THE UNIVERSITY OF TEXAS AT SAN ANTONIO, COLLEGE OF BUSINESS

Working Paper SERIES

WP # 0034ECO-566-2012

Date August 13, 2012

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Economic Development and the Welfare Costs of Inflation*

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Abstract

It has been widely observed that the role of money in the financial system varies across developing and advanced countries. While the connections between economic development and the effects of monetary policy on macroeconomic outcomes appear to be well understood, their consequences for living standards across the world are not. That is, existing research on the welfare costs of inflation has focused nearly exclusively on the United States. In contrast to the existing literature, this paper seeks to determine the gains from eliminating inflation across a broad section of countries. These countries vary according to their: (i) level of economic development, (ii) reliance on cash for transactions, and (iii) average inflation rates. Upon calibrating our model to quantify the role of money for transactions in the economy, we find that there are substantial differences in welfare costs across countries. Notably, the welfare costs of inflation in advanced countries such as the United States are quite low. In particular, the cost of inflation in countries such as Germany and the United States may be as low as 0.3%. However, the gains from eliminating inflation in the developing world are much higher. Differences in total factor productivity promote capital accumulation and reduce the reliance on cash in advanced countries so that the effective tax rate on capital formation is mitigated.

JEL Codes: E41, E52, E31, O42

Keywords: Economic Development, Financial Development, Inflation

1 Introduction

It has been widely observed that the role of money in the financial system varies across developing and advanced countries. There are a host of reasons behind why this phenomenon occurs. For instance, Roubini and Sala-i-Martin (1995) stress that governments in less developed economies repress the financial sector in order to maintain a high demand for cash balances and a large seigniorage tax base. Recent work by Schneider and Enste (2000) demonstrates that low-income countries have a large informal sector, in which transactions are made primarily in cash. In particular, they observe that the underground sector may be as large as 76% of the economy in developing countries but may be as low as 8% in OECD countries. Whatever the reason – countries with high levels of income tend to be less dependent on cash for transactions.

In addition to the level of income, inflation can have significant implications for the choice of financial instruments in the economy. For instance, Demirgüç-Kunt and Maksimovic (1999) point out that banks may be reluctant to issue long term credit in high

*We thank Karl Boulware, Anna Cai, and Jenny Minier for comments.

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inflation environments, increasing the private sector's reliance on short term contracting and cash for investment and consumption purposes.[1] Thus, banks may hold highly liquid portfolios despite the low return to money balances. The effects of inflation on banks' liquidity is examined by Haslag and Koo (1999). In particular, in a sample of 109 countries, Haslag and Koo (1999) find a positive correlation between the average level of inflation and bank reserves.

Obviously, the intensity of cash usage in the economy can have significant consequences for the costs of inflation on the economy. In fact, recent work by Boel and Camera (2009) demonstrates that the burden of inflation depends on the availability of assets (markets) other than money in which agents can use to hedge against inflation. Therefore, the welfare costs of inflation are increasing with the amount of money holding.

Because countries differ in their degree of reliance on cash, one should expect the effects of inflation on welfare to be asymmetric. Notably, research effort devoted to studying the welfare costs of inflation (or the gains from completely eliminating inflation) has focused nearly exclusively on the United States.[2] Though there are some exceptions, the general consensus is that the welfare cost of 10% inflation is approximately 1% of consumption. However, there are a number of important reasons to be skeptical about this conclusion as representative across countries. First, the U.S. economy is quite advanced. In turn, the degree of reliance on cash is likely to be smaller than in lower income countries. Moreover, the postwar U.S. inflation experience has been quite timid compared to other countries.[3]

As central banks have generally pursued policies to lower inflation rates, this paper seeks to develop a framework to quantify the benefits from eliminating inflation across a broad section of economies. Interestingly, the countries in our sample differ in three fundamental ways: (i) the level of economic development, (ii) the reliance on cash for transactions, and (iii) average inflation rates. As in Cooley and Hansen (1991) and Lucas (2000), a consumption-based (compensating variation) measure of welfare losses from inflation is constructed.

Section 2 employs a modified cash-in-advance model based upon Ghossoub and Reed (2010, 2012). The central hypothesis in the model is that cash is less important for conducting transactions in economies with high levels of capital formation and low average inflation rates. This assumption reflects cross-country differences in the reliance observed in previous work discussed above.

Section 3 proceeds with our calibration analysis to construct measures of the welfare costs of inflation. As in much of the literature on economic growth, we study economies included in the Summers and Heston (1991) data set. However, we limit our analysis to the 16 countries with grades for data quality of a B- or above. Average inflation rates are constructed using GDP deflators from the International Financial Statistics.

By quantifying the role of cash on the basis of an economy's level of development and inflation, the welfare costs of inflation appear to be much lower than previous estimates – for example, welfare costs for the United States drop to nearly 0.4%. However, the findings also suggest that gains from eliminating inflation are highest among developing

[1] Using a sample of 30 countries, Demirgüç-Kunt and Maksimovic (1999) find a negative correlation between firms' usage of long term debt and inflation. See also Rousseau and Wachtel (2001) for a discussion on the linkages between inflation and financial sector performance.

[2] An exception includes recent work by Boel and Camera (2011) that examines the welfare costs of inflation in OECD countries. Using a Lagos and Wright (2005) setting, they find the costs of inflation to be significantly below unity for most countries in their sample when trade is conducted through perfectly competitive Walrasian markets. Notably, their work does not account for cross country differences in the extent of reliance on cash - an important factor in the transmission of inflation into the economy, as previously found in Boel and Camera (2009).

[3] Calibrating their model to match the U.S data, Boel and Camera (2009) find the welfare costs of inflation to be as low as 0.004 percent when alternative assets to money can be used to hedge against inflation.

countries. For example, the welfare costs for South Korea (the lowest income country) stand close to 1.7%. This seems to be driven by differences in total factor productivity that promote capital accumulation and reduce the reliance on cash in advanced countries so that the effective tax rate on capital formation is mitigated.

2 The Model

We study a representative agent economy in continuous time, where agents are infinitely-lived and have perfect foresight. Following Stockman (1981), agents need cash to consume and invest in capital goods. The cash-in-advance constraint is such that:

$$\Gamma\left(\bar{k}\left(t\right),\bar{\pi}\right)\left(c(t)+\dot{k}\left(t\right)\right)\leq m(t) \tag{1}$$

where $c(t)$ and $m(t)$ are consumption and real money balances. In addition, $\Gamma\left(\bar{k}\left(t\right),\bar{\pi}\right)\in(0,1)$, reflects the degree of reliance on cash.[4] In contrast to previous work, we consider that there are external effects from the average capital stock, $\bar{k}\left(t\right)$, and the average level of inflation, $\bar{\pi}$, into the reliance on cash. In particular, the reliance on cash is lower in countries with high levels of capital formation (more developed economies) and low inflation rates. As income is higher in economies with high levels of capital formation, these assumptions mirror the linkages between the reliance on cash, economic development, and inflation across countries.

The function $\Gamma\left(\bar{k}\left(t\right),\bar{\pi}\right)$ is such that $\Gamma_1<0$, $\Gamma_{11}>0$, $\Gamma_2>0$, and $\Gamma_{22}\leq 0$. Moreover, $\underset{\bar{k}(t)\rightarrow\infty}{lim}\ \Gamma\rightarrow 0$ and $\underset{\bar{k}(t)\rightarrow\underline{k}}{lim}\ \Gamma\rightarrow 1$, where $\underline{k}>0$ is a lower bound on capital formation, under which all transactions are monetary.

We assume that there is no source of uncertainty in this economy. Therefore, a representative individual's optimization problem is:

$$\underset{c(t)}{Max}\int_0^{\infty}e^{-\rho t}u(c(t))dt \tag{2}$$

subject to:

$$\dot{k}\left(t\right)+\dot{m}(t)=f(k(t))-\delta k(t)-\pi m(t)+v(t)-c(t) \tag{3}$$

and the cash-in-advance constraint, (1), where ρ represents the discount rate in the economy, and δ and π are the depreciation and inflation rates, respectively. The parameter $v(t)$ is the lump-sum transfer of money from the monetary authority at time t.

We apply Pontryagin's Maximum Principle to solve the agent's problem. We concentrate on studying the behavior of the economy in steady-state such that $\dot{c}\left(t\right)=\dot{m}(t)=\dot{k}\left(t\right)=0$. A few lines of algebra yields the following modified golden rule equation:

$$f^{'}\left(k^{*}\right)=\left(\rho+\delta\right)+\rho\left(\rho+\pi\right)\Gamma\left(k^{*},\pi\right)\equiv\psi\left(k^{*},\pi\right) \tag{4}$$

The modified golden rule relates an individual's marginal benefit of maintaining a higher steady-state stock of capital relative to its cost. The term, $\rho\left(\rho+\pi\right)\Gamma\left(k^{*},\pi\right)$ reflects the additional amount of cash required to increase capital investment by one unit. In contrast to previous work such as Stockman (1981), a higher amount of capital accumulation allows individuals to reduce their reliance on cash since $\Gamma_1<0$. This in turn reduces the cost of investment, ψ, which spurs investment activity.

[4] One may also interpret Γ as a measure of the degree of sophistication in the payments system. In this manner, a lower value of Γ implies that the payments system is more advanced as agents do not need to use as much cash to conduct transactions.

We proceed to examine the existence and uniqueness of steady-state equilibria. The equilibrium amount of capital is the solution to the polynomial (4).

Proposition 1. *Suppose* $f'(\underline{k}) > (\rho+\delta)+\rho(\rho+\pi)$. *Under this condition, a steady-state exists and is unique. Moreover, inflation adversely affects capital formation and welfare.*

The proof of Proposition 1 is straightforward and therefore we omit it. In this setting, inflation affects the economy in three different ways. First, as in Stockman (1981), agents economize on cash holding under a higher inflation rate, which reduces their levels of investment and consumption. Additionally, inflation has a direct impact on agents' reliance on cash. Since inflation raises the need to use cash in the economy, agents are more exposed to it. Finally, the lower level of economic development increases the need for agents to hold money, which exacerbates the effects of inflation.

Because the reliance on cash varies with a country's level of development and inflation rate, the welfare costs of inflation should vary significantly across countries. We address this issue in the following section.

3 Welfare Effects of Inflation

We proceed to examine how the welfare costs of inflation vary across countries. In order to do so, we parametrize the model described above and solve it numerically. Our numerical analysis indicates that the welfare costs of inflation vary significantly across countries. Interestingly, the gains from eliminating inflation appear to be the highest among less-developed countries.

In order to make cross country comparisons, we use a sample of countries from the Penn World table in Summers and Heston (1991). For each country, average real GDP per person is obtained. The sample period for real GDP for most countries is 1950-1988. Due to issues in the quality of the data, we focus our attention on countries with a quality rating of $B-$ and above. Furthermore, we use the GDP deflator from the International Financial Statistics data set to measure prices. For a given country j, the average inflation rate is calculated in the following manner:

$$\pi^j = \frac{\ln P^j_{i+N} - \ln P^j_i}{N} * 100$$

where P^j_i is the price level in country j in the initial period, i, and N is the number of years in the sample for which price data is available. A list of the countries used along with a summary of the data are provided in Table 1 immediately below:

Country	Real GDP Per Capita (1985 Intl Prices)	GDP Deflator$_i$	GDP Deflator$_{i+N}$	Average Inflation Rate	GDP Period	Inflation Period	Grade
Australia	13321	8.79	63.39	6.81	1950-1988	1959-1988	A-
Belgium	11495	15.44	68.41	4.25	1950-1988	1953-1988	A
Canada	16272	11.47	74.99	4.94	1950-1988	1950-1988	A-
Finland	12360	7.44	68.67	7.94	1950-1988	1960-1988	A-
France	12190	6.00	75.13	6.65	1950-1988	1950-1988	A-
Germany	12604	23.77	75.02	3.02	1950-1988	1960-1988	A
Greece	5857	0.48	22.14	10.10	1950-1988	1950-1988	A-
Ireland	6239	3.13	52.66	7.43	1950-1988	1950-1988	A-
Japan	12209	15.99	98.24	5.50	1950-1988	1955-1988	A
Netherlands	11468	13.16	66.81	5.08	1950-1988	1956-1988	A
New Zealand	9864	5.79	70.59	7.35	1950-1988	1954-1988	A-
South Korea	5156	0.20	48.00	15.66	1953-1988	1953-1988	B-
Spain	7406	2.06	47.37	9.22	1950-1988	1954-1988	A-
Sweden	12991	5.50	62.67	6.40	1950-1988	1950-1988	A-
United Kingdom	11982	4.13	57.05	6.91	1950-1988	1950-1988	A
United States	18339	14.62	66.97	4.00	1950-1988	1950-1988	A

Table 1: Data Summary

As illustrated in Figure 1 below, it is generally observed that higher income countries have lower inflation rates.

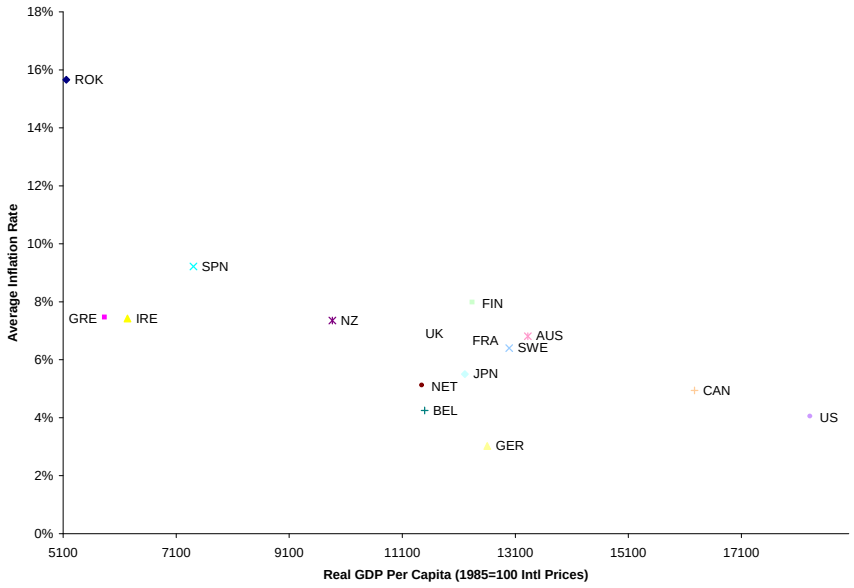

Figure 1: Developed Countries Are Associated with Lower Inflation Rates

In order to calibrate our model, we assume that the reliance on cash is given by $\Gamma(k, \bar{\pi}) = \frac{\Gamma_0}{k^\lambda}\bar{\pi}$. The parameter $\lambda \geq 0$ reflects the importance of economic development on

the reliance on cash. Moreover, let the production function be given by $y = Ak^{\alpha}$, where α is the capital share of total output. Finally, the preferences of a representative agent are expressed by $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, where $1/\sigma$ is the intertemporal elasticity of substitution. The values assigned to the parameters of the model are as follows. First, as in previous studies, capital contributes 1/3 to total output, with $\alpha = 1/3$. Next, following Lucas (2000), capital depreciates at a rate $\delta = 0.025$ and the coefficient of relative risk aversion is such that the intertemporal elasticity of substitution is .5. Thus, $\sigma = 2$. Additionally, from the growth literature, we set $\rho = 0.05$.

The first step in our calibration exercise aims at choosing a value for the level of total factor productivity, A. In order to do so, we follow standard cash-in-advance models such as Stockman (1981) by assuming that all transactions are made in cash. That is, $\Gamma = 1$. In this case, the modified golden rule is simply:

$$k^* = \left(\frac{1}{A\alpha(\rho+\delta) + \rho(\rho+\bar{\pi})} \right)^{\frac{1}{1-\alpha}}$$

Based upon the average inflation rate for each country, we choose a value of TFP to match average real GDP for each country. Though the exact calculations are listed in the Appendix, the following Figure shows our results:

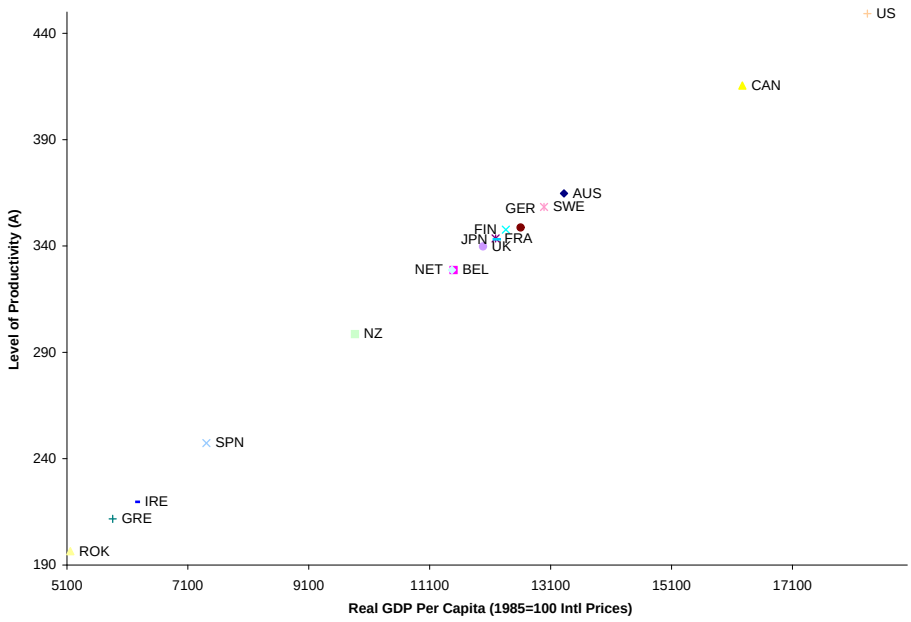

Figure 2: TFP and Real GDP Across Countries

We proceed to discuss the reliance on cash generated by the model. As a benchmark, we assume that the reliance on cash is independent of an economy's level of development. That is, we assume that $\lambda = 0$. Using data for the U.S. economy, we choose a reliance on cash so that an average inflation rate of 10% is associated with a 1% welfare loss. *Consequently, following Cooley and Hansen (1991) and Lucas (2000), the welfare cost of inflation is around 1% if the reliance on cash is independent of a country's level of economic development.*[5]

[5] We were unable to calibrate Γ_0 for each country as previous studies focus almost exclusively on the

As in previous work, a consumption-based (compensating variation) measure of welfare loss is constructed. Let c_0^* be the amount of consumption in a steady-state with a constant money supply and c_1^* be the amount at 10% money growth. Using the functional form for preferences and the parameters discussed above, the welfare costs of inflation can simply be expressed as:

$$\Delta W = \frac{c_0^*}{c_1^*} - 1$$

Our calibration exercise seeks to demonstrate the impact of economic development (through the level of financial development) on the welfare cost of inflation. In addition, a core part of our analysis is that the inflationary-environment of each country may distort activity and increase a country's reliance on cash. This aspect of our work follows observations by Haslag and Koo (1999), Demirgüç-Kunt and Maksimovic (1999), and Schneider and Enste (2000). Notably, low-inflation environments do not present the same degree of distortions to transactions patterns that are present in high-inflation environments. Consequently, the reliance on cash is lower in low-inflation economies. This point is further emphasized by Ghossoub and Reed (2010, 2012).

Thus, our benchmark measure of the reliance on cash will be chosen so that the reliance on cash endogenously responds to the economy's inflation rate. Based upon the average annual inflation rate for the United States over our sample period, the model generates a value of $\Gamma = \Gamma_0 \bar{\pi} = .411$. This number should be interpreted as a reading on the average reliance on cash for the U.S. economy from 1950-1988 *if the reliance on cash was independent of the level of capital formation*. That is, nearly 40% of transactions would involve cash as a means of payment.

We next turn to calculations which take into account that the level of financial development (as evinced by the role of cash in the economy) responds to the overall level of economic development. Since λ reflects the linkages between economic development and the demand for cash balances, we choose its value to match estimates of the elasticity of money demand. According to a recent study by Ball (2001), the income elasticity of money demand in the United States is around 0.5. Thus, in combination with parameters already pinned down from the benchmark calibration in which the cost of inflation was 1% of consumption, we examine the data to provide a value of λ to match the the elasticity of money demand in the United States. Our calibration analysis finds that λ is equal to 0.0831.[6]

Based upon our model, we find that the reliance on cash in the United States is well below 20% over our sample period. Furthermore, we can obtain estimates of the reliance on cash for other countries from the calibrated value of λ for the United States but accounting for the inflation experience and the calibrated levels of the capital stock for each country from the modified golden rule.

Figure 3 shows our estimates for the reliance on cash across countries. Note that the reliance on cash in Germany is also below 20%. Canada is slightly over 20%. However,

United Sates. However, one may anticipate that less developed countries have a much higher reliance on cash, independent from the level of inflation or the level of development (higher Γ_0), due to regulatory measures and poorly developed financial systems. Therefore, the welfare calculations conducted in this study might under-state the welfare costs of inflation in less developed economies.

[6] While λ may vary across countries, data and modeling limitations prevent us from calibrating its value for each country in our sample. In particular, due to the cash in advance constraint specification, the income elasticity of money is always below unity, which prevents us from calibrating λ to match income elasticities above one. Furthermore, we are not aware of previous studies that generate income elasticities for countries in our sample within the same sample period.

Spain and Greece are much higher at 40%.

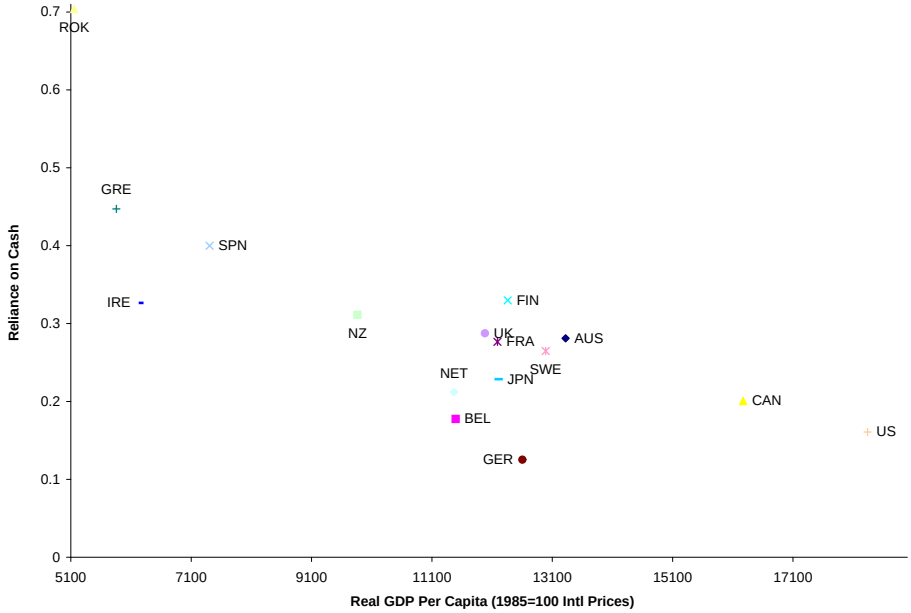

Figure 3: Reliance on Cash Across Countries

In turn, we are able to calculate our estimates for the welfare cost of inflation across countries. The estimates are shown in Figure 4 below.[7] Interestingly, the welfare costs of inflation for most countries in our sample are only a fraction of the 1% previously found in the literature for the U.S. economy. Thus, *failing to take into account how an economy's level of financial development responds to the level of economic development may seriously over-state the welfare cost of inflation.*

[7] Our calculations are also presented in Table 2 in the appendix.

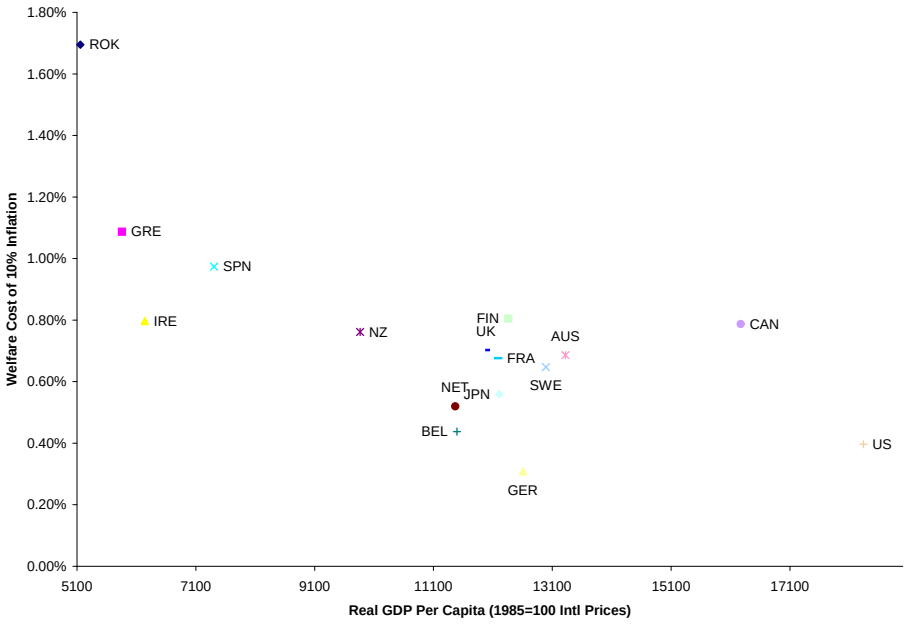

Figure 4: Welfare Costs of Inflation Across Countries

For example, our estimates indicate that the costs of inflation for the United States are around .4%.[8]

Notably, the welfare costs of inflation are higher in poor countries. There are two primary reasons for these differences. First, poor countries tend to have high average inflation rates and a high reliance on cash. This renders the economy more exposed to inflation. In addition, poor countries have low levels of productivity. Therefore, they cannot absorb the tax on capital from inflation as much as advanced economies. Figure 4 indicates that the gains from completely eliminating inflation are highest for South Korea (1.7%), Greece (1.08%), and Spain (.97%).[9] Not surprisingly, South Korea, Greece, and Spain are among the lowest productivity countries in the sample.

By comparison, the costs of inflation are lowest in Germany (.31%), the United States (.4%), and Belgium (.43%). It should also be recognized that productivity in the United States is the highest in the sample. Such differences in total factor productivity are important as productivity promotes capital accumulation and reduces the reliance on cash in advanced countries so that the effective tax rate on capital formation is mitigated.[10]

[8] Boel and Camera (2011) also find the welfare costs of inflation to be below unity under price taking, for most OECD countries. Our calculations are slightly higher than theirs. This can be due to many factors including differences in the sampling period and more importantly, cross-country differences in the reliance on cash.

[9] Reed and Waller (2006) construct a monetary model in which individuals are exposed to persisent income risk. Acquiring money balances helps individuals insure themselves against future loss of income. They find that the welfare cost of inefficient risk sharing (due to 10% inflation) can reach nearly 1.6% of steady-state consumption.

[10] In a model with idiosyncratic risk and the possibility of default, Aiyagari and Williamson (2000) find that there are virtually no gains from eliminating inflation.

4 Conclusions

In recent years, many countries have pursued methods to lower inflation rates.[11] The main route towards this objective is to structure central banks so that they are more independent from political pressure.[12] With so much effort devoted towards lowering inflation in many countries, it seems imperative to try to understand how such policies would affect living standards across countries. Fortunately, the seminal work by Cooley and Hansen (1991) and Lucas (2000) provides a rigorous methodology to attempt to quantify the gains from eliminating inflation. However, much of the existing research on the welfare costs of inflation has focused almost exclusively on the United States. In contrast to previous research, this paper seeks to determine the gains from eliminating inflation across a broad section of countries. These countries vary according to their: (i) level of economic development, (ii) reliance on cash for transactions, and (iii) average inflation rates. Upon calibrating our model to quantify the reliance on cash in each economy, we find that there are substantial differences in welfare costs across countries. Notably, our numerical estimates imply that welfare costs in the developing world are likely to be much larger than the 1% number previously reported for the United States. By comparison, the costs of inflation in advanced economies such as Germany and the United States may be as low as 0.31%. This seems to be largely driven by differences in total factor productivity across countries, allowing advanced economies to more effectively absorb taxes on capital.

[11] Aiyagari (1990) questions the desirability of zero inflation policies.

[12] See, for example, Alesina (1988), Alesina and Summers (1993), and Walsh (1995).

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5 Appendix:

	ΔW (λ=0.0831)	A	Γ
Australia	0.686%	364.723	0.281086
Belgium	0.438%	328.685	0.177532
Canada	0.787%	415.455	0.200444
Finland	0.805%	347.673	0.329762
France	0.676%	343.561	0.276491
Germany	0.309%	348.714	0.125248
Greece	1.087%	211.715	0.44717
Ireland	0.797%	219.682	0.3265
Japan	0.559%	343.111	0.22858
Netherlands	0.519%	328.727	0.212017
New Zealand	0.762%	298.551	0.311219
South Korea	1.695%	196.519	0.703873
Spain	0.974%	247.321	0.399895
Sweden	0.647%	358.345	0.26469
United Kingdom	0.702%	339.799	0.287518
United States	0.397%	449.238	0.160751

Table 2: Welfare Costs of 10% Inflation