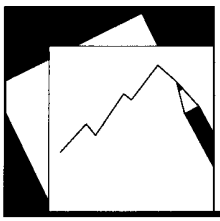
WP/12/189



IMF Working Paper

On Price Stability and Welfare

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INTERNATIONAL MONETARY FUND

 WP/12/189

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Monetary and Capital Markets Department

On Price Stability and Welfare

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July 2012

Abstract

The financial crisis in the advanced countries that began in 2007 has led central bankers to adopt unconventional policy measures as policy interest rates neared the zero bound. One suggestion (Blanchard, Dell'Ariccia, and Mauro, 2010) has been to raise inflation targets to provide more room for policy rate easing during crises. This paper addresses a different issue: the relationship between inflation and welfare. The literature is surveyed and a model is developed. A key conclusion is that an increase in inflation targets gives rise to additional welfare costs, even after the extra room to maneuver above the zero lower bound for nominal policy rates is taken into account. Based on parameter values that fit U.S. data, the additional welfare costs of raising inflation targets from 2 to 4 percent are estimated at about 0.3 percent of annual real income. A rise to 10 percent would yield additional welfare costs of about 1 percent of real income. Other parameter values yield welfare costs as high as 7 (respectively 30) percent of real income for raising inflation targets from 2 to 4 (respectively from 2 to 10) percent. The full costs of raising inflation targets are likely to be higher because the model used to generate these estimates does not account for higher inflation-induced volatility.

JEL Classification Numbers: C02, E31, E41, E47

Keywords: Inflation, welfare, interest rates, monetary policy.

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[1] I would like to thank Karl Habermeier for encouraging me to undertake this project and for his advice and thoughtful suggestions. I am grateful to Fabian Valencia for helpful comments.

Contents **Page**

Tables

Figures

I. INTRODUCTION

During what has become known as the "Golden Age of Central Banking" (Gerlach and others, 2009) that began in the early 1980s, monetary policy brought and kept inflation down, without adverse effects on growth and employment. Even beyond the advanced economies, price stability has become the key objective of monetary policy through the more widespread adoption of inflation targeting (Roger and Stone, 2005).

The financial crisis that began in 2007 has led to questioning of price stability as the principal objective of monetary policy. Several lines of argument have been advanced.

First, higher steady-state inflation would have been associated with higher nominal policy rates, which would have provided more scope for interest rate cuts in response to the crisis shock, thus limiting the need for presumably less effective unconventional monetary policy tools (quantitative easing and credit easing) (Blanchard, Dell'Ariccia, and Mauro, 2010).

Second, the governments of most advanced economies have promised the public far more in spending on retirement benefits and healthcare than the economy can sustain. This has led to high and rising levels of public debt. Inflation, it is argued, offers a way to reduce the real value of the public debt (Reinhart and Rogoff, 2010).

Third, in some emerging market economies, we have seen a resurfacing of the argument that low inflation constrains economic growth. The idea is that a more active macroeconomic policy that tolerates inflation will allow for a more steady expansion of the economy that avoids downturns. Chowdhury and Siregar (2004) provide some evidence for this argument.

This paper examines these largely macroeconomic issues, but also reviews the microeconomic or welfare-economic foundations of different rates of inflation. To a considerable extent, the discussion draws on the existing literature, but the paper also presents a dynamic general equilibrium model to illustrate the relationship between economic welfare and inflation.

During the financial crisis that began in 2007, low inflation and correspondingly low nominal policy rates meant that central banks quickly reached the zero lower bound for nominal rates. At that point, they were obliged to use a range of unconventional monetary policy tools, such as direct purchases of longer-dated government securities. This experience has reopened a discussion on whether a higher inflation target, and correspondingly higher average short-term interest rates, would have provided more scope to respond to the crisis. This point is not a new one (Fuhrer and Madigan, 1997).

Targeting a relatively higher inflation rate would significantly reduce the frequency of hitting the zero lower bound (Adam and Billi, 2007). If a higher inflation target, say 4 percent, were in place before the recent crisis; this probably would have made a difference, whereby nominal interest rates would have been higher and would provided more scope to policymakers (Blanchard, Dell'Ariccia, and Mauro, 2010).

After documenting why major central banks choose inflation targets around 2 percent, the paper simulates the welfare impact of raising inflation targets above 2 percent. The paper uses two approaches: the opportunity cost of holding real money balances approach and the menu cost approach. It finds that the welfare costs from the menu cost approach are negligible relative to the ones coming from the opportunity cost of holding real money balances approach, in line with Burstein and Hellwig (2008). This suggests that the welfare impact of the productive time devoted to activities that economize on cash balances greatly outweighs that of the menu cost of adjusting prices.

Using a conservative representative-agent general equilibrium model, and based on parameter values that are consistent with U.S. data, the paper estimates the welfare costs associated with various levels of inflation targets, in particular, 2, 4, and 10 percent. The findings suggest that the additional welfare costs of raising inflation targets from 2 to 4 percent are equal to about 0.3 percent of real income. For a rise from 2 to 10 percent, the additional welfare costs are estimated at about 1 percent of real income. Finally, the use of other values for the constant parameter in the money demand curves yields estimates as high as 7 percent of real income for raising the inflation target from 2 to 4 and 30 percent of real income for raising the target from 2 to10 percent.

The paper is organized as follows. Section II surveys research on inflation and growth, and documents why major central banks choose inflation targets around 2 percent. Section III examines the relationship between inflation and welfare. Section IV weighs the benefits of raising inflation targets against its welfare costs. Section V concludes.

II. Inflation and Growth

In this section we survey research on the link between inflation and growth. We document why major central banks around the world often set their inflation targets at around 2 percent.

Generating rapid and sustained output growth in conjunction with low inflation is at the forefront of macroeconomic policy. Thus, the conduct of monetary policy involves making judgments about longer-term inflation targets against which current performance can be assessed. It is well accepted that inflation generates costly economic distortions. More precisely, inflation imposes significant real costs by reducing the efficiency with which the price setting mechanism allocates resources and by generating uncertainty. These costs often arise because institutional arrangements, namely taxation and contracting systems, do not fully adapt to inflation, and because high inflation is often associated with high volatility and unpredictability (OECD, 1994).

The desire to eliminate these costs makes a strong case for targeting zero inflation in the long run. However, with downward nominal price rigidity, zero or very low inflation could be harmful by impeding adjustment to real shocks. For example, a real wage reduction that might be necessary to stimulate growth in the face of some adverse shock could be easier to

achieve with moderate inflation. This raises the fundamental debate about the relationship between inflation and growth, especially the threshold effect of inflation on growth.

Several studies analyze the link between inflation and growth. From these studies emerges much empirical evidence[2] that inflation has a negative impact on growth, strengthening the case for policymakers to aim for low inflation in the long run. But the question arises, how low should inflation be? In other words, what is the optimal rate of inflation?

Numerous empirical papers have addressed this question by focusing on whether the relationship between inflation and growth is nonlinear. The nonlinear relationship between inflation and long-run growth was first highlighted by Fisher (1993). He highlights a positive relationship if inflation rates are low and a negative one at high rates of inflation. This latter relationship weakened as inflation increased. Sarel (1996), testing for the existence of a structural break in the inflation-growth relationship finds evidence of a structural break at an annual inflation rate of 8 percent. Above that rate, inflation has a strong and negative impact on growth. The impact of inflation on growth for rates below that threshold is inconclusive or slightly positive.

Ghosh and Phillips (1998), using a larger (compared to Sarel's) set of panel data covering 145 countries in 1960–96, find that at an inflation rate around 2.5 percent or lower, inflation and growth are positively correlated. Above that threshold, inflation and growth are negatively correlated, but the relationship is convex in the sense that the marginal negative impact of inflation on growth declines as inflation increases. They find that the negative inflation-growth relationship holds in both time and cross-section dimensions. In addition they find that growth costs of disinflation are the most significant when the disinflation pace is severe or, importantly, when the initial inflation rate is already low, say less than 6 percent.

Akerlof, Dickens, and Perry (1996) provide evidence of downward nominal rigidities and argue that low inflation triggers higher unemployment, because it is not enough to lower real wages. The paper is often seen as a warning against an inflation target below 3 percent. However, the paper also reveals that although the unemployment rate is quite high at an inflation rate below 2 percent, it drastically declines once the inflation rate reaches 2 percent as shown in Figure 3 of Akerlof, Dickens, and Perry (1996). Also, as highlighted by Svensson (2001), Akerlof, Dickens, and Perry's (1996) analysis not only disregards the possible change in wage-setting behavior in an environment of credible low-inflation policy, but also relies on inflation data higher than 2–3 percent, which could have biased their results.

Following Akerlof, Dickens, and Perry (1996), Wyplosz (2001) also examines the relationship between equilibrium unemployment and long-run inflation, focusing on European countries. His findings imply the possibility of higher unemployment at low

[2] See among others Barro (1995), Fisher (1993), Bruno and Easterly (1998), Sbordone and Kuttner (1994), De Gregorio (1992), Fisher, Sahay, and Végh (1996).

inflation rates for his sample of countries.[3] His results support the view that a moderate level of inflation facilitates wage adjustment and provides some lower unemployment. However, Wyplosz (2001) emphasizes numerous caveats and weaknesses in his findings. For example, not only are his confidence intervals wide, he also explicitly shows that the Phillips-curve estimates are very problematic.[4] He warns that the most reasonable conclusion from his findings seems to be that "we do not know yet how low inflation should be."

Akerlof, Dickens, and Perry (2000), reexamining the question, come to a different conclusion of lower unemployment at low but positive inflation. Although the new finding is driven by the assumption of workers having permanent monetary illusions, whereby part of the population is indefinitely fooled by low inflation reducing their real wages, it does challenge their earlier results—the possibility of higher unemployment at low inflation rates.

Khan and Senhadji (2001), reanalyzing the inflation-growth relationship, use new econometric techniques developed by Chan and Tsay (1998) and Hansen (1999) and rely on bootstrap methods to analyze the significance level of the threshold variable. They find that the threshold level that triggers the negative relationship between inflation and growth is estimated at 1–3 percent for industrial countries and 11–12 percent for developing countries. Their findings suggest that inflation targets should be differentiated by whether countries are industrialized or developing.

These empirical studies are supported by recent monetary models, which find a long-run relationship between inflation and real activity. The result is mainly driven by symmetric nominal rigidities and asynchronized time-dependent price setting behavior in an intertemporal setup (Woodford, 2003; Benigno and Ricci, 2010). Echoing the need for differentiated inflation targets, Benigno and Ricci's (2010) monetary model indicates that relatively high inflation may facilitate intratemporal and intertemporal relative price adjustments in countries with substantial macroeconomic volatility. The authors point out that only countries experiencing larger volatility may find it desirable to target a higher inflation rate.

Furthermore, their simulations are quite revealing. They find that an advanced country enjoying a low macroeconomic volatility of 2 percent and low inflation of 2 percent might face an output gap of minus 1.2 percent. However, if the moderation ends, bringing macroeconomic volatility to 5 percent, which is more likely with higher inflation targets, their estimates show that the output gap might widen to minus 1.6 percent. If indexed bonds can help to protect investors from inflation risk in the presence of higher inflation volatility, other distortions such as lower real money balances and a greater dispersion of relative prices remain, and their effects on output could justify the widening of the output gap. These various studies point to a nonlinear and inverted u-shape relationship between inflation and growth. It also emerges that there is no complete unanimity about a single threshold estimate

[3] Germany, France, Netherlands, and Switzerland.

[4] These weaknesses were also pointed out in Svensson (2001).

beyond which inflation is harmful to growth. However, there is overwhelming evidence indicating that inflation targets should be below 3 percent for industrialized countries.

Perhaps in light of this evidence, central banks in industrialized countries have always chosen inflation targets around 2 percent. For example, the Reserve Bank of New Zealand has a target range of 1–3 percent with a midpoint target of 1.5 percent. Bank of Canada and Sveriges Risbank (Sweden) have a target of 2 percent with a fluctuation margin of ±1 percent. In Norway, Norges Bank has a target 2.5 percent with a fluctuation margin of ±1 percent. Though in the United States the Federal Reserve does not have an explicit target, the inflation forecasts of the U.S. Federal Reserve Governors and Reserve Bank Presidents indicate that the Fed has an implicit inflation target range of 1.75–2 percent, suggesting a target near 2 percent (Kohn, 2010). In the United Kingdom, the Bank of England has a target of 2.5 percent. The Reserve Bank of Australia has an inflation target on the business cycle that could be interpreted as a target of 2.5 percent.

In the euro area, the definition of stability of the harmonized index of consumer prices (HICP) stipulates a target range from zero or an infinitesimal positive number to 2 percent, which leaves the midpoint somewhere between 1 and 2 percent. Svensson (2001) highlights that working backwards from the construction of the M3 reference value leads to a midpoint target of 1.5 percent for the euro area. Since December 1999, the Swiss National Bank has followed the Eurosystem definition of price stability. Table 1 summarizes the inflation targets for selected countries. These targets or midpoints range from around 1.5 percent to 2.5 percent.

Recent studies argue against targets above these ranges. For example, Billi and Khan (2008)—using a modern macroeconomic model calibrated to U.S. data and after accounting for the zero interest rate bound—estimates the optimal inflation that maximizes the economic well-being of the public to be 0.7 to 1.4 percent a year. Schmitt-Grohe and Uribe (2010) estimate that the optimal rate of inflation predicted by leading theories of monetary nonneutrality ranges from minus the real rate of interest to numbers insignificantly above zero. Stark (2010) reports that in the euro area, for example, raising the inflation target to 4 percent has the potential of shaving annually about 0.5 percentage point off trend growth.

Clearly, there is a large consensus about inflation targets around 2 percent or even less, at least for industrialized countries. Below we investigate whether increasing inflation targets from 2 to 4 percent generates any additional welfare costs.

Table 1. Inflation Targets or Definitions of Price Stability in Selected Countries

Country	Indicator	Numerical Value Definition/Target	Ex Ante Horizon [1]
Australia	CPI	2–3%, with 2.5% midpoint target	Medium term
Canada	CPI	2% with a fluctuation margin of ±1%	Medium term with focus on six to eight quarters ahead
Euro area	HICP	Below 2% Definition of price stability	Medium term (not sole focus on inflation forecasts; prominent role for monetary developments that exhibit a medium-term relationship with prices)
New Zealand	CPI (excluding credit services)	1–3% with a midpoint target of 1.5%	Medium term
Norway	CPI Focus on core inflation	2½% with a fluctuation margin of ±1% Target	Main focus on two years ahead inflation forecast
Sweden	CPI	2% with a fluctuation margin of ±1%	Main focus on one to two years ahead inflation forecast with possibility of extending horizon
Switzerland	CPI	Below 2% Definition of price stability	Medium term with a focus on three years ahead inflation forecast
United Kingdom	RPIX (Retail Price Index excluding mortgage interest payments)	2.5%	Medium term with a focus on two years ahead inflation forecast
United States	Not specified Focus on several inflation measures	Not specified, but an implicit target range of 1.75–2%	

[1] Ex ante horizon: the horizon over which the Central Bank will seek to pursue its objective or reestablish it after a shock has occurred.

Sources: September 2005 *World Economic Outlook*, Castelnuovo, Nicoletti-Altimari, and Rodriguez-Palenzuela 2003, Kohn 2010.

III. Inflation and Welfare: A General Equilibrium Approach

In this section, using a general equilibrium framework, we simulate the welfare costs for various inflation targets. In particular, we investigate whether raising inflation targets above 2 percent entails any additional welfare costs, and if so by how much.

Early attempts at formalizing the welfare cost of inflation can be traced back to Bailey (1956) and Friedman (1969). Their approach, which is based on partial equilibrium, treats real money balances as consumption goods, and the welfare cost is measured by computing the appropriate area under the money demand curve. Calibration of this traditional approach finds the cost of inflation to be low (Fischer, 1981; Lucas, 1981). Using a monetary base as the definition of money, Fischer (1981) finds the deadweight loss associated with an increase of inflation from zero to 10 percent to be just 0.3 percent of GNP. Using M1, Lucas (1981) places such a cost at 0.45 percent of GNP.

Many studies find these estimates small, relative to the potential cost of a disinflationary recession, and adopt a general equilibrium approach, which identifies several other distortions of inflation tax. For example, Cooley and Hansen (1989, 1991) find that inflation forces agents to inefficiently substitute out-of-market activity into leisure. Karni (1974) finds that inflation forces agents to devote productive time to activities that enable them to economize on their cash balances. More specifically, Dostey and Ireland (1996) find that Karni's specification implies that inflation draws a fraction of the labor force out of the goods production sector and into the financial sector.

The distinctive feature of Dotsey and Ireland's (1996) framework, compared to earlier general equilibrium works, is that it uses an explicit transactions technology whose parameterization generates a money demand function that is interest-elastic like those estimated with U.S. data. Their calibrations suggest that when currency is used as the relevant definition of money, 4 percent inflation generates a welfare cost of about 0.41 percent a year. This cost jumps to over 1 percent of output a year when M1 is used for money. These estimates clearly suggest that the Bailey-Friedman partial equilibrium approach can substantially underestimate the true cost of inflation.

In a more recent study, Lucas (2000) using the Sidrauski (1967a, b) general equilibrium framework shows that Bailey's welfare cost measure could be regarded as an approximation of a general equilibrium measure. Lucas (2000) finds that a welfare cost associated with a 10 percent inflation rate is about 1 percent of real income. Building on Lucas (2000), Cysne (2009) theoretically shows that under the assumption of quasi-linear utilities, Bailey's measure could be obtained exactly in Sidrauski's general equilibrium framework.

Henriksen and Kydland (2010) propose a model decomposing the welfare cost of inflation into three distinct components. The first stems from the opportunity cost of holding currency and demand deposits, the second is related to inflation's distortion of labor input and capital accumulation, and the third emanates from the costs incurred to avoid the inflation tax on currency and deposits. A key distinctive feature of the model is that household's use of deposits for good purchases entails a parameterized fixed cost, and the replenishing of its money balances involves spending some parameterized units of time. In the Bailey (1956) and Lucas (2000) frameworks, instead, all of this is modeled through interest rates. The intuition is that the nominal interest rate captures the opportunity costs for holding non-interest-bearing reserves, and as such the time or resources spent to avoid holding them increases the interest rate. Henriksen and Kydland's (2010) estimates based on this

decomposition and that are sensitive to the magnitude of the values attributed to the two parameters highlighted above, place the welfare cost from the actions taken to avoid inflation tax as the greatest.

Subsequent studies to Lucas (2000) provide microfoundations to Bailey's (1956) and Lucas's (2000) frameworks and rationalize their estimates of the welfare cost of inflation. For example, Lagos and Wright (2005) propose a new framework with explicit microfoundations based on a search-theoretical model of monetary exchange, which is analytically tractable without extreme restrictions or assumptions on how much cash economic agents can hold, as was the case in previous search models. A key condition for the tractability of the model is the assumption of quasi-linear preferences, which make the distribution of money holding degenerate. Whereas the Lagos and Wright (2005) model yields welfare cost estimates higher than that of the traditional Bailey (1956) and Lucas (2000) methodology, Graig and Rocheteau (2008) reconcile the two approaches, pinning down the condition under which they yield the same estimates and making the new framework as offering microfoundations to the traditional one.

Craig and Rocheteau (2008) show that the welfare cost measures derived from the Bailey (1956) and Lucas (2000) methodology can be rationalized by a particular version of the search model. More precisely, under the assumption that money holders can appropriate the marginal social return of their real balances—which is the case when buyers have all the bargaining power to set the prices that would prevail or when pricing is competitive—the welfare cost of inflation as predicted by the search model is essentially the same as the one predicted by Bailey (1956) and Lucas (2000) methodology. Under alternative pricing mechanisms, the welfare cost of inflation can be exacerbated. In other words, under non-competitive-pricing mechanisms, the search model tends to provide higher estimates of the welfare cost of inflation compared to the traditional methodology. In this paper, Bailey's (1956) and Lucas's (2000) traditional methodology is adopted to see whether despite this conservative approach, raising the inflation target from 2 to 4 percent would generate sizeable additional welfare costs.

While all these models are based on a representative agent, a very new body of research based on heterogeneous agents is emerging. In this new research, money demand is heterogeneous and leads to more substantial welfare costs. With log utility functions, a 10 percent inflation rate could be associated with a welfare cost as high as 15 percent of consumption. Moreover, when the inequality of cash distribution is sufficiently large, the welfare costs of moderate inflation could be as high as 20 percent of consumption (Wen, 2009a, b; Wen, 2010). These estimates appear much higher, and new research might be needed for confirmation.

In this paper, we are interested in any potential costs that an increase in inflation targets might cause. To capture the various distortions associated with the inflation tax and at the same time to minimize overestimations of the welfare costs, we adopt a more conservative approach by considering a representative-agent general equilibrium model that yields moderate estimates. In particular, we refrain from heterogeneous-agent general equilibrium

model. If the use of this conservative approach still yields positive additional welfare costs for an increase in inflation target, then caution would be recommended about increasing inflation targets.

We consider two channels through which inflation affects welfare. The first stems from the effects of inflation on the opportunity cost of holding real money balances (Bailey, 1956; Friedman, 1969; Lucas, 2000). The second is based on the menu costs or the presence of nominal rigidities, whereby fluctuations in relative prices between products whose prices adjust and products whose prices do not, distort the composition of output from efficiency. This process negatively affects the aggregate productivity and welfare (Burstein and Hellwig, 2008; Golosov and Lucas, 2007; and Woodford 2003). As illustrated below, the menu cost effects on welfare appear negligible though relative to the opportunity cost of real money balances. We present, however, a sketch of the framework, which captures this second channel.

A. The Opportunity Cost Channel

The opportunity cost channel for analyzing welfare goes back to Bailey (1956) and Friedman (1969) and has been recently amplified by Lucas (2000). The idea is that the quantity of money demanded is influenced by the costs and returns from holding it. Thus, no economic agent has incentives to hold non-interest-bearing money. The reality however, is that someone has to hold all this cash or reserves that other economic agents are trying not to hold, so that all these efforts cancel out. As such the resources or all the hours economic agents spent to avoid holding non-interest-bearing money were wasted rather than devoted to real activities.

Because the nominal interest rate captures the opportunity cost for holding non-interest-bearing reserves, the time or resources spent to avoid holding them increases with the nominal interest rate. Thus, society might be better off if monetary authorities were to adopt policies that reduce inflation and hence interest rates. In other words, policies that raise inflation targets might generate welfare losses. The following simple model that captures such losses is proposed.

B. A Simple Model of Inflation and Welfare

We consider a standard Sidrauski (1967a, b) framework and draw on Lucas (2000) and Cysne (2009). Within that framework and for our analysis we use Fischer's equation linking the nominal interest rate, the real interest rate, and inflation expectations. We make the crucial assumption that for a given inflation target, economic agents set their inflation expectations at a rate at least equal to the explicitly or implicitly announced inflation target. These considerations allow us to derive a closed form for the lower bound of welfare costs using various preferences.

The representative household's utility is determined by real consumption *c* and the holding of real balances $z = M/P$ where *M* stands for money and *P* for price level. We consider a continuous time setting where households begin period *t* with M_t units of money. They pay a

lump-sum tax or receive a lump-sum transfer H_t depending on whether H_t is positive or negative (respectively). Households are also allowed to invest in bonds denoted *B*. Households' preferences are

$$\int_0^{\infty} e^{-\delta t} U(C_t, z_t)\, dt, \qquad \delta > 0 \qquad (1)$$

where the current period utility function *U* is concave, strictly increasing in both *C* and *z*.

Households maximize their preferences subject to the budget constraint

$$\dot{M}_t + \dot{B}_t = P_t Y_t - P_t C_t - H_t + iB_t$$

where *Y* stands for real output and *i* the nominal interest rate.

Setting $b = B/P$, $h = H/P$, $\pi = \dot{P}/P$ (the rate of inflation) the budget constraint becomes

$$\dot{z}_t + \dot{b}_t = Y_t - C_t - h_t - \pi_t z_t + (i_t - \pi_t) b_t \qquad (2)$$

Solving for *C* in (2) and substituting it in (1), the first order conditions (Euler equations) yield

$$i_t = \pi_t + \delta \qquad (3)$$

$$\frac{U_{C_t}}{Y_t} = \frac{U_{z_t}}{i_t} \qquad (4)$$

Market clearing condition for goods implies:

$$C_t = Y_t \; \forall t \qquad (5)$$

In steady state $\dot{z} = \dot{b} = 0$, and the budget constraint boils down to

$$h + \pi z = (i - \pi) b \qquad (6)$$

The welfare cost *w (i)* of a positive inflation rate and hence the associated nominal interest rate *i* is defined following Lucas (2000) and Cysne (2009) as the additional income the representative household would need to be indifferent between the interest rate *i* and an interest rate equal to 0. That is, *w (i)* solves

$$U\left[(1 + w(i))Y, z(i)\right] = U\left[Y, z(0)\right] \qquad (7)$$

Consider first the following functional form—same as in Lucas (2000) and Cysne (2009)—for the period utility *U*

$$U_1(C,z)=\frac{1}{1-\sigma}\left[C\varphi\left(\frac{z}{C}\right)\right]^{1-\sigma},\sigma>0,\quad \sigma\neq 1 \qquad (8)$$

where φ is a strictly increasing and concave function. With this utility function, making use of (4), yields

$$\frac{\varphi'\left(\frac{z}{Y}\right)}{\varphi\left(\frac{z}{Y}\right)-\frac{z}{Y}\varphi'\left(\frac{z}{Y}\right)}=i$$

and the welfare cost $w_1(i)$ solves the following differential equation

$$w_1'(i)=-\psi\left(\frac{m(i)}{1+w_1(i)}\right)m'(i),\qquad w_1(0)=0 \quad (9)$$

ere *m(i)* is the money-income ratio and ψ is the inverse of the money demand function *m*.[5]To solve for a closed form we follow Cysne (2009) and consider the log-log money demand function $m(i)=Ki^{-\alpha},\quad \alpha>0$. In this case, (9) yields $w_1(i)=-1+\left(1-Ki^{1-\alpha}\right)^{\frac{\alpha}{1-\alpha}}$ (10)

Now consider a monotonic transformation of quasi-linear preference,[6] that is,

$$U_2(C,z)=g\left(C+\left[\frac{z}{\alpha}\left(1+\log\left(\frac{K}{z}\right)\right)\right]\right), \qquad (11)$$
$$\alpha>0,K>0\quad g'>0,g''\leq 0,\lambda'(z)>0,\lambda''(z)<0,\forall z\in(0,K)$$

This leads to a semi-log money demand function $m(i)=Ke^{-\alpha i}$ and (7) and (11) yield

$$w_2(i)=\frac{K}{\alpha}-\frac{Ke^{-\alpha i}}{\alpha}(1+\alpha i) \qquad (12)$$

To carry out our analysis, we make use of these two welfare functions, equations (10) and (12), derived from existing models. We denote the inflation target by π^t and inflation expectations by π^e. By the usual Fischer's equation we can express the nominal interest rate

[5] One can think of the real balances *z=M/P=L(i , Y)* where *L* takes the form *L(i , Y)=m(i)Y, that is, z/Y= m(i),* see Lucas (2000) for details.

[6] With this class of utility function, Cysne (2009) shows that Bailey's welfare cost measure coincides exactly with the one obtained from Sidrauski's general equilibrium framework.

$$i = r + \pi^e \qquad (13)$$

where *r* stands for real interest rate.

We assume that economic agents set inflation expectations at least equal to the inflation target, that is,

$$\pi^e \geq \pi^t \qquad (14)$$

Combining (13) and (14) we have

$$i = r + \pi^e \geq r + \pi^t \qquad (15)$$

Moreover, for any real interest rate higher or equal to $-\pi^t$, the zero lower bound nominal interest rate condition is satisfied, that is, $i \geq 0$.

Notice that $w_1(i)$ and $w_2(i)$ are increasing for $i \geq 0$ (see Figures 1, 2, 3, and 4 for reasonable parameter values). Thus (10) and (15) yield

$$w_1(i) \geq \underline{w}_1^{\pi^t}(r) \qquad (16)$$

where

$$\underline{w}_1^{\pi^t}(r) = -1 + \left[1 - K\left(r + \pi^t\right)^{1-\alpha}\right]^{\frac{\alpha}{1-\alpha}} \qquad (17)$$

Similarly, (12) and (15) yield

$$w_2(i) \geq \underline{w}_2^{\pi^t}(r) \qquad (18) \text{ where } \underline{w}_2^{\pi^t}(r) = \frac{K}{\alpha} - \frac{Ke^{-\alpha\left(r+\pi^t\right)}}{\alpha}\left[1 + \alpha\left(r + \pi^t\right)\right] \qquad (19)$$

$\underline{w}_1^{\pi^t}(r)$ and $\underline{w}_2^{\pi^t}(r)$ represent the lower bound measures of the welfare costs for a given inflation target π^t for the utility classes defined respectively in (8) and (11). We examine below how sensitive these lower bounds are to changes in inflation targets. In addition to focusing on inflation targets, we also examine welfare costs resulting from changes in actual inflation. For this, we use $1 + i = (1 + r)(1 + \pi)$.[7] Thus (10) becomes

$$w_1(r) = -1 + \left(1 - K\left[(1 + r)(1 + \pi) - 1\right]^{1-\alpha}\right)^{\frac{\alpha}{1-\alpha}} \qquad (20)$$

and (12) becomes

[7] Notice that π denotes actual inflation (not expected inflation as in Fischer's equation) and there are no restrictions on π or r that would make $r\pi$ negligible, forcing the identity to boil down to $i = r + \pi$.

$$w_2(r) = \frac{K}{\alpha} - \frac{Ke^{-\alpha\left[(1+r)(1+\pi)-1\right]}}{\alpha}\left(1+\alpha\left[(1+r)(1+\pi)-1\right]\right) \qquad (21)$$

Model calibration

To calibrate the minimum welfare costs—equations (17) and (19)—derived from the model we use parameter measures consistent with U.S. data. Based on U.S. time series data on real money balances, income, and interest rates in 1900–94, Lucas (2000) finds that the parameter value that fits α better for the log-log money demand function ($m(i) = Ki^{-\alpha}$) is 0.5, and the value of *K* is about 0.05. For the semi-log demand function ($m(i) = Ke^{-\alpha i}$), $\alpha = 7$ and $K = 0.3548$. His analysis points to the log-log money demand function as a better fit for U.S. data, and he implicitly advocates the adoption of Friedman's (1969) rule of zero nominal interest rate or equivalently a deflation policy.

Reexamining the question and extending the data to cover more recent years, more precisely, using U.S. data from 1900 to 2006, Ireland (2009) finds, contrary to Lucas (2000), that the money demand function exhibits some satiation point that limits money demand under the Friedman (1969) rule, making the semi-log demand function a better fit. He finds real money balances to be less elastic to interest rates with an estimate of 1.7944 compared to 7 in Lucas (2000). Ireland's (2009) corresponding constant is estimated at 0.1686.

For the analysis in this paper, we use both Lucas (2000) and Ireland (2009) parameter values consistent with empirical data. In addition we also test $K = \exp(0.05)$ for the log-log demand curve and $K = \exp(0.3548)$ and $K = \exp(0.1686)$ for the semi-log demand curves to see how neutralizing the impact of log on *K* would affect the welfare cost functions.

With these parameters we simulate $\underline{w}_1^{\pi'}(r)$ and $\underline{w}_2^{\pi'}(r)$ for various values of inflation targets. The simulations consider real interest rates and inflations consistent with the lower bound nominal interest constraint. We report the results for inflation targets of 2 percent, 4 percent, and 10 percent (Figures 5–10). The welfare change results are reported in terms of real income equivalent variation.

The results clearly show that an increase in inflation target shifts the entire lower bound welfare cost function up, whether it is the log-log money demand function or the semi-log demand function. For the log-log money demand function the shift slightly shrinks as the real interest rate rises, suggesting the additional welfare costs generated by a rise in inflation target are slightly higher at low real interest rates. For the semi-log demand function the shift slightly widens as the real interest rate increases, suggesting that the additional welfare costs generated by a rise in inflation target slightly increase with the real interest rate. This suggests that while a rise in inflation target unequivocally generates additional welfare costs regardless of the money demand function, the type of money demand matters to evaluate these costs at various real interest rates. The use of $K = \exp(0.05)$ for the log-log function

and $K = \exp(0.3548)$ or $K = \exp(01686)$ for the semi-log function appears not to alter the shape of the cost functions but does affect the magnitude of the welfare costs.

The log-log money demand curve results based Lucas (2000) parameter values—For 2 percent real interest, for example, using the log-log money demand function based on Lucas parameter values, an inflation target of 2 percent is associated, at a minimum, with welfare costs equal to 1 percent of real income (Figure 5). An inflation target of 4 percent generates welfare costs equal to about 1.25 percent of real income, while a 10 percent inflation target is associated with welfare costs equal to 1.75 percent of real income. These estimates suggest that at 2 percent interest and using the log-log money demand function, raising the inflation target from 2 to 4 percent would generate, at a minimum, additional welfare costs equal to 0.25 percent of real income. For a rise in the inflation target from 2 to 10 percent, the minimum additional costs are equal to about 0.75 percent of real income (Figure 5).[8]

For a 5 percent real interest rate, for example, still using the log-log money demand function with the same parameter values, an inflation target of 2 percent yields welfare costs equal to about 1.3 percent of real income. An inflation target of 4 percent is associated with welfare costs equal to about 1.55 percent of real income, while a 10 percent inflation target yields welfare costs equal to about 2 percent of real income. A rise in the inflation target from 2 to 4 percent would yield an equal of 0.25 percent of real income in terms of welfare costs. A rise in the inflation target from 2 to 10 percent would yield costs equal to about 0.7 percent. For the log-log demand curve, for relatively low inflation targets, the additional welfare costs of raising the inflation target from one steady state to another appear almost the same regardless of the rate of real interest. For relatively high inflation targets, the additional costs seem to decrease slightly at high rates of real interest. These costs are not negligible, however, and suggest that raising inflation targets is costly (Figure 5).

The results for the other parameter value for the constant, that is, $K = \exp(0.05)$, are even more substantial. For example, for a 2 percent real interest rate, a 2 percent inflation target generates welfare costs equal to about 27 percent of real income. An inflation target of 4 percent yields welfare costs equal to about 34 percent of real income. An inflation target of 10 percent is associated with a loss of real income of more than 55 percent (Figure 6).

For a 5 percent real interest rate, a 2 percent inflation target yields welfare costs equal to about 39 percent of real income. An inflation target of 4 percent is associated with costs equal to about 46 percent, while a target of 10 percent would give rise to welfare costs of about 69 percent (Figure 6). These estimates, which are sensitive to the magnitude of the constant *K*, indicate that raising inflation targets from 2 to 4 percent could yield additional costs of about 7 percent of real income and a rise from 2 to 10 percent could generate additional costs of about 30 percent of real income (Table 2).

[8] Notice that we simulate here the lower bound welfare cost for various inflation targets.

The semi-log money demand results based Lucas (2000) parameter values—For a 2 percent real interest rate and the semi-log money demand curve based on Lucas parameter values, a 2 percent inflation target is associated, at a minimum, with welfare costs equal to slightly more than 0.1 percent of real income. An inflation target of 4 percent yields costs equal to 0.3 percent, and a target of 10 percent is associated with costs equal to more than 1 percent of real income. These estimates suggest that for the semi-log demand curve, a rise in the inflation target from 2 to 4 percent would generate additional welfare costs equal to about 0.2 percent of real income. For a rise from 2 to 10 percent the minimum additional costs amount to more than 0.7 percent of real income (Figure 7).

For a 5 percent interest rate, the minimum welfare costs associated with a target of 2 percent are slightly less than 0.5 percent of real income. A target of 4 percent yields about 0.75 percent, and a 10 percent target yields slightly less than 1.5 percent of real income. Thus, the additional welfare costs from raising the inflation target from 2 to 4 percent are equal to about 0.25 percent of real income. A rise from 2 to 10 percent generates welfare costs equal to about 1 percent of real income (Figure 7). For the semi-log money demand function, the additional welfare costs of raising inflation target from one steady state to another seem to increase with the real interest rate.

Considering the other parameter value for the constant, that is, $K = \exp(0.3548)$, the results suggest that for a 2 percent real interest rate, for example, an inflation target of 2 percent generates welfare costs equal to about 0.65 percent of real income. A target of 4 percent is associated with welfare costs equal to about 1.3 percent of real income, while 10 percent yields welfare costs equal to more than 4 percent of real income. These estimates suggest that a rise in inflation targets from 2 to 4 percent generates additional costs equal to 0.65 percent in real income (Figure 8). For a 5 percent real interest rate, a 2 percent inflation target yields welfare costs equal to less than 2 percent of real income. A target of 4 percent is associated with costs equal to about 3 percent, while a 10 percent inflation target yields costs of less than 6 percent of real income (Figure 8).

The semi-log money demand results based Ireland (2009) parameter values—with these parameter values ($\alpha = 1.7944$ and $K = 0.1686$), a rise in the inflation target from 2 to 4 percent would be associated with additional welfare costs equal to 0.025 percent of real income for a 2 percent real interest rate. The additional welfare costs would be 0.16 percent if the inflation target were to rise from 2 to 10 percent. For a 5 percent real interest rate, a rise from 2 to 4 percent in inflation would yield additional welfare costs of about 0.05 percent. A rise from 2 to 10 percent would lead to about 0.22 percent of real income (Figure 9).

The use of $K = \exp(0.1686)$ at a 2 percent real interest rate yields additional welfare costs of about 0.25 percent of real income for a rise from 2 to 4 percent in inflation target and 1.2 percent of real income for a rise from 2 to 10 percent in the inflation target. At a 5 percent real interest rate, the additional welfare costs stand at 0.3 percent of real income for an inflation target rising from 2 to 4 percent, and at 1.5 percent of real income if the inflation target were to rise from 2 to 10 percent (Figure 10). Table 2 summarizes the results.

To sum up, for the parameter values that fit U.S. data, the additional welfare costs of raising the inflation target from 2 to 4 percent range from about 0.03 percent to about 0.3 percent of real income, considering both log-log and semi-log demand curves and elasticity estimates from Lucas (2000) and Ireland (2009). The additional costs associated with a rise from 2 to 10 percent range from about 0.2 percent to about 1 percent regardless of the money demand curve or the rate of real interest. Using $K = \exp(0.05)$ for the log-log demand function and $K = \exp(0.3548)$ or $K = \exp(0.1686)$ for the semi-log demand curve to neutralize the impact of log on *K* substantially affects the magnitude of the welfare costs, which can be as high as 7 percent of real income for raising the inflation target from 2 to 4 and 30 percent of real income for raising the target from 2 to10 percent (Table2).

It emerges from our analysis that for an economy similar to the United States, raising inflation targets from 2 to 4 percent could entail welfare costs of about 0.3 percent of annual real income. A rise from 2 to 10 percent would generate additional costs equal to about 1 percent of real income. For other parameter values, the estimates can be as high as 7 percent for raising inflation from 2 to 4 percent. These costs could reach 30 percent if the inflation target were to be raised to 10 percent. The results suggest that even after adopting a conservative approach by considering representative-agent general equilibrium models that yield relatively low estimates, we still find unequivocally positive additional welfare costs for raising inflation targets. Our findings suggest that although raising the inflation target will alleviate the frequency of hitting the zero lower bound for the nominal interest rate, one needs to be mindful of the additional welfare costs that such an option might generate.

The calibrations based on actual inflation—equations (20) and (21)—yield results very similar to the ones based on inflation targets. The only exception is a slight upward bias for the calibration results based on actual inflation (Figures 11, 12, 13, and 14).[9]

Table 2. Summary of the Calibration Results

Real Interest Rate			2 percent		5 percent	
			Additional welfare costs of rising inflation target (percent of real Income)		Additional welfare costs of rising inflation target (percent of real Income)	
	α	K	From 2 to 4 percent	From 2 to 10 percent	From 2 to 4 percent	From 2 to 10 percent
Log-Log money demand function	0.5	0.05	0.25	0.75	0.25	0.7
	0.5	exp(0.05)	7	30	7	30
Semi-Log money demand function	7	0.3548	0.2	0.7	0.25	1
	7	exp(0.3548)	0.65	3.35	1	4
	1.7944	0.1686	0.025	0.16	0.05	0.22
	1.7944	exp(0.1686)	0.25	1.2	0.3	1.5

Source: Author's estimates.

[9] Given the similarity of the inflation target findings, we show only the results based on the elasticities derived from Lucas (2000).

C. The Menu Cost Channel

The idea governing the menu cost framework is that individual prices will be constant most of the time and then will occasionally jump to a new level. As such, the key driving force will be the firm's decision to adjust price or not to adjust. Thus, the framework will center on a Bellman equation for price-setting firms that produce differentiated consumption goods with technologies subject to random shocks, and a set price subject to a menu cost of adjustment.

To highlight the effects of menu costs on the welfare costs of inflation, Burstein and Hellwig's (2008) model is adopted. The model above is then adjusted to yield a sketch of the Burstein-Hellwig framework. The production technology is now explicit with a decreasing return to scale. The economy is subject to two types of shocks: an idiosyncratic demand shock a_{kt} and a firm-specific cost shock ν_{kt} for each sector or differentiated good *k.* The shocks a_{kt} and ν_{kt} follow an AR (1) process. To account for nominal rigidities we introduce a nominal wage (*W*), which induces making labor (*L*) explicit in the model.
Thus, equation (1) above becomes

$$\int_0^{\infty} e^{-\delta t} U(C_t, z_t, L_t) dt, \qquad \delta > 0 \qquad (21)$$

The budget constraint above changes to

$$\dot{M}_t + \dot{B}_t = W_t L_t - P_t C_t - H_t + iB_t + \Sigma_t \qquad (22)$$

where Σ_t denotes the aggregate earnings or profits for the corporate sector.

There is no competition for the production of each variety *k*, which uses labor l_{kt} and can be expressed as $y_{kt} = \nu_{kt} l_{kt}^{\beta}$, where $\beta \leq 1$. The aggregate output *Y* is assembled according to the constant elasticity of substitution $Y_t = \left[\int_0^1 a_{kt}^{1/\theta} y_{kt}^{(\theta-1)/\theta} dk \right]^{\theta/\theta-1}$. The time *t* earnings (exclusive of the menu costs) of the monopolistic firm producing the variety *k* can be expressed as $\varpi_{kt} = p_{kt} y_{kt} - W_t l_{kt}$, where p_{kt} denotes the price for variety *k* at time *t*.

The price adjustment mechanism is governed by the dynamics of the pair of idiosyncratic shocks $s = (a, \nu)$ in the sense that in each period *t*, firms observe the realization of $s_{kt} = (a_{kt}, \nu_{kt})$ and decide whether to hire *F* units of labor, to change their price, or not to do so. Denoted by $V(p;s)$ the present value of profits for a firm with current price *p* (prior to its price adjustment decision) can be characterized using the following Bellman equation:

$$V(p;s) = \max \left\{ V\left(p^*(s);s\right) - WF, \varpi(p,s) + e^{-\delta} \int_{s'} V(p;s') d\xi(s'|s) \right\} \qquad (23)$$

One can normalize the nominal variables by *M* and make inflation explicit in (23), where the normalized correspondent of a nominal variable x is denoted $\hat{x}$, thus, $p^*(s) = \arg\max_{\hat{p}} V(\hat{p}; s)$ and $\xi(s' \mid s)$ is the transition probability from s to *s'*.

Equation (23) is the main equation that governs the process of distorting the composition of output from efficiency, whereby the aggregate productivity and welfare are negatively affected. The equilibrium characterization and the calibration follow Burstein and Hellwig (2008). The firm's optimal price adjustment decision rule $\tilde{p}(\hat{p}; s)$ is characterized by two values $\underline{p}(s)$ and $\overline{p}(s)$ around the optimal price $p^*(s)$ for which $V(\underline{p}(s); s) = V(\overline{p}(s); s) = V^*(s) - \hat{W}F$, whereby the firm keeps its price constant if $\hat{p} \in [\underline{p}(s), \overline{p}(s)]$ and adjusts its price to $p^*(s)$ otherwise. Good market clearing requires *Y=C*. Steady-state equilibrium is characterized by an optimal pricing rule $\tilde{p}$, a cross-sectional and stationary distribution Φ generated by the optimal pricing rule $\tilde{p}$, and $(C, L, \hat{P}, \hat{W})$, with $\tilde{p}$ solving (23), and $(C, L, \hat{P}, \hat{W})$ satisfying the household optimality conditions, the price indexing rule, and the labor supply rule.

The calibration of the model shows that the menu costs change the welfare costs of inflation by less than 0.002 percent for an increase in inflation from zero to 2 percent. For an increase from zero to 4 percent, the menu costs change the welfare costs by less than 0.004. For an increase to 10 percent inflation the menu cost impact is less than 0.01 percent (Burstein and Hellwig, 2008). Thus, the additional welfare costs owing to the menu cost channel for increasing inflation from 2 to 4 percent are less than 0.002 percent.

To summarize, these estimates clearly suggest that the welfare costs of raising inflation targets emanating from the menu costs are negligible compared to the ones from the opportunity cost of real money balances in subsection A. The opportunity cost of holding real money balances channel appears the most significant for measuring the welfare costs of inflation. The menu cost model implies that while inflation might trigger price adjustments, it has little effect on the average magnitude of price changes. The magnitude of price changes is the key parameter that governs the extent of fluctuations in relative prices, which in turn is at the core of distorting output composition from efficiency, lowering aggregate productivity and welfare, because some goods become inefficiently expensive. The findings suggest that the welfare impact of the productive time devoted to activities enabling economization on cash balances—owing to inflation—and which is at the core of the opportunity cost channel, greatly outweighs the welfare impact of the menu cost channel.

D. Some Caveats

It is worth mentioning that the models highlighted above look only at the welfare cost of moving from one steady state to another under certainty, in the sense that they do not account

for the uncertainty a higher inflation regime may induce. Thus, the calibrations here may vastly underestimate the full costs of raising inflation targets.

Empirical evidence suggests that higher inflation is associated with higher inflation variability, and hence higher uncertainty (Okun, 1971; Logue and Willet, 1976; Ball and Cecchetti, 1990). Using a sample from the Organisation for Economic Co-operation and Development (OECD), Okun (1971) convincingly shows that countries with high inflation would also experience more variable inflation rates. Logue and Willet (1976) argue that for any investment decision, the higher the inflation rate the more crucial the ability to distinguish the real from the inflation component of future nominal returns. Strong presumptions of greater volatility of inflationary expectations for higher rates of inflation tend to make investment decisions more difficult. As such, higher rates of inflation will tend to induce greater variability in actual investment and hence greater variability in actual inflation for any given set of financial policies. The variable state of price movements, by injecting uncertainty into the economic decision making, has the potential to give rise to higher, economy-wide volatility.

Analyzing the U.S. inflation debate in the early seventies—where the 4 percent unemployment rate accepted as a target for full employment was thought to require an inflation rate of 5 percent, contrary to the 2 percent in the fifties and the sixties—Okun (1971) argues that if the 5 percent inflation could be fully anticipated, it would impose only minor social costs. However, he cautions that such an economic state as steady, where inflation would be fully anticipated, has never existed and can never be attained. He goes on to characterize economic decision making as an art that cannot produce a steady inflation. Thus, the very acceptance by policymakers of higher inflation targets would influence expectations in such a way that would make prices rise more rapidly and less steadily.

Raising the inflation target is bound to raise questions about how policymakers would react when the inflation rate goes above the target. Okun's (1971) conclusion is very revealing: the only safe forecast about the inflation rate is that it will fluctuate; and the policymakers' responses to unforeseen inflationary spurts are subject to uncertainty. Furthermore, based on the dilemma of the desire to disinflate when inflation is higher while fearing recession at the same time, Ball (1992) proposes a theoretical model rationalizing why high inflation raises inflation uncertainty.

Clearly, while these models have produced some estimates of inflation costs, they need to be looked at as indicative. The models do not capture all the factors affecting inflation dynamics. Thus, the analysis in this paper simply aims at showing some minimum ranges of the additional welfare costs of raising inflation targets. In short, the full costs of inflation are yet to be estimated.

IV. Balancing Costs and Benefits

The conduct of monetary policy in an environment of low inflation and low nominal interest is challenging. This is even so if on top of such an environment the country is hit by an

adverse shock because policymakers' scope of intervention is greatly limited. One way out is for countries to set inflation targets moderately high, thereby making nominal interest rates relatively high. Higher inflation targets appear to significantly reduce the frequency of hitting the zero lower bound (Adam and Billi, 2007). Thus, the key advantage of raising inflation targets is to avoid hitting the zero lower bound of nominal interest rates, thereby maintaining the effectiveness of the conventional monetary tools.

However, one needs to weigh this advantage against potential inflation costs. How strong is the incompatibility of the zero lower bound on nominal interest rates and setting low inflation targets of 2 percent? Schmitt-Grohe and Uribe (2010) argue that the zero bound on nominal rates does not represent an impediment for setting targets near or below zero.

In this paper, examining the potential impacts of raising inflation targets above 2 percent, we find that although this will reduce the frequency of hitting the zero lower bound, it does generate strictly positive net welfare costs. Even after controlling for the zero lower bound, these costs are estimated at about 0.3 percent of real income for raising targets from 2 to 4 percent and at about 1 percent if the targets were raised to 10 percent. For other parameter values the welfare costs could be as high as 7 percent of real income for raising the inflation target from 2 to 4 and 30 percent of real income for raising the target from 2 to10 percent.

Although the concerns about hitting the zero lower bound are legitimate, especially in light of the recent financial crisis, and make raising inflation targets appealing, our findings call for great caution about such an option. Our findings suggest that monetary policies should not be judged by looking solely at the frequency at which nominal interest rates' lower bound is reached.

Looking a few decades back could also help elucidate the issue. In the late 1970s and early 1980s, many countries including the United States, experienced high inflation. A broad consensus then emerged that such an outcome was unacceptable (Billi and Kahn, 2008). As a consequence, central banks around the world adopted policies to bring inflation down. Thus, given the history of inflation dynamics, raising inflation targets today would amount to questioning the earlier consensus and could be seen as challenging the very policies that brought inflation down a few decades earlier.

An increase in inflation targets would raise questions about central banks' commitment to price stability. There is no guarantee that inflation would be maintained at a new higher level. As Bernanke (2010) points out, if inflation targets were raised to 4 percent, nobody knows whether they will later go to 5 percent, or more, and it will be costly to bring them down. Anchoring inflation expectations at a low rate of 2 percent has worked in the past, but nobody knows how successful it will be to anchor inflation expectations at a moderate rate of 4 percent. If expectation anchoring were to fail and inflation to reach 5, 6, or 10 percent, this would generate additional welfare costs as high as 10 percent of real income.

In short, while raising inflation targets may appear appealing because it will make policymakers' decisions easier in the presence of a crisis; great caution needs to be exercised.

One thing we learned from the recent financial crisis is that even though the conduct of monetary policy was challenging because short-term interest rates got close to zero very quickly, the unconventional monetary policy measures used have overall achieved their goals (Gagnon and others, 2010; Yehoue, 2009). Thus, it might be useful to explore alternative monetary instruments to expand the existing conventional monetary tools.

V. CONCLUDING REMARKS

In light of the challenges posed by the conduct of monetary policy during the recent financial crisis, central bankers in advanced and emerging economies adopted unconventional measures as policy interest rates neared the zero bound. One suggestion to avoid coming to this extreme in the future is to raise inflation targets to provide more room for policy easing during crises. This paper examines the impact of inflation on welfare.

It first surveys research on inflation, growth, and welfare, and documents why major central banks around the world often set their inflation targets around 2 percent. It then examines the relationship between inflation and welfare. In particular, the paper analyzes the impact on welfare of raising inflation targets above 2 percent. This is done by focusing on two channels. The first is the opportunity cost channel, whereby raising inflation targets increases the opportunity cost of holding real money balances. The second is related to menu costs and provides a microfoundation for price stickiness. In the menu cost model, fluctuations in relative prices between products whose prices adjust and products whose prices do not, distort the composition of output from efficiency, lower aggregate productivity, and reduce welfare.

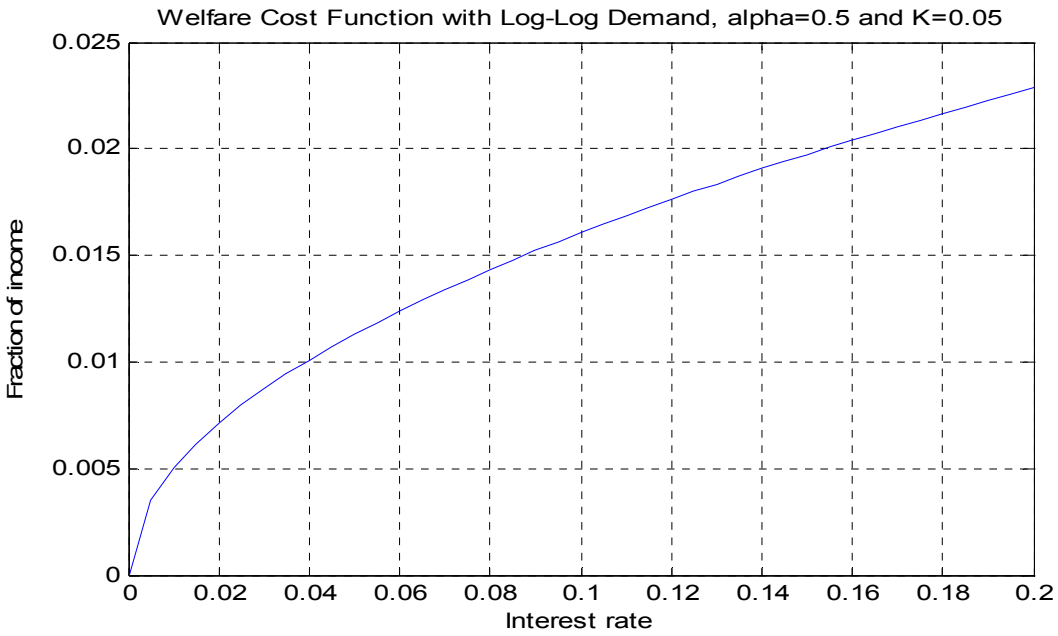
The calibrations reveal that the welfare costs coming from the menu costs are negligible compared to the ones coming from the opportunity cost of holding real money balances. This is in line with (Burstein and Hellwig, 2008), even though the framework used in this paper for the opportunity cost channel is different from theirs.[10]

The key finding of this paper is that an increase in inflation targets generates additional welfare costs, even after taking into account the constraint of the zero lower bound on nominal interest rates. Based on parameter values consistent with U.S. data and using a conservative approach, it is estimated that a rise in inflation targets from 2 to 4 percent gives rise to additional welfare costs equal to about 0.3 percent of real income. These additional welfare costs could be as high as 7 percent of real income, depending on parameter values. Notice that the opportunity cost model used to generate these estimates does not capture all the factors affecting inflation dynamics. For example, it does not account for the fact that higher inflation is associated with greater inflation volatility. As highlighted above, the analysis simply aims at showing some minimum ranges of the additional welfare costs of raising inflation targets. In other words, the full costs of raising inflation targets are likely to be higher than the analysis suggests. Thus, while acknowledging the appeal of raising

[10] The paper does rely on their framework for the menu cost channel.

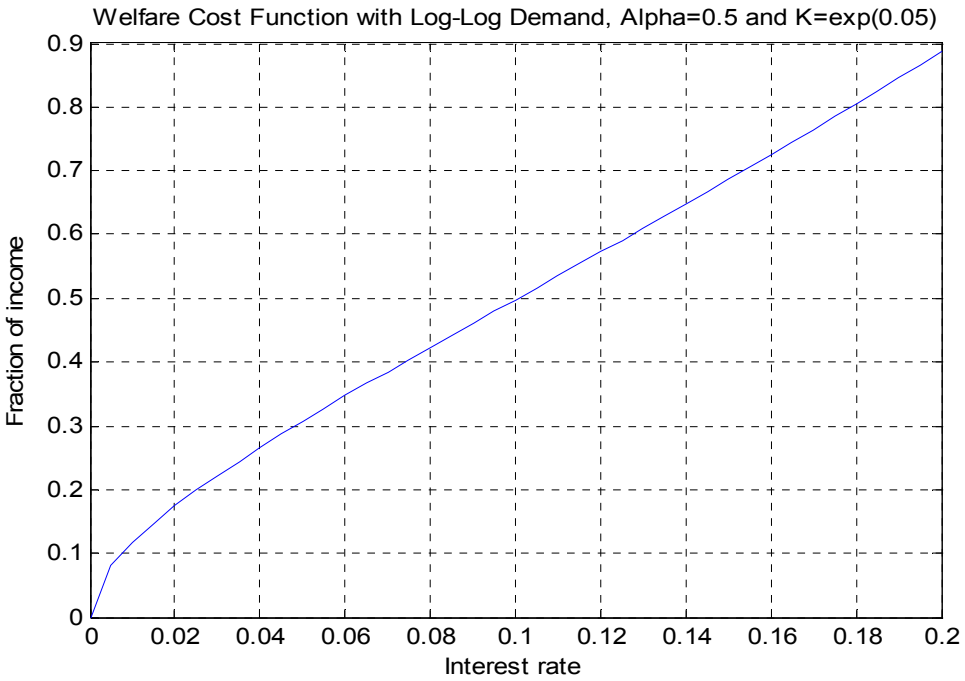
inflation targets to offer more room to maneuver to policymakers in the conduct of monetary policy, the analysis in this paper recommends caution about adopting such an option.

Figure 1. Welfare Cost Function with Log-Log Money Demand Function, Alpha = 0.5 and K = (0.05)



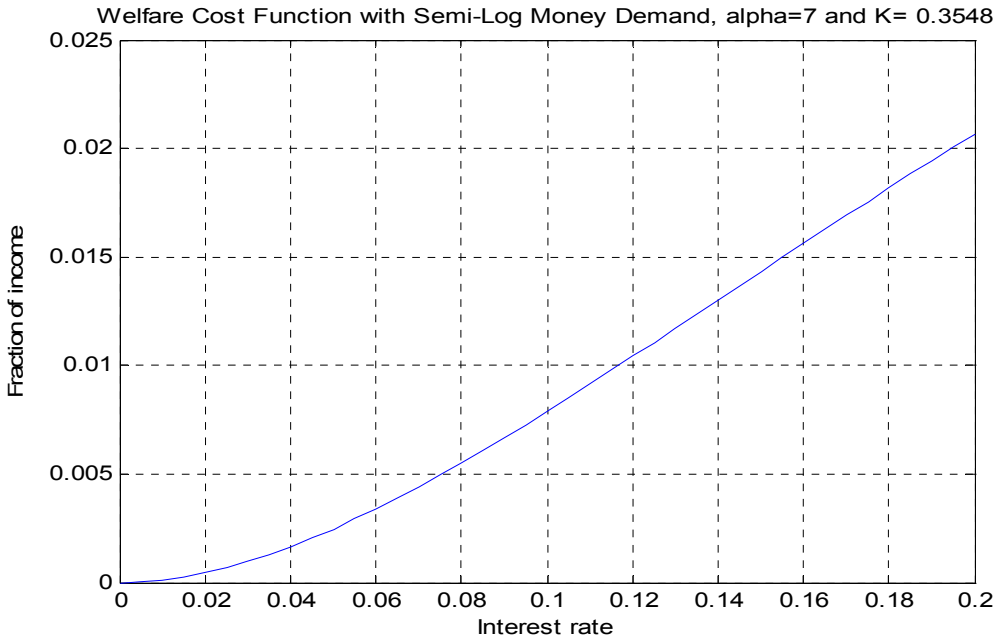
Source: Author's calibration.

Figure 2. Welfare Cost Function with Log-Log Money Demand Function, Alpha = 0.5 and K = exp (0.05)



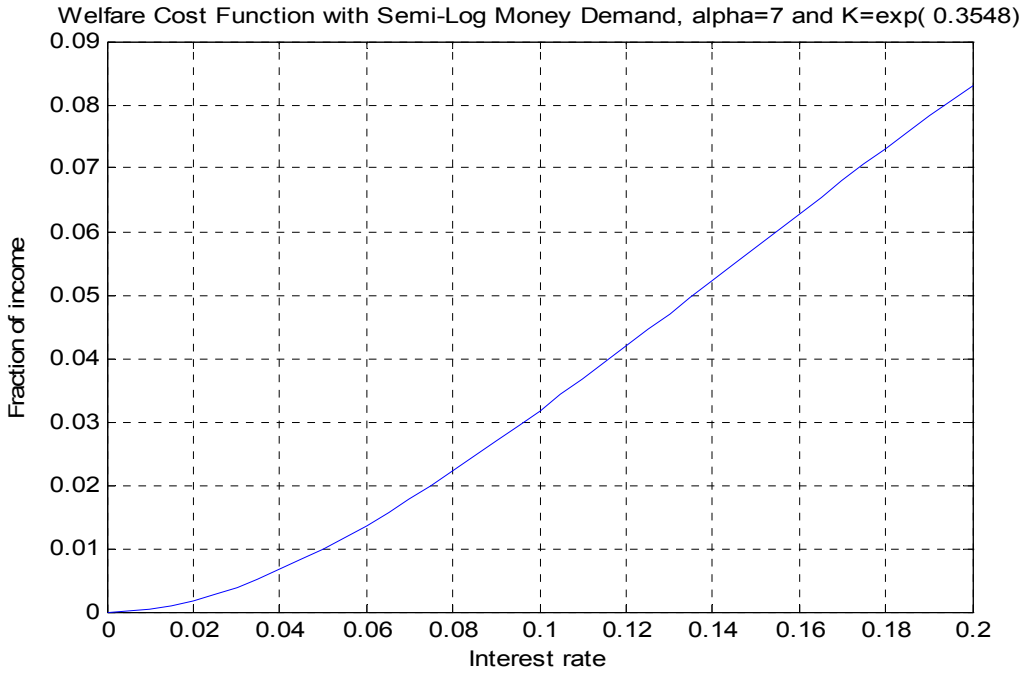
Source: Author's calibration.

Figure 3. Welfare Cost Function with Semi-Log Money Demand Function, Alpha = 7 and K = (0.3548)



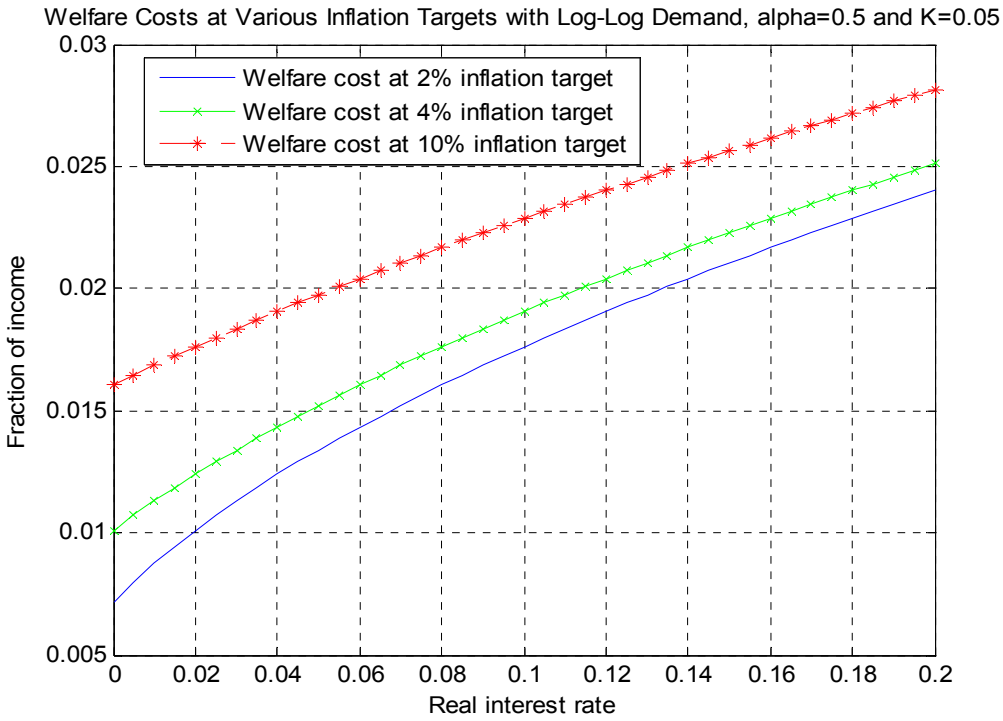
Source: Author's calibration.

Figure 4. Welfare Cost Function with Semi-Log Money Demand Function, Alpha = 7 and K = exp (0.3548)



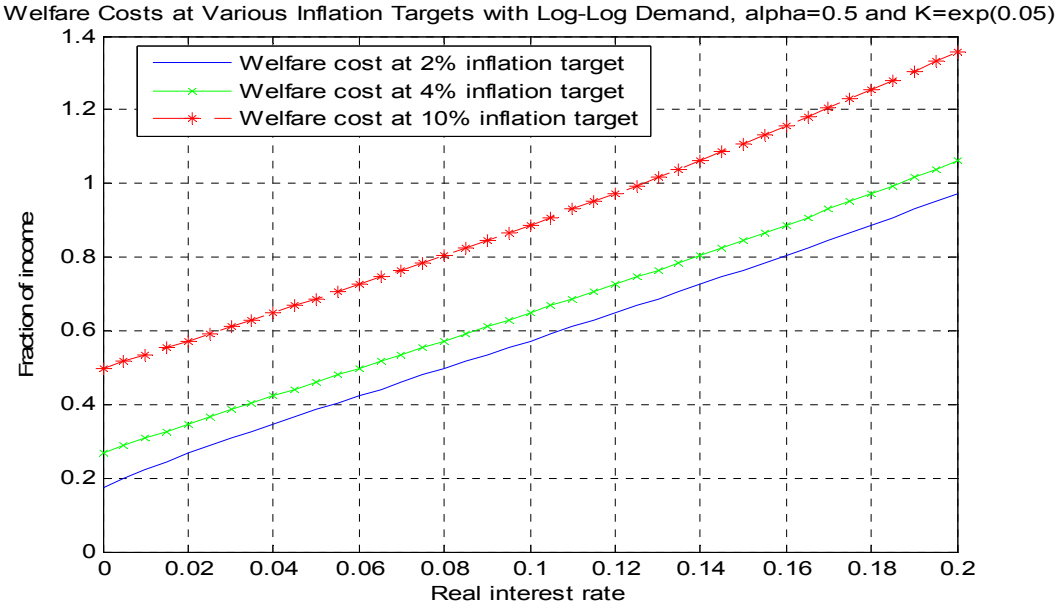
Source: Author's calibration.

Figure 5. Welfare Costs at Various Inflation Targets with Log-Log Money Demand Function, Alpha = 0.5 and K = (0.05)



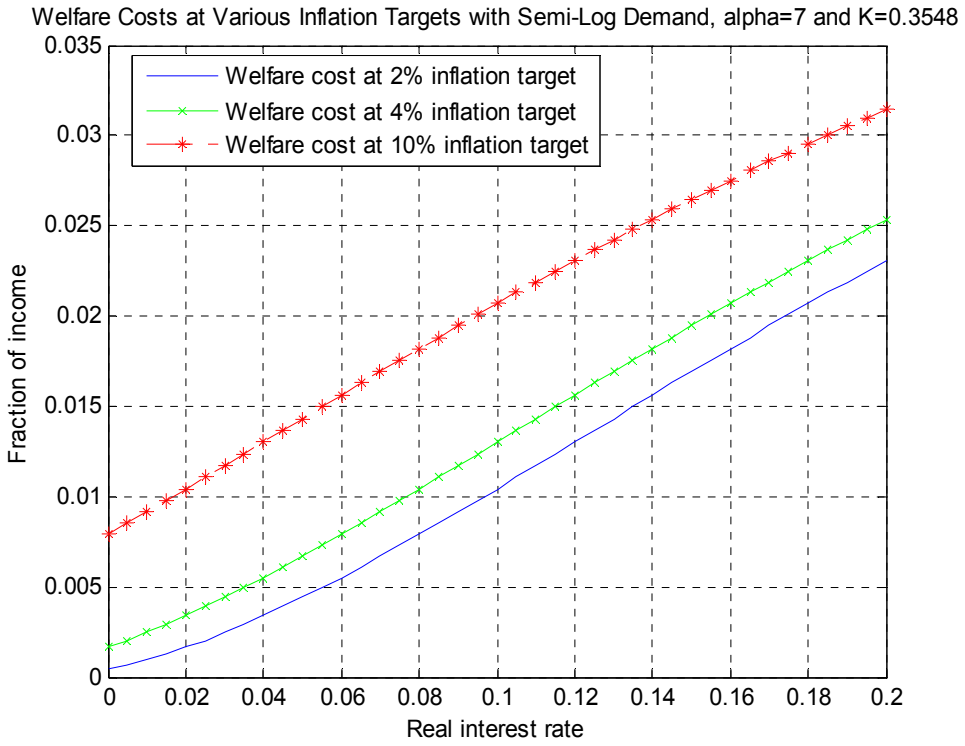
Source: Author's calibrations.

Figure 6. Welfare Costs at Various Inflation Targets with Log-Log Money Demand Function, Alpha = 0.5 and K = exp (0.05)



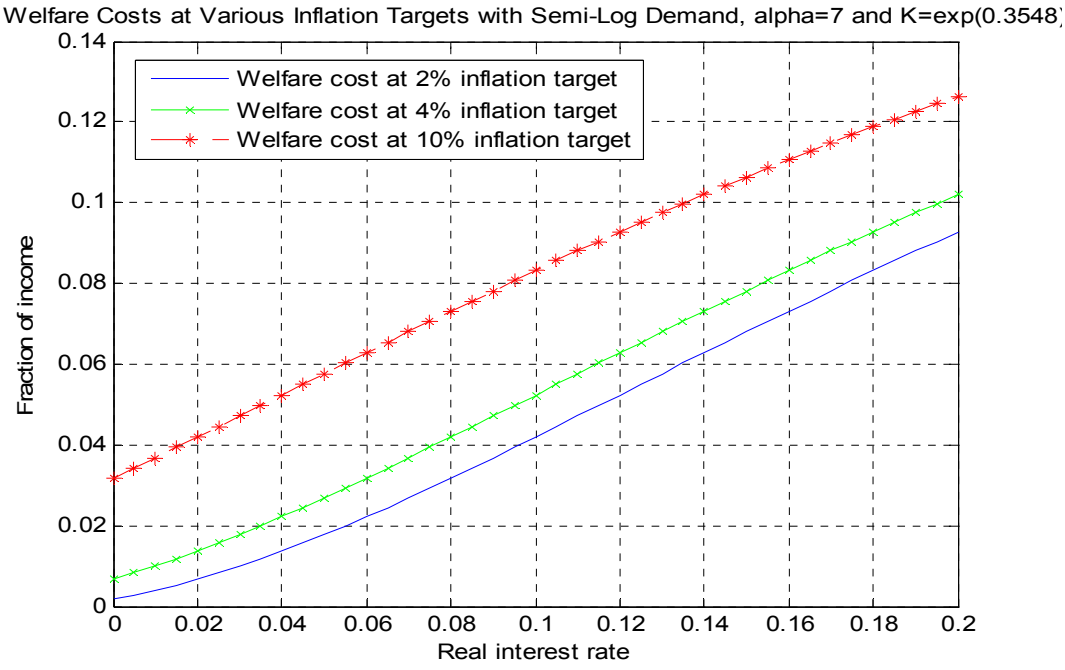
Source: Author's calibrations.

Figure 7. Welfare Costs at Various Inflation Targets with Semi-Log Money Demand Function, Alpha = 7 and K = (0.3548)



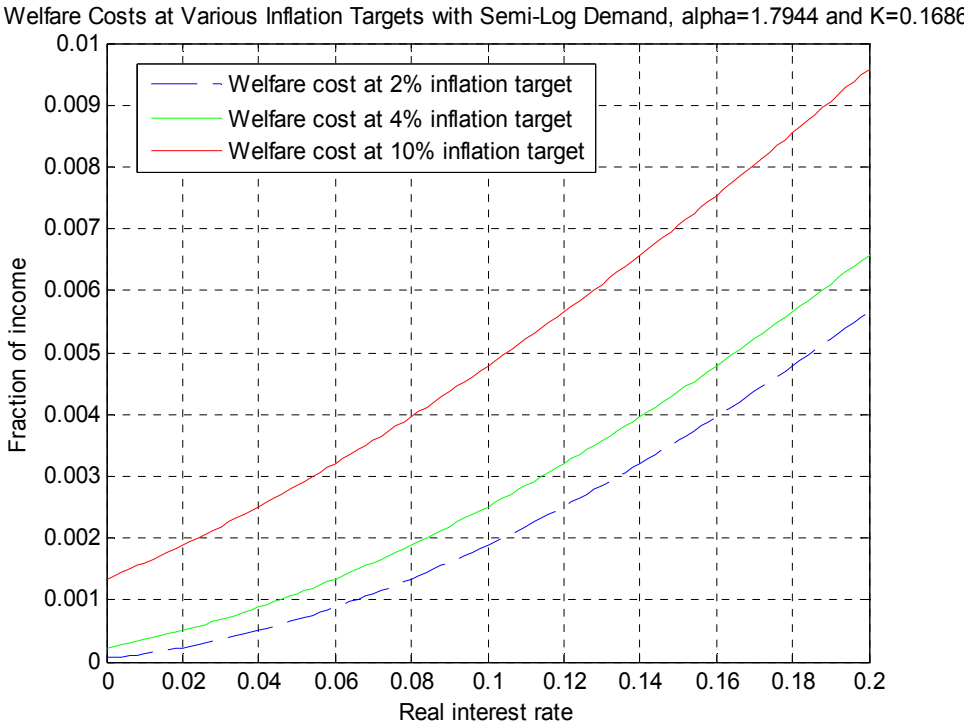
Source: Author's calibrations.

Figure 8. Welfare Costs at Various Inflation Targets with Semi-Log Money Demand Function, Alpha = 7 and K = exp (0.3548)



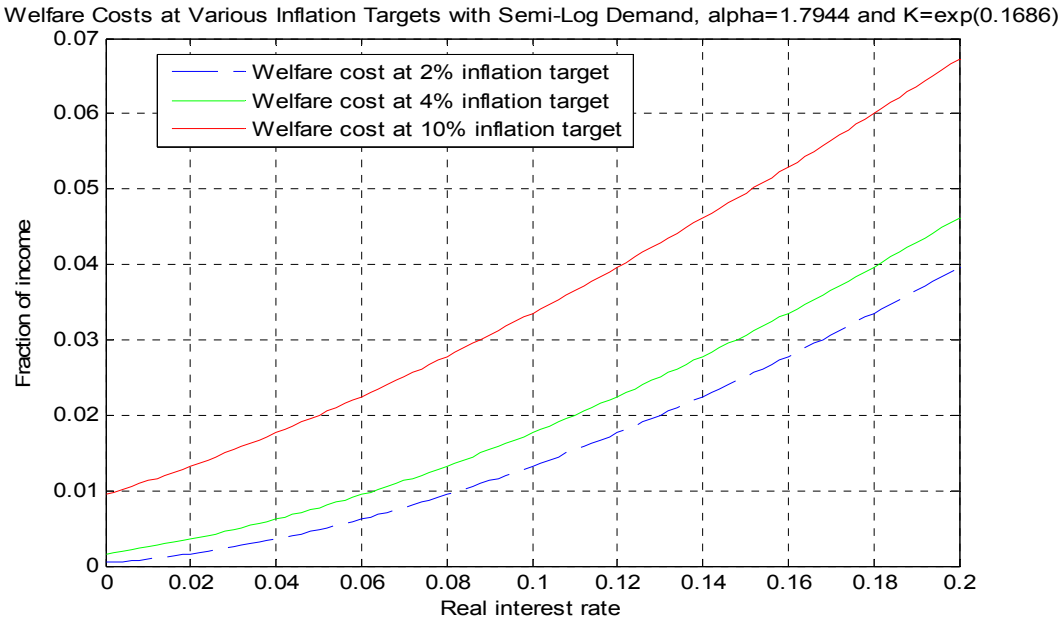
Source: Author's calibrations.

Figure 9. Welfare Costs at Various Inflation Targets with Semi-Log Money Demand Function , Alpha = 1.7944 and K = (0.1686)



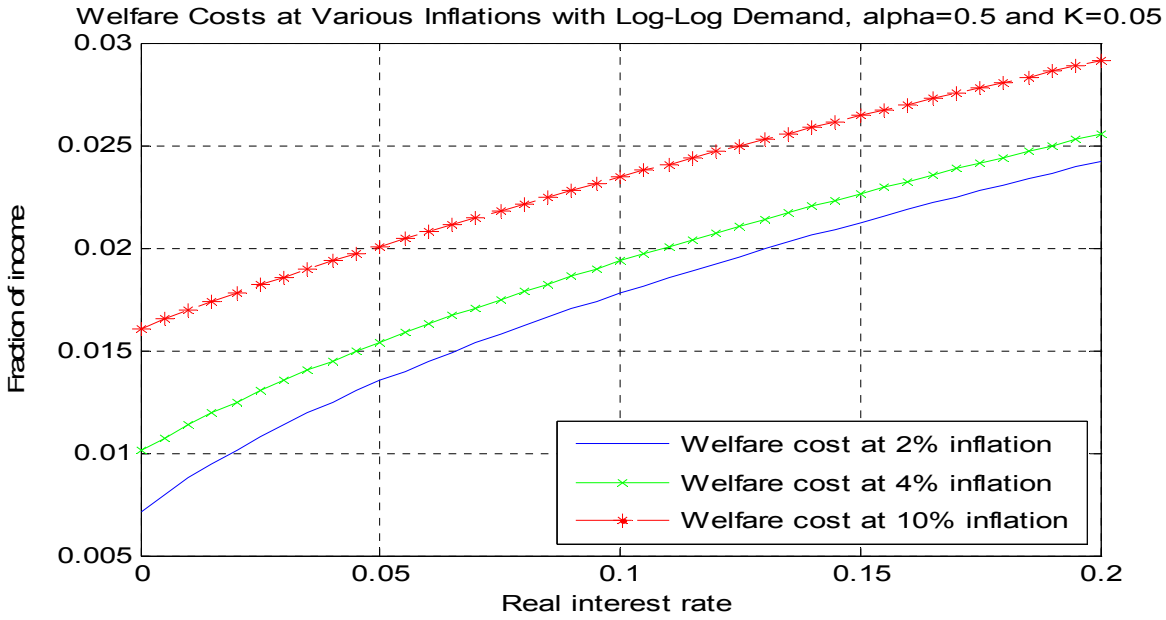
Source: Author's calibrations.

Figure 10. Welfare Costs at Various Inflation Targets with Semi-Log Money Demand Function, Alpha = 1.7944 and K = exp (0.1686)



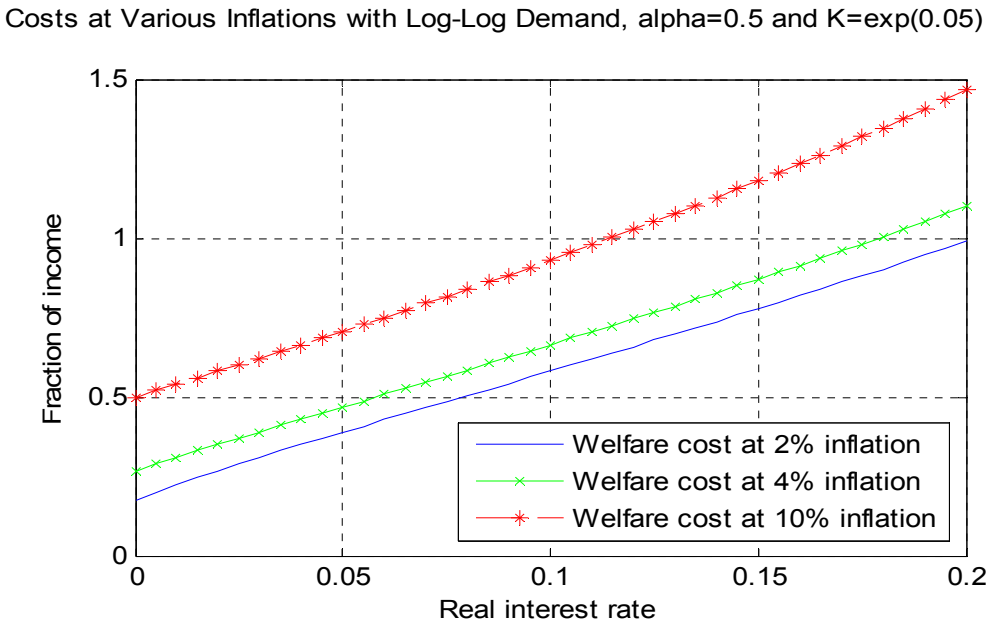
Source: Author's calibrations.

Figure 11. Welfare Costs at Various Inflations with Log-Log Money Demand Function, Alpha = 0.5 and K = (0.05)



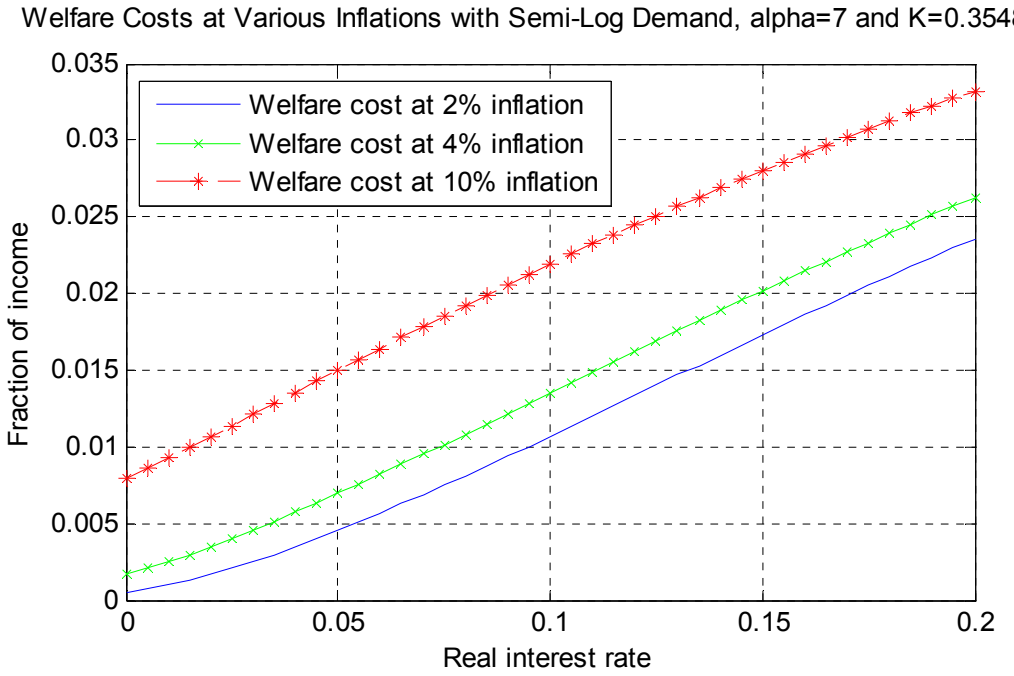
Source: Author's calibrations.

Figure 12. Welfare Costs at Various Inflations with Log-Log Money Demand Function, Alpha = 0.5 and K = exp (0.05)



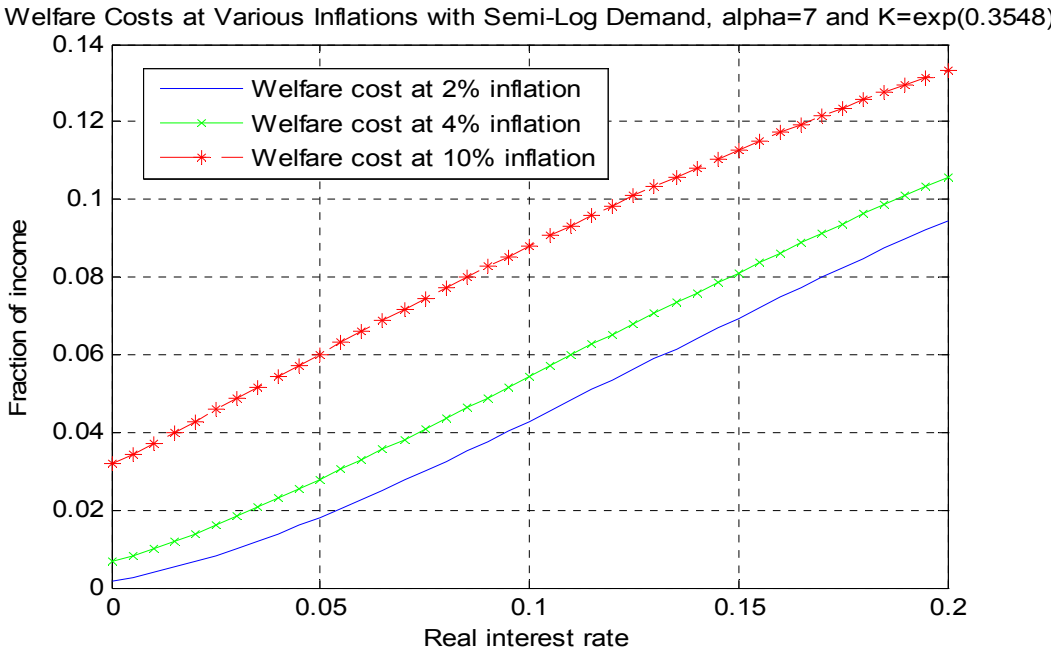
Source: Author's calibrations

Figure 13. Welfare Costs at Various Inflations with Semi-Log Money Demand Function, Alpha = 7 and K = (0.3548)



Source: Author's calibrations.

Figure 14. Welfare Costs at Various Inflations with Semi-Log Money Demand Function, Alpha = 7 and K = exp (0.3548)



Source: Author's calibrations.

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