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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, 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 0.5%. This seems to be largely driven by differences in total factor productivity across countries, allowing advanced economies to more effectively absorb taxes on capital.

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.[1] There are a host of reasons behind why this phenomenon occurs. For example, Roubini and Sala-i-Martin (1995) stress that governments in poor countries intentionally repress the financial sector in order to

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[1] See, for example, Hancock and Humphrey (1998).

generate a high demand for cash balances and a large seigniorage tax base. Hancock and Humphrey (1998) posit that the development of the payments system varies in significant ways across countries, leading to variation in the reliance on cash. Recent work by Ghossoub and Reed (2009) proposes the degree of liquidity risk depends on the economy's level of development. Consequently, financial institutions in developing countries allocate a large fraction of deposits to money. Whatever the reason – countries with high levels of income tend to be less dependent on cash for transactions. Furthermore, it is also clear that inflation rates in the developing world are higher than in advanced economies.

While the connections between economic development and monetary policy appear to be well understood, their consequences for living standards across the world are not. Thus far, 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. Though there are some exceptions, the general consensus is that the welfare cost of 10% inflation is approximately 1% of consumption. However, there are two 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.

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 develops a theoretical framework that is capable of qualitatively understanding the relationships between inflation and development across countries. The central hypothesis in the model is that cash is less important for conducting transactions in advanced countries. Interestingly, the model demonstrates that multiple steady-state equilibria are possible. If there are *decreasing* returns from the level of development to the reliance on cash, the steady-state is unique and monetary policy generates a reverse-Tobin effect. Nevertheless, if there are *increasing* returns from development to lower transactions costs, multiple steady-states can emerge. In the low capital steady-state, the reliance on cash is high and the level of economic activity is low. Naturally, monetary policy also generates a reverse-Tobin effect. This prediction is in line with the experiences of developing countries in which inflation is associated with lower levels of investment and income. Nevertheless, in the high capital steady-state, the cost of capital is low and monetary policy yields a Tobin effect. This result has most recently been observed by Ahmed and Rogers (2000) using annual data for the United States.

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. In order to appropriately assess the type of steady-state equilibrium to calibrate, we construct a simple plot of inflation rates against GDP. While there may be some exceptions, the data indicate that there is a negative relationship between inflation and real income in our sample. Therefore, we focus on economies in which there are decreasing returns from the level of national income to the reliance on cash. As stated previously, these economies are associated with a reverse-Tobin effect.

The calibration analysis begins by constructing welfare numbers which are consistent with previous studies of the U.S. economy. In the initial stages of our work, we pin down total factor productivity and depreciation rates to match the average level of real GDP reported in Summers and Heston (1991). The degree of reliance on cash is selected to match the 1% welfare cost of 10% inflation reported in Cooley and Hansen (1991) and Lucas (2000). Our estimates of the cash-in-advance parameter indicate that nearly 60% of transactions involve cash as a means of payment.

Prior to deriving estimates for the remaining countries in our sample, we select parameters that exactly match the average level of output and inflation rates for each observation. As a benchmark, we start out by assuming that each economy has the same degree of transactions costs as the United States. That is, the parameter in the cash-in-advance model is held fixed. The analysis reveals some interesting features in the data. In particular, total factor productivity is generally negatively related to the average inflation rate in each country. As expected, higher income countries tend to have lower inflation rates.

The paper proceeds by constructing measures of welfare costs across countries in the sample. However, the welfare gains from eliminating inflation are all about the same. Yet, as previously mentioned, there is reason to be highly skeptical of the findings at this stage since each country is assumed to have the same reliance on cash as the U.S. economy.

As introduced in the benchmark model, countries with higher levels of income generally are less dependent on cash for transactions. In order to discipline our range of values for transactions costs, we parameterize the model to match recent estimates of the income 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 world-wide cost of inflation stood at 1% of consumption, we examine the data so that transactions costs in the cash-in-advance constraint are consistent with the findings by Ball (2001).

By quantifying the role of cash on the basis of an economy's level of development, the welfare costs of inflation appear to be much lower than previous estimates – for example, welfare costs for the United States drop to nearly 0.59%. However, the findings also suggest that gains from eliminating inflation are highest among developing countries. For example, the welfare costs for South Korea (the lowest income country) stand close to 0.63%. Yet, these differences appear to be modest.

In describing the data in the sample, we noted three key differences. First, coun-

tries in our sample would vary according to their level of development. Second, there would be significant variation in the degree of reliance on cash for transactions. Finally, there are important differences in the inflation experiences of each country.

Failing to account for the latter category could lead to inaccuracies in the determination of welfare costs across countries. In particular, *inflation* can exacerbate inefficiencies and raise transactions costs. For example, Aiyagari et. al. (1988) stress that the size of the economy's credit service sector expands along with the country's inflation rate in order to help individuals economize on transactions costs. Obviously, this represents a problem since resources will be diverted away from productive activity.

Thus, we conclude our analysis by studying how the welfare costs of inflation vary with (i) the level of economic development and (ii) the economy's average inflation experience. In this pursuit, the benefits from eliminating inflation are highest for South Korea (2.40%), Greece (1.45%), and Spain (1.40%). The calibration results indicate that money is used more extensively in these countries as well: South Korea (nearly 100% of transactions), Greece (93% of transactions), and Spain (84%) of transactions. Not surprisingly, these are also the lowest productivity countries in our sample. By comparison, the costs of inflation are lowest in Germany (.410%), the United States (.440%), and Belgium (.450%). Moreover, cash is not as important for conducting transactions in these countries. For example, estimates for the United States indicate that only around one-third of transactions require money.

In conclusion, our analysis demonstrates that the welfare gains from eliminating inflation vary significantly across countries. This claim is based on two observations from our study. First, the welfare costs of inflation are highest among the lowest productivity countries. One explanation for this observation is that advanced economies can more effectively absorb taxes on capital due to inflation since they are generally high productivity countries. Second, the gains from eliminating inflation in the developing world also appear to be significant since cash is used extensively for transactions.

2 The Model

We consider a modified cash-in-advance model in which the use of cash responds to the extent of economic development. For a given amount of purchases of consumption and investment, the function $\Gamma\left(\bar{k}\left(t\right)\right)$ is decreasing in the average capital stock, $\bar{k}\left(t\right)$. In this manner, a higher value of Γ implies that exchange is more difficult to accomplish and individuals require more money balances to obtain goods. However, at higher levels of economic development, there is less need to use money balances as a means of payment. In contrast to both Lucas (1980) and Stockman (1981), the cash-in-advance constraint applies to both consumption and investment goods:

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

in which $c(t)$ and $m(t)$ are consumption and real money balances.

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:

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

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 $\dot{c}(t) = \dot{m}(t) = \dot{k}(t) = 0$. A few lines of algebra yields the following modified golden rule equation:

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

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, $\rho(\rho + \pi)\Gamma(k^*)$ represents that in order to acquire a higher level of capital accumulation, individuals must purchase more goods using money balances. In contrast to previous work such as Stockman (1981), a higher amount of capital accumulation allows individuals to reduce their reliance on cash since $\Gamma'(\bar{k}) \leq 0$. This in turn reduces the cost of investment, ψ, which spurs investment activity.

We proceed to examine the existence and uniqueness of steady-state equilibria. The equilibrium amount of capital is the solution to the polynomial (4). Unlike standard cash in advance models, the level of investment affects the income derived from capital and the cost of investment simultaneously. Specifically, a higher level of investment reduces its marginal return. However, the marginal cost of capital also declines as pointed out above. Notably, the characteristics of $\Gamma(k)$ determine the shape of the cost function, $\psi(k, \pi)$, and therefore are important in determining when a steady-state exists. As described below, it also possible that multiple equilibria occur.

Proposition 1. *Suppose* $\Gamma(k)$ *is such that:*

i. Case 1: $\Gamma''(k) > 0$, $\Gamma\epsilon\left(0, \bar{\Gamma}_0\right)$ *and* $\bar{\Gamma}_0 \leq 1$. *Under these conditions, a steady-state exists and is unique.*

ii. Case 2: $\Gamma''(k) \leq 0$, $\Gamma\epsilon\left(0, \bar{\Gamma}_0\right)$ *and* $k \in \left(0, \bar{k}\right)$.

a. If $f'\left(\bar{k}\right) < (\rho + \delta)$, *a steady-state exists and is unique.*

b. If $f'\left(\bar{k}\right) \geq (\rho + \delta)$*, two steady-states exist. One steady-state has a low level of capital formation and a high reliance on cash. The other steady-state has a high level of economic activity and a low reliance on cash.*[2]

The proof of Proposition 1 is straightforward and therefore we omit it. The Proposition states that the number of steady-states depends on the sign of $\Gamma''(k)$. Under Case 1, as $\Gamma''(k) > 0$, the *marginal* impact of the capital stock declines. That is, although the reliance on cash is lower in more developed economies, the change in the need for cash exhibits diminishing returns. As a result, the marginal cost of investment is convex in k. Consequently, as illustrated in Figure 1 below, a steady-state exists and is unique:

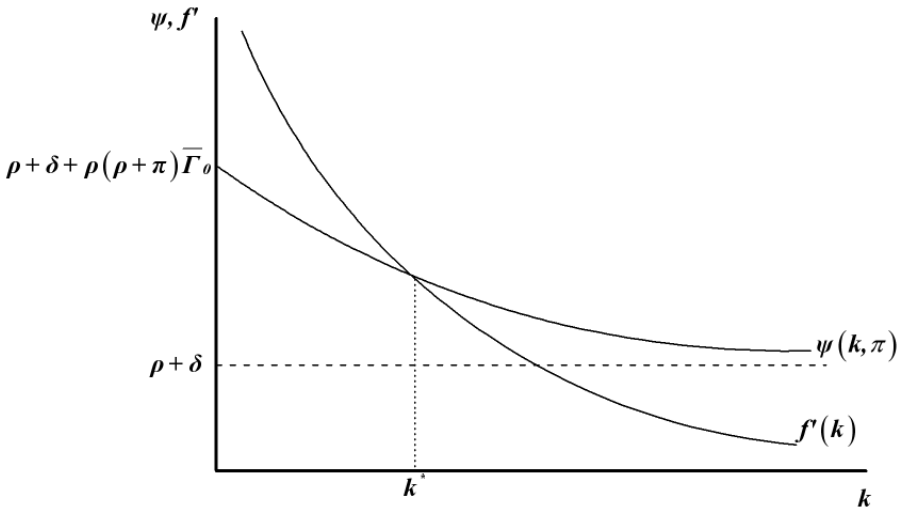

Figure 1: Uniqueness of Steady-State when $\Gamma''(k) > 0$

By comparison, in Case 2, $\Gamma''(k) \leq 0$. In this setting, there are increasing returns from economic development. Notably, there is an upper bound on capital, $\bar{k}$, at which the economy is cashless. The steady-state is unique if at $\bar{k}$, $\psi\left(\bar{k}, \pi\right) > f'\left(\bar{k}\right)$. Please refer to Figure 2 below for an illustration:

[2] In Ghossoub and Reed (2009), uncertainty regarding liquidity risk leads to a banking sector that emerges and provides risk pooling services to depositors. In their structure, the probability of a liquidity shock is $\pi(\bar{k}) = \frac{\pi_0}{k}$. Due to the potential for strategic complementarities, multiple steady-state equilibria are possible. By comparison, in the current deterministic setting, $\Gamma''(k) \leq 0$, is a necessary condition for multiple steady-states.

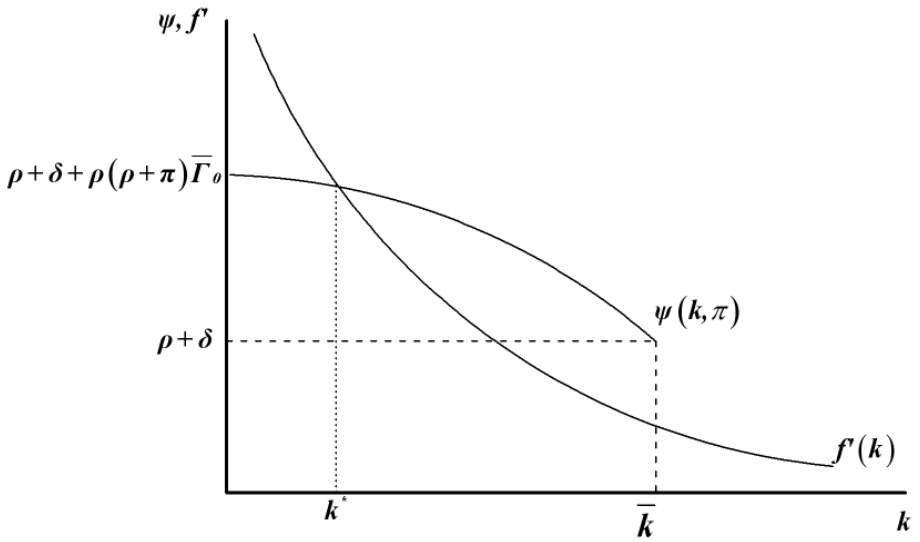

Figure 2: Uniqueness of Steady-State when $\Gamma^{''}(k) < 0$

However, if $f^{'}\left(\bar{k}\right) \geq (\rho + \delta)$, both curves intersect twice in the feasible range, $k \leq \bar{k}$. This result is illustrated in Figure 3:

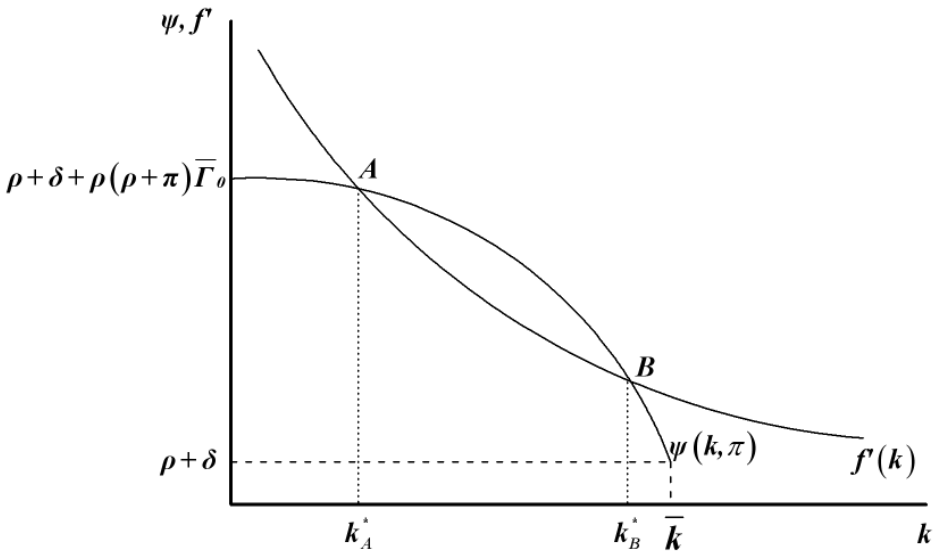

Figure 3: Multiplicity of Steady-States

As can be observed from the Figure, steady-state A is characterized with low levels of investment. Poor economic performance is exacerbated by a high degree of reliance on cash and a high cost of capital. By comparison, due to the high level of capital formation in economy B, there is little need to use cash to conduct transactions and interest rates are low. Therefore, the financial system is more efficient compared to that in economy A.

We proceed to study the effects of monetary policy. It is clear from (4) that inflation raises the cost of investment. If the reliance on cash is independent of the level of development, inflation unambiguously reduces capital formation. However, this is not necessarily the case in our setting. In particular, the effects of monetary policy depend on the extent of economic development. This result is summarized in the following Proposition.

Proposition 2. *Suppose that case 1 applies. In this economy, a higher rate of money growth adversely affects capital formation. Next, consider case 2. If the steady-state is unique, monetary policy generates a reverse-Tobin effect. In contrast, the effects of monetary policy are not symmetric when multiple steady-states are present. In particular, they depend on the economy's stage of development. Specifically, inflation adversely affects capital formation in the economy with a low level of development. By comparison, investment activity increases with inflation if the economy is at high stages of development.*

Equation (4) indicates that at a given capital stock, the cost of investment increases with the inflation rate. Because transactions costs are not too sensitive to the state of economic development, $\Gamma^{''}(k) > 0$, agents respond to higher costs by cutting their level of investment. The lower level of capital formation raises the reliance on cash, which further reduces the level of economic activity. Furthermore, inflation has similar effects in case 2 when the steady-state is unique.[3]

Interestingly, the effects of monetary policy can be qualitatively different across stages of economic development. This is exemplified by the possibility of multiple steady-states. In the low capital steady-state, the costs of additional capital are high. Consequently, a reverse-Tobin effect will be observed. However, in advanced economies with little need for cash, the higher costs of holding money become the dominant factor. Thus, in developed economies, standard Tobin effect logic applies. This result is consistent with recent work by Ahmed and Rogers (2000) who find evidence of a Tobin effect for the United States.[4]

[3] Initial monetary growth models such as Money-in-the-Utility-Function and Cash-in-Advance models do not generate consistent implications for monetary policy. However, Wang and Yip (1992) show that both models generate reverse-Tobin effects if households face a consumption-leisure tradeoff.

[4] Ghossoub and Reed (2009) and Ghossoub (2009) demonstrate that the effects of monetary policy depend on the degree of exposure to liquidity risk. As individuals in poor countries are likely to experience liquidity shocks, financial institutions hold large amounts of cash. Among advanced economies, there is less risk – thus, financial institutions hold more productive assets. Moreover, in developed economies, inflation promotes capital formation.

In the standard model with an exogenous level of transactions costs, inflation only has an adverse effect on the extent of capital accumulation. *In contrast, since the capital stock also has an impact on the reliance on cash, there are additional transmission channels for monetary policy.* This indicates that previous estimates of the welfare costs of inflation are likely to be miscalculated. *In our framework, the gains from eliminating inflation depend on the economy's stage of development.* We address these issues 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

According to the table, the three highest inflation countries in the sample are: South Korea (15.7%), Greece (10.1%), and Spain (9.22%). The corresponding levels of Real GDP are: \$5,156, \$5,857, and \$7,406 respectively. Consequently, average income in the highest inflation countries stands near \$6,140. At the other extreme, the three lowest inflation countries are: Germany (3.02%), the United States (4.00%), and Belgium (4.25%). Income levels in these countries are equal to: \$12,604, \$18,339, and \$11,495. The average income among the lowest inflation countries is around \$14,146 – more than double the amount of the highest inflation countries. Moreover, as illustrated in Figure 4 below, it is generally observed that higher income countries have lower inflation rates.

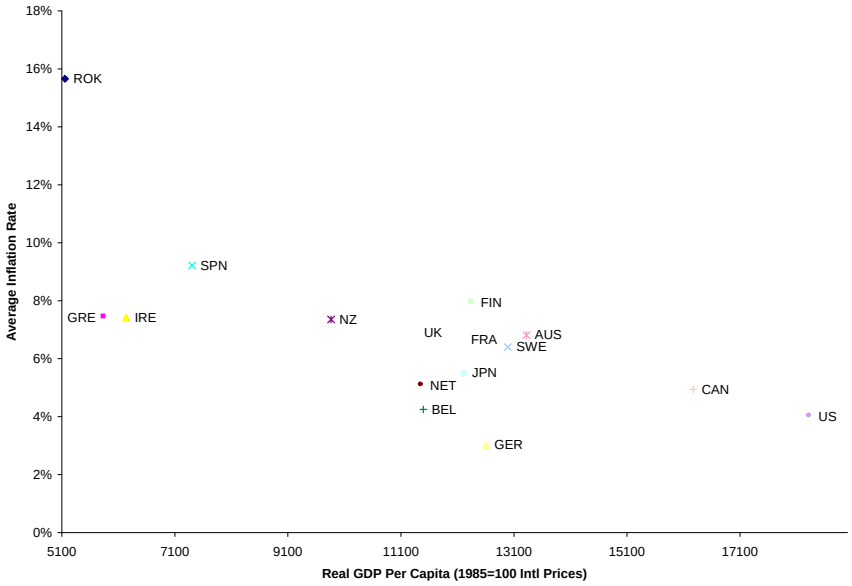

Figure 4: Developed Countries Are Associated with Lower Inflation Rates

Given the observations from our data about the relationship between economic development and monetary policy, we focus on the steady-state from Case 1 of Proposition 1 in our calibration work. In particular, we assume that the reliance on cash is given by $\Gamma(k) = \frac{\Gamma_0}{k^\lambda}$. 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 σ is the coefficient of relative risk aversion. 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), 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 $\rho = 0.05$.

As a benchmark, we follow standard cash-in-advance models in which the reliance on cash is independent of an economy's level of development. That is, we assume that $\lambda = 0$. Subsequently, we choose the level of productivity and depreciation rate in the following manner. We first pick A and δ to match the average level of output and inflation for the U.S. over the sample period. This is achieved by assuming that all trades in the economy are monetary. That is, $\Gamma_0 = 1$. The model generates a depreciation rate, $\delta = .042$ which is close to the .05 previously estimated in the data. *Then, using the parameters above, we choose a level of productivity for each country*

that exactly matches the average level of output and inflation of that country over the sample period. The results are illustrated in Figure 5 below:

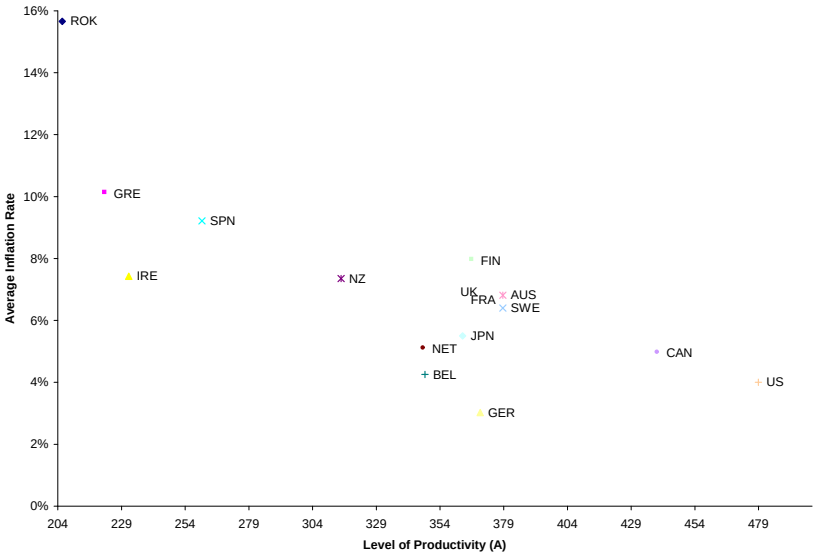

Figure 5: High Productivity Countries Tend to Have Lower Inflation Rates

As a point of comparison, we review how the relationship between productivity and inflation is connected to the relationship between inflation and income reported in the discussion of Figure 4. We reported above that the three highest inflation countries in the sample are: South Korea, Greece, and Spain. Interestingly, these also appear to be the lowest productivity countries. That is, South Korea, Greece, and Ireland have the lowest productivity rates. In terms of the highest productivity countries, the relationship is not as clear – while Germany, Belgium, and the United States have the lowest average inflation rates, Australia, Canada, and the United States have the three highest measures of productivity.

We proceed to discuss our choice of Γ_0. Using data for the U.S. economy, we choose Γ_0 so that an average inflation rate of 10% is associated with a 1% welfare loss. This mirrors estimates previously obtained by Cooley and Hansen (1991) and Lucas (2000). 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:

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

In combination with the previous parameters to match real income for the United States, the model generates a value of $\Gamma_0 = .588$. This number should be interpreted as a reading on the average reliance on cash for the U.S. economy from 1950-1988. That is, nearly 60% of transactions involve cash as a means of payment.

In contrast to previous work, our primary objective is to provide estimates for the welfare costs of inflation across a broad section of countries. As stated previously, these countries vary according to their: (i) level of economic development, (ii) reliance on cash for transactions, and (iii) average inflation rates. As a benchmark, we use the value of Γ_0 derived from information about the U.S. economy above. To generate some initial impressions, we assume that the reliance on cash is independent of the economy's state of development. The results are listed in Table 2 below:

	Y	π	ΔW (λ=0)	A
South Korea	5156	15.661%	1.001%	205.756
Greece	5857	10.102%	1.001%	222.870
Ireland	6239	7.426%	1.001%	231.872
Spain	7406	9.218%	1.001%	260.560
New Zealand	9864	7.354%	1.001%	315.140
Netherlands	11468	5.077%	1.001%	347.810
Belgium	11495	4.253%	1.001%	348.063
United Kingdom	11982	6.906%	1.001%	358.844
France	12190	6.652%	1.001%	362.900
Japan	12209	5.502%	1.001%	362.866
Finland	12360	7.938%	1.001%	366.780
Germany	12604	3.024%	1.001%	369.751
Sweden	12991	6.402%	1.001%	378.626
Australia	13321	6.812%	1.001%	378.640
Canada	16272	4.942%	1.001%	439.631
United States	18339	4.004%	1.000%	478.903

Table 2: Welfare Costs of Inflation in Benchmark Model

Although there are substantial differences in productivity and inflation rates in the data, the welfare costs of inflation are very close to estimates for the United States. This may at first seem implausible. Yet, it is important to remember how the welfare costs of inflation are calculated:

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

Since the reliance on cash is held fixed, the welfare costs of inflation just boils down to a ratio of consumption levels. As productivity and the reliance on cash are the

same across steady-states, estimates of the welfare cost would be very close to the results for the United States.

So, an important question remains: *how does the stage of economic development affect the welfare costs of inflation? Obviously, there is reason to be highly skeptical about the initial results since the model does not take into account that the reliance on cash varies across the levels of economic development.* Thus, we return to the specification in which the level of development affects transactions costs: $\Gamma(k) = \frac{\Gamma_0}{k^\lambda}$. Under this functional form for the use of cash, the parameter λ reflects how much economic development affects the need for cash payments. Before conducting detailed calibration analysis, we first perform comparative steady-state analysis on the U.S. economy according to different values of λ. The results are listed in Table 3 below:

λ	k	$\Gamma(k)$	ΔW
0.00	65772	.588	1.00%
0.01	65935	.526	0.90%
0.02	66081	.471	0.80%
0.03	66212	.421	0.72%
0.04	66330	.377	0.64%
0.05	66436	.337	0.58%

Table 3: Welfare Costs and the Reliance on Cash

Interestingly, accounting for variations in the reliance on cash may provide a much different impression of the welfare costs of inflation. For instance, if $\lambda = .04$, the welfare costs of 10% inflation are around 2/3 of the 1% number previously found in the literature. Intuitively, in more advanced economies, there is less need to to use cash to conduct transactions. This is magnified in economies with higher values of λ. Therefore, as observed from the marginal cost side of the modified golden rule, (4), there is a lower tax on capital from inflation.

While the comparative static conducted on the U.S. economy provides a feel of how variations in the reliance on cash matter for calculations of the welfare costs of inflation, the parameter λ has to be selected based upon the data. 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 0.04829.

Now that the reliance on cash depends on an economy's level of economic development, the welfare costs of inflation appear to be much lower than previous calculations for the United States. For example, our estimates indicate that the costs of inflation for the United States are equal to .588% – nearly half of previous reports.

We are particularly interested in studying how the gains from eliminating inflation depend on the reliance on cash across countries. Rather than blindly developing

"confidence intervals" for λ across countries, we restrict ourselves to the estimate of $\lambda = 0.04829$ for the United States. Consequently, $\Gamma(k) = \frac{\Gamma_0}{k^{0.04829}}$. Since more advanced countries have larger capital stocks, the functional form directly implies that the reliance on cash will be higher in the world's poorest countries. In Figure 6, we present our estimates for the welfare costs across different levels of economic development. Though the value of λ generated by the model is small, it reveals important differences in the welfare costs of inflation across countries. *Notably, the welfare costs of inflation are higher in poor countries.* There are two primary reasons for these differences. *First, poor countries have a high reliance on cash.* This renders the economy more exposed to inflation. *In addition, as illustrated in Figure 5, poor countries have low levels of productivity. Therefore, they cannot absorb the tax on capital from inflation as much as advanced economies.*

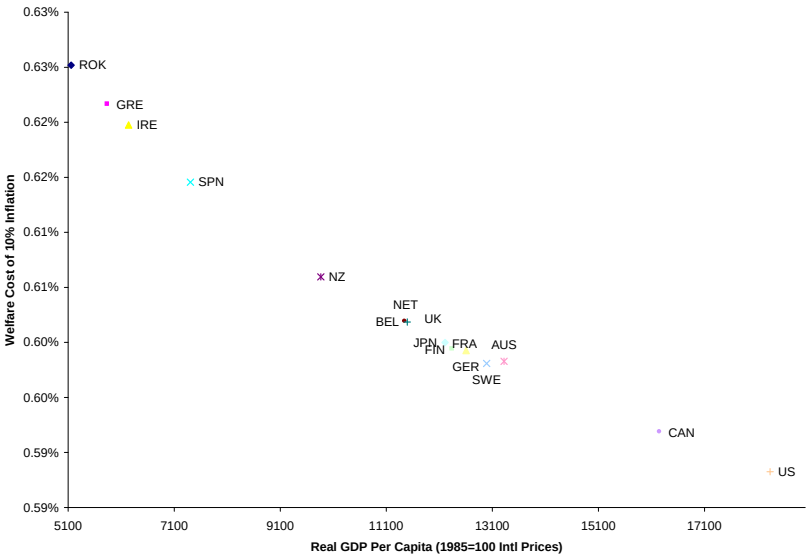

Figure 6: Economic Development and the Welfare Cost of Inflation

Our work clearly demonstrates that the gains from eliminating inflation are the highest among developing countries. In particular, the welfare costs of inflation range between .588 for the United States and .625 for Korea. Yet, these differences appear to be modest. Under the specification of $\Gamma(k)$ used in the numerical exercise above, the level of development has a direct impact on the reliance on cash. In describing the data in the sample, we noted three key differences. First, countries in our sample would vary according to their level of development. Second, there would be significant variation in the degree of reliance on cash for transactions. Finally, there are important differences in the inflation experiences of each country.

Failing to account for the latter category could lead to inaccuracies in the determination of welfare costs across countries. In particular, *inflation* can exacerbate inefficiencies and raise transactions costs. For example, Aiyagari et. al. (1988) stress that the size of the economy's credit service sector expands along with the country's inflation rate in order to help individuals economize on transactions costs. Obviously, this represents a problem since resources will be diverted away from productive activity. In English (1999), agents can purchase transactions services at higher inflation rates.

Obviously, our framework does not include an intermediary sector – but, the assumption that transactions costs increase in response to the inflation rate is easily captured in the model. At higher inflation rates, transactions costs rise, and income is pulled away from productive purposes to services that facilitate transactions. Following this reasoning, we proceed to examine an alternative functional form for $\Gamma(k)$ to account for any direct impact that inflation may have on transactions costs and financial sector performance. In particular, we consider that $\Gamma(k,\overline{\pi}) = \frac{\Gamma_0}{k^\lambda}\overline{\pi}$, where $\overline{\pi}$ is the average inflation rate in a particular country. Under the new specification of $\Gamma(k,\overline{\pi})$, we posit that transactions costs are higher in countries with high inflation.

The calibration procedure is identical to the previous algorithm. The estimated values for productivity are close to the numbers derived earlier. As a benchmark, we first examine the welfare costs of inflation when $\lambda = 0$. Under this condition, the level of development does not affect the need for cash. However, in contrast to the previous approach, the reliance on cash is higher in high inflation countries. *Because inflation diverts resources away from productive purposes, the welfare costs of inflation are much higher in less developed economies.* This result is illustrated in Figure 7 below. Interestingly, inflation is four times more costly in Korea than in the United States – almost 3.8% for Korea; the standard 1% consumption loss reported by Cooley and Hansen and Lucas for the United States continues to show up.[5] *Thus, allowing for inflation to affect transactions costs does not radically change our calculations for the welfare costs of inflation in the United States relative to the previous literature. Nevertheless, inflation appears to be more costly in other countries.*

[5] 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. In a paper with search-based microfoundations for monetary exchange, Rocheateau and Wright (2003) conclude that the gains from elminating inflation could be as high as 5% if prices in individual trades are determined by bargaining.

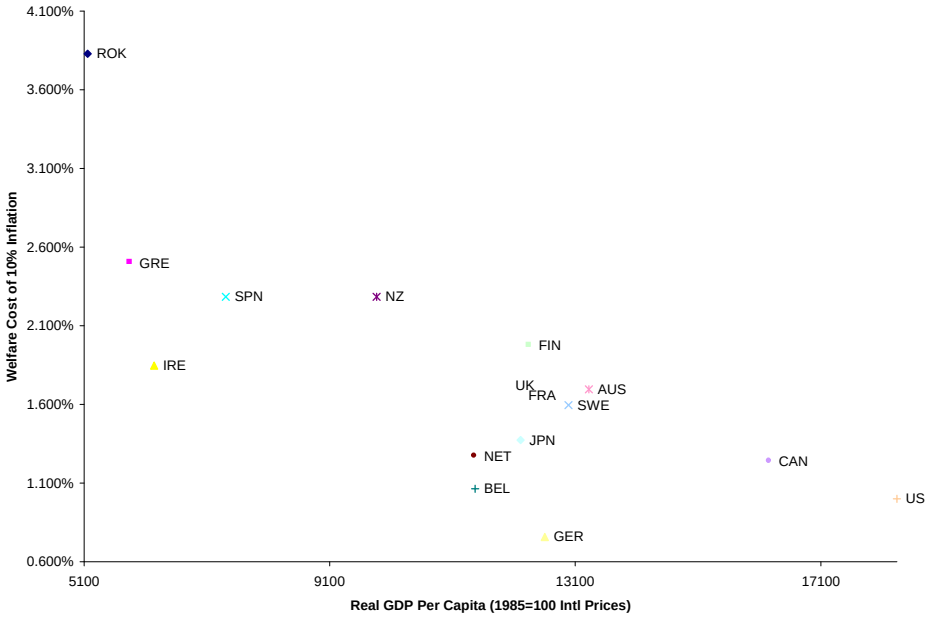

Figure 7: Inflation, Transactions Costs, and the Welfare Loss of Inflation

We conclude our analysis by studying how the welfare costs of inflation vary with (i) the level of economic development and (ii) the economy's average inflation experience, $\overline{\pi}$. That is, we use the value of the parameter λ that is generated by the model. Based upon our estimates for the United States, we continue to use the calibrated values of Γ_0 and λ of 14.7 and 0.484 respectively. As in the previous example, the welfare costs of inflation are much lower when we account for cross-country differences in the reliance on cash.

Notably, the welfare costs of inflation for the United States are identical to those obtained earlier (around .6%), in which we only accounted for the role of economic development in the need for monetary transactions. However, accounting for variations in the average level of inflation across other countries in the sample reveals significantly different impressions. First, Figure 8 indicates that the gains from completely eliminating inflation are highest for South Korea (2.40%), Greece (1.45%), and Spain (1.40%). Not surprisingly, as discussed earlier, South Korea, Greece, and

Spain also represent the lowest productivity countries in the sample.

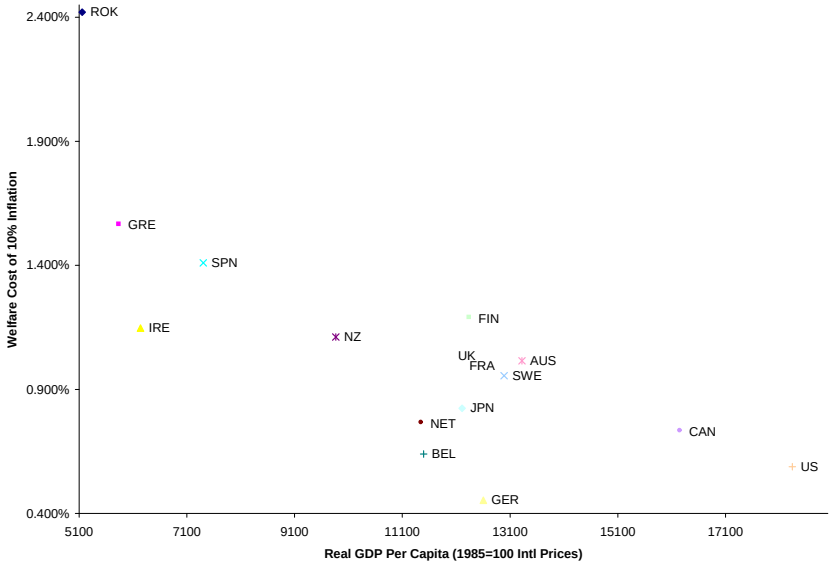

Figure 8: Economic Development, Average Inflation, and the Welfare Costs of Inflation Across Countries

By comparison, the costs of inflation are lowest in Germany (.410%), the United States (.440%), and Belgium (.450%). It should also be recognized that productivity in the United States is the highest in the sample.[6]

It is also clear that economies with a higher degree of reliance on cash would experience the largest gains from eliminating inflation. Please refer to Figure 9 below to examine the relationship between economic development and the reliance on cash.

[6] If monetary policy generates a Tobin effect in low inflation countries like the United States, the welfare costs would be even lower. Moreover, in a model with idiosyncratic risk and the possibility of default, Aiyagari and Williamson find that there are virtually no gains from eliminating inflation. On the other hand, Imrohorglu (1992) concludes that the welfare cost of inefficient risk sharing is around 1% of steady-state consumption if inflation increases to 10%.

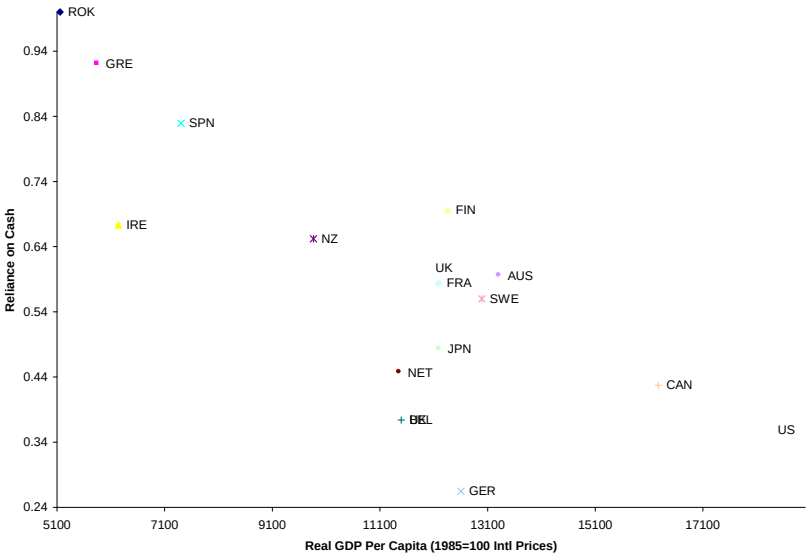

Figure 9: Variations in the Role of Cash Across Levels of Development

Our calibration results indicate that money is more extensively used for transactions in South Korea (nearly 100%), Greece (93%), and Spain (84%). Again, these are also the lowest productivity countries in the sample. However, cash is not nearly as important in advanced countries. Among the countries with the lowest costs of inflation, there is much less use of cash: Germany (24%), Belgium (34%), and the United States (34%).

The analysis indicates that the level of economic development is an important factor for monetary policy. This observation is based on two pieces of information determined from our study. *First, the welfare costs of inflation are highest among the lowest productivity countries.* This implies that advanced economies can more effectively absorb the taxation of capital resulting from inflation. *Second, the gains from eliminating inflation would be the most significant in the developing world since cash is more extensively used for transactions.*

4 Conclusions

In recent years, many countries have pursued methods to lower inflation rates.[7] The main route towards this objective is to structure central banks so that they are more independent from political pressure.[8] With so much effort devoted towards lowering

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

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

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 0.5%. This seems to be largely driven by differences in total factor productivity across countries, allowing advanced economies to more effectively absorb taxes on capital.

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