Inflation and Structural Reforms in Different Societies (Game Theory Approach)

Central Bank of Armenia

Working Paper 2023/05

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March 2023

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Abstract

The combination of structural reforms and inflation differs across countries. There are many evidences which claim about a trade-off between reforms and inflation. While reforms have their effects in the long run and are costly for government, the latter can get benefits from inflation financing in the short run. Our aim is to find the main driving forces of policies based on which various governments choose different proportions of structural reforms and inflation. We extend Barro and Gordon (1983) framework by introducing reforms into the model and design a non-cooperative game between public and government. The paper shows that the forward lookingness of public could be considered a key driving force of making reforms. Less forward looking public, which appears mostly in developing countries, cannot see the long run benefits of reforms and enjoys short run inflationary results. More forward looking public, contrarily, requires government to make reforms and avoid creating inflation. The paper also simulates a dynamic game, tracing a policy path which enhances the amount of reforms over periods. Conducted reforms, in turn, increase forward lookingness resulting in a loop of amplifying reforms. Thus it is important for developing countries to primarily conduct a policy which involves at least negligible amount of reforms.

JEL classification: C72, C73, D90, H30,
Keywords: Nash equilibrium, noncooperative game, dynamic game, inflation, reform

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The views expressed in this paper are those of the authors and do not necessarily represent the views or policies of the Central Bank of Armenia.

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1 Introduction

Governments around the world conduct different policies regarding choosing proportion of structural reforms and inflation. According to Acemoglu et al. (2001): "...differences in economic institutions are the fundamental cause of cross-country differences in economic growth and prosperity". In advanced countries economic growth mostly stems from previously founded economic institutions and continuously conducted structural reforms. Developing and low income countries, on the other hand, have a weak performance on implemented reforms and rely mora e on inflation.

According to many theoretical and empirical studies, reforms generate gains in the long run, whereas inflation gives short run benefits to the economy. Making reforms is considered costly for the government, as any other economic agent, government dislikes working too. Therefore making reforms brings disutility to the government. Creating surprise inflation in its turn causes short-run expansions in the economic activity and reductions in the real value of the government's nominal liability. Increase in the economic growth due to inflation is explained through expectational Phillips Curve: Unanticipated monetary expansions, reflected as an increase of actual inflation from its expected level increase economic activity for the short run or, equivalently, decrease unemployment rate from its natural level. Moreover, governments also tend to intentionally create surprise inflation, which will result in a devaluation of local currency and the amount owed by the government in that currency. As a result, government's future real expenditures for interest and principal is lowered. In other words, surprise inflation can be considered as a source of revenue for the government. Barro and Gordon (1983) refer to this phenomena as inflationary finance. Thus surprise inflation enters government's utility function with a positive sign, encouraging government to create more inflation and to display short run outcomes. This paper discusses key driving forces stimulating policymakers to choose different combinations of structural reforms and inflation across countries.

The work of Barro and Gordon (1983) is vital for understanding the main incentives of policymakers for doing inflation and the costs regarding with that policy. They discuss two different policies. First one is the discretion, where policymaker optimizes its behavior of setting inflation every period by taking inflationary expectations as given. The second is the policy under a rule, to which policymaker commits. They obtain a reputational equilibrium which is considered the weighted average of those of discretion and ideal rule.

Backus and Driffil (1985) use Barro and Gordon (1983) framework to construct a non-cooperative, one period bi-matrix game and obtain, that policymakers always tend to create inflation. We incorporate structural reforms in that model. As stated by Acemoglu et al. (2005): "...humans themselves decide to organize their societies that determines whether or not they prosper". Thus we consider forward lookingness of the public as a main driving force for conducting reforms. Contrary to inflation which gives rapid results, structural reforms have their effect in the long run. Therefore less forward looking pub-

lic, mostly appearing in emerging countries, appreciates short-run inflationary results and ignore long-run benefits of implemented reforms. More forward looking public, on the other hand, requires government to make reforms and avoid creating inflation. Forward lookingness is introduced with both its exogenous and endogenous natures. The endogenous forward lookingness is modeled as a growing function of structural reforms and is decreasing in inflation. In addition, it is assumed that public has some initial, autonomous forward lookingness, regardless the amount of implemented reforms.

In static model we get the Nash equilibrium where policymaker tends to create inflation and avoids making reforms. As stated in Barro and Gordon (1983) model, policymaker chooses current inflation rate to maximize its payoff function, taking current and future inflationary expectations as given. Later we extend the model into multiple-period dynamic game with endogenous forward lookingness, where we obtain gradual amplification of conducted reforms. The reforms increase forward lookingness in their turn, creating a loop of enhancing reforms. Changes in parameter values result in different equilibria. Particularly higher and lower initial forward lookingness provides small and large amount of reforms, respectively. We also introduce the concept of inflation-resistant public, in which government avoids inflation. The last exercise refers to the independence of the central bank or credibility of government. The main result of that exercise is that even when public is not forward looking, in the case of having highly independent central bank or highly credible government, economy can end up in a good equilibrium (high amount of reforms and low inflation). Paper also does sensitivity analysis in regard to model parameters. Giving range of values to one parameter and fixing the remaining ones around their initial values, we plot reforms and inflation levels and obtain a trade-off between inflation and structural reforms.

Barro and Gordon (1983) also introduces the concepts of temptation to deviate from policy rule and enforcement which act as a pressure on policymaker, restricting him from cheating on rule. We encompass those concepts into our model by introducing structural reforms into it. Temptation is modeled as a difference of government's payoffs which result from conducting discretionary policy and abiding with rule. On the other hand, cheating on the rule is costly as government faces the infamous time inconsistency developed by Kydland and Prescott (1977), according to which "Current decisions of economic agents depend upon expected future policy, and these expectations are not invariant to the plans selected". Thus expectations are modeled in a way to match with discretion in the next period, if government reneges on the rule in the current period. Enforcement is modeled as a present value of difference between government's future payoffs resulting from abiding the rule and cheating on it. We obtain that there is a trade-off between inflation and reforms in the case of some inflation values. In the case of higher level of conducted reforms, government is allowed to create both higher and lower levels of inflation. Meanwhile, low amount of reforms impose policymaker to create higher inflation for the good short-term results.

The paper also compares the model generated results with structural reforms

data constructed by Alesina et al. (2020). Model fits data well for advanced and emerging economies.

The rest of the paper is organised as follows. Section 2 presents the literature review. Section 3 portrays some stylized facts with regard to structural reforms, inflation and forward lookingness. Section 4 presents a simple one period bimatrix game. Section 5 introduces structural reforms with public's forward lookingness in the simple model and solves it for both static and dynamic cases. It also discusses some exercises regarding the game and introduces the concepts of temptation and enforcement. Section 6 checks model's power to fit data for advanced and emerging economies. Section 7 concludes.

2 Literature review

There is a considerable amount of literature which claim about the positive relationship between structural reforms and output growth or economic performance.

Particularly to find the cause of the differences in income per capita among countries, Acemoglu et al. (2001) estimates the impact of institutions on economic performance.

$$\begin{array}{c}\text{Today's}\\ \text{institutions}\end{array} \longleftarrow \begin{array}{c}\text{Early}\\ \text{institutions}\end{array} \longleftarrow \begin{array}{c}\text{European}\\ \text{settlements}\end{array} \longleftarrow \begin{array}{c}\text{Mortality}\\ \text{rate}\end{array}$$

They imply that today's institutions are the results of previous reforms. The latter in turn, have roots going back to the type of European settlements. Based on mortality rate of indigenous people, there were two kinds of colonization policies: extractive and neo-collonism. Thus mortality rate can be used as an instrumental variable for today's reforms.

$$inst = \phi_0 - 0.61 log(mortality) + u$$
$$log(GDP) = \psi_0 + 0.94 \hat{inst} + \varepsilon$$

Using property right index as a measure of reforms, they regress it on mortality rate and obtain a negative relation. Next they estimate the impact of obtained fitted values of that regression on GDP per capita and obtain strong positive relation. Thus institutions are crucial for economic growth.

Abed and Davoodi (2000) assess the relative importance of structural reforms versus corruption in explaining macroeconomic performance in transitory economies. They find out that for the main macroeconomic variables, including GDP growth, structural reforms dominate corruption. By regressing real per capita growth rate on corruption index, structural reform index and other control variables with both cross sectional and panel data, they obtain more positive and significant relation between GDP growth and reforms. Progress in structural reforms reduces corruption. They also calculate direct and indirect (through low corruption) impacts of structural reform on economic performance. The results show that both direct and indirect (and thus total) effect of the re-

forms on real per capita GDP growth rate is positive, with direct result being larger than indirect one.

Lusinyan (2018) studies the impact of structural reforms on the long run GDP growth in Argentina based on production function approach. The growth of the GDP is decomposed into its three supply side channels: capital accumulation, labor utilization, and total factor productivity and for each channel the impact of reforms is estimated. The paper finds, that structural reforms affect long-term GDP growth through all three channels significantly. The largest effect comes through the productivity channel, which is considered the main channel affecting growth by many strudies (Bourles et al (2013); Dabla-Norris et al (2016); Bailliu et al (2016); Égert (2017)). Product market deregulation, in turn, boosts employment (Fiori et al, 2012; Gal and Theising, 2015; Schiantarelli, 2016). Regulation affects investment through price markups and entry costs (Blanchard and Giavazzi (2001); Alesina and others (2005)), cost of adjusting capital stock and the rate of return on capital. Paper later combines the effects from supply channels to derive the total impact on growth. In result, business regulatory environment reform adds 1–1.5% to annual growth of GDP.

Lusinyan (2013) notes potential positive effects of structural reforms on GDP and productivity in Italy. The paper emphasizes that positive relationship between reforms and economic performance can be found especially in the long run (Bouis and Duval (2011); Barnes et al (2013)). In the short run, however, the impact of the reforms can be small or even negative because of adjustment costs, especially in case of job protection and unemployment benefits reforms (Cacciatore et al. (2012)), particularly when these are undertaken in severely depressed economies (Bouis and others (2012)). Paper uses IMF's Global Integrated Monetary and Fiscal model to study impact of reforms in Italy. It is obtained that reforms covering half the gap in product and labor markets with the rest of the euro area and best practice cases in OECD raise real GDP by 5.75% after 5 years and by 10.5% in the long run.

As mentioned above, reforms generate gains in the long run, while making reforms is costly in the short run. Creating surprise inflation, on the other hand, expands economic activity in the short run (Jaganath Behera, 2014). Thus governments create inflation to show short-run results. Surprise inflation also tends to reduce the real value of government's nominal liability. In this way it can be considered as a source of revenue for the government. Barro and Gordon (1983a) refer to this phenomena as inflationary finance. According to them, inflation is evidence of a government that cannot make credible promises. Such governments, optimally inflate to enjoy the short-run benefits of price-level surprises. Depending on which types of agents are best represented in the government (creditors or debtors), either surprise inflation or surprise deflation can provide short-run gains for the government, but it is commonly assumed in the literature that surprise inflation is desirable. The benefits of surprise inflation include temporary increases in output and decreases in real values of government debts.

Barro and Gordon (1983a), and Cukierman, Edwards and Tabellini (1992) argue that government debt or deficit is a potential determinant of the inflation

tax. Because the inflation tax can be used as a direct way to generate seigniorage or reduce the real value of government's debt, governments with larger nominal government debts would be inclined to inflate more.

José Pablo Barquero Romero and Kerry Loaiza Marín (2017) studies the positive relationship between inflation and public debt. The paper uses annual data of 52 countries during 1965-2014 and obtain the following result for net debtor developing countries: The increase of 1 percentage point in the growth rate of debt in the long run leads to the increase in price level by 1-3.5 percentage points.

Reinhart and Rogoff (2010) explore the relation between inflation, government debt and economic growth. They use data of 44 countries for 200 years and obtain, that whereas the link between growth and debt seems relatively weak at "normal" debt levels, median growth rates for countries with public debt over roughly 90 percent of GDP are about one percent lower than otherwise; average (mean) growth rates are several percent lower. They also found that for emerging economies, high public debt levels coincide with higher inflation. Many studies claim that the optimal inflation tax should increase with government spending (Mankiw, 1987, Veigh, 1989, and Poterba and Rotemberg, 1990). Thus government debt can also be interpreted as a type of inflation.

Moreover, in many empirical studies there exists a negative relationship between government debt and economic growth, which also indicates the indirect negative connection of inflation and economic performance (Shuanglin Lin and Kim Sosin (2001), Manmohan S. Kumar and Jaejoon Woo (2010), Bettina Fincke and Alfred Greiner (2013), Hadhek Zouhaier and Mrad Fatma (2014), Vighneswara Swamy (2015), Panagiotis Pegkas (2018)).

This chain of literature suggests the negative relationship between structural reforms and inflation. Particularly, Rajan (2004) studies the link between average inflation tax and average GDP real growth rate for different countries. depending on whether institutional quality (or government effectiveness) is above or below its median, countries are separated into two groups. The paper plots the real growth of a country's GDP, averaged over 1980 to 1995 against average inflation tax over the same period, separately for countries with below median levels of government effectiveness and countries above median. The negative slope is steeper in the former, suggesting that slower growth is correlated with more inflation in countries with weak institutions.

Abed and Davoodi (2000) regress inflation on structural reform index, corruption index and other control variables with both panel and cross sectional analysis. They obtain that Lower corruption and deeper structural reforms are associated with lower inflation. Cross sectional analysis shows that lower inflation is associated with lower government deficit.

If we think of reforms as some sort of educational programs, Stiegert et al (2007) notes the following: "Improving job mediation and raising the workforce's educational attainment tends to reduce bottlenecks in the labour market and helps align wage developments with labour productivity growth, thus lowering potential inflationary pressures. For an analysis, see ECB (2002)".

Jong-Won Yoon et al (2014) obtains negative relationship between inflation

and elderly share of population for 30 OECD countried during 1960-2013 and negative relation between life expectancy and inflation for Japan during the same period. both elderly share and life expectancy can be considered as the proxy of forward lookingness, which in turn affects reforms positively. Thus there is a trade-off between Structural reforms and inflation.

3 Empirical evidence

In this section we present some data about reforms and develop some patterns about reforms across country groups and time. We use comprehensive dataset of Alesina et al. (2020) and give some stylized facts about reforms and its connections with politics. They use data of 90 countries dating back from 1973 to 2014. 29 countries in their set are advanced economies, 50 are emerging economies and 21 are low-income countries.

Overall six indicators have been used to describe the reforms in that countries: domestic finance, capital and current accounts, trade, product markets, and labor markets . These indicators are scaled from zero to one, where higher values represent greater liberalization. Figure 1 shows that overall reforms have been increased throughout the history. As one can see from the graph, advanced economies are more liberalized than emerging ones, which, in turn exceed in liberalization compared to low-income economies.

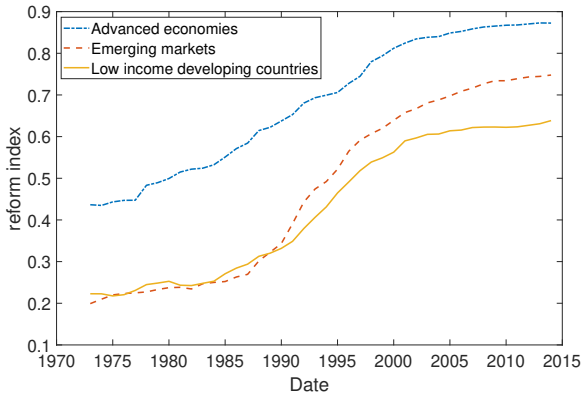

Figure 1: Reform progress across country groups throughout the years. Higher levels denote more liberalization.

Change in reforms index represent the size of reforms in the current period. Figure 2 shows percentage changes in reforms and inflation for advanced economies between 1975 and 2015.

We calculate the average volume of reforms and inflation for the full sample and for different time periods based on three sub-samples. Using those values we also calculate the ratio of average inflation to average reform, which is shown

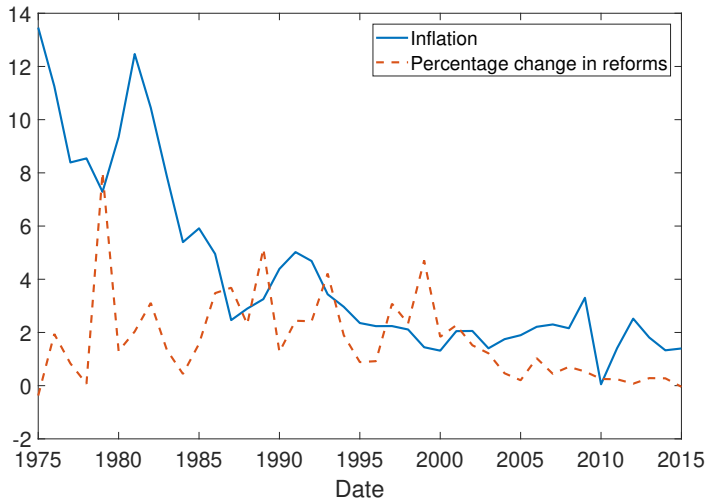

Figure 2: Percentage change in reforms versus inflation for advanced economies between 1975 and 2015.

in Table 1. Particularly, in the case of advanced economies, in a period, when reforms are lower than average, inflation/reforms ratio is higher (2001-2005). In the first sub-sample (1974) higher reforms are parallel with high inflation, which results in a high inflation/reform ratio. On the other hand, second sub-sample (1983-2000) is characterized by the low inflation/reform ratio.

	average reform	average inflation	inflation/reform ratio
Full sample (1974-2015)	1.7	4.2	2.4
1974-1982	2.03	9.8	4.8
1983-2000	2.4	3.2	1.3
2001-2015	0.5	1.8	3.5

Table 1: Average values of inflation and reform and their ratio of advanced economies for different periods

This empiric result can be considered as a representation of opposite movements of inflation and reforms.
The same exercise is done for the emerging economies.

Judging by the graph above, we seclude three different time periods. The first one is low-reform period (1980-1987), the second one is the period, when conducted reforms are the highest (1988-1997) and the modern times, when less reforms are conducted (1998-2014). Average value of reforms and inflation both

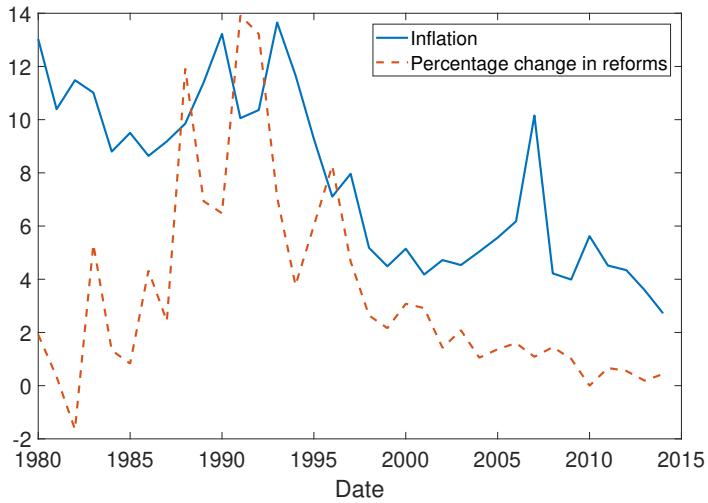

Figure 3: Percentage change in reforms versus inflation for emerging economies between 1980 and 2014.

for full sample and sab-samples, and corresponding ratios of inflation to reform are stored in Table 2.

	average reform	average inflation	inflation/reform ratio
Full sample (1980-2014)	3.4	7.7	2.2
1980-1987	1.8	10.2	5.5
1988-1997	8.2	10.4	1.2
1998-2014	1.3	4.9	3.5

Table 2: Average values of inflation and reform and their ratio of emerging markets for different periods

In a periods of low reforms, inflation/reforms ratio is higher. On the contrary, when reforms are higher than the average, inflation/reforms ratio is lower.

In the case of the low-income countries, the divergence of the movement of inflation of reforms can be seen in Figure 4. As in the previous cases, we separate three time regions: low- reform period (1980-1987), high reform period (1988-2001) and incoming second low-reform period (2002-2014)

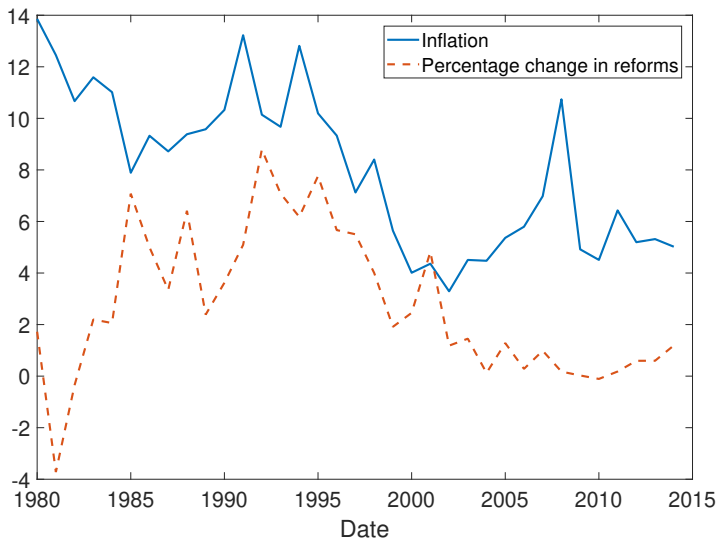

Figure 4: Percentage change in reforms versus inflation for low-income developing countries between 1980 and 2014.

Looking at the graph, we can see that in the case of the low reform periods the government has only one choice to satisfy public, which is creating high inflation. In the case of high reform periods it can cause either high or low inflation, as its options become wider when its credibility increases due to implemented reforms. As reforms exceed their sample average, inflation/reform ratio is becoming lower. When reforms are less than the average value, the above mentioned ratio is higher.

	average reform	average inflation	inflation/reform ratio
Full sample (1980-2014)	2.8	8.1	2.9
1980-1987	2.2	10.7	4.9
1988-2001	5.1	8.9	1.7

Table 3: Average values of inflation and reform and their ratio of low-income developing countries for different periods

These exercises indicate the opposite movements in inflation and reforms

and the trade-off government has to face while choosing between inflation and reforms.

One of the main factors that can affect authorities' decisions about creating inflation is Central bank independence. The latter refers to the absence of government's influence on Central bank to conduct a monetary policy. Politicians tend to pressure monetary authorities to create inflation and ensure short time economic expansion in favour of their own political capital. However this entails in high inflationary costs in the long run in terms of high uncertainty and more decline in output. We match 102 countries' data of inflation and Central bank independence between 1998-2015. [1]

Figure 5: Inflation and the index of central bank independence for 102 countries in the period of 1998-2015

The trend line shows a negative relationship between inflation and central bank independence index. The more independent is the central bank, the more likely it will conduct low inflationary policy. Thus independence of monetary authority is crucial for maintaining stable low inflation. Rather showing short-run results, it is more important to accomplish long-run good economic performance. This can be done by having better institutions.

As suggested by Acemoglu et al (2001), The data of life expectancy throughout the years across different country groups confirm this claim. We see that life expectancy is decreasing based on the economic position of country groups.

[1] The index of central bank independence is obtained from N. Nergiz Dincer & Barry Eichengreen, (2014)

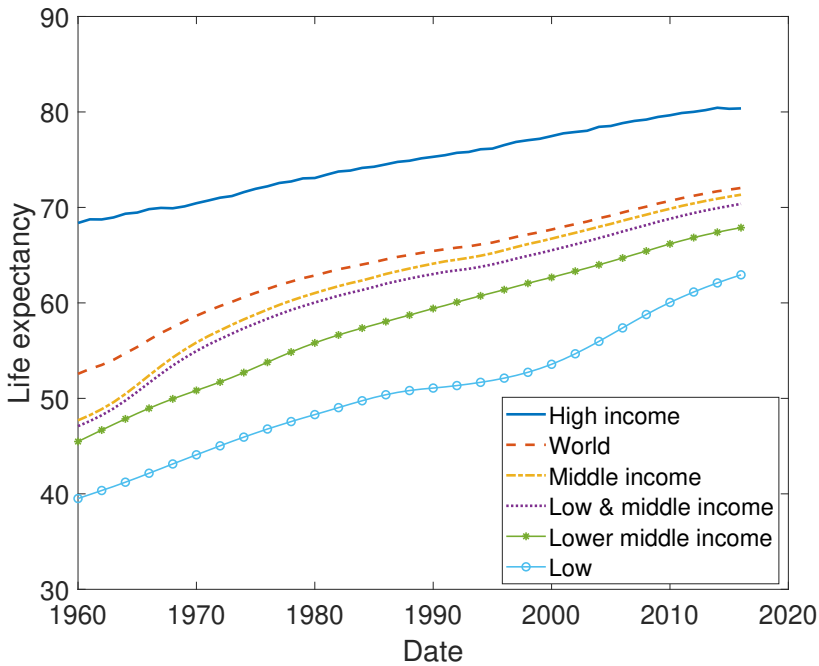

Figure 6: The average number of years a newborn would live if age-specific mortality rates in the current year were to stay the same throughout its life for different country groups from 1960-2016. Source: World Bank

In our model we consider forward lookingness as a proxy of mortality rate. Another interpretation of forward lookingness is the interest rate. From Euler equation we obtain: [2]

$$1 = \beta \frac{C_t^{\sigma}}{C_{t+1}^{\sigma}} \frac{I_t}{\pi_{t+1}}$$

In steady state, the interest rate is represented by the following equation.

$$I = \frac{1}{\beta}$$

Where β is forward lookingness. Thus, nominal interest rate is the inverse of proxy variable for the forward lookingness. Looking at the sample average data of government securities and treasury bills interest rates (IMF), we imply that high-income countries have lower average interest rates throughout the history.

[2] Gali (2008)

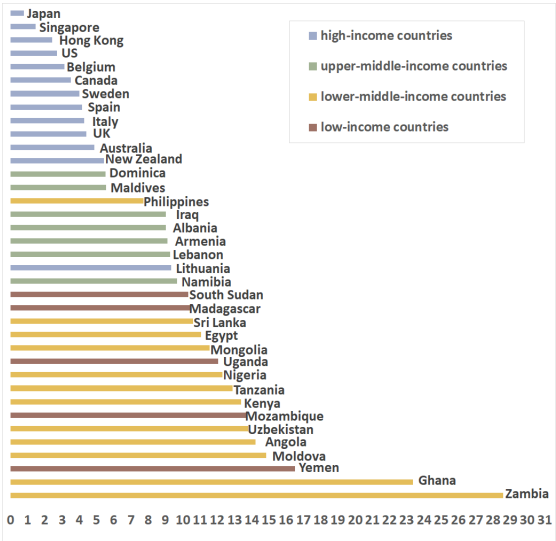

Figure 7: Government securities and treasury bills interest rates percent per annum. Source: International Financial Statistics (IFS)

3

Figure 8 shows, that lower interest rates in some terms can indicate public's higher forward lookingness and therefore country's development level.

4 Simple static model of inflation bias

As in David Backus and John Driffill (1985), this section develops Barro and Gordon (1983) model, which analyses macroeconomic policy and interaction between policymaker and private agents in a game theory approach. Output is determined by an expectational, New classical version of Philips curve:

$$y = y_n + (\pi - \pi^e) \tag{4.0.1}$$

Where y is the output, y_n is the natural level of output, and π and π^e are respectively actual and expected inflation. According to equation (2.0.1), if people form their expectations rationally, the actual output equals the natural rate of output. Unexpected monetary expansion that leads to excess inflation above its anticipated level, increases economic activity and pushes output over its natural level. Surprise inflation also reduces government's liabilities by depreciating the real value of government bonds, which results in a decrease of government's future real expenses for interest and principal. These circumstances give the policymaker an incentive to create an unexpected inflation shocks in the economy. Nevertheless, there are many economic costs regarding with inflation including uncertainty and hence lack of investments, reduction of competitiveness in foreign market and decrease in export due to higher costs, menu costs, shoe

leather costs, income redistribution, decrease of real income and real value of bonds and hence loss of purchasing power, cost of reducing inflation, fiscal drag, etc. Therefore a relatively low and stable level of inflation is more desirable.

The one-period payoff function for the government can be presented as a cost function with opposite sign.

$$\begin{aligned} u_g(\pi, \pi^e) &= -\frac{a}{2}\pi^2 + b(y - y_n) \\ &= -\frac{a}{2}\pi^2 + b(\pi - \pi^e) \end{aligned} \tag{4.0.2}$$

Government's objective reflects public's preferences. Public's payoff function is represented as in Backus and Driffill (1985) given by the following.

$$u_p(\pi, \pi^e) = -(\pi - \pi^e)^2 \tag{4.0.3}$$

We evaluate the payoffs in the case of different policies in the simultaneous, non cooperative game framework. In this game, players choose their actions or strategies simultaneously and without coordination. The combination of their actions determine the values of their payoffs. We consider full information games, where each player's payoff function is apparent for every agent.

We start with analysing the discretionary policy, that is solving the problem case by case. Given inflation expectations, government chooses π level of inflation to maximize its payoff function. the solution is

$$\pi = b/a \tag{4.0.4}$$

With a rational expectations, public solves the maximization problem for government and forms its expectations accordingly

$$\pi^e = b/a \tag{4.0.5}$$

the payoffs in this case are $u_g = -\frac{1}{2}b^2/a$ and $u_p = 0$

This is the Nash solution to the game in which players have no incentive to change their initial strategy. If one player keeps the strategy unchanged, the other one does not improve their condition by deviating from the initial strategy.

Now we consider the case of commitments, when government follows a rule for determining inflation. We have a zero inflation solution with zero payoffs. This case is considered Pareto optimal equilibrium, because neither government, nor public can improve their payoffs without making the other one worse off. The solution to the game is Nash equilibrium, which is Pareto inferior to this solution. As stated in Barro and Gordon (1983), this inefficiency is the result of government's failure to commit itself to noninflationary rule. If government could follow a particular rule for inflation, it would adjust its steps to inflationary expectations and minimize the remaining cost of inflation, $(\frac{a}{2})\pi^2$, will lead to zero inflation solution.

$$\pi = \pi^e = 0$$

However, government faces a temptation to deviate from its rule because of benefits accomplished by surprise inflation. When people expect government not to inflate according to the rule, it motivates government to renege on commitment and gain extra payoffs and higher output. But government fails to convince public to maintain low inflationary expectations, which increases expected inflation above zero. Therefore government's credibility is a central issue. Public should not believe government because the latter is non-credible. If an opportunity to create inflation is given to the government, it will choose to create inflation. With normalization of $a = b = 2$, the game can be illustrated as a payoff matrix given each player's strategies.

		Government	
		$\pi = 0$	$\pi = 1$
Public	$\pi^e = 0$	(0;0)	(-1;1)
	$\pi^e = 1$	(-1;-2)	(0;-1)

Table 4: Bimatrix game of the simple one-period model

Government has two options: avoiding inflation ($\pi = 0$) and creating an inflation ($\pi = 1$). In each case public either does ($\pi^e = 1$) or doesn't expect inflation ($\pi^e = 0$). The matrix cells indicate public's (the first number) and government's (the second number) payoff function's outcome given variable values.
Government maximizes its payoff by rows. It chooses $max(0, 1) = 1$ from the first row and $max(-2, -1) = -1$ from the second row. Thus $x = 1$ happens to be a dominant strategy for the government, which is a course of actions resulting in the highest payoff for the government regardless of public's choice. This fact stimulates public to expect government to inflate. Mathematically, it maximizes it's payoff by columns choosing $max(0, -1) = 0$ from the first column and $max(-1, 0) = 0$ from the second column. In this case public does not have a dominant strategy. The intersection of government's and public's choice courses leads to a Pareto - inferior Nash equilibrium result $\pi = \pi^e = 1$.

5 Introduction of structural reforms into the model

Besides inflation, government has additional tools to stimulate the economy, which are the structural reforms made in the economy. This involves the work efforts and expenditures of government to make more flexible labor market, improve the quality of public taxation systems, encourage innovation and investments, boost the productivity and many other stimulus to the economic growth. A structural reform brings public utility and enters in the payoff function with a positive sign. Public's payoff becomes:

$$u_p(\pi, \pi^e, N) = -(\pi - \pi^e)^2 + dN \tag{5.0.1}$$

Where N are the structural reforms made by government. The coefficient of reforms, d, indicates forward lookingness of the public. The greater d is,

the more forward-looking public becomes and forces government to do more reforms. In contrast to inflation, that gives fast results, structural reforms affect in the long run and less forward looking public can't see its benefits. This is the reason why d is smaller in the case of less forward-looking public. As any economic agent, government receives disutility that stems from working or making reforms. Thus we introduce structural reforms in government's payoff with a negative coefficient. We also insert public's payoff in the government utility function with some weight.

$$u_g(\pi, \pi^e, N) = -0.5a\pi^2 + b(\pi - \pi^e) - cN + eu(p)(\pi, \pi^e, N)) \tag{5.0.2}$$

The coefficient e can be interpreted as a political capital or possibility that government will be elected. It also indicates in what extent government cares about its public and can be called benevolence coefficient. With structural reforms in the model, the payoff matrix of government's and public's utility functions becomes:

		Government			
		$\pi = 0$ N=0	$\pi = 1$ N=0	$\pi = 0$ N=1	$\pi = 1$ N=1
Public	$\pi^e = 0$	u_p(0,0,0) u_g(0,0,0)	u_p(1,0,0) u_g(1,0,0)	u_p(0,0,1) u_g(0,0,1)	u_p(1,0,1) u_g(1,0,1)
	$\pi^e = 1$	u_p(0,1,0) u_g(0,1,0)	u_p(1,1,0) u_g(1,1,0)	u_p(0,1,1) u_g(0,1,1)	u_p(1,1,1) u_g(1,1,1)

Table 5: Tabular representation of the bimatrix one-period game with structural reforms incorporated in it.

Where Government has 4 options, that are combinations of making reforms or not working and creating or avoiding inflation. As in former case, we maximize payoffs for each player and the intersection of each player's choice courses gives a result of Nash equilibrium, which may not be unique and a game can have multiple Nash equilibriums. By changing the forward lookingness of public we consider two cases of calibration

5.1 Solution to the less forward looking public's case

We examine the case of less forward-looking public, which emphasizes inflation by being fascinated with short-term results. The calibration of parameters is:

$$a = 2; \quad b = 2; \quad c = 1; \quad e = 0.9; \quad d = 0.2$$

The lack of public forward lookingness is expressed in a smaller d. In this case the payoff matrix gets the form in Table 6.

By maximizing each column public gets a zigzag course of choice, which excludes the dominant strategy:

- $max(0; -1) = 0$
- $max(-1; 0) = 0$
- $max(0.2; -0.8) = 0.2$
- $max(-0.8; 0.2) = 0.2$

		Government			
		$\pi = 0$ N=0	$\pi = 1$ N=0	$\pi = 0$ N=1	$\pi = 1$ N=1
Public	$\pi^e = 0$	$(0; 0)$	$(-1; 0.1)$	(0.2;-0.82)	$(-0.8; -0.72)$
	$\pi^e = 1$	$(-1; -2.9)$	$(0; -1)$	$(-0.8; -3.72)$	$(0.2; -1.82)$

Table 6: Bimatrix static game with low exogenous forward lookingness

On the other hand, government obtains a dominant strategy of inflating and not making reforms (the second column). The government's choices are:

- $max(0; 0.1; -0.82; -0.72) = 0.1$
- $max(-2.9; -1; -3.72; -1.82) = -1$

In the second column public gets the result of $max(-1, 0) = 0$. Therefore, Nash equilibrium becomes $(-1, 0)$, which corresponds to the case, where government doesn't work and creates inflation and public expects inflation.

5.2 Solution to the more forward looking public's case

Now we turn to more forward looking public's case, in which public emphasizes government's work and makes government do reforms. The parameter d is higher and the acceptance rate of government from public is slightly more essential in this case. The calibration of parameters is presented below:

$$a = 2; \quad b = 2; \quad c = 1; \quad e = 1.1; \quad d = 2$$

Payoff matrix generates the following results.

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	$\pi^e = 0$	$(0; 0)$	$(-1; -0.1)$	$(2; 1.2)$	$(1; 1.1)$
	$\pi^e = 1$	$(-1; -3.1)$	$(0; -1)$	$(1; -1.9)$	$(2; 0.2)$

Table 7: Bimatrix static game with high exogenous forward lookingness and higher benevolence

In this example, both government and public do not have dominant strategies. Public choices are:

- $max(0; -1) = 0$
- $max(-1; 0) = 0$

- $max(2;1) = 2$
- $max(1;2) = 2$

Government choices are:

- $max(0;-0.1;1.2;1.1) = 1.2$
- $max(-3.1;-1;-1.9;0.2) = 0.2$

In this case, both government and public don't have dominant strategies. We get two Nash equilibria: $(2, 1.2)$ and $(2, 0.2)$, The first one corresponds to the case when government avoids inflation and makes reforms. The second one shows the situation, where government creates both inflation and reforms. It is important to note that in both cases government makes reforms, regardless of inflation level.

There is also a case where benevolence coefficient remains the same and the only parameter that changes is forward lookingness. We consider the following calibration:

$$a = 2; \quad b = 2; \quad c = 1; \quad e = 0.9; \quad d = 2$$

The payoff matrix becomes:

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	$\pi^e = 0$	$(0;0)$	$(-1;-0.1)$	$(2;0.8)$	$(1;0.9)$
	$\pi^e = 1$	$(-1;-2.9)$	$(0;-1)$	$(1;-2.1)$	$(2;-0.2)$

Table 8: Bimatrix static game with high exogenous forward lookingness

The equilibrium becomes $(2;-0.2)$, where government makes reforms and creates inflation. To summarize, we can note that when public is less forward looking, it makes government create inflation and government does not work by making reforms. In the case of more forward looking public, government has to make reforms regardless there's inflation or not. Furthermore, if government cares more about public or has higher possibility of being elected, it has wider range of choices of inflation levels. When the election probability is low, its activity is restricted within higher inflation values. When government has little political capital, it wants to show some positive results. Thus government simultaneously creates inflation and makes reforms. In the case of high political capital, government has more options to choose inflation level.

5.3 Endogenous forward lookingness

This section discuses the game process and obtained results, when forward lookingness is modeled as endogenous variable. We model forward lookingness as a

growing function of reforms and decreasing function of inflation. We have collected historical mean data of inflation and its volatility for 194 countries over the world. As one can see in Figure 9, there is a positive correlation between inflation and its volatility. Higher volatility of inflation generates uncertainty in the economy, which in turn makes people short sighted and myopic. Thus, high inflation results in a reduction of people's forward lookingness. Reforms, on the other hand, increase forward lookingness of people.

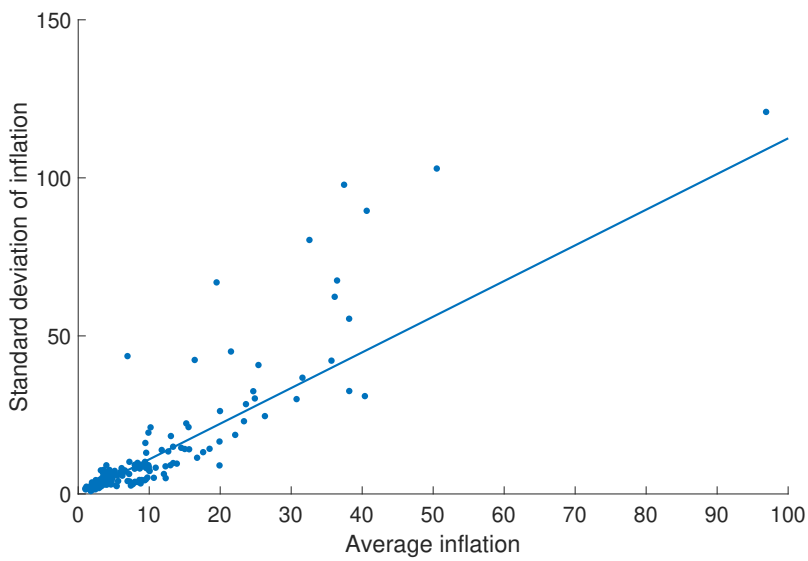

Figure 8: figure 1: Historical average inflation and its volatility of more than 190 countries

The following positive relationship between average inflation and its standard deviation is also consistent for the lower values of inflation (See Appendix A).

We incorporate endogenous forward lookingness in a model using the following equation:

$$d = d_0 - \alpha\pi + \beta N \tag{5.3.1}$$

As a result, public's and government's utility functions get the following forms:

$$u_p = -(\pi - \pi^e)^2 + N[d_0 - \alpha\pi + \beta N] \tag{5.3.2}$$

$$u_g = -0.5a\pi^2 + b(\pi - \pi^e) - cN^\gamma + e[-(\pi - \pi^e)^2 + N(d_0 - \alpha\pi + \beta N)] \tag{5.3.3}$$

We have also included some degree of reforms in the government's utility function. The most convenient and trade-off expressing degree is quadratic form

of reforms. Reform coefficient in government payoff function, c, indicates disutility that government receives from working or making reforms. α and β are respectively the inflation and reform coefficients in forward lookingness function. Differentiating public's payoff function and by writing first order condition, we obtain optimal inflation expectations:

$$u_{p,\pi^e} = 2(\pi - \pi^e) \tag{5.3.4}$$

$$\pi = \pi^e \tag{5.3.5}$$

We also calculate derivative of government's payoff function with respect to inflation and reforms.

$$u_{g,\pi} = -a\pi + b - \alpha N e \tag{5.3.6}$$

$$u_{g,N} = -c\gamma N^{\gamma-1} + ed_0 - \alpha\pi e + 2e\beta N \tag{5.3.7}$$

And the first order conditions become:

$$\pi = \frac{b - \alpha N e}{a} \tag{5.3.8}$$

$$0 = -c\gamma N^{\gamma-1} + d_0 e - \alpha\left[\frac{b - \alpha N e}{a}\right]e + 2e\beta N \tag{5.3.9}$$

Where reforms are being presented by parameters of the model, and inflation is a decreasing function of reforms. The latter fact emphasizes the trade-off between inflation and reforms. With the specification of $\gamma = 2$, we have the following form of reforms:

$$N = \frac{1}{\frac{\alpha^2 e^2}{a} + 2e\beta - 2c}\left[\frac{\alpha b e}{a} - d_0 e\right] \tag{5.3.10}$$

We use the following calibration:

$$a = 1.6; \quad b = 1.2; \quad c = 0.5; \quad d = 0.7; \quad e = 0.9; \quad \alpha = 0.6; \quad \beta = 0.4$$

We give range of values to the parameters around their initial values and plot reforms and inflation against particular value range of parameter given fixed values of other parameters. We see descriptive trade-off between reforms and inflation in the case of different parameter values (see Appendix B). Particularly, we see that high credibility leads to the decline of inflation and increase in reforms (Figure 14) as the higher credibility has government among public, the more probably it will conduct reforms and decrease inflation. Higher gains from inflation, on the other hand, cause low reforms and high inflation (Figure 15). Likewise, when government gets higher disutility from reforms, it makes low amount of reforms, rather creates higher inflation (Figure 16). Next is the initial forward lookingness. Higher forward looking public makes government do little inflation and high amount of reforms. Thus higher forward lookingness of society entails in high reforms and low inflation (Figure 17). Benevolence of government also contributes to making higher reforms. When government cares more about the public, it makes high reforms and avoids from creating high inflation (Figure 18).

5.4 Static game

In this section we take a particular value from our given range of values for parameters. Particularly, using calibration above, we build a static game and obtain payoff matrix represented in Table 9.

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	π^e=0	(0;0)	(-1;-0.5)	(1.1;-0.4)	(-0.5;-0.5)
	$x^e = 1$	(-1;-2.1)	(0;-0.8)	(0.1;-1.6)	(0.5;-0.8)

Table 9: Static bimatrix game with endogenous forward lookingness

There are two equilibria. In the first equilibrium, government doesn't make reforms and creates inflation and public anticipates inflation, while in the second one government does totally opposite, it avoids inflation and makes reforms, and public does not expect inflation.

5.5 Some exercises of the static game

5.5.1 Equilibrium under different levels of initial forward lookingness

In this section we present some basic exercises of the static game. We fix the parameter values with the following calibration:

$$a = 1.6; \quad b = 1.2; \quad c = 0.5; \quad e = 0.9; \quad \alpha = 0.6; \quad \beta = 0.4$$

Then we fluctuate the value of initial forward lookingness at three different levels and obtain equilibria in each case.

1. The case with the low initial forward looking public: $d_0 = 0.1$

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	π^e=0	(0;0)	(-1;-0.5)	(0.5;-0.05)	(-1.1;-1.09)
	$x^e = 1$	(-1;-2.1)	(0;-0.8)	(-0.5;-2.1)	(-0.1;-1.3)

Table 10: Payoff matrix for static game with low initial forward lookingness

In this case we obtain two equilibria. In the first one government avoids inflation and does not make any reform, and public does not anticipate inflation. In the second equilibrium government creates inflation and does not make reforms and public expects inflation. In both cases we get no reforms because of the low forward lookingness of public.

2. The case with the medium initial forward looking public: $d_0 = 0.5$

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	π^e=0	(0;0)	(-1;-0.5)	(0.9;0.3)	(-0.73;-0.7)
	$x^e = 1$	(-1;-2.1)	(0;-0.8)	(-0.1;-1.7)	(0.3;-1.03)

Table 11: Payoff matrix for static game with medium initial forward lookingness

In the case of medium initial forward lookingness equilibrium move to the transmission phase, where two kinds of opposite cases emerge: government creates inflation and public anticipates that, which forces government not to make any reforms. And the second case is when government avoids inflation and public does not expect any inflation and government works or does some reforms.

3. The case with the high forward looking public: $d_0 = 0.9$

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	π^e=0	(0;0)	(-1;-0.5)	(1.3;0.6)	(-0.3;-0.37)
	$x^e = 1$	(-1;-2.1)	(0;-0.8)	(0.3;-1.4)	(0.7;-0.6)

Table 12: Payoff matrix for static game with high initial forward lookingness

In the last case, where public has high forward lookingness, the equilibria are being emerged in the cases, where government makes reforms, regardless of inflation level.

5.5.2 Solution to inflation-resistant public's case

In this case public hates inflation. It is introduced into the model with inflation having a certain coefficient in public's payoff function. In particular, public's payoff function becomes:

$$u_p = -(2.5\pi - \pi^e)^2 + dN \tag{5.5.1}$$
$$d = d_0 - \alpha\pi + \beta N$$

We use the following calibration:

$$a = 1.6 \quad b = 1.2 \quad c = 0.5 \quad d_0 = 0.7 \quad e = 0.9 \quad \alpha = 0.6 \quad \beta = 0.4$$

The payoff matrix gets the following output:

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	π^e=0	(0;0)	(-6.2;-5.2)	(1.1;0.4)	(-5.7;-5.2)
	$x^e = 1$	(-1;-2.1)	(-2.2;-2.8)	(0.1;-1.6)	(-1.7;-2.8)

Table 13: Payoff matrix for static game where public resists inflation

In this particular case we obtain a single equilibrium, where government avoids creating inflation and public does not expect any inflation. As a result, this kind of public requires government to make reforms.

5.5.3 Solution to inflation-resistant and less forward looking public's case

We consider the previous situation with the additional assumption of less forward looking public. We give the following calibration to the parameters of the model:

$$a = 1.6 \quad b = 1.2 \quad c = 0.5 \quad d_0 = 0.1 \quad e = 0.9 \quad \alpha = 0.6 \quad \beta = 0.4$$

The obtained results are presented in Table 14:

		Government			
		$\pi = 0$ $N = 0$	$\pi = 1$ $N = 0$	$\pi = 0$ $N = 1$	$\pi = 1$ $N = 1$
Public	π^e=0	(0;0)	(-6.2;-5.2)	(0.5;-0.05)	(-6.3;-5.8)
	$x^e = 1$	(-1;-2.1)	(-2.2;-2.8)	(-0.5;-2.1)	(-2.3;-3.4)

Table 14: Payoff matrix for static game where public is both inflation resistant and less forward looking

The equilibrium is shifted to the case, where government does not make any inflation or reforms, and public does not have inflationary expectations. The absence of reforms derives from the low initial forward lookingness, and the non existent inflation is the result of public's resistance towards the inflation.

5.5.4 Independence of Central bank

We use the following calibration of the parameters:

$$b = 1.2 \quad c = 0.5 \quad e = 0.9 \quad \alpha = 0.6 \quad \beta = 0.4$$

By fixing initial forward lookingness at a certain level and changing the values of central bank's independence, we get different results which are captured in table 15.

d=0.2			
	π	π^e	N
$a < 0.52$	1	1	0
$0.52 \geq a \leq 4.12$	1	1	0
	0	0	1
$a > 4.12$	0	0	1
d=2			
	π	π^e	N
$a < 3.12$	0	0	1
	1	1	1
$a \geq 3.12$	0	0	1

Table 15: Equilibrium results in for different values of central bank independence and public's forward lookingness

We obtain that in the case of low forward lookingness, when the central bank has a low independence, government tends to create inflation and avoids working. In the case of average values of independence, economy falls into transmission phase and two opposite equilibria emerge: the equilibrium that emerges in the previous case and the new equilibrium, where government avoids creating inflation and does some reforms. In the case of highly independent central bank, we move towards the equilibrium, where government does not cause inflation and makes reforms. Thus when public's forward lookingness is low, the only way to make reforms and have low inflation in the economy is to have a highly independent central bank.

In the case of high forward looking public, we have two main results. First, when central bank has low independence, government can either cause inflation or avoid making inflation. As the independence of central bank rises, we move towards the equilibrium, where government has only one option, that is to avoid making inflation. This result is in line with the existing literature, which claim the negative relationship between inflation rate and central bank independence (Banaian, Laney, and Willett (1983), Alesina (1988, 1989), Grilli, Masciandaro, and Tabellini (1991) , Cukierman (1992), Fratianni and Huang (1992), Alesina and Summers (1993)). In all these cases we see that government has to make reforms, which is the outcome of high initial forward lookingness of the public.

5.6 Temptation and Enforcement

We have introduced two main policies for policymaker so far: discretion and the rules (commitment). Under discretion policymaker chooses current level of inflation by maximizing its payoff in every period while treating inflationary expectations as given. Under discretion we obtain Nash equilibrium, which is not optimal one. Under the commitment it relates its instrument to the state of the economy by creating time path for our target variable, inflation, and sticks to it. Under the rules we get Pareto optimal equilibrium, which is zero inflation solution. However, as noted above, government drifts from its rule because of being unable to committing itself to noninflationary policy. It is tempting for government to create inflation in the absence of inflationary expectations and thus getting extra benefits in terms of higher payoffs. But we have assumed that public forms its expectations rationally and in the case of discretion government fails to convince public about sticking to credible rule. Public solves government's payoff maximization problem and expects as much inflation as government creates.

Now let's assume, that government somehow has been successful in making public form zero (or low) inflationary expectations. For example government can achieve that result by sticking to the zero or low inflationary rule for a certain period. Thus in the absence of inflationary expectations government is being temped to deviate from the rule and create inflation according to discretion. This gives the government extra payoffs, which can be a temptation for it.

This paper models temptation as a difference of payoffs between cheating when people anticipate the rule and abiding the rule.

$$Temptation = \hat{u_g}(\hat{\pi}, \pi^e = 0, \hat{N}) - u_g^*(\pi, \pi^e = 0, N) \tag{5.6.1}$$

Where $\hat{u}_g$ is government's payoff in the case of cheating, when people anticipate the rule, u_g^* is the payoff of government when it abides the rule. $\hat{N}$ is reform's level achieved at discretion and is a function of parameters of the model given by (3.3.10) equation. By inserting corresponding expressions for utilities in each case, we obtain:

$$\begin{aligned} \hat{u_g}(\hat{\pi}, \pi^e = 0, \hat{N}) - u_g^*(\pi, \pi^e = 0, N) = \\ = -0.5a\hat{\pi}^2 + b\hat{\pi} - c\hat{N}^\gamma + e[-\hat{\pi}^2 + \hat{N}(d_0 - \alpha\hat{\pi} + \beta\hat{N}] \\ -[-0.5a\pi^2 + b\pi - cN^\gamma + e[(-\pi^2) + N(d_0 - \alpha\pi + \beta N)]] \end{aligned} \tag{5.6.2}$$

However, as discussed above, there is a cost for doing discretion for government. We can refer to it as a decrease in credibility of government or loss in public's trust towards government's policy. This cost may force government to deviate from the rule as little as possible. We make some initial assumptions. As in Barro and Gordon (1983), if previous inflation meets the expectations, public anticipates the rule in current period. If it departs from expectations,

people form their current expectations based on discretion:

$$\pi_t^e = \pi_t^* \quad if \quad \pi_{t-1} = \pi_{t-1}^e$$
$$\pi_t^e = \hat{\pi}_t \quad if \quad \pi_{t-1} \neq \pi_{t-1}^e$$

We model enforcement (or punishment by public) as a current value of the difference of payoffs between abiding the rule and cheating in the next period.

$$Enforcement = E[q(u_g^*(\pi^* = \pi^e = \pi, N) - \hat{u}_g(\hat{\pi} = \pi^e, \hat{N}))] \tag{5.6.3}$$

By inserting corresponding equations, we get the following result:

$$\begin{aligned} &E[q(u_g^*(\pi^* = \pi^e = \pi, N) - \hat{u}_g(\hat{\pi} = \pi^e, \hat{N}))] \\ &= q(-0.5a\pi^2 - cN^\gamma + eN(d_0 - \alpha\pi + \beta N) \\ &-[-0.5a\hat{\pi}^2 - c\hat{N}^\gamma + e\hat{N}(d_0 - \alpha\hat{\pi} + \beta\hat{N})]) \end{aligned} \tag{5.6.4}$$

Where π^* and $N^* = N$ are inflation and reform values in the case of commitment or a particular rule. $\hat{\pi}$ and $\hat{N}$ are the values under discretion, given by (3.3.8) and (3.3.10) equations.

In order to analyse the sensitivity of temptation and enforcement to inflation and reforms, we give the following calibration to the parameters of the model and plot the 3D graphs of temptation and enforcement with respect to inflation and reforms

$$a = 1.6 \quad b = 1.2 \quad c = 0.5 \quad d_0 = 0.7 \quad e = 0.1 \quad \alpha = 0.6 \quad \beta = 0.4 \quad q = 0.96$$

The graphs are presented in Appendix C. The obtained results are in line with those of Barro and Gordon (1982). Temptation is decreasing with the increase of inflation. Because the higher inflation is indicated by the rule, the lower is the extra payoff obtained under discretion. Looking from the side of reforms, we see that temptation is increasing with reforms, which also indicates trade-off between reforms and inflation. As the rule requires higher reforms, government's temptation to renege from that rule rises. Judging from the overall look, temptation is considered as a convex function with respect to inflation and reforms. As rule indicates higher inflation, both temptation to cheat and punishment for it decrease. Thus enforcement decreases with the inflation as well. As in Barro and Gordon (1983), we got enforcement functions as a concave one and decreasing with inflation. Enforcement is decreasing with reforms as well with the negligible amount. The following two graphs (Figure 10 and Figure 11) capture the interaction of temptation and enforcement.

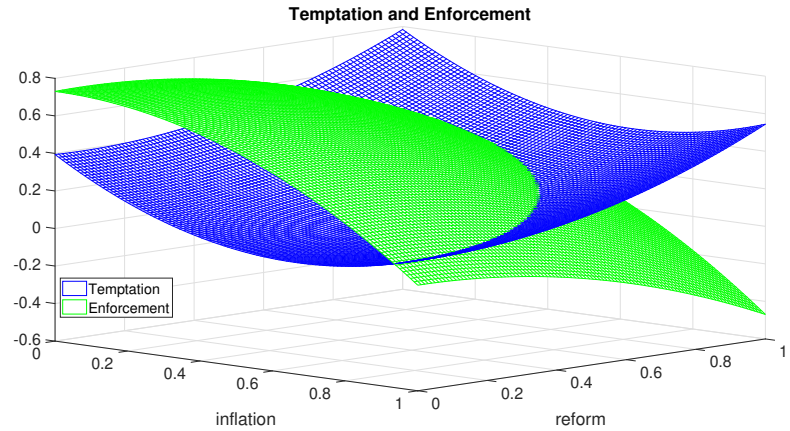

Figure 9: Graphical representation of the interaction between Temptation and Enforcement

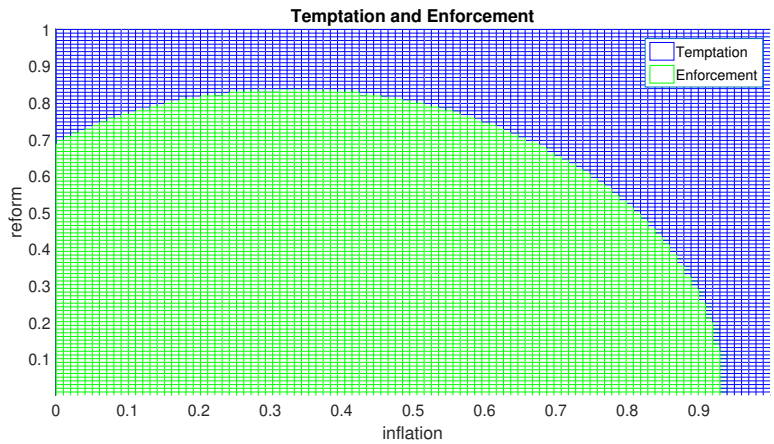

Figure 10: The Interaction of Temptation and Enforcement: look from the above

We can confirm two primary results:

1. There is a trade-off between inflation and reforms in the case of 0.3 or higher values of inflation

2. At higher reform values government is able to make higher and lower inflation. Otherwise, it has to create higher inflation to show some good results to the public.

5.7 Dynamic game

In this section we extend the analysis to dynamic game with multiple periods. We consider multiple iterations. This game has not only full but also perfect information, which means that in each step the players know the the full history of previous actions. We assume there are multiple stages for government for choosing between reforms and inflation. Particularly we set three values for each player's tools. We assume that government has 3 steps for inflation and reforms, whose combinations are government's options:

$$N = 0.1, \quad 0.55, \quad 1$$
$$\pi = 0.1, \quad 0.55, \quad 1$$

Government's payoff function has the form:

$$u_{g_i} = -0.5a\pi^2 + b(\pi - \pi^e) - cN + eu_{p_i}(\pi, \pi^e, N, d_i) \tag{5.7.1}$$

Public has 3 options for inflation expectations:

$$\pi^e = 0.1, \quad 0.55, \quad 1$$

Public's payoff function is therefore given by the following:

$$u_{p_i} = -(\pi - \pi^e)^2 + N(d_0 - \alpha\pi_i + \beta N_i) \tag{5.7.2}$$

Where π_i and N_i are inflation's and reform's chosen level at i^{th} iteration.

On each step the participants decide their actions, which have their influence on the forward lookingness. Thus we model the forward lookingness as an endogenous variable which changes per iteration. It is assumed that public's forward lookingness is increasing with the amount of conducted reforms and decreasing with created inflation. Moreover, public has some amount of initial forward lookingness, which is autonomous and doesn't depend on the level of reforms and inflation. We imply the same equation for forward lookingness as in static game:

$$d = d_0 - \alpha\pi + \beta N$$

We give the following calibration to the parameters of the model:

$$a = 1.6 \quad b = 1.2 \quad c = 0.5 \quad e = 0.9 \quad d_0 = 0.3 \quad \alpha = 0.3 \quad \beta = 0.5$$

As a repetition of one-period static game, dynamic game can be run for multiple iterations. Particularly here we run the game for three iterations and present the results with each step.

1.

$$\pi = 0.55, \quad N = 0.1$$
$$\pi = 1, \quad N = 0.1$$

2.

$$\pi = 0.55, \quad N = 0.55$$
$$\pi = 1, \quad N = 0.55$$

3.

$$\pi = 0.55, \quad N = 1$$
$$\pi = 1, \quad N = 1$$

In each iteration we obtain two Nash equilibrium. In the first iteration government makes small amount of reforms. Little amount of reforms raises public's forward lookingness. In the next iteration government increases the amount of reform til average level. In the final step government reaches the highest amount of reform. In all these iterations they create moderate or high inflation, which is based on many parameters of the model, including the independence of Central bank and government's benevolence. In each iteration the value of forward lookingness raises as a result of the increase in the amount of reforms.

6 Fitting data to the model

This section discusses the ability of model to fit data on reforms for advanced and emerging economies. We use Alesina et al. (2020)'s comprehensive reform database, which includes data of 90 advanced and emerging economies from 1973 to 2014. We compare that dataset with a dynamic model generated reform values. Data on natural interest rates for advanced economies are collected using Laubach-Williams (2003) method. We also use data for life expectancy from the World Bank for emerging economies. The following subsections present the comparison of actual data with the values of reforms and forward lookingness obtained by model simulations for advanced and emerging economies.

6.1 Advanced economies

Combining the data of reforms from Alesina et al. (2020) with the values of reforms generated from the simulations of dynamic game, we see that simulation results are in line with actual data of reforms. Dynamic model generates reform data close to Alesina et al. (2020) for advanced economies. Next we try to compare forward lookingness series generated by dynamic model with actual data of its inverse proxy, which is natural interest rate. We see that model generated forward lookingness is highly negatively correlated with natural interest rate of advanced economies calculated with the method proposed by Laubach and Williams (2003)

6.2 Emerging economies

This subsection discusses the comparison of model generated reform series with the reform data of emerging economies, which is presented in Figure 13. Dynamic model generates reform data close to Alesina et al. (2020) for emerging economies. We use data of life expectancy as a proxy for forward lookingness and compare them. Path of model generated forward lookingness is close to life

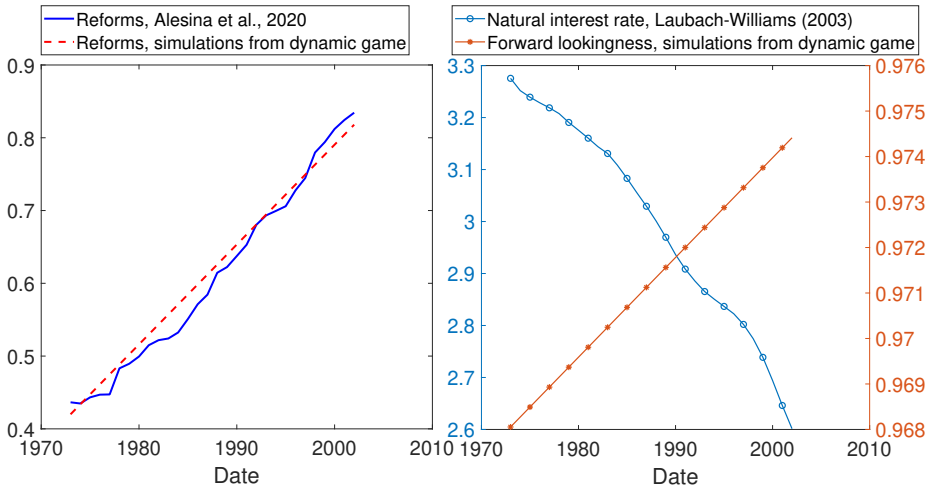

Figure 1: Fitting data to model simulations for advanced economies

expectancy of emerging economies. As a result, we conclude that model is quite powerful to fit the data on reforms for both advanced and emerging economies.

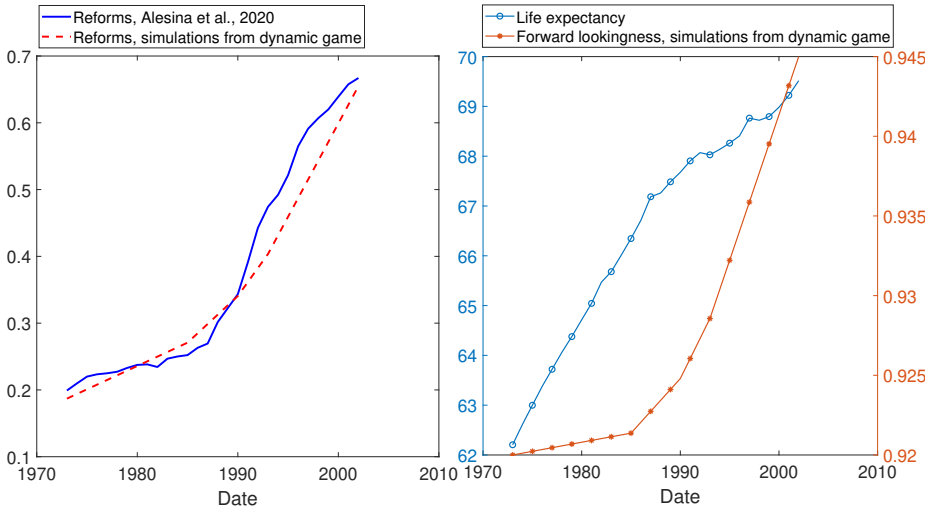

Figure 2: Fitting data to model simulations for emerging economies

7 Conclusion

This paper integrates policy analysis of creating inflation versus making reforms in the game theory framework. We use Barro and Gordon's (1983) model and Backus and Driffil's approach to build a simple one-period bi-matrix game of two players: government and public. Each player has a payoff which is a function of actual and expected inflation. The obtained Nash equilibrium, which is inferior to Pareto optimum, implies that government will create inflation. We develop our model by introducing structural reforms and public's forward lookingness in the game. While reforms are assumed to be beneficial to public, they bring disutility to government. At first, forward lookingness is introduced as an exogenous variable and based on its two different values we solve two typical problems. Then we endogenize forward lookingness by presenting it as a function of its initial value, inflation and reforms. We run the static game and obtain two different Nash equilibria.

Thereafter we do some exercises regarding with endogenous forward lookingness in the static game. Particularly, in the first exercise we give different values to the initial forward lookingness and obtain a result, in which higher initial forward lookingness is associated with avoiding inflation and creating reforms. In the next exercise we introduce inflation-resistant public which tries to minimise inflation in its payoff function. For both less and more forward looking public we obtain zero (or negligible amount of) inflation in this case, and the amount of reforms depend on the magnitude of forward lookingness. The last exercise is concerned with the coefficient of central bank's independence. There is a quite negative relationship between central bank's independence and inflation level for the most countries in the world. Thus increasing the independence of monetary authorities by huge amount we get the result in which government conducts structural reforms and avoids inflation even in the case of low forward looking public.

Moreover, additional exercises are done regarding with temptation of creating inflation and its punishment by incorporating reforms in it. Temptation is modeled as a deviation of government's payoff coming from discretion from sticking to a rule. Enforcement refers to the punishment which prevents authorities from creating high inflation. It is modeled as a present value of the differences in government's payoffs in the next periods between deviation from the rule and sticking to rule. By cheating on rule, government suffers loses in terms of credibility. The obtained results are in line with those of Barro and Gordon (1983). Temptation decreases with inflation, as sticking with rule becomes easier. Thus punishment declines as well with the increase of inflation. We extend this exercise by inserting structural reforms in it. As expected, temptation increases with the increase of reforms, as the latter brings disutility to government and motivates to renege on rule. However, enforcement decreases with the increase of reforms.

Next we extend the model to the case of multiple period dynamic model, where we obtain the set of equilibria, that starts with negligible amount of reforms and reaches to high amount of reforms throughout the periods. We

also do some sensitivity analysis with respect to model parameters. By fixing one of the parameters and giving others a range of values we obtain a trade-off between inflation and reforms.

Lastly, we check data fit of our model. By comparing model simulations to reform data obtained from Alesina et al. (2020), we show that our model fits data on reforms of advanced and emerging economies quite well. The comparison of natural interest rate and life expectancy data with model generated simulation values for forward lookingness allows to consider them as inverse proxy and proxy for the forward lookingness respectively.

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8 Appendix

8.1 Appendix A. The relationship between average inflation and its standard deviation

This appendix introduces the positive relationship between inflation and its standard deviation for lower values of inflation.

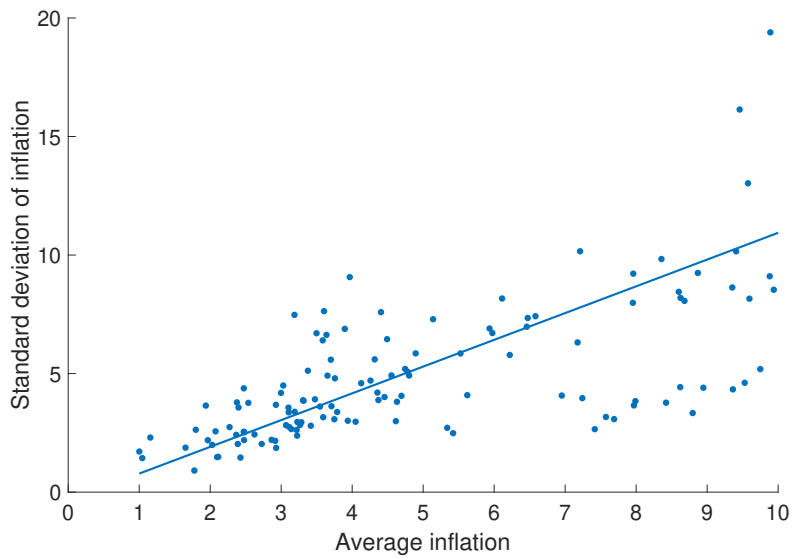

Figure 3: average inflation and its volatility up to 10 maximum inflation value

8.2 Appendix B. Inflation and Reform graphs against parameters

This appendix shows the graphs of inflation and reforms against model parameters. We consider the following calibration:

$$a = 1.6; \quad b = 1.2; \quad c = 0.5; \quad d = 0.7; \quad e = 0.9; \quad \alpha = 0.6; \quad \beta = 0.4$$

This calibration is compiled in a way to emphasize the trade-off between making reforms and creating inflation. We plot inflation's and reforms' graphs against value range of a particular parameter around its given calibration, while holding the rest of the parameters fixed at given calibration values. Here are the results.

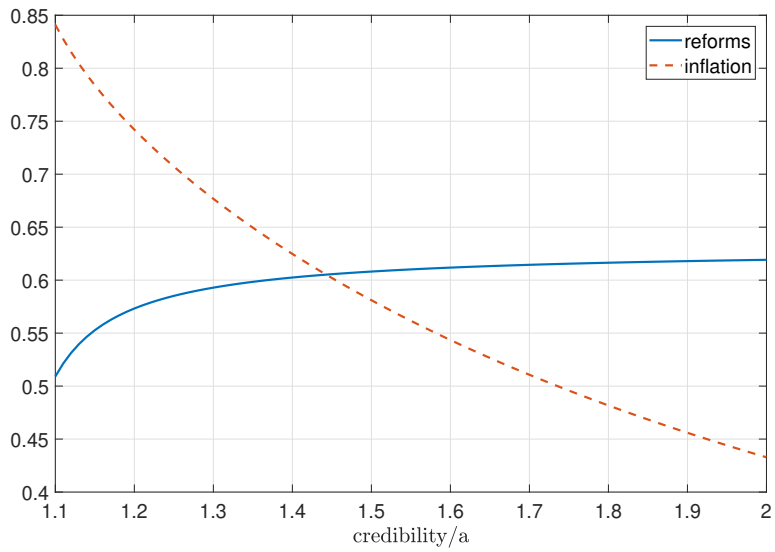

Figure 4: Reforms & Inflation with respect to credibility

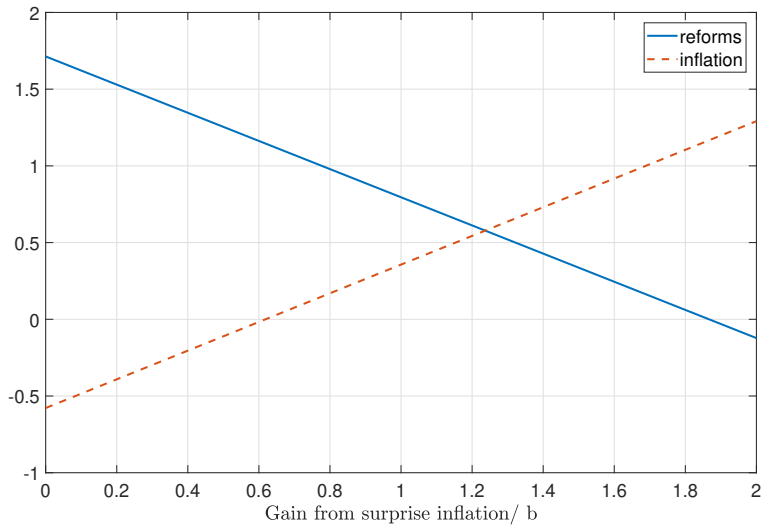

Figure 5: Reforms & Inflation with respect to surprise inflation gain

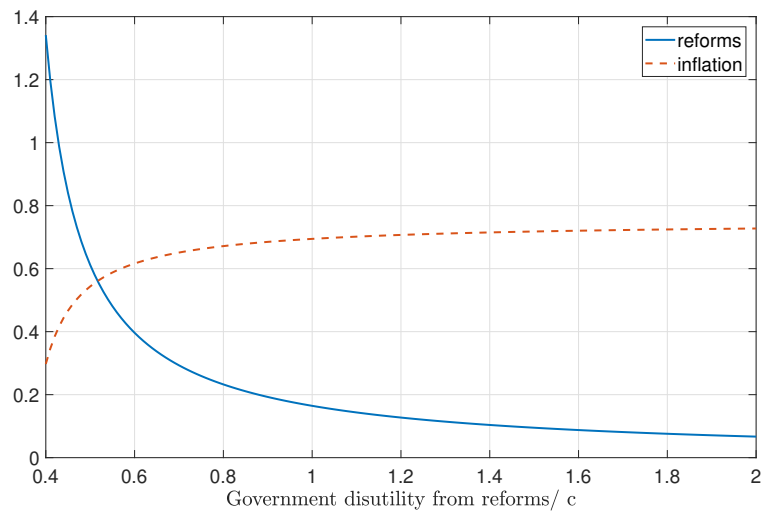

Figure 6: Reforms & Inflation with respect to government's disutility from reforms

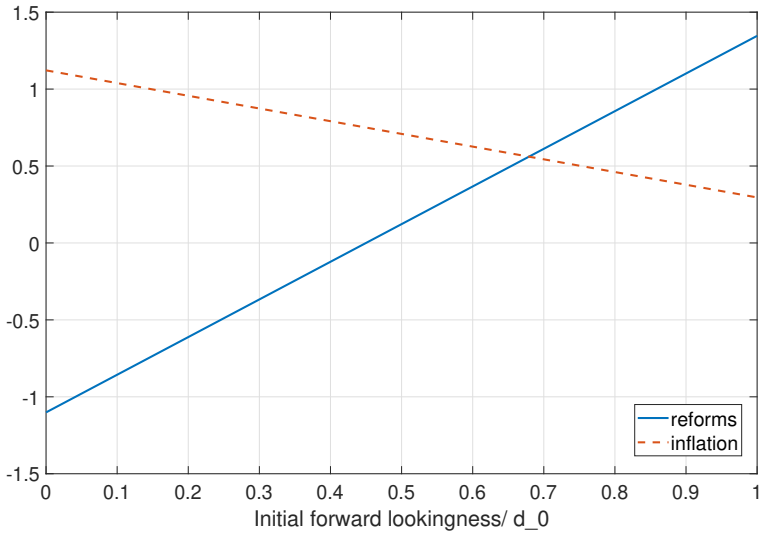

Figure 7: Reforms & Inflation with respect to initial forward lookingness

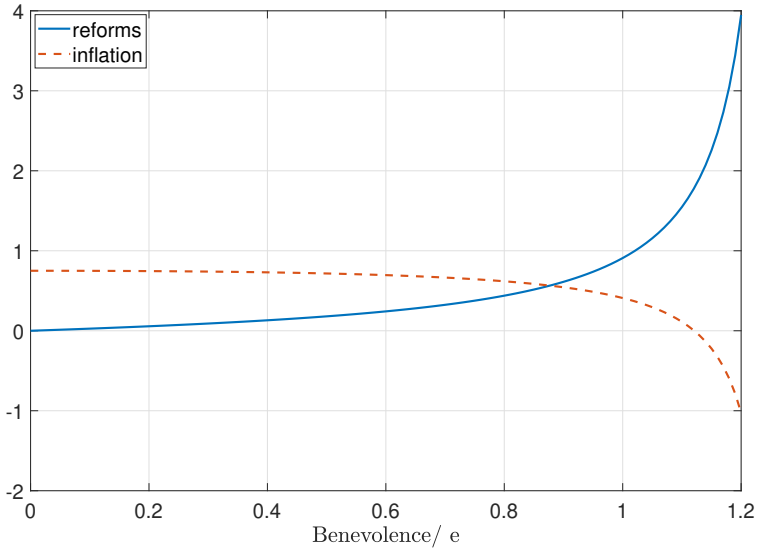

Figure 8: Reforms & Inflation with respect to benevolence

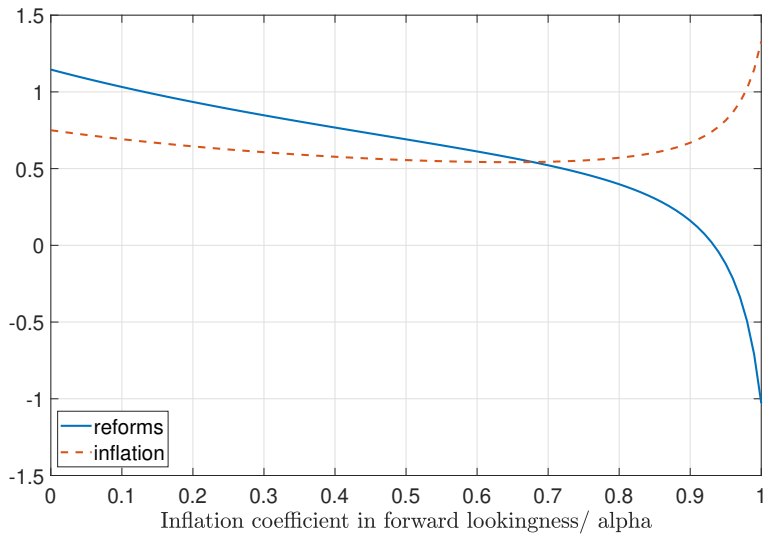

Figure 9: Reforms & Inflation with respect to Inflation coefficient in forward lookingness

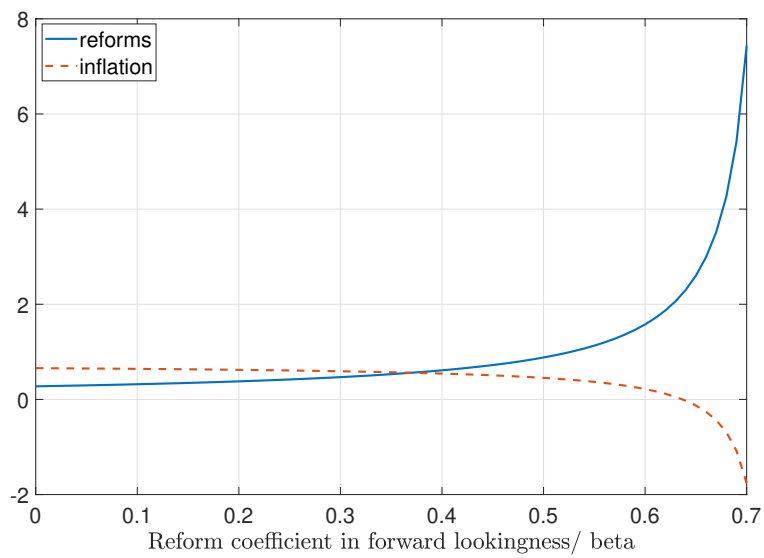

Figure 10: Reforms & Inflation with respect to Reform coefficient in forward lookingness

8.3 Appendix C. 3D graphs of temptation and enforcement with respect to inflation and reforms.

In this appendix we try to analyse the sensitivity of temptation and enforcement with respect to inflation and reforms. We give the following calibration to the model parameters and plot 3D graphs of temptation and enforcement against inflation and reforms.

$$a = 1.6 \quad b = 1.2 \quad c = 0.5 \quad d_0 = 0.7 \quad e = 0.1 \quad \alpha = 0.6 \quad \beta = 0.4 \quad q = 0.96$$

We obtain the following results.

8.3.1 Temptation graphs

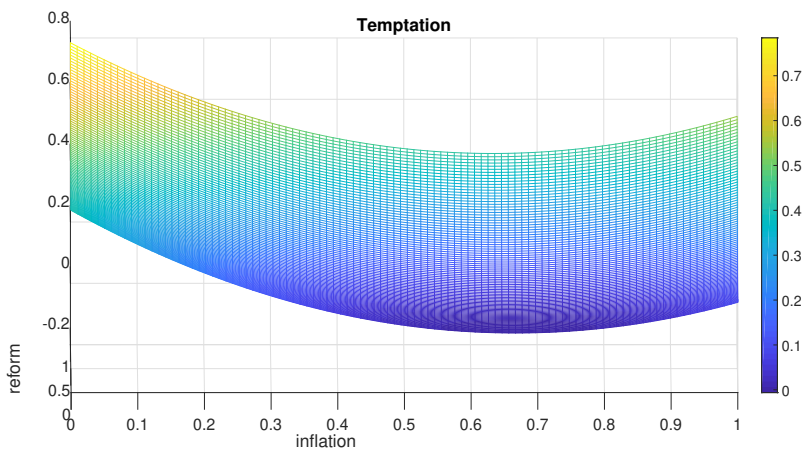

Figure 11: Temptation with respect to inflation and reforms: The sight from inflation

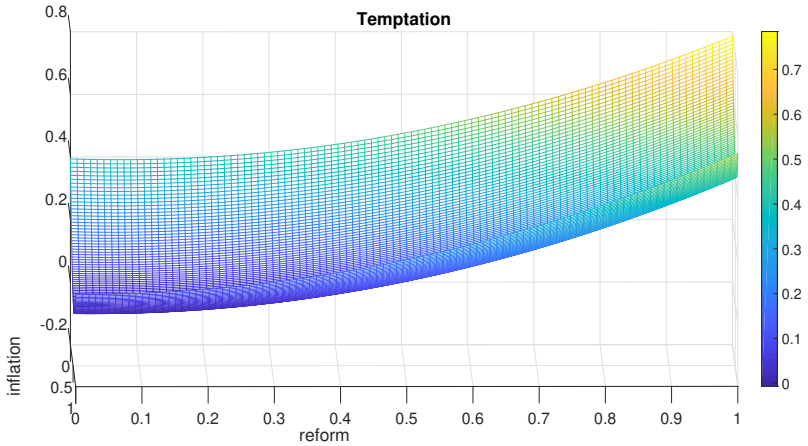

Figure 12: Temptation with respect to inflation and reforms: The sight from reforms

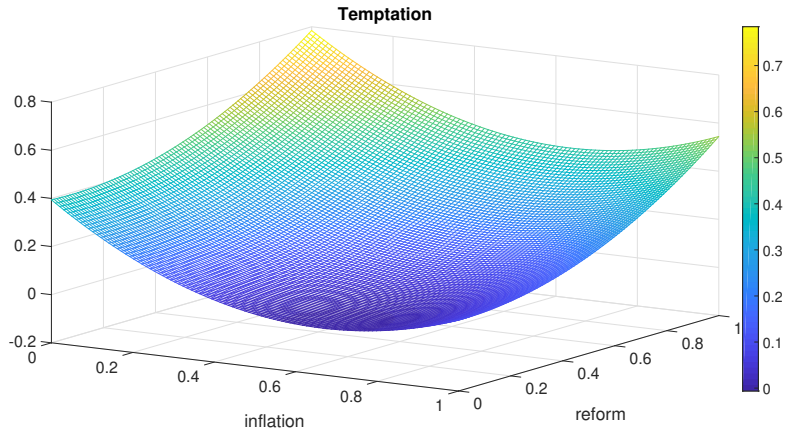

Figure 13: Temptation with respect to inflation and reforms: The overall look

8.3.2 Enforcement graphs

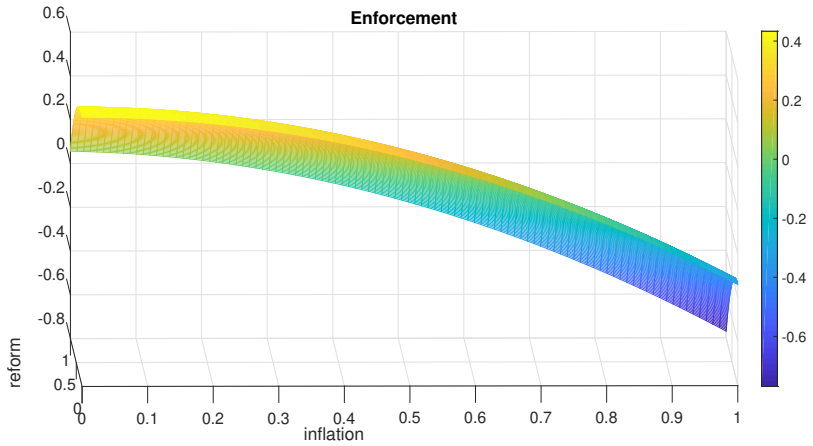

Figure 14: Enforcement with respect to inflation and reforms: The sight from inflation

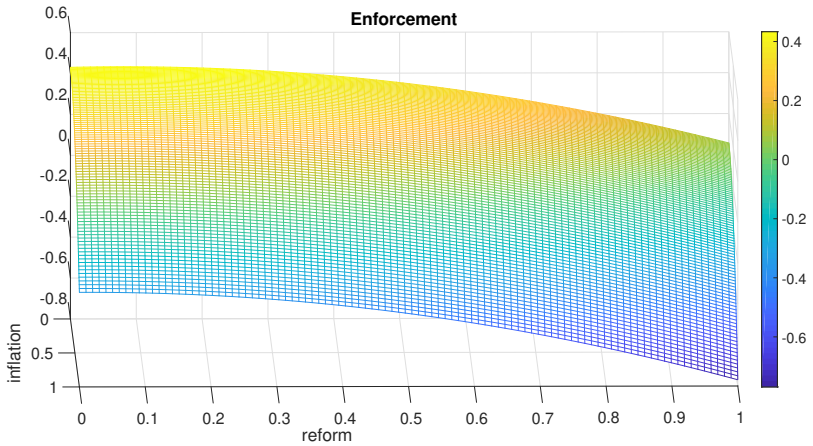

Figure 15: Enforcement with respect to inflation and reforms: The sight from reforms

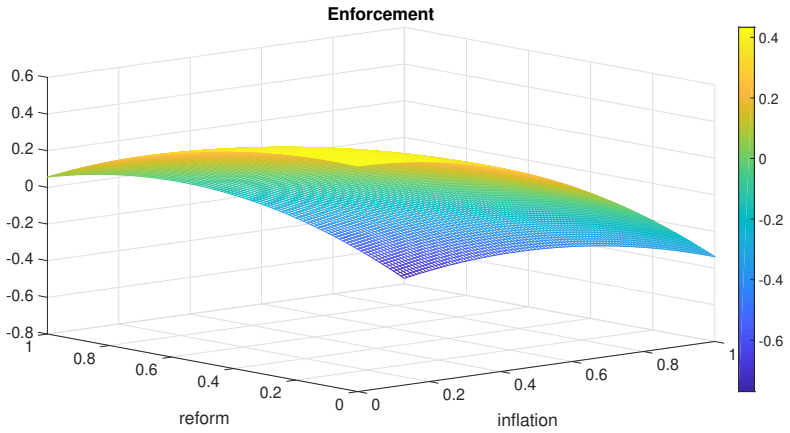

Figure 16: Enforcement with respect to inflation and reforms: The overall look