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Macroeconomic Volatility, Institutional Instability, and the Incentive to Innovate*

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This study investigates the channels through which macroeconomic and institutional instability hinders innovative investment undertakings financed by the domestic private sector. The analysis is based on a sample of 44 countries and considers various instability dimensions. The results suggest a negative impact of real, monetary, and political instability on the aggregate level of R&D financed by the business sector. Thus, highlighting the importance of stable macro-institutional environments in preventing avoidance or abandonment of private innovation undertakings.

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*JEL Classification: C33, O11, O31, O33*

Abbreviations: EMU, FE, GDP, HI, RHS, R&D, 2SLS.

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## 1. Introduction

The importance of private sector's innovation is widely recognised in the economic growth literature (Romer, 1990; Grossman and Helpman, 1991). However, pronounced disparities persist in the shares of private Research and Development (R&D) investment across countries. Figure 1 below may help gauge the extent of the cross-country disparity existing in private sectors' R&D engagement, within the panel of economies used in this study. A number of structural factors have been investigated at length and proposed by the literature to explain such variation. This paper seeks to analyse such issue by focusing on the impact that macroeconomic and institutional instability. The reason for considering such perspective is related to the inherently high risk content of R&D investment, which is due to both its longer than average maturity horizon and to its high budget requirements (Katz, 1987). Hence, firms' plans to spend on costly and risky innovative projects may be subject to revision in uncertain environments, resulting in low aggregate private innovation spending. In what follows, it will be shown that such hypothesis is supported by the findings of our empirical analysis.

[INSERT FIGURE 1]

A number of microeconomic studies attribute firms' abandonment or avoidance of innovative investment undertakings to the existence of a cash-flow effect, which financially constrains them and hinders their innovative spending during downturns (Bohva-Padilla et al, 2009, Aghion et al, 2010). To the contrary, following the Schumpeterian analysis of the business cycle and Hall's reorganizational capital theory (1991), Saint-Paul (1993) maintains that, during recessions, the opportunity cost faced by innovating firms in terms of foregone profits is lower, as the value of expected sales decreases. This should provide an incentive for firms to allocate resources to R&D during recessionary phases. However, Rafferty and Funk (2008) and Aghion et al. (2012) show that the existence of an asymmetry in binding constraints causes cash-flow effects to bind more during recessions than expansions. The result is that during recessions firms disinvest more than what they invest during expansions. Instead, the 'opportunity-cost' effect is shown to bind more during expansions. As a result, firms tend to relocate resources away from R&D, and towards sales, when positive demand shocks occur, but the opposite is less likely to happen during negative shocks. In addition, Bohva-Padilla et al. (2009) show that counter-cyclicality in R&D spending is more likely in small and medium-sized firms, which tend to experience binding credit constraints the most; whereas, pro-cyclicality is more likely for non-credit constrained firms, such as multinationals.

This paper represents a contribution to the existing literature on volatility and innovation in a few respects. Firstly, the literature described above concentrates on recessions, while this study extends the focus to overall volatility in relation to firms' innovative behavior. Secondly, the research question has only been tackled at the firm level, and most often focusing on OECD-based firms only. The present study analyses, instead, cross-country variations in the level of national private R&D. This is done in an attempt to uncover aggregate response patterns to macro-institutional instability which go beyond individual productive sectors' dynamics. A final contribution is represented by the estimation of separate impacts for various sub-components of aggregate volatility. This allows to disentangle a number of contemporaneous yet different dimensions co-existing in unstable macro-institutional environments. The econometric findings suggest, in addition, that such impacts exhibit non-linearities and threshold effects.

## 2. Data and Model

The panel covers 15 years (1994-2008) and 44 countries. Unfortunately, the limitation of aggregate innovation data is its scarcity. In particular, the panel suffers from an underrepresentation of African countries that needs to be acknowledged. The choice of regressors included in the model specification has taken into account and sought comparison with a variety of stability indicators used in the literature, and it includes a number of control variables which have been used by the literature on the determinants of innovative investment. The benchmark econometric specification is as follows:

$$(1) \qquad y_{it} = a_i + \sum_{j=1}^{m} \beta_j X_{j,it} + \sum_{k=1}^{n} \gamma_k Z_{k,it} + \sum_{l=1}^{q} \theta_l V_{l,it} + \varepsilon_{it}$$

where the dependent variable, $y_{it}$, is *BusinessR&D*: the share of investment in R&D financed by the domestic business sector, calculated as a % of GDP. The right hand side of the regression includes three variable vectors, alongside a vector of time-invariant country fixed effects, $\alpha_i$.[1] The set $\{X_{j,it}\}_{j=1}^{m}$ and $\{Z_{k,it}\}_{k=1}^{n}$ contain, respectively, endogenous and exogenous control variables commonly used in the literature surrounding the determinants of R&D investment.

Specifically, the following variables enter $\{X_{j,it}\}_{j=1}^{m}$: GDP per capita (in log-form) controls for countries' overall level of development.[2] To capture potential non-linearities in the relationship between development level and private R&D spending, an interaction of GDP per capita with a dummy variable (*HighIncome*) was also included. The dummy takes the value of 1 for countries classified as middle to high income by the World Bank's Atlas classification system and zero otherwise. The share of publicly financed R&D is used to capture the role of public investment, which may be complementary to private innovative investment or may crowd it out (David et al., 2000). Finally, this vector also contains a measure of trade openness calculated as the sum of exports and imports to GDP. Trade openness has been used by the literature (Smolny, 2003; Sameti *et al.*, 2010) to capture the contribution that international exchange is likely to have on the ease and pace of innovation and technological progress.

The real interest rate appears among the exogenous control set $\{Z_{k,it}\}_{k=1}^{n}$, alongside, a measure of stock market capitalization. The latter has been used in a number of studies to proxy for financial development; but it also captures the effect of higher levels of both credit availability and risk diversification accessible to the business sector (David et al., 2000; Levine and Zervos, 1996). In addition, a measure of property rights protection is also included to reflect the importance this variable is believed to play in explaining the pace of innovation (Varsakelis; 2001; Lin et al., 2010). Finally, as a component of government expenditure appears in the model (public R&D) a measure of overall government deficit/surplus to GDP is also included. This is done in order to achieve a consistent specification of the public budget constraint (Bose et al., 2007; Katsimi and Sarantides, 2012). At the same time, this variable proxies for the quality of public account management. While, strictly speaking, the latter is not a standard indicator of instability, it nonetheless provides a measure of fiscal reliability, and it has been used in the literature in this way (Fisher, 1993; Burnside and Dollar, 2000).

The third vector $\{V_{l,it}\}_{l=1}^{q}$ is composed by instability indicators. The Polity IV 'State Fragility Index' is used as an indicator of institutional stability. The index rates countries according to the fragility of their effectiveness and legitimacy, in four performance dimensions: security, policy, economics, and social cohesion. Institutional uncertainty affects many elements of the macroeconomic business environment, via, for example, failing policy commitments; switching tax and incentive regimes; or revised economic targets and priorities (Fosu, 1992; Alesina et al., 1996). Real, financial and monetary volatility are represented, respectively, by the coefficient of variation of (log) GDP per capita, stock market capitalisation, and real interest rate.[3] Recurrent fluctuations in output proxy for the instability in the overall level of savings and aggregate demand; whereas variability in stock market capitalisation rates or in lending interest rates influence the cost of capital.

The model is, first, estimated using a simple within-group estimator, which takes care of time-invariant country specific fixed effects. Subsequently, to evaluate the model's dynamics of adjustment and to address any potential simultaneity bias, the same estimation is applied to a specification where the lags of all endogenous variables are used instead of their levels. However, standard within-group panel techniques may exacerbate measurement errors and does not deal with cross-sectional dependence concerns. Following Pesaran (2004) and Baltagi (2005), if such cross-sectional dependence is caused by unobserved common factors uncorrelated with the included regressors, the standard within-group estimator will still be consistent. But, if this is not the case, a solution is the estimation of fixed-effect IVs, provided weak identification of the instruments is not an issue (De Hoyos and Sarafidis, 2006). Therefore, a within-group Two Stage Least Squares (2SLS) model is estimated last, with a varying set of instruments. First, internal instruments are used, that is, first and second lags of all endogenous variables. Because private innovative investment is likely to exhibit lagged response patterns to changes in the variables appearing on the RHS of the regression, the use of time-lagged internal instruments allows for the evaluation of such 'adjustment dynamics'. This is, in general, a second-best strategy, as, ideally, one would want to use excluded variables that are highly correlated with the endogenous controls but do not belong in the model specification. Despite the difficulty of finding variables meeting such requirements in macroeconomic settings, we attempt to test the robustness of the benchmark model by using a set of external instruments, too.

## 3. Results

The benchmark regression in equation (1) is estimated in Table 1 in its basic, more parsimonious, form first. Subsequently, all volatility indicators are progressively included. Columns (1)-(7) are within-group estimates, while column (8)-(10) are 2SLS-FE estimates. In the most basic regression specification, both GDP per capita and its interaction term are significant, albeit of opposite sign. This suggests the existence of a threshold level of GDP per capita after which Business R&D and the level of a development are positively related. Such threshold value of average national GDP per capita occurs, in this sample, at about $3000 per year.[4] The lending interest rate enters with a negative coefficient, as expected. The coefficient of stock market capitalisation indicates that more developed financial markets positively relate to the share of privately funded R&D, possibly thanks to enhanced capital stock accumulation and productivity. The latter result is in line with Levine and Zervos (1996) and Greenwood and Smith (1997). All other covariates enter the basic within-group specification with coefficient insignificantly different from zero.

[INSERT TABLE 1]

Successively, moving from left to right in columns (2)-(5), the instability measures are added one at a time, separately. All enter with a negative sign, which indicates that excessive fluctuations in stock market capitalization rates, in aggregate output, in lending interest rates, and in the political environment all negatively affect private innovative investment. These findings are in line with those of Barro (1991), Alesina et al. (1996), Fosu (2003), Aghion et al. (2012). In column (6), all volatility measures are included in the benchmark at the same time. Two relevant changes take place: the results now indicate that improved fiscal performance is positively related to private innovation spending, while financial volatility is no longer significant when the other measures of real, monetary and political instability are included at the same time. This may indicate that, when financial volatility appeared on its own, its positive coefficient might have been partly capturing the effect of the other three components.

One possible drawback of the results presented thus far is that they may be biased by reverse causation between the dependent variable and the endogenous covariates.To address this, in column (7), all endogenous variables are replaced by their first lag. While all results are substantially very similar to the ones previously presented, something to note is the fact that the level of GDP per capita turns insignificant, as does State Fragility. A further concern, as anticipated above, is that related to the potential presence of cross-sectional dependence. To address that, as well as to improve upon the treatment of endogeneity, a within-group 2SLS model is estimated in columns (8)-(10). In column (8), only the first lag is used in the internal instrument set, and in column (9) only the second lag. Both the interest rate and the index of property right protection lose significance in (8), while government balance gains it. All other results carry over from (7). In column (9), again the core results regarding the instability measures only slightly vary in magnitude. The interest rate is once again significant, as is government R&D expenditure albeit only at the 10% level.[5] A concern with the results of (8) and (9) arises, however, as the Kleibergen-Paap F statistics is considerably below 10, indicating that the identification of these models is weak. A Hansen-J statistics for the overidentification test is not reported for either because the equations are exactly identified.

To improve upon such shortcomings, in column (10) both sets of lags are combined in the instrumentation strategy. Once again, results carry over from previous specifications in that the impact of the level of development is overall positive, but the result is driven, in this sample, by middle to high income countries only. In fact, low income levels appear to be marginally detrimental to private innovative investment. Neither public R&D spending nor trade openness have an impact which is significantly different from zero, evidence similar to that reported by David et al. (2000) and Varsakelis (2001). Improves rule of law enforcement leads to higher aggregate innovation spending, a result in line with Varsakelis (2001) and Lin et al. (2010). The stock market capitalization rate is again insignificant when estimated along the other instability measures. Because this variable has never entered the regression with a non-zero impact, except when estimated on its own, it will dropped from all subsequent robustness tests. Real, monetary and political instability confirm their negative relationship with private R&D investment. The instruments validity for the benchmark is confirmed by the F and Hansen-J statistics of (10), indicating that the regression is correctly identified.

In order to provide a quantitative interpretation of the coefficient magnitude for the instability indicators, it may be useful to refer to the summary statistics table (Table 2 below). The real volatility coefficient reported in column (10) of Table 1, can be interpreted in percentage change terms (see Appendix B for details). It indicates that, in this sample, a 0.1 % point increase in the coefficient of variation of (log) GDP per capita, leads to a 0.014% point decrease in private R&D spending. As for monetary volatility: half a standard deviation increase in the coefficient of variation of the interest rate results approximately in a 0.05% point decrease in R&D. Finally, a 2 point increase in the 'State Fragility' Index (which ranges from 0 to 25) leads to a 0.046% point decrease in aggregate Business R&D spending. Considering that the minimum sample value of Business R&D as a share of GDP is equal to 0.0007%, and its mean is 0.71%, it can be seen that such impacts are non-trivial.[6]

[INSERT TABLE 2]

## 4. Robustness Analysis

In the following section, the robustness of the findings reported so far is tested by re-estimating the benchmark under various modifications. It will be shown that the basic findings are not affected. To start with, the benchmark specification is repeated in column (1) of Table 3 to facilitate comparison. As already mentioned, using internal instruments may not be a viable option if lags of the endogenous variables belong themselves to the model. To address this concern, in column (2), external instruments are substituted to the internal. Recall that the endogenous variables are (log) GDP per capita and its interaction term, government R&D expenditure, and trade openness. The external instruments are the infant mortality rate, adjusted life expectancy, total tax revenue (%GDP),[7] and an aggregate regional average of the trade openness measure used in the rest of the analysis.

[INSERT TABLE 3]

The core results are not altered, except for the fact that rule of law loses significance, while trade openness gains a positive and significant coefficient. A summary of the first stage regression statistics is presented in Table B1 of Appendix B below. All F-tests, except that for the government R&D regression, point towards the significance of the excluded instruments. Nevertheless, the Angrist-Pischke multivariate F-test indicates there may be a problem of weak identification in both the trade openness and government R&D reduced form regressions. As it is well known, weak identification decreases considerably the explanatory power of 2SLS. Therefore, because the Hansen-J statistics in column (1) indicates that the exclusion restrictions are valid when internal instruments are used, the specification where internal rather than external instruments are used remains our preferred specification. Next, in column (3), time dummies are added to control for any time effect common across countries. All results carry over with no significant variation. However, because no time dummy is significant, they are all dropped from any subsequent estimation.[8]

I turn, now, to the analysis of potential non-linearities. The impact of volatility on investment has been suggested to exhibit threshold effects. Sarkar (2000) argues that a positive relationship occurs at low uncertainty levels, which switches to negative when uncertainty rises beyond a critical threshold. To test this hypothesis, quadratic terms are included in column (4), and interaction terms in (5). The quadratic terms for both real and monetary volatility indicate that, as either volatility dimension increases, R&D spending decreases at a decreasing rate.[9] The rest of the results carry over from previous specifications. In (5), we test whether the impact of instability varies according to the phase of the business cycle. To do this, a measure of GDP deviation from its mean was created[10] and interacted with each volatility indicator. The interaction terms should indicate whether any difference exists between the impact of volatility during a recession and its impact during an expansion.

It appears that, only for the monetary volatility component, as the phase of the cycle improves, volatility in the interest rate becomes less of a hindrance to private R&D spending. This result is line with the claim, made by the body of microeconometric literature reported above, that uncertainty has less of a negative effect when credit constraint are not as binding (Aghion and Saint Paul, 1998; Rafferty and Funk, 2008; Bohva-Padilla et al., 2009; Aghion et al., 2012). If such 'credit constraint' effect is the prevailing force underlying different investment responses along the business cycle, then this may account for the failure to identify a similar impact in the case of real and political instability. Moreover, uncertainty in output and state effectiveness levels is less observable than fluctuations in the official lending interest rate. For this reason, the aggregate spending adjustment to real or political instability may be not as correlated or synchronised to the phase of the cycle as it is the case of interest rate variations. No other change takes place with regards to all other results.

Next, in column (6) and (7), I test the robustness of the volatility impacts uncovered so far to variations in the way instability is measured, or variations in the channel through which the impact takes place. In particular, in (6), I use the standard deviation of both (log) GDP per capita and interest rate instead of their coefficient of variation. A great part of the literature agrees on the coefficient of variation being a more robust indicator of volatility than the standard deviation. Mobarak (2005) and Klomp and de Haan (2009) argue that the latter is an absolute measure of variation and it is very sensitive to noise in the data. The normalisation involved in the coefficient of variation, instead, makes it a relative measure of variation. In this respect, Klomp and de Haan (2009) show that the coefficient of variation allows to appropriately control for co-movements of similar countries, due, for example, to the effect of common business cycle patterns. Nonetheless, some shortcomings still persist in this measure. For example, for mean values close to zero, the coefficient of variation will approach infinity and be sensitive to small changes in the mean. All basic results remain identical in (6). Real and monetary instability have the same qualitative impact, but, here, the coefficient of real volatility indicates that a 0.01 of standard deviation increase in (log) GDP per capita leads to a 0.05% point decrease in Business R&D. While an increase of two standard deviations in the real interest rate generates a 0.006% point decrease.

In column (7), I verify the robustness of the institutional instability indicator by adding a measure of political constraints and an interaction between state fragility and political constraints. Henisz (2002) has constructed and used the ‘Political Constraint’ variable to show that constraints on the ease of policy shifts, in any given country, are conducive to infrastructural investment, and specifically to innovative investment. The index takes up values between 0 and 1, with higher values indicating more stringent political constraints. The idea is that, when any political actor can easily influence policy change, the resulting institutional framework will be more unstable. The political constraint measure is included in the model together with *StateFragility* and an interaction between the two. The impact of state fragility remains negative, however, its magnitude increases. Unlike in Henisz (2002), higher political constraints appear to hinder private R&D spending. This seemingly contradictory result can be reconciled if one considers that a slow pace of policy change is negatively correlated to innovation when it proxies for a conservative societal structure, or a malfunctioning National System of Innovation, as argued by Lundvall (1992). On the other hand, however, the interaction term between institutional instability and the political constraints index has a positive sign. This indicates that, given a negative impact of state fragility on business innovation, increased political constraints mitigate such negative impact, by limiting the extent to which instability can produce abrupt policy shifts.

Column (8) and (9) carry out some further robustness checks, via the inclusion of additional control variables. As pointed out by Serven (2003), fluctuations in the nominal exchange rate can affect the export/import incentives of firms. In (8), this international dimension is brought into the picture by adding the exchange rate level among the explanatory variables. At the same time, the coefficient of variation of the official exchange rate is also included to control for the effect of recurrent fluctuations in its level. Two additional terms are also constructed by interacting a dummy variable (EMU), with both the exchange rate level and its volatility. EMU takes the value of 1 for the countries which joined the European Monetary Union (EMU), but only in the year they switched currency regime. When the exchange rate is interacted with EMU, the interaction term controls for the structural break taking place when the euro currency regime is adopted, by correcting for the switch in measurement units.[11] Instead, the interaction term between the volatility of the exchange rate and EMU is used to capture the increased exchange rate stability which followed the adoption of the common currency by the Euro Zone economies. While all previous results remain identical, none of the four variables enters the regression significantly. This result contradicts Serven (2003), but it is not an uncommon finding in the literature, as argued in Wang and Barrett (2007).

Moving to column (9), a number of additional regressors is included. Democracy takes values from 10 (democracies) to 0 (autocratic regimes). *HighTechExports* refers to the GDP share of high-tech exports and it has been instrumented with its first and second lag to account for its likely endogeneity. *TaxRevenue* refers to the level of overall fiscal imposition to GDP. None of these variables enters the regression significantly. Though neither the significance nor the qualitative impact of all other variables is altered, both the F-stat and the Hansen-J statistic deteriorate sharply. In the last robustness test of column (10), I restrict the estimation sample to OECD countries only. This is done, first of all, because instability levels can be expected to be lower in these countries during the time span considered. At the same time, firms in high-income countries are likely to exhibit lower financial constraints and to have access to better developed financial markets. The combination of all such factors may result in firms' improved ability to cope with volatility. Thanks to the availability of a longer time series, the reduced panel covers fewer countries (17) but 28 years (1981-2008).

The results shown in column (10) lend some support to our hypothesis, in that the impact of real, monetary, political, and financial instability is inconclusive.[12] On the other hand, both the level of aggregate GDP per capita and the level of financial development are positive predictors of private R&D spending.[13] In addition, trade openness also appears to have a positive impact on Business R&D in this sample (significant at the 10% level). This result is in line with the theoretical (Porter, 1990; Lundvall, 1992; Nelson, 1993) and empirical findings (Smolny, 2003; Sameti et al., 2010; Wang, 2010) of a number of studies showing that international openness is likely to positively impact technological progress, due to increased external exposure and interaction. Finally, an interesting finding of this specification is the negative relationship linking Business R&D to the index of property rights protection. However, this result should not be seen as surprising, given that the protection standards of physical and intellectual property rights enforced in OECD economies is already very high. Thus the result may indicate that there exists a certain threshold, after which stricter enforcement levels can prove detrimental to innovation incentives and diffusion (Bessen and Maskin, 2009).

## 5. Conclusions

This paper has studied the impact of macro-institutional instability on private innovative investment. The underlying motivation for investigating such relationship lies in the consideration that innovation is crucial to growth and development. Yet, its long maturity horizon coupled with its high-budget nature make it an intrinsically riskier type of investment. The empirical analysis has therefore sought to clarify the relationship between various dimensions of volatility and aggregate private R&D spending in unstable macro-institutional environments. The findings presented above suggest three channels through which macro-institutional volatility negatively affects business R&D investment, that is, political, real and monetary volatility. Such impact has been shown to exhibit non-linearities and to be larger for higher values of the real and monetary volatility dimensions. In addition, the negative effect of monetary instability appears to be mitigated during expansionary phases, in the sample considered. Lastly, the evidence on financial and international volatility is inconclusive. An important limitation to bear in mind when interpreting the above results is that the study inevitably overlooks all forms of incremental, small-scale, grassroots or non-industrial innovation, for which aggregate secondary data does not exist.The indirect policy implication deriving from such findings points towards the desirability of safeguarding stable macroeconomic and institutional environments if encouraging private innovation engagement is a priority. Considerations regarding the most appropriate policy tools are beyond the scope of this paper. However, an interesting avenue for further research seems to be the investigation of the role that targeted counter-cyclical policy interventions and firm subsidisation may play in preserving private profitability horizons and incentives.

**References**

Acemoglu, Daron and Zilibotti, Fabrizio, “Productivity Differences”, *Quarterly Journal of Economics*, 116 (2001):563-606.

Aghion, Philippe, Angeletos, George, Banerjee, Abjit and Manova, Kalina, “Volatility and Growth: Credit Constraints and the Composition of Investment”, *Journal of Monetary Economics,* 57(2010):246-65.

Aghion, Philippe, Askenazy, Philippe, Berman, Nicolas, Cette, Gilbert, Eymard, Laurent, “Credit Constraints and the Cyclicality of R&D Investment: Evidence from France”, *Journal of the European Economic Association*, 10(2012): 1001-24.

Aghion, Philippe and Saint-Paul, Gilles, "Virtues of Bad Times, Interactions between Productivity Growth and Economic Fluctuations", *Macroeconomic Dynamics,* 2(1998): 322-44.

Alesina, Alberto, Ozler, Soule, Roubini, Nouriel, Swagel, Phillip, "Political Instability and Economic Growth", *Journal of Economic June*. 1(1996):189-211.

Baltagi, Badi, *Econometric Analysis of Panel Data*, New York: Wiley, 2005.

Barro, Robert, "Economic Growth in a Cross Section of Countries", *Quarterly Journal of Economics,* 106 (1991): 407- 43.

Beck, Thorsten, Demirgüç-Kunt, Asli and Levine, Ross, "A New Database on Financial Development and Structure". *The World Bank Economic Review* 14(2000): 597-605.

Bessen, James and Maskin, Eric, "Sequential Innovation, Patents, and Imitation" *Rand Journal of Economics*, 40(2009): 611–35

Bohva-Padilla, Simona, Damijan, Joze and Konings, Jozef, "Financial Constraints and the Cyclicality of R&D Investment: Evidence from Slovenia". KU Leuven, LICOS - Discussion paper series n. 23909(2009): 1-17.

Bose, Neil, Holman, Jill and Neanidis, Kyriakos (2007) 'The Optimal Public Expenditure Financing Policy: does the Level of Economic Development Matter?' *Economic Inquiry*, 45(2007): 433-52

David, Paul, Hall, Browyn and Toole, Andrew, "Is public R&D a complement or substitute for private R&D? A review of the econometric evidence", *Research Policy*, 29(2000): 497-529.

De Hoyos, Rafael, and Sarafidis, Vasilis, "Testing for Cross-Sectional Dependence in Panel Data Models", *The Stata Journal*, 6(2006): 482-96.

Fisher, Stanley, "The Role of Macroeconomic Factors in Growth", *Journal of Monetary Economics,* 32(1993):485-512.

Fosu, Augustin, "Political Instability and Economic Growth: Evidence from Sub-Saharan Africa", *Economic Development and Cultural Change*, 40(1992): 829-41.

Fosu, Augustin, “Political Instability and Export Performance in Sub-Saharan Africa”, *The Journal of Development Studies*, 39(2003), 68-82.

Greenwood, Jeremy and Smith, Bruce, “Financial Markets in Development, and the Development of Financial Markets’. *Journal of Economic Dynamics and Controls*, 21(1997):145-81.

Grossman, Gene and Helpman, Elhanan, *Innovation and Growth in the Global Economy*, MIT Press, 1991

Hall, Robert, Recession as Reorganization, NBER Macroeconomics Annuals, 1991.

Henisz, Witold, “The Institutional Environment for Infrastructure Investment”, *Industrial and Corporate Change*, 11(2002): 355-89.

Katz, Jorge, *Technology Generation in Latin American Manufacturing Industries*, The Macmillan Press, 1987.

Klomp, Jeroen and de Haan, Jacob, “Political Institutions and Economic Volatility”, *European Journal of Political Economy,* 25(2009): 311-26.

Levine, Ross and Zervos, Sara, “Stock Market Development and Long-Run Growth”, *The World Bank Economic Review*, 10(1996): 323-39.

Lin, Chen, Lin, Ping and Song, Frank, “Property Rights Protection and Corporate R&D: Evidence from China”, *Journal of Development Economics*, 93(2010):49-62.

Lucas, Robert, “On the Mechanics of Economic Development”, *Journal of Monetary Economics*, 22(1988): 3-42.

Lundvall, Bengt-Åke, *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers, 1992.

Mobarak, Ahmed, “Democracy, Volatility and Economic Development”, *The Review of Economics and Statistics*, 87(2005): 348-61.

Neanidis, Kyriakos and Savva, Christos, “Macroeconomic Uncertainty, Inflation and Growth: Regime - dependent Effects in the G7”, *Journal of Macroeconomics*, 35(2010): 81-92.

Nelson, Robert, *National Innovation Systems. A Comparative Analysis*, Oxford University Press, 1993

Pesaran, Hashem, "General diagnostic tests for cross section dependence in panels", University of Cambridge, Faculty of Economics, Cambridge Working Papers in Economics n. 0435, 2004

Porter, Michael, *The Competitive Advantage of Nations*, Free Press, New York, 1990.

Rafferty, Matthew and Funk, Mark, "Asymmetric Effects of the Business Cycle on Firm-Financed R&D", *Economics of Innovation and New Technology,* 17(2008): 497-510.

Romer, Paul, "Endogenous Technological Change", J*ournal of Political Economy*, 98(1990): 71-102.

Saint-Paul, Gilles, "Productivity Growth and the Structure and of the Business Cycle", *European Economic Review*, 37(1993)*:* 861-90.

Sameti, Majid, Ranjbar, Homayoun and Anoushesh, Shahrzad, "Determinants of R&D Investment: Evidence from OECD countries", *The Journal of Knowledge Economy and Knowledge Management,* FALL (2010): 35-42.

Sarkar, Sudipto, "On the Investment-Uncertainty Relationship in a Real Options Model", *Journal of Economic Dynamics and Controls*, 24(2000): 219-25.

Serven, Luis, "Real-Exchange-Rate Uncertainty and Private Investment in LDCs", *The Review of Economics and Statistics*, 85(2003): 212–18.

Smolny, Werner, "Determinants of Innovation Behavior and Investment Estimates for West German Manufacturing Firms". *Economics of Innovation and New Technology,* 12(2003): 449–63.

Varsakelis, Nikos, "The Impact of Patent Protection, Economy Openness and National Culture on R&D Investment: a Cross-Country Empirical Investigation", *Research Policy*, 30(2001): 1059-68.

Wang, Eric, "Determinants of R&D Investment: The Extreme-Bounds-Analysis Approach Applied to 26 OECD Countries", *Research Policy*, 39 (2010): 103-16.

Wang, Kai Li and Barrett, Christopher, “Estimating the Effects of Exchange Rate Volatility on Exports Volumes”, *Journal of Agricultural and Resource Economics,* 32(2007): 225-55.

**Notes**

1. A vector of time-varying common effects is also included in the benchmark (column 11, Table 1), though, because never significant, it is dropped from all subsequent estimations.
2. The relevance of human capital availability for the innovation process has been highlighted by both theory (Lucas, 1988; Acemoglu and Zilibotti, 2001) and empirics (Wang, 2010). The reason why such variable is excluded from this analysis is because of its very high correlation with GDP.
3. Technical details on the construction of the volatility indicators can be found in Appendix B.
4. The World Bank Atlas Classification System defines as lower middle income countries all countries with an average GNI per capita between the annual value of $1026-4035.
5. Note that, due to the structure of the dataset, using the second rather than the first lag to instrument the endogenous variable results in a higher number of observations. This is due to the fact that some countries only provide innovation spending data, every two years.
6. In calculating such impacts, the standardisation is done by considering a change of half of the observed standard deviation, reported in Table 2 (i.e. 0.1 for the coefficient of variation of (log) GDP per capita, around 0.5 for the standard deviation of the interest rate, 2 for State Fragility).
7. Tax Revenue will also appear on its own in a subsequent specification.
8. The time dummies coefficients are not reported in the table for reasons of space.
9. A quadratic term of *StateFragility* is not included due to the ordinal nature of this variable.
10. The mean of (log) GDP per capita is calculated across the entire 1994-2008 time window. For each country, this is then subtracted from each year’s realised (log) GDP per capita value.

11. Most EMU countries in my sample joined the currency union in 1999; the rest between 2001 and 2007. When the switch takes place, LCU denominated exchange rates turn to euro denominations. The EMU dummy takes into account the break to avoid biasing the estimation.

12. Note that *StateFragility* could not be used in this sample due to its time coverage (earliest data period is 1994). Therefore Henisz's Political Constraint Index is used instead.

13. Note that, in this sample, due to the data availability restrictions for the 1980s, stock market capitalisation has been substituted by a measure of private credit by commercial banks as a proxy for financial development.

## Appendix A: Data and Country Appendix

*Table A1. Data Sources*

| | | |
|---|---|---|
| **BusinessR&D** | R&D spending by the private sector (%GDP) | OECD-MSTI Database<br>UNESCO - Stats.uis<br>RICYT.org |
| **GovernmentR&D** | R&D spending by the public sector (%GDP) | OECD-MSTI Database<br>UNESCO - Stats.uis<br>RICYT.org |
| **LogGDPpercapita** | Log(Total Output / Population) | World Bank-WDI |
| **InterestRate** | Real interest rate based on lending rate charged to businesses by commercial banks (3 months-1 year) | Own calculation. Raw data from World Bank-WDI |
| **Balance** | Overall Deficit/Surlpus (%GDP) | IMF -Government Finance Statistics |
| **PropertyRights** | 0-10 Index where 10 indicates the highest level of rule of law enforcement | Economic Freedom of the World – Area 2: Legal System and Property Rights |
| **TradeOpenness** | (Exports + Imports) / GDP | World Bank-WDI |
| **StockMarket** | Value of listed shares to GDP, calculated using the deflation: $\{(0.5)*[F_t/P_{et}+F_{t-1}/P_{et-1}]\}/(GDP_t/P_{at})$, where F is stock market capitalization, $P_e$ is end-of period CPI, and $P_a$ is average annual CPI | Database on Financial Development and Structure (Beck et al. 2000) |
| ***StateFragility*** | The Index scores countries on effectiveness and | POLITY IV Dataset |

| | | |
|---|---|---|
| | legitimacy in four dimensions: security, political, economic, and social. Scores are 0-25 where 0 indicates very stable countries | |
| **PoliticalConstraints** | The index measures the feasibility of policy change It ranges from 0-1, with higher scores indicating more political constraint | Henisz' Political Constraints Index III Dataset |
| **ExchangeRate** | Nominal Exchange Rate (LCU per US$) | World Bank-WDI IMF–International Financial Statistics |
| **Democracy** | The index ranges from -10 to 10, where -10 is the score given to authoritarian regimes | POLITY IV Dataset |
| **HighTechExports** | High-Tech Exports/ Tot Manufacturing Exp | World Bank-WDI |
| **TaxRevenue** | Tot Tax Revenue / GDP | IMF- Governance Finance Statistics |
| **FinancialDeveleopment** | Private credit by deposit money banks and other financial institutions to GDP, calculated using the deflation:$\{(0.5)*[F_t/P_{et}+F_{t-1}/P_{et-1}]\}/(GDP_t/P_{at})$ where F is stock market capitalization, $P_e$ is end-of period CPI, and $P_a$ is average annual CPI | Database on Financial Development and Structure (Beck et al. 2000) |
| **InfantMortality** | Infant Mortality Rate per 1000 live births | World Bank - WDI |
| **LifeExpectancy** | Adjusted Life Expectancy at birth | World Bank - WDI |

*Table A2. Country List*

| | | | | |
|---|---|---|---|---|
| Argentina | Cyprus* | Ireland*† | Mongolia | Slovak Rep* |
| Australia† | Czech Rep* | Israel*† | Netherlands*† | Slovenia* |
| Austria*† | Denmark*† | Italy*† | Norway† | South Africa |
| Belgium*† | Estonia* | Japan† | Panama | Spain** |
| Bolivia | Finland *† | Korea Rep*† | Paraguay | Thailand |
| Brazil | France** | Kuwait | Philippines | Uganda |
| Bulgaria | Germany*† | Latvia* | Poland* | Ukraine |
| Canada*† | Hungary* | Lithuania | Portugal*† | United Kingdom*† |
| Chile | Iceland*† | Malaysia | Romania | United States*† |
| China | India | Malta* | Russia | Uruguay |
| Colombia | Iran | Mexico | Singapore* | Venezuela |

*High-Income countries (ATLAS classification) *†OECD countries included in the robustness analysis †OECD countries appearing in the robustness analysis only.

## Appendix B: Technical Appendix

### *B1. First Stage results*

*Table b1. Summary of Results for 1st Stage Regressions*

| | **F-test of excluded Ivs** | **Angrist-Pischke Weak Identification test** | **Underidentification test** |
|---|---|---|---|
| **LogGDPpercapita** | 63.53*** | 24.15 | 59.68*** |

| | | | |
|---|---|---|---|
| **LogGDPpercapita*HighIncome** | 49.17*** | 31.13 | 76.92*** |
| **GovernmentR&D** | 4.65*** | 4.12 | 10.19*** |
| **TradeOpenness** | 14.45*** | 5.47 | 13.52*** |
| **Obs.** | 341 | 341 | 341 |
| **Stock-Yogo weak identification crit. value (5%)** | | 18.37 | |

Notes: first-stage test statistics are heteroskedasticity-robust

*B2. Notes on the Construction of the Volatility Measures*

The Coefficient of Variation is a normalized measure of dispersion of a variable's distribution over a certain time period. It is calculated as the ratio of the standard deviation to the mean of a series.

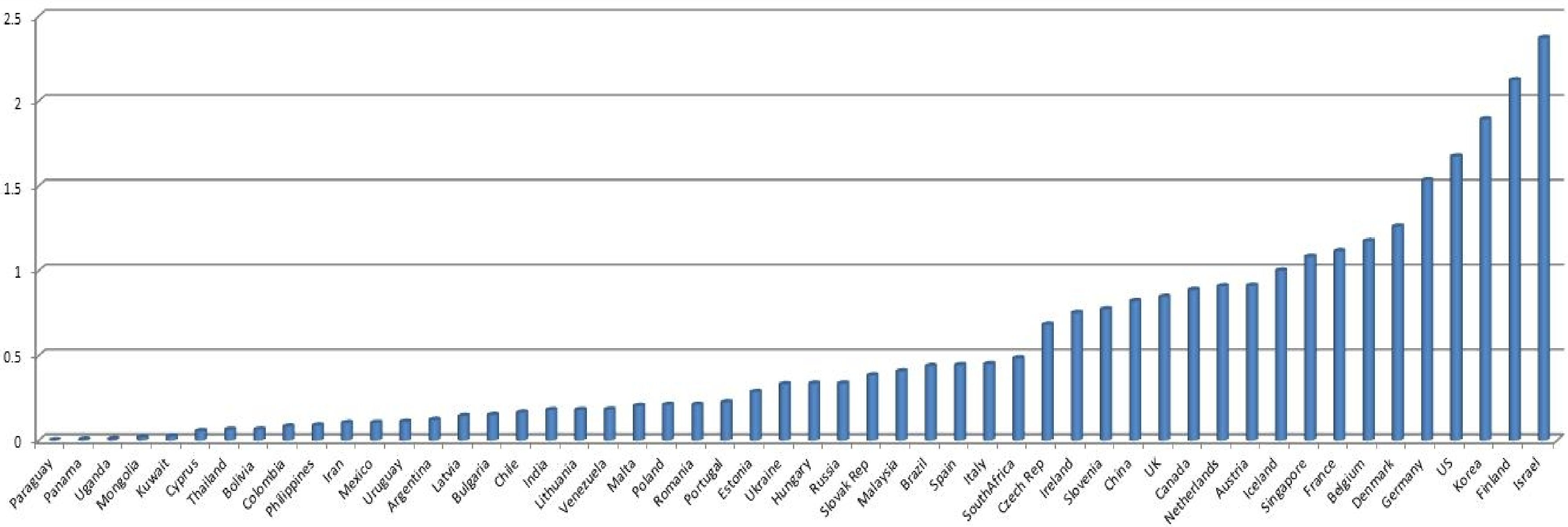
$$\text{(A1)} \qquad v = \left( {}^{\sigma}/_{\mu} \right)$$

where the standard deviation is calculated as follows

$$\text{(A2)} \qquad \sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

In this paper, a two year rolling window is utilised to calculate both the mean and the standard deviation of (log) GDP per capita, real interest rate and stock market capitalisation. Thus real, monetary and financial volatility, in this context, is defined as the ratio of the standard deviation to the mean of the rolling window. A backward looking strategy has been used in constructing such window, to reflect the type of knowledge agents might have of volatility at time *t*. Note that, because of the log transformation with which GDP per capita appears in the regressions, the coefficient magnitude of real volatility is not comparable to that of the other volatility measures. To restore visual comparability, the coefficient of variation of GDP per capita has been multiplied by 100. Its quantitative interpretation will however also be in percentage change terms.

*Figure 1. Business R&D (%GDP)*




*The values represent the ratio of Business Funded R&D to GDP, and they are calculated as a national average over the time span 1994-2008 (Raw data is from the OECD, Main Science&Technology Database, UNESCO UIS and RICYT*

*Table 1. Benchmark Results*

| | FE | | | | | | | 2SLS-FE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** | **(10)** |
| **LogGDPpercapita** | -0.262*** | -0.261*** | -0.231** | -0.175* | -0.321** | -0.246* | -0.224 | -0.232** | -0.423*** | **-0.226*** |
| | (0.088) | (0.089) | (0.092) | (0.098) | (0.139) | (0.135) | (0.138) | (0.111) | (0.144) | (0.126) |
| **LogGDPpercapita* HighIncome** | 0.635*** | 0.623*** | 0.547*** | 0.619*** | 0.671*** | 0.49*** | 0.579*** | 0.56*** | 0.616*** | **0.532*** |
| | (0.165) | (0.166) | (0.142) | (0.193) | (0.19) | (0.162) | (0.206) | (0.098) | (0.119) | (0.113) |
| **InterestRate** | -0.003* | -0.003* | -0.003* | -0.004** | -0.004** | -0.005*** | -0.002* | -0.001 | -0.005*** | **-0.004*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) | (0.001) | (0.002) | (0.001) |
| **StockMarket** | 0.151*** | 0.154*** | 0.152*** | 0.124*** | 0.133*** | 0.144*** | 0.12** | 0.118*** | 0.113*** | **0.088*** |
| | (0.036) | (0.036) | (0.034) | (0.035) | (0.035) | (0.036) | (0.053) | (0.034) | (0.038) | (0.029) |
| **Balance** | 0.004 | 0.004 | 0.005 | 0.003 | 0.003 | 0.006* | 0.004 | 0.005* | 0.010*** | **0.005*** |
| | (0.005) | (0.005) | (0.005) | (0.004) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| **PropertyRights** | 0.002 | 0.002 | -0.002 | 0.009 | 0.009 | 0.005 | 0.017 | 0.013 | 0.007 | **0.019**** |
| | (0.008) | (0.008) | (0.008) | (0.012) | (0.012) | (0.012) | (0.013) | (0.008) | (0.011) | (0.009) |
| **GovernmentR&D** | 0.215 | 0.213 | 0.261 | 0.204 | 0.179 | 0.169 | 0.103 | 0.283 | 0.466* | **0.159** |
| | (0.189) | (0.190) | (0.181) | (0.222) | (0.21) | (0.188) | (0.124) | (0.175) | (0.246) | (0.180) |
| **TradeOpenness** | 0.057 | 0.059 | 0.086 | 0.018 | 0.029 | 0.092 | 0.035 | 0.059 | 0.143 | **0.030** |
| | (0.069) | (0.069) | (0.069) | (0.065) | (0.066) | (0.067) | (0.077) | (0.096) | (0.166) | (0.098) |
| **StockMarketCoV** | | -0.080* | | | | -0.040 | -0.037 | -0.011 | -0.011 | **-0.026** |
| | | (0.048) | | | | (0.039) | (0.038) | (0.041) | (0.050) | (0.046) |
| **LogGDPpercapCoV** | | | -0.133** | | | -0.205*** | -0.111** | -0.14*** | -0.226*** | **-0.142*** |
| | | | (0.054) | | | (0.053) | (0.05) | (0.037) | (0.055) | (0.040) |
| **InterestRateCoV** | | | | -0.005** | | -0.009*** | -0.009** | -0.008*** | -0.010*** | **-0.010*** |
| | | | | (0.002) | | (0.002) | (0.004) | (0.003) | (0.003) | (0.003) |
| ***StateFragility*** | | | | | -0.020* | -0.022* | -0.016 | -0.017* | -0.028** | **-0.023**** |
| | | | | | (0.011) | (0.012) | (0.012) | (0.009) | (0.011) | (0.009) |
| **Obs.** | 398 | 396 | 393 | 343 | 340 | 338 | 294 | 295 | 305 | 284 |
| **$R^2$** | 0.37 | 0.38 | 0.39 | 0.36 | 0.3 | 0.3 | 0.31 | 0.41 | 0.4 | 0.38 |
| **N. country** | 59 | 59 | 59 | 58 | 57 | 57 | 52 | 46 | 50 | 44 |
| **Wald F** | . | . | . | . | . | . | . | 2.8 | 3 | 10 |
| **Hansen-J** | . | . | . | . | . | . | . | . | . | 0.13 |

Heteroskedasticity-robust standard errors reported in brackets. Significance level: p<0.1***p<0.01 **p<0.05 *p<0.1. Columns (1)-(7) report within-estimator results. In (7), all endogenous regressors are lagged. Columns (8)-(10) report the 2SLS-FE results. In (8) and (9), respectively, only the first lag and second lag, in (10), first and second lags are combined. The results in (10) appear in bold to indicate this is the benchmark specification.

*Table 2. Summary Statistics*

| Variable | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|
| **BusinessR&D** | 0.709 | 0.714 | 0.0007 | 3.402 |
| **GovernmentR&D** | 0.465 | 0.238 | 0.02 | 1.054 |
| **LogGDPpercapita** | 9.016 | 1.109 | 5.645 | 10.55 |
| **LogGDPpercapita* HighIncome** | 9.562 | 0.662 | 7.973 | 10.55 |
| **InterestRate** | 6.082 | 6.433 | 0 | 43.8 |
| **StockMarket** | 0.624 | 0.58 | 0.006 | 3.084 |
| **PropertyRights** | 6.79 | 1.565 | 1.599 | 10 |
| **Balance** | -1.34 | 3.101 | -12.67 | 11.37 |
| **TradeOpenness** | 0.97 | 0.626 | 0.234 | 4.381 |
| ***StateFragility*** | 3.214 | 4.058 | 0 | 16 |
| **LogGDPpercapCoV** | 0.324 | 0.241 | 0.009 | 1.271 |
| **InterestRateCoV** | 0.531 | 1.148 | 0.0005 | 11.74 |
| **StockMarketCoV** | 0.14 | 0.12 | 0.0007 | 0.813 |
| **ExchangeRate** | 189.7 | 746.3 | 0.298 | 9170 |
| **ExchangeRateCoV** | 0.082 | 0.186 | 0 | 1.38 |
| **LogGDPpercap_StDev** | 0.029 | 0.019 | 0.0009 | 0.094 |
| **InterestRate_StDev** | 2.689 | 4.014 | 0.374 | 41.84 |
| **PoliticalConstraints** | 0.447 | 0.142 | 0 | 0.718 |
| **Democracy** | 8.641 | 3.116 | -7 | 10 |
| **HighTechExports** | 16.61 | 14.7 | 0.513 | 73.59 |
| **TaxRevenue** | 18.07 | 6.033 | 0.957 | 33.19 |
| **FinancialDevelopment** | 0.929 | 0.381 | 0.229 | 2.024 |
| **FinancialDevelopmentCoV** | 0.345 | 0.386 | 0 | 0.266 |

*Table 3. Robustness Checks*

| | 2SLS-FE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** | **(10)** |
| **LogGDPpercapita** | **-0.226*** | -0.983*** | -0.359** | -0.42*** | -0.243 | -0.407*** | -0.24** | -0.247** | -0.354** | 0.635*** |
| | (0.126) | (0.332) | (0.179) | (0.148) | (0.290) | (0.127) | (0.111) | (0.119) | (0.152) | (0.245) |
| **LogGDPpercapita* HighIncome** | **0.532***** | 0.822*** | 0.61*** | 0.659*** | 0.54*** | 0.678*** | 0.428*** | 0.529*** | 0.604*** | |
| | (0.113) | (0.238) | (0.134) | (0.133) | (0.152) | (0.108) | (0.108) | (0.112) | (0.172) | |
| **InterestRate** | **-0.004***** | -0.002* | -0.004*** | -0.004** | -0.003** | -0.002** | -0.004*** | -0.004*** | -0.003* | 0.011 |
| | (0.001) | (0.001) | (0.001) | (0.002) | (0.002) | (0.001) | (0.001) | (0.001) | (0.002) | (0.009) |
| **StockMarket** | **0.088***** | 0.101** | 0.09*** | 0.098*** | 0.092** | 0.1*** | 0.091*** | 0.089*** | 0.075** | |
| | (0.029) | (0.043) | (0.033) | (0.031) | (0.037) | (0.03) | (0.031) | (0.031) | (0.032) | |
| **Balance** | **0.005*** | 0.011** | 0.009*** | 0.006* | 0.004 | 0.003 | 0.004 | 0.004 | 0.004 | -0.01 |
| | (0.003) | (0.005) | (0.003) | (0.003) | (0.003) | (0.002) | (0.004) | (0.003) | (0.003) | (0.006) |
| **PropertyRights** | **0.019**** | 0.011 | 0.019** | 0.023** | 0.02** | 0.012* | 0.019* | 0.018** | 0.021* | -0.028* |
| | (0.009) | (0.013) | (0.009) | (0.010) | (0.01) | (0.007) | (0.01) | (0.009) | (0.012) | (0.016) |
| **GovernmentR&D** | **0.159** | 0.271 | 0.121 | 0.143 | 0.162 | 0.218 | -0.08 | 0.099 | 0.223 | 0.205 |
| | (0.180) | (0.793) | (0.155) | (0.178) | (0.178) | (0.160) | (0.141) | (0.167) | (0.204) | (0.216) |
| **TradeOpenness** | **0.030** | 0.928** | 0.002 | 0.048 | 0.033 | 0.031 | 0.053 | 0.059 | 0.204 | 0.543* |
| | (0.098) | (0.4) | (0.098) | (0.096) | (0.098) | (0.104) | (0.087) | (0.096) | (0.129) | (0.286) |
| **StockMarketCoV** | **-0.026** | -0.017 | -0.057 | | | | | | | |
| | (0.046) | (0.065) | (0.049) | | | | | | | |
| **LogGDPpercapCoV** | **-0.142***** | -0.289*** | -0.125*** | -0.28*** | -0.121*** | | -0.126*** | -0.139*** | -0.157*** | 0.091 |
| | (0.040) | (0.08) | (0.04) | (0.108) | (0.043) | | (0.036) | (0.044) | (0.046) | 0.11 |
| **InterestRateCoV** | **-0.01***** | -0.015*** | -0.009*** | -0.118** | -0.01** | | -0.011*** | -0.009*** | -0.011*** | -0.143 |
| | (0.003) | (0.004) | (0.003) | (0.052) | (0.005) | | (0.002) | (0.003) | (0.003) | (0.103) |
| ***StateFragility*** | **-0.023**** | -0.048** | -0.026** | -0.032*** | -0.025** | -0.02** | -0.056*** | -0.025*** | -0.023** | |
| | (0.009) | (0.016) | (0.01) | (0.011) | (0.012) | (0.008) | (0.014) | (0.009) | (0.011) | |
| **LogGDPpercapitaCoV_sq** | | | | 0.173* | | | | | | |
| | | | | (0.100) | | | | | | |
| **InterestRateCoV_sq** | | | | 0.077* | | | | | | |
| | | | | (0.042) | | | | | | |
| **LogGDPpercapitaCoV_nonlin** | | | | | -0.157 | | | | | |
| | | | | | (0.313) | | | | | |
| **InterestRateCoV_nonlin** | | | | | 0.001** | | | | | |
| | | | | | (0.00) | | | | | |
| ***StateFragility*_nonlin** | | | | | -0.00 | | | | | |
| | | | | | (0.001) | | | | | |
| **LogGDPpercap_StDev** | | | | | | -1.057** | | | | |
| | | | | | | (0.429) | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **InterestRate_StDev** | | | | | | -0.003** | | | | |
| | | | | | | (0.001) | | | | |
| **PoliticalConstraints** | | | | | | | -0.434*** | | | 1.75 |
| | | | | | | | (0.121) | | | (1.09) |
| ***StateFragility* *PoliticalConstraints** | | | | | | | 0.061*** | | | |
| | | | | | | | (0.019) | | | |
| **ExchangeRate** | | | | | | | | -0.00 | | |
| | | | | | | | | (0.00) | | |
| **ExchangeRateEMU** | | | | | | | | -0.039 | | |
| | | | | | | | | (0.025) | | |
| **ExchangeRateCoV** | | | | | | | | -0.029 | | |
| | | | | | | | | (0.085) | | |
| **ExchangeRateCovEMU** | | | | | | | | 0.042 | | |
| | | | | | | | | (0.092) | | |
| **Democracy** | | | | | | | | | -0.003 | |
| | | | | | | | | | (0.013) | |
| **HighTechExports** | | | | | | | | | -0.002 | |
| | | | | | | | | | (0.004) | |
| **TaxRevenue** | | | | | | | | | 0.009 | |
| | | | | | | | | | (0.006) | |
| **FinancialDevelopment** | | | | | | | | | | 0.145* |
| | | | | | | | | | | (0.083) |
| **FinancialDevelopmentCoV** | | | | | | | | | | 0.132 |
| | | | | | | | | | | (0.348) |
| **Obs.** | 284 | 341 | 284 | 259 | 278 | 252 | 275 | 284 | 268 | 248 |
| **$R^2$** | 0.38 | 0.15 | 0.42 | 0.39 | 0.36 | 0.35 | 0.35 | 0.37 | 0.4 | 0.22 |
| **N. country** | 44 | 47 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 16 |
| **Wald-F** | 10 | 1.4 | 11 | 10.5 | 8.6 | 8.6 | 10 | 8.3 | 4 | 59.3 |
| **Hansen-J** | 0.13 | 0.08 | 0.49 | 0.35 | 0.42 | 0.16 | 0.24 | 0.17 | 0.09 | 0.12 |

Heteroskedasticity-robust standard errors in brackets. Significance levels: ***p<0.01 **p<0.05 *p<0.1. Column (1) corresponds to the benchmark model in column (10) of Table 2. In (2), external instruments are used. In (3), time dummies are added. In (4) and (5), non-linearities are modelled. In (6), new political instability measures are included. In (7), the coefficient of variation is substituted by the standard deviation. In (8), the exchange rate and its volatility are added. In (9), three additional regressors are included. In column (10), the benchmark specification in (1) is estimated in an OECD country panel.