649**	**0.306**	**0.430**	**0.732**

Notes: *, ** and *** refer to a significance level of 10, 5 and 1%, . For others, see Table 5.

The above testing-down procedure is repeated with the de-jure (IMF) classification. The regression is well specified, according to the diagnostic statistics (p(AR2)=0.724; p(Hansen)=0.191). The coefficient on the lagged dependent variable is within the range established by FE and OLS and hence, this supports its validity.

Table 7. Comparison statistics of System-GMM with OLS and FE in terms of the estimated coefficient on the lagged dependent variable (IMF classification)

	FE	OLS	System-GMM
Growth(-1)	0.124	0.248	**0.219**
AR(1) (p-value)	0.0000	0.3984	**0.000**
AR(2) (p-value)	-	-	**0.724**
Hansen (p-value)	-	-	**0.191**

Table 8 takes the issue further. Contrary to the de-facto classification, in the overall specification, the IMF's de-jure classification of the exchange-rate regime reveals some significant effect on growth. Namely, estimates suggest that a de-jure peg performs better than de-jure float with a magnitude of almost 4 p.p., while de-jure flexible rate delivers better growth performance with a magnitude of about 2 p.p. Hence, studies that use de-jure classification and terminate their investigation at this point, might end up with invalid conclusion. Namely, this discrepancy compared to the de-facto classification disappears when specifications for developing countries and two sub-periods are observed; in those specifications de-jure exchange-rate regimes are insignificant in explaining growth. For the same reasons specified above, column (7) in Table 8 differentiates transition, developing and developed economies, but finds no different results. All the other coefficients in the regressions are of similar magnitude and sign as when de-facto classification is used and this is a kind of robustness check of the obtained results. Considering the duration of peg yields to similar conclusions – insignificance of peg (duration) in explaining growth and hence it is not reported.

Table 8. Growth regression under IMF (de-jure) classification of exchange-rate regimes

Dependent variable: *Real per capita GDP growth*	**FE** (1)	**OLS** (2)	**System-GMM** (3)	**Developing countries** (4)	**Sub-periods** **1976-1990** (5)	**1991-2006** **(6)**	**1991-2006 – Lev. of devel.** **(7)**
Real per capita GDP growth(-1)	0.124***	0.248***	**0.219****	0.146*	0.091	0.336***	0.360***
Initial GDP in 1975	-	-0.15	**0.827**	-0.039	-3.031	-3.631	-0.069
Life expectancy at birth (inverse)	-	-0.279	**15.067**	11.321	6.532	-18.507	-5.643
Inflation	-1.277***	-0.831	**0.674**	-2.999*	-1.688	4.624	3.421
Average years of schooling	-	-0.074	**0.926**	2.328*	3.096	-0.173	-0.958
Log of fertility rate	0.428	0.077	**-3.878**	7.0	-0.165	2.426	-0.283
Trade openness	4.007***	2.468***	**5.541**	14.07***	31.196	-0.614	-5.060
Government consumption to GDP	-23.16***	-6.82***	**-34.085**	4.024	-3.680	-3.770	-26.776
Investment to GDP	-0.007	0.003	**0.054**	0.727	-0.371	-0.126	-0.013
Democracy index	-0.362	-0.229	**-0.307**	-1.873	-2.05	-0.248	-1.817
Democracy index squared	0.034	0.003	**-0.016**	0.221	0.407	-0.112	0.143
Fixed ERR	*0.435*	*0.012*	***3.884****	*3.138*	*1.412*	*2.853*	*3.381*
Limited flexible ERR	*0.329*	*0.202***	***1.128***	*-2.875*	*3.718*	*1.570*	*0.620*
Flexible ERR	*0.348*	*0.495*	***2.166****	*1.344*	*4.881*	*2.076*	*12.962*
Free floating ERR	*Omitted cat*	*Omitted cat*	***Omitted cat***	*Omitted cat*	*Omitted cat*	*Omitted cat*	*Omitted cat*
Other cat. (dual market / free fal.)	*-0.666*	*-1.776*	***-8.252***	*-3.61*	*1.079*	-	-
Δ Log of population	-94.227***	-64.77***	**-49.797**	-113.017	4.560	-99.55*	-57.152**
Dummy for the Euro zone	-0.393	-0.91***	**-1.266**		-7.513	-2.459	-4.061
Dummy for survivor bias	0.923	0.656	**0.127**	2.444		-1.301	-0.617
Dummy for Latin A. and Caribbean	-	-0.834***	**-0.693**	-1.177	-0.388	-2.505	-2.143
Dummy for Sub-Saharan Africa	-	-0.287	**-1.367**	-5.904	-4.138	2.709	0.646
Fixed ERR in Transition countries							-0.924
Lim-flex ERR in Transition countries							2.892
Flexible ERR in Transition countries							-10.599
Fixed ERR in Developing countries							-3.348
Lim-flex ERR in Developing countries							-0.790
Flexible ERR in Developing countries							-13.309
Wald test (p-value)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
AR(2) (p-value)	**-**	**-**	**0.724**	**0.460**	**0.612**	**0.415**	**0.461**
No instruments	**-**	**-**	**54**	**52**	**36**	**44**	**52**
Hansen (p-value)	**-**	**-**	**0.191**	**0.345**	**0.756**	**0.197**	**0.557**
Difference in Hansen (p-value)			**0.143**	**0.638**	**0.980**	**0.145**	**0.749**

Notes: *, ** and *** refer to a significance level of 10, 5 and 1%, respectively. All regressions are two-step system GMM. The Windmeijer (2005) corrected standard errors reported in parentheses.

The specification for the period 1991-2006 uses the initial level of real per capita GDP in 1990. The level in 1989 is used as instrument to correct for possible measurement error. Life expectancy at birth refers to 1990.

In general the conclusion, having encompassing all theoretical and modelling aspects discussed in section 2 and Petreski (forthcoming), and in this study, is that the empirical evidence suggests that *exchange-rate regime does not affect output growth*, as a general rule. No empirical grounds were established that coefficients in the regression suffer the Lucas critique. Observing two sub-periods or developing countries led to the same conclusion – insignificance of the exchange-rate regime. Observation of the de-facto versus de-jure regime does not matter in that respect. Specifically, although de-facto classification accounts for the actual behaviour of the exchange rate, any capital controls and any devaluation or crises episodes which were all apparent in the developing, including transition, economies during 1990s and early 2000s, conclusion is the same – the exchange-rate regime does not affect economic growth, no matter of the regimes' classification, observed time period or level of development of countries. The duration of peg is not important either. The duration and developing-countries group was especially considered for the period 1991-2006, a period in which episodes of devaluation and currency crises were observed, which might have played a role in affecting growth. However, this was not the case. The empirical findings suggest, however, that there is very marginally significant positive effect of an exchange-rate peg on growth according to the de-jure classification for the entire sample, but is insignificant in all other de-jure specifications.

7. Conclusion

The aim of this study was to articulate the arguments as to the relationship between the exchange-rate regime and growth present in the literature and to empirically investigate whether and how the exchange-rate regime affects output growth, by addressing some of the drawbacks in the current empirical studies. At theoretical level, the directions in which the regime may impinge on productivity, investment, trade and thus, on the output growth are plentiful. Mainly, theoretical considerations relate the exchange-rate effect on growth to the level of uncertainty imposed by flexible option of the rate. However, while reduced policy uncertainty under ERT promotes an environment which is conductive to production factor growth, trade and hence to output, such targets do not provide an adjustment mechanism in times of shocks, thus stimulating protectionist behaviour, price distortion signals and therefore misallocation of resources in the economy. Consequently, the relationship remains blurred and requires more in-depth empirical investigation.

The review of the empirical studies, however, came to a conclusion neither. Whereas one group of studies found that a pegged exchange rate stimulates growth, while a flexible one does not, another group concluded the opposite holds. Moreover, a third group of studies came up with no effect or inconclusive results. The latter could be due to a measurement error in the exchange-rate regimes' classifications (Levy-Yeyati and Sturzenegger, 2002), divergences in measuring exchange-rate uncertainty (Du and Zhu, 2001) or sampling bias (Huang and Malhorta, 2004). A great part of the studies focuses on the parameter of the exchange-rate dummy, but do not appropriately control for other country characteristics nor apply appropriate growth framework (Bleaney and Francisco, 2007). Also, the issue of endogeneity is not treated at all or inappropriate instruments are repeatedly used (Huang and Malhorta, 2004; Bleaney and Francisco, 2007). Very few studies pay attention to the capital controls, an issue closely related to the exchange-rate regime and only one study puts the issue in the context of monetary regimes. Du and Zhu (2001) add that results from many empirical studies differ among counties when the same method of examination is applied and even for the same country at different points of time.

An overall critique of the literature examining the relationship between exchange-rate regime and growth is offered by Goldstein (2002), whose assertion from the beginning of this study might be helpful: as a nominal variable, the exchange rate (regime) does not affect the long-run economic growth. In addition, the empirical evidence is condemned because of growth-framework, endogeneity, sample-selection bias and the so-called peso problem (which arises if the sample period does not include instances of the kind of severe economic stress that can lead to foreign exchange system demise). Moreover, in the majority of studies, parameters in the regressions are time-invariant which might be problematic, because conditions on the world capital market changed, especially since the end of the Breton-Woods system.

For the purpose of the empirical investigation, a minimally specified growth model has been defined. The study addressed other important issues, which are presently - partially or entirely - missing from the exchange-rate regimes literature. Namely, the investigation contrasts use of the de-jure (IMF) versus a de-facto (Reinhart and Rogoff, 2004) exchange-rate classification; draws attention to the Lucas critique, i.e. how parameters in the equation may change when the exchange-rate regime changes; and discusses and addresses the endogeneity bias, present in the growth and exchange-rate-regimes literature. The empirical investigation covers the post-Bretton-Woods era (1976-2006) and includes 169 countries.

A dynamic system-GMM panel method has been used to account for the potential endogeneity of the lagged dependent and all independent variables in the growth regression, by using valid lags of explanatory variables' levels and differences as instruments. The validity of the included instruments is acceptable when judged by the appropriate tests. The main finding is that the exchange rate regime is not significant in explaining output growth. No empirical grounds were established for the coefficients in the regression as suffering from the Lucas critique. Observing two sub-periods or developing countries only led to the same conclusion – the insignificance of the exchange-rate regime. Using the de-facto versus de-jure classification of exchange rates did not matter in that respect. Specifically, although the de-facto classification accounts for the actual behaviour of the exchange rate, including any capital controls and any devaluation or crises episodes, which were all apparent in the developing, including transition, economies during 1990s and early 2000s, the conclusion is the same – the exchange-rate regime does not affect economic growth, no matter the classification, observed time period or level of development of countries. The duration of peg is also not of importance. The duration and developing-countries group was especially considered for the period 1991-2006, with numbers of episodes of devaluation and currency crises, which were expected to have played a role in affecting growth. However, these expectations proved incorrect.

Reverting to the general findings, though, if the exchange-rate regime, as a nominal variable, is found not to affect growth, then it might be important in affecting its departure from the long-run level, i.e. the output volatility. Further research should examine if the exchange-rate regime is significant in explaining output volatility.

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APPENDIX A – Variables

A.1. Growth variables: definitions, sources and expected signs

Variable		Theory and expected sign	Source	Notes
Dependent variable				
Real Per Capita GDP growth	GROWTH		IMF, World Economic Outlook	This variable is expressed in percentages (i.e. value of 3 refers to 3% and is not settled as 0.03).
Independent variables				
Initial values				
Log(Initial Per Capita GDP)	LGDP75 LGDP90 (for regressions 1991-2006)	Neo-classical theory - Solow model (-)	IMF, World Economic Outlook	Observation for 1975 (1990) – a predetermined variable. Earlier values (average over 1970-1974; and value in 1989) are used in the list of instruments in order to lessen the tendency to overestimate the convergence rate because of temporary measurement error in GDP
Life expectancy at birth (reciprocal value)	LIFE1 LIFE2 (for regressions 1991-2006)	Neo-classical theory - Augmented Solow model (-)	World Bank Database	An observation in 1975 (1990)– a predetermined variable. The reciprocal value is multiplied by 100 to avoid parameter with many decimals.
Log of Population	LPOPUL	Neo-classical theory - Solow model (-) Endogenous theories (+)	IMF, World Economic Outlook UNSD, Demographic statistics	Exogenous
Policy and object-to-policy variables				
Educational attainment	EDUC	Neo-classical theory - Augmented Solow model (+)	World Bank Database	Average years of secondary and higher schooling, observed as average values over 5-year periods for 1985-2006. Previous values are unavailable.
Log of Fertility rate	LFERTIL	Neo-classical theory - Solow model (-)	UNPD World Population Prospects, 2006	Total lifetime live births for the typical woman over her expected lifetime. It enters as a log of the averages 1985-1990; 1990-1995; 1995-2000 and 2000-2005. Previous and annual values are unavailable.
Government consumption ratio	GCGDP	Neo-classical theory - Solow	IMF, World Economic Outlook	Ratio of nominal government consumption to

		model (-) Endogenous theories (-)	World Bank estimated	nominal GDP.
Trade openness	TO	Neo-classical theory - Solow model (+) Endogenous theories (+)	IMF, Trade Statistics	Ratio of export plus import over two over GDP.
Investment ratio	INVGDP	Neo-classical theory - Solow model (+)	IMF, World Economic Outlook	Ratio of gross capital formation to GDP.
Inflation rate	INF	Neo-classical theory - Solow model (-) Endogenous theories (-)	IMF, World Economic Outlook	Consumer price inflation
Exchange rate regimes	RRx IMFx	Exchange-rate regime theories (insignificant or sign mixed)	Official IMF classification De-facto classification by Reinhart and Rogoff (2004)	x represents the type of ERR: 1 – fix; 2 – limited flexibility; 3 – flexible; 4 – free float; 5 – free falling (RR only); OT –other (like dual markets; IMF only)
Institutional variables				
Democracy index	DEM	Theory of institutional factors of growth (-); squared term (+)	Freedom House	The index of political rights

A.2. Full specification of dummy variables

Notation	Value 1	Value 0	Source
Exchange-rate regimes			
RR1	If fixed	Otherwise	De-facto RR classification
RR2	If limited-flexible	Otherwise	De-facto RR classification
RR3	If flexible	Otherwise	De-facto RR classification
RR4	If free float	Otherwise	De-facto RR classification
RR5DUAL	If free falling or dual market	Otherwise	De-facto RR classification
IMF1	If fixed	Otherwise	IMF web
IMF2	If limited-flexible	Otherwise	IMF web
IMF3	If flexible	Otherwise	IMF web
IMF4	If free float	Otherwise	IMF web
IMFOT	If dual market exists	Otherwise	IMF web
Other dummies related to the exchange-rate regime			
EURERM	If a country belongs to the Euro zone and the ERM II - 12 (mainly the period 1991-2006) + UK in 1991 and 1992	Otherwise	Eurostat
Survivor bias			

SURVIVOR	If in the particular year inflation rate exceeds 30%	Otherwise	Based on CPI measure; IMF, World Economic Outlook
Geographic groupings			
LATCAR	If the country belongs to the region **Latin America and the Caribbean:** Argentina; Belize; Bolivia; Brazil; Chile; Colombia; Costa Rica; Dominica; Dominican Republic; Ecuador; El Salvador; Grenada; Guatemala; Guyana; Haiti; Honduras; Jamaica; Mexico; Nicaragua; Panama; Paraguay; Peru; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Suriname; Uruguay; Venezuela.	Otherwise	World Bank groupings
SAHAR	If the country belongs to the region **Sub-Saharan Africa:** Angola; Benin; Botswana; Burkina Faso; Burundi; Cameroon; Cape Verde; Central African Republic; Chad; Congo, Rep; Côte d'Ivoire; Ethiopia; Gabon; Gambia, The; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; São Tomé and Principe; Senegal; Seychelles; Sierra Leone; South Africa; Sudan; Swaziland; Tanzania; Togo; Uganda; Zambia; Zimbabwe.	Otherwise	World Bank groupings
Development groupings			
ADVAN	**Developed (advanced) market economies** Australia; Austria; Belgium; Bermuda; Brunei Darussalam; Canada; Cyprus; Denmark; Finland; France; Germany; Greece; Hong Kong, Iceland; Ireland ; Italy; Japan; Rep.; Kuwait; Luxembourg; Netherlands; New Zealand; Norway; Portugal; Qatar; Singapore; Slovenia; Spain; Sweden; Switzerland; United Arab Emirates; United Kingdom; United States.	Otherwise	World Bank groupings, Group high-income countries
TRANS	**Transition markets** Albania; Armenia; Azerbaijan; Belarus; Bosnia-Herzegovina; Bulgaria; China; Croatia; Czech Republic; Estonia; Georgia; Hungary; Kazakhstan; Kyrgyzstan; Latvia; Lithuania; Macedonia; Moldova; Mongolia; Poland; Romania; Russian Federation; Serbia/Montenegro; Slovakia; Slovenia; Tajikistan; Ukraine; Uzbekistan; Vietnam	Otherwise	SSRN
DEVEL	**Developing economies (includes transition countries)** Albania; Armenia; Azerbaijan; Belarus; Bosnia-Herzegovina; Bulgaria; China; Croatia; Czech Republic; Estonia; Georgia; Hungary; Kazakhstan; Kyrgyzstan; Latvia; Lithuania; Macedonia; Moldova; Mongolia; Poland; Romania; Russian Federation; Serbia/Montenegro; Slovakia; Slovenia; Tajikistan; Ukraine; Uzbekistan; Vietnam + All	Otherwise	Residual

	the remaining in the sample		

APPENDIX B – Descriptive analysis

B.1. Growth under alternative regimes and classifications (whole sample)

	Average growth rate	
	RR (2004) de-facto classification	IMF de-jure classification
fixed	2.18	1.81
limited-flexible	2.69	2.53
flexible	2.05	2.64
free-floating	2.39	2.08
free falling	0.52	n.a.

B.2. Growth under alternative regimes and classifications (countries' development level)

	Average growth rate			
	Reinhart and Rogoff (2004) de-facto classification		IMF de-jure classification	
	Advanced economies	Developing economies	Advanced economies	Developing economies
fixed	2.21	2.17	1.95	1.79
limited-flexible	1.64	2.94	2.24	2.62
flexible	2.04	2.05	2.34	2.68
free-floating	1.65	2.64	1.94	2.11
free falling	-0.26	0.55	n.a.	n.a.