# Disentangling the debt-growth nexus

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*Our paper investigates the connection between debt and growth and some related variables such as inflation and the monetary base growth. Using CS-ARDL, CS-DL and system GMM methods, we provide evidence of the injurious consequences of debt and inflation on growth. However, the negative effect of both variable vanishes in emerging countries. Considering the choice between debt and money financing, the first one proves to be detrimental to growth while the other seems to have a positive effect. Nevertheless, monetary base growth may lead to inflation and its associated negative effects in the long-run. A threshold analysis provide some weak evidence of their existence. They are at least likely to be country-specific and are usually lower in developed countries.*

## I. Introduction

The present paper will investigate the relationship between debt and growth, which became a relatively hot topic after the financial crisis and Reinhart and Rogoff (2010) controversial paper. Many other papers were published in the following years and most of them provide evidence of a negative impact of debt on growth above a certain threshold, typically between 80 and 100 % of GDP.[1] However, they often failed to account for the numerous econometric issues that can arise in this context: cross-sectional dependencies across countries, slope heterogeneities, presence of a feedback effect, endogenous variables, possible measurement errors...

More recently, a breakthrough appeared in the working paper of Chudik et al. (2013). Their approach focuses on the long-run relationship between GDP growth and growth in the debt-to-GDP ratio. They also included inflation in the analysis as an attempt to investigate the counterpart of the debt-growth relationship in countries which cannot issue debt and print money instead.

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[1] Gross Domestic Product.

These two relationships were estimated by the means of a newly developed estimator that they call CS-DL.[2] This estimator presents some features that are different from those of the CS-ARDL[3] estimator, which can be viewed as complementary to the CS-DL estimator. Indeed, the CS-DL estimator is applicable in many situations in which the CS-ARDL may be inappropriate, and vice versa. While the CS-DL estimator allows for residual serial correlation and/or breaks in the process of the error term and do not require to find a correct specification of the lag length,[4] it is inconsistent in the presence of a feedback effect. Nevertheless, their Monte-Carlo simulations show that the bias of the CS-DL is relatively small in practice when there is a feedback effect. Both simulations and theoretical properties indicate a quite interesting estimation procedure, which they use to shed some light on the debt-growth puzzle.

Using the CS-DL as well as the CS-ARDL estimator to estimate the long-run relationships, they showed that it exists a detrimental effect of debt on growth but emphasized that only permanent augmentations in debt, measured as a percentage of GDP, affect growth in the long-run. The different specification used also indicated evidence that inflation harms growth in the long-run. An important part of our paper focuses on the method of Chudik et al. (2013), which provided very interesting findings while actually tackling most of the econometric issues that have been encountered previously in the literature. Slope heterogeneity is allowed for, common effects on countries are captured by the model etc. However, some of their choices can be discussed and potential misspecifications may be analyzed. Some robustness tests can also be conducted. Hence, we will analyze their methodology, test its robustness and look at possible improvements. The paper is structured as follows. First of all, the different links that economic theory postulates among the variables of interest are clarified. Since there is a two-way causality between debt and growth, both directions are detailed in Section 2. The role of inflation and the monetary base is also discussed. Secondly, the methodology of Chudik et al. (2013) and in particular, the CS-ARDL and CS-DL estimators will be presented.

Then, Section 4 turns to the empirical analysis. It is divided in 4 subsections. The dataset that were constituted is first presented. Next, the regressions run by Chudik et al. (2013) are replicated in our slightly larger dataset. These regressions are then submitted to some robustness check and changes in specification. In particular, the relevance of the selected variables

[2]Cross-sectionally augmented distributed lag.
[3]Cross-sectionally autoregressive distributed lag.
[4]The derivation of the CS-DL regression actually requires the inversion of a lag polynomial, implying the necessity of a lag truncation.

is assessed by looking at some alternatives such as change in the monetary base instead of inflation or change in the debt burden instead of change in debt. There is some uncertainty about which variables really matter, which seems worth clarifying. The influence of the income level of countries on the results will also be assessed. Finally, the last subsection investigates the models by the mean of another estimator.

Section 5 concludes the paper.

## II. Survey of relationships among the variables

The relationships between debt and growth are quite complex. Debt can affect growth through several channels, more or less directly, in a nonlinear fashion, possibly only above a certain threshold. Moreover, the causality runs not only from debt to growth but also from growth to debt. As Tica et al. (2014) have shown, the variables Granger cause each other.

The relationship between inflation or money and growth may seem simpler but the literature still provides conflicting results about the significance and the direction of the effect.

Therefore, it seems appropriate to start this paper by a theoretical analysis, which clarifies the potential channels involved, and to look at information and predictions provided by economic theory.

### A. *Simultaneous variations due to a third variable*

Most of the econometric and economic interest is related to the causal relationship between variables. However, a simple way in which debt and growth are related is through the effect of government expenditures. Let's look at a debt reduction: the government adjusts its budget which may be detrimental to economic growth. The size of the effect depends on the measures taken. When public consumption and investment are involved, the effects tend to be stronger. Conversely, when measures affect transfers from the government to the households, the effects are likely to be weaker (Nautet and Van Meensel, 2011).

Note that we have no causation here, debt and growth are affected by a third factor: government expenditures. The level of debt at the end of a period is directly dependent on the amount that was spent by the government, which also affects GDP growth in the current period or even in the future.

### B. *Debt effects on growth*

The relationship from debt to growth is the one that most people were trying to capture in the literature. From a theoretical perspective, a very high debt level can have damaging consequences on the economy although issuing a moderate amount of debt certainly helps improve the population's well-being.

A relatively small level of debt can allow a country to reach a higher growth rate since it may enable the government to finance some productive investments (Aschauer, 2000). Moreover, investment in the stock of public goods may allow the economy to reach a long-run optimal growth path faster (Aizenman, Kletzer and Pinto, 2007).

However, too high a debt can lead to crowding out effects and debt overhang. If debt is too high, its sustainability may be doubted and investors may be concerned about the capacities of the government management, causing a downward pressure on economic growth. The associated long-run effect is thus mostly negative; lowering the debt level would imply lower interest charges, not only because the debt is smaller but also because interest risk premiums fall as public finances improve. Additional resources become available and can be used to reduce tax or increase government expenditures (Nautet and Van Meensel, 2011).

This discussion suggests the existence of the threshold effect which has been estimated in the econometric literature (see, for instance, Kumar and Woo (2010), Checherita-Westphal and Rother (2012) or Chudik et al. (2013)): debt really affects growth when it has become sufficiently big to cast doubts about its sustainability. The effect is thus fundamentally non-linear; low debt has a nonnegative effect on growth while high debt is probably harmful.

This non-linear effect is exactly what Checherita-Westphal and Rother (2012) found when they analyzed the relationship between debt and growth. They estimated a threshold of 90-100% of GDP below which raising debt is beneficial to growth but above which debt has negative effects.

Besides these findings, many researchers have found a negative impact of debt on growth, at least above a certain threshold. In particular, Reinhart and Rogoff (2010) have found such a relationship using correlation analyses. The potential shortcoming here is that only correlation is taken into account; the study does not account for reverse causality and does not control for other determinants of growth. Another study by Kumar and Woo (2010) provides evidence of a negative and non-linear impact of debt on growth. In this study, endogeneity and reverse causality is accounted for as it makes use of several estimation procedures (POLS,[5] Within and Between estimators, and system GMM[6]). However, measurement errors make things difficult and estimators that may mitigate it (e.g., the Between estimator) do not deal with the omitted variable bias. There is then a trade-off among the different estimators; each approach has a potential flaw.

Finally, Chudik et al. (2013) provide a completely different approach to deal with the numerous issues arising in this context. Their study developed a new estimation technique – the CS-DL estimator discussed in Section 3 – and takes care of cross-sectional dependencies and heterogeneity across countries. Using CS-ARDL regressions and their newly-developed CS-DL estimator to estimate the long-run relationship between economic growth and debt-to-GDP ratio growth, they obtain evidence of an inverse connection. They also insist on the negative relationship between *rising* debt and economic growth and therefore point out the importance of debt trajectory. Finally, their threshold analysis indicates that, while it exists some thresholds that differ across countries, they only trigger a decline in economic growth if the debt is still rising. The market does not worry if a country is above the threshold as long as debt is not rising.

### *C. Channels of transmission*

The next question is that of the channels of transmission. Through which variables does debt impact growth? Theoretically, the chain of effects can take the form depicted in Figure 1. It shows that interest rates and interest charges occupy a central place in the picture; they are the fundamental link between debt and growth factors. Hence, the long-run impact generally results from a variation of interest charges that directly affects the main determinants of growth.

Econometric studies have tried to determine the channels through which debt can really affect growth. Schclarek et al. (2004) argues that the private capital accumulation is the main channel through which debt has an impact on growth. Similarly, Kumar and Woo (2010) claim that reduced investment and slower growth of capital stock are to blame. Checherita-Westphal and Rother (2012) suggest that public saving, public investment and total factor productivity are the main causes of the slowdown in growth when debt increases. Other channels of transmission were reported in the literature. In particular, public debt can influence growth via higher long-term interest rates (Gale and Orszag, 2003; Baldacci and Kumar, 2010), higher future

[5] Pooled Ordinary Least Squares.
[6] Generalized Method of Moments.

distortionary taxation (Barro, 1979; Dotsey, 1994) and less impactful countercyclical fiscal policies, which leads to larger volatility and lower growth (Aghion and Kharroubi, 2007).

We have thus a non-linear, indirect effect of debt on (future) growth that can manifest itself through several different channels which have not been decidedly identified yet. The composition of the debt, whether it is made of short or long term liabilities, and the currency denomination of the debt could also play a role. Moreover, there is actually a feedback effect since growth has an impact on debt. This is the topic of the next subsection.

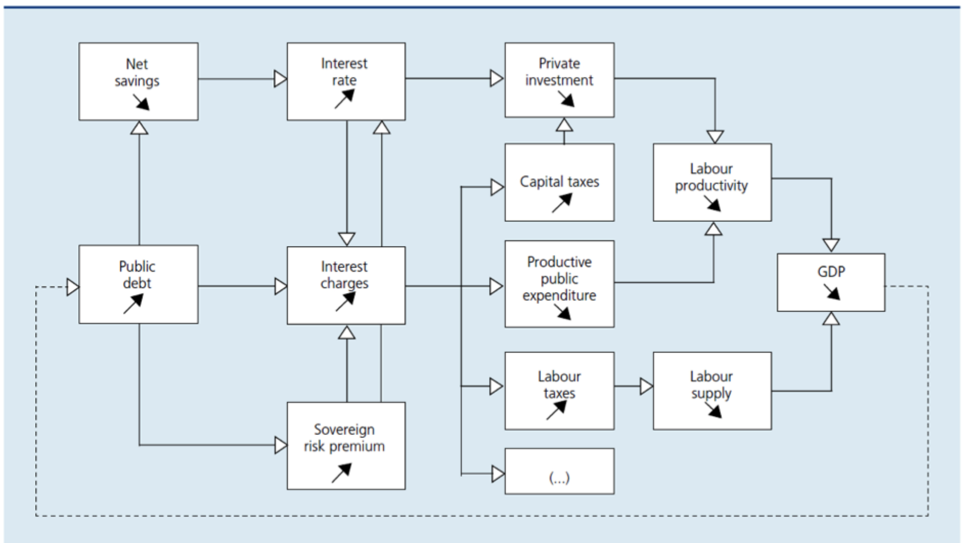


Figure 1. : Transmission Mechanisms

Source: Nautet and Van Meensel (2011)

### D. *Growth effects on debt*

Dube (2013) points out that causality can go both ways. Indeed, countercyclical fiscal policy leads to tax reduction and expenditure expansion, and automatic stabilizers raise debt in recessions. In addition, the evolution of the debt-to-GDP ratio, which is the common representation of the debt level, is directly related to economic growth. Tica et al. (2014) provide some evidence that both variable Granger cause each other.

More insight on this perspective can be obtained by looking at the debt dynamics. Consider an open economy in which the government can borrow abroad or domestically. Its total debt in local currency is given by the domestic debt plus the value of the foreign currency denominated debt multiplied by the exchange rate (International Monetary Fund, 2014):

$$D_t = D_t^D + e_t D_t^F \tag{1}$$

The flow budget constraint reads

$$D_t^D + e_t D_t^F = (1 + i_t^D)D_{t-1}^D + (1 + i_t^F)e_t D_{t-1}^F - PB_t + OT_t \tag{2}$$

Where $i_t^D$ denotes the nominal interest rate on domestic debt, $i_t^F$ represents the nominal interest rate on foreign debt, $PB_t$ is the primary balance and $OT_t$ indicates the other transactions. To obtain the relationship in terms percentages of GDP, which are represented by lower cases, both sides are divided by the nominal GDP. Reorganizing yields

$$d_t = \frac{1 + i_t^w + \alpha_{t-1}\epsilon_t(1 + i_t^F)}{(1 + g_t)(1 + \pi_t)} d_{t-1} - pb_t + ot_t \tag{3}$$

Where $g_t$ is the economic growth rate, $\pi_t$ is the inflation rate, $i_t^w$ is the effective nominal interest rate and

$$\alpha_{t-1} = e_{t-1}\frac{D_{t-1}^F}{D_{t-1}}; \epsilon_t = \frac{e_t}{e_{t-1}} - 1 \tag{4}$$

Hence, debt, when measured as the debt-to-GDP ratio, is mechanically related to the growth rate of the corresponding time period.

This can also be written as:

(5)

$$\Delta d_t = \frac{i_t^w - \pi_t(1 + g_t)}{(1 + g_t)(1 + \pi_t)} d_{t-1} - \frac{g_t}{(1 + g_t)(1 + \pi_t)} d_{t-1} + \frac{\alpha_{t-1}\epsilon_t(1 + i_t^F)}{(1 + g_t)(1 + \pi_t)} d_{t-1} - pb_t + ot_t$$

Change in the debt-to-GDP ratio can thus be decomposed in several components: the contribution of the effective real interest rate, the contribution of the real GDP growth, the contribution of the exchange rate depreciation, the primary balance and the other transactions.

Hence, both debt and its first differences are related to the economic growth of the current period. Debt or its change is necessarily endogenous in a growth equation. Accounting for the effect of, e.g. automatic stabilizers, it cannot be excluded that further lags of growth are also involved in the relationship. It can also be seen that interest rates and the depreciation of the exchange rate are also directly involved in the mechanical variation in debt, to which the government deficit is finally added.

It can finally be noted that the increase in debt is a bit different from the actual deficit run by the government. Considering Chudik et al. (2013)'s conclusion that rising debt harms growth once a certain threshold has been exceeded, it could be interesting to see if the result actually holds for the deficit. Do markets care more about the actual evolution of the debt or about the government performance in terms of balance?

### *E. The role of inflation and the monetary base*

Issuing debt is not the only way to finance a deficit. Governments that do not have an easy access to the debt market often resort to printing additional money. It is one of the interesting contributions of Chudik et al. (2013) who looked at inflation as the counterpart of debt in no-market-access economies in their regressions.

The economic and the econometric literature both provide conflicting results about the inflation-growth nexus.

On the one hand, Sidrauski (1967) proposed an economic model in which money is an argument of the utility function. At least with a general equilibrium perspective, this kind of model leads to a superneutrality of money, which implies that inflation has no influence on growth. Similar results can be obtained in cash-in-advance models Clower (1967) which forces people to hold money in order to realize their transactions because goods and services must be fully paid with cash. See for instance Ireland (1994).

Dornbusch and Frenkel (1973) obtain ambiguous effects of inflation on real variables when the model introduces money via a transaction cost function, but according to Saving (1971) and Kimbrough (1986) this ambiguity vanishes when money is viewed as a transaction device in a shopping-time technology framework.

On the other hand, Tobin (1965) argues that higher inflation generates a higher level of output and increases investment when money is considered as a substitute for capital. Bayoumi and Gagnon (1996) have similar results for investment, that is, higher inflation leads to a higher level of investment if there are distortions in the tax system. Furthermore, it has also been shown that higher inflation actually decreases capital stock and real-money balances when cash-in-advance constraints are applied to investment (Stockman, 1981). Gomme (1993), Barro (2001) and De Gregorio (1993) corroborate Stockman (1981) results since they show that a diverse scope of models produces a negative relationship between growth and inflation; the latter reduces growth by lowering investment and product.

According to the empirical literature, the relationship between inflation and growth seems to be non-linear. Indeed, Khan and Khan and Ssnhadji (2001) argue that there exists a threshold below which inflation has a no significant effect, but above which it has a strongly significant negative effect. One may wonder what the inflation rate threshold is. Some empirical findings show that increasing the annual inflation rate from 10 to 20% results in a lower annual growth rate ranging between 0.2% and 0.7%, while an increase in the inflation rate from 5 to 50% causes a fall in per capita growth of 2.2% per annum, ceteris paribus. See Chari, Jones and Manuelli (1996), Roubini and Sala-i-Martin (1992), among others.

However, this non-linear and negative relationship between inflation and growth is not robust due to misspecifications. Ericsson, Irons and Tryon (2001) reject the hypothesis of a long-run relationship between output growth and inflation due to the cointegration of inflation with the log-level of output. Similarly, taking into account the inflation-growth endogeneity bias, Gillman and Nakov (2004) invalidate the negative non-linear theory.

Finally, the study of Chudik et al. (2013) concluded that inflation has a negative and significant impact on economic growth. However, inflation is only an indirect and imperfect measure of a government that monetizes its deficit. It may be interesting to look directly at the variation in money supply.

## III. The CS-ARDL and CS-DL estimators

Chudik et al. (2013) claim from the outset that there exist heterogeneities across countries and that coefficient parameters must be allowed to across cross-sectional units, that spillover effects must be taken into account and that inflation is relevant for countries that cannot have debt. Then, they want to focus on the long-run relationship between the variables and recover the corresponding coefficients.

In order to do so, they use two estimators: the CS-ARDL and the CS-DL, which are briefly presented below.

### A. CS-ARDL estimator

Let's start with a VAR(1) model with two variables that are jointly determined, $x_t$ and $y_t$, to illustrate. The results generalize to VAR($p$) models. Define $z_t = (x_t, y_t)'$,

$$z_t = \Phi z_{t-1} + e_t \tag{6}$$

Then $e_{y_t}$ can be decomposed as $e_{y_t} = E[e_{y_t}|e_{x_t}] + u_t$.

The first equation in the VAR can then be expressed as:

$$Y_t = \alpha y_{t-1} + \beta_0 x_{t-1} + \beta_1 x_{t-1} + u_t \tag{7}$$

With $\alpha = \Phi_{11} - \omega\Phi_{21}$, $\omega = \frac{cov(e_{y_t};e_{x_t})}{var(e_{x_t})}$, $\beta_0 = \omega$, $\beta_1 = \Phi_{12} - \omega\Phi_{22}$. $u_t$ is orthogonal to $x_t$ and its lags.

Therefore, for an initial VAR model, endogeneity can be gotten rid of by putting enough dynamics. The long-run relationship can then be apprehended through

$$\theta = \frac{\beta_0 + \beta_1}{(1-\alpha)} \tag{8}$$

If we allow for heterogeneity, we get a more complex equation:

$$y_{it} = \sum \alpha_{il} y_{i,t-l} + \sum \beta_{il} x_{i,t-l} + u_{it} \tag{9}$$

Leading to a similar long-run coefficient, which nevertheless differs across countries:

$$\theta_i = \frac{\sum \beta_{il}}{1 - \sum \alpha_{il}} \tag{10}$$

If there are unobserved common factors, $f_t$, $u_{it} = \gamma_i{}' f_t + \epsilon_{it}$, they would lead to a bias if they were correlated with $x$, but augmenting the regression by cross-section averages allows to mitigate the commonality problem.

Chudik et al. (2013) insist that the long-run estimates are valid regardless of the integrating order of the variables and whether they are exogenous or not. However, sample uncertainty could be large when the sum of the alphas is close to one and when the size dimension is not large enough. In particular, the estimates suffer from an $O(T^{-1})$ bias. Note also the necessity of correctly specifying the lag length.

CS-DL ESTIMATOR

We can regroup all lags of the dependent variable on the left-hand-side and inverse the lag polynomial to get

$$y_{it} = (1 - \alpha_i L)^{-1} \beta_i' x_{it} + (1 - \alpha_i L)^{-1} \gamma_i' f_t + (1 - \alpha_i L)^{-1} \epsilon_{it} \tag{11}$$

Serial correlation is induced by the inverted lagged polynomial multiplying $\epsilon$. However, augmenting by cross-sectional averages mitigates this issue. Hence, we end up with regressions augmented by differences of $x_{it}$ and their lags as well as by cross-sectional averages. The long-run can thus be estimated directly in this setting, considering the coefficient on $x_{it}$.

Chudik et al. (2013) derived the distribution of $\hat{\theta}_P$ and $\hat{\theta}_{MG} = \frac{1}{N} \sum \hat{\theta}_i$ which are respectively the pooled estimator of the long-run coefficients and the mean-group estimator. Both can be shown to be consistent and asymptotically normal under some assumptions and regularity conditions.

## IV. Empirical analysis

### A. Data

Our analysis will be based on a dataset regrouping several variables coming from two different datasets. It first contains data on the gross government debt-to-GDP ratios coming from the work of Abbas et al. (2010) who created a well-furnished database covering nearly the entire IMF membership (174 countries) and spanning a particularly long time period. The database was constructed by bringing together a number of other datasets and information from original sources.

Many other variables were retrieved from a dataset made available by Kaminsky, Reinhart and Végh (2005). From this dataset, we used or constructed several variables such as the real GDP growth rate, the inflation rate, the monetary growth, the government balance and interest expenses.

To classify the countries according to their level of development, we used the World Bank income level classification of year 2000. Each year, the World Bank publishes an analytical classification of the world's economies based on estimates of gross national income per capita. Every economy is classified as low income, middle income (subdivided into lower middle and upper middle), or high income.

Since the CS-(AR)DL methods allow for slope heterogeneities and rely very much on the temporal dimension, countries for which the number of observations was too limited had to be dropped, although this may lead to a sample selection issue. Another possible limit of our dataset is that the variables involved are prone to measurement errors. This problem might even be exacerbated by the first-differences, which are used later in the analysis.

Compared to the dataset of Chudik et al. (2013), the cross-sectional dimension of our dataset is a bit larger but we have in general fewer years available in the temporal dimension. However, the time dimension remains high enough for the CS-ARDL and the CS-DL estimators to perform correctly and our dataset allows us to base most regressions on a higher total number of observations. We also notice that our dataset contains a higher number of low income countries.

### *B. Replication*

The purpose of our first regressions is simply to replicate the results obtained by Chudik et al. (2013) using a slightly different – and larger – dataset to see if similar outcomes could be obtained.

Three types of specification have been retained in the study of Chudik et al. (2013). The first one only analyses the relationship between inflation and growth; the second looks at the link between debt/GDP growth and growth; the third one uses both inflation and growth in the debt-to-GDP ratio as regressors in the economic equation. The three regressions are estimated by the means of ARDL models with one, two and three lags. These ARDL are then augmented by cross-sectional average to account for commonality effects. Finally, the models are estimated with the CS-DL estimator, again with three different lag length specifications.

#### Change in debt

Table A1 displays the coefficients for the inflation rate and the change in the debt-to-GDP ratio obtained from the ARDL regressions. We find evidence of a negative connection between change in debt and growth. Regardless of the lag length, the coefficient on the change in the debt-to-GDP ratio is negative and significant in the regression without inflation. When inflation is added, the coefficient remains negative and significant except for the ARDL of order 3. As shown by Table A2, the results do not change much when the regression is augmented by cross-sectional averages.

Regressions using the CS-DL estimator and displayed in Table A3 also yield significant negative coefficients, whose values fall between -0.08 and -0.07 regardless of the lag length. The results are very similar when inflation is added, except for the CS-DL of order 3 for which the coefficient loses significance.

The estimates for the change in the debt-to-GDP ratio across all regressions range between -0.0605 and 0.101 when it is significant, which is usually the case. These results are similar to those of the original study, though their coefficients are slightly smaller in absolute value.

### Inflation

The ARDL regressions provide evidence of a negative impact of inflation on growth. However, the effect tends to disappear when the change in debt is controlled for. The coefficient is less precisely estimated in this case, and it even changes sign for the order 2 and 3. Augmenting by cross-sectional averages does not change the result, a different outcome than that of Chudik et al. (2013). Mitigating the commonality effect does not seem to affect the result in our case.

The CS-DL provides some evidence of a negative effect of inflation on growth at the first lag length, regardless of whether the change in debt is included or not. For the second order, only the case where the change in debt is included delivers a significant negative estimate for the inflation coefficient. Finally, the long-run coefficient on inflation is not significant at the third lag length. In all cases, the magnitude of the coefficient is larger in absolute value when the change in debt is controlled for but the standard errors are larger, except for the third order CS-DL, so there is usually more uncertainty about the value of the coefficient. Apart for the third lag length, this is similar to the results of Chudik et al. (2013).

### Threshold analysis

Three different kinds of threshold analyses are conducted. The first one simply includes a threshold dummy to see if economic growth is lower above a certain threshold. The second uses interactive threshold effects, i.e. it adds an interaction term between the positive changes in debt and the threshold dummy. The idea is to check if a rise in debt, while being above the threshold, triggers a downward pressure on growth. The third regression includes both the dummy and the interaction terms. Compared to Chudik et al. (2013), we introduce an extra threshold at 100% that our dataset allows us to test considering that we have enough observations fulfilling the requirements above the threshold. The results are displayed in Table A4.

Evidence of a threshold effect is not as compelling as in Chudik et al. (2013). When testing the threshold dummy alone using the CS-DL model, we do not find any significant coefficient, whatever the debt level considered. This part is in accordance with their results. Contrariwise, we only find one significant interaction term when running the regressions with the interactive threshold effects only. The significant interaction term is found only for a threshold at 100% and is significant at a 10% confidence level. Our results therefore do not confirm Chudik et al. (2013)'s observation of a significant threshold for the interaction term at 60%, 80% and 90%. Evidence of a threshold is much less strong in our case, and the threshold appears to be higher.

This could be explained by the fact that, even though it is larger, our dataset is also much more heterogeneous. The CS-DL approach allows for country-specific slopes, which are then averaged to get the estimated coefficient. Despite the reasonably good small sample properties of this estimator, huge heterogeneities may prevent us from getting a reliable coefficient with a limited number of countries.

### *C. Model variations*

#### Relevance of the variables

If governments finance themselves by issuing money, inflation may only be an imperfect and indirect measure of that behavior. Money supply growth is the direct counterpart of debt growth in this context and the monetary base growth may therefore be more appropriate than inflation.

Moreover, the change in the debt burden may be more related to growth than the change in debt itself. It could be argued that debt does not have the same effect on growth when interest rates are different, and that the actual burden on the government is actually what matters.

Finally, we could wonder if the deficit also triggers a downward pressure on growth when debt reaches a certain threshold. Does the conclusion that rising debt is detrimental to growth apply to a negatively balanced budget, or do we really need debt to be rising?

The ARDL, CS-ARDL and CS-DL models were used to test these hypotheses. In some cases, the algorithm failed to converge but we were able to recover the coefficients by re-scaling the variables. The coefficients obtained for the monetary base growth, the burden (defined as the total interest expenses supported by the consolidated government) and the change of debt-to-GDP ratio are displayed in Tables A5 to A7.

The results for monetary base growth indicate a positive relationship with economic growth. However, the coefficient shrinks when the change in debt is added to the analysis, causing it to lose significance most of the time. When money growth and the change in the debt burden are used together, money growth regains its significance and is much larger, especially in ARDL models. The CS-ARDL models provide less compelling evidence, the significance disappearing when the lag order is higher than 1.

The change in the burden is usually negative and significant when used alone in the growth equation but also when the monetary base growth is controlled for. However, the estimators do not allow us to determine whether it is the change in the debt burden or the change in debt itself that affects economic growth; the standard errors are way bigger when those two variables are included in the analysis, preventing us from getting significant estimates.

The threshold analysis was conducted for the government deficit. However, it was not possible to get reliable estimates from the associated regressions.[7] Since thresholds were also difficult to detect in the standard threshold analysis, this is hardly surprising. A proper threshold analysis would probably require additional observations.

### Measurement concerns

Chudik et al. (2013) measure the change in debt as the growth rate of the debt-to-GDP ratio. Hence, it is a relative measure of the change in debt with respect to the debt-to-GDP ratio, not the number of percentage points by which the ratio varies from one year to another. It could be interesting to see if the results differ when change in debt is measured as the difference between the debt-to-GDP ratios of two successive periods.

Moreover, it could be argued that the results of a rising debt being harmful to growth above a certain threshold is actually triggered by the fact that the relative growth of the debt-to-GDP ratio represents a much higher percentage point increase when debt is initially above 90% of GDP than it does

[7] In order to remain concise and considering the absence of added value of displaying the results, these results are not inserted them in the appendix.

when debt is at, say, 20% of GDP. This may cause the interaction term to be significant because debt/GDP rises by more percentage points and not because rising debt is actually detrimental to growth above the threshold.

When the change in debt is measured as the absolute change in percentage points of the debt-to-GDP ratio, there is still strong evidence of a damaging effect of debt on growth, as it can be seen in Table A8 to A10. The coefficients are always negative and significant in the ARDL case. However, controlling for commonality effects by the mean of cross-sectional average augmentation leads to no significant parameters for the order 3 and a non-significant parameter for the order 1 when inflation is included.

In the CS-DL case, the change in debt is always significant even though less precisely estimated when the inflation is added to the regression.

In the threshold analysis, whose results are displayed in Table A11, it is especially interesting to notice that the interaction term is never significant, even at the 100% level, when debt variations are measured as the absolute change in percentage points of the debt-to-GDP ratio. Hence, the results indicate that a one percentage point increase in the debt-to-GDP ratio does not lead to a particular trigger of downward growth pressure even when the country has reached a certain threshold. Only an increase by one percent of the initial debt-to-GDP ratio does.

Testing the implications of this different way to measure the change in debt directly on the dataset of Chudik et al. (2013) yields the results displayed in Table 12. The level of significance of the interaction terms completely vanishes for the thresholds of 60% and 70% and drops to respectively 10% and 5% for the thresholds 80% and 90%. It can therefore be wondered if Chudik et al. (2013) did not underestimate the actual value of the threshold by using the growth rate of the debt-to-GDP ratio instead of the difference between the debt-to-GDP ratios of two successive periods.

### Specification issues: non-linearities

While the previous analysis allows us to discern some features of the relationship between growth and the other variables, the potentially nonlinear effect of the independent variables has not been considered yet. It is, however, not unreasonable to believe that the growth of debt-to-GDP ratio, the inflation and the monetary base growth might be characterized by a nonlinear functional form in an economic growth equation model.

The nonlinearity of these three variables was tested by using again the

ARDL, CS-ARDL and CS-DL with one to three lags. The coefficients estimated for the change in debt-to-GDP ratio are displayed in Table A13, A15 and A17. Considering the measurement concerns raised in the previous section, the non-linearity of change in debt-to-GDP ratio was also tested when using the difference between the debt-to-GDP ratios of two successive periods. The reader can find the corresponding coefficients in Table A14, A16 and A18. The coefficients obtained when testing the nonlinearity of the inflation and the monetary base growth can be found in Table A19 to A21.

**Debt-to-GDP ratio growth**

The change in debt could have a non-linear impact on growth. It is likely that, for instance, sustainability concerns are more than proportionally affected by change in debt.

However, almost no evidence of non-linearity appears when the square of the change in debt is added to the ARDL, CS-ARDL or CS-DL regressions. With the exception of the CS-DL of order 3 and only when change in debt is measured as the difference in debt-to-GDP between two periods, the coefficient on the square is never significant.

**Inflation**

In our sample, there are several instances of negative inflation. Since we do not believe that a strong deflation foster growth, nor that a strong inflation does, it makes sense to include the square of inflation to allow for a non-constant effect of inflation on growth. It could be that there is an optimal value of inflation, probably close to 0, and that large positive or negative values of inflation are both detrimental to growth.

In the ARDL of order 1 regression without the change in debt, inflation appears negative and significant at 10% confidence level. In the CS-ARDL with two lags without the change in debt, its square is significant at 10% size, suggesting that strong inflation or strong deflation are both harmful to growth. Apart from these two regressions, inflation-related coefficients are always insignificant, casting serious doubts about the robustness and reliability of these results. Hence, we do not find convincing evidence of a quadratic functional form of inflation, in particular when the change in debt-to-GDP ratio is also introduced in the regression.

**Monetary base growth**

It is also likely that the functional form of monetary growth in the conditional expectation model for economic growth is non-linear. For instance, even if a moderate level of increase in the money supply could be associated with higher economic growth, there could very well be a turning point beyond which the increase in the monetary base is too strong and becomes detrimental to growth. It could also simply be argued that a concavity or convexity is needed to reflect some potential less than proportional or more than proportional reactions of growth to monetary growth.

Looking at the regressions on money growth and its square, we find that money growth coefficients are significant and positive, except for the CS-ARDL of second order, while its square is insignificant. When we control for the change in debt, interesting cases arise in the CS-ARDL and CS-DL of order 1: the coefficient on the square is negative and significant while the coefficient on money growth is positive and also significant. This implies a positive turning point for the parabola, implying that higher money growth leads to higher growth only up to a point that we can estimate around 20% - 30%.[8] Beyond this point, increasing money growth is harmful to economic growth.[9] Again, the results suggest some interesting features but there is a lack of accuracy in the other regressions that would allow us to draw more definitive conclusions.

### The influence of the country income level

The difference between our results and those obtained by Chudik et al. (2013) might be due to the differences in the cross-sectional composition of the datasets. Their dataset contains 40 countries, amongst which only 3 were classified as low income countries by the World Bank in 2000. 18 Countries were classified as high income countries while the remaining 19 countries belong to the middle income category. Clearly, there seems to be an under-representation of low income countries in their dataset.

Contrariwise, our dataset, while not as strongly balanced as theirs, contains many more low income countries. The subset of our dataset used to replicate Chudik et al. (2013) regressions contains 63 countries amongst which 21 countries belong to the low income category and 28 to the middle income category. Hence, only 14 countries are classified as high income countries, which is less than 25% of countries.

Considering this, we replicated Chudik et al. (2013)'s regressions for each category of income level in order to check the robustness of their results. The

[8] The turning point is estimated at 23.23% for the CS-ARDL case and at 29.87% for the CS-DL.
[9] Note that the sample contains observations both below and above this turning point.

outputs can be found in Table A22 to A30.

Surprisingly, and if we except the CS-DL regression of order 2 of both change in growth-to-GDP ratio and inflation, inflation does not seem to have a significant impact on growth in the low income countries. On the contrary, inflation seems to have a particularly important and negative impact on growth for high income countries. This indicates that low-income countries, which may not have access to the debt market, do not seem to suffer so much from inflation while high-income countries cannot issue additional money instead of borrowing on the debt market without damaging consequences on growth.

When looking at the impact of a change in the debt-to-GDP ratio to the growth rate of GDP, we get different results depending on the models that are used. The ARDL models of order 1 and 2 speaks in favor of a strongly significant and negative impact for the low income countries but this result disappears when the regression is augmented by cross-sectional averages or when the CS-DL models are used. Once commonality effects are taken into account, we do not find clear evidence that a change of debt-to-GDP ratio has an impact on the growth rate of GDP for low income countries. For middle income countries, however, we do find clear evidence of a negative and significant impact of debt on growth in most models. Finally, the results for high income countries are not very clear. The ARDL and CS-ARDL models do not find any significant impact while the CS-DL models speak in favor of a significant impact.

Considering our finding that change in debt and inflation do not seem to impact so much growth for the low income countries, it is of interest to look at the threshold effects when excluding these countries. The results can be found in Table A31 and slightly diverge from those obtained in section 3.3.3. Very interestingly, we now find significant and negative coefficients for the interactive terms corresponding to the 70%, 90% and 100% threshold. It can also be noted that the coefficients are larger in absolute term for all but one threshold. Hence, the results are now a lot closer to those obtained by Chudik et al. (2013) when low-income countries are not included in the analysis. It suggests that the threshold for low-income countries do not exist or are way higher.

It can be seen that debt and inflation have much more damaging consequences in developed countries than in low income countries. Maybe markets are much more forgiving for countries that are not fully developed yet while they are prompt to sanction developed countries that let its debt and price level rising too fast.

### D. Alternative models

We now turn to alternative models for estimating the relationships of interest. We start by describing the numerous econometric issues that arise in this framework before presenting our regression model.

#### Econometric issues

First of all, unobserved heterogeneities may raise some difficulties. They amount to allowing for different intercept among countries, which is likely to be relevant since assuming that emerging and developed countries probably share the same growth-intercept is not realistic. Moreover, the quality of government management, the government efficiency or other country-specific features can hardly be considered independent of regressors such as debt or money growth.

Macroeconomic time effects may not be negligible when dealing with growth; the inclusion of time dummies may prove relevant. In a similar way, we have the commonality problem raised by Chudik et al. (2013).

Since growth has also an effect on debt, strict exogeneity is clearly ruled out. In the presence of the reverse causality (simultaneity even) discussed in Section 2 and of the likely measurement errors, even contemporaneous exogeneity is not granted.

In addition, growth may be related to its lags. A dynamic setup might also be relevant.

Finally, non-linearities cannot a priori be excluded in the functional form, as suggested by some of the previous results. Considering the endogeneity issues both with respect to the unobserved heterogeneity and with respect to the idiosyncratic error terms, few possibilities remain to get consistent and reliable estimates. A FE-IV method could be implemented but finding instruments that are both relevant and exogenous proves itself difficult.

The alternative is to use first differences and to rely on the (possibly delayed) sequential exogeneity assumption then to construct internal instruments, leading to methods such as difference or system GMM.

### E. System GMM

The system GMM method uses both level and differenced equation and constructs internal instruments using lags of the variables (Blundell and

Bond, 1998). The use of the level equation relies on the additional assumption that the lagged differences are uncorrelated to the unobserved heterogeneity. The estimation has been carried out by the means of the command *xtabond2* (Roodman, 2006), which is particularly configurable. In particular, it allows us to specify the lags of the variable to be used as instruments in a very flexible way. Since the instruments tend to be weak in this setup, only one or two numbers of lags were used as instruments. The total number of instruments is reported at the end of each system GMM regression.

Moreover, the options included twostep robust, executing then the two-steps estimator with Windmeijer (2005) correction. The two steps implement a more efficient and heteroscedascity-robust estimator while Windmeijer (2005) correction avoids a downward bias of the standard errors. Forward orthogonal deviations have been preferred, in particular because they do not magnify gaps in the data as much as differences do.

The system GMM methods proved to be quite powerful but is also quite sensible to the lags chosen as instrument, so the results sometimes lack some robustness. We provide the results for two different specifications: the case where second lags are used as instruments for the endogenous change in debt variable and the case where the second and third lags are used.

The change in debt, and by extension the change in the debt burden, were treated as naturally endogenous given the reversed causality implied by the debt dynamics. Inflation, which is sometimes argued to be affected by growth, has been treated as exogenous in a first step but has also been instrumented with its second-order lag in an additional regression.

Table A32 displays the results for a system GMM estimation of a regression involving the change in debt, the change in the debt burden, money growth and money growth squared. The model has been estimated with and without year dummies but also with different choices of lag for the instruments.

Interestingly, the change in the debt burden is negative and significant in the first regression while the change in debt is usually not significant. This indicates that the variable that actually harms growth is the debt burden rather than debt itself; it suggests that the interest rate to which the country is confronted plays a fundamental role in the determination of the growth rate within the debt-growth nexus. However, it is only significant at the 10% level and the result is not robust to another choice of lag for the instrument or to the inclusion of year dummies. This is rather weak evidence.

The inclusion of inflation changes dramatically the results with most variables becoming significant. They can be found in Table A33. There is evidence of the negative connection between the change in debt and economic growth whereas the change in the debt burden does not seem to matter. The coefficient on money growth and its square are both always positive and significant. While the parabolic structure implies a negative turning point, only one observation, the Denmark in 2000, is actually on the other side of this turning point. What the quadratic term actually captures is thus the concavity of the relationship rather than the turning point. Finally, the negative coefficient of the square of inflation suggests that strong inflation or strong deflation are both prejudicial to growth.

Notice however that Sargan's test of overidentifying restrictions, for which the p-value is provided at the end of each regression, indicates a clear rejection of the null. While this could be due to the fact that the test is not robust, it is also likely to be due to exogeneity violations. The abnormally high p-value of the Hansen test suggests that it has been weakened by the number of instruments and that it is probably not reliable.

Turning to the model where inflation was treated as potentially endogenous and whose outcomes are displayed in Table A34, it can be noticed that the results are in the same direction as those of the previous table since the coefficients remain of the same sign. However, the significance of the estimated parameters is much less compelling. The square of inflation as well as the change in debt have an associated coefficient which is only significant in one of the lag specification and only when year dummies are not included. The inclusion of those same year dummies causes the change in the debt burden to lose its significant effect on economic growth compared to the case where they are excluded. Overidentifying restriction tests are still casting some doubts about the validity of the results and the instruments. Using even higher lags which are more likely to be exogenous but could very well be less relevant does not improve the results.

The table A35 displays additional regressions in which the lagged value of the dependent variable, economic growth, was included. The associated coefficient was assessed as significant, especially when time dummies are included. It can be noted that the second choice of the instrument matrix obtains a far better result for Sargan's test. This specification also coincides with the cases where the lagged dependent variable is the largest and most significant, with estimates at 0.561 (without year dummies) and 0.495 (with year dummies).

Interestingly, the auto regressive tests provided by *xtabond2* indicate that first-differences are correlated at the first-order but not at the second-order, suggesting that the original error term may be spherical.

The change-in-debt coefficient remains significant in all specifications, at least at the 5% level. The conclusions for the monetary base growth are similar to those of the previous regressions but its square has a significant estimated parameter only with the first choice of instruments when year dummies are included.

## V. Conclusion

The previous section provided numerous models meant to disentangle the debt-growth nexus and to shed some light on the variables involved in this particular framework. It can be seen that no straightforward, clear-cut conclusion pops out. However, we believe the above regressions provide some evidence of the detrimental effect that debt can have on economic growth. The alternative, issuing money, does not seem to share the same drawback although it can lead to high inflation and its negative consequences, the least not being this exact same slowdown in economic growth at the end. Nonetheless, evidence of debt and inflation's injurious consequences tends to be weaker in low-income economies, suggesting that only developed countries are concerned.

There is much more uncertainty about the existence – and even more about the level – of the thresholds discussed in Chudik et al. (2013). We agree with their argument that thresholds may be individual-specific due to the strong heterogeneity among countries. Considering the high discrepancies across countries, especially between emerging and developing countries, the estimation of threshold is quite complicated and recovering similar threshold estimates using different data set is not guaranteed, unless the number of countries is particularly large.

The analysis showed that thresholds are likely to exist around 60-100% of GDP for developed countries. Nevertheless, such a level of debt does not seem to trigger injurious consequences on economic growth in low-income countries. Moreover, inflation and rising debt do not seem to have deleterious effects in these countries.

Therefore, there is evidence that emerging countries do not suffer as much as developed countries from rising debt and inflation. The threshold above which rising debt harms growth is higher - if it exists - and damages of inflation are less obvious. Developed countries, on the other hand, are punished when they are not able to control inflation or when their debt ratio gets out of hand.

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# Appendix

List of abbreviations

| Abbreviation | Variable |
|---|---|
| $\pi$ | Inflation |
| $\pi^2$ | Inflation squared |
| $\delta_D$ | Percentage change of the debt-to-GDP ratio |
| $\delta_D^2$ | Square of percentage change of the debt-to-GDP ratio |
| $\delta_{D}.$ | Absolute change in the debt-to-GDP ratio |
| $\delta_{D.}^2$ | Square of the absolute change in the debt-to-GDP ratio |
| $\tau$ | Threshold dummy |
| $\iota$ | Interaction term |
| $\delta_M$ | Reserve money real growth rate |
| $\delta_M^2$ | Square of the Reserve money real growth rate |
| $\delta_B$ | Percentage change of the consolidated government interest payment as % of GDP |

Table A1—: Replication: ARDL

| | ARDL (1 lag) | | | ARDL (2 lags) | | | ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\pi$ | -0.0731*** | | -0.0384 | -0.0534** | | 0.00618 | -0.117** | | 0.0805 |
| | (0.0212) | | (0.0261) | (0.0239) | | (0.0326) | (0.0552) | | (0.244) |
| $\delta_D$ | | -0.101*** | -0.0780*** | | -0.0828*** | -0.0888*** | | -0.0822*** | 0.189 |
| | | (0.0234) | (0.0161) | | (0.0193) | (0.0235) | | (0.0268) | (0.180) |
| Obs. | 2460 | 1877 | 1846 | 2397 | 1776 | 1747 | 2334 | 1678 | 1650 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A2—: Replication: CS-ARDL

| | CS-ARDL (1 lag) | | | CS-ARDL (2 lags) | | | CS-ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\pi$ | -0.0774*** | | -0.0773 | -0.260 | | -0.0186 | -0.138* | | 2.560 |
| | (0.0281) | | (0.0903) | (0.216) | | (0.0448) | (0.0726) | | (2.595) |
| $\delta_D$ | | -0.0605*** | -0.0709*** | | -0.0766*** | -0.0902 | | 0.523 | 0.379 |
| | | (0.0168) | (0.0208) | | (0.0225) | (0.0297) | | (0.794) | (0.386) |
| Obs. | 2444 | 1844 | 1830 | 2389 | 1760 | 1747 | 2334 | 1678 | 1650 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3—: Replication: CS-DL

| | CS-DL (1 lag) | | | CS-DL (2 lags) | | | CS-DL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\pi$ | -0.0475** | | -0.0564* | -0.0318 | | -0.0919* | -0.0390 | | -0.0729 |
| | (0.0239) | | (0.0312) | (0.0240) | | (0.0511) | (0.0263) | | (0.107) |
| $\delta_D$ | | -0.0743*** | -0.0711*** | | -0.0733*** | -0.0821** | | -0.0797*** | -0.0505 |
| | | (0.0148) | (0.0196) | | (0.0174) | (0.0350) | | (0.0193) | (0.0855) |
| Obs. | 2457 | 1849 | 1831 | 2406 | 1773 | 1741 | 2351 | 1698 | 1360 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4—: Replication: Threshold Analysis

| | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|
| (i) POLS | | | | | | | | |
| $\tau$ | -0.0178*** | -0.0162*** | -0.0154*** | -0.0138*** | -0.0139*** | -0.0137*** | -0.0127*** | -0.0147*** |
| | (0.00215) | (0.00200) | (0.00199) | (0.00214) | (0.00243) | (0.00285) | (0.00318) | (0.00398) |
| Obs. | 2058 | 2058 | 2058 | 2058 | 2058 | 2058 | 2058 | 2058 |
| (ii) MG | | | | | | | | |
| $\tau$ | -0.0148*** | -0.0128*** | -0.0135*** | -0.0120*** | -0.0117*** | -0.0115*** | -0.00745* | -0.00967* |
| | (0.00395) | (0.00339) | (0.00322) | (0.00350) | (0.00360) | (0.00395) | (0.00403) | (0.00525) |
| Obs. | 1603 | 1861 | 1763 | 1699 | 1443 | 1182 | 1110 | 1110 |
| (iii) CS-DL MG regression with threshold dummy | | | | | | | | |
| $\tau$ | -0.00417 | -0.0155 | -0.0178* | -0.00546 | -0.0179 | -0.0229 | 0.00967 | -0.0129 |
| | (0.00819) | (0.0164) | (0.00995) | (0.00845) | (0.0157) | (0.0191) | (0.0137) | (0.0110) |
| $\delta_D$ | -0.0674 | -0.123 | -0.0795 | -0.0762 | -0.0698 | -0.0592 | -0.0421 | -0.0594 |
| | (0.0865) | (0.100) | (0.105) | (0.112) | (0.132) | (0.164) | (0.163) | (0.142) |
| $\pi$ | -0.206 | -0.260 | -0.0645 | -0.0225 | -0.0373 | 0.0583 | 0.120 | 0.218* |
| | (0.135) | (0.176) | (0.131) | (0.118) | (0.130) | (0.167) | (0.184) | (0.129) |
| Obs. | 918 | 1140 | 1095 | 1010 | 866 | 681 | 681 | 582 |
| (iv) CS-DL MG regressions with threshold dummy and interactive threshold effects | | | | | | | | |
| $\tau$ | -0.00225 | 0.00526 | -0.0698 | -0.00438 | -0.00135 | -0.00143 | 0.0126 | -0.0234* |
| | (0.0114) | (0.0105) | (0.0506) | (0.00878) | (0.0112) | (0.0122) | (0.0171) | (0.0129) |
| $\delta_D$ | 0.00361 | -0.0626 | -0.0539 | -0.00156 | -0.00501 | -0.00420 | 0.0622 | -0.0399 |
| | (0.123) | (0.134) | (0.142) | (0.152) | (0.184) | (0.223) | (0.246) | (0.168) |
| $\pi$ | -0.164 | 0.0640 | -0.0909 | 0.106 | 0.0476 | 0.167 | 0.330 | 0.298** |
| | (0.169) | (0.150) | (0.158) | (0.149) | (0.169) | (0.207) | (0.240) | (0.143) |
| $\iota$ | 0.0549 | 0.00886 | 0.509 | -0.0591 | -0.0674 | -0.0213 | -0.0775 | -0.0359 |
| | (0.0507) | (0.0588) | (0.538) | (0.0484) | (0.0518) | (0.0654) | (0.0856) | (0.0736) |
| Obs. | 800 | 1090 | 1095 | 940 | 791 | 641 | 582 | 582 |
| (v) CS-DL MG regressions with interactive threshold effects | | | | | | | | |
| $\delta_D$ | -0.174** | -0.117** | -0.133* | -0.113** | -0.115* | -0.155* | -0.155* | -0.0295 |
| | (0.0786) | (0.0535) | (0.0693) | (0.0557) | (0.0663) | (0.0858) | (0.0892) | (0.176) |
| $\pi$ | -0.195* | -0.0742 | -0.0559 | 0.0438 | -0.00851 | 0.0612 | 0.105 | 0.271* |
| | (0.0998) | (0.107) | (0.0702) | (0.0829) | (0.0742) | (0.103) | (0.112) | (0.139) |
| $\iota$ | 0.0493 | -0.0512 | -0.0180 | -0.0388 | -0.0785 | -0.0513 | -0.258 | -0.189** |
| | (0.0705) | (0.0520) | (0.0608) | (0.0589) | (0.0525) | (0.0711) | (0.173) | (0.0900) |
| Obs. | 1252 | 1217 | 1095 | 970 | 826 | 641 | 641 | 542 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5—: Relevance of the variables: ARDL

| | ARDL (1 lag) | | | | | ARDL (2 lags) | | | | | ARDL (3 lags) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) |
| $\delta_M$ | 0.101*** | | 0.0543* | | 0.254* | 0.0748*** | | 0.0334 | | 0.125*** | 0.0662* | | 0.0307 | | 0.116** |
| | (0.0297) | | (0.0290) | | (0.134) | (0.0272) | | (0.0393) | | (0.0416) | (0.0345) | | (0.0580) | | (0.0518) |
| $\delta_B$ | | -0.0250 | | -0.0148 | -0.0284 | | -0.0438*** | | -0.0243 | -0.0534*** | | -0.0226 | | -0.486 | -0.0447** |
| | | (0.0262) | | (0.0221) | (0.0277) | | (0.0140) | | (0.0262) | (0.0187) | | (0.0213) | | (0.435) | (0.0198) |
| $\delta_D$ | | | -0.0736*** | -0.0539 | | | | -0.0855*** | -0.0529 | | | | -0.0927*** | 0.330 | |
| | | | (0.0266) | (0.0445) | | | | (0.0238) | (0.0342) | | | | (0.0319) | (0.327) | |
| Obs. | 1123 | 734 | 948 | 642 | 734 | 1095 | 704 | 904 | 607 | 704 | 1067 | 675 | 862 | 573 | 675 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6—: Relevance of the variables: CS-ARDL

| | CS-ARDL (1 lag) | | | | | CS-ARDL (2 lags) | | | | | CS-ARDL (3 lags) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) |
| $\delta_M$ | 0.0695** | | -0.0300 | | 0.186** | 0.0363 | | -0.190 | | 0.0267 | 0.0351 | | -0.112 | | 0.306 |
| | (0.0274) | | (0.0742) | | (0.0800) | (0.0309) | | (0.139) | | (0.0665) | (0.0456) | | (0.0326) | | (0.197) |
| $\delta_B$ | | -0.0378 | | 0.00171 | -0.0372* | | -0.0642*** | | -0.0889 | -0.0328 | | -0.0512 | | 5.058 | 0.00636 |
| | | (0.0274) | | (0.0493) | (0.0205) | | (0.0209) | | (0.0761) | (0.0316) | | (0.0620) | | (5.094) | (0.0326) |
| $\delta_D$ | | | 0.0327 | -0.202 | | | | -0.0339 | -0.0638 | | | | -0.0774*** | -5.379 | |
| | | | (0.0976) | (0.165) | | | | (0.0569) | (0.0482) | | | | (0.0288) | (5.234) | |
| Obs. | 1108 | 721 | 935 | 631 | 721 | 1095 | 704 | 904 | 607 | 704 | 1067 | 675 | 862 | 573 | 675 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A7—: Relevance of the variables: CS-DL

| | CS-DL (1 lag) | | | | | CS-DL (2 lags) | | | | | CS-DL (3 lags) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) |
| $\delta_M$ | 0.0436** | | 0.0166 | | 0.0660* | 0.0337 | | 0.0235 | | 0.107* | 0.0215 | | -0.00616 | | 0.0780 |
| | (0.0198) | | (0.0200) | | (0.0392) | (0.0244) | | (0.0434) | | (0.0590) | (0.0285) | | (0.0558) | | (0.0627) |
| $\delta_B$ | | -0.0614*** | | -0.0602 | -0.0551*** | | -0.0722*** | | -0.249 | -0.0872*** | | -0.0472** | | -0.0275 | -0.102* |
| | | (0.0151) | | (0.0820) | (0.0190) | | (0.0179) | | (0.171) | (0.0311) | | (0.0222) | | (0.0649) | (0.0574) |
| $\delta_D$ | | | -0.0518** | 0.0101 | | | | -0.0536** | 0.118 | | | | -0.0718** | -0.0406 | |
| | | | (0.0208) | (0.0685) | | | | (0.0235) | (0.108) | | | | (0.0292) | (0.0627) | |
| Obs. | 1121 | 708 | 925 | 619 | 708 | 1120 | 691 | 900 | 505 | 691 | 1119 | 675 | 809 | 387 | 625 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A8—: Measurement concerns: ARDL

| | ARDL (1 lag) | | | ARDL (2 lags) | | | ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\pi$ | -0.0731*** | | -0.0377 | -0.0534** | | 0.0000584 | -0.117** | | -0.126 |
| | (0.0212) | | (0.0250) | (0.0239) | | (0.0296) | (0.0552) | | (0.112) |
| $\delta_D$. | | -0.00173*** | -0.00194*** | | -0.00189*** | -0.00222*** | | -0.00132* | -0.00283** |
| | | (0.000432) | (0.000363) | | (0.000462) | (0.000545) | | (0.000678) | (0.00126) |
| Obs. | 2460 | 1877 | 1846 | 2397 | 1776 | 1747 | 2334 | 1678 | 1650 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A9—: Measurement concerns: CS-ARDL

| | CS-ARDL (1 lag) | | | CS-ARDL (2 lags) | | | CS-ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\pi$ | -0.0774*** | | -0.0569 | -0.260 | | -0.0261 | -0.138* | | -0.345 |
| | (0.0281) | | (0.0548) | (0.216) | | (0.0696) | (0.0726) | | (0.266) |
| $\delta_D$. | | -0.00166*** | -0.000508 | | -0.00213* | -0.00241** | | -0.00383 | 0.00224 |
| | | (0.000379) | (0.000898) | | (0.00116) | (0.00112) | | (0.00260) | (0.00319) |
| Obs. | 2444 | 1844 | 1830 | 2389 | 1760 | 1747 | 2334 | 1678 | 1650 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A10—: Measurement concerns: CS-DL

| | CS-DL (1 lag) | | | CS-DL (2 lags) | | | CS-DL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\pi$ | -0.0475** | | -0.0526 | -0.0318 | | -0.149* | -0.0390 | | -0.0340 |
| | (0.0239) | | (0.0352) | (0.0240) | | (0.0764) | (0.0263) | | (0.103) |
| $\delta_D$. | | -0.00176*** | -0.00137*** | | -0.00185*** | -0.00224* | | -0.00285*** | -0.00350** |
| | | (0.000314) | (0.000454) | | (0.000479) | (0.00117) | | (0.000709) | (0.00136) |
| Obs. | 2457 | 1849 | 1831 | 2406 | 1773 | 1741 | 2351 | 1698 | 1360 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A11—: Measurement concerns: Threshold Analysis

| | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|
| (i) POLS | | | | | | | | |
| $\tau$ | -0.0178*** | -0.0162*** | -0.0154*** | -0.0138*** | -0.0139*** | -0.0137*** | -0.0127*** | -0.0147*** |
| | (0.00215) | (0.00200) | (0.00199) | (0.00214) | (0.00243) | (0.00285) | (0.00318) | (0.00398) |
| Obs. | 2058 | 2058 | 2058 | 2058 | 2058 | 2058 | 2058 | 2058 |
| (ii) MG | | | | | | | | |
| $\tau$ | -0.0148*** | -0.0128*** | -0.0135*** | -0.0120*** | -0.0117*** | -0.0115*** | -0.00745* | -0.00967* |
| | (0.00395) | (0.00339) | (0.00322) | (0.00350) | (0.00360) | (0.00395) | (0.00403) | (0.00525) |
| Obs. | 1603 | 1861 | 1763 | 1699 | 1443 | 1182 | 1110 | 1110 |
| (iii) CS-DL MG regression with threshold dummy | | | | | | | | |
| $\tau$ | -0.00607 | -0.00424 | -0.0141* | -0.00218 | -0.0000854 | 0.00595 | 0.0187 | -0.00230 |
| | (0.00797) | (0.00761) | (0.00813) | (0.00855) | (0.00851) | (0.0102) | (0.0139) | (0.0104) |
| $\delta_D$. | -0.00410*** | -0.00435*** | -0.00386*** | -0.00324*** | -0.00359*** | -0.00407*** | -0.00459*** | -0.00374** |
| | (0.00131) | (0.00101) | (0.00115) | (0.000962) | (0.000972) | (0.00116) | (0.00146) | (0.00162) |
| $\pi$ | -0.305*** | -0.151 | -0.163* | -0.111 | -0.0787 | 0.0258 | -0.00513 | 0.118 |
| | (0.113) | (0.0969) | (0.0934) | (0.0716) | (0.0680) | (0.0944) | (0.136) | (0.105) |
| Obs. | 918 | 1140 | 1095 | 1010 | 866 | 681 | 681 | 582 |
| (iv) CS-DL MG regressions with threshold dummy and interactive threshold effects | | | | | | | | |
| $\tau$ | -0.0157 | -0.0334** | -0.0445 | -0.0208** | -0.00279 | 0.00336 | -0.0258 | -0.0499** |
| | (0.0118) | (0.0160) | (0.0280) | (0.00891) | (0.0187) | (0.0225) | (0.0258) | (0.0210) |
| $\delta_D$. | -0.00468* | -0.00578*** | -0.00507*** | -0.00418** | -0.00530** | -0.00670** | -0.00590** | -0.00572** |
| | (0.00268) | (0.00180) | (0.00192) | (0.00194) | (0.00224) | (0.00262) | (0.00293) | (0.00279) |
| $\pi$ | -0.271** | -0.240* | -0.166** | -0.115* | -0.0841 | 0.0697 | 0.102 | 0.128 |
| | (0.126) | (0.140) | (0.0837) | (0.0656) | (0.0870) | (0.126) | (0.159) | (0.122) |
| $\iota$ | 0.00240 | 0.00242 | 0.00768 | 0.00226 | 0.00257 | 0.00397 | 0.00399 | 0.00282 |
| | (0.00247) | (0.00184) | (0.00601) | (0.00195) | (0.00225) | (0.00261) | (0.00301) | (0.00192) |
| Obs. | 800 | 1090 | 1095 | 940 | 791 | 641 | 582 | 582 |
| (v) CS-DL MG regressions with interactive threshold effects | | | | | | | | |
| $\delta_D$. | -0.00370*** | -0.00416*** | -0.00472*** | -0.00367** | -0.00456** | -0.00628*** | -0.00634*** | -0.00763** |
| | (0.00141) | (0.00143) | (0.00172) | (0.00166) | (0.00197) | (0.00235) | (0.00240) | (0.00372) |
| $\pi$ | -0.172** | -0.160* | -0.137** | -0.0760 | -0.0739 | 0.0440 | 0.0752 | 0.118 |
| | (0.0827) | (0.0821) | (0.0659) | (0.0604) | (0.0644) | (0.105) | (0.121) | (0.127) |
| $\iota$ | 0.00136 | -0.00000465 | 0.00126 | 0.00107 | 0.00124 | 0.00251 | 0.00164 | 0.00102 |
| | (0.00150) | (0.00142) | (0.00152) | (0.00166) | (0.00176) | (0.00213) | (0.00218) | (0.00177) |
| Obs. | 1252 | 1217 | 1095 | 970 | 826 | 641 | 641 | 542 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A12—: Measurement concerns: Threshold Analysis using Chudik et al.'s dataset

| | 30% | 40% | 50% | 60% | 70% | 80% | 90% |
|---|---|---|---|---|---|---|---|
| (i) POLS | | | | | | | |
| $\tau$ | -0.00824*** | -0.00908*** | -0.00860*** | -0.00897*** | -0.00855*** | -0.00889*** | -0.0109*** |
| | (0.00199) | (0.00188) | (0.00190) | (0.00211) | (0.00263) | (0.00327) | (0.00370) |
| Obs. | 1696 | 1696 | 1696 | 1696 | 1696 | 1696 | 1696 |
| (ii) MG | | | | | | | |
| $\tau$ | -0.00766** | -0.0101*** | -0.0115*** | -0.0114*** | -0.0158*** | -0.0197*** | -0.0213*** |
| | (0.00323) | (0.00293) | (0.00340) | (0.00342) | (0.00330) | (0.00419) | (0.00389) |
| Obs. | 1353 | 1531 | 1322 | 1332 | 1203 | 810 | 589 |
| (iii) CS-DL MG regression with threshold dummy | | | | | | | |
| $\tau$ | -0.00215 | -0.00675 | -0.00646 | -0.00464 | -0.00336 | -0.0138 | -0.00874 |
| | (0.00947) | (0.00717) | (0.00795) | (0.00732) | (0.00852) | (0.0109) | (0.0142) |
| $\delta_D$. | -0.00211** | -0.00202** | -0.00139*** | -0.00119** | -0.00152*** | -0.00169*** | -0.00199*** |
| | (0.000856) | (0.000831) | (0.000417) | (0.000467) | (0.000399) | (0.000339) | (0.000530) |
| $\pi$ | -0.0816 | -0.0730 | -0.0937 | -0.0487 | -0.130*** | -0.153* | -0.0837 |
| | (0.0550) | (0.0540) | (0.0595) | (0.0504) | (0.0452) | (0.0798) | (0.0953) |
| Obs. | 1251 | 1377 | 1226 | 1236 | 1115 | 710 | 547 |
| (iv) CS-DL MG regressions with threshold dummy and interactive threshold effects | | | | | | | |
| $\tau$ | -0.0000199 | -0.00768 | -0.00101 | -0.00616 | -0.0231 | -0.00811 | 0.00699 |
| | (0.00552) | (0.00512) | (0.00876) | (0.00670) | (0.0175) | (0.0150) | (0.0171) |
| $\delta_D$. | -0.00242*** | -0.00206*** | -0.00206*** | -0.00143** | -0.00165*** | -0.00195*** | -0.00192*** |
| | (0.000746) | (0.000606) | (0.000505) | (0.000576) | (0.000510) | (0.000561) | (0.000654) |
| $\pi$ | -0.0840 | -0.0438 | -0.0814 | -0.0579 | -0.107** | -0.120 | -0.0697 |
| | (0.0552) | (0.0594) | (0.0588) | (0.0404) | (0.0478) | (0.0845) | (0.0937) |
| $\iota$ | 0.000926 | 0.00134** | 0.000567 | -0.000404 | -0.00112 | -0.00159 | -0.000817 |
| | (0.000634) | (0.000608) | (0.000929) | (0.000768) | (0.00142) | (0.00112) | (0.000906) |
| Obs. | 1184 | 1310 | 1226 | 1236 | 999 | 710 | 547 |
| (v) CS-DL MG regressions with interactive threshold effects | | | | | | | |
| $\delta_D$. | -0.00288*** | -0.00290*** | -0.00160*** | -0.00161*** | -0.00169*** | -0.00176*** | -0.00191*** |
| | (0.000781) | (0.000785) | (0.000524) | (0.000494) | (0.000449) | (0.000572) | (0.000633) |
| $\pi$ | -0.0406 | -0.0326 | -0.0539 | -0.0798* | -0.100** | -0.0238 | 0.00569 |
| | (0.0414) | (0.0447) | (0.0455) | (0.0426) | (0.0447) | (0.0667) | (0.0941) |
| $\iota$ | 0.000936* | 0.000697 | -0.0000142 | -0.000618 | -0.00107 | -0.00121* | -0.00113** |
| | (0.000547) | (0.000611) | (0.000749) | (0.000769) | (0.000798) | (0.000628) | (0.000571) |
| Obs. | 1487 | 1414 | 1263 | 1236 | 1115 | 710 | 547 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A13—: Nonlinearity: ARDL
(percentage change in debt/GDP ratio)

| | Order 1 | Order 2 | Order 3 |
|---|---|---|---|
| $\delta_D$ | -0.135*** | -0.155*** | -0.354** |
| | (0.0279) | (0.0387) | (0.181) |
| $\delta_D^2$ | 0.228 | 0.407 | 1.910 |
| | (0.161) | (0.270) | (1.782) |
| Obs. | 1877 | 1776 | 1678 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A14—: Nonlinearity issue: ARDL
(absolute change in debt/GDP ratio)

| | Order 1 | Order 2 | Order 3 |
|---|---|---|---|
| $\delta_{D.}$ | -0.003797*** | -0.007858 | -0.005546* |
| | (0.001360) | (0.005628) | (0.003134) |
| $\delta_{D.}^2$ | -0.0000937 | 0.001255 | -0.000119 |
| | (0.000117) | (0.001360) | (0.000647) |
| Obs. | 1877 | 1776 | 1678 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A15—: Nonlinearity: CS-ARDL
(percentage change in debt/GDP ratio)

| | Order 1 | Order 2 | Order 3 |
|---|---|---|---|
| $\delta_D$ | -0.101** | -0.0111 | -0.150 |
| | (0.0421) | (0.0686) | (0.328) |
| $\delta_D^2$ | 0.0560 | -0.347 | -5.116 |
| | (0.221) | (0.408) | (5.715) |
| Obs. | 1860 | 1776 | 1678 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A16—: Nonlinearity: CS-ARDL
(absolute change in debt/GDP ratio)

| | Order 1 | Order 2 | Order 3 |
|---|---|---|---|
| $\delta_{D.}$ | -0.001269 | 0.01148 | -0.004936* |
| | (0.001781) | (0.01651) | (0.002627) |
| $\delta_{D.}^2$ | -0.000192 | -0.000535 | -0.0000304 |
| | (0.000207) | (0.000665) | (0.000814) |
| Obs. | 1860 | 1776 | 1678 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A17—: Nonlinearity: CS-DL
(percentage change in debt/GDP ratio)

| | Order 1 | Order 2 | Order 3 |
|---|---|---|---|
| $\delta_D$ | -0.107*** | -0.107 | -0.0528 |
| | (0.0234) | (0.0664) | (0.0739) |
| $\delta_D^2$ | 0.0620 | 0.334 | 0.0316 |
| | (0.167) | (0.280) | (0.380) |
| Obs. | 1849 | 1773 | 1405 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A18—: Nonlinearity: CS-DL
(absolute change in debt/GDP ratio)

| | Order 1 | Order 2 | Order 3 |
|---|---|---|---|
| $\delta_{D.}$ | -0.002263** | -0.0000816 | 0.000501 |
| | (0.000971) | (0.002880) | (0.001356) |
| $\delta_{D.}^2$ | -0.000145 | -0.000407 | -0.000662** |
| | (0.000143) | (0.000302) | (0.000270) |
| Obs. | 1849 | 1773 | 1405 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A19—: ARDL - Squares of inflation/money_growth

| | ARDL (1 lag) | | | | ARDL (2 lags) | | | | ARDL (3 lags) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| $\pi$ | 0.0263 | | | 0.0306 | -0.183* | | | -0.0445 | -0.258 | | | -0.322 |
| | (0.0857) | | | (0.104) | (0.0960) | | | (0.152) | (0.178) | | | (0.255) |
| $\pi^2$ | -1.075 | | | -0.593 | 0.698 | | | -0.109 | 4.090 | | | 5.482 |
| | (0.960) | | | (0.808) | (0.577) | | | (1.123) | (4.105) | | | (4.319) |
| $\delta_M$ | | 0.0965*** | -0.119 | | | 0.0804** | 0.0476 | | | 0.0745** | 0.0240 | |
| | | (0.0259) | (0.225) | | | (0.0370) | (0.0610) | | | (0.0374) | (0.0876) | |
| $\delta_M^2$ | | -0.0720 | 0.0998 | | | -0.0534 | 0.0205 | | | -0.0725 | 0.0164 | |
| | | (0.0778) | (0.274) | | | (0.101) | (0.201) | | | (0.0936) | (0.290) | |
| $\delta_D$ | | | 0.0415 | -0.0912*** | | | -0.0997*** | -0.0995*** | | | -0.116 | -0.0817** |
| | | | (0.131) | (0.0149) | | | (0.0262) | (0.0318) | | | (0.0737) | (0.0365) |
| Obs. | 2460 | 2375 | 1810 | 1846 | 2397 | 2312 | 1711 | 1747 | 2343 | 2297 | 1632 | 1651 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A20—: CS-ARDL - Squares of inflation/money_growth

| | CS-ARDL (1 lag) | | | | CS-ARDL (2 lags) | | | | CS-ARDL (3 lags) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| $\pi$ | 0.0982 | | | -0.0546 | -0.101 | | | -0.240 | -1.229 | | | -0.148 |
| | (0.0818) | | | (0.119) | (0.144) | | | (0.281) | (1.164) | | | (0.255) |
| $\pi^2$ | -1.360* | | | 0.410 | 0.172 | | | 0.383 | 30.80 | | | -0.921 |
| | (0.825) | | | (0.815) | (0.763) | | | (0.946) | (30.89) | | | (2.011) |
| $\delta_M$ | | 0.0912*** | 0.230*** | | | 0.0619 | 0.502* | | | 0.0838** | 0.249 | |
| | | (0.0233) | (0.0806) | | | (0.0489) | (0.281) | | | (0.0331) | (0.361) | |
| $\delta_M^2$ | | -0.0830 | -0.376** | | | -0.000543 | -1.169 | | | -0.0880 | -0.0997 | |
| | | (0.0702) | (0.174) | | | (0.146) | (1.078) | | | (0.0917) | (0.113) | |
| $\delta_D$ | | | -0.108** | -0.0701*** | | | 0.256 | -0.0181 | | | -0.236*** | -0.0942** |
| | | | (0.0478) | (0.0211) | | | (0.233) | (0.0903) | | | (0.0921) | (0.0374) |
| Obs. | 2452 | 2355 | 1795 | 1838 | 2397 | 2312 | 1711 | 1747 | 2343 | 2297 | 1632 | 1651 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A21—: CS-DL - Squares of inflation/money_growth

| | CS-DL (1 lag) | | | | CS-DL (2 lags) | | | | CS-DL (3 lags) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| $\pi$ | 0.0829 | | -0.0986 | | -0.0154 | | -0.408 | | 0.0173 | | 0.656 | |
| | (0.0741) | | (0.105) | | (0.100) | | (0.317) | | (0.137) | | (0.769) | |
| $\pi^2$ | -1.185 | | 0.527 | | -0.962 | | 0.704 | | -2.160 | | -1.224 | |
| | (0.724) | | (0.665) | | (1.197) | | (1.334) | | (2.271) | | (3.234) | |
| $\delta_M$ | | 0.0878*** | | 0.138** | | 0.103*** | | -0.0967 | | 0.113** | | 0.132 |
| | | (0.0222) | | (0.0560) | | (0.0341) | | (0.173) | | (0.0575) | | (0.129) |
| $\delta_M^2$ | | -0.0979 | | -0.297** | | -0.126 | | 0.577 | | -0.233 | | -0.256 |
| | | (0.0598) | | (0.149) | | (0.0917) | | (0.669) | | (0.204) | | (0.454) |
| $\delta_D$ | | | -0.0637*** | -0.0761*** | | | -0.130* | 0.00148 | | | -0.114** | -0.0760* |
| | | | (0.0219) | (0.0209) | | | (0.0674) | (0.0554) | | | (0.0479) | (0.0395) |
| Obs. | 2457 | 2383 | 1831 | 1786 | 2406 | 2366 | 1437 | 1397 | 2351 | 2348 | 1221 | 1221 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A22—: Income level classification: ARDL - Inflation

| | ARDL (1 lag) | | | ARDL (2 lags) | | | ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\pi$ | -0.207*** | -0.0610** | 0.0000128 | -0.141*** | -0.0521 | 0.00316 | -0.409* | -0.0791** | 0.0263 |
| | (0.0293) | (0.0296) | (0.0367) | (0.0425) | (0.0338) | (0.0453) | (0.211) | (0.0372) | (0.0514) |
| Obs. | 544 | 1094 | 822 | 530 | 1066 | 801 | 516 | 1038 | 780 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A23—: Income level classification: ARDL - Growth of debt

| | ARDL (1 lag) | | | ARDL (2 lags) | | | ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\delta_D$ | -0.0473 | -0.140*** | -0.0845*** | -0.0487 | -0.0836*** | -0.104*** | -0.0640 | -0.121*** | -0.0425 |
| | (0.0488) | (0.0424) | (0.0247) | (0.0498) | (0.0225) | (0.0377) | (0.0573) | (0.0294) | (0.0591) |
| Obs. | 546 | 838 | 493 | 528 | 793 | 455 | 511 | 749 | 418 |
| Obs. | 546 | 838 | 493 | 528 | 793 | 455 | 511 | 749 | 418 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A24—: Income level classification: ARDL - Growth of debt & Inflation

| | ARDL (1 lag) | | | ARDL (2 lags) | | | ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\pi$ | -0.0996* | -0.0451 | 0.0112 | -0.0592 | 0.00520 | 0.0511 | 0.701 | -0.224 | 0.0726 |
| | (0.0595) | (0.0387) | (0.0430) | (0.0990) | (0.0355) | (0.0556) | (1.064) | (0.146) | (0.0807) |
| $\delta_D$ | -0.0414 | -0.100*** | -0.0729*** | -0.0414 | -0.110*** | -0.0919** | 0.855 | 0.0977 | -0.134 |
| | (0.0548) | (0.0154) | (0.0246) | (0.0716) | (0.0253) | (0.0407) | (0.734) | (0.147) | (0.0853) |
| Obs. | 537 | 820 | 489 | 521 | 775 | 451 | 505 | 731 | 414 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A25—: Income level classification: CS-ARDL - Inflation

| | CS-ARDL (1 lag) | | | CS-ARDL (2 lags) | | | CS-ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\pi$ | -0.253*** | -0.0656* | 0.0240 | -1.120 | -0.0589 | 0.0448 | -0.429* | -0.148 | 0.0683 |
| | (0.0679) | (0.0360) | (0.0385) | (0.959) | (0.0452) | (0.0456) | (0.247) | (0.0920) | (0.0500) |
| Obs. | 528 | 1094 | 822 | 522 | 1066 | 801 | 516 | 1038 | 780 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A26—: Income level classification: CS-ARDL - Growth of debt

| | CS-ARDL (1 lag) | | | CS-ARDL (2 lags) | | | CS-ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\delta_D$ | -0.0620 | -0.0754*** | -0.0397 | -0.0632 | -0.0827*** | -0.0774 | 0.0182 | -0.478 | 2.194 |
| | (0.0431) | (0.0173) | (0.0354) | (0.0420) | (0.0259) | (0.0522) | (0.0547) | (0.395) | (2.318) |
| Obs. | 525 | 828 | 491 | 518 | 788 | 454 | 511 | 749 | 418 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A27—: Income level classification: CS-ARDL - Growth of debt & Inflation

| | CS-ARDL (1 lag) | | | CS-ARDL (2 lags) | | | CS-ARDL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\delta_D$ | -0.0573 | -0.0741*** | -0.0758* | 0.0128 | -0.0645 | -0.125 | 0.337 | -0.106* | -0.160* |
| | (0.0464) | (0.0246) | (0.0446) | (0.0569) | (0.0641) | (0.219) | (0.420) | (0.0577) | (0.0863) |
| $\pi$ | -0.283*** | -0.0965 | 0.0851 | -0.233** | -0.0507 | -0.436 | 0.225 | -0.0943 | -0.122* |
| | (0.0573) | (0.145) | (0.184) | (0.109) | (0.128) | (0.664) | (0.415) | (0.136) | (0.063) |
| Obs. | 521 | 820 | 489 | 513 | 775 | 451 | 505 | 731 | 414 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A28—: Income level classification: CS-DL - Inflation

| | CS-DL (1 lag) | | | CS-DL (2 lags) | | | CS-DL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\pi$ | -0.188*** | -0.0315 | 0.0251 | -0.135*** | -0.0363 | 0.0430 | -0.126*** | -0.0768* | 0.0696 |
| | (0.0636) | (0.0275) | (0.0353) | (0.0479) | (0.0338) | (0.0410) | (0.0402) | (0.0404) | (0.0430) |
| Obs. | 537 | 1095 | 825 | 532 | 1068 | 806 | 523 | 1041 | 787 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A29—: Income level classification: CS-DL - Growth of debt

| | CS-DL (1 lag) | | | CS-DL (2 lags) | | | CS-DL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\delta_D$ | -0.0794** | -0.0896*** | -0.0505 | -0.0607* | -0.0833*** | -0.0684 | -0.0637** | -0.104*** | -0.0586 |
| | (0.0369) | (0.0161) | (0.0308) | (0.0362) | (0.0168) | (0.0417) | (0.0324) | (0.0169) | (0.0493) |
| Obs. | 528 | 830 | 491 | 524 | 795 | 454 | 519 | 761 | 418 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A30—: Income level classification: CS-DL - Growth of debt & Inflation

| | CS-DL (1 lag) | | | CS-DL (2 lags) | | | CS-DL (3 lags) | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| $\delta_D$ | -0.0760** | -0.0783*** | -0.0583 | -0.0901 | -0.0875** | -0.0696 | -0.0909 | -0.195*** | 0.365 |
| | (0.0376) | (0.0257) | (0.0417) | (0.0585) | (0.0341) | (0.0882) | (0.0581) | (0.0643) | (0.371) |
| $\pi$ | -0.199*** | -0.00164 | -0.0344 | -0.0820 | 0.00712 | -0.231** | -0.0200 | -0.148 | 0.0273 |
| | (0.0346) | (0.0579) | (0.0398) | (0.0829) | (0.0704) | (0.104) | (0.129) | (0.134) | (0.392) |
| Obs. | 522 | 820 | 489 | 515 | 775 | 451 | 508 | 635 | 217 |

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A31—: Threshold Effects - Without low income countries

| | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|
| (i) POLS | | | | | | | | |
| $\tau$ | -0.0209*** | -0.0189*** | -0.0179*** | -0.0158*** | -0.0160*** | -0.0160*** | -0.0136*** | -0.0166*** |
| | (0.00225) | (0.00214) | (0.00214) | (0.00239) | (0.00288) | (0.00337) | (0.00349) | (0.00450) |
| Obs. | 1489 | 1489 | 1489 | 1489 | 1489 | 1489 | 1489 | 1489 |
| (ii) MG | | | | | | | | |
| $\tau$ | -0.0195*** | -0.0159*** | -0.0185*** | -0.0160*** | -0.0162*** | -0.0189*** | -0.0141*** | -0.0201*** |
| | (0.00430) | (0.00376) | (0.00302) | (0.00397) | (0.00371) | (0.00362) | (0.00435) | (0.00617) |
| Obs. | 1131 | 1338 | 1246 | 1182 | 953 | 692 | 692 | 692 |
| (iii) CS-DL MG regression with threshold dummy | | | | | | | | |
| $\tau$ | -0.00492 | -0.00312 | -0.0170** | -0.00779 | -0.0101 | -0.0152** | -0.00000572 | -0.0185 |
| | (0.00706) | (0.00669) | (0.00692) | (0.00780) | (0.00631) | (0.00742) | (0.0156) | (0.0121) |
| $\delta_D$ | -0.141*** | -0.202*** | -0.154*** | -0.166*** | -0.179*** | -0.202** | -0.184** | -0.166* |
| | (0.0363) | (0.0536) | (0.0531) | (0.0553) | (0.0638) | (0.0835) | (0.0858) | (0.0899) |
| $\pi$ | -0.284** | -0.232** | -0.0914 | -0.0906 | -0.117 | -0.00769 | 0.00177 | 0.152 |
| | (0.131) | (0.115) | (0.104) | (0.0930) | (0.0864) | (0.131) | (0.186) | (0.140) |
| Obs. | 787 | 980 | 961 | 876 | 732 | 547 | 547 | 477 |
| (iv) CS-DL MG regressions with threshold dummy and interactive threshold effects | | | | | | | | |
| $\tau$ | -0.00560 | -0.00620 | -0.0778 | -0.0129** | -0.00915 | -0.0122 | 0.00191 | -0.0315** |
| | (0.00844) | (0.00740) | (0.0578) | (0.00653) | (0.00935) | (0.00920) | (0.0183) | (0.0157) |
| $\delta_D$ | -0.102** | -0.201*** | -0.149** | -0.146*** | -0.175*** | -0.221*** | -0.170* | -0.192** |
| | (0.0479) | (0.0667) | (0.0685) | (0.0535) | (0.0609) | (0.0787) | (0.0890) | (0.0868) |
| $\pi$ | -0.278* | -0.119 | -0.111 | -0.0227 | -0.127 | -0.00688 | 0.143 | 0.206 |
| | (0.151) | (0.0931) | (0.0807) | (0.0989) | (0.0868) | (0.138) | (0.189) | (0.137) |
| $\iota$ | 0.0520 | -0.0147 | 0.624 | -0.0810* | -0.0829 | -0.0238 | -0.0952 | -0.0449 |
| | (0.0599) | (0.0621) | (0.630) | (0.0475) | (0.0558) | (0.0758) | (0.102) | (0.0858) |
| Obs. | 669 | 930 | 961 | 806 | 657 | 507 | 477 | 477 |
| (v) CS-DL MG regressions with interactive threshold effects | | | | | | | | |
| $\delta_D$ | -0.194** | -0.143*** | -0.166** | -0.154*** | -0.151*** | -0.213*** | -0.221** | -0.188* |
| | (0.0844) | (0.0517) | (0.0714) | (0.0506) | (0.0583) | (0.0808) | (0.0896) | (0.0977) |
| $\pi$ | -0.234** | -0.104 | -0.0951 | 0.00955 | -0.0482 | 0.0350 | 0.0949 | 0.178 |
| | (0.115) | (0.124) | (0.0754) | (0.0932) | (0.0852) | (0.131) | (0.145) | (0.127) |
| $\iota$ | 0.0414 | -0.0886 | -0.0621 | -0.0842 | -0.130*** | -0.111 | -0.389* | -0.252** |
| | (0.0819) | (0.0549) | (0.0608) | (0.0599) | (0.0505) | (0.0783) | (0.217) | (0.0997) |
| Obs. | 1092 | 1057 | 961 | 836 | 692 | 507 | 507 | 437 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A32—: System GMM

| | $Z_1$ No year dummies | $Z_2$ No year dummies | $Z_1$ Year dummies | $Z_2$ Year dummies |
|---|---|---|---|---|
| $\delta_{D.}$ | -0.000193 | 0.00000128 | -0.0000908 | 0.000249 |
| | (0.000450) | (0.000381) | (0.000758) | (0.000576) |
| $\delta_B$ | -0.00809* | -0.00592 | -0.00847 | -0.00845 |
| | (0.00430) | (0.00452) | (0.00574) | (0.00594) |
| $\delta_M$ | 0.0000501 | 0.0000188 | 0.000106 | 0.0000390 |
| | (0.000109) | (0.000112) | (0.000147) | (0.000122) |
| $\delta_M^2$ | -0.000000627 | -0.000000511 | -0.000000965 | -0.000000313 |
| | (0.000000791) | (0.000000701) | (0.00000138) | (0.000000917) |
| Obs. | 326 | 326 | 326 | 326 |
| Sargan (p) | 0.000000967 | 0.00319 | 1.44e-08 | 0.000877 |
| Hansen (p) | 1.000 | 0.971 | 1.000 | 1.000 |
| AR1($p$) | 0.0161 | 0.0177 | 0.00858 | 0.0215 |
| AR2($p$) | 0.0200 | 0.0246 | 0.148 | 0.0570 |
| Instruments | 79 | 57 | 93 | 71 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A33—: System GMM - Exogenous Inflation

| | $Z_1$ No year dummies | $Z_2$ No year dummies | $Z_1$ Year dummies | $Z_2$ Year dummies |
|---|---|---|---|---|
| $\delta_{D.}$ | -0.00147*** | -0.00139*** | -0.00150*** | -0.00138*** |
| | (0.000293) | (0.000261) | (0.000268) | (0.000201) |
| $\delta_B$ | 0.000399 | 0.00287 | 0.00101 | 0.00320 |
| | (0.00483) | (0.00591) | (0.00545) | (0.00542) |
| $\delta_M$ | 0.000312** | 0.000315*** | 0.000362*** | 0.000389*** |
| | (0.000123) | (0.000116) | (0.000116) | (0.000121) |
| $\delta_M^2$ | 0.00000350*** | 0.00000312*** | 0.00000338*** | 0.00000304*** |
| | (0.00000107) | (0.00000115) | (0.00000117) | (0.00000104) |
| $\pi$ | -0.000426 | -0.000533* | -0.000630* | -0.000824*** |
| | (0.000316) | (0.000294) | (0.000339) | (0.000280) |
| $\pi^2$ | -0.00000393*** | -0.00000331*** | -0.00000360*** | -0.00000276*** |
| | (0.000000895) | (0.000000888) | (0.000000890) | (0.000000709) |
| Obs. | 326 | 326 | 326 | 326 |
| Sargan (p) | 6.08e-15 | 7.88e-12 | 5.99e-16 | 2.89e-12 |
| Hansen (p) | 1 | 1 | 1 | 1 |
| AR1($p$) | 0.00264 | 0.00268 | 0.00456 | 0.00642 |
| AR2($p$) | 0.00794 | 0.00848 | 0.0494 | 0.0941 |
| Instruments | 181 | 159 | 195 | 173 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A34—: System GMM - Endogenous Inflation

| | $Z_1$ No year dummies | $Z_2$ No year dummies | $Z_1$ Year dummies | $Z_2$ Year dummies |
|---|---|---|---|---|
| $\delta_{D.}$ | -0.000989** | -0.000657 | -0.000630 | -0.000305 |
| | (0.000464) | (0.000430) | (0.000534) | (0.000573) |
| $\delta_B$ | -0.00734** | -0.00688* | -0.00995 | -0.00596 |
| | (0.00373) | (0.00359) | (0.00797) | (0.00788) |
| $\delta_M$ | 0.000250* | 0.000168 | 0.000300* | 0.000213 |
| | (0.000141) | (0.000114) | (0.000168) | (0.000169) |
| $\delta_M^2$ | 0.00000152*** | 0.00000106** | 0.00000155** | 0.00000160 |
| | (0.000000566) | (0.000000420) | (0.000000719) | (0.00000129) |
| $\pi$ | -0.000207 | -0.000355 | -0.000468 | -0.000682 |
| | (0.000439) | (0.000401) | (0.000697) | (0.00154) |
| $\pi^2$ | -0.00000240** | -0.00000124 | -0.00000155 | -0.000000634 |
| | (0.00000119) | (0.00000106) | (0.00000188) | (0.00000430) |
| Obs. | 326 | 326 | 326 | 326 |
| Sargan (p) | 0.00000106 | 0.000346 | 1.12e-08 | 0.000291 |
| Hansen (p) | 1.000 | 0.988 | 1.000 | 1.000 |
| AR1($p$) | 0.00699 | 0.0112 | 0.00258 | 0.0131 |
| AR2($p$) | 0.00951 | 0.0127 | 0.117 | 0.0343 |
| Instruments | 81 | 59 | 95 | 73 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A35—: Sytem GMM - Dynamically complete model

| | $Z_1$ No year dummies | $Z_2$ No year dummies | $Z_1$ Year dummies | $Z_2$ Year dummies |
|---|---|---|---|---|
| $y_{-1}$ | 0.321 | 0.561*** | 0.247* | 0.495*** |
| | (0.217) | (0.108) | (0.141) | (0.115) |
| $\delta_{D.}$ | -0.00171*** | -0.00150*** | -0.00141** | -0.00166*** |
| | (0.000489) | (0.000519) | (0.000557) | (0.000495) |
| $\delta_M$ | 0.000333* | 0.000461*** | 0.000308** | 0.000382*** |
| | (0.000185) | (0.000112) | (0.000133) | (0.0000930) |
| $\delta_M^2$ | 0.00000177 | 0.000000772 | 0.00000268** | 0.00000173 |
| | (0.00000154) | (0.00000151) | (0.00000123) | (0.00000113) |
| $\pi$ | -0.000286 | -0.000634 | -0.000918 | -0.000466 |
| | (0.000533) | (0.000418) | (0.000649) | (0.000529) |
| $\pi^2$ | -0.00000281 | -0.000000987 | -0.00000167 | -0.00000220 |
| | (0.00000205) | (0.00000177) | (0.00000222) | (0.00000172) |
| Obs. | 436 | 436 | 436 | 436 |
| Sargan (p) | 0.0000887 | 0.0499 | 0.00181 | 0.212 |
| Hansen (p) | 0.0218 | 0.146 | 0.0732 | 0.568 |
| AR1($p$) | 0.0481 | 0.0394 | 0.0536 | 0.0471 |
| AR2($p$) | 0.676 | 0.525 | 0.671 | 0.512 |
| Instruments | 17 | 17 | 31 | 31 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$