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GROWTH EFFECTS OF INFLATION UNDER THE PRESENCE OF INFORMALITY

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ABSTRACT

In this paper we build an endogenous growth model in which the informal economy is subject to a cash-in-advance constraint along with physical capital accumulation and consumption. In this setting, we find that inflation generally adversely affects long-run growth. However; this effect strongly interacts with the size of the informal economy. Specifically, the negative effect becomes milder (and can even be positive) under the presence of a large informal economy. Moreover, using an annual cross-country panel data set of 161 countries over the period 1950-2010 we also provide some empirical support for the mechanism of our theory.

Keywords: growth, inflation, informal economy, panel data

JEL classification numbers: C23, E26, O17, O42

I. INTRODUCTION

The relationship between inflation and economic growth is one of the most debated and extensively investigated topics in economic literature. There is a vast empirical and theoretical literature investigating this relationship. From a theoretical point of view, several different mechanisms have been suggested in the literature and most of the papers within the theoretical framework tend to emphasise a negative effect of inflation on economic growth. (See Barro, 1991; Rebelo, 1991; Levine and Renelt, 1992; Chari, Jones and Manuelli, 1995; Bose, 2002; Blackburn and Pelloni, 2004, and Varvarigos, 2010 for a non-exhaustive list of theoretical papers in the literature). However, as empirical tests of this relationship produce conflicting results, the exact nature of this adverse effect is far from being justified empirically (See Temple, 2000 for an excellent survey of this literature). Accordingly, the extent of this relationship changes depending on the type of econometric specification, size of the dataset, number of countries and time periods used in the empirical analysis.

Similar to the relationship between growth and inflation, the extent of the informal (shadow) economy and tax evasion is generally viewed among the key issues for an economy (See Schneider and Enste, 2000; Torgler and Schneider, 2007 and much more recently Elgin (2010, 2015) and Elgin and Oztunali (2012) among many others). Informality, sometimes also titled

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shadow, hidden, black, parallel, second or underground economy (or sector) is defined by Hart (2008) as a set of economic activities that takes place outside the framework of bureaucratic public and private sector establishments. Another paper by Ihrig and Moe (2004) defines it as a sector, which produces legal goods, but does not comply with (most if not all) government regulations. Similarly, Schneider, Buehn and Montenegro (2010) define it as a set of market-based economic activities that are consciously covered up from government in order not to face with regulation and taxation. Generally it is seen as a low productive, labour-intensive sector operating on small-scale production. Informality is widespread and poses serious economic, social and political challenges across the world; however many issues about its nature and consequences of informality remain largely under-explored or unresolved. Moreover, one of its main characteristics is that, compared to the formal economy, the informal economy does not have access to various other financial tools and mediums of exchange and relies on cash-use much more extensively (See Portes and Sassen-Koob, 1987; Schneider, Buehn and Montenegro, 2010; Elgin and Oztunali, 2012 among many others). Dating back to Cagan (1958) this is why several monetary aggregates are generally seen as indicators of informal economy when one tries to measure the size of it (See Schneider, Buehn and Montenegro, 2010 for a discussion of the monetary approach to measure the size of the informal sector). Moreover, under the presence of informality, due to the existence of tax evasion in the economy, the government will need to rely on indirect taxation through the financial intermediaries as well as seigniorage revenues (See Roubini and Sala-i Martin, 1992, 1995, and Elgin and Uras, 2013). Therefore, presence of informality has serious repercussions on the formal economy through its effects on inflation and growth.

In this paper, aiming to combine these two strands of the literature, we explore the interrelationship between growth, size of the informal economy and inflation. To this end, we first build an endogenous growth model in which the informal economy is subject to a cash-in-advance (CIA) constraint along with physical capital and consumption. We make this assumption to refer to the extensive reliance of the informal economy on cash. In this setting, we find that inflation adversely affects long-run growth; however this effect interacts with the size of the informal economy. More specifically, as higher inflation distorts the informal economy at a higher degree (due to its higher reliance on cash), informal households and firms will have more incentives to go formal with higher inflation. In a sense, inflation acts as a tax asymmetrically levied on the informal sector. That is, inflation creates a further incentive for the household to give up informal labour and devote more time to formal labour when the inflation rate is higher, taming the adverse effects of inflation on growth. Using a cross-country panel data set of 161 countries over the period 1950-2010 we also provide some empirical support for the mechanism of our theory.

As mentioned earlier, the empirical literature on the relationship between growth and inflation does not provide a strong consensus on the nature of this relationship. On the one hand, Fischer (1991) finds that a 10 percent points increase in a country's inflation rate is associated with a reduction of the growth rate in the amounts 0.3 and 0.4 percent, depending on several other correlates. Similarly, Barro (1995) argues that every 10 percentage point increase in inflation lowers the growth rate by about 0.2-0.3 percent and more importantly this relationship indeed might be nonlinear. On the other hand, however, the Mundell-Tobin effect à la Mundell (1963) and Tobin (1965) implies that a higher inflation might lead to a reduction in the real interest rate that in turn could be associated with a higher rate of economic growth (See Azariadis and Smith (1996) for a similar result). Empirically, McTaggart (1992) finds that variability in inflation has a positive impact on growth in Australia. On the other hand, Bruno and Easterly (1998) suggest that a negative relationship between growth and inflation exists in high frequency data when including extreme inflation outliers. Finally, Khan and Senhadji (2001) indicate the existence of

a non-linear relationship in which there is a negative relationship between inflation and growth above a threshold level of inflation that is around 1-3 percent for industrial economies and 11-12 percent for developing ones. To summarize, the majority of the empirical analyses in the literature find the effect of inflation on growth to be empirically negative (Also see Kormendi and Meguire, 1985 and Grier and Perry, 2000 among many others). As a contribution to the empirical literature on the relationship between growth and inflation, our paper might be viewed as a further support for the existence of a non-linear relationship between these two variables. However, we show that this non-linearity originates from the variation in the size of the informal economy which the existing literature did not take into account.

Even though the literature on informal economy is growing in recent years, the financial and monetary implications of the informal economy are very much under-investigated. Roubini and Sala-i Martin (1995), Aruoba (2010) and Elgin and Uras (2013) are some exceptions in this regard. Roubini and Sala-i Martin (1995) argue that, under the presence of extensive tax evasion a government would rely on financial repression through seigniorage which would increase inflation and reduce economic growth. However, they do not consider the asymmetric effect of inflation on formal and informal economies and therefore neglect the potential positive effect of inflation that manifests itself as a shift from the informal to formal economy. Finally, in a more recent paper Elgin and Uras (2013) examine the relationship between informal economy and financial development as measured by various indicators. They obtain an inverted-U relationship between financial development and size of the informal economy; that is financial development increases with informality at lower levels and decreases at higher levels of informal economy. Considering that financial development is one of the main determinants of economic growth, this result is related to our model; however these authors do not consider the linkage between informal economy and growth through inflation.

In addition to being a contribution to the literature on the relationship between growth and inflation, our paper also has several policy implications both for monetary and fiscal policymakers. We show that the presence of an informal economy which constitutes a severe drawback for fiscal policy and heavily relies on cash has several effects on the transmission and growth effects of monetary policy. Following our results, policy implications complement those of the existing papers in literature. More specifically, according to our study, the public policy should focus more on taking measures to increase tax enforcement on the informal sector and reduce frictions in the financial market that manifest themselves as a liquidity constraint on investment expenditures in the model.

The remainder of the paper is organized as follows: In section II we present the theoretical model with its full characterization. Next in section III we report the numerical simulations of the model. Then in section IV we conduct an empirical analysis which provides a strong support for the model's predictions. Finally, in section V we make a discussion and present some concluding remarks.

II. MODEL

To model an economy with an informal sector, money and growth, we use a two-sector (formal and informal) endogenous growth model with a cash-in-advance constraint.[1]

[1]In an alternative environment, a money-in-the-utility framework would open up the possibility of a rich dynamic behaviour (Matsuyama, 1991). With elastic labour supply, the Sidrausky-Brock money in the utility model implies that although capital per worker is independent of the growth rate of the money supply, the supply of labour is not. Depending on the specific utility function, this may result in a positive or a negative relationship between the growth rate of money and the stock of capital per capita. Moreover, one

In this setting there is a continuum of infinitely lived households. These households have access to two production technologies, namely formal and informal, yet they are identical in their preferences. Time is discrete and denoted by $t = 1, 2, \ldots$. The timing of events is as follows: First, households choose their cash holdings. Then, they decide on their labour supply in formal and informal sectors and purchase goods. Finally, they get a lump sum monetary transfer after the goods market closes and arrange their portfolios for the next period.

In this setting, the representative household solves the following problem:

$$\max_{\{C_t, K_{t+1}, L_{ft}, L_{it}, {M_{t+1}}^d\}} \sum_{t=0}^{\infty} \beta^t U(C_t)$$

$$\text{subject to } C_t + \psi(K_{t+1} - (1-\delta)K_t) + \zeta B {L_{it}}^{\gamma} = \frac{{M_t}^d}{P_t}$$

$$C_t + K_{t+1} - (1-\delta)K_t + \frac{{M_{t+1}}^d}{P_t} = (1-\tau)A K_t {L_{ft}}^{\alpha}$$

$$+ (1-\rho\tau)B {L_{it}}^{\gamma} + \frac{M_t + v_t}{P_t}$$

$$L_{ft} + L_{it} = T$$

$$C_t, K_{t+1}, L_{ft}, L_{it}, M_{t+1}^d \geq 0$$

$$\lim_{t\to\infty} \beta^t \lambda_t K_{t+1} = 0$$

$$\psi, \alpha, \gamma, \delta, \zeta, \rho \in [0, 1], \beta \in (0, 1)$$

Here K_t, and C_t denote physical capital stock and consumption, respectively. Physical capital depreciates at a rate $\delta \in [0, 1]$ and L_{ft} and L_{it} represent formal and informal labor supply while A and B are productivity parameters of the two sectors, respectively. The relationship of money and lump sum transfers, v_t is given by $M_{t+1} = M_t + v_t$, so that M_{t+1} stands for nominal money holdings after the transfer and M_{t+1}^d denotes amount of nominal money demand for the following period.[2]

On the production side of the economy, output can be produced both by using formal and informal technologies. To have a room for endogenous growth, the formal sector technology exhibits increasing returns to scale at the aggregate level. When written at the individual firm-level, the technology still exhibits constant returns to scale with spillover effects at the aggregate level.[3] This is the crucial driving force behind the endogeneity of growth[4] in the model. Moreover, the informal economy only uses labor as an input and operates using a decreasing returns to scale technology.[5] Formal output is taxed by the government at an exogenous rate $\tau \in [0, 1]$

should also remember that Danthine, Donaldson, and Smith (1987) show that in a stochastic version of the Sidrausky-Brock model, money is no longer super-neutral. In our case, depending on the form of the utility function, in a money-in-the-utility framework we also can obtain a non-linear relationship between inflation and growth under the presence of informality.

[2]Our model resembles that of Chari, Jones and Manuelli (1995) and Dotsey and Sarte (2000).

[3]As this does not make any difference at the aggregate level, for the sake of simplicity we do not write the problem using firm-level technologies.

[4]The use of the increasing returns to scale production function is needed to achieve perpetual growth in the economy. Notice that the Dotsey and Sarte (2000) gets around this problem by assuming an AK production function.

[5]See Ihrig and Moe (2004) and Elgin (2010) for a discussion of why such a function represents informal production processes well.

which can only be partially enforced for informal output. Here ρ denotes the tax enforcement parameter measuring how well taxes are enforced in the informal sector.[6]

In this setup, the representative households maximises her discounted utility subject to three constraints: The first one is the CIA constraint, the second one denotes the resource feasibility constraint and finally the last one is household's time constraint. In the CIA constraint, $\psi > 0$ reflects the fraction of investment that is subject to the CIA constraint. In this regard, similar to Dotsey and Sarte (2000), ψ might be interpreted as a proxy measuring how well financial (or credit) markets function, i.e., we should expect ψ to take a lower value when the level of financial development in a country is higher. Moreover, $\zeta > 0$ is a parameter governing how much output produced in the informal sector is subject to the cash-in-advance constraint. In a sense, with this parameter being positive, the informal economy absorbs some of the cash available to consumption and investment in the formal economy. Remembering that the shadow economy uses cash at a higher degree than the formal economy (See Schneider and Enste, 2000). This is not an unrealistic assumption.

We further assume that the money supply grows at a rate z_t, i.e., the government issues money at this exogenous rate z_t.[7]

$$M_{t+1} = z_t M_t$$

Finally, in this environment the market clearing conditions are given by the following two equations:

$$\begin{aligned} {M_t}^d &= M_t \\ C_t + K_{t+1} - (1-\delta)K_t + G_t &= A K_t {L_{ft}}^{\alpha} + B {L_{it}}^{\gamma} \\ G_t &= \tau A K_t {L_{ft}}^{\alpha} + \rho \tau B {L_{it}}^{\gamma} \end{aligned}$$

The first equation illustrates the money market equilibrium, whereas the second one denotes the goods market equilibrium. The last equation denotes the government budget constraint.

II.1 Characterization

First-order conditions are given as follows:

$$C_t : \beta^t U'(C_t) - \lambda_t - \sigma_t = 0 \tag{1}$$

$$K_{t+1} : -\psi[\lambda_t - (1-\delta)\lambda_{t+1}] - \sigma_t + \sigma_{t+1}[(1-\delta + (1-\tau)A {L_{ft+1}}^{\alpha}] = 0 \tag{2}$$

$$L_{it} : -\lambda_t \zeta \gamma B {L_{it}}^{\gamma-1} + \sigma_t[\gamma(1-\rho\tau)B {L_{it}}^{\gamma-1} - \alpha(1-\tau)A K_t {L_{ft}}^{\alpha-1}] = 0 \tag{3}$$

$${M_{t+1}}^d : -\frac{\sigma_t}{P_t} + \left[\frac{\lambda_{t+1} + \sigma_{t+1}}{P_{t+1}}\right] = 0 \tag{4}$$

[6]The tax revenue of the government is spent for activities that are not modelled here.

[7]We assume that the CIA constraint always binds. For the log utility case, the condition required for this is that $z \geq \beta$

By combining household's first-order conditions, the following Euler Equation (EE) is obtained that governs the law of motion for consumption:

$$\psi U'(C_t) = -(1-\psi)\beta U'(C_{t+1})\frac{P_t}{P_{t+1}} + \beta(1-\delta)\psi U'(C_{t+1}) + \beta^2[(1-\delta)(1-\psi) + (1-\tau)AL_{ft+1}^{\alpha}]U'(C_{t+2})\frac{P_{t+1}}{P_{t+2}}$$

Obtaining analytical solution in two-sector models is always very difficult (if not impossible) and unfortunately in this case it is not possible to obtain an analytical solution expressing the growth rate of the formal economy in the balanced growth-path as a function of money growth rate z_t and other parameters of the economy. This is why we rely on numerical simulations which we present in the next section.

III. MODEL SIMULATION

III.1 Parameter choice

Throughout the simulations we assume that the utility function is logarithmic and labor is supplied inelastically.[8] Before starting the discussion of the simulation exercise we need to choose values for various parameters of the model. For β and δ we use the values 0.96 and 0.08, respectively. Notice that these are standard values generally used in the real business cycle (RBC) literature. Moreover, we normalize the time endowment T to 100 which allows us to interpret L_f and L_i as the percent of total time devoted to production in the formal and informal sectors, respectively. To choose a value for α we target a capital - formal output ratio of 2.75 which is the average capital-output ratio[9] for the countries which will be used in the empirical analysis in the next section. The calibrated value[10] of α is 0.6. As for γ we use the value reported by Roca, Moreno and Sanchez (2001). For the formal sector TFP parameter, we rely on the value also used by Dotsey and Sarte (2000) and as for the informal sector TFP, we aim to match the TFP ratio obtained from the calculations of Elgin and Oztunali (2012) and use the ratio of the informal sector TFP to the formal one as reported by Ihrig and Moe, in conjunction with the formal sector TFP value used in the current paper.[11] Finally, the tax rate imposed on the formal sector, τ, is calibrated[12] so that in our first numerical exercise, the size of the informal sector (as percentage of the formal economy) matches the average size in our informal economy dataset 36.54 percent corresponding to an average inflation rate about 7.78 percent (See the next section for a description of the dataset). Table 1 lists the parameter values used in the numerical exercises. The remaining parameters are ζ, ψ, ρ and z and we will make comparative-static exercises with respect to these variables.

[8]We assume that $U(C_t) = ln(C_t)$. However, we also have run several simulations with different standard functional forms and obtained qualitatively similar results.

[9]We use the standard perpetual-inventory method to calculate the capital stock series for each country.

[10]As we are using an increasing returns to scale function for the formal sector and a decreasing returns to scale function for the informal sector, one cannot exactly interpret α and γ as the labor shares.

[11]Notice that B is significantly larger than A. This is not surprising considering the same results in several other papers in the literature. One among these, Ihrig and Moe (2004), argue that this might be due to the fact that B incorporates both total factor productivity and the sector-specific capital used in informal sector. Also see Elgin and Oztunali (2012) for a similar argument. However,we experimented several different values here and obtained qualitatively similar results. These are available upon request from the corresponding author.

[12]In an alternative simulation experiment, we used a fixed value for the tax burden and calibrated γ again to match the size of the informal sector as percentage of GDP; however obtained qualitatively similar results.

TABLE 1
Parameter values

Parameter	*Description*	*Value*	*Source*
β	Discount Factor	0.96	Standard RBC Literature
δ	Depreciation	0.08	Standard RBC Literature
T	Time Constraint	100	Normalisation
α	Labor Share (Formal Sector)	0.60	Calibrated
γ	Labor Share (Informal Sector)	0.65	Calibrated
A	Formal Sector TFP	0.175	Dotsey and Sarte (2000)
B	Informal Sector TFP	4.61	Calibrated
τ	Tax Burden	0.12	Calibrated

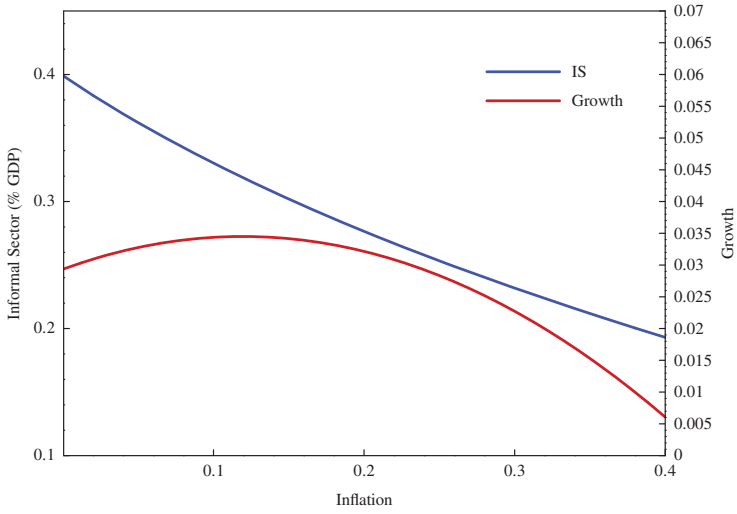

Fig. 1. Growth vs. Inflation when $\zeta = 1$.

III.2 Simulation

In all the simulations below, we vary z_t such that the associated inflation rate varies between 0 and 40 percent. Under this variation, we then plot the behaviour of the size of the informal economy (as percentage of the formal economy, i.e., $\frac{BL_{it}{}^{\gamma}}{AK_tL_{ft}{}^{\alpha}}$) and growth of the formal economy (i.e., $\frac{AK_{t+1}L_{f,t+1}{}^{\alpha}}{AK_tL_{ft}{}^{\alpha}}$).

Our first numerical example, illustrated in Figure 1, analyses the growth implications of variable monetary policy for the case when the the informal economy is fully subject to the CIA constraint, i.e., $\zeta = 1$.[13] In that case, we observe that with a higher rate of inflation, the informal sector declines drastically, meaning that there is a shift of labor supply from informal to formal economy. This shift makes the growth reducing effect of inflation (through the CIA constraint on investment) milder and actually, the growth rate increases slightly for lower levels of inflation but then is reduced sharply. Under the specified parameter values, the growth maximising inflation rate is slightly above 10 percent.

[13]For figures 1 and 2, we set $\psi = 0.10$ as in Dotsey and Sarte (2000) and $\rho = 0.03$ as in Busato and Chiarini (2004).

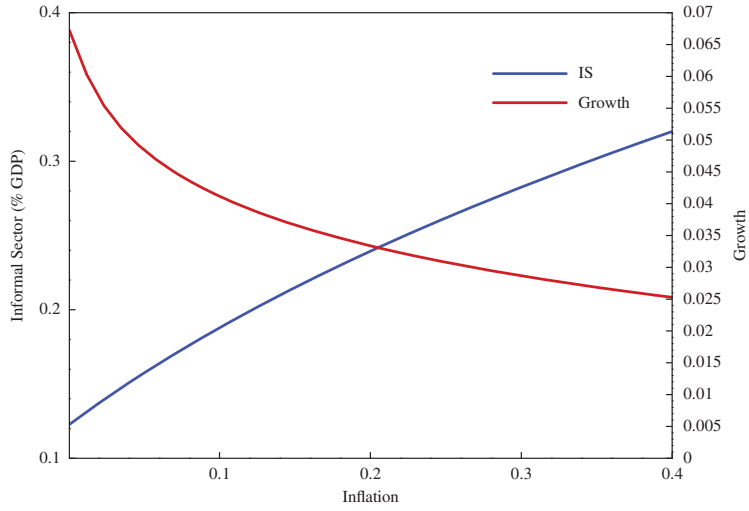

Fig. 2. Growth vs. Inflation when $\zeta = 0$.

Next, in Figure 2 we present simulation results setting $\zeta = 0$, that is when the informal economy is not subject to the CIA constraint. Under this assumption, a higher rate of growth money (and therefore inflation) does not distort the informal economy as it is not subject to the liquidity constraint and therefore is associated with a larger informal economy and also lower growth rate of the formal economy. In this case obviously, the growth maximizing inflation rate is exactly equal to 0. Another conclusion one can obtain from the first two numerical simulation exercises is that the growth-maximizing inflation rate varies between 0 and 10 percent when we let ζ to vary between 0 and 1, respectively. That is, the more the informal economy is subject to the CIA constraint, the higher the growth-maximizing rate of inflation in this simulated economy.

Finally, in figures 3 and 4 we conduct two simulation exercises to check the response of the growth-inflation relationship under the presence of informality when we change the values of two policy parameters, i.e., ψ and ρ. Here we assume that $\zeta = 1$, i.e., the informal economy is fully subject to the CIA constraint. That is why the inverted-U relationship between growth and inflation still persists in these simulations.

In Figure 3, we run two simulations one with $\psi = 0.35$ (denoted by weak constraint) and another one with $\psi = 0.65$. This illustrates that a stricter liquidity constraint on investment expenditures (i.e., less efficient financial markets and a lower degree of financial development), increases the volatility of output growth with respect to inflation. Moreover, the growth maximizing inflation rate is significantly lower in the simulation with weak constraint (8 percent) compared to the one with stricter constraint (12 percent).

On the other hand, in Figure 4, we observe another comparative-static result with respect to the tax enforcement parameter ρ. So far, in all the previous simulations we have used $\rho = 0.03$. For Figure 4, we use two more different values for this parameter, one when $\rho = 0$ (low enforcement), and $\rho = 0.75$ (high enforcement). Here, we observe that under stricter tax enforcement on the informal sector, the growth rate is significantly larger for all levels of inflation. Moreover, the growth maximizing inflation rate is also lower with stricter enforcement. The reason behind this observation is that stricter enforcement on informal sector income acts as a further distortion on the intra-temporal decision-making of the household. In this case, increasing inflation creates

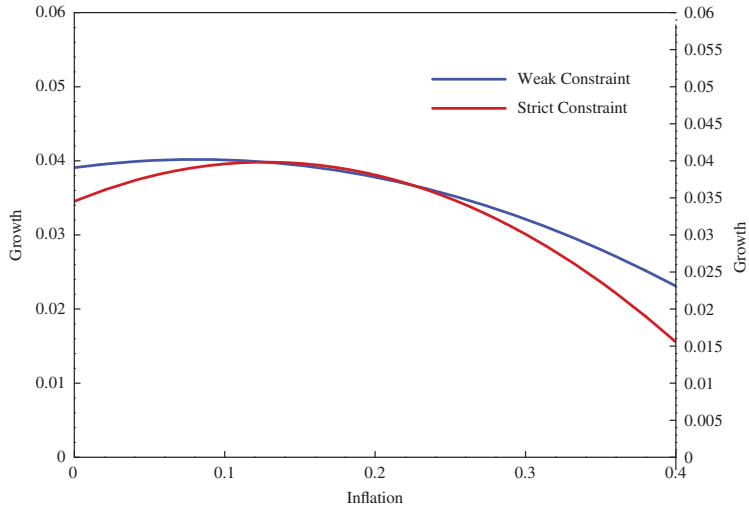

Fig. 3. Growth vs. Inflation with different values of ψ.

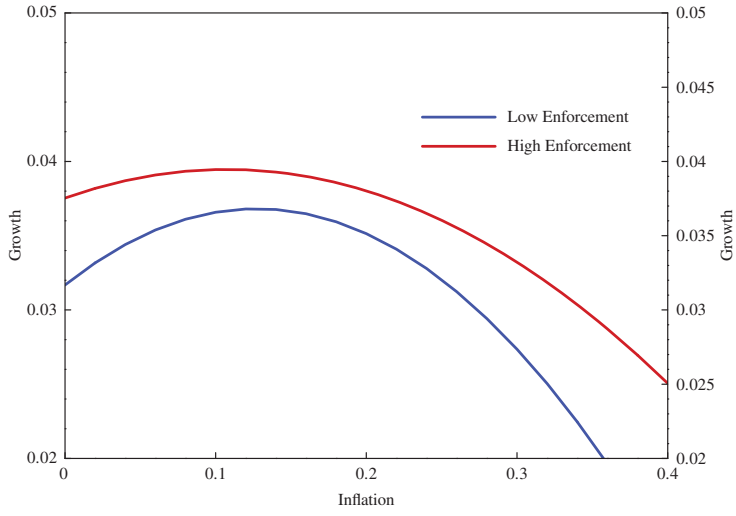

Fig. 4. Growth vs. Inflation with different values of ρ.

further incentives for the household to devote more time to the formal sector, thereby increasing growth of the formal sector output.

III.3 Informality if the CIA constraint

A quick comparison of figures 1 and 2 reveals that the contribution of our paper would be limited if the degree at which the informal sector is subject to the CIA constraint (i.e., ζ) is zero or very close to zero. Unfortunately, it is not possible to find a direct counterpart of ζ in the data; therefore in this subsection we conduct a deeper analysis about the effects of ζ on the relationship between inflation, informality and growth.

TABLE 2
Growth maximizing levels of inflation and informal sector with varying ζ

ζ	*Inflation* (%)	*Informal Sector* (% *GDP*)	*Growth* (%)
0	0.00	12.24	6.72
0.2	4.25	17.50	5.64
0.4	7.50	22.39	4.80
0.6	10.25	25.30	4.20
0.8	12.75	28.75	3.65
1.0	14.75	32.10	3.45
2.0	15.25	32.45	3.00

The first exercise that we conduct is to find the growth maximizing levels of inflation and informal sector size with increasing ζ. To this end, in Table 2 we report the triple (Informal sector size, inflation, growth) with maximised growth rates for different values of ζ ranging from 0 to 1 in intervals of length equal to 0.2. We also report the values of the triple for $\zeta = 2$. Here we observe that the growth maximizing level of inflation as well as informal sector size rise, albeit with a decreasing rate, with increasing ζ. Nevertheless, the maximized growth rate is significantly reduced, again with a decreasing rate. Notice that, this exercise does not rule out the inverted-U relationship between inflation and growth; as this non-linear relationship still holds for a fixed value of ζ.

In the final analysis, we estimate the parameter ζ using Bayesian estimation[14] techniques with average informal sector size as percentage GDP from the data as the observable data series. For all other parameters,[15] we report the values reported in Table 1 and $\psi = 0.10$, as well as $\rho = 0.03$ as in the benchmark simulation. We conduct the estimation for a few selected economies ranging from Bolivia with the largest average informal sector size to the USA with the smallest informal sector size in the data set we will use in the next section for the empirical analysis. For each country in the analysis, as the prior distribution we use the uniform distribution[16] with lower and upper bounds of 0 and 1, respectively. Table 3 reports the means of the posterior distribution, as well as the Bayesian 95 percent intervals (2.5 percent and 97.5 percent, respectively) for the ζ estimates in different countries. What we observe from Table 3, the estimates means for all the particular countries are positive and significantly different from zero. We also observe that countries with a larger informal sector, tend to have a larger estimated value for ζ, consistent with Table 2.

IV. EMPIRICAL ANALYSIS

In this section we run panel regressions to gain a deeper understanding of the relationship between growth and inflation and how informal economy interacts with this relationship. We

[14]Following the standard practice in the literature, we run three chains each of size 150,000 Metropolis-Hasting draws and discard the first 10,000 iterations.

[15]For the inflation rate, z, we use the average inflation rate of the corresponding country.

[16]Considering that our choice of the uniform distribution might seem somewhat arbitrary, we also have experimented estimations using the beta distributions with different means ranging from 0.25 to 0.75 with standard deviations ranging from 0.05 to 0.20 and obtained qualitatively similar results with respect to the non-negativity of the estimate of ζ as well as the ranking of the estimated values of ζ for the selected economies in Table 3.

TABLE 3
Bayesian estimation of ζ for few selected economies

	2.5 %	*97.5 %*	*Mean*
Bolivia	0.45	0.63	0.54
Egypt	0.34	0.60	0.47
Italy	0.19	0.25	0.22
Japan	0.07	0.15	0.11
Luxemburg	0.06	0.12	0.09
Mexico	0.30	0.44	0.37
Turkey	0.32	0.50	0.41
UK	0.13	0.21	0.17
USA	0.13	0.25	0.19
Zimbabwe	0.62	0.90	0.76

TABLE 4
Complete dataset summary statistics: 1950-2010

	Mean	*Std. Dev.*	*Minimum*	*Maximum*	*Observations*
Growth (%)	2.31	7.19	−27.12	29.13	7484
Inflation (%)	7.78	7.11	−12.18	165.12	7484
Informal Sector Size (in % GDP)	36.54	14.78	8.07	80.33	7395
GDP per-capita (thousand USD)	8.37	11.31	0.12	159.14	7645
Openness (% GDP)	68.43	49.23	2.32	443.18	7645
Government exp. ((%)GDP)	10.83	7.27	0.28	58.59	7645
Investment (% GDP)	22.56	11.17	0.23	51.29	7144
Corruption Control	3.13	1.38	0.00	6.00	2812
Law and Order	3.67	1.52	0.00	0.00	2812
Fiscal Deficit (% GDP)	−0.71	4.20	−19.12	49.55	2112

will first discuss the econometric methodology, then the dataset and finally we will present the estimation results.

IV.1 Methodology

Our benchmark analysis involves estimating the following regression equation in the static panel data setting:

$$Gr_{i,t} = \alpha_0 + \alpha_1 \pi_{i,t} + \alpha_2 \pi_{i,t} IS_{i,t} + \sum_{k=3}^{n} \alpha_k X_{ki,t} + \theta_i + \gamma_t + \epsilon_{i,t}$$

Here for country i in year t, $\mathrm{Gr}_{i,t}$ denotes growth rate of GDP, $\pi_{i,t}$ is the inflation rate and $IS_{i,t}$ is the size of the informal economy as percentage of GDP. Moreover, $X_{k_{i,t}}$ are the other explanatory variables that might be associated with growth and θ_i, γ_t are the country and period fixed effects, respectively. Among the control variables we also include the informal economy size to understand whether there is an unconditional effect of the informal sector or a conditional one with inflation as argued in the model simulations in the previous section. Finally, $\epsilon_{i,t}$ denotes the error term.

TABLE 5
Growth, inflation and informality: FE estimations

Growth	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Inflation	−0.27*	−0.27*	−0.26*	−0.27*	−0.31*	−0.25*	−0.25*	−0.24*	0.19*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.08)	(0.07)	(0.07)	(0.06)
IS·Inflation	0.45*	0.44*	0.43*	0.43*	0.52*	0.47*	0.49*	0.48*	
	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.10)	(0.10)	(0.10)	
IS		1.01	1.13	1.17	1.22	0.77	0.76	−0.60	
		(1.09)	(1.08)	(1.08)	(0.85)	(0.75)	(0.74)	(0.80)	
Inflation^2									−0.12**
									(0.06)
Openness		0.005	0.007***	0.007**	0.003*	0.001	0.001	0.002***	
		(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	
Gov. exp.			−0.20*	−0.19*	−0.15*	−0.09**	−0.09**	−0.08**	
			(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	
GDP per-cap.				0.001	0.003**	0.001	0.001	0.001	
				(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	
Investment					0.14*	0.11**	0.10**	0.09***	
					(0.04)	(0.05)	(0.05)	(0.05)	
Corr. Cont.						0.57	0.54	0.50	
						(0.38)	(0.46)	(0.45)	
Law							1.10	1.18	
							(0.88)	(0.76)	
Fisc. Def.								−0.30**	
								(0.15)	
R-squared	0.02	0.02	0.02	0.02	0.05	0.05	0.05	0.10	0.02
Observations	7242	7242	7242	7242	7242	2811	2811	2112	7242
F-Test	14.49	13.38	17.01	6.34	8.87	7.67	7.54	7.52	16.20
Time F-test	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00

Notes: All panel regressions include a country fixed effect and year dummies. Time F-test gives the p-value for the joint significance of year dummies. Robust standard errors are reported in parentheses. *, **, *** denote 1, 5 and 10% confidence levels, respectively. In all regressions a constant is also included but not reported.

In the benchmark analysis, we will use the fixed-effects (FE) estimator using annual data However, we will also report results of further regressions using the FE estimator with 5-year averaged data to rule out business cycle effects and ordinary least squares (OLS) in the static panel data setting.

Moreover, to capture persistence and also potentially mean-reverting dynamics in our dependent variable, we also report results of the dynamic panel data estimation using the GMM estimator developed by Arellano and Bond (1991) where one-period lagged values of the regressors are used as instruments.[17] In the dynamic panel data setting we estimate the following equation:

$$Gr_{i,t} = \beta_0 + \beta_1 Gr_{i,t-1} + \beta_2 \pi_{i,t} + \beta_3 IS_{i,t} + \sum_{k=4}^{n} \beta_k X_{k_{i,t}} + \theta_i + \gamma_t + \epsilon_{i,t}$$

[17]Further estimations have been conducted to address the potential existence of a two-directional causality between informal sector size and economic growth. We also have run regressions using the IV estimator of Anderson and Hsiao (1982). All the results presented below are qualitatively robust to these different econometric specifications. Moreover, these additional results are also available upon request from the corresponding author.

TABLE 6
Growth, inflation and informality: FE estimations with 5-year averages

Growth	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Inflation	−0.18*	−0.17*	−0.17*	−0.16*	−0.15*	−0.15*	−0.15**	−0.14**	0.13*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.03)
IS·Inflation	0.27*	0.25*	0.25*	0.23*	0.23*	0.37*	0.39*	0.39*	
	(0.08)	(0.08)	(0.08)	(0.07)	(0.07)	(0.09)	(0.09)	(0.09)	
IS		0.89	0.87	0.80	0.92	0.90	0.55	0.20	
		(1.01)	(1.02)	(1.03)	(0.99)	(0.82)	(0.84)	(0.29)	
Inflation^2									−0.09**
									(0.05)
Openness		0.01***	0.01***	0.001	0.02**	0.02**	0.02***	0.02**	
		(0.005)	(0.005)	(0.005)	(0.01)	(0.01)	(0.01)	(0.01)	
Gov. exp.			−0.09*	−0.06***	−0.09**	−0.08**	−0.09**	−0.08**	
			(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	
GDP per-cap.				0.001*	0.002**	0.002**	0.001	0.001	
				(0.0003)	(0.001)	(0.001)	(0.001)	(0.001)	
Investment					0.53*	0.57*	0.44**	0.45**	
					(0.20)	(0.20)	(0.21)	(0.21)	
Corr. Cont.						0.57	0.54	0.50	
						(0.48)	(0.46)	(0.45)	
Law							1.10	1.19	
							(0.88)	(0.76)	
Fisc. Def.								−0.29**	
								(0.15)	
R-squared	0.12	0.16	0.16	0.17	0.18	0.18	0.18	0.21	0.11
Observations	1366	1366	1366	1366	1366	826	825	816	1366
F-Test	18.01	16.38	15.39	16.41	14.99	14.47	13.78	13.51	18.11
Time F-Test	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00

Notes: All panel regressions include a country fixed effect and year dummies. Time F-test gives the p-value for the joint significance of year dummies. Robust standard errors are reported in parentheses. *, **, *** denote 1, 5 and 10% confidence levels, respectively. In all regressions a constant is also included but not reported.

In the dynamic panel data estimations, p-values corresponding to two tests are also provided in all of the tables. One of these tests is the Hansen J-test for over-identifying restrictions and the other one is the AR (2) test for autocorrelation. The tests provide support for the exogeneity of the instruments and absence of autocorrelation in the specified order, respectively.

In all the different types of regressions we are especially interested in the estimates signs and magnitudes of the coefficients of inflation and the interaction term between inflation and informal economy size. Given our simulation results in the previous section, what we expect them to be are negative and positive, respectively. Moreover, given the inverted-U relationship we obtained in most of the simulations in the previous section, we will also include a squared-inflation term (denoted by inflation^2) among the control variables. In this case we expect to observe a positive sign for the estimated coefficient of inflation and negative sign for the estimated coefficient of the squared term.

IV.2 Data

Empirical studies on informality are rare due to the lack of large datasets of informal economy size. One such exception is the one constructed by Elgin and Oztunali (2012) for 161 countries

TABLE 7
Growth, inflation and informality: GMM estimations with 5-year averaged data

Growth	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
L. Growth	0.05**	0.04**	0.06*	0.07*	0.04*	0.05**	0.05**	0.05**	0.06*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Inflation	−0.29*	−0.27**	−0.26**	−0.26**	−0.25**	−0.24*	−0.24*	−0.25*	0.18**
	(0.10)	(0.13)	(0.13)	(0.13)	(0.12)	(0.08)	(0.08)	(0.08)	(0.08)
IS·Inflation	0.33*	0.34*	0.34*	0.33*	0.30*	0.27**	0.27**	0.26**	
	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)	(0.13)	(0.13)	(0.13)	
IS		1.23	1.17	1.17	1.00	0.87	0.84	0.64	
		(0.81)	(0.82)	(0.83)	(0.69)	(0.52)	(0.54)	(0.49)	
Inflation^2									−0.12*
									(0.04)
Openness		−0.01	−0.01	−0.01	0.02***	0.03	0.05	0.05	
		(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.04)	(0.04)	
Gov. exp.			−0.08	−0.07	0.07***	−0.08	−0.07	−0.02	
			(0.07)	(0.07)	(0.04)	(0.07)	(0.06)	(0.05)	
GDP per-cap.				0.003	0.001	0.0003	0.0003	0.0002	
				(0.002)	(0.002)	(0.0003)	(0.0003)	(0.0002)	
Investment					0.23**	0.29*	0.29*	0.28*	
					(0.12)	(0.10)	(0.10)	(0.11)	
Corr. Cont.						0.71	0.70	0.70	
						(0.58)	(0.56)	(0.55)	
Law							0.30	0.33	
							(0.70)	(0.68)	
Fisc. Def.								−0.07	
								(0.05)	
Observations	1105	1105	1105	1105	938	595	594	585	1105
Time F-Test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Hansen J-Test	0.32	0.31	0.27	0.35	0.39	0.43	0.36	0.41	0.26
AR (2) Test	0.29	0.30	0.26	0.25	0.22	0.24	0.23	0.22	0.24

Notes: All panel regressions include a country fixed effect and year dummies. Time F-test gives the p-value for the joint significance of year dummies. Robust standard errors are reported in parentheses. *, **, *** denote 1, 5 and 10% confidence levels, respectively. In all regressions a constant is also included but not reported.

over the period from 1950 to 2010. Considering the length of the time-series dimension we use this dataset for informal economy size.[18] Data for growth of GDP is obtained from the Penn World Tables 8.0. (PWT). We have also constructed inflation series from PWT using the GDP deflator.[19] As for control variables we use, trade openness (defined as the ratio of the sum of exports and imports to GDP), government spending (as percentage of GDP) and investment expenditures (as percentage of GDP). We also obtained these variables from PWT. As measures of institutional quality, we use two institutional quality indices, i.e., corruption control and law and order indices. These indices are obtained from the International Country Risk Guide of the

[18]However, as a robustness check we also have used the shadow economy data reported by Buehn and Schneider (2012) and our empirical results did not change qualitatively. These estimations are not reported in the text but are available from the corresponding author.

[19]Alternatively, we also used inflation series calculated based on consumer price indices from World Development Indicators and our results did not change significantly. These estimations are also available from the corresponding author.

TABLE 8
Growth, inflation and informality: OLS estimations

Growth	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Inflation	−0.24*	−0.26*	−0.26*	−0.29*	−0.24*	−0.22*	−0.23*	−0.24*	0.30*
	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)
IS·Inflation	0.21*	0.23*	0.23*	0.27*	0.26*	0.25*	0.26*	0.25*	
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.08)	(0.08)	(0.09)	
IS		0.44	0.37	0.35	0.23	0.27	0.14	0.15	
		(0.31)	(0.32)	(0.33)	(0.29)	(0.28)	(0.24)	(0.19)	
Inflation^2									−0.15***
									(0.08)
Openness		0.01*	0.01*	0.01*	0.01*	0.02*	0.02**	0.03*	
		(0.003)	(0.003)	(0.003)	(0.003)	(0.01)	(0.01)	(0.01)	
Gov. exp.			−0.04**	−0.04**	−0.05**	−0.05**	−0.06*	−0.05**	
			(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	
GDP per-cap.				0.0004**	0.0004**	0.001	0.001	0.001	
				(0.0002)	(0.0002)	(0.001)	(0.001)	(0.001)	
Investment					0.33*	0.35*	0.36*	0.37*	
					(0.11)	(0.12)	(0.12)	(0.13)	
Corr. Cont.						0.92**	0.93**	0.94**	
						(0.45)	(0.45)	(0.45)	
Law							1.03	0.99	
							(0.88)	(0.84)	
Fisc. Def.								−0.04	
								(0.03)	
R-squared	0.04	0.06	0.06	0.14	0.18	0.20	0.22	0.23	0.03
Observations	1366	1366	1366	1366	1199	826	825	816	1366
F-Test	10.26	10.15	9.80	8.67	9.92	9.57	8.73	7.85	9.87

Notes: All panel regressions include a country fixed effect and year dummies. Time F-test gives the p-value for the joint significance of year dummies. Robust standard errors are reported in parentheses. *, **, *** denote 1, 5 and 10% confidence levels, respectively. In all regressions a constant is also included but not reported.

PRS Group. Unfortunately, the institutional quality indices are only available after 1984 and only for 141 countries. Finally, we also use fiscal deficit (percentage GDP) which we obtained from World Development Indicators. Table 4 provides descriptive statistics of all the variables used in the analysis. Moreover, the list of countries is given in the appendix.

IV.3 Estimation results

Results for the benchmark estimation with annual data and using the fixed-effect estimator are reported in Table 5. Considering that the estimated coefficient of inflation is negative and that of the interaction term of inflation with informality (i.e., the coefficient of IS·Inflation) is positive in all the regressions, we observe that the estimation results are in line with our simulations in the previous section. Moreover, this relationship is also robust to the inclusion of various control variables to the regression equation. In regression 9 we also observe support for the existence of an inverted-U relationship between growth and inflation as suggested by our simulations in the previous section.

Next, in Table 6, to rule out business cycle effects that might constitute a bias in the annual data, we report the FE estimation results using 5-year averaged data. Moreover, in Table 7 we

report estimation results obtained with the GMM estimator in the dynamic panel data setting and finally in Table 8 results using the OLS estimator. We observe from these tables that our results are also robust to different econometric specifications.

V. CONCLUSION

In this paper we studied the growth effects of inflation under the presence of informality. First, we constructed a model through which the presence of informality significantly interacts with the relationship between growth and inflation. The model implies that informality has significant effects on the transmission and growth effects of monetary policy. Specifically, we showed that the adverse effects of inflation on growth gets milder under the presence of informality. Moreover, under certain conditions, the effect might even be positive. Moreover, using a cross-country panel data set of 161 countries over the period 1950-2010 we also provided empirical support for the mechanism of our theory.

Our study can be extended in a number ways to investigate various other macroeconomic issues linked to informal sector and growth effects of monetary policy. One such issue is to investigate how exactly informality affects financial intermediation as this effect might create a further distortion for the transmission of monetary policy. Another such issue might involve giving a more active role for the fiscal and monetary policy authority in such an environment. These we leave to future work.

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APPENDIX

List of Countries in the Empirical Analysis

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Democratic Republic of Congo, Republic of Congo, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Republic of Korea, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macao, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovak Republic, Slovenia, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syria, Taiwan, Tajikistan, Tanzania, Thailand, Togo, Trinidad-Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Yemen Zambia, Zimbabwe