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# Nonlinear effects of public debt on inflation. Does the size of the shadow economy matter?

Bogdan Andrei Dumitrescu [a], Meral Kagitci [b], Cosmin-Octavian Cepoi [a,*]

[a] Bucharest University of Economic Studies - Money and Banking Department
[b] Bucharest University of Economic Studies - Finance Department

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ABSTRACT

This paper explores the nonlinear effects of public debt on inflation. Using a sample of 22 emerging economies, our results provide evidence regarding the existence of threshold effects between inflation and public debt. Specifically, we find that emerging countries with a relatively low shadow economy can accommodate increases in public debt without the additional welfare costs that are associated with higher inflation. In contrast, those countries where the shadow economy exceeds 24.3% of GDP face greater macroeconomic costs in terms of inflation. Consequently, they have less room for manoeuvre when dealing with the effects of the COVID-19 pandemic

## 1. Introduction

The impact of public debt on macroeconomic variables, such as economic growth, investment, consumption or interest rates, has been largely debated in the literature. However, little is known about the effect of public debt on inflation, which can significantly influence macroeconomic management. In general, it is acknowledged that high and volatile inflation is detrimental to economic growth and imposes important welfare costs (Baharumshah et al., 2016).

Due to the current COVID-19 pandemic, most countries have additional requirements for resources to finance health spending, provide support for troubled agents and invest in the economic recovery. A large part of these resources is expected to come from increasing public debt, especially in the short term. According to IMF's World Economic Outlook Update from June 2020, "global public debt is expected to reach an all-time high, exceeding 101 percent of GDP in 2020–21, a surge of 19 percentage points from a year ago". Therefore, it is crucial for governments and central banks to accurately assess the impact of increasing public debt, especially in emerging economies, given that their capability to collect taxes to pay their debts is considerably inferior to developed economies (Medina and Schneider, 2017).

Countries with large informal sectors are associated with reduced tax revenues and poor governance. Consequently, they are more vulnerable and less able to raise the level of public indebtedness to cope with the effects of the COVID-19 pandemic. In this respect, we expect the presence of threshold-effects in the inflation-public debt nexus, and we believe that an approach that uses the shadow economy as a threshold variable can capture many useful stylised facts for policy makers.

The objective of this paper is to empirically investigate the short-run impact of increasing the public debt on inflation which is conditional on the size of the shadow economy. First, we will test the existence of threshold effects between inflation and public debt.

* Corresponding author.
*E-mail addresses:* bogdan.dumitrescu@fin.ase.ro (B.A. Dumitrescu), meral.kagitci@ase.ro (M. Kagitci), cosmin.cepoi@fin.ase.ro (C.-O. Cepoi).

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Second, as the relationship between the variables indicated nonlinearities, we will use panel smooth transition regression (PSTR) to capture the short-run impact.

The results suggest that an increase in public debt leads to higher inflation in countries where the shadow economy exceeds 24.3% of GDP. In contrast, in countries where the informal sector is below the threshold, an increase in the level of public debt leads to a reduction in inflation. Overall, these results highlight the higher macroeconomic costs that are faced by countries with a large shadow economy when increasing the level of public indebtedness. Consequently, there is less room for manoeuvre when dealing with the effects of the COVID-19 pandemic. The remainder of the paper has the following structure: Section 2 lays out the data and the methodology, Section 3 presents the results and Section 4 contains the conclusion.

## 2. Research design

### 2.1. Data description

We use data for the across 22 emerging markets covering the 2006 to 2015 period which was the longest period with data available for the shadow economy across the aforementioned countries. We chose the emerging countries according to the IMF classification. Some descriptive statistics are in Table 1.

The sample includes Argentina, Brazil, Chile, China, Colombia, Czech Republic, Hong Kong, Hungary, India, Indonesia, Israel, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Singapore, South Africa, South Korea, Thailand and Turkey. Our choice of time period is limited by data availability. The episodes of high inflation or deflation were extremely rare in the sample (less than 3% of observations). However, in a robustness check we run the threshold regression without high-inflation countries like Argentina or Turkey and find similar estimates. In Table 1 we present some descriptive statistics.

### 2.2. Methodology

To investigate the presence of a threshold-effect in inflation, we will use the PSTR model. This relies on the panel transition regression (PTR), which was developed by Hansen (1999):

$$Y_{it} = \begin{cases} \mu_i + \alpha_1' X_{it} + \varepsilon_{it}, & S_{it} \le \tau \\ \mu_i + \alpha_2' X_{it} + \varepsilon_{it}, & S_{it} > \tau \end{cases} \tag{1}$$

In Eq. (1), $i = 1, \ldots, N$ and $t = 1, \ldots, T$ denote the time and country dimensions of the panel, respectively. The dependent variable $Y_{it}$ is represented by inflation, $S_{it}$ is the threshold variable[1], $X_{it}$ is a vector of exogenous covariates[2], including public debt, $\mu_i$ are country specific effects and $\varepsilon_{it}$ is the error term.

In the PTR model, the two groups of observations below and above the threshold are precisely identified and distinguished by an abrupt transition from one regime to another. To account for smooth and gradual shifts via $j = \overline{1, r}$ transition functions among $r + 1$ distinct regimes, González et al. (2005) introduced the following PSTR representation:

$$Y_{it} = \mu_i + \beta_0' X_{it} + \sum_{j=1}^{r} \beta_j' X_{it} F\left(S_{it}^{(j)};\ \gamma_j, \tau_j\right) + \varepsilon_{i,t} \tag{2}$$

**Table 1**
Descriptive statistics.

| Variables | *Mean* | *Min* | *Max* | *St. Dev* |
|---|---|---|---|---|
| Inflation (Δ% CPI) | 4.70 | -0.90 | 38.00 | 4.05 |
| Shadow Economy (%GDP) | 24.71 | 9.20 | 51.36 | 9.94 |
| Government debt (%GDP) | 42.16 | 0.06 | 106.74 | 22.96 |
| GDP per capita (log) | 9.13 | 6.67 | 10.95 | 0.90 |

(*continued on next page*)

[1] We use the estimates of the shadow economy from **Medina and Schneider (2017)**. A larger shadow economy affects a country's ability to attract budgetary revenues, which leads to a lower public debt tolerance. To this point, Reinhart et al, (2003) introduced the concept of debt intolerance, stating that emerging countries are able to support much lower levels of debt compared to advanced economies. Moreover, "a larger shadow economy should give governments an incentive to shift revenue sources from taxes to inflation" **(Mazhar, and Méon, 2017)**. For these reasons, we chose the shadow economy as the threshold variable.

[2] In line with **Garriga and Rodriguez (2020)** and **Jašová et al. (2020),** alongside public debt (source: IMF), covariates (X) include economic growth, lagged inflation, unemployment, foreign direct investments, trade openness, government effectiveness (source: WDI), financial openness (source: Chinn and Hiro, 2006), oil price (source: Thomson Reuters), an exchange rate dummy for managed or free floats (source: **Ilzetzki et al., 2017**) and a dummy variable for the economic crises.

**Table 1** (*continued*)

| Variables | *Mean* | *Min* | *Max* | *St. Dev* |
|---|---|---|---|---|
| Lagged inflation (Δ% CPI)) | 4.72 | -0.90 | 38.00 | 4.08 |
| Unemployment rate (%) | 6.66 | 0.49 | 25.16 | 4.68 |
| Net foreign direct inv. (%GDP) | 5.64 | -15.99 | 58.52 | 9.10 |
| Trade openness (%GDP) | 103.49 | 22.11 | 442.62 | 98.60 |
| Financial Openness | 0.53 | -1.90 | 2.37 | 1.40 |
| Gov. Effectiveness | 0.50 | -0.67 | 2.44 | 0.71 |
| Oil Price(USD) | 73.08 | 41.85 | 91.48 | 16.94 |
| Crises Dummy | 0.30 | 0.00 | 1.00 | 0.46 |
| Exch. Rate Dummy | 0.66 | 0.00 | 1.00 | 0.47 |

In Eq. (2), we allow for $r$ transitions functions $F(S_{it}^{(j)};\ \gamma_j,\tau_j)$, which are normalised to lie between 0 and 1 and have the following three key features: the threshold variable $S_{it}$, the slope of each transition function $\gamma_j$ and the location parameters, $\tau_j$. Following Teräsvirta (1994), we will use the following logistic transition function presented in Eq. (3)::

$$F\left(S_{it}^{(j)};\ \gamma_j, c_j\right) = \left[1 + exp\left(-\gamma \prod_{l=1}^{m}(S_{it} - \tau_l)\right)\right]^{-1} \tag{3}$$

with $\gamma > 0$ and $\tau_1 \leq \tau_2 \leq \ldots \leq \tau_m$. As González et al. (2005) suggested, a value of 1 or 2 for $m$ can capture the common types of variations. Estimating Eq. (2) involves removing the individual effects $\mu_i$ before applying nonlinear least squares to the transformed data.( Eq(3), Table 2, Table 3)

## 3. Results

### 3.1. Linearity investigation

Before estimating Eq. (2), it is mandatory to test the existence of a possible nonlinear relation within the empirical model. By employing three different linearity tests, we will first investigate the presence of a regime-switching effect. The results and the corresponding *p*-values are presented in Table 2.

The empirical findings lead to the rejection of the null hypothesis at 10% level, which is the linear relationship between inflation and covariates ($H_0$: $r = 0$), in favour of the alternative ($H_1$: $r = 1$). Moreover, one transition function is better suited to capture the nonlinear effect in terms of the inflation that is generated by the shadow economy compared to the other specifications ($r \geq 2$).

**Table 2**
Linearity and no remaining heterogeneity tests.

| Test | $H_0$: $r = 0$ vs. $H_1$: $r = 1$ | $H_0$: $r = 1$ vs. $H_1$: $r = 2$ |
|---|---|---|
| Lagrange Multiplier – Wald ($LM_W$) | 19.101 (0.059) | 8.915 (0.630) |
| Lagrange Multiplier – Fischer ($LM_F$) | 1.616 (0.097) | 0.634 (0.798) |
| Likelihood Ratio | 19.981 (0.046) | 9.101 (0.613) |

Note: p-values are reported in parenthesis.

**Table 3**
PSTR estimates.

| Variables | Regime 1:$\beta_0$ | Nonlinear part:$\beta_1$ | Regime 2:$\beta_0 + \beta_1$ | Change inRegime 2 vs. Regime 1 |
|---|---|---|---|---|
| Government debt | -0.0964** | 0.1742** | 0.0778** | ↑ |
| Log GDP per capita | -0.1339 | -0.0045 | -0.1384 | - |
| Lagged inflation | 0.1936*** | 0.1420** | 0.3356** | ↑ |
| Unemployment | 0.0175 | -0.1431 | -0.1256 | - |
| Foreign direct inv. | -0.0035 | 0.2544 | 0.2509 | - |
| Trade openness | 0.0199 | 0.0109 | 0.0308 | - |
| Financial Openness | -0.0221** | 0.0241** | 0.0020** | ↑ |
| Gov. Effectiveness | 0.0348 | -0.0304 | 0.0044 | - |
| Oil Price | 0.0341 | -0.0123 | 0.0218 | - |
| Crises Dummy | -0.0068 | -0.0025 | -0.0093 | - |
| Exch. Rate Dummy | 0.0275** | -0.0345** | -0.0070** | ↑ |
| Threshold | 24.32% | | | |

(*continued on next page*)

**Table 3** (*continued*)

| Variables | Regime 1:$\beta_0$ | Nonlinear part:$\beta_1$ | Regime 2:$\beta_0 + \beta_1$ | Change inRegime 2 vs. Regime 1 |
|---|---|---|---|---|
| Slope(γ) | 1.3266 | | | |
| $R^2$ | 0.6766 | | | |
| Observations | 220 | | | |

### 3.2. PSTR estimates

Table 3 presents the parameter estimates from the PSTR model considering a logistic transition function (i.e., $m = 1$). The estimated slope parameter is relatively small, which indicates a smooth and gradual movement between regimes. As robustness checks, we estimated Eq. (2) based on a logistic quadratic transition function (i.e., m=2). The results do not change significantly. Furthermore, the estimates retain their signs and statistical significance when considering only the public debt as an explanatory variable.

In Regime 1, we report a novel negative relationship between public debt and inflation, which implies that when the shadow economy is lower than 24.3%, 1 pp increase in the level of public debt results in approximately 0.1 pp lower inflation. This suggests that emerging countries with a relatively low shadow economy can accommodate increases in public debt without the additional welfare costs that are associated with higher inflation. This could be explained by the increased capacity of these countries to support debt, as well as the lower risk to allow a higher inflation, as pointed out by Mazhar and Méon (2017). However, once the scale of the shadow economy-to-GDP ratio exceeds the threshold – which seems consistent with a change in the debt tolerance of these countries-, and we move forward into the second extreme regime, 1 pp increase in the level of public debt is detrimental to inflation by 0.08 pp. This result confirms the conventional wisdom stated in the studies by Aizenman and Marion (2011) and Bhattarai et al. (2014) among others. According to the latter, "a higher level of public debt outstanding, not matched by sufficient tax increases, is translated into higher wealth for households, which increases spending and thereby inflation". Additionally, the incentive to shift revenue sources from taxes to inflation is now higher, as argued by Mazhar and Méon (2017).

Fig. 1 displays the nonlinear relationship of the transition variable. In Regime 1, there are 32% of cases, whereas 34% are in the second extreme regime. The rest of them are recorded in-between observations. From a mathematical perspective, the intersection point between the two lines will have the following coordinates: the threshold value of the shadow economy and the inflection value, which change the shape of the logistic transition function from convex to concave. We notice a relatively low value for the estimated slope parameter, γ=1.3266 which suggests a smooth movement from one regime to another. Indeed, shifting from a high informal sector to a low-informal sector requires a period of economic transition which can involve large structural changes. More to the point, Fig. 1 shows that transition is more gradual when a country with a shadow economy close to the threshold is managing to reduce it and to enter the first regime.

## 4. Conclusion

This paper analyses the nonlinear effects of public debt on inflation using the shadow economy as a transition variable across 22

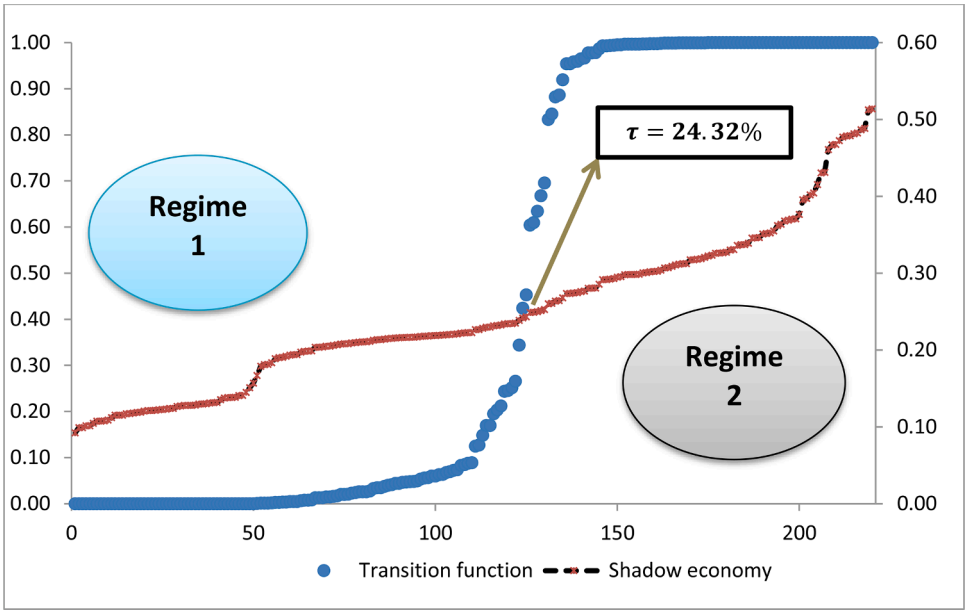


**Fig. 1.** Estimated transition function over the shadow economy.

emerging economies. We reveal the existence of a nonlinear smooth transition across the distribution of inflation, depending on the level of the shadow economy. The threshold level of regime switching regarding the shadow economy share to GDP is endogenously found to be 24.3%. Below this level, emerging countries can accommodate the increase in public debt without the welfare costs that are generated by higher inflation, whereas above this threshold, inflation increases as public debt becomes higher. These results point to less room for manoeuvre for policy makers in emerging countries with a high level of the shadow economy in response to the crisis that has been generated by the COVID-19 pandemic.

## CRediT authorship contribution statement

**Bogdan Andrei Dumitrescu:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Meral Kagitci:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Cosmin-Octavian Cepoi:** Methodology, Data curation, Software, Writing – original draft, Writing – review & editing.

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