GROWTH EFFECTS OF INFLATION
UNDER THE PRESENCE OF INFORMALITY

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BOĞAZİÇİ UNIVERSITY

2013

GROWTH EFFECTS OF INFLATION
UNDER THE PRESENCE OF INFORMALITY

Thesis submitted to the
Institute for Graduate Studies in the Social Sciences
in partial fulfillment of the requirements for the degree of

Master of Arts
in
Economics

by
Dila Asfuroğlu

Boğaziçi University
2013

Growth Effects of Inflation under the Presence of Informality

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August 2013

Thesis Abstract

Dila Asfuroğlu, "Growth Effects of Inflation under the Presence of Informality"

In this paper we study the interrelationship between growth, size of the informal economy and inflation. We build an endogenous growth model in which the informal economy is subject to a cash-in-advance constraint along with physical capital and consumption. In this setting, we find that inflation adversely affects long-term growth. However; this effect strongly interacts with informality. Specifically, it becomes milder (and can even be positive) in the presence of a large informal economy. Moreover, using an annual cross-country panel data set of 161 countries over the period 1950 – 2009, we also provide strong empirical support for the mechanism of our theory.

Tez Özeti

Dila Asfuroğlu, "Kayıt Dışı Ekonomi Varlığında Enflasyonun Ekonomik Büyümeye Etkileri"

Bu makalede ekonomik büyüme, kayıtdışı ekonomi ve enflasyonun birbirleriyle olan ilişkisini incelemekteyiz. Kullandığımız endojen büyüme modelinde kayıt dışı ekonomi, tüketim ve maddi sermaye peşin ödeme kısıtı altındadır. Bu durumda, enflasyon uzun dönemli ekonomik büyümeyi olumsuz olarak etkiler. Ancak; bu etki kayıt dışı ekonominin varlığıyla etkileşim halindedir. Yani, bu olumsuz etki kayıt dışı ekonomi yüksek olduğunda giderek azalır (hatta pozitif olabilir). Buna ek olarak, 161 ülkenin 1950-2009 yılları arasındaki yıllık panel verilerine dayanarak kurduğumuz teorinin işleyişini ampirik olarak desteklemekteyiz.

ACKNOWLEGMENTS

I would like to express my sincere thanks to all my family members for their support during the preparation of this paper.

Assist. Prof. Ceyhun Elgin, my thesis advisor, not only provided the roadmap of this work but also contributed to its quality with his expertise and experience. I also would like to thank Assist. Prof. Tolga Umut Kuzubaş and Assoc. Prof. Murat Taşdemir for their comments.

I am also thankful to TUBITAK for their financial support during my graduate studies.

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CHAPTER 1

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 focusing on this relationship. From a theoretical viewpoint, several different mechanisms have been suggested in the literature, most of which indicate a negative effect of inflation on economic growth. (See, Jones and Manuelli, 1990; Barro, 1991; Rebello, 1991; Levine and Renelt, 1992; and Chari, Jones and Manuelli, 1995). However, since empirical tests of this relationship produce conflicting results, the exact nature of this adverse effect is far from being justified empirically. Therefore, it can be said that 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 are among key issues for an economy. (See Schneider and Enste, 2000; Torgler and Schneider, 2007 and much more recently Elgin, 2010 among many others.) Informality, sometimes also titled shadow, hidden, black, parallel, second or underground economy (or sector) is defined by Hart (2008) as a set of economic activities that take place outside the framework of bureaucratic public and private sector establishments.[1]Generally it is seen as a low

[1] Another paper by Ihrig and Moe (2004) defines it as a sector, which produces legal goods, but does not comply with government regulations. Schneider, Buehn and Montenegro (2010) define it as a set

productive, labor-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 the 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 more extensively. Dating back to Cagan (1958) this is why several monetary aggregates are generally seen as indicators of informal economy when one tries to measure its extent. (See Schneider, Buehn and Montenegro, 2010.) Moreover, under the presence of informality, due to the existence of tax evasion in the economy, the government has 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 repercussion 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 strongly interacts with the size of the informal economy. More specifically, as higher inflation distorts informal economy at a higher degree (due to their higher reliance on cash), informal

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of market-based economic activities that are consciously covered up from government in order not to face with regulation and taxation.

households and firms will have more incentives to go formal with higher inflation. This will reduce the adverse effect of inflation on the growth of the formal economy. Using a cross-country panel data set of 161 countries over the period 1950 – 2009, we also provide strong empirical support for the mechanism of our theory.

As mentioned earlier, the empirical literature on the relationship between growth and inflation do not provide any consensus on the nature of this relationship. 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 has not taken into account.

Even though the literature on informal economy has grown 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. Similarly, Auroba (2010) argues that higher levels of informal activity are associated with lower income tax rates and higher inflation. He also recognizes that a government whose main objective is to raise a fixed amount of revenue in the least distorting way might use inflation as a tool to reduce the size of the informal

economy. However, this paper does not consider the effect of this on the relationship between growth and inflation. Finally, in a more recent paper Elgin and Uras (2013) examine the relationship between the 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 the informal economy and growth through inflation.

In addition to contributing to the literature on the relationship between growth and inflation, our paper also has several policy implications both for monetary and fiscal policy makers. 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 the next chapter, we provide a broad literature review of theoretical papers. In chapter 3, we present the theoretical model with its full characterization and report the numerical simulations of the model. In the next chapter, we conduct an empirical analysis in line with the

model predictions. Finally, in chapter 5 we make a discussion and present some concluding remarks.

CHAPTER 2

LITERATURE SURVEY

Jones and Manuelli (1990) utilize an endogenous growth model with a cash-in-advance constraint on the expenditure of consumption goods to analyze how the growth rate is affected by the rate of inflation. Under this setting, they use both nominal rigidities on tax (in the form of real marginal tax rate changes) and distortion in the labor-supply choice. Although both provide a negative correlation between inflation and growth rate, they state that the growth effect is moderate in size for a considerable rate of inflation and quite small at low to moderate levels of inflation. In particular, the nominal depreciation allowances case leads to a decrease from 2% to1.9% in growth rate when inflation is increased from 0% to 50%. In the Lucas-style effective labor case, the growth effect is dependent on the substitutability/complementarity of cash and credit goods. For the substitutes case, the association is non-linear, as the growth rate first falls to 1.8% for 50% money growth and increases back to 2% as inflation rises whereas in the case of complements, when money growth is 200%, the growth rate decreases to 1.1%.

Fisher (1991) controls for impacts of variables, such as budget deficit size, secondary school enrolment rate, investment share, income level and so on, and finds a negative relationship between inflation and growth by using countries from Latin America, Asia and Africa covering the years from 1960 to 1988. He uses cross-sectional regressions and instrumental variable estimations and shows that a 10 percent point increase in inflation rate is associated with a reduction of the growth

rate about 0.3 and 0.4 percent. Moreover, the evidence in this paper seems to suggest that this relationship might be nonlinear as the growth effect of inflation decreases in increased levels of inflation. Particularly, he finds that a 10 percent point increase in inflation rate is associated with a 1.3 percent point reduction in the growth rate for countries that are in low inflation category, a 0.75 percent point reduction for those in the middle inflation category and a 0.2 percent point decrease for those in the high inflation category where categories are defined according to average inflation rate of the corresponding country. Fisher (1993) also notes the existence of a positive association at low rates of inflation and a negative one as inflation rises.

Levine and Renelt (1992) can be seen as the investigations of cross-country empirics of growth in which they also evaluate the robustness of the correlation between growth and inflation. They examine this empirical relationship covering the years 1960-1989 for almost 120 countries and find that inflation is not robustly correlated with growth. Yet, they indicate that fast-grower countries, which had growth rates higher than the mean growth rate over the given period, had an average inflation rate of 12.34 percent while slow-growers had that of 31.13 percent.

McTaggart (1992) analyzes the cost of inflation in Australia considering both its level and variability. In this paper, higher variability in inflation is associated with higher uncertainty and Australian data is said to exhibit this positive relationship between the level of inflation and uncertainty. As inflation is claimed to have considerable and identifiable effects on the factors of production through distorting the labor market via nominal wage contracts and interacting capital market via nominal rigidities, empirical analysis in this study embeds inflation into the equation in a way that it directly affects both capital and labor. Results suggest that the level

of inflation has a negative effect on growth while its variability has a positive effect. Numerically, this translates into an increase in level of output by 0.25 percentage points due to a one percent point reduction in inflation.

Barro (1995) uses the data of around 100 countries that covers the period 1960-1990 to measure the effect of inflation on growth. Regression results show that if average inflation is increased by 10 percentage points, the effect of this change lowers the growth rate by 0.2-0.3 percentage points, holding country characteristics constant. However, this evidence of adverse relationship is stressed to be clear with the inclusion of high-inflation experiences, specifically, with the inclusion of countries in which inflation surpasses a rate between 10 and 20 percent. He also finds that although the negative impact of inflation on growth is small, it has long-term effects. For instance, ten percentage points rise in long-term average inflation rate per year is estimated to result in a lower level of real GDP after thirty years by 4%-7%. Besides, he indicates the relationship to be nonlinear.

Chari, Jones and Manuelli (1995) examine a variety of endogenous growth models with transaction demand for money to explore the association between inflation and growth. Utilizing calibrations of their various models, they find that 10 percent point increase in inflation rate decreases growth rate much less than the 0.5 percent point found in the empirical literature and this negative association is not guaranteed in all kinds of models. As the inflation rate per se has a trivial effect on the growth rate, they include changes in financial regulations and money supply, namely simultaneously changing money growth rates and reserve requirement. With financial regulations, banking and the interaction of inflation with these regulations, they observe substantial impacts on growth using a data of 88 countries.

Bruno and Easterly (1998) address a historical explanation of what happened during high inflation crises. The correlation between cross-section inflation and growth averages for 1961-1994 loses significance with the omission of a single observation which experienced hyperinflation and negative growth in the 1980s. In other words, they find that the significance and sign of the cross-section correlation depend crucially on the inclusion of the countries with high inflation crises. They characterize the behavior of the output growth before, during and after the high inflation crises in which a country is assumed to be when its level of inflation is above threshold level of 40%. After high inflation crisis, they find that inflation returns to its pre-crises level and growth recovery is experienced and this recovery compensates some or all of the output loss during high inflation crisis. Their pooled data (cross-country regressions) suggests significant negative correlation between growth and inflation; yet this result is not supported with the omission of high inflation countries. Therefore, they conclude that there is no robust evidence of growth inflation relationship at any frequency except high inflation crises.

Mundell (1963) argues that when money rate of interest increases by less than the rate of inflation and therefore real rate of interest falls, inflation reduces wealth which in turn stimulates saving and acceleration of growth is experienced together with investment boom. In short, positive association between inflation and growth follows that an increase in inflation causes an increase in capital investment, and in turn, an increase in growth.

Tobin (1965) makes money a store value in the economy. In this economy, individuals substitute current consumption for future consumption by holding money or accumulating capital. The Tobin effect, therefore, assumes money as a substitute

to capital. If the inflation rate increases, the return to money falls and people reduce their money holdings as money has lower return than capital and the opportunity cost of cash holding rises. Hence, the reallocation of savings from money to capital results in an increase in capital per worker. Thus, greater capital intensity promotes growth. In other words, as the higher inflation rate raises the level of output, inflation exhibits a positive relationship with growth under this setting.

In their paper, Khan and Senhadji (2001) examine the existence of threshold effects in the relationship between growth and inflation using empirical analysis. Their aim was to answer whether there is a statistically significant threshold level of inflation below and above which inflation affects growth differently which derives from the non-linear relationship between inflation and growth. Their data includes 140 countries that covers the period 1960-1998 and illustrates that the association between growth and inflation is positive for low levels of inflation and becomes negative for higher levels of inflation. To test the existence of a threshold effect, they estimate the five-year average of the panel data and find that there is a threshold effect and the threshold is 1-3 percent inflation rate for industrial economies while 7-11 percent for developing ones. Both groups show a statistically significant and positive relationship between inflation and growth below the threshold level and a statistically significant and a stronger negative relationship for above the threshold level. Numerically, an increase in inflation from 3 to 30 percent will result in a reduction of growth by 0.67 percentage points in developing countries and by 0.95 percentage points in industrial ones. On the other hand, reducing the inflation rate of a developing country from 60 percent to 15 percent will increase its growth by 1.15 percentage points. They also stress that their result with respect to inflation rate

above threshold level is robust to the exclusion of high-inflation countries and data frequency.

Finally, for an exhaustive survey of the literature, Temple (2000) can be reviewed.

CHAPTER 3

MODEL

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

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,... . The timing of events resembles the one described in Svensson (1985) and is as follows: First, households choose their cash holdings. Then, they decide on their labor 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 maximization problem:

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

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

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

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

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

Here, K_t and C_t denote physical capital stock and consumption, respectively. Physical capital depreciates at a rate δ and L_{ft} and L_{it} represent formal and informal labor supply while A and B productivity parameters of the two sectors, respectively. The relationship of money and lump sum transfers, v_t, is $M_{t+1}=M_t+v_t$, 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. The formal sector technology exhibits increasing returns to scale at the aggregate level.[3] This is the crucial driving force behind the endogeneity of growth in the model. Moreover, the informal economy only uses labor as an input and operates using a decreasing returns to scale technology.[4] Formal output is taxed by the government at an exogenous rate $\tau \in [0,1]$ 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.

In this setup, the representative household maximizes 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 first constraint, ψ reflects the fraction of investment that is subject to the CIA constraint. In this regard, ψ might be interpreted as a proxy measuring

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

[3] When written at the individual firm-level, the technology might still be viewed to be constant returns to scale with spillover effects at the aggregate level. 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] See Ihrig and Moe (2004) and Elgin (2010) for a discussion.

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, ζ 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.

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 [5];

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

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

$$M_{t+1}^{d} = M_t$$
$$C_t + K_{t+1}-(1-\delta) K_t =A K_t L_{ft}^{\alpha}+B L_{it}^{\gamma}$$

The first equation illustrates the money market equilibrium, whereas the second one denotes the goods market equilibrium.

Characterization

First-order conditions are given as follows:

[5] Assume CIA always has to bind. For log utility case, the condition required for this is $z \geq \beta$.

$$C_t : U'(C_t) - \lambda_t - \sigma_t = 0$$

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

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

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

By combining household's firs-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.

Model Simulations

Before starting the discussion of the simulation exercise we need to choose values for various parameters of the model. For β, δ and α we use the values 0.96, 0.08 and 0.67, 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. As for γ we use the value reported by Roca, Moreno and Sanchez (2001). The value for the formal sector TFP, we rely on the value also used by Dotsey and Sarte (2000) to examine the relationship between growth and inflation. As for the informal sector TFP, we use the ratio of the informal sector to TFP to the formal one as reported by Ihrig and Moe, in conjunction with the formal sector TFP value we use in the current paper.[6] Finally, the tax rate imposed on the formal sector, τ, is calibrated so that in our first numerical exercise, the size of the informal sector (as % of the formal economy matches the average size in our informal economy dataset 36.54% corresponding to an average inflation rate about 7.78%. (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.

Table 1: Parameter Values

Parameter	Description	Value	Source
β	Discount Factor	0.96	Standard RBC Literature
δ	Depreciation	0.08	Standard RBC Literature
α	Labor Share (Formal Sector)	0.67	Standard RBC Literature
T	Time Constraint	100	Normalization
γ	Labor Share (Informal Sector)	0.65	Roca, Moreno and Sanchez (2001)
A	Formal Sector TFP	0.175	Dotsey and Sarte (2000)
B	Informal Sector TFP	4.61	Ihrig and Moe (2004)
τ	Tax Burden	0.12	Calibrated

In all the simulations below, we vary z_t such that the associated inflation rate varies between 0 and 40%. Under this variation, we then plot the behavior of the size of the

[6] Notice that B is significantly larger than A. Ihrig and Moe (2004) argue that this might be due to the fact that B incorporates total factor productivity and the sector-specific capital used in informal sector. Also see Elgin and Oztunali (2012) for this.

informal economy (as % 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, analyzes the growth implications of variable monetary policy for the case when the informal economy is perfectly subject to the CIA constraint, i.e. $\zeta=1$.[7] 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.

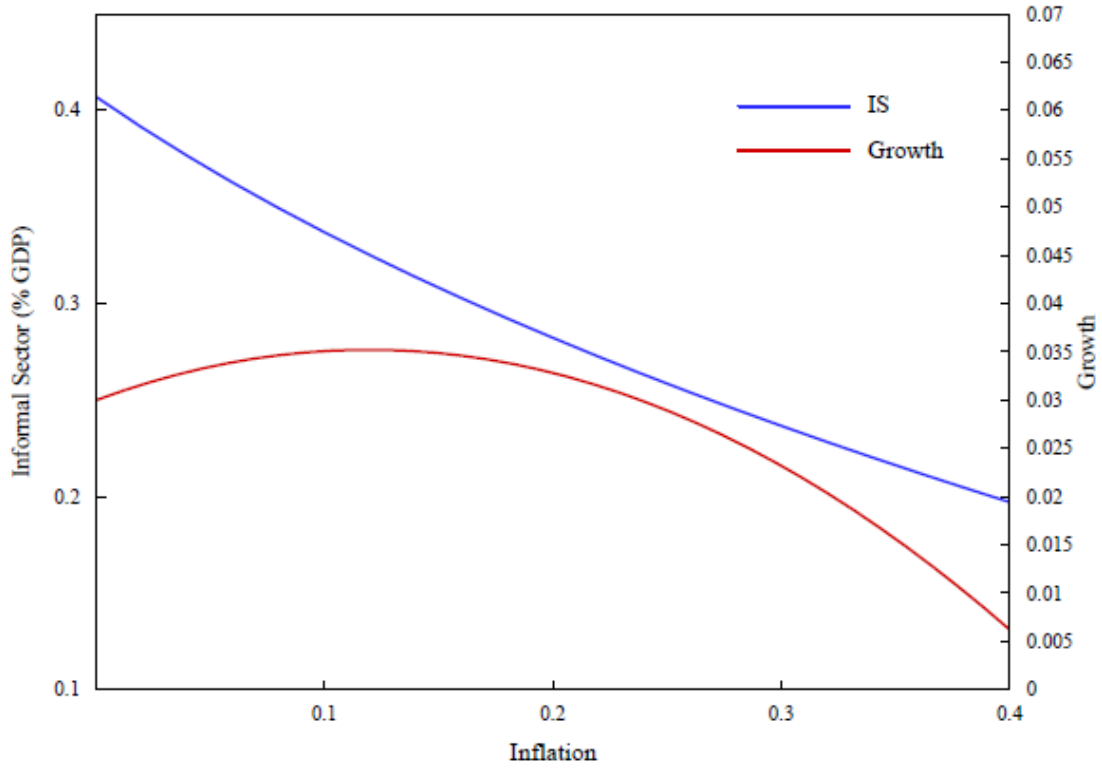

Figure 1: Growth vs. inflation when $\zeta = 1$

[7] 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).

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.

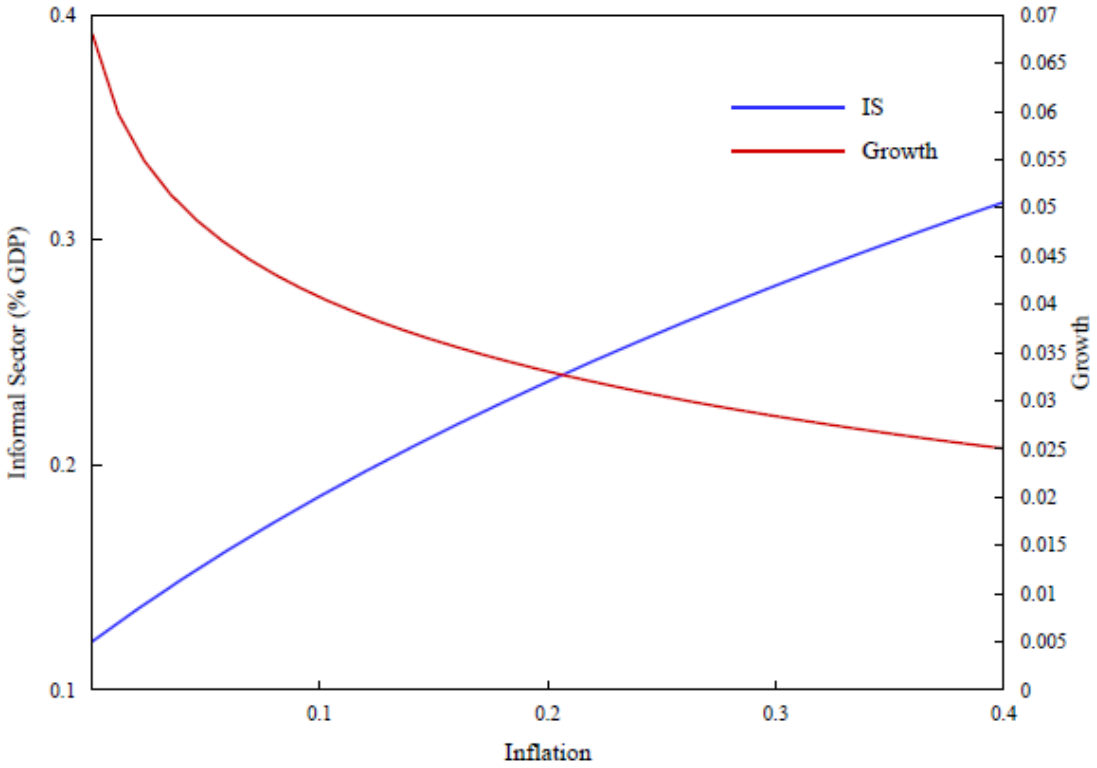

Figure 2: Growth vs. inflation when $\zeta = 0$

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 perfectly subject to the CIA constraint. That is why the inverted-U relationship between growth and inflation still persists in these simulations.

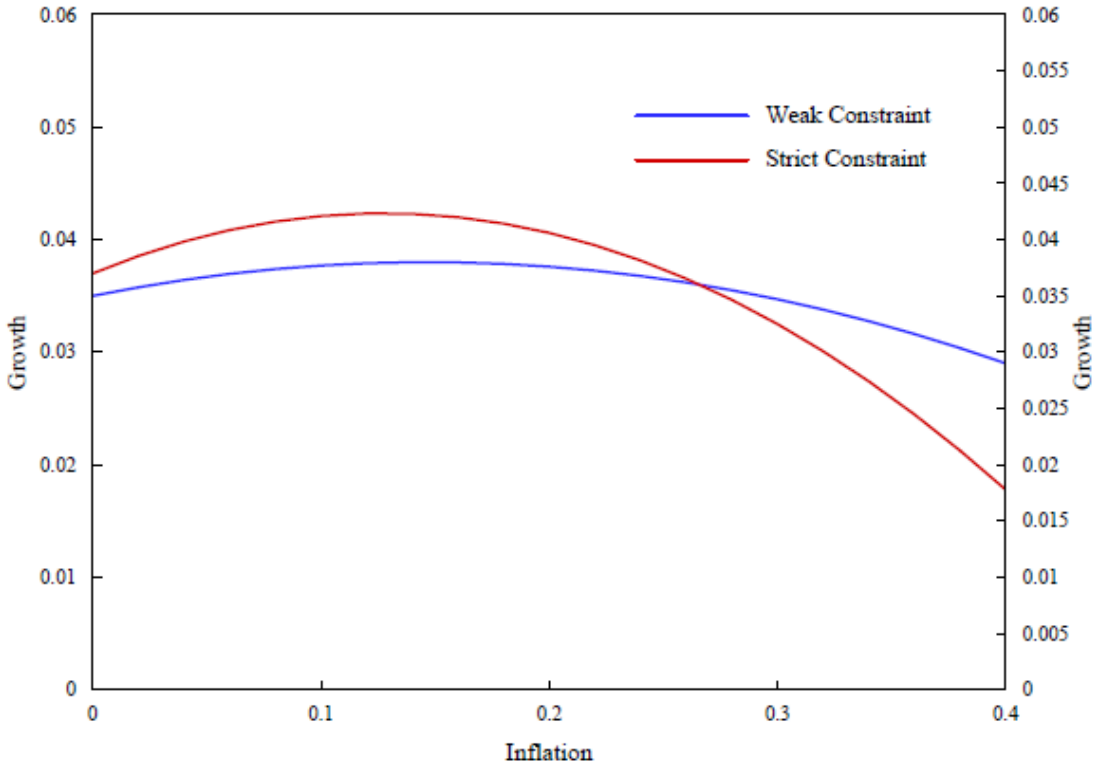

Figure 3: Growth vs. inflation with different values of ψ

In Figure 3, we run two simulations one with ψ =0.35 (denoted by weak constraint) and another one with ψ =0.65. This illustrates that a stricter liquidity constraint on investment expenditures (i.e. less efficient financial markets, a lower degree of financial development), increases the volatility of output growth. On the other hand, in Figure 4, we observe comparative-static results with respect to the tax enforcement parameter ρ. So far, in all the previous simulations we have used ρ=0.03. For Figure 4, we use two more different values for this parameter, one when ρ=0.25 (denoted by low enforcement), and ρ=0.75 (denoted by high enforcement). We observe that a higher degree of tax enforcement increases the range of inflation that might affect growth in a positive way.

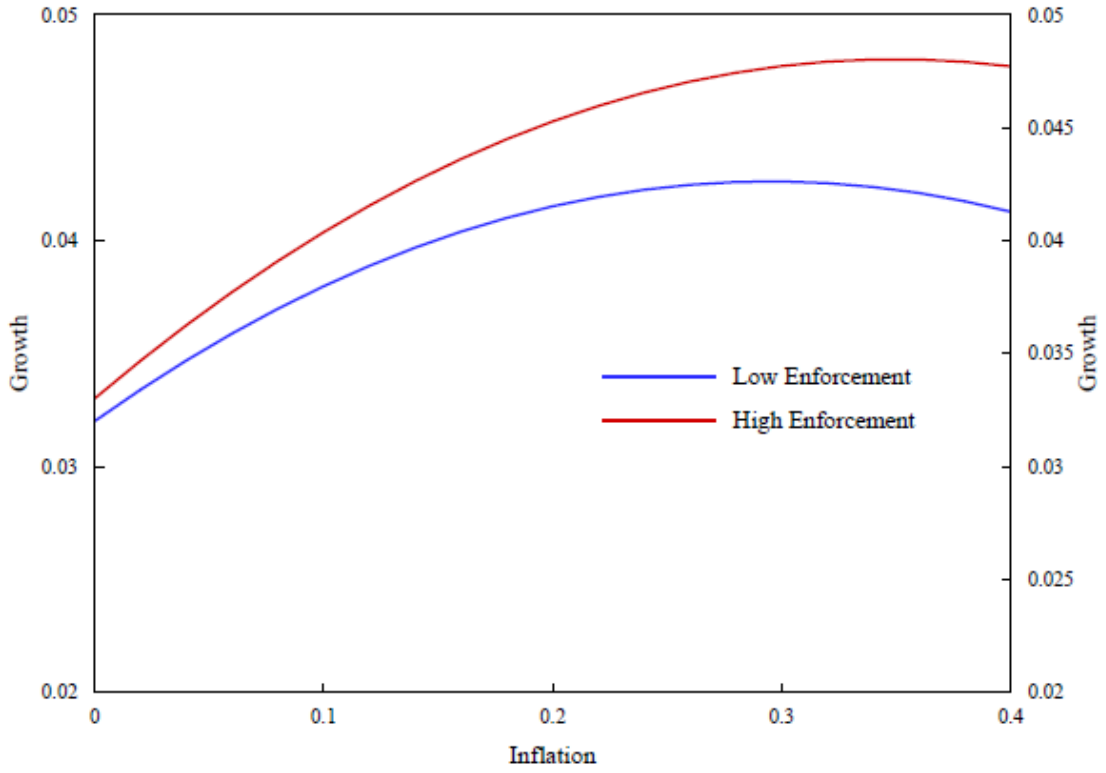

Figure 4: Growth vs. inflation with different values of ρ

CHAPTER 4

EMPIRICAL ANALYSIS

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

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, $Gr_{i,t}$ denotes growth rate of GDP, $\pi_{i,t}$ is the inflation rate and $IS_{i,t}$ is the size of the informal economy as % 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. Finally, $\varepsilon_{i,t}$ denotes the error term.

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.[8] In the dynamic panel data setting we estimate the following equation:

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

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

[8] Further estimations have been conducted to address potential existence of a two-directional causality between informal sector size and measures of financial development. We also run regressions using the IV estimator of Anderson and Hsiao (1982). These are available upon request from the corresponding author.

a positive sign for the estimated coefficient of inflation and negative sign for the estimated coefficient of the squared term.

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 over the period from 1950 to 2009. Considering the length of the time-series dimension we use this dataset for informal economy size.[9] Data for growth of GDP is obtained from the Penn World Tables 7.1 (PWT). We have also constructed inflation series from PWT using the GDP deflator.[10] As for control variables we use, trade openness (defined as the ratio of the sum of exports and imports to GDP), government spending (as % of GDP) and investment expenditures (as % 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 PRS Group. Unfortunately, the institutional quality indices are only available after 1984 and only for 141 countries. Finally, we also use fiscal deficit (% GDP) which we obtained from World Development Indicators. Table 2

[9] 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.

[10] 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.

provides descriptive statistics of all the variables used in the analysis. Moreover, the list of countries used in the analysis are given in the appendix.

Table 2: Complete Dataset Summary Statistics: 1950-2009

	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

Estimation Results

Results for the benchmark estimation with annual data and using the fixed - effect estimator are reported in Table 3. Considering that the estimated coefficient of inflation is negative and that of the interaction term of inflation with informality 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.

Table 3: Growth, Inflation and Informality: FE Estimations with Annual Data

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)	
Inflation^2									-0.12**
									(0.06)
Openness		0.005	0.006***	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	0.04	0.05	0.05	0.10	0.02
Observations	7242	7242	7242	7242	7242	2811	2811	2112	7242
F-Test	14.80	13.45	17.48	6.46	8.93	7.77	7.60	7.62	16.20
Time F-test	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00

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 Table 4, 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 5 we report estimation results obtained with the GMM estimator in the dynamic panel data setting and finally in Table 6 results using the OLS estimator. We observe from these tables that our results are also robust to different econometric specifications.

Table 4: 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)	
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	0.15	0.16	0.17	0.18	0.18	0.18	0.20	0.11
Observations	1366	1366	1366	1366	1366	826	825	816	1366
F-Test	18.25	16.49	15.84	16.71	15.39	14.87	14.01	13.72	18.11
Time F-Test	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00

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.

Table 5: Growth, Inflation and Informality: GMM Estimations with 5-year Averages

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)	
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	0.29	0.30	0.26	0.32	0.33	0.41	0.37	0.40	0.26
AR (2) Test	0.24	0.32	0.28	0.27	0.19	0.21	0.23	0.20	0.24

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.

Table 6: 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)	
$Inflation^2$									-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	0.05	0.06	0.13	0.17	0.19	0.21	0.22	0.03
Observations	1366	1366	1366	1366	1199	826	825	816	1366
F-Test	10.46	10.95	9.91	8.97	10.21	9.77	8.85	8.01	9.87

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.

CHAPTER 5

CONCLUSION

In this paper we studied the growth effects of inflation under the presence of informality. First, we have 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 effect of inflation on growth gets milder under the presence of informality. Moreover, under certain conditions, the effect might be even positive. Moreover, using a cross-country panel data set of 161 countries over the period 1950 - 2009 we also provided strong 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.

APPENDIX

List of Countries in the Empirical Analysis

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Bosnia, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Chile, China, Colombia, Democratic Republic of Congo, Republic of Congo, Costa Rica, Cote Divore, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, 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, Korea Republic, Kuwait, Kyrgyzstan, Latvia, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, 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, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syria, Taiwan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

REFERENCES

Anderson T.W., Hsiao, C. (1982). *Formulation and Estimation of Dynamic Models using Panel Data*, Journal of Econometrics, 18, 67-82.

Arellano M., Bond, S.R. (1991). *Some Specification tests for Panel Data: Monte Carlo Evidence and an Application to Employment Equations*, Review of Economic Studies, 58, 277-298.

Barro, R.J. (1991). *Economic growth in a cross section of countries*, Quarterly Journal of Economics, 106, 407-43.

Barro, R.J. (1995). *Inflation and economic growth*, Bank of England Quarterly Bulletin, 166-76.

Bruno, M. and Easterly, W. (1998). *Inflation crises and long-run growth*. Journal of Monetary Economics, 41, 3-26.

Buehn, A., and F. Schneider. (2012). *Shadow Economies around the World: Novel Insights, Accepted Knowledge, and New Estimates*. International Tax and Public Finance 19, 1, 139-171.

Busato, F. Chiarini, B. (2004). *Market and underground activities in a two-sector dynamic equilibrium model*, Economic Theory, 23(4), 831-861.

Cagan, P. (1958). *The demand for currency relative to the total money supply*, Journal of Political Economy 66 (4), 303-328.

Chari, V.V., Manuelli R.E., Jones, L.E. (1995). *The Growth Effects of Monetary Policy*, Federal Reserve Bank of Minneapolis Quarterly Review, Vol. 19 No.4 18-32.

Chari, V. V., Jones, E. L., Manuelli, R. R. (1996). *Inflation, growth, and financial intermediation*, Proceedings, Federal Reserve Bank of St. Louis, issue May, pages 41-58.

Dotsey, M. and Sarte, P.D. (2000). *Inflation uncertainity and growth in a cash-in-advance economy*, Journal of Monetary Economics, (45), 631-655.

Elgin, C. (2010). *Political Turnover, Taxes and the Shadow Economy*, Working Papers 2010/08, Bogazici University, Department of Economics.

Elgin, C., Oztunali, O. (2012). *Shadow Economies around the World: Model Based Estimates*, Working Papers 2012/05, Bogazici University, Department of Economics.

Elgin, C., Uras, R. B. (2013). *Is Informality a Barrier to Financial Development?*, Forthcoming in Series Journal of the Spanish Economic Association.

Fischer, S. (1991). *Growth, macroeconomics and development*, NBER Macroeconomics Annual 1991, Vol. 6, ed. Olivier Jean Blanchard and Stanley Fischer, pp.329-64. Cambridge, Mass.: MIT Press/National Bureau of Economic Research.

Jones, L. E., Manuelli, R. R. (1995). *Growth and the effects of inflation*, Journal of Economic Dynamics and Control, 19(8), pp. 1405-1428.

Khan, M. S., Senhadji, A. S. (2001). *Threshold Effects in the Relationship between Inflation and Growth*, IMF Staff Papers, 48 (1), 1-21.

Levine, R., Renelt, D. (1992). *A sensitivity analysis of cross-country growth regressions*, American Economic Review 82, 942-63.

McTaggart, D. (1992). *The cost of inflation in Australia*, In: Blundell-Wignall, A. (Ed.), Inflation, Disinflation and Monetary Policy, Reserve Bank of Australia.

Mundell, R. (1963). *Inflation and Real Interest*, Journal of Political Economy 71 (3): 280283.

Tobin, J. (1965). *Money and Economic Growth*, Econometrica 33 (4): 671684.

Ordonez, J.C.L. (2010). *Informal Sector, Productivity and Tax Collection*, MRPA Working Paper.

Rebelo, S. (1991). *Long-run policy analysis and long-run growth*, Journal of Political Economy 99, 500-21.

Roca, J. C. C., Moreno, C. D., Sanchez, J. E.G. (2001). *Underground economy and aggregate fluctuations*, Spanish Economic Review, vol. 3(1), pages 41-53.

Roubini, N., Sala-i Martin, X. (1992). *Financial repression and economic growth*, J Dev Econ, 39 (1), 5-30.

Roubini, N., Sala-i-Martin, X. (1995). *A growth model of inflation, tax evasion, and financial repression*, Journal of Monetary Economics, vol. 35(2), pages 275-301.

Schneider, F., Enste, D.H. (2000). *Shadow Economies: Size, Causes, and Consequences*, J Econ Lit, 38 (1), 77-114.

Schneider, F., Buehn, A., Montenegro, C.E. (2010). *Shadow Economies all over the World*, World Bank Policy Research Working Paper 5356.

Svensson, L. E. O., (1985). *Money and asset prices in a cash-in-advance economy*, Journal of Political Economy 93, 919-944.

Temple, J. (2000). *Inflation and Growth: Stories Short and Tall*, Journal of Economic Surveys 14(4): 397426.

Torgler B., Schneider, F. (2007). *Shadow Economy, Tax Morale, Governance and Institutional Quality: A Panel Analysis*, IZA Discussion Papers, 2563.