MONETARY POLICY, BANKING, AND GROWTH

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Monetary Policy,

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Abstract: There is a substantial literature looking at the effects of fiscal policy and growth. In this paper, I examine the effects of monetary policy. I present cross-country evidence suggesting that both inflation and reserve requirements seem to matter for growth. I then specify a simple general equilibrium model with endogenous growth in which inflation-rate effects operate through a simple intermediary. The intermediary faces a reserve requirement so that both monetary policy instruments can be examined. In computational experiments, I show that this model can account for the stylized empirical facts. Because of the growth-rate effects, the welfare costs of inflation of moderate inflation are much larger than previous estimates.

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1. Introduction

Fisher and Modigliani (1978) exhaustively list the costs associated with inflation. In recent years, a growing body of evidence is consistent with the notion that slower output growth may be added to the Fisher-Modigliani list. Specifically, analyses by Kormendi and Meguire (1985), Fisher (1991), DeGregario (1992), Gomme (1993), Wynne (1993), among others, find a negative correlation between the inflation rate and output growth both across countries and over time.[1]

Economic theory has offered several alternative mechanisms to account for this stylized fact. One approach, found in work by Greenwood and Huffman (1987), Cooley and Hansen (1989), and Gomme (1993), inflation operates through the labor-leisure decision. A higher inflation rate taxes the cash good--consumption--causing agents to substitute for the credit good--leisure. An increase in the inflation rate results in less output, hence a decline in the current period growth rate. In another approach, Jones and Manuelli (1995) specify a model in which monetary policy operates through distortion in fiscal policy; there is a nominal depreciation allowance in the tax code.[2] An increase in the inflation rate decreases the real depreciation allowance on capital, and consequently lowers the real return on capital. In Jones and Manuelli, a permanent increase in the inflation rate results in a permanently lower rate of output growth.

There is also a substantial literature on the role that financial intermediaries play in determining growth. In Greenwood and Jovanavic (1990), the intermediary possesses economies

[1] Levine and Renelt (1992) find the evidence on the inflation-output growth relationship is somewhat fragile when one accounts for other potential factors that would influence growth.

[2] One of the caveats to studying the inflation-growth relationship is the appropriate interpretation of the evidence. Specifically, there is a high correlation between countries with high inflation and those with volatile inflation. An alternative class of models seeks to explain the adverse effects that volatile inflation will have on economic growth. See Tomassi (1994) for an example of this approach. Here, I will concentrate on the level of inflation as the determining factor.

of scale in processing information. The reduction in costs translates into equilibrium outcomes in which projects with a higher probability of payoff are given credit. The returns are, on average, better with an intermediary than without, so that capital accumulation and consequently, growth occur at a faster rate. The existence of an intermediary also leads to faster growth in Bencivenga and Smith (1991). The Bencivenga and Smith result is a straightforward application of the law of large numbers; risk-averse agents face idiosyncratic liquidity shocks. In the aggregate, however, liquidity needs can be predicted with certainty. Thus, an intermediary can meet the aggregate liquidity needs and purchase more capital than the sum of agents would. In short, without an intermediary, agents will self-insure, holding more money and less capital. The intermediary, by offering deposits payable on demand, can meet the aggregate liquidity needs, buying more capital, and thus obtain faster growth than the non-intermediary environment.

The purpose of this paper is to ask, What are the links between intermediation, inflation, and economic growth? To answer this question, I will offer one bridge the literature on banking and growth with that literature examining the correlation between inflation and growth. In particular, I specify a simple, general equilibrium model that will account for the negative correlation between the inflation rate and output growth in a model in which the financial intermediary faces a reserve requirement. The main insight from this model is that both inflation and the reserve requirement act as taxes on fiat money. Consequently, an increase in either monetary policy tool results in slower growth and reduces welfare.

To motivate this investigation, it is first important to determine if there is any evidence indicating that reserve requirements have quantitatively important effects on economic growth. Such an empirical finding, coupled with the evidence on the inflation rate and output growth, is consistent with the notion that inflation adversely affects economic growth through the intermediation process. Such evidence would, therefore, leads to conceptualizing models in which the links between through the banking system and economic growth are important.

One of the more attractive features of this paper is that the model merges the literature on banking and growth with the literature on inflation and growth. I assume that there is a friction in the capital market that intermediaries solve; namely, banks are more efficient at pooling together small savers than are individual firms such that direct financing is not possible. Pooling services are necessary because there is a minimum-size restriction on the capital good such that any one saver cannot satisfy the minimum requirement alone. Together, the assumptions lead to a specification in which all financing is external.

With a reserve requirement, the intermediary must hold fiat money balances. The inflation-rate tax falls on the saver through the return offered on deposits. The size of the wedge between the deposit rate and the marginal product of capital is a function of both monetary policy tools. For example, the inflation-rate effect on growth is larger as the reserve requirement ratio is higher. Similarly, an increase in the reserve requirement has a larger impact on growth when the inflation rate is high.

The main findings in this paper can be characterized easily. First, the cross-country evidence suggests that both the inflation rate and reserve requirements are quantitatively important. Specifically, (i) high-reserve-requirement countries do tend to grow slower than low-reserve-requirement countries; and (ii) high-inflation countries tend to grow more slowly than low-inflation countries. I specify a general equilibrium model in which raising either the inflation rate or the reserve requirement ratio result in slower growth. The computational experiments indicate that growth-rate effects are quite large in this model. Indeed, much larger than some earlier estimates. One of things that this paper indicates is that the welfare effects of inflation are larger than those reported in previously published papers. Even when the model is recalibrated to quantitatively match the inflation-rate and reserve-requirement effects estimated in the empirical part of this paper, the welfare effects are more than twice as large as previous estimates.

The organization of this paper is as follows. In Section 2, I examine the cross-country evidence, asking whether the data suggest that countries with high reserve requirements grow more slowly than those with low reserve requirements. The evidence suggests that reserve requirements and inflation each are quantitatively important. I specify the general equilibrium model in Section 3. The model is capable of qualitatively accounting for the stylized facts obtained in Section 2. In Section 4, I calibrate the model and run some simple computational experiments to calculate the impact that movements in the anticipated inflation rate and reserve requirement ratios would have in the model. I briefly summarize the paper's main findings in Section 5.

2. Empirical Evidence

In this section, I examine the relationship between per-capita output growth and both the inflation rate and reserve requirement ratio across countries. In this analysis, I use time-averaged measures of these three variables. Thus, the evidence bears on the following question: Is there a systematic relationship between either the average rate inflation or the average reserve requirement ratio, or both, and the average per-capita output growth rate across countries? In particular, I am interested in determining whether countries with high average reserve requirement ratios systematically tend to grow more slowly than those countries with lower average reserve requirements. It will also be useful for this data set to reconfirm that the high average inflation rate countries systematically tend to grow more slowly than low average inflation rate countries.

One may ask why not use a time-series to maximize the number of observations? Certainly, a pooled time-series, cross-section approach would permit a far greater number of observations. It is likely that the increased number of observations would lead to increased variability in the sample, which potentially could be useful for consistent parameter estimates and statistical inference. However, in looking at the reserve requirement structures across countries, one is struck by the number of times that central banks change the definition of deposits against which reserve requirement apply. To illustrate the problem, note that the Federal Reserve distinguished U.S. commercial banks by geographic location until the 1960s. Commercial banks designated as "Reserve city banks," for example, faced a higher reserve requirement ratio than those banks designated "country banks." Later, the Federal Reserve switched to a scheme in which the bank's deposit size was the factor determining what the reserve requirement ratio. I briefly review the history of reserve requirement in the United States to convey their convoluted nature, especially when viewed over time. The U.S. is not isolated in administering convoluted reserve-requirement structures. Movements in reserve requirement ratios due to structural rearrangements is not what I want to measure and could potentially inflate standard errors. The time-averaged approach reduces variability across time as compared with a time-series approach.

Researchers are also plagued by the issue of how to appropriately measure the reserve requirement ratio. Ideally, one would want a measure of the average, marginal reserve requirement ratio over time. Unfortunately, such data are not published for fear that competitors could identify individual banks. The solution used here is to calculate the average reserve requirement ratio. Even with this definition, many central banks' do not publish required reserves data. Using data available from *International Financial Statistics* (*IFS*), I calculate the ratio of bank reserves to the sum of checkable, or sight, deposits plus saving accounts. (These deposit categories are predominantly the ones against which reserve requirements apply.) The implicit assumption is that excess reserves ratio is insignificant because it is small and nearly constant, so that the reserve ratio is treated as being a binding constraint.[3] As a further check, each country in this study is checked to determine that indeed, reserve requirements are a policy tool.

I identify the set of countries, applying the following criterion. The country must have annual observations for per-capita output, consumer prices, bank reserves, and deposits, for the period 1965-90. As noted above, each country must also have reserve requirements and those must apply for at least thirteen years (half the sample observations) during the period 1965-90. From the *IFS*, I find 60 countries that satisfy all these criteria. For this set, I calculate the mean values of per-capita output growth, the inflation rate, and the reserve ratio for each country. (A list of the countries and the mean values for each data series is presented in the Data Appendix.) All subsequent analysis reported below is based on these observations, unless otherwise noted.

The main purpose of this exercise is to find out whether the two monetary policy variables--inflation and reserve requirement ratios--are correlated with per-capita output growth rates. The estimations equations do not have obvious structural interpretations. Indeed, very little will be done to show that regression results are robust. Instead, the results are useful ways to summarize correlations. The "why"part is left for the theory section.[4]

A first pass through the data looks at whether high reserve requirement countries grow slower than low reserve requirement countries. Summary statistics for the cross-country data

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[3] This is a reasonable approximation for the U.S. Excess reserves are a small fraction of deposits, and the excess reserve-to-deposit ratio moves very little over time.

[4] In addition to the structural interpretation problems, Fischer (1991) notes that the standard set of macroeconomic indicators are not truly exogenous.

are reported in Table 1. In addition, I calculate the mean growth rate for countries identified as 'high" reserve requirement countries. High means that the average reserve requirement ratio is more than one standard deviation above the full-sample mean. For the twelve countries identified as having "high" reserve requirements, the mean reserve requirement ratio is 30%. The mean growth rate of per-capita output for these twelve countries is 1.5%. Similarly, for the ten countries identified as having "low" reserve requirements, the mean reserve requirement is 3.4% and a mean output growth is 2.9%. This preliminary evidence suggests that countries with high reserve requirements do grow slower than countries with low reserve requirements.

I also examine differences between high and low inflation countries. One difference is that I define "high" and "low" as being only 1/2 standard deviation away from the full-sample average. There are twelve countries with average inflation rate less than 1/2 standard deviation below the mean inflation rate. For these "low" inflation countries, the mean rate of output growth is 4.6%. Nine countries were identified as "high" inflation countries, and their mean growth rate is 1.2%. This evidence supports the notion that high inflation countries tend to grow more slowly than low inflation countries.

What is the typical association between reserve requirements, inflation, and output growth. Table 2 reports the simple correlations for the output growth, inflation rate, and reserve requirement series. The data show a negative correlation between reserve requirement and growth and between inflation and growth. Interestingly, there is a positive correlation between the inflation rate and reserve requirement.[5] Thus, the simple correlations support the

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[5] A similar finding is observed in time-series evidence from this U.S. Haslag and Hein (1995) and Chari, Jones and Manuelli (1995) find evidence for the U.S. that reserve requirements and inflation money growth are positively correlated. Chari, et al use this feature in the data to run computational experiments in which money growth and reserve requirements are coordinated. They argue that combination policy results in the model's quantitative estimates being closer to what is observed in the data.

evidence presented in Table 1; high inflation and high reserve requirement countries tend to have slower growth compared with low inflation and low reserve requirement countries. In addition, high reserve requirement countries tend to have higher inflation.

I also report the partial correlations in order to get a quantitative measure of the relationship between reserve requirements, inflation, and growth. Table 3 reports the results of three per-capita output growth regressions: one specifying the reserve requirement ratio independent variable, another specifying the inflation rate as the lone independent variable, and a third in which both reserve requirements and inflation are both explanatory variables. The key result from these regressions is that there is a significant negative correlation between the monetary policy variables and per-capita output growth in the bivariate regressions. While this evidence repeats the qualitative evidence presented in the simple correlations, the regression estimates provide a quantitative measure of the size of the co-movements. Moreover, with both monetary policy variables in the regression, one can control for the other monetary policy variable, so that the coefficient on the reserve requirement is the change in output growth for a one-percentage-point change in reserve requirements, holding the inflation rate constant.

As Table 3 shows, the coefficient on both the inflation rate and reserve requirement ratio are negative, but neither is statistically significant. The size of the coefficients are roughly the same in the last regressions as in the bivariate regressions.[6] Note that the standard errors for the coefficients have increased for both variables. One possible explanation for the disappearance of statistical significance is that multicollinearity is present. Indeed, the

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[6] The coefficient on the inflation rate is only about half the size of the coefficients reported in Fischer. What appears to be responsible for the coefficient being only -0.2, instead of Fischer -0.4, is the sample and estimation technique. Fischer had a shorter horizon (1970-85), a slightly larger sample (73 countries) and used a pooled time-series cross section approach. Shortening the horizon gives greater weight to the relatively high-inflation, low-growth period experienced by many countries in the 1970s. It is not too surprising, therefore, that he finds a somewhat larger inflation-rate coefficient.

correlations presented in Table 2 indicate that reserve requirements and inflation are positively correlated with a correlation coefficient of 0.5, and could therefore, account for significant correlations the bivariate regressions that disappear in the trivariate regressions.

Overall, the evidence suggests that both reserve requirements and inflation are inversely related to per-capita growth. Thus, based on the correlations, one sees that high reserve requirement and high inflation countries systematically tend to grow more slowly than countries with low reserve requirement and low inflation. There seems to some tendency for low inflation countries to also have low reserve requirements. What quantitative evidence I present suggests that holding the reserve requirement constant, lowering the inflation rate ten-percentage-points will, on average, be associated with a 1.5-percentage point increase in output growth. The cross-country evidence also suggests that holding the inflation rate constant and lowering the reserve requirement ratio ten-percentage-points will, on average, be associated with a 3.5-percentage-point increase in output growth.

3. The Model

The economic environment consists of three types of decisionmakers: firms, households, and banks. In each period, firms maximize profits in a perfectly competitive markets for both inputs and outputs. Firms produce a single consumption good, Y_t, where $t = 0, 1, 2, \ldots$ indexes periods. Production is accomplished using a common-knowledge technology, represented by

$$Y_t = AK_t, \qquad A > 0, \tag{1}$$

where K denotes capital. Equation (1) specifies a constant-returns technology in which the quantity K is interpreted as a composite of both physical and human capital.[7] The firm pays the

[7] The linear specification assumes that these two forms of disaggregated capital are perfect substitutes in production. Barro (1990) shows that each type of capital can have decreasing returns alone, but constant returns in both applied together.

rental price, q, for the composite input and sells the output at the price, p. Note that p is measured in units of fiat money while q is the real rental price of capital. King and Rebelo (1990) and Rebelo (1991) explore the properties of this linear production technology. The authors show that the linear production function captures mostly all the long-run policy implications of more general convex models of endogenous growth in which the accumulation of multiple capital goods is considered explicitly.

Over time, capital depreciates at the rate δ and is expanded by investment X. I assume that the consumption good is costlessly transformed into the capital good at a one-for-one rate. Thus, the law of motion for capital is expressed as

$$K_{t+1} = (1-\delta)K_t + X_t. \tag{2}$$

All capital must be intermediated. Banks operate in a perfectly competitive environment and costlessly transform deposits into the capital good. Banks exist because there is a minimum investment size, κ_t.[8] I further assume that the minimum investment size is a linear function of output.[9] This assumption guarantees that the small saver does not outgrow the need for intermediation services. The bank accepts deposits and chooses it assets. The legal requirement puts a lower bound on the fraction of nominal deposits that the bank holds in the form of fiat money. For cases in which fiat money is rate of return dominated, the reserve requirement is a binding constraint. Formally, the period-t profit maximization condition is:

[8] This illiquidity assumption is adapted from Bryant and Wallace (1980) and Scott Freeman (1987), who employs this technology in stationary economies to generate the need for financial intermediation. Essentially, the primitive intermediary serves a pooling function for small savers.

[9] This assumption may be motivated by appeal to some information frictions that keep banks from making loans larger than some fraction of output.

$$pr_t^b = p_t[r_t + 1 - \delta]k_t + r_t - p_t q_t D_t, \tag{3}$$

where pr^b is bank profits, r is the amount of reserve balances carried by the banks, D_t denotes the quantity of goods deposited last period and carried over to period t, and q is then also interpreted as the real return offered on deposits. The initial stock of reserves, r_0, is given. The bank's period-t profit is maximized subject to $k_t + r_t/p_t \leq D_t$ (the balance-sheet equation) and $res_t \geq \gamma_{t-1}p_{t-1}D_t$ (the reserve requirement), where γ denotes the reserve requirement ratio. The bank's zero-profit condition implies that the real return offered on deposits, q_t, equals $(1-\gamma_{t-1})[r_t + 1-\delta] + \gamma_{t-1}\, p_{t-1}/p_t$. In addition, I assume that $p_{t-1}/p_t < r_t + 1-\delta$ so that reserves are rate of return dominated. Rate-of-return dominance ensures that banks hold reserves up to the amount required; that is, $r_t = \gamma_{t-1}p_{t-1}D_t$.

Households in this model economy are atomistic, infinitely lived with preferences described by the time separable CES utility function

$$U = \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \tag{4}$$

where c is the quantity of the consumption good, $0 < \beta < 1$ is the time rate of preference, and $\sigma > 0$ where $1/\sigma$ is the elasticity of intertemporal substitution. Population is assumed constant such that there is no aggregation bias in treating movements in per-capita quantities as equal to movements in aggregate quantities.

In each period t, the government makes a lump-sum transfer equal to G_t units worth of the consumption good. I assume that seignorage revenue is the only means of financing the transfer. The government budget constraint, therefore, is

$$G_t = (M_t - M_{t-1})/p_t. \tag{5}$$

This transfer, combined with income and the gross return on goods deposited at banks, is used by households to purchase the consumption good and deposits that will be carried over into the next period. Formally, the household's date-t budget constraint is

$$R_t D_t + G_t = c_t + D_{t+1}, \tag{6}$$

where D_t denotes the deposits (measured in units of the consumption good) carried forward to date *t* from date *t-1*, and R_t is the gross rate of return on these deposits.

In addition, the representative household faces a terminal constraint. Consistent with this terminal constraint is the notion that the household can sell claims against future deposits, but never at a value greater than can be repaid. The terminal constraint is

$$\lim_{T\to\infty}\left[\frac{D_T}{\prod_{s=0}^{T-1} R_s}\right] = 0 , \tag{7}$$

which guarantees that the period budget constraints (6) can be combined into an infinite horizon, present value budget constraint. Since the marginal utility of consumption goes to infinity as consumption goes to zero, an interior solution for c_t and D_{t+1} is guaranteed.

Consumers take the initial positive quantity deposits, D_0, and the sequences $\{\gamma_t\}_{t=0}^{\infty}$ (where γ denotes the reserve requirement ratio), $\{M_t\}_{t=0}^{\infty}$, $\{G_t\}_{t=0}^{\infty}$, and $\{R_t\}_{t=0}^{\infty}$, as given when maximizing (4) subject to (6) and (7).

The government is assumed to have committed itself to a sequence of $\{\gamma_t\}_{t=0}^{\infty}$, $\{M_t\}_{t=0}^{\infty}$, taking the sequence of interest rates as given. The government takes the initial stock of deposits, D_0, and the sequence of deposits, $\{D_t\}_{t=0}^{\infty}$, as given, and knows the sequence of the price level, $\{p_t\}_{t=0}^{\infty}$, that is consistent with the path for the money stock. The date-t price level is determined by the money market equilibrium condition:

$$M_{t-1} = \gamma_t D_t p_{t-1}. \tag{8}$$

The implication is that the sequence of transfer payments is determined by the sequence of fiat money, the sequence of reserve requirement ratios, and, implicitly, the sequence of prices. Money carried over from date t-1 purchases $1/p_t$ units of the date t consumption good. Hence, the gross rate of return on fiat money is p_{t-1}/p_t. Throughout this paper, I assume that $A + (1-\delta) > p_{t-1}/p_t$.

The demand for money represented in equation (8) characterizes one part of the bank's asset allocation decision. Because money is rate-of-return dominated, the bank will invest all deposits above the required amount in capital; that is, $K_t = (1-\gamma_t)D_t$. The return to the bank's portfolio (and hence, to depositors) is represented as:

$$R_t = (1-\gamma_t)[A+(1-\delta)] + \gamma_t \frac{p_{t-1}}{p_t}, \tag{9}$$

where $A+(1-\delta)$ is the gross return on capital after replacement, and p_{t-1}/p_t is the gross return on fiat money balances. The return on deposits is simply a weighted average of the returns to the two assets held by banks, with the weight being a function of the reserve requirement ratio. With $p_{t-1}/p_t < A+(1-\delta)$ (rate of return dominance), equation (9) implies that the return offered by banks is inversely related to changes in the reserve requirement ratio.

The representative person's first-order condition implies that output, deposits, and consumption grow at the rate ρ_t between dates t-1 and t. Along the balanced growth path, the rate is expressed as

$$\rho_t = (\beta R_t)^{1/\sigma} = (\beta[(1-\gamma_t)(A+1-\delta)++\gamma_t \frac{p_{t-1}}{p_t}])^{1/\sigma}. \tag{10}$$

Equation (10) implies that the economy's growth rate is inversely related to the reserve requirement ratio. David Romer (1985) and Scott Freeman (1987) show how reserve requirements could crowd out capital. Their results, however, apply to the effect that changes in reserve requirements have on the *level* of output. One immediately sees that in the limit, with $\gamma = 0$, monetary policy becomes is divorced from output growth. As in Jones and Manuelli, if one considers a case in which reserve requirements are absent, then the rate of return on capital is independent of changes in money growth. In this paper, the reserve requirement ratio affects capital accumulation through the gross return offered by the agent's portfolio. The intuition behind this effect is straightforward. According to the Keynes-Ramsey rule, a decline in the return to the agent's portfolio relative to the time rate of preference increases current consumption, depressing capital accumulation and reducing growth.[10]

Equation (10) also implies that the economy's growth rate is inversely related to the rate of money growth, denoted θ, and, hence, to inflation. Suppose the supply of money follows the rule: $M_t = \theta M_{t-1}$. As noted above, the rate-of-return dominance condition requires that $\theta > 1$ and $\gamma > 0$ so that the reserve requirement is a binding constraint. Using equation (8), and recognizing that $D_{t+1}/D_t = \rho$, then for a given rate of growth, $\theta = \rho\pi$. In equation (9), constant money growth implies that $p_{t-1}/p_t = 1/\pi$. As money growth rises, the inflation rate rises and the rate of output growth falls. The intuition is the same for an increase in the reserve requirement ratio; higher inflation drives down the return offered on deposits, making date-t consumption more attractive. This result is qualitatively similar to that in Greenwood and Huffman, but the mechanism is very different. With a positive reserve requirement ratio, higher inflation makes money balances less attractive. Instead of influencing the intratemporal tradeoff as occurs in the models with a cash-in-advance constraint, higher inflation results in a lower return on intermediated capital, translating into slower output growth. Thus, the mechanism highlights the role that monetary policy actions have on intertemporal substitution.

For a constant reserve requirement ratio and constant money growth, output, consumption, and deposits all grow at the same rate across time; that is, $\rho = \beta\{(1-\gamma)[A+(1-\delta)] + \gamma/\pi\}$. As King and Rebelo note, the representative person in this model economy has finite utility if and only if $\beta\rho^{1-\sigma} < 1$. This condition holds in all the experiments conducted in this paper.

[10] Jones and Manuelli (1990) briefly discuss the negative effect a decrease in the (after-tax) return has on output growth across two countries.

4. Monetary Policy and Growth

In this section, I examine the quantitative impact changes in monetary policy have on the growth rate of the model economy.

4.1 Calibration

Obviously, to proceed one must select a set of parameter values. For this analysis, the model's period is assumed to correspond to one year. Following King and Rebelo, the growth rate of technology (ρ) is 2%. Following Jones and Manuelli, I set $\sigma = 2$ and $\delta = 0.1$. My benchmark case calibrates both monetary policy variables to their full-sample means. Hence, $\pi = 1.119$ and $\gamma = 0.153$. As noted above, selecting the inflation rate determines ρ, and with these two values pins down the model's rate of money growth by $\theta = \pi\rho$. With $\gamma = 0.153$ and $A = 0.165$, the gross after-reserve-requirement return on deposits is 1.039, so that $\beta = 0.9819 = (1.02/1.039)$.[11]

4.2 Computational Experiments

I proceed by examining the effects that changes in the inflation rate and reserve requirement ratio have in the model. Specifically, I am interested in computing the growth-rate effects and welfare effects for the model when one considers changes in the monetary policy variables in isolation. One can then determine how "close" the model's estimates are to those presented in the cross-country regressions.

I begin with the case in which the inflation-rate effects are computed. For this experiment, I use $\gamma = 0.153$ and vary the inflation rate between 0% and 99%. The question is, "What would the growth rate be for an economy in which the expected inflation rate is π_0, where $\pi_0 \in [1.0,1.99]$. Figure 1 plots the output growth rate and inflation rate combinations obtained

[11] The parameters are consistent with rate of return equal to 6.5% when the reserve requirement ratio equals zero. In general, $\beta = 1.02/R$, where R is given by equation (8).

for this set of expected inflation rates. The plot shows that the model economy's growth rate is nearly a linear response to movements in the inflation rate over the range of inflation rates considered.[12] A ten-percentage-point reduction in the inflation rate adds roughly 0.65 percentage points to the rate of output growth. Recall that many cross-country studies present estimates of the around -0.4 and that in Table 3, the estimate was -0.2. Hence, the inflation-rate effect in this economy is quite large compared with what the data indicate.

I consider the another experiment, holding the inflation rate at 11.9% ($\pi = 1.119$) and letting the reserve requirement vary between 0% and 99% (that is, $\gamma_0 \in [0,0.99]$). Figure 2 plots the output growth rate and reserve requirement combinations for this case. Here, a 10-percentage-point reduction in the reserve requirement ratio adds slightly more than 0.8-percentage-points to output growth. As with the inflation rate, the reserve-requirement effects using the benchmark parameter settings are large compared with the regression coefficient, which are roughly -0.4.

Note that in equation (10), monetary policy affects the real return on deposits through a product of the reserve requirement and the inflation rate. One way to diminish the size of the inflation-rate effect, for example, would be to lower the reserve requirement setting in the computational experiments. Likewise for the reserve-requirement effect, lower the inflation rate from its benchmark setting. I set the inflation rate at 3%, running the same computational experiments as presented in Figure 1. For this case, a 10-percentage-point reduction in the reserve requirement results in the growth rate of output rising 0.45-percentage-points, which is in line with the parameter estimates obtained from the actual data. Similarly, if the reserve

[12] A the inflation rate rises to say 1500%, the output growth response flattens substantially. Thus, the model economy asymptotically (w.r.t. the inflation rate) approaches a lower bound for the growth rate. In other words, there is a maximum rate at which the model economy will decline.

requirement is set at 5% and using the same range of inflation values, the computational experiment estimates the effect of lowering the inflation rate 10-percentage-points would result in output growth increasing by 0.22-percentage-points.

Next, I consider the welfare of both inflation and reserve requirements. The measure of welfare requires comparison of the sequences of consumption under the alternative policies. Let $\{c^0_t\}^\infty_{t=1}$ denote the sequence of consumption when the policy instrument is set equal to initial value and let $\{c^1_t\}^\infty_{t=1}$ be the sequence of consumption under the new policy setting. when the reserve requirement is 10%. Then the calculation is

$$U(\{c^0_t\}(1+\phi)^\infty_{t=1}) = U(\{c^1_t\}^\infty_{t=1}). \tag{11}$$

Then ϕ measures the percentage-change in consumption that would be necessary to make the agent just as well off in the initial policy setting as in the new policy setting. To simulate the consumption path, a special case of the model is established in which the initial capital stock, K_0, is set equal to 1. Welfare is measured as ϕ.

I consider four cases. In the first two, I calculate the welfare costs of eliminating the reserve requirement ratio. I consider two inflation-rate settings; one in which $\pi = 11.9\%$ and another in which $\pi = 3\%$. Thus, in addition to the benchmark parameter settings, I can calculate the welfare costs for a cash in which the growth-rate effects are quite close to those found in the data. Table 4 reports the welfare costs for these four cases. Note that date-1 consumption falls as the reserve requirement falls. Agents, substitute away from consumption toward capital as return on capital rises. The welfare costs of the reserve requirement is 10.6% when inflation rate is at 11.9% and is 2.9% when the inflation rate is 3%. Note that the welfare costs follow the change in the growth rate, which, as noted above, is less responsive to eliminating the reserve requirement ratio when the inflation rate is low.

The bottom part of Table 4 considers two cases in which a moderate (10%) inflation is eliminated. In the first case $\gamma = 0.153$ while in the second case, I set $\gamma = 0.05$.[13] The welfare costs of eliminating a moderate inflation is 7.1% at the high reserve requirement setting and 0.7% when reserve requirements for the low-reserve-requirement setting.

The results are not too surprising. When the growth-rate effects are large, the welfare costs of the policy are large. These welfare costs fall as the growth-rate effect falls. Growth appears to be the dominant factor in calculating these growth rate effects.[14] Even with a low reserve requirements, however, the welfare costs of inflation are over four times the estimates presented in Cooley and Hansen (1989). The reserve requirement clearly has larger growth-rate effects as compared with previous papers. Both Gomme (1993) and Jones and Manuelli (1995) study environments in which growth is endogenous. In both papers, the inflation tax operates, however, through the labor-leisure tradeoff. The growth-rate effects and welfare costs calculations are much larger in this setup.

Overall, the model economy indicates that movements in either the inflation rate or reserve requirement ratio will have large impacts on economic growth, especially relative to the other model economies. The key feature is that the reserve-requirement setup transmits changes in monetary policy directly into changes in the return to deposits. Since deposits are the only means of financing capital accumulation, the large effects are not too surprising. In the

[13] One justification for this reserve requirement setting is that banks would hold some reserve even with positive inflation. In the model economy, the reserve requirement is binding. Perhaps, in a more complicated environment, the difference between required reserves and desired reserves is smaller because the desired reserve ratio is not zero. Of course, this is pure speculation since the more complicated environment is not specified here.

[14] There are of course two difference between this analysis and earlier models. One is the fact that the growth-rate effects can be large and the other is the use of reserve requirements as the rationale for holding money balances instead of a cash-in-advance constraint.

literature with cash-in-advance constraints, what matters is the substitutability between the cash and credit goods. The results in this article suggest that leisure is not as responsive to the inflation tax as is the return to deposits.

5. Summary

In this paper, I examine a general equilibrium model with endogenous growth. The economy has a monetary equilibrium because banks face a reserve requirement. The model, therefore, permits one to study monetary policy effects on economic growth through a banking system. The main contribution of the paper is an examination of monetary policy effects on growth and development when operating through intermediaries.

Are intermediaries important in linking monetary policy and growth? Based on cross-country evidence presented in this paper, the answer is yes. In particular, I find that reserve requirements matter for growth in the sense that high average reserve requirement countries systematically tend to grow more slowly than low average reserve requirement countries. There is some evidence supporting this notion even when one controls for the inflation rate.
The data also show indicate a negative correlation between inflation and output growth, which is consistent with other cross-country studies. The empirical evidence support the view that monetary policy, operating through the banking system, may be important for growth and development.

The model economy can account for the negative correlations between output growth and both reserve requirements and inflation. I run some computational experiments to determine how close the model comes quantitatively to the regression coefficients presented in this article. Calibrating the model with the "benchmark" monetary policy settings results in the model economy producing "too large" a reserve-requirement effect and inflation-rate effect as compared with the regression coefficients. I consider some alternative policy parameter settings that do quantitatively match the regression coefficient. Even in these "revised" computational experiments, the welfare costs of inflation in this model economy are large relative to estimates found in the literature. Not surprisingly, the welfare cost calculations are associated with the greater estimates of the growth-rate effects calculated for this economy.

Overall, the model economy shows that monetary policy effects can be quite substantial in terms of growth-rate effects and the welfare costs in a setting with an intermediary. Specifically, the empirical evidence suggests that reserve requirements have quantitatively important effects for growth and development. The model economy then provides a theoretical basis which accounts for this quantitative relationship and which indicates that the welfare costs associated with movements in monetary policy instruments can be large when compared with previous estimates.

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Data Appendix

Name	Avg. Per Capita Output	Avg. Inflation	Avg. Res. Req.
Australia	2.202	7.018	8.534
Austria	2.974	4.470	7.780
Belgium	3.088	5.003	3.304
Canada	2.869	5.589	5.622
Chile	1.535	74.149	35.036
Congo	1.726	6.337	4.429
Costa Rica	2.002	13.555	26.299
Cote d'Ivoire	-0.574	7.061	7.518
Cyprus	5.292	4.637	18.654
Denmark	2.524	7.226	4.268
Domin. Rep.	1.770	12.825	39.632
Ecuador	2.435	18.226	31.884
El Salvador	0.469	10.233	28.167
Ethiopia	-0.149	6.254	21.893
Finland	3.404	7.688	3.640
France	3.000	6.685	3.642
Gabon	5.853	7.398	4.565
Gambia	1.175	10.246	20.371
Germany	3.228	3.435	10.357
Ghana	-0.321	36.722	33.662
Greece	3.973	11.877	16.280
Guatemala	1.042	8.543	25.045
Guyana	-0.598	10.272	22.980
Honduras	0.637	6.134	12.614
Iceland	4.150	26.884	23.190
India	2.108	7.802	9.815
Iran	1.425	11.051	28.559
Ireland	3.639	8.792	11.131
Jamaica	0.958	12.744	16.839
Japan	4.803	5.642	2.455
Korea	6.683	11.618	15.686
Liberia	-0.657	7.000	21.170
Madagascar	-0.836	11.132	7.856
Malta	6.312	3.609	22.511
Mauritius	3.194	9.335	8.696
Mexico	2.084	29.541	29.616
Morocco	2.016	6.075	4.386
Nepal	0.620	8.464	15.919
Netherlands	2.684	4.689	0.917
New Zealand	1.500	9.022	10.494
Niger	0.269	6.018	14.739
Norway	3.225	6.858	3.222
Pakistan	4.791	7.634	10.700

Paraguay	2.070	12.932	47.203
Phillipines	1.574	11.751	11.814
Singapore	0.931	9.352	6.510
South Africa	6.717	3.586	7.956
Spain	3.801	10.313	8.684
Sri Lanka	2.238	8.077	17.458
Sudan	0.312	20.423	29.447
Sweden	2.421	6.970	2.128
Switzerland	1.985	3.923	10.568
Syria	2.870	11.687	29.997
Tanzania	0.449	19.374	4.958
Thailand	5.014	5.570	7.186
United Kingdom	2.175	8.148	6.646
United States	1.977	5.122	7.086
Uruguay	1.044	58.127	29.736
Venezuala	0.478	11.519	19.321
Zambia	-0.459	21.822	19.577

Table 1

Summary statistics across countries

Full-sample:

	Mean	Stnd Dev.
rr	15.3%	10.8%
infl	11.9%	12.1%
py	2.2%	1.9%

High reserve requirement countries:

rr	30.0%
py	1.5%

Low reserve requirement countries:

rr	3.4%
py	2.9%

High inflation countries:

infl	30.0%
py	1.5%

Low inflation countries:

infl	3.4%
py	2.9%

Table 2

Simple correlation coefficients

	Reserve requirement	Inflation rate
Output growth	-0.27	-0.23
Inflation rate	0.53	----

Table 3

Cross-Country per-capita output growth regressions

$$py_i = \underset{(0.022)}{1.062} - \underset{(0.02)}{0.035} infl_i$$

$$py_i = \underset{(0.004)}{1.029} - \underset{(0.022)}{0.046} rr_i$$

$$py_i = \underset{(0.024)}{1.049} - \underset{(0.026)}{0.035} rr_i - \underset{(0.023)}{0.019} infl$$

Legend: py - per-capita output growth
infl - inflation rate
rr - ratio of bank reserves to deposits

Table 4

Welfare costs of reserve requirements and inflation rate

I: $\pi = 11.9\%$

	$\gamma = 15.3\%$	$\gamma = 0\%$	% chng
Initial consumption	0.0547	0.0420	-23.2
Growth rate	1.03	2.30	1.27
Welfare (ϕ)	-----	----	10.6

II. $\pi = 3\%$

Initial consumption	0.0489	0.0420	-14.1
Growth rate	1.61	2.3	0.69
Welfare (ϕ)	-----	----	2.9

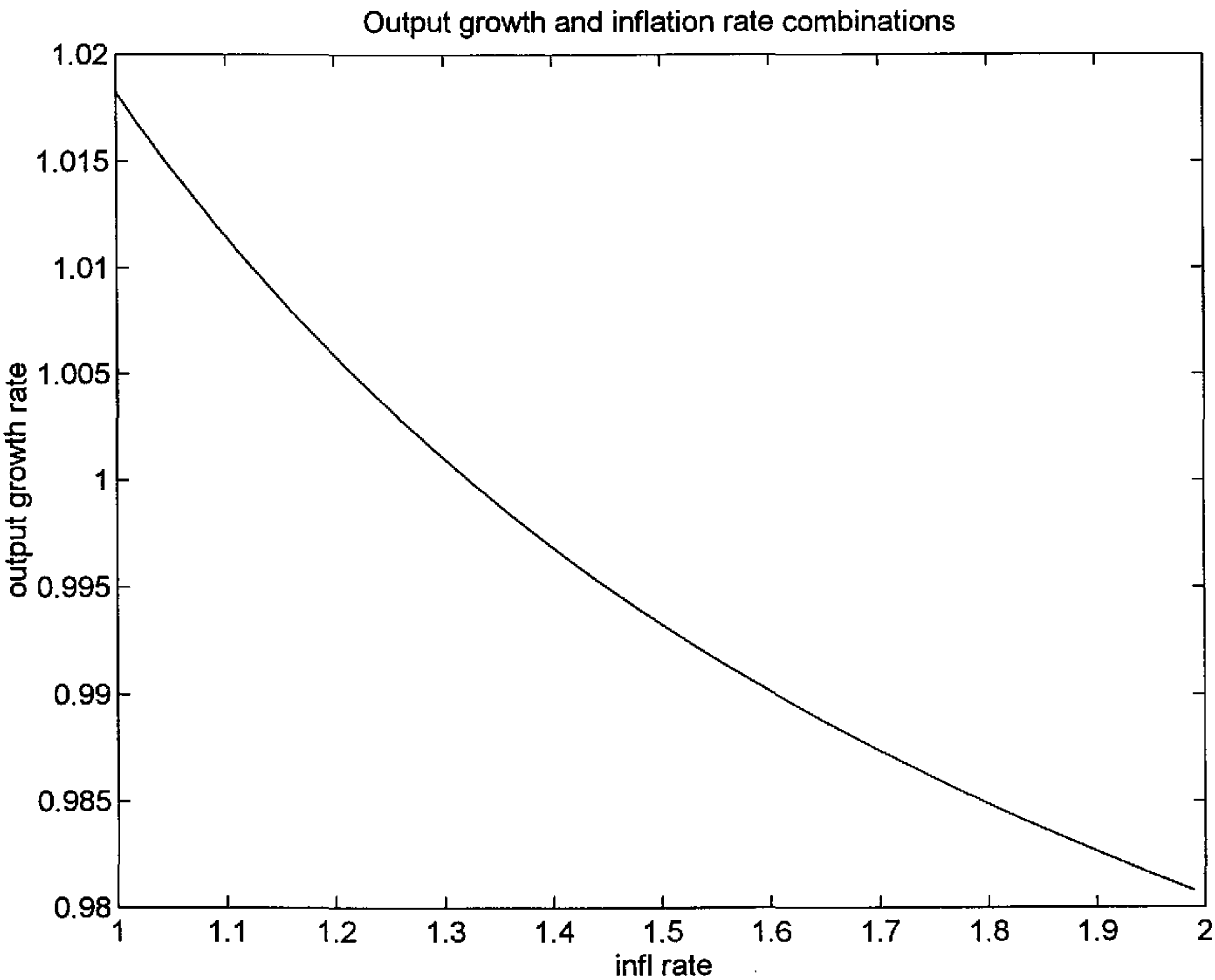
III: $\gamma = 15.3\%$

	$\pi = 10\%$	$\pi = 0\%$	% chng
Initial consumption	0.0535	0.0468	-12.5
Growth rate	1.15	1.82	0.67
Welfare (ϕ)	-----	----	7.1

IV. $\gamma = 5\%$

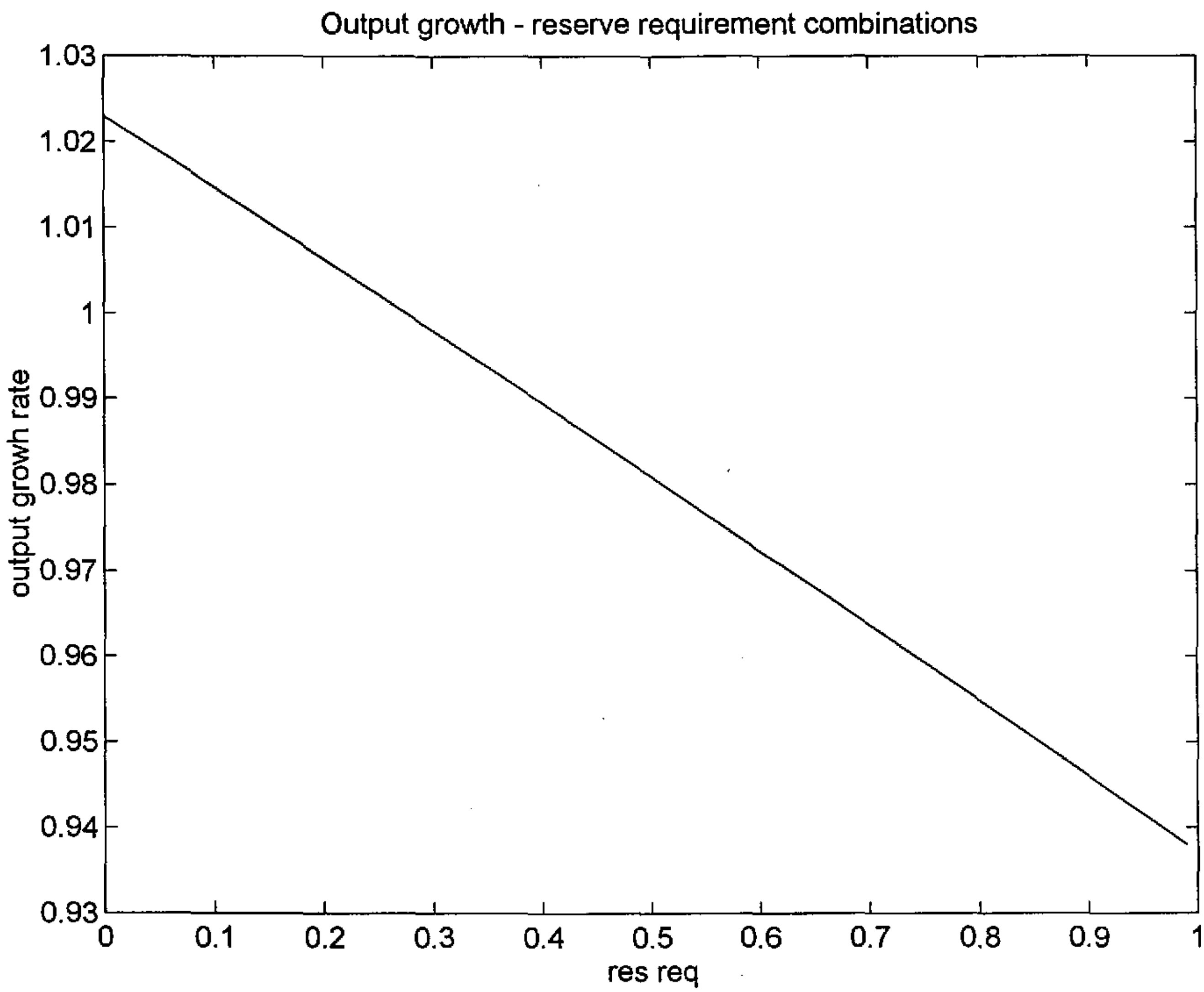
Initial consumption	0.0457	0.0436	-4.6
Growth rate	1.93	2.14	0.21
Welfare (ϕ)	-----	----	0.7

Figure 1



Output growth and inflation rate combinations
output growth rate
infl rate
1.02
1.015
1.01
1.005
1
0.995
0.99
0.985
0.98
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2

Figure 2



Output growth - reserve requirement combinations
output growh rate
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
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