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Essays on Monetary Economics

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Essays on Monetary Economics

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Dedicated to my aunt Ulufer Onen.

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Essays on Monetary Economics

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In the first chapter, I examine an incomplete markets economy in a politico-economic general equilibrium setting in which the median voter chooses the inflation rate. I use an environment where individuals face an uninsurable idiosyncratic labor productivity shock, and money is the only asset. Being an effective tax on savings, inflation acts as a redistribution mechanism transferring resources from the rich to the poor. I show that the median voter chooses a positive inflation rate as the politico-economic equilibrium outcome.

In the second chapter, I analyze how forming a monetary union affects consumption and earnings inequalities through monetary policy changes implied by adopting a common currency. I use a two country open-economy, overlapping-generations model with heterogenous individuals to investigate these effects. In the model, inflation tax is the only redistributive tool and consumption and earnings inequalities are decreasing functions of inflation. When forming a monetary union, countries face a trade-off between the undesirable

distributional effects of losing their monetary autonomy and benefits from the elimination of trade frictions. Findings suggest that when countries choose to do so, the country with higher initial inflation will definitely experience a fall in its inflation, hence an increase in its inequalities. In the country with lower initial inflation, however, inflation and inequalities might go in either direction depending on the degree of heterogeneity and the trade dependency between the countries. As the inflationary effect of uniting its monetary policy with a high inflation country can dominate the reducing effect of vanished trade frictions on inflation, this country might have an increase in its inflation, and a decrease in its inequalities.

Finally, in the third chapter, I compare the indirect measure of inflation expectations derived by Ireland (1996b) to the direct measures obtained from expectations surveys in two case studies: the US and Turkey. Our results show that the inflation bounds calculated for US data are more volatile than survey results, and are too narrow to contain them due to low standard errors in consumption growth series stemming from high persistence. For the Turkish case, on the other hand, out of three different surveys on inflation expectations in Turkey compared with the bounds computed using Turkish data, expectations obtained by the Consumer Tendency Survey fall within these bounds throughout the whole sample period. Moreover we show that, as Fisher's theory suggests, real interest rates are extremely volatile in Turkey and movements in nominal interest rates cannot be directly used as an indicator of changes in inflation expectations.

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Chapter 1

Inflation in a Politico-Economic General Equilibrium

1.1 Introduction

On the contrary to what Friedman's (1969) optimum quantity of money rule suggests, we have observed a positive inflation rate in almost every episode of the US post WWII data. This study claims that this observation might be observed as an outcome of a political equilibrium. Specifically, the question studied in this paper is "Can we support the observed positive inflation rate by a politico-economic general equilibrium?". To answer this question, I employ a model economy with production where individuals face uninsurable idiosyncratic shocks to their productivity. Money is the only asset in the economy and provides partial insurance. Particularly, individuals hold money to smooth their consumption. Seignorage revenue is transferred back to households in a lump-sum fashion. These assumptions give rise to a monetary equilibrium where a positive inflation rate is desirable for the poorer households. Inflation is costly on the other hand, being an effective tax on savings, it distorts savings decision. I endogenize the inflation rate in a one-time-voting political equilibrium where individuals choose their most preferred inflation rate by computing its consequences and the median of these votes is obeyed by the government operating in full commitment. I found that, mainly due to positively skewed US earnings and wealth distribution, the median voter chooses a positive inflation rate in political equilibrium even though the social planner chooses a negative inflation rate.

There are welfare and distributional effects of inflation on economies. Most of the studies in the literature regarding inflation have only considered welfare effects. Optimality of the Friedman rule has been the center of almost all studies in this area [1]. Relationship between inflation and inequality, on the other hand, have not been studied until more recently and limited in number. This paper analyzes effects of inequality on inflation[2]. Among the few studies in the literature analyzing this direction, Bhattacharya et al. (2001)[3] examine how political factors affect the equilibrium determination of inflation in an overlapping generations framework. They find a non-monotonic relationship between income inequality and inflation. Bullard and Waller (2004) compare three central bank setups in terms of welfare consequences and find substantial inflationary bias when central banks are designed to apply majority voting rule. Albanesi (2007), on the other hand, studies distributional effects on inflation in a political economy framework other than the majority voting rule. Particularly, Albanesi (2007) has an economy with two types of agents,

[1] Among others, see Kimbrough (1986), Ireland (1996a), Chari et al. (1996) and Correia and Teles (1996).

[2] For studies on the other direction of the causality, i.e. distributional effects of inflation, see, for example, Erosa and Ventura (2002), Doepke and Schneider (2006a) and Doepke and Schneider (2006b).

[3] Later distributed as Bhattacharya et al. (2005a).

the rich and the poor, playing a Nash bargaining game where the rich has a higher bargaining power. It is shown that the model can support the positive correlation between inflation and inequality in cross-sectional country data. In that economy, the poor suffers more from inflation because they hold more liquid assets as a fraction of their total wealth consistent with the data facts mentioned in Erosa and Ventura (2002) (see also Attanasio et al. (2002), Easterly and Fischer (2001) and Mulligan and Sala-i-Martin (2000)). Erosa and Ventura report that in the US low income households use cash for a greater fraction of their total purchases relative to high income households. These data facts are captured in my model too, i.e. the poor has a higher cash holdings to total wealth ratio (since consumption is smoothed, wealthy individuals have a lower consumption to savings ratio and, in turn, a lower cash balances to wealth ratio). However, unlike in Albanesi (2007), the rich suffers more from inflation because seignorage transfers are lower than the consumption tax incurred to them. One important aspect of my model is earnings mobility[4] where individuals are not stuck to their types and they can be rich (poor) sometime in the future even though they are poor today (rich). This dynamic feature lacks in previous related literature, and is the center to their analyses.

Doepke and Schneider (2006a) document large distributional effects as a consequence of the high inflation episode in the seventies in US. In an overlapping generations framework where rich and old agents are the main losers

[4]See, for example, Díaz-Giménez et al. (1997) for why mobility exists in real life.

from inflation, they argue that welfare was improved by the help of transfers financed by seignorage revenue. Borrowing constrained individuals benefit the most from these transfers. In another study, Doepke and Schneider (2006b) show that even moderate levels of inflation lead to substantial wealth redistribution. Similar to these studies, inflation acts as a redistribution mechanism from the rich to the poor in my model.

Political process in a country has been modeled in several ways in the context of economics. The most widely used political scheme is the one where the median voter deciding on the policy rule that the government applies[5]. The median voter hypothesis assumes that every individual in the economy votes and political influence does not differ within population[6]. The determination of the economic policy by median voter was used in the literature first by Meltzer and Richard (1981) and a dynamic version was introduced by Krusell and Ríos-Rull (1999). After these two seminal papers, several papers studied taxation in the political economy framework (see, for example, Krusell et al. (1997), Azzimonti et al. (2006) and Corbae et al. (2009)). The main feature of these studies is that the median voter is poorer than the voter with mean capital holdings and therefore votes for a higher level of proportional tax than what the mean agent would vote. The same principal holds in my paper. Particularly, labor productivity is introduced to the model used in the seminal

[5]For a discussion about the median voter hypothesis see, for example, Schwabish et al. (2003).

[6]The full rationality of individuals (both as a consumer and a voter) is, of course, another underlying assumption.

paper by Imrohoroglu (1992) and inflation is endogenized in a political economy framework. Due to positively skewed earnings and wealth distributions of US, the median voter chooses an inflation rate that is higher than welfare maximizing level of inflation in my model economy. When computing the consequences of their preferred inflation rate, individuals face a tradeoff between advantages and disadvantages of a positive inflation. As a disadvantage, inflation distorts savings decision and reduces risk sharing. That is, individuals economize on their cash balances at a higher inflation rate and since the risk averse agents insure themselves through money higher inflation reduces overall welfare. Since there is earnings mobility, overall welfare is embedded in individuals' future value. On the other hand, a higher inflation rate means higher transfers, and transfers are higher than the inflation tax on individuals with lower wealth. The latter effect dominates the former to some extent for the parameters calibrated for US economy and therefore, the median voter outcome can support the positive inflation rate observed in the real world. Results in this paper show that the median voter chooses 1.1% inflation rate for the US economy while the Friedman rule is optimal in the planner solution.

The outline of the paper is as follows. Next section introduces the model I use in this study. Section 1.3 explains the parametrization while Section 1.4 presents the results. Sensitivity analysis of the results are reported in section 1.5. Finally, section 1.6 concludes the paper.

1.2 The Model

In this section, I introduce the theoretical model used in the paper. I use a model similar to the one used in Imrohoroglu (1992). She models an economy with idiosyncratic employment shocks and individuals hold cash balances to smooth their consumption stream. I introduce labor productivity to her model. Particularly, individuals face the productivity shock instead of an employment shock.

1.2.1 The Environment

The model economy is populated by a continuum of infinitely lived ex-ante identical households of measure one. There is no aggregate shock but individuals face an uninsurable idiosyncratic labor productivity shock realized in the beginning of each period. The timing of the events in a given period is as follows. Each period, individuals wake up with their nominal cash balances M_t and observe their productivity shock ϵ_t. Then, they give their labor supply decision n_t and receive labor income $\epsilon_t n_t$ (the wage rate is normalized to 1). The government decides on the money supply M_{t+1}^s and the lump-sum taxes/transfers τ_t are made. Individuals decide how much to consume c_t and how much to save M_{t+1}. Individuals are not allowed to print money and this is reflected in the nonnegativity constraint on M_{t+1} below.

The exogenous productivity shock ϵ_t is independent and identically distributed across agents and follow an S-state first order Markov process over time with the support $\epsilon_t \in \{\epsilon^1, \epsilon^2, ..., \epsilon^S\}$ and the stationary transition probability matrix $\Pi(\epsilon_{t+1}|\epsilon_t)$. Let P_t and $m_t = M_t/P_t$ be the dollar price of the good and the real money holdings, respectively. An agent with asset level m_t and observing productivity shock ϵ_t maximizes his expected discounted lifetime utility:

$$E_t \left\{ \sum_{j=0}^{\infty} \beta^j U(c_{t+j}, n_{t+j}) \right\} \tag{1.1}$$

subject to the following budget constraint:

$$c_t + M_{t+1}/P_t \leq n_t \epsilon_t + M_t/P_t + \tau_t \tag{1.2}$$

$$c_t \geq 0, \qquad M_{t+1} \geq 0$$

The utility function used in this paper is originally proposed by Greenwood et al. (1988) which has the form:

$$U(c_t, n_t) = \frac{1}{1-\sigma} \left[c_t - \chi \frac{n_t^{1+1/\nu}}{1+1/\nu} \right]^{1-\sigma} \tag{1.3}$$

where σ is the coefficient of relative risk aversion and ν is the intertemporal (Frisch) elasticity of labor supply. As it will be shown later, this selection of utility function allows, in equilibrium, the labor supply decision to be independent of the asset level of an individual.

The government changes money supply such that prices change according to the committed inflation rate $\pi_t = P_{t+1}/P_t$. Particularly, government applies the following operation:

$$M_{t+1}^s = (1 + \xi_t) M_t^s \tag{1.4}$$

and has the following nominal budget constraint:

$$T_t = P_t \tau_t = M_{t+1}^s - M_t^s \tag{1.5}$$

where T_t and τ_t are nominal and real transfers/taxes, respectively. That is, government transfers the seignorage revenue back to households in a lump-sum fashion. This is the key point in understanding the redistribution mechanism and its role in political equilibrium outcome. Particularly, poorer households will enjoy a higher inflation rate, at least for the first few periods. One can see from the budget constraint (1.2) that the money held loses its purchasing power next period in case of a positive inflation and inflation acts as a tax on savings in this model. The consumption loss due to inflation tax is lower than the transfers for poorer households compared to richer households. For economies with median wealth level sufficiently lower than mean wealth level, more individuals will ask for a higher inflation rate due to this mechanism.

On the other hand, it should be noted that since the government is assumed to have full commitment and there is no aggregate uncertainty, i.e. there is perfect information about the actions taken by the government and agents can foresee the resulting price changes stemming from the government's actions. Since agents only care about the real variables in the economy, only the inflation rate matters for them. Therefore, we can think of the government setting (and committing to) the inflation rate even though the prices are actually set in the competitive market. For better readability, I'll use only real variables in recursive competitive equilibrium and exchange the government policy (ξ) with perceived inflation rate (π) in individual's information set in the subsection below.

1.2.2 Recursive Competitive Equilibrium

Now, I will introduce the recursive interpretation of the model. Time subscripts are suppressed and x denotes x_t, x' denotes x_{t+1}. The individual state space can be represented simply by (m, ϵ).

Let the joint distribution of asset levels and productivity shocks be denoted by $\Gamma(m, \epsilon)$ with law of motion $\Gamma' = H(\Gamma, \pi)$. So, the aggregate labor supply is given by:

$$N = \int \epsilon n \, d\Gamma(k, \epsilon) \tag{1.6}$$

Then, the dynamic programming problem solved by agents can be written as:

$$
\begin{aligned}
V(m,\epsilon;\Gamma,\pi) = \max_{c,n,m'} U(c,n) + \beta E_{\epsilon'|\epsilon} V(m',\epsilon';\Gamma',\pi') \\
s.t. \\
c + m'(1+\pi) = n\epsilon + m + \tau \\
\Gamma' = H(\Gamma,\pi) \\
\pi' = \Psi(\Gamma,\pi) \\
c \geq 0, \quad m' \geq 0
\end{aligned}
\tag{1.7}
$$

where Ψ is the function of the perceived law of motion of inflation.

The solution to this problem generate the following decision rules:

$$m' = \zeta(m,\epsilon;\Gamma,\pi),\ c = \omega(m,\epsilon;\Gamma,\pi) \text{ and } n = \eta(m,\epsilon;\Gamma,\pi)$$

Finally, the resource constraint is formulated as below:

$$\int \omega \, d\Gamma(m,\epsilon) = \int \eta\epsilon \, d\Gamma(m,\epsilon) \tag{1.8}$$

Next, I define the recursive competitive equilibrium for the given perceived law of motion of inflation:

Definition 1.2.1 (RCE)**.** Given $\Psi(\Gamma,\pi)$, a **Recursive Competitive Equilibrium** is a set of functions $\{V,\zeta,\omega,\eta,H,\tau\}$ such that:

1. Given (Γ,τ,H,Ψ), functions $\{V,\zeta,\omega,\eta\}$ solve the individual optimization problem defined in (1.7);

2. The resource constraint (1.8) is satisfied;

3. The government budget constraint (1.5) is satisfied;

4. $H(\Gamma, \pi)$ is given by

$$\Gamma'(m', \epsilon') = \int 1_{\{\zeta(m,\epsilon;\Gamma,\pi)=m'\}} \Pi(\epsilon'|\epsilon) d\Gamma(m, \epsilon).$$

1.2.3 Characterization of the Equilibrium

The problem defined above has the following first order conditions:

$$U_c(c, n) = \lambda \tag{1.9}$$

$$U_n(c, n) + \epsilon\lambda = 0 \tag{1.10}$$

$$\lambda(1 + \pi) = \beta E_{\epsilon'|\epsilon} V_{m'}(m', \epsilon') \tag{1.11}$$

where λ is the Lagrange multiplier for the budget constraint On the other hand, subscripts used in functions U and V denote partial derivatives, e.g. $U_c(c, n)$ denotes $\frac{\partial U(c,n)}{\partial c}$. Combining first order conditions (1.9) and (1.10), and using the assumed form of utility function yield:

$$n = \left[\frac{\epsilon}{\chi}\right]^{\nu} \tag{1.12}$$

Equation (1.12) has an important implication. Particularly, labor supply decision is independent of the cash at hand. Since it depends only on individual's productivity shock, there are S types of individual labor supply levels observed in this economy and the aggregate labor supply can be written simply by:

$$N = \sum_{i=1}^{S} \overline{\Pi}(\epsilon^i) \frac{{\epsilon^i}^{1+\nu}}{\chi^\nu} \tag{1.13}$$

where $\overline{\Pi}$ is the invariant probability distribution. This simplification has a significant computational tractability. Individual optimization is computed for given aggregate quantities, aggregate labor is fixed due to the particular assumption on preferences. Without this form of utility function, another state variable would be needed.

Second, more productive agents work more (n is an increasing function of ϵ for any positive parameter value of ν). This is simply because the substitution effect dominates the income effect, it is more costly to enjoy leisure for the agents with higher return to work (ϵ is the return to allocate unit time to work). Finally, we can clearly see from (1.12) and (1.13) that labor supply decision is independent on the inflation rate. Clearly, inflation has more adverse effects in a model where labor supply is distorted by inflation.

Euler equation can be derived from (1.11) and (1.9):

$$U_c(c,n)(1+\pi) = \beta E_{\epsilon'|\epsilon} U_{c'}(c',n') \tag{1.14}$$

Interpretation of the Euler equation is standard. Precisely, individuals equate the marginal cost of increasing savings to the marginal benefit of increased consumption tomorrow.

Next, I will define the politico economic equilibrium by endogenizing the inflation rate.

1.2.4 Politico Economic Recursive Competitive Equilibrium

The main contribution of this study is endogenizing the inflation rate in a political economy concept. Particularly, individuals vote for the inflation rate which will maximize their lifetime utility. For simplicity, I restrict my attention to the case where voting takes place only once and the chosen inflation rate is permanent[7]. Parallel to the literature in this subject, I assume that the median voter is the decisive voter.

As mentioned in detail in Corbae et al. (2009), the median voter can not be known by examining the asset levels or other individual state variables. Specifically, the median voter outcome is determined by computing the inflation rate that each individual would choose and then by ordering the votes. The median of the most preferred inflation rates, in general, is different than what the individual with median asset level would choose.

At the time of the elections, households with state $(m, \epsilon; \Gamma, \pi)$ compute their values for different alternatives of future inflation rates which the government will commit for lifetime, not necessarily determined by the perceived law of motion $\pi' = \Psi(\Gamma, \pi)$, but some other rate, π'. Then, the individuals' problem is to optimize:

[7]For more detailed alternative mechanisms, see Corbae et al. (2009).

$$
\begin{aligned}
\widetilde{V}(m,\epsilon;\Gamma,\pi,\pi') = \max_{c,n,m'} & U(c,n) + \beta V(m',\epsilon';\Gamma',\pi') \\
& s.t. \\
c + m'(1+\pi) &= n\epsilon + m + \tau \\
\Gamma' &= \widetilde{H}(\Gamma,\pi,\pi')
\end{aligned} \tag{1.15}
$$

where $\widetilde{H}$ is the election-period law of motion of Γ induced by deviating from Ψ. All future evolutions of distributions are determined by H such that:

$$
\begin{aligned}
\Gamma' &= \widetilde{H}(\Gamma,\pi,\pi') \\
\Gamma'' &= H(\widetilde{H}(\Gamma,\pi,\pi'),\tau') \\
\Gamma''' &= H[H(\widetilde{H}(\Gamma,\pi,\pi'),\tau'),\tau'] \\
&...
\end{aligned}
$$

The solution to this problem generates the following decision rules:

$$
m = \widetilde{\zeta}(m,\epsilon;\Gamma,\pi,\pi'),\ c = \widetilde{\omega}(m,\epsilon;\Gamma,\pi,\pi') \,\text{and}\, n = \widetilde{\eta}(m,\epsilon;\Gamma,\pi,\pi')
$$

It is now time to define the politico-economic RCE.

Definition 1.2.2 (PRCE)**.** Given $\Psi(\Gamma,\pi)$, a **Politico-Economic Recursive Competitive Equilibrium** is such that:

1. A set of functions $\{V,\zeta,\omega,\eta,H,\tau\}$ that constitute a RCE;

2. A set of functions $\{\widetilde{V},\widetilde{\zeta},\widetilde{\omega},\widetilde{\eta}\}$ that solve (1.15) at prices which clear markets and the government budget constraint;

3. $\widetilde{H}(\Gamma, \pi, \pi')$ is given by

$$\Gamma'(m', \epsilon') = \int 1_{\{\widetilde{\zeta}(m,\epsilon;\Gamma,\pi)=m'\}} \Pi(\epsilon'|\epsilon) d\Gamma(m, \epsilon)$$

   with continuation values satisfying (i);

4. Household i with individual state $(m, \epsilon)_i$ chooses the inflation rate π^i where

$$\pi^i = argmax_{\pi'} \widetilde{V}((m, \epsilon)_i; \Gamma, \pi, \pi');$$

5. The policy is determined by the median of the most preferred inflation rates, π^{med} which satisfies

$$\int 1_{\{(m,\epsilon):\pi^i \geq \pi^{med}\}} d\Gamma(m, \epsilon) \geq \frac{1}{2}$$
$$\int 1_{\{(m,\epsilon):\pi^i \leq \pi^{med}\}} d\Gamma(m, \epsilon) \geq \frac{1}{2}$$

Single-peaked preferences is essential for the existence of politico-economic equilibrium. Figure 1.1 depicts the indirect utility function for individuals with median money holding evaluated at 1.0% inflation rate. The single-peakedness can be observed from this figure. Moreover, indirect utility of the individual with median asset level and the higher productivity shock peaks at a lower inflation rate. Now, I define the steady state politico-economic recursive competitive equilibrium.

Definition 1.2.3 (SSPRCE)**.** A **Steady State PRCE** is a PRCE such that $\Gamma^* = H(\Gamma^*, \pi^*)$ and $\pi^* = \Psi(\Gamma^*, \pi^*)$.

The next section introduces the parametrization used in this paper.

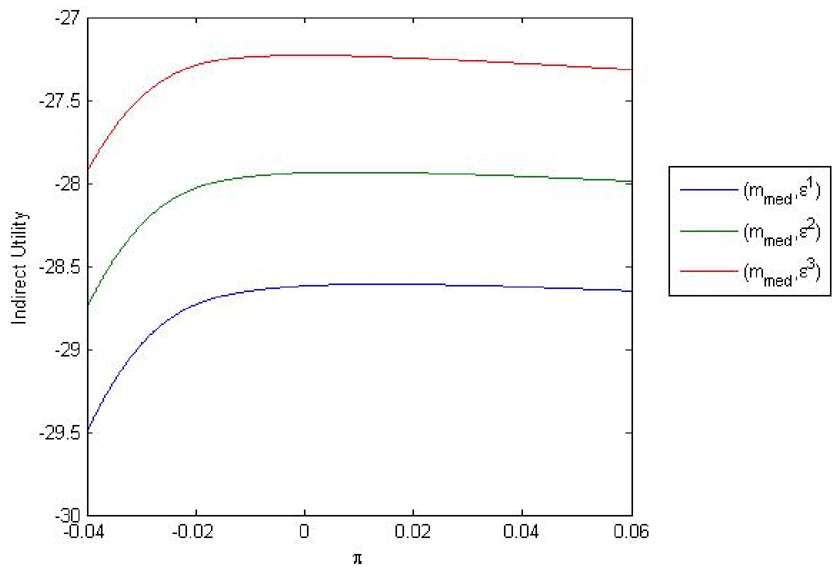

Figure 1.1: Single-peaked preferences

1.3 Parametrization

I parameterize the model for the US economy. The model period is one year. Calibrated parameter values of aggregate economy are given in Table 1.1. The calibrations of β, and σ are pretty much standard in the literature. MaCurdy (1981) estimates the intertemporal Frisch elasticity ν to be between 0.1 and 0.45. I choose this parameter to be 0.3 similar to Corbae et al. (2009).

Disutility parameter χ is chosen to match the aggregate labor supply[8] 1/3.

[8] Corbae et al. (2009) takes a higher χ value but targets a similar aggregate labor supply level.

Table 1.1: Parameter Values

Parameter		Value
Discount Factor	β	0.96
Risk aversion	σ	1.0
Elasticity of labor supply	ν	0.3
Disutility	χ	43

Parameters regarding the idiosyncratic labor productivity shocks are taken from Davila et al. (2005), where they calibrate the economy in Aiyagari (1994) using a three-state Markov process (instead of seven in the original Aiyagari paper). These parameter values are presented in Table 1.2.

Table 1.2: Labor Productivity Parameters

Value	Transition Probabilities		
$\epsilon^1(0.78)$	0.66	0.27	0.07
$\epsilon^2(1.00)$	0.28	0.44	0.28
$\epsilon^3(1.27)$	0.07	0.27	0.66

1.4 Results

This section presents the main findings of the paper. The computational algorithm to compute equilibria in political economy framework is standard and explained in detail in the relevant papers listed above. The algorithm used in this paper is similar to them except for a few slight differences. In particular, there is one continuous state and one discrete state for individuals while aggregate states are the distribution of agents and the inflation rate. The computation procedure consists of the following stages. First, steady state

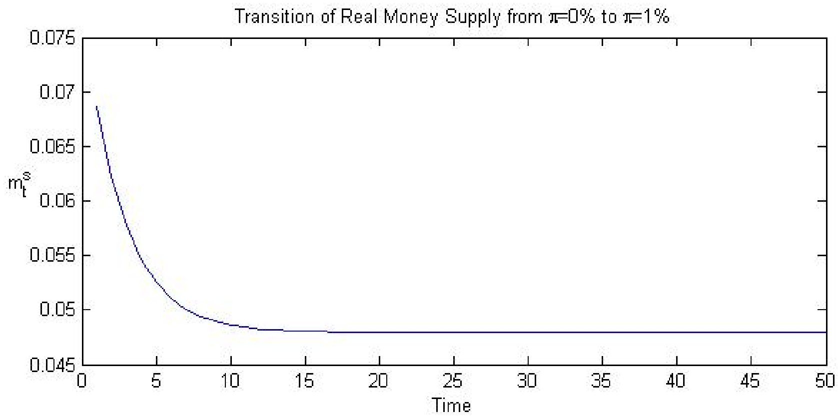

Figure 1.2: Aggregate money supply transition

recursive competitive equilibria are solved for an initial grid of inflation rates[9]. Second, transitions from each steady state to others are computed. In order to do that, I take 50 as the maximum number of periods to reach steady state and do backward induction[10]. Figure 1.2 shows a sample transition of the aggregate real money supply transition from 0% inflation rate to 1.0%. Third, PRCE is computed. Specifically, individual votes found by comparing their values at the beginning of the transitions for each initial steady state. Finally, SSPRCE is found for the given grid of inflation rates. If the median of the most preferred inflation rates is found to be on the boundary of the grid, i.e. the lowest or the highest inflation rate in the grid is chosen, then the grid is adjusted until an interior solution is attained.

[9] I choose 10^{-12}, 10^{-6} and 10^{-6} for tolerance values while computing steady state value functions, aggregate values in steady state and aggregate values in transition, respectively.

[10] Transition in longer time periods are also computed but convergence to a new steady state is satisfied before 50 periods.

My results suggest that the median voter chooses 1.1% inflation rate for the calibrated US economy. The social planner chooses the Friedman to be optimal in this economy. This corresponds to an inflation rate of -4.17%. Clearly, the median voter outcome underpredicts the average inflation observed in US data. The main reason for this is that saving money is the only tool for risk sharing in this model economy and therefore inflation tax on savings has an amplified effect. Under a richer environment with more tools for risk sharing, this effect would be smaller and the median voter outcome inflation rate would be closer to data. As it will be shown in the next section, this result is robust to parameter selection, that is a positive inflation rate is always supported by the model for the relevant partition of the parameter space. That's because through its redistributive feature, inflation transfers resources from the rich to the poor and the median voter is poorer than the mean agent.

1.5 Sensitivity Analysis

This section tests the robustness of the results. Specifically, several values of the key parameters are fed into the algorithm and the results are analyzed. The sensitivity of the results are examined for two parameters, namely σ, and ν. Tables 1.3 and 1.4 show equilibrium inflation rates chosen by the median voter for several values of these two parameters, changing only one of them at a time.

The sensitivity analysis shows that the results are robust to parameter value selection. Specifically, a positive inflation rate can be supported by

Table 1.3: Sensitivity of the Results for Different σ Values

Value	Median Voter Outcome
0.7	0.7%
1.5	1.7%
2.0	2.2%

the median voter outcome. As we examine Table 1.3, we observe that as the relative risk aversion parameter increases, the median voter chooses a higher inflation rate. This is intuitive because as individuals become more risk averse, a higher degree of insurance is needed. Since inflation acts as a partial insurance mechanism in this model, a higher σ leads to a higher inflation rate to be chosen politically.

Table 1.4: Sensitivity of the Results for Different ν Values

Value	Median Voter Outcome
0.2	1.2%
0.4	1.0%
0.45	0.95%

Table 1.4, on the other hand, examines sensitivity of the results to intertemporal Frisch elasticity. As the elasticity parameter value increases, median voter inflation decreases. The results are robust to the selection of this parameter too, a positive inflation rate can still be supported.

1.6 Conclusion

Inflation rate in US has been consistently positive after WWII. Assuming that inflation can precisely be determined by monetary policy, this observation is inconsistent with the Friedman rule. This paper argues that this inconsistency is a result of a political process where agents vote for the inflation rate. In order to show this, I used an incomplete markets general equilibrium model in a political economy framework and calibrated it to US data. Results provide evidence that the model can support the observed positive inflation rate. Equilibrium inflation rate delivered by the model underpredicts average inflation in data mainly due to the fact that being the only tool for risk sharing, money demand is highly affected by the inflation tax in this model economy. Under a richer environment with more tools for risk sharing, this effect would be smaller.

Chapter 2

Effects of Monetary Unions on Inequalities

2.1 Introduction

The formation of the European Monetary Union has been an important motivation for many researchers. Various aspects of unions have been analyzed, and researchers have tried to characterize benefits and costs of joining a monetary union. Benefits from improvements in microeconomic efficiency and increase in macroeconomic stability and growth along with possible related costs have been studied for the last four decades. A detailed analysis on the costs and benefits of monetary unions was performed by De Grauwe (2007). Among others, the issue of inequality is a highly important yet undiscovered aspect that comes to mind especially when one takes into account that each country has a unique demographic structure. We show in this study that those differences in demographics combined with the adoption of a common currency will affect consumption and earnings inequalities in each country in a different way. In our setting, there are benefits from forming a union since using a common currency eliminates the portfolio adjustment costs. Committing to a common currency leads to these gains at the expense of monetary policy autonomy where countries cannot use inflation as a tool to redistribute resources. Instead, the common central bank has control over the inflation level.

In this study, we use a theoretical model to explore the question: "How does forming a monetary union affect the consumption and earnings inequalities in countries with asymmetric demographic structures?". We employ a heterogenous agents environment to study the effects of inflation with redistribution through transfers. A two-country dynamic equilibrium open-economy model is used to analyze different outcomes that monetary unions will produce. In a similar setting to Cooper and Kempf (2003), we use an OLG model with two open-economy countries. Ex-ante identical individuals receive private information productivity shocks. The monetary authority, unable to utilize optimal risk-sharing, maximizes domestic welfare. Individuals try to maximize their utility by selecting an optimal portfolio of currencies before the realization of their taste shocks on domestic and foreign consumption goods. Rich individuals, holding more money, suffer from a high inflation while poor individuals benefit from it as it leads to higher lump-sum transfers[1]. Without a monetary union, each government sets inefficiently high inflation tax (beggar thy neighbor policy), creating comparably lower inequality. Poor individuals gain from inflation tax through higher transfers when independent policy makers compete.

[1]Existence of asymmetric information renders the fiscal redistributive tools ineffective and leaves the money as the only way of transferring wealth from rich to poor. As Bhattacharya et al. (2005b) prove this point in their paper, under heterogeneity of agents and the lack of fiscal tools to redistribute wealth among agents, Friedman's rule is no longer optimal since inflation is the only way to redistribute wealth among agents.

Researchers studied the welfare effects of forming a monetary union, but none of them analyzed the distributional aspects in a structural model setting. Relevant literature on unions suggests that forming a common currency area might eliminate the welfare costs associated with competing monetary policies[2]. Independent monetary authorities optimize domestic welfare by implementing a higher inflation rate to gain from terms of trade. This finding is supported by Cooley and Quadrini (2003) using dependent production technologies in different countries, and by Celentani et al. (2007) through international risk-sharing with incomplete markets. Monetary unions eliminate those losses created by competing monetary policies and lead to a lower inflation-higher welfare outcome. Following Mundell (1961), Cooper and Kempf (2003) obtained the welfare improving results by eliminating local currency and portfolio adjustment constraints through forming a monetary union. Our model differs from the existing literature in two ways: First, we use a heterogenous agents model to analyze consumption and earnings inequalities where there are two types of agents with different productivity levels. Second, we allow for asymmetry among countries in terms of their fractions of types, so that interests of the union and its member countries do not match perfectly.

Even though there is not much question about the importance of the distributional aspects of inflation, there is no commonly agreed way of modeling it. One basic distinction concerns the losers and winners of inflation. Meh and Terajima (2008) found that the distributional effects of inflation are

[2]For a rich and recent literature survey on monetary unions, see Mongelli (2005).

sizeable even for low and moderate inflation episodes. Old households, rich households, and the middle-aged middle-class lose with inflation, largely due to their sizeable holdings of bonds and non-indexed defined benefit pension assets. Erosa and Ventura (2002) study the link between inflation and inequality in a model where poor households hold more cash as a fraction of their total assets than rich households do, and deal with the effect of anticipated inflation on cash holdings. There is no redistribution through any means and as a result, the poor are the losers of inflation. Albanesi (2007) takes a similar approach, but uses a political economy model wherein the higher vulnerability of the poor against inflation results in lower bargaining power and a bigger loss from inflation in equilibrium. On the other hand, Doepke and Schneider (2006b) argue that cash is only a very small portion of the portfolio for nominal assets, hence rich and old people are the main losers due to unanticipated inflation, along with foreigners that hold domestic assets. Also, Albanesi (2003) shows that unanticipated changes in the price level do affect consumption allocation, since they redistribute wealth across agents with different outstanding levels of nominal claims on the government. In our model, similar to the latter approach, highly productive individuals suffer more from higher inflation, because they hold more nominal assets than agents with low productivity.

The remainder of this paper is organized as follows. The next section introduces our model and defines the local currency equilibrium. Section 2.3 analyzes the inequality effects of inflation in the local currency case. Section

2.4 studies the equilibrium and inequalities in a monetary union. Section 2.5 concludes the paper.

2.2 The Model

We describe the model economy in this section. An overlapping generations structure is implemented in a two country open-economy setting. All agents live for two periods in which they work when they are young and consume when they are old. Individuals consume both home and foreign produced perishable goods and are subject to ex-ante taste shocks that determine how much utility they get from consumption of each good. Taste shocks are realized once the first period ends, and only after the portfolio choices are already made[3]. Taste shocks do not create heterogeneity in work and portfolio choices since these are made before taste shocks are realized. However, individuals are born with a productivity shock which is unobservable to others and determines how much they can produce when young. Different levels of productivity do provide different levels of work and consumption decisions. Countries, named as "home" and "foreign", issue their own currency and require domestic goods to be purchased by their own currency (local currency (LC) constraint) [4].

There are two key assumptions to our analysis. The first one is full commitment technology through which government announces money growth

[3]This timing friction accounts for the costs to adjust portfolio in exchange markets and renders the use of a single currency beneficial for both countries.

[4]This assumption is essential for portfolio choice to be important.

rate at the beginning of time (once and for all). Therefore agents know how much transfer they will be receiving next period. Transfers are financed by printing new money in that period. The second key assumption is that labor is immobile.

Timing is as follows: Cohort t individuals are born at time t, observe their productivity types, make their labor and portfolio decisions based on their expectations about idiosyncratic taste shocks. Young agents of cohort t sell their output to old agents of cohort $t-1$ in the goods market for home currency only, and then go to the exchange market to get foreign currency according to their portfolio decisions. At the beginning of time $t+1$, they observe their taste shocks, receive transfers from the government and go to the goods market for buying home and foreign goods [5]. Since the exchange market is closed transfers can only be used to purchase domestic goods.

2.2.1 Households

There is a continuum of ex-ante identical households in each cohort. Each individual in cohort t starts their first period by observing their productivity type, $i \in \{g, b\}$ representing good and bad, and give labor decision n_t before observing their taste for domestic goods consumption θ, which is realized at the beginning of time $t+1$. We assume that the proportion of good and bad type agents in a country is time invariant and publicly known.

[5] Note that portfolios cannot be adjusted in the second period after seeing the idiosyncratic taste shocks

We denote the proportion of good type home agents as γ. Due to the cash-in-advance constraint, they give their domestic and foreign currency holding decisions ($m_t^{h,i}$ and $m_t^{f,i}$, respectively) at time t as well. Therefore, an i type agent in home country solves the following optimization problem:

$$\max_{n_t^i, m_t^{h,i}, m_t^{f,i}} E_\theta\{\theta ln(c_{t+1}^{h,i}) + (1-\theta) ln(c_{t+1}^{f,i})\} - g(n_t^i) \tag{2.1}$$

subject to the following constraints:

$$y_t^i = \alpha^i n_t^i$$

$$c_{t+1}^{h,i} = \frac{m_t^{h,i} + \tau_{t+1}}{p_{t+1}}, \quad c_{t+1}^{f,i} = \frac{m_t^{f,i}}{p_{t+1}^*} \tag{2.2}$$

$$y_t^i p_t = m_t^{h,i} + m_t^{f,i} e_t \tag{2.3}$$

where $m_t^{h,i}, m_t^{f,i} \geq 0; \quad n_t^i \in [0,1]$.

Disutility from work $g(n_t^i)$ in the maximization problem (2.1) is increasing in labor, that is $g'(n_t^i) > 0$, and strictly convex, $g''(n_t^i) > 0$. $c_{t+1}^{h,i}$ and $c_{t+1}^{f,i}$ stand for domestic and foreign good consumption levels, respectively. θ is the idiosyncratic taste shock which determines the utility received from consuming domestic good and assumed to be distributed independently across countries, cohorts and agents from a distribution $H(\theta)$ with mean $\overline{\theta}$. Output y_t^i is determined by the first constraint where α^i is the individual specific private information productivity level. Price levels in consumption equations (2.2) are denoted by p_{t+1} for domestic price level and p^*_{t+1} for foreign price level[6]. τ_{t+1} is the transfer to old agents at time $t+1$[7]. The last equation (2.3) identifies the portfolio decision, young agents convert their output to domestic and foreign currency where e_t stands for the nominal exchange rate.

Individual optimization is determined by the following two equations:

$$g'(n^i_t) = \frac{\overline{\theta}\alpha^i p_t}{c^{h,i}_{t+1} p_{t+1}} \tag{2.4}$$

$$\frac{c^{h,i}_{t+1}}{c^{f,i}_{t+1}} = \frac{\overline{\theta} e_t p^*_{t+1}}{(1-\overline{\theta}) p_{t+1}} \tag{2.5}$$

The first condition (2.4) equates marginal disutility from work today to marginal utility of an additional unit of labor in terms of home good consumption. The second condition (2.5), on the other hand, relates the consumption shares to their ratio of expected costs. Note that they depend on the expectation of the taste shock because decisions are given ex-ante.

2.2.2 Market Clearing

There are five markets cleared each period, two goods markets, two money markets and and one exchange market. Home and foreign goods market clearing conditions are as follows:

[6] We use asterisk (*) for foreign country variables.

[7] Note that government delivers the same amount of transfers to all types since type is unobservable. This creates re-distributional effects for monetary policy.

$$M_t = p_t[\gamma\alpha^g n_t^g + (1-\gamma)\alpha^b n_t^b]$$

$$M_t^* = p_t^*[\gamma^*\alpha^g n_t^{*g} + (1-\gamma^*)\alpha^b n_t^{*b}]$$

Money markets clearing conditions are defined by:

$$M_t = \gamma m_t^{h,g} + (1-\gamma)m_t^{h,b} + \gamma^* m_t^{*h,g} + (1-\gamma^*)m_t^{*h,b}$$

$$M_t^* = \gamma m_t^{f,g} + (1-\gamma)m_t^{f,b} + \gamma^* m_t^{*f,g} + (1-\gamma^*)m_t^{*f,b}$$

Exchange market has the following clearing condition:

$$\gamma^* m_t^{*h,g} + (1-\gamma^*)m_t^{*h,b} = e_t[\gamma m_t^{f,g} + (1-\gamma)m_t^{f,b}]$$

Home money stock evolves as:

$$M_{t+1} = M_t(1+\sigma)$$

where σ is the fixed rate of money growth set by the home government. We assume governments follow balanced budgets, therefore tomorrow's transfers are directly financed by money injection. That is,

$$\tau_{t+1} = M_t \sigma$$

Before we move on to the equilibrium section, it is useful to define portfolio shares so that we can talk about real variables in the steady state. Let ϕ^i (ϕ^{*i}) denote the share of domestic (foreign) money stock held by type i agents of home (foreign) country. More specifically:

$$\phi_t^g = \frac{\gamma m_t^{h,g}}{M_t}, \quad \phi_t^b = \frac{(1-\gamma) m_t^{h,b}}{M_t} \tag{2.6}$$

Similarly, the economy wide portfolio share defined as:

$$\phi_t = \phi_t^g + \phi_t^b \tag{2.7}$$

denotes the fraction of home currency held inside the country.

2.2.3 Equilibrium

We restrict our attention to steady state monetary equilibria. Given the rates of money growth rates σ and σ^*, we will first characterize the monetary steady state equilibrium, and then we will solve the government's problem to find the optimal level of money growth.

2.2.3.1 Monetary Steady State Equilibrium

Given money growth rates σ and σ^*, a monetary steady state equilibrium is a list of consumption allocations $(c^{h,g}, c^{h,b}, c^{f,g}, c^{f,b}, c^{*h,g}, c^{*h,b}, c^{*f,g}, c^{*f,b})$, portfolio shares $(\phi^g, \phi^b, \phi^{*g}, \phi^{*b})$, employment decisions $(n^g, n^b, n^{*g}, n^{*b})$ and a sequence of prices $(p_t, p_t^*, e_t)_{t=1}^{\infty}$ such that individual optimization conditions (2.4) and (2.5) are satisfied and market clearing conditions given above are met. The following proposition ensures an interior monetary equilibrium exists in which people hold both home and foreign currency.

Proposition 2.2.1. *For every $(\sigma \in (-1, 1/Z), \sigma^* \in (-1, 1/Z))$ there exists a unique, interior monetary steady state equilibrium characterized by:*

$$\phi = \frac{1 - \sigma Z}{1 + Z}, \quad \phi^* = \frac{1 - \sigma^* Z}{1 + Z} \tag{2.8}$$

Steady state employment levels (for home and foreign) are the unique solution to these set of equations:

$$\frac{\alpha^g}{g'(n^g)} = \alpha^g n^g (1 + \sigma\gamma) + \alpha^b n^b (\sigma(1 - \gamma)) \tag{2.9}$$

$$\frac{\alpha^b}{g'(n^b)} = \alpha^b n^b (1 + \sigma(1 - \gamma)) + \alpha^g n^g (\sigma\gamma) \tag{2.10}$$

and the consumption levels satisfy:

$$c^{h,g} = \overline{\theta} Y \kappa(\sigma) \quad c^{h,b} = \overline{\theta} Y \frac{(1 - \gamma\kappa(\sigma))}{1 - \gamma} \tag{2.11}$$

$$c^{f,g} = (1 - \overline{\theta}^*) Y^* \kappa^*(\sigma^*) \quad c^{f,b} = (1 - \overline{\theta}^*) Y^* \frac{(1 - \gamma^*\kappa^*(\sigma^*))}{1 - \gamma^*} \tag{2.12}$$

where

$$Z \equiv \frac{1 - \overline{\theta}}{\overline{\theta}}, \quad \kappa(\sigma) = \frac{\phi^g/\gamma + \sigma}{\phi + \sigma}, \quad Y = \gamma\alpha^g n^g + (1 - \gamma)\alpha^b n^b$$

Proof. See Appendix. □

Looking at the consumption equation, we see that out of total home production Y, $\overline{\theta}$ proportion goes to home agents, and the rest goes to foreign agents. $\gamma\kappa(\sigma)$ and $(1 - \gamma\kappa(\sigma))$ determine per capita consumption shares of good and bad type agents in the economy, respectively. We will later prove that $\kappa(\sigma)$ is greater than one, meaning that good types will always be consuming more than bad types.

2.2.3.2 Determination of Equilibrium Inflation Rates

Now we can turn to the government's problem. Utilitarian government for home country will be choosing the level of inflation to maximize:

$$
\begin{aligned}
V^{LC}(\sigma,\sigma^*) = & E_\theta\{\gamma(\theta ln(c^{h,g}) + (1-\theta)ln(c^{f,g})) \\
& + (1-\gamma)(\theta ln(c^{h,b}) + (1-\theta)ln(c^{f,b}))\} \\
& - \gamma g(n^g) - (1-\gamma)g(n^b)
\end{aligned} \tag{2.13}
$$

Government maximizes the weighted average expected utility of a generation t population. Choice of generation does not really matter as any two generations are ex-ante identical, due to our assumption about timing of government announcing σ, once and for all in the very beginning.

Proposition 2.2.2. *Equilibrium level of σ that solves government's problem (2.13) is strictly positive and independent of the level of foreign inflation level.*

Proof. See Appendix. □

Equilibrium money growth rate is strictly positive because of two effects that stem from the basic structure of our model. Terms of trade effect in our model is especially strong due to Cobb-Douglas utility function assumption, therefore an inelastic portion of the foreign portfolio is being held in home currency and government will want to tax that. A second effect for positive inflation is that, even in the absence of terms of trade effect, inflation tax is the only way government can redistribute wealth and choose the optimum level of allocations in the economy.

2.3 Inequality Effects of Inflation, LC Case

We now turn our attention to how individual decision rules respond to changes in inflation level. In particular, we prove in this section that the consumption and earnings inequalities decrease as inflation rises. First, we show that high productive agents work more than low productive agents.

Proposition 2.3.1. *At any level of positive inflation, good types work more than bad types, that is:*

$$n^g \geq n^b$$

holds with equality only if $\sigma = 0$*. Moreover,*

$$\frac{dn^g}{d\sigma} < 0, \frac{dn^b}{d\sigma} < 0.$$

Proof. See Appendix. □

When inflation equals zero, income and substitution effects of a higher α cancel each other out due to logarithmic utility. Therefore good and bad types work the same amount. However, for positive inflation levels, the amount of transfers are proportionately higher for bad types than it is for good types, so income effect dominates substitution effect, for both types. Especially for the poor, transfers are a higher proportion of their wealth, so their work decision is distorted more, as income effect dominates substitution effect even more for them. As a result, good types work more than bad types at positive inflation levels.

As stated in the second part of the proposition, inflation distorts labor supply decisions for both types. This is a standard result stemming from decreased returns to work with higher inflation. Next, we show that they actually consume more than the bad types as well.

Proposition 2.3.2. *Good type agents consume more of both goods in any equilibrium with non-negative inflation rates* [8]*,*

$$\kappa(\sigma) > 1, \quad \frac{(1-\gamma\kappa(\sigma))}{1-\gamma} < 1 \qquad \forall\ \sigma \geq 0$$

and $\kappa(\sigma)$ is decreasing in σ.

Proof. See Appendix. □

Note that $\kappa(\sigma)$ and $\frac{(1-\gamma\kappa(\sigma))}{1-\gamma}$ are per capita consumption shares of both home and foreign production for good and bad types, respectively. This proposition suggests that, at any inflation rate, the shares for good types are always greater than those of low types. As good types work more than bad types,

[8] Actually this is true for all levels of inflation, but negative inflation levels are never an outcome of a steady state monetary equilibrium.

and their productivity level is higher, they will hold more money and consume more.

More importantly, the gap between those shares converge to zero as inflation goes up. There are two effects working in opposite directions. First, bad types decrease their production levels more than good types. However the second effect, i.e. the transfer effect, dominates the first effect as the decrease in labor levels is less than order one, so transfers go up despite the decrease in production levels. As a result, consumption gap decreases.

Now we will analyze the distributional effects of inflation. We use two different measures of inequality. The first one, earnings inequality, is a measure of pre-transfer income inequality which effectively focuses on distortionary effects of inflation on work decisions. The second one, consumption inequality, measures inequality in consumption levels which is equivalent to disposable income in our model[9].

Definition 2.3.1. Earnings inequality is defined as

$$\Delta_{E.I.} = \alpha^g n^g - \alpha^b n^b$$

Let $\mu \in [0, 1]$ be any consumption weight of domestic good used in forming a consumption basket. Then, consumption inequality defined as:

$$\Delta_{C.I.} = (\mu c^{h,g} + (1-\mu)c^{f,g}) - (\mu c^{h,b} + (1-\mu)c^{f,b})$$

[9]Our model is a static one where all earnings are saved when young and consumed when old. Hence, disposable income is completely spent on consumption.

Lemma 2.3.3. *For any $\sigma \geq 0$, $n^g - n^b$ is an increasing function of inflation.*

Proof. See Appendix. □

That is, as inflation rises, bad types decrease their labor decisions more than good types do. This is because of our convexity of disutility assumption (equivalently, concavity of utility from leisure). For a given level of decrease in marginal utility from consumption due to higher transfers, individuals decrease their marginal utility from leisure as well. Already enjoying a higher level of leisure, bad types increase their leisure more compared to good type agents.

Based on our definitions of inequalities, we present our main result of this section. Particularly, we prove that inequality decreases with inflation under local currency case [10].

Proposition 2.3.4. *For any $\sigma \geq 0$, $\Delta_{E.I.}$ and $\Delta_{C.I.}$ are decreasing functions of inflation in the local currency case.*

Proof. See Appendix. □

Intuitively, relative price of one unit of leisure in terms of home consumption good, i.e. $\alpha^i/(1+\sigma)$, is higher for good types than bad types.

[10] We will prove the common currency counterpart of this result in the next section.

Moreover, the gap between these two prices is decreasing in inflation. So, at a higher inflation rate, real returns to work for good and bad types will be closer to each other. Individual optimality requires marginal rate of substitution between leisure and consumption to be equal to their relative prices. As a result, as those relative price ratios for different types converge to each other, and through Lemma 2.3.3, consumption levels should get closer.

2.4 Common Currency (CC) Case

Now we analyze the effects of using a common currency on inflation levels and inequalities. We assume that countries differ only in their fractions of types[11], i.e. $\gamma \neq \gamma^*$. This assumption is sufficient for us to analyze the distributional aspects of monetary union for countries with different inequality levels[12]. Agreeing to a common currency arrangement will imply the use of a single currency issued and governed by a single monetary authority. We will show that the adoption of a common currency will not lead to Friedman Rule, unlike previous literature, due to heterogeneity. Individual problem of a type i home agent in common currency case is as follows:

$$\max_{n_t^i, c_{t+1}^{h,i}(\theta), c_{t+1}^{f,i}(\theta)} E_\theta\{\theta ln(c_{t+1}^{h,i}(\theta)) + (1-\theta) ln(c_{t+1}^{f,i})(\theta)\} - g(n_t^i) \qquad (2.14)$$

[11] We assume that individuals have the same taste distribution across countries.

[12] Given this setup, each country will have a separate optimum level of inflation in the local currency case because they need different levels of redistribution across types.

subject to the following constraint:

$$c^{h,i}_{t+1}(\theta)q^h_{t+1} + c^{f,i}_{t+1}(\theta)q^f_{t+1} = q^h_t n^i_t + \tau^{cc}_{t+1} \equiv I^i_{t+1} \ , \qquad \forall \ \theta.$$

where q^h_t, q^f_t represent home and foreign good prices at time t, respectively, τ^{cc}_{t+1} is transfer[13] and I^i_{t+1} is total disposable income of a type i agent at time $t+1$. In this setting, individuals no longer face the need to choose their portfolio before they see their preference realization. This leads to a two step decision making process where, for given values of θ and I^i_{t+1}, we first get the consumption levels as follows:

$$c^{h,i}_{t+1}(\theta) = \frac{\theta I^i_{t+1}}{q^h_{t+1}} \quad and \quad c^{f,i}_{t+1}(\theta) = \frac{(1-\theta)I^i_{t+1}}{q^f_{t+1}} \tag{2.15}$$

and then we plug this consumption levels into the optimization problem and solve for the optimal labor choices:

$$g'(n^i_t) = \frac{\alpha^i q^h_t \theta}{q^h_{t+1} c^{h,i}_{t+1}(\theta)} = \frac{\alpha^i q^h_t}{I^i_{t+1}} \tag{2.16}$$

[13] It is assumed that per capita nominal transfers are distributed evenly among member countries.

Note here that optimal consumption decisions are functions of observed taste shocks, θs, rather than their expected levels as it was the case under local currency. The portfolio adjustment friction no longer exists and individuals hold their nominal money balances in the form of a single currency and decide how much to buy from each good when they are old.

Under common currency, there are three markets cleared each period, two goods markets and one money market. Home and foreign goods market clearing conditions are as follows:

$$\overline{\theta}(\gamma I_{t+1}^{g} + (1-\gamma)I_{t+1}^{b}) + (1-\overline{\theta})(\gamma^{*} I_{t+1}^{*g} + (1-\gamma^{*})I_{t+1}^{*b}) = q_{t+1}^{h} Y$$

$$(1-\overline{\theta})(\gamma I_{t+1}^{g} + (1-\gamma)I_{t+1}^{b}) + \overline{\theta}(\gamma^{*} I_{t+1}^{*g} + (1-\gamma^{*})I_{t+1}^{*b}) = q_{t+1}^{f} Y^{*}$$

Money market clearing condition is defined by:

$$M_{t}^{cc} = \gamma I_{t}^{g} + (1-\gamma)I_{t}^{b} + \gamma^{*} I_{t}^{*g} + (1-\gamma^{*})I_{t}^{*b}$$

Money stock evolves as:

$$M_{t+1}^{cc} = M_{t}^{cc}(1+\sigma^{cc})$$

Assuming the monetary union follow balanced budgets, tomorrow's transfers are directly financed by money injection. That is,

$$\tau_{t+1}^{cc} = M_t^{cc}\sigma^{cc}$$

2.4.1 Common Currency Equilibrium

We now define the common currency steady state equilibrium. Given money growth rate σ^{cc}, we will first characterize the equilibrium, and then solve the government's problem to find the optimal level of money growth rate in the monetary union.

2.4.1.1 Common Currency Steady State Equilibrium

Given money growth rate σ^{cc}, a common currency steady state equilibrium is a list of consumption allocations $(c^{h,g}, c^{h,b}, c^{f,g}, c^{f,b}, c^{*h,g}, c^{*h,b}, c^{*f,g}, c^{*f,b})$, employment decisions $(n^g, n^b, n^{*g}, n^{*b})$ and a sequence of prices $(q_t^h, q_t^f)_{t=1}^{\infty}$ such that individual optimization conditions (2.15) and (2.16) are satisfied and market clearing conditions given above are met.

Proposition 2.4.1. *For every $\sigma^{cc} > -1$ there exists a unique common currency steady state equilibrium where the steady state employment levels are the unique solution to these set of equations:*

$$\frac{\alpha^g}{g'(n^g)} = \alpha^g n^g(1 + \sigma^{cc}\gamma) + \alpha^b n^b(\sigma^{cc}(1 - \gamma)) \quad (2.17)$$

$$\frac{\alpha^b}{g'(n^b)} = \alpha^b n^b(1 + \sigma^{cc}(1-\gamma)) + \alpha^g n^g(\sigma^{cc}\gamma) \tag{2.18}$$

$$\frac{\alpha^g}{g'(n^{*g})} = \alpha^g n^{*g}(1 + \sigma^{cc}\gamma^*) + \alpha^b n^{*b}(\sigma^{cc}(1-\gamma^*)) \tag{2.19}$$

$$\frac{\alpha^b}{g'(n^{*b})} = \alpha^b n^{*b}(1 + \sigma^{cc}(1-\gamma^*)) + \alpha^g n^{*g}(\sigma^{cc}\gamma^*) \tag{2.20}$$

Proof. See Appendix. □

Due to inelastic and symmetric portfolio shares (i.e. the same distribution of θs across countries), we have a balanced trade scheme (i.e. net exports are zero) and nominal outputs are equal $q^h Y = q^f Y^*$. The reason behind the balanced trade is that, on average, they enjoy each others' good evenly and the portion of transfers that countries spend on each other are equal[14]. Essentially, there are no intercountry transfers in steady state and total money demands are equal in both countries. Therefore, steady state employment levels are determined by equations similar to the ones in local currency case. In other words, equations 2.17-2.20 are analogous to 2.9-2.10.

In this setup, government's problem becomes:

[14]If taste distributions were asymmetric, we would have trade imbalances and intercountry transfers. In that case, it would be harder to isolate the distributional effects we are after.

$$
\begin{aligned}
V^{CC}(\sigma) = & E_\theta\{\gamma(\theta ln(c^{h,g}) + (1-\theta)ln(c^{f,g})) \\
& + (1-\gamma)(\theta ln(c^{h,b}) + (1-\theta)ln(c^{f,b})) \\
& + \gamma^*(\theta ln(c^{*f,g}) + (1-\theta)ln(c^{*h,g})) \\
& + (1-\gamma^*)(\theta ln(c^{*f,b}) + (1-\theta)ln(c^{*h,b}))\} \\
& - \gamma g(n^g) - (1-\gamma)g(n^b) - \gamma^* g(n^{*g}) - (1-\gamma^*)g(n^{*b})
\end{aligned} \tag{2.21}
$$

The only difference in government's problem compared to the previous case is that the population doubled. However, if we plug the consumption levels in this objective function, we will see that σ will now affect both country production levels and there is no benefit of high inflation through the channel it was beneficial in the previous case (i.e. inflation tax on foreigners).

Proposition 2.4.2. *The optimal level of money growth rate in a common currency area is strictly positive and cannot be greater than the local currency equilibrium levels of money growth rates in both countries.*

$$0 < \sigma^{cc} < \max\{\sigma^{LC}, \sigma^{*LC}\}$$

Proof. See Appendix. □

Here σ^{LC} and σ^{*LC} are optimal money growth rates in the pre-common currency case for home and foreign countries, respectively. This proposition states that the inflation rate has to go down in at least one of the countries after forming the monetary union. In other words, when two countries with different population ratios of good types decide to form a monetary union, optimum level of inflation for the union will either be lower than or in between the local currency inflation levels.

There are two key parameters which determine where the optimum inflation will fall when they switch to use a common currency. First one is $\overline{\theta}$, which is decisive about how dependent the countries are on each other and how much benefit there is to gain from forming a monetary union. The higher the dependency is, the more likely it is that the inflation will fall below the pre-union inflation rates in both countries. This result stems from the fact that the common currency level of inflation is independent of the dependency ratio $(1-\overline{\theta})$, therefore it will fall to a certain level regardless of the initial inflation levels. So, the higher the initial levels of inflation are, the more likely it is to experience a fall in inflation for both countries. On the other hand, in cases where the initial levels of inflation were low (very little beggar-thy-neighbor policy due to high $\overline{\theta}$s), the country with the lower initial rate of inflation is more likely to experience a rise in the inflation level. Therefore, as we prove later, level of inequality in each country might fall or rise after joining the union depending on this parameter.

The second key parameter is the productivity ratio of good and bad types[15], i.e. α^g/α^b. This ratio determines the intensity of inflationary policy needed to redistribute resources between the types. The higher this ratio is, the more likely it is that the common currency level of inflation falls in between the local currency levels. The reason behind this finding is the concavity of the value function with respect to σ. As there are two effects determining the optimal inflation level in the local currency case (heterogeneity and beggar-thy-neighbor policy) and heterogeneity is the only source of positive inflation in the common currency case, the latter is amplified more with a higher productivity ratio of types. Therefore, as countries form a monetary union in an environment with a higher ratio of productivity levels, it is more probable that inflation will go up in one of the countries, and levels of inequalities will move in opposite directions.

Figure 2.1 depicts the frontier which separates the possible cases into two areas for common currency inflation level[16]. The area to the left of the frontier contains the parameters for which the common currency level of inflation is lower than the local currency optimum inflation levels of both countries. For the parameters that lie to the right, the common currency inflation level might fall in between the local currency optimum inflation levels. For parameters on the right side of the frontier, if the two countries have sufficiently different levels of heterogeneity (determined by γ and γ^*), inflation levels will

[15]Note that the optimum level of inflation depends only on the ratio of productivities, not their levels.

[16]We used $g(n) = \frac{9}{2}n^2$ to match the steady state equilibrium employment levels to 1/3 when there is no inflation.

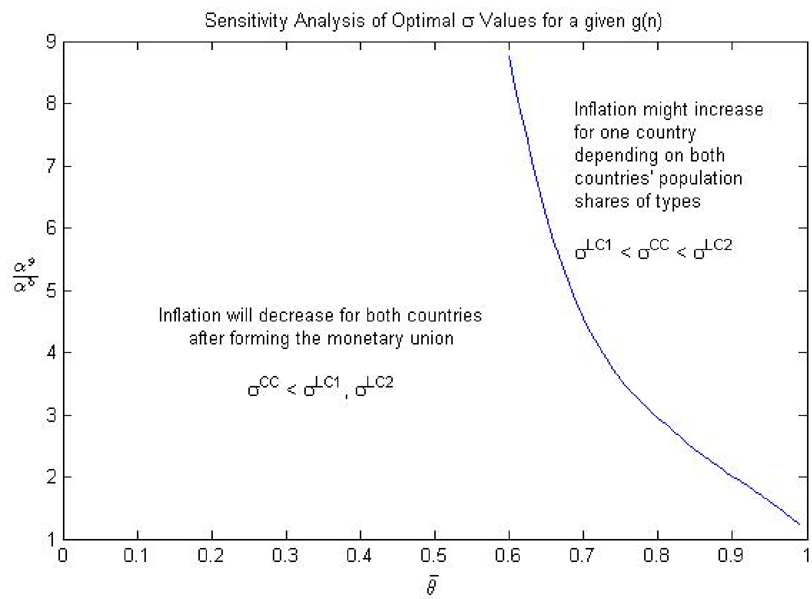

Figure 2.1: Sensitivity Analysis

go in opposite directions in the two countries. The country with the more symmetric distribution of types, e.g. $\gamma = 0.5$, will experience a fall in inflation after joining the monetary union while the other country, e.g. $\gamma = 0.1$ or $\gamma = 0.9$, will have a higher inflation.

There are two effects determining the new inflation rate. The first one is the elimination of the trade frictions. This is a reducing effect on inflation for both countries. Because countries can not tax foreigners through monetary policy in the common currency case. The other one is the distributional effect. This effect moves in opposite directions for the two countries unless the countries are identical (distributional effect is zero in this special case). For the more unequal country, distributional effect is going to be negative because joining a monetary union with a more equal country will lead to a lower common currency inflation rate. Hence the two effects work in the same direction and result in a decrease in inflation for the more unequal country. The more equal country, however, will experience an increasing distributional effect on inflation. Therefore, for a given set of parameters that lie to the right of the frontier depicted in the figure above, the more equal country will have an increase in inflation if the two countries are sufficiently different in inequalities.

Now we will state our main proposition of this paper. This result is the counterpart of proposition 2.3.4, and shows that inequalities are decreasing in inflation in the common currency case as well. Moreover, we show that one can simply compare the measures of earnings and consumption inequalities before and after the formation of common currency, therefore differences between the two steady states can be analyzed.

Proposition 2.4.3. *As defined in 2.3.1, $\Delta_{E.I.}$ and $\Delta_{C.I.}$ are decreasing functions of inflation for any $\sigma \geq 0$ in the common currency case.*

Proof. See Appendix. □

Note here that, $\Delta_{E.I.}$ and $\Delta_{C.I.}$ have the same exact responses to σ as in the local currency case. In other words, one can compare the inequality levels only by looking at the changes in inflation rates.

Combining propositions 2.4.2 and 2.4.3, possible outcomes of establishing a common currency area can be analyzed in terms of inequalities. Since inequalities respond to inflation monotonically, either both countries will have a higher inequality due to lower inflation or inequalities will move in opposite directions depending on the aforementioned conditions.

Even without any trade frictions that exist in the local currency case, a positive inflation rate would be desirable in this environment due to existing heterogeneity. That is, Friedman rule does not apply here because a positive amount of redistribution increases total welfare due to concavity. Countries with different demographics (i.e. different γs) need different amounts of transfers. Joining a monetary union will change the demographics (common central bank will take the whole population into account) and hence will lead to a sub-optimal amount of transfers for both countries. Given this point, how close the countries are in terms of their γs will play an important role determining the benefits from forming a union. In the extreme case, where both countries have the same exact γ, there will be no loss from surrendering a country's monetary tools to a common central bank.

2.5 Conclusion

In this paper, we studied how changes in inflation associated with the adoption of a common currency can alter the levels of consumption and earnings inequalities. We showed that asymmetric demographic structures of countries combined with the adoption of a common currency affect these inequalities in each country in a different way.

There is a monotonically negative relation between inflation and inequality in our setting. Specifically, individuals are born with an unobservable idiosyncratic shock[17] and money is the only saving technology available. Benevolent governments redistribute seignorage income. We proved that earnings and consumption inequalities are decreasing functions of inflation. Intuition behind this finding is that inflation, through its redistributive feature, taxes income away from the rich. Suffering from high levels of taxation, the rich has an incentive to decrease their output more than the poor [18]. Total output goes down and together with decreasing earnings inequality, consumption inequality also falls as inflation rises.

Adoption of a common currency results in an inflation rate lower than the one in the local currency case in at least one of the countries. We provide conditions under which it falls for both countries. The main reason for the decrease is, with establishment of a monetary union, governments no longer need to exhibit "beggar thy neighbor" policies. Particularly, in the local currency case, governments levy inflation tax on foreign individuals who have inelastic portfolio decisions. Therefore, governments have an incentive to increase inflation rate more than the common currency rate of inflation. On the other hand, the main reason for a possible increase of inflation in one country is demographic asymmetry between countries (the country with an initially low level of inflation will experience a rise in inflation in this case).

One important assumption in our analysis is the identical taste dis-

[17]That renders the fiscal tools not implementable because of unobservable types.
[18]This takes us back to Proposition 2.3.1.

tributions across countries. Relaxing this assumption would lead to trade imbalances and hence intercountry transfers of resources which might be an important further study to pursue. Another interesting extension could be including labor mobility as it would create non-trivial results on how income distribution in both countries are going to be affected by migration.

Chapter 3

Direct vs. Indirect Measures of Inflation Expectations

3.1 Introduction

The ultimate goal of any central bank policy is to achieve and maintain price stability. As an unobserved component, inflation expectations are very crucial for determining future inflation, mainly through price and wage setting behaviors. Therefore those expectations need to be measured with sufficient precision. In this study we derive bounds for inflation expectations for the US and Turkey using the relationship between interest rates and inflation expectations, and compare these bounds to the results of survey data in these two countries. Particularly, we recalculate inflation bounds in Ireland (1996b) using one-year returns and compare these bounds with the direct measures of inflation expectations, which are the median responses of the Livingston survey. We apply the same procedure to Turkish data in an attempt to seek a plausible indicator for Turkish inflation expectations[1].

Our results show that, for US data, the inflation bounds suggested by

[1]As we will show later in the paper, restricting our attention to a developed country, US, might lead to adverse conclusions and we believe Turkish economy is a good case for developing countries.

Ireland (1996b) are more volatile than survey results, and too narrow to contain them, due to low standard errors in consumption growth series stemming from high persistence. This result seems to be discouraging for the usefulness of bounds, but the Turkish case offers better results in favor of this approach. Calculated real interest rates are very volatile in Turkey and therefore movements in the nominal interest rates themselves cannot be used as an indicator of changes in inflation expectations. Taking risk premia into account, we derive bounds on inflation expectations and they are in accordance with the results of the Consumer Tendency Survey in Turkey.

No matter which type of monetary policy is preferred, discretion or a rule, measuring agents' expectations about inflation has been an important part of the research held by economists in central banks. Under a discretionary policymaker, the monetary policy is a game between the central bank and individuals where the central bank optimizes its policy outcomes subject to the individual expectations [2]. Hence, central banks need information about individual expectations and should conduct research on measuring inflation expectations. On the other hand, under an implicitly followed or an explicitly defined policy rule (e.g. inflation targeting), it is essential to obtain information on individual expectations. The success of a full-fledged inflation targeting regime relies on the credibility of the central bank and this credibility is measured by forecast errors (see Johnson, 1998). As Mishkin (1999) claims, inflation targeting is actually practiced very far from a rigid rule and

[2] See Barro and Gordon (1983) for the positive theory of monetary policy and inflation.

requires that the central bank use all available information to determine the appropriate policy actions to achieve its inflation target [3]. King (1994) and Bowen (1995) emphasize the importance of inflation expectations: under inflation targeting, the inflation expectations are the intermediate goal and should be explicitly targeted. Svensson (1997) shows that inflation targeting implies inflation *forecast* targeting, and it is the best solution under the existing problems in implementation, monitoring, and evaluation of the inflation targeting regime. The problems stem from the significant control lag, which, as he mentions, 1.5 to 2 years. Since accountability and commitment mechanisms are the main strengths of inflation targeting regimes, those problems reduce the efficiency of the regime. Inflation forecast targeting solves this problem and the central bank's inflation forecast becomes an intermediate target. Nevertheless, Bernanke and Woodford (1997) find that direct targeting of private-sector forecasts may lead to indeterminacy of the rational expectations equilibrium. Moreover, they also show that stabilization of the forecast has other undesirable properties. Still, they argue that private-sector forecasts and forecasts inferred from financial markets should be part of the information gathered by the central bank.

Signals about changes in inflation expectations through several variables and their importance in monetary policy have also been widely studied. Goodfriend (1993) measures the Fed's credibility by movements of inflation ex-

[3] In more recent research, Mishkin (2007) shows the direct implications of inflation expectations on inflation realizations and hence overall economic performance.

pectations reflected in the long-term interest rate. According to Goodfriend, for much of the 1979-1992 period the Fed's policy actions were directed at resisting inflation scares signaled by large sustained increases in the long-term interest rate. Asset prices, on the other hand, are high frequency data and carry an important amount of information about individual expectations in an efficient market. Among others, Cecchetti et al. (2000) find strong support for including stock prices directly in the central bank's policy rule whereas Bernanke and Gertler (2000, 2001) argue that monetary policy should not respond to changes in asset prices except when they signal changes in inflation expectations.

Literature on the relationship between future inflation and interest rates starts with Fisher's (1907) early work with a postulate that nominal interest rates, in a perfect foresight world, are equal to the real rate of return plus the future rate of inflation. A vast number of researchers have agreed on this principle. However, the discussion about the composition of the two components has been immense [4]. Two views have been raised about the relationship between the real rate and inflation expectations. The first view, following Mundell (1963) and Tobin (1965) claims that the expected real return component of nominal interest rates is negatively related to the expected inflation component. The intuition behind this view is that in an environment with high inflation, agents economize on their nominal asset holdings and hold more real balances which result in a lower marginal product of capital. The second view

[4] For a very detailed literature survey, see section 3 of Stock and Watson (2003).

is contrary to the first one. This view started with Fama (1975), and advocates the constancy of the real rate through time, and hence that nominal interest rates can be used as a signal of future inflation expectations.

Using the short-term US Treasury Bills data, particularly regarding one to six months treasuries, Fama (1975) found that the real interest rate is fairly constant through time and expected inflation is responsible for the variations in nominal interest rates. He used an autoregressive time series model for the inflation rate and showed that the bond market is efficient, in the sense that nominal interest rates contain all the information about future inflation that is in the time-series of past inflation. Subsequent comments and studies by Hess and Bicksler (1975), Joines (1977), Carlson (1977), Garbade and Wachtel (1978), Fama (1976), Fama and Gibbons (1982) and Crowder and Hoffman (1996) presented tests that rejected Fama's hypothesis. Nelson and Schwert (1977) asserted that Fama's tests had very little power because the lack of autocorrelation in ex-post real rates does not necessarily imply the constancy of ex-ante real rates, especially if the variance of forecast errors is high compared to the variance of the ex-ante real rate. More importantly, they claimed that the market draws on information beyond the past inflation rates. Therefore, an autoregressive time-series model might be misleading. Using quarterly data, Mishkin (1981) tried to tackle this question with the help of a large set of explanatory variables, particularly growth in monetary aggregates and output as well as the unemployment rate, investment to capital ratio and first order lags, in an ordinary least squares regression. His findings also rejected Fama's (1975) hypothesis and he also found evidence for the negative relationship between inflation expectations and the real interest rate, reaffirming the Mundell-Tobin effect.

Discussion of the relation of inflation expectations to the ex-ante real rate has extended even further after the uncertainty was introduced into the Fisher equation by Lucas (1978). He suggested that, in a world with uncertainty, nominal interest rates consist of a risk premium along with the real rate of return and an inflation premium. Thus, variations in nominal interest rates could be stemming from other sources than inflation expectations. In particular, his model indicates that movements of nominal interest rates will accurately signal changes in inflationary expectations if and only if real interest rates are stable and risk premia are small. None of these three components are observable, but Ireland (1996b) managed to characterize bounds on inflation expectations using the risk premium. Using ten-year US Treasury bond yields, he showed that real interest rates are quite stable. Therefore, natural limits on risk premia [5] allowed him to draw the bounds on inflation expectations, which are pretty close to each other for US data due to a low risk premium. Ayuso and Salido (1998) applied his methodology to Spanish data and compared the ex-ante real rates with the ex-post real rates. They found that most of the difference between the ex-ante and ex-post real interest rates come from agents' expectation errors; i.e., bounds on expected inflation driven from Lucas's model are not wide enough to contain the inflation level.

[5] As will be explained later, there are natural limits on risk premia.

Surveys on expectations about macroeconomic variables present direct measures on individual expectations and have the main advantage that expectations derived from survey results are undistorted by any auxiliary assumptions compared to the indirect measures summarized above (see, for example, Berk (2000)). There are disadvantages to using surveys as well, as survey results are vulnerable to sampling errors and the specific questions asked might affect the outcome significantly. More importantly, participants may not give their decisions based on their responses in the survey (see Chan-Lee (1980)). For further discussion about the properties of surveys of expectations, see Roberts (1997).

In a recent study, Ang et al. (2007) found that surveys about individual expectations forecast inflation significantly better than a wide range of forecasting models which can be classified under three approaches: namely time series ARIMA models, regressions using real activity measures motivated from the Phillips curve, and regressions using term structures of interest rates. They used three main surveys available for US data (the Livingston, Michigan, and the Survey of Professional Forecasters (SPF) surveys) and found that SPF performs slightly worse than the Livingston and Michigan surveys. Moreover, they claimed that although there is theoretical support that combining forecasts of many approaches (see Stock and Watson, 2002) outperforms single forecasting models, combining their span of forecasts of inflation does not generally lead to better out-of-sample forecasting performance empirically. Our approach differs from theirs in the sense that we don't analyze the performances of inflation forecasts but rather compare direct and indirect approaches that yield inflation expectations.

Research on inflation expectations in Turkey is relatively new and purely empirical. In one of the earlier works, Sahinbeyoglu and Yalcin (2000) analyzed inflation expectations in Turkey by applying regressions with several explanatory variables, following Mishkin (1981). They found that the term structure of nominal interest rates has valuable information about inflation expectations. However, their findings suggest a negative relationship between the term structure of nominal interest rates and the future path of inflation, contrary to relevant studies in the literature. They related this result to the instability of the financial markets in Turkey.

Berument and Malatyali (2001) used a time series approach to analyze the relationship between interest rates and inflation in Turkey for the 1989-1998 period. They employed GARCH models to identify anticipated and unanticipated inflation. Their findings support the existence of the Mundell-Tobin effect for the case of Turkey, suggesting that the chronically high level of inflation leads to low real rates and stimulates the Turkish economy [6]. Our study departs from theirs as well as from other relevant studies using Turkish data in a couple of ways. First, we use a forward-looking model for the inflation expectations while they assume purely adaptive expectations behavior. Expectations should not be modeled by pure time-series models, because

[6] In a more recent paper, Gul and Acikalin (2008) rejected Fisher's hypothesis for Turkish data without using risk premia in the regression equation.

individuals have a larger set of information than just the inflation series, and they use this set fully in their decision-making processes. Therefore, similar to Ireland (1996b), we use individual consumption decisions to derive information about inflation expectations. Second, our approach doesn't identify inflation components; rather, it presents inflation bounds incorporated with the inflation risk premium. Our main contribution to this literature is comparing the Turkish survey data with these bounds and testing the usefulness of these survey results.

Literature using Turkish survey data on expectations is relatively limited, mainly due to the fact that a well established survey only dates back to 1987. The first survey on expectations in Turkey has been conducted on participants from a pool of firm managers, and represents the expectations of only one side of the economy. Two recent surveys on expectations aimed to fill this gap. Research based on these surveys started with Karadas and Ogunc (2003) where they tested and could not reject the rationality of inflation expectations of the firm side. On the other hand, a set of regression analyses by Kara and Kucuk-Tuger (2005) showed that formation of expectations, measured directly through three expectations surveys available in Turkey, were highly biased and inefficient [7]. Their findings point to a significant correlation of expectation errors with lagged effects of exchange rate movements suggesting a problem in agents' understanding of the exchange rate pass-through in Turkey. A more

[7] Barlas-Ozer and Mutluer (2005) also found evidence on systematic bias in inflation expectations.

recent study in 2009 by the same authors claimed a decrease in the degree of this bias and inefficiency, and that the level of inflation in Turkey has become relatively stable.

The outline of the paper is as follows. The next section introduces the model we use to analyze the relationship between interest rates and inflation. Section 3.3 explains the estimation methodology. The data used in this study for the US case is presented in section 3.4 and the results are given in section 3.5. The Turkish data is explained in section 3.6 and the results are presented in section 3.7. Finally, section 3.8 concludes the paper.

3.2 The Model

In this section, we introduce a version of the theoretical model originally proposed by Lucas (1978). Our model economy is populated by a continuum of infinitely lived households. The representative agent receives a stream of income, y_t. Each period, he chooses how much to consume c_t and how much to invest on two assets: one real asset b_t that costs one unit of consumption good at time t and returns r_t consumption good at time $t+1$, and one nominal asset B_t [8] costs P_t at time t and returns R_t at time $t+1$ that can be traded with consumption good at the price P_{t+1}.

There is uncertainty about future variables that will help us form the bounds on inflation expectations following Ireland (1996b). The uncertainty is

[8] All nominal variables are represented in capital letters throughout the paper.

about future prices, income, consumption, interest rates, and bond holdings. That is, our representative agent may not learn the exact values of P_t, y_t, c_t, R_t, r_t, B_t, and b_t until the beginning of period t; before then, he regards these variables as random. As far as timing is concerned, representative agent receives his period income and the returns on their assets invested previously, observes period values of the variables listed above and allocates his period resources in consumption and investment for future periods. The agent faces the following optimization problem:

$$\max E_t \left\{ \sum_{j=0}^{\infty} \beta^j ln(c_{t+j}) \right\} \tag{3.1}$$

subject to the following budget constraint:

$$c_t + b_t + B_t/P_t \leq y_t + r_{t-1}b_{t-1} + R_{t-1}B_{t-1}/P_t \tag{3.2}$$

Solution to this optimization problem yields the following two conditions relating bond returns to expected inverse consumption growth and expected inflation.

$$1/r_t = \beta E_t[(1/x_{t+1})] \tag{3.3}$$

$$1/R_t = \beta E_t[(1/x_{t+1})(1/\pi_{t+1})] \tag{3.4}$$

where $x_{t+1} = c_{t+1}/c_t$ and $\pi_{t+1} = P_{t+1}/P_t$ are the rate of consumption and inflation, respectively. The first equation is relating the expected consumption ratio to ex-ante real interest rate. The second equation presents this relation in terms of nominal variables, i.e. nominal interest rates and expected inflation rate. Even though the ex-ante real interest rates are unobservable, this equation lets us use consumption data as a way to obtain an estimate for them. One can rewrite equation (3.4) as:

$$1/R_t = \beta Cov_t[(1/x_{t+1}), (1/\pi_{t+1})] + \beta E_t[1/x_{t+1}]E_t[1/\pi_{t+1}] \tag{3.5}$$

combining with equation (3.3), we get:

$$1/R_t = \beta Cov_t[(1/x_{t+1}), (1/\pi_{t+1})] + (1/r_t)E_t[1/\pi_{t+1}] \tag{3.6}$$

Equation (3.6) is a generalized version of the well-known Fisher equation, which relates real interest rates to inflation and nominal interest rates. This version of Fisher's equation does that under the existence of risk stemmed from uncertainty. Sign of the covariance term here determines how the nominal interest rates are affected by the relation between inverse consumption growth and inflation rate. This risk premium term accounts for the uncertainty about future variables and will help us derive the bounds on inflation expectations. To investigate this relationship further and derive the bounds, we follow by replacing the risk premium term as:

$$\beta Cov_t[(1/x_{t+1}), (1/\pi_{t+1})] = \beta \rho_t Std_t[1/x_{t+1}]Std_t[1/\pi_{t+1}] \tag{3.7}$$

where ρ_t is the correlation coefficient defined by:

$$\rho_t = Cov_t[(1/x_{t+1}), (1/\pi_{t+1})]/\{Std_t[1/x_{t+1}]Std_t[1/\pi_{t+1}]\} \tag{3.8}$$

Using the fact that the correlation coefficient has to be between -1 and 1, we derive the following inequality:

$$Std_t[1/x_{t+1}]Std_t[1/\pi_{t+1}] \geq Cov_t[(1/x_{t+1}),(1/\pi_{t+1})] \geq -Std_t[1/x_{t+1}]Std_t[1/\pi_{t+1}] \tag{3.9}$$

This inequality puts bounds on the covariance term we are interested in. Following Ireland (1996b), we impose the additional assumption on the size of the coefficient of variation for $1/\pi_{t+1}$:

$$Std_t[1/\pi_{t+1}]/E_t[1/\pi_{t+1}] \leq 1 \tag{3.10}$$

As Ireland (1996b) has done it for US case, we justified this assumption by looking at the Turkish data as well and found that the coefficient of variation never exceeded 0.05 for 1998-2008 period. Hence, similar to Ireland (1996b), our bounds are extremely conservative.

In the light of equation (3.10), rearranging equation (3.9) using (3.5) gives us:

$$\begin{aligned} \beta R_t\{E_t[1/x_{t+1}] + Std_t[1/x_{t+1}]\} &\geq 1/E[1/\pi_{t+1}] \\ &\geq \beta R_t\{E_t[1/x_{t+1}] - Std_t[1/x_{t+1}]\} \end{aligned} \tag{3.11}$$

This is almost exactly what one needs to derive the bounds on expected inflation. If we use the approximation:

$$1/E_t[1/\pi_{t+1}] \approx E_t[\pi_{t+1}] \tag{3.12}$$

then we have the bounds ready to be estimated. The width of the bounds will be dependent on the size of the risk premium, which in term will be estimated using the consumption ratio using aggregate consumption data. Now we move on the next section for details on how we estimate these bounds.

3.3 Estimation Methodology for the Real Interest Rate and Bounds on Expected Inflation

We use the same estimation technique proposed by Ireland (1996b). The relationship between observed variables, nominal interest rate and consumption, and unobserved variables, real interest rate and bounds on expected inflation, are proposed by equations (3.3) and (3.11). The only two unknowns in these equations are $E_t[1/x_{t+1}]$ and $Std_t[1/x_{t+1}]$, namely expectation and standard deviation of next period's inverse growth rate of aggregate consumption, and can be estimated through a time series model fit to $1/x_{t+1}$. Now, for convenience, let $g_{t+1} = 1/x_{t+1}$ and assume that g_{t+1} follows an AR(1) process such that

$$g_{t+1} = \gamma + \rho g_t + \epsilon_{t+1} \tag{3.13}$$

where γ is a constant and ρ is the AR(1) parameter. ϵ_{t+1} is the random error term and satisfies

$$E_t[\epsilon_{t+1}] = 0, Std_t[\epsilon_{t+1}] = \sigma, E_t[\epsilon_{t+1}\epsilon_{t-j}] = 0, E_t[\epsilon_{t+1}g_{t-j}] = 0 \ \forall j \tag{3.14}$$

where σ is constant through time. Next, we define the data we use for US.

3.4 US Data

Our model period is one quarter, similar to Ireland (1996b), but we use annual bond yields instead of ten-year returns, i.e. 4-period-ahead expectations are used. Since the model period is finer than the interval of bond yields, estimation using ordinary least squares give consistent estimates of AR parameters but biased σ estimates (see Hansen and Hodrick (1980) [9]). Consistent estimates of σ are derived using the method proposed in Hansen and Hodrick (1980), modified as suggested by Newey and West (1987).

We analyzed 1959:1 to 2009:1 period for US data. The nominal interest rate is measured by the market yield on U.S. Treasury bonds at 1-year constant maturity achieved from the Federal Reserve database. Per capita consumption values are found by dividing the seasonally adjusted series of real personal aggregate nondurables and services expenditures [10] by the size of the noninstitutional civilian population, ages 16 and over [11].

3.4.1 Livingston Survey

As discussed in Croushore (1997), the Livingston survey is the oldest survey on expectations. Survey participants are selected mainly from firm

[9] Hansen and Hodrick (1980) further show that k-step-ahead OLS estimator is dominant to the OLS estimator proposed by the resampling at every kth integer in the sense that (1) the latter exceeds in error variance over the former by a positive definite matrix, and (2) using the former has a higher power in testing the null hypothesis. Therefore, the estimation strategy used in our paper is superior to the natural alternative of adjusting the model period to one year.

[10] Consumption Data Source: Bureau of Economic Analysis.

[11] Population Data Source: Labor Force Statistics from the Current Population Survey.

managers, investment and commercial bankers, professors and professionals from labor organizations, government and insurance companies. Twice each year, they are asked about their forecasts of a wide variety of macroeconomic variables with a forecast time span ranging from current month to 10 years. We calculated percentage difference between median responses of forecasts for the consumer price index (CPI) level 12 months after the survey date and that for current survey date [12].

3.5 Results for US Data

Results for US data is depicted in Figure 3.1. Bounds for inflation expectations are far wider in our model based on one-year returns compared to ten-year returns of Ireland's, bound width is between 1.32% and 1.52% in our model while it is 0.15% to 0.17% in Ireland's. However, they are still too narrow to contain survey results. Particularly, bounds do not contain survey results 53% of the time. The Livingston survey results offer a much smoother path for the inflation expectations than the expectations derived from our model. The main reason behind this result is the excess volatility in nominal interest rates compared to inverse growth in consumption. With a lower variability in the real rate suggested by the observed stable path of inverse consumption growth, inflation expectations capture most of the variability in nominal rates.

[12] Livingston Data Source: Federal Reserve Bank of Philadelphia.

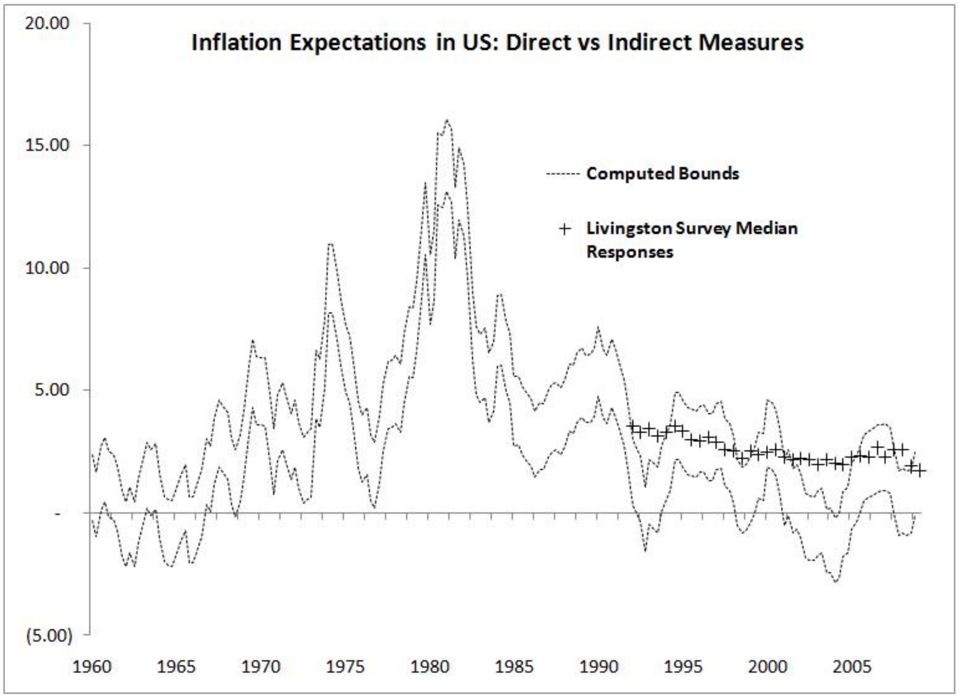

Figure 3.1: Inflation Expectations in US: Direct vs Indirect Measures

We now turn our attention to Turkish data where there is higher variability in real rates and risk premia as it will be shown later below.

3.6 Turkish Data

This section analyzes 2000-2009 period for Turkish data. There are reasons for this choice. First, Turkey experienced a disinflation and stabilization process starting from 2000 and a more stable state has been reached by the end of 2003. These two different environments offer a good analysis diversity. Second, and more importantly, data availability on surveys limits our set of possible dates. Only one of the surveys was available before 2001 while the other two surveys we analyzed have starting dates of 2001 and 2003.

Data is gathered as follows. The nominal interest rates are yearly compounded interest rates of treasury discounted auctions [13], available monthly for our sample period. There have been three months where the Turkish Treasury did not auction bills but since no two or more such instances occurred in a certain quarter, we just ignored those dates when we get quarterly averages. Consumption data is obtained by dividing seasonally adjusted private final consumption expenditure figures [14] by the estimated quarterly population, ages between 15 and 64. Mid-year population estimates and population growth rates are combined with age dependency ratio [15] and interpolated to achieve quarterly population figures.

3.6.1 Consumer Tendency Survey

Starting from 2003, TURKSTAT and CBRT have jointly conducted the Consumer Tendency Survey (CTS), which aims at measuring consumer tendencies and expectations for general economic course, job opportunities, personal financial standing and market developments in order to assess their expenditure behavior as well as their expectations. The scope of the survey includes all individuals who are 15 and above and have a job that provide

[13]Nominal Interest Rates Source: Turkish Undersecretariat of Treasury.
[14]Consumption Data Source: OECD Quarterly National Accounts Dataset, LNBQRSA measure.
[15]Population Data Source: TURKSTAT.

income, in urban or rural areas of Turkey. Survey frequency is one month and the participant size changes between 7100 and 8700 for the 2003-2009 period. Inflation expectations are asked as the direction of changes in prices over the next 12 months and hence point estimates of inflation expectations are unavailable and need to be derived. A recent study by Oral (2009) that quantifies answers about inflation expectations of this survey is used for this purpose.

3.6.2 Survey of Expectations

The Survey of Expectations (SoE) has been conducted by CBRT in order to closely monitor the expectations of experts, professionals and decision makers from the financial and real sectors. The survey aims to provide direct measures for expectations of consumer price inflation, interest rates, exchange rate, current account balance and gross national product growth rate. It is conducted twice a month, in the first and third weeks of every month. A non-probabilistic sampling method based on participation of selected volunteers is used due to the small sample size of the survey. Size of the participation varies between 42 and 102 for the 2001-2009 period. Point estimates for the relevant variables are asked to survey participants. The appropriate mean is calculated by using mean, median, mode, alpha-trimmed mean and outlier analysis by the CBRT and is the main measure used in this paper.

3.6.3 Business Tendency Survey

CBRT has been carrying out the Business Tendency Survey (BTS) since December 1987. BTS is a monthly survey and produce indicators that reflect the short-term tendencies in the manufacturing industry. The survey compiles the assessments of the senior managers on the recent past, current and expected future course of business environment. Since the survey participants are from the production side of the economy, producer prices inflation is asked instead of consumer prices inflation. Therefore, results derived from this survey is only for comparison purposes.

3.7 Results for Turkish Data

We first derive ex-ante real interest rates from our model and compare them with the ex-post real rates calculated using nominal returns and actual inflation. Figure 3.2 depicts both series [16]. It can be seen as a data fact that ex-post real rates are highly volatile. Even though the induced ex-ante real rates are less volatile than the ex-post rates, they vary within a range of -6.9% to 17.6%, which makes it impossible to infer inflation expectations movements directly from a change in nominal interest rates. Therefore, deriving bounds for Turkish inflation expectations is more important and essential compared to US case.

The bounds for inflation expectations are derived for Turkish data and

[16] Note that we covered 1998-2009 period in the figure while our time period for comparison purposes is 2000-2009.

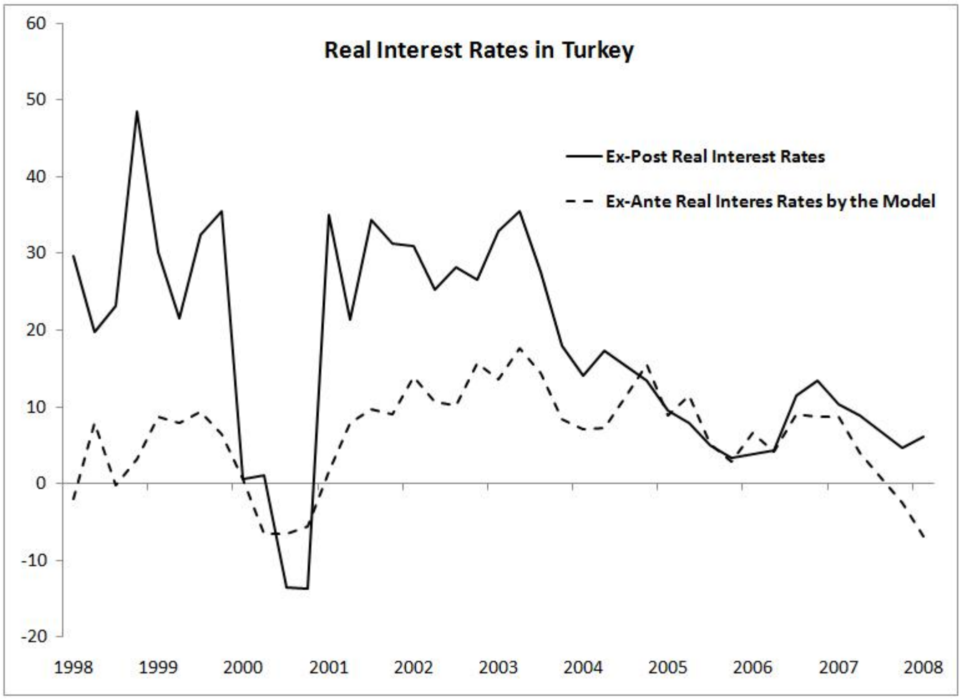

Figure 3.2: Ex-ante and Ex-post Real Rates in Turkey

compared with the three different expectations surveys mentioned above. Our model is expected to capture the inflation expectations of a representative consumer, therefore one can expect bounds computed from our model to contain survey results from CTS better than the other two surveys. Hence, we first analyze the Consumer Tendency Survey in Figure 3.3. Actual inflation series is also drawn for comparison purposes. Because of the late availability of the survey, we can make a comparison only for the stable inflation path starting from late 2003. For this same reason, an analysis of the disinflation process in Turkey, during 2000-2003, is not possible with this particular survey data.

Our results show that the CTS responses are contained within the bounds for the whole sample period.

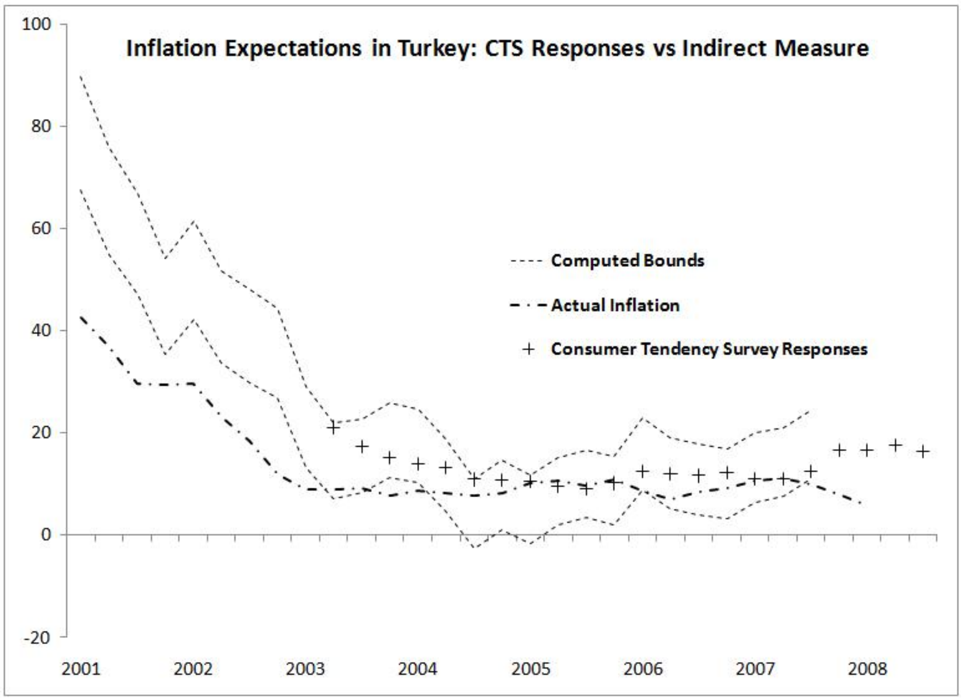

Figure 3.3: Inflation Expectations in TR: CTS vs Model

The survey results of SoE is one of the main indicators of the economy followed closely by CBRT. We can observe in Figure 3.4 that survey results could not be contained well by our bounds most of the time. The failure rate is 52% for the full sample period and 32% for the 2003-2008 period.

Although the participants of the BTS are only firm managers and they are asked about whole sale price inflation rather than inflation in CPI, we present its results in Figure 3.5 for comparison purposes. Our bounds seem to

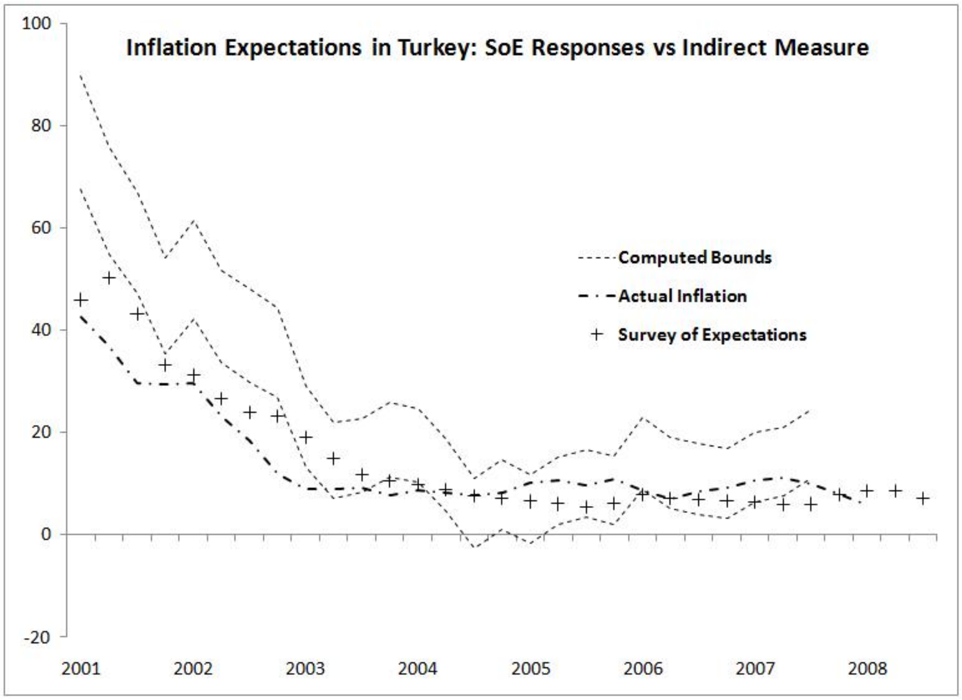

Figure 3.4: Inflation Expectations in TR: SoE vs Model

capture the levels and movements in inflation expectations measured by BTS much better than those by SoE, with a failure rate of 30% for the full sample period.

We can observe a systematic bias in inflation expectations measured by both approaches in the sense that expected inflation is higher than actual inflation for most of the time, especially during disinflation process. This result complies with the previous literature. In particular, Johnson (2002) listed the relevant literature suggesting that in the early years of inflation targets, expected inflation exceeds actual inflation, and in observing unexpected disin-

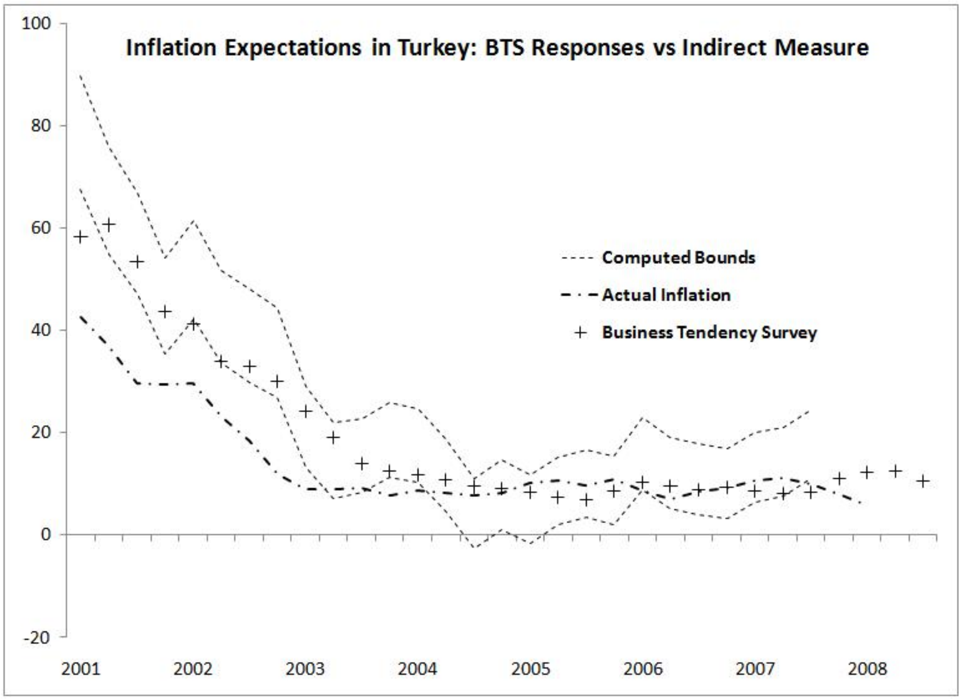

Figure 3.5: Inflation Expectations in TR: BTS vs Model

flation, infer that inflation targets did not shift expected inflation very much.

3.8 Conclusion

Measuring inflation expectations is one of the main goals for central banks. There are direct and indirect measures available to central banks and many different techniques have been proposed in the literature. In this study, we tested the bounds of inflation expectations obtained from Ireland (1996b), an indirect measure, using multiple survey results, a direct measure, in two countries, US and Turkey. Our results indicate that, those bounds do a better job containing the survey results in Turkey compared to US. The main reason behind this fact is the sensitivity of the Ireland's methodology to the movements in consumption growth rates. As the estimate for the ex-ante interest rates are calculated using the consumption growth rates in our model, and Turkish consumption data is a lot more volatile than its US counterpart, inflation expectations bounds for Turkey are a lot wider than they are for US case.

A secondary result obtained from our analysis is that, unlike in US, real interest rates are extremely volatile in Turkey and movements in nominal interest rates can not be used to predict the changes in inflation expectations. Due to a stable real interest rate and low risk premia in US, Ireland (1996b) suggests that movements in the nominal interest rates primarily reflect changes in inflationary expectations. However, Turkish case offers unstable real rates and high risk premia, and therefore computing a good measure of inflation expectations is more essential.

Evidently, out of 4 surveys we compared, CTS fell within the bounds for the whole sample period which implies a zero failure rate. However, Livingston survey, SoE and BTS have 53%, 52% and 30%, recpectively. These failure rates are significantly higher than CTS' failure rate. This result is not so surprising as Ireland (1996b)'s model fits the problem of an ordinary consumer the best, not a producer's. That's why one should expect the CTS results to be most comparable to Ireland (1996b)'s bounds. For this reason, a good indirect measure should account for consumers and producers at the same time. That might be one aspect Ireland (1996b)'s bounds is missing.

This study is the first attempt to compare direct and indirect measures of inflation expectations. The purpose of this study is not to improve the predictive power of Ireland (1996b)'s bounds on inflation expectations but compare them with the available direct measures. A natural extension would be to improve the model to account for producer's side so that the bounds fit other surveys as well. One direction for further research is modifying the model in a way that it can be used for parameter estimation in a cross-country setting (e.g. risk aversion, tightness of borrowing constraints, etc.). This field is very open to further research and policy makers in developing countries especially, need reliable measures of inflations expectations due to high volatility.

Appendix

Appendix 1

Proofs

Proof of Proposition 2.2.1. Using (2.2) in (2.5),

$$\frac{\overline{\theta}}{(1-\overline{\theta})} = \frac{m_t^{h,i} + \tau_{t+1}}{m_t^{f,i} e_t} \tag{1.1}$$

Multiplying both sides with γ and $(1-\gamma)$ for good and bad types, respectively, and summing up we get:

$$\frac{\overline{\theta}}{(1-\overline{\theta})} = \frac{\gamma(m_t^{h,g} + \tau_{t+1}) + (1-\gamma)(m_t^{h,b} + \tau_{t+1})}{\gamma m_t^{f,g} e_t + (1-\gamma) m_t^{f,b} e_t}$$

Then, using exchange rate market clearing condition and money market evolution rule,

$$\frac{\overline{\theta}}{(1-\overline{\theta})} = \frac{\sigma + \phi}{1-\phi} \tag{1.2}$$

(1.2) suggests that individuals allocate their portfolio share proportional to their expected taste shocks. Solving for ϕ, we reach the proposed relationship between ϕ, Z and σ.

Steady state employment levels can be found as follows. First, we use the portfolio decision (1.1) to get home currency holding of home agents:

$$m_t^{h,i} = \overline{\theta}(\alpha^i n_t^i p_t + \tau_{t+1}) - \tau_{t+1}$$

Then, substituting this into (2.4) together with (2.2), we obtain steady state employment levels from two equations-two unknowns presented as the second of the steady state conditions in the proposition.

Finally, we show consumption levels satisfy (2.11) and (2.12). (2.4) and (2.2) suggest that

$$c_{t+1}^{h,g} = \frac{Y}{1+\sigma}\left(\frac{\phi^g}{\gamma} + \sigma\right), \quad c_{t+1}^{h,b} = \frac{Y}{1+\sigma}\left(\frac{\phi^b}{1-\gamma} + \sigma\right) \tag{1.3}$$

Combining money market clearing conditions for home and foreign countries as well as exchange rate markets yield the following money stock relation between countries:

$$(1-\phi)M_t = e_t(1-\phi^*)M_t^* \tag{1.4}$$

Using this and the equality $p_t Y = M_t$ in the portfolio decision, we have

$$c_{t+1}^{f,g} = \frac{(1-\overline{\theta})}{\overline{\theta}} \frac{1-\phi^*}{1-\phi} \frac{1+\sigma}{1+\sigma^*} \frac{Y^*}{Y} c_{t+1}^{h,g}$$

Substituting (1.3),

$$c_{t+1}^{f,g} = \frac{(1-\overline{\theta})}{\overline{\theta}} \left(\frac{\phi^g}{\gamma} + \sigma\right) \frac{1-\phi^*}{1-\phi} \frac{Y^*}{1+\sigma^*} \tag{1.5}$$

This equation and its counterpart for the bad type agents together with (1.2) yield the consumption levels. □

Proof of Proposition 2.2.2. Substituting (2.11) and (2.12) into government's problem, we achieve the following first order condition:

$$\begin{aligned}\gamma \frac{d\kappa(\sigma)}{d\sigma} \left(\frac{1}{\kappa(\sigma)} - \frac{1-\gamma}{1-\gamma\kappa(\sigma)}\right) &= \gamma\alpha^g \frac{dn^g}{d\sigma}\left(\frac{g'(n^g)}{\alpha^g} - \frac{\overline{\theta}}{Y}\right) \\ &\quad + (1-\gamma)\alpha^b \frac{dn^b}{d\sigma}\left(\frac{g'(n^b)}{\alpha^b} - \frac{\overline{\theta}}{Y}\right)\end{aligned} \tag{1.6}$$

As we will prove in proposition 2.3.2, difference of inverse consumption shares in the parenthesis on the left hand side and $\frac{d\kappa(\sigma)}{d\sigma}$ are both negative. Hence, left hand side is always positive. Therefore, at optimum, right hand side of the equality should be positive as well. Now we will show that for any $\sigma \leq Z$, right hand side cannot be positive. Firstly, we proved in proposition 2.3.1 that both $\frac{dn^g}{d\sigma}$ and $\frac{dn^b}{d\sigma}$ are negative. It remains to show that, for $\sigma \leq Z$, $(g'(n^g)/\alpha^g - \overline{\theta}/Y)$ and $(g'(n^b)/\alpha^b - \overline{\theta}/Y)$ are both positive which will imply that right hand side is negative, which is a contradiction. We proved in proposition 2.3.2 that $\frac{g'(n^g)}{\alpha^g} < \frac{g'(n^b)}{\alpha^b}$, therefore it is sufficient to show that $(g'(n^g)/\alpha^g - \overline{\theta}/Y) > 0$. Assume that it is not, that is:

$$\frac{g'(n^g)}{\alpha^g} \leq \frac{\overline{\theta}}{Y}$$

plugging in from 1.10 and using the definition of Y and organize the terms, we get:

$$\alpha^g n^g(1 + \gamma(\sigma - 1/\overline{\theta})) + \alpha^b n^b((1 - \gamma)(\sigma - 1/\overline{\theta})) \geq 0$$

which is a contradiction since both terms on the left hand side are negative for $\sigma \leq Z$, which concludes the proof.

□

Proof of Proposition 2.3.1. For $\sigma = 0$, employment levels satisfying (2.9) and (2.10) also satisfy $n^g(0)g'(n^g(0)) = n^b(0)g'(n^b(0)) = 1$. Therefore $n^g(0) = n^b(0)$ is satisfied and due to convexity of disutility function, the solution is unique.

For $\sigma > 0$, suppose $n^g \leq n^b$. Then, $\frac{g'(n^g)}{\alpha^g} \leq \frac{g'(n^b)}{\alpha^b}$. Combining with (2.9) and (2.10), $n^g g'(n^g) > n^b g'(n^b)$. Contradiction.

Now we prove the second part of the proposition. Equating (1.10) and (1.11) implies $\alpha^g(n^g - \frac{1}{g'(n^g)}) = \alpha^b(n^b - \frac{1}{g'(n^b)})$. Differentiating both sides w.r.t σ, we reach the following relation for response of employment to inflation:

$$-\alpha^g \frac{dn^g}{d\sigma}\left(1 + \frac{g''(n^g)}{(g'(n^g))^2}\right) = -\alpha^b \frac{dn^b}{d\sigma}\left(1 + \frac{g''(n^b)}{(g'(n^b))^2}\right) \tag{1.7}$$

This suggests that responses of employment to inflation have the same signs for good and bad types. Moreover, using convexity of g[1] and $n^g \geq n^b$, we can get $\frac{g''(n^g)}{(g'(n^g))^2} < \frac{g''(n^b)}{(g'(n^b))^2}$, which helps us determine:

$$-\alpha^g \frac{dn^g}{d\sigma} > -\alpha^b \frac{dn^b}{d\sigma} \tag{1.8}$$

Now, total differentiating (1.10) we get:

$$\frac{dn^g}{d\sigma} = -\frac{(g'(n^g))^2[Y/\alpha_g + \sigma(1-\gamma)\frac{dn^b}{d\sigma}\alpha_b/\alpha_g]}{g''(n^g) + (g'(n^g))^2(1+\sigma\gamma)} \tag{1.9}$$

[1]Note that integration on convex functions is a convex operation, which means that g is a convex transformation of g', and g' is a convex transformation of g''; then one can show that g'/g'' is an increasing function.

We see that $\frac{dn^g}{d\sigma}$ and $\frac{dn^b}{d\sigma}$ can't be both positive, suggesting that both are negative. That is, as inflation rises, real return to work decreases and hence, all the individuals in the economy work less.

□

Proof of Proposition 2.3.2. By working on right hand sides of (2.9) and (2.10), these two equations can be simplified as:

$$\frac{\alpha^g}{g'(n^g)} = \alpha^g n^g + \sigma Y \tag{1.10}$$

$$\frac{\alpha^b}{g'(n^b)} = \alpha^b n^b + \sigma Y \tag{1.11}$$

Since RHS of (1.10) is bigger than that of (1.11), we have $\frac{g'(n^g)}{\alpha^g} < \frac{g'(n^b)}{\alpha^b}$. Using (2.4), we have $c_{t+1}^{h,g} > c_{t+1}^{h,b}$. Similarly, (1.3) yields

$$\left(\frac{\phi^g}{\gamma} + \sigma\right) > \left(\frac{\phi^b}{1-\gamma} + \sigma\right) \tag{1.12}$$

Substituting this into (2.11) completes the first part of the proof. For the second part, see the proof of Proposition 2.2.2. □

Proof of Lemma 2.3.3. Dividing first order conditions (2.4) for good and bad types gives us:

$$\frac{g'(n^g)}{g'(n^b)} = \frac{\alpha^g}{\alpha^b}\frac{c^{h,b}}{c^{h,g}} \tag{1.13}$$

We will later prove in proposition 2.3.4 that RHS gets bigger as inflation increases. So, LHS should also increase. Together with the convexity of disutility, we complete the proof. □

Proof of Proposition 2.3.4. To prove that earnings inequality is decreasing in σ, we simply use (1.8). Next we show that the proof for consumption inequality follows from this equation as well. Equations (2.2), (2.3) and (2.5) simplify to

$$c^{h,i}_{t+1} = \frac{\overline{\theta}(\alpha^i n^i p_t + \tau_{t+1})}{p_{t+1}}$$

Then, inequality for home goods consumption between good and bad types will be:

$$c^{h,g}_{t+1} - c^{h,b}_{t+1} = \frac{\overline{\theta}}{1+\sigma}(\alpha^g n^g - \alpha^b n^b) \tag{1.14}$$

As seen easily, the term in the parenthesis is earnings inequality and the coefficient term is also decreasing in σ. Therefore, consumption inequality for home goods is decreasing in σ. This suggests that $c^{h,g}/c^{h,b}$ is also a decreasing function of σ and we know from the definition in (2.11) that $c^{h,g}/c^{h,b} = c^{f,g}/c^{f,b}$. So, the same result applies to foreign goods inequality as well.

Therefore consumption inequality is:

$$(\mu c_{t+1}^{h,g} + (1-\mu)c_{t+1}^{f,g}) - (\mu c_{t+1}^{h,b} + (1-\mu)c_{t+1}^{f,b}) = \mu(c_{t+1}^{h,g} - c_{t+1}^{h,b}) + (1-\mu)(c_{t+1}^{f,g} - c_{t+1}^{f,b}) \tag{1.15}$$

For any given consumption weights μ, we know that both terms in the right hand side of (1.15) are decreasing in σ, and so is any convex combination of them. This completes the proof.

□

Proof of Proposition 2.4.1. First, we need to show that $q^h Y = q^f Y^*$. To show that we will use the market clearing condition for home goods:

$$\overline{\theta}(\gamma I_{t+1}^{g} + (1-\gamma)I_{t+1}^{b}) + (1-\overline{\theta})(\gamma^* I_{t+1}^{*g} + (1-\gamma^*)I_{t+1}^{*b}) = q_{t+1}^{h} Y \tag{1.16}$$

Now we plug $q_t^h n_t^i + \tau_{t+1}^{cc} \equiv I_{t+1}^i$ in on the left hand side. Reorganizing the equation, we obtain: $\tau^{cc} = Y q_{t+1}^h - \overline{\theta} Y q_t^h - (1-\overline{\theta}) Y^* q_t^f$ and we repeat the same procedure for foreign goods market and get:

$$\frac{Y^*}{Y} = \frac{q_{t+1}^h/q_t^h + (1-2\overline{\theta})}{q_{t+1}^f/q_t^f + (1-2\overline{\theta})} \frac{q_t^h}{q_t^f} \tag{1.17}$$

Using stationarity, we have $q^h_{t+1}/q^f_{t+1} = q^h_t/q^f_t$ and plugging this in, we obtain $q^hY = q^fY^*$. Now, the rest of the proof is as follows: we take (2.16) and put I in from the budget constraint and using $q^hY = q^fY^*$ we obtain the equations (2.17)-(2.20), and the uniqueness follow from the convexity of $g(n)$. □

Proof of Proposition 2.4.2. First, we define the components of the value functions as follows. Let

$$\begin{aligned} h_1(\gamma,\sigma) &= -\left[\gamma(ln\frac{g'(n^g)}{\alpha^g} + g(n^g)) + (1-\gamma)(ln\frac{g'(n^b)}{\alpha^b} + g(n^b))\right] \\ h_2(\sigma) &= ln(1+\sigma) \\ h_3(\overline{\theta}) &= E_\theta[\theta ln\theta + (1-\theta)ln(1-\theta)] \\ h_4(\overline{\theta}) &= \overline{\theta}ln\overline{\theta} + (1-\overline{\theta})ln(1-\overline{\theta}) \end{aligned}$$

Then, we can write

$$\begin{aligned} V^{cc}(\sigma^{cc}) &= h_1(\gamma,\sigma^{cc}) + h_1(\gamma^*,\sigma^{cc}) - 2h_2(\sigma^{cc}) + 2h_3(\overline{\theta}) \\ V^{LC}(\gamma,\sigma^{LC}) &= h_1(\gamma,\sigma^{LC}) - h_2(\sigma^{LC}) + h_4(\overline{\theta}) + (1-\overline{\theta})ln\frac{Y^*\kappa^*}{Y\kappa} \\ V^{*LC}(\gamma^*,\sigma^{*LC}) &= h_1(\gamma^*,\sigma^{*LC}) - h_2(\sigma^{*LC}) + h_4(\overline{\theta}) - (1-\overline{\theta})ln\frac{Y^*\kappa^*}{Y\kappa} \end{aligned}$$

Now, WLOG, assume $\sigma^{*LC} > \sigma^{LC}$. Then, using optimality, we have

$$h_1'(\gamma,\sigma^{LC}) = \frac{1}{1+\sigma^{LC}} + (1-\overline{\theta})\frac{dY\kappa}{d\sigma}|_{\sigma=\sigma^{LC}} \tag{1.18}$$

while

$$h_1'(\gamma,\sigma^{*LC}) < \frac{1}{1+\sigma^{*LC}} + (1-\overline{\theta})\frac{dY\kappa}{d\sigma}|_{\sigma=\sigma^{*LC}} \tag{1.19}$$

Since we have already proved that Y and κ are decreasing in σ,

$$h_1'(\gamma, \sigma^{*LC}) < \frac{1}{1 + \sigma^{*LC}} \quad (1.20)$$

Similarly, we can derive

$$h_1'(\gamma^*, \sigma^{*LC}) < \frac{1}{1 + \sigma^{*LC}} \quad (1.21)$$

Then,

$$h_1'(\gamma, \sigma^{*LC}) + h_1'(\gamma^*, \sigma^{*LC}) < \frac{2}{1 + \sigma^{*LC}} \quad (1.22)$$

Optimization for the common currency case suggests:

$$h_1'(\gamma, \sigma^{cc}) + h_1'(\gamma^*, \sigma^{cc}) = \frac{2}{1 + \sigma^{cc}} \quad (1.23)$$

Therefore, since σ^{cc} is the optimum, we have $\sigma^{*LC} > \sigma^{cc}$. That is, σ^{cc} cannot be greater than the higher of the two local currency equilibrium inflation rates. □

Proof of Proposition 2.4.3. First, we start by showing that $\Delta_{E.I.}$ is decreasing in σ^{cc}. Note that since equations (2.17)-(2.20) are the exact counterparts for equations (2.9) and (2.10), their responses to inflation is going to be the same. So, $\Delta_{E.I.}$ is decreasing in σ^{cc} following the proof of proposition 2.3.4.

Next, we show that the proof for consumption inequality follows from earnings inequality as in proposition 2.3.4. Using 2.15, we get:

$$c_{t+1}^{h,g} - c_{t+1}^{h,b} = \frac{\theta}{1 + \sigma}(\alpha^g n^g - \alpha^b n^b) \quad (1.24)$$

The rest of the proof follows from the proof of proposition 2.3.4. □

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