Liquidity, Innovation and Growth*

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Abstract

Many countries simultaneously suffer from high rates of inflation, low growth rates of per capita income and poorly developed financial sectors. In this paper, we integrate a microfounded model of money and finance into a model of endogenous growth to examine the effects of inflation and financial development. A novel feature of the model is that the market for innovation goods is decentralized. Financial intermediaries arise endogenously to provide liquid funds to the innovation sector. We calibrate the model to address two quantitative issues. One is the effects of an exogenous improvement in the productivity of the financial sector on welfare and per capita growth. The other is the effects of inflation on welfare and growth. Consistent with the data but in contrast to previous work, reducing inflation generates large gains in the growth rate of per capita income as well as in welfare.

Keywords: Money; Credit, Innovation; Growth.
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1 Introduction

Many countries simultaneously suffer from high rates of inflation, low growth rates of per capita income and poorly developed financial sectors. For example, during the period from 1960-1995, Bolivia had an average annual inflation rate of 50%, a low growth rate of per capita income of 0.36%, and a share of the financial sector in GDP that was about 5 times smaller than the share in the US. In this paper, we integrate a microfounded model of money and finance into a model of endogenous growth to examine the effects of inflation and financial development. We calibrate the model to address two quantitative issues. One is how inflation quantitatively affects welfare and the growth rate of per capita income. The other is how an exogenous improvement in the productivity of the financial sector quantitatively affects welfare and growth.

The empirical literature has documented that financial development has a robust and positive effect on economic growth and that inflation has robust and negative effects on financial development and growth (e.g., Levine et al, 2000, Boyd et al, 2001, and King and Levine, 1993a,b). These effects are sizable, even after controlling for country-specific factors such as the level of a country's development, political factors, trade and price distortions, and fiscal policy. For example, the regression coefficients in Levine et al (2000) suggest that an exogenous improvement in financial intermediation from the level in India to the sample average in the period 1960-1995 (i.e., an increase of 28%) can increase annual growth rate of per capita income by 0.6 percentage points. The regression coefficients in Boyd et al (2001) suggest that an increase in inflation by the median value in the sample (9%) can reduce financial intermediation by 26% in low-inflation countries.

Table 1 (Data): Inflation, growth and financial development

	annual inflation (%)	net growth rate of real pc income (%)	bank credit[a]	liquid liabilities[b]	net interest margin[c]
Low	5.58	3.00	0.48	0.65	0.030
Mid	9.26	1.88	0.28	0.43	0.035
High	30.58	1.40	0.18	0.29	0.059

[a]Defined as claims on private sector by deposit money banks, as share of GDP. [b]Defined as currency plus demand and interest-bearing liabilities of banks and nonbank financial intermediaries, as share of GDP.
[c]Defined as interest income earned minus interest income paid divided by total assets

Table 1 displays the relationship between inflation, real per capita growth, and three commonly used measures of financial development or the financial sector size.[1] One measure is bank credit, defined as claims on private sector by deposit money banks as share of GDP. The second measure is liquid liabilities, defined as currency plus demand and interest-bearing liabilities of banks and nonbank financial intermediaries, as share of GDP. The third measure is the net interest margin, defined as the ratio of interest income earned minus interest income paid by total assets. While a high level of bank credit or liquid liabilities indicates high development and efficiency of the financial sector, a high net interest margin indicates low development and efficiency.[2] Table 1 clearly shows that countries with higher growth in real GDP per capita tend to have both larger financial sectors and lower rates of inflation. This evidence suggests that one needs to examine the effects of financial sector size, the efficiency of financial intermediaries and inflation on economic growth.

Although these empirical findings are suggestive, it is not clear how to interpret them. One possible interpretation is that the statistical relationships are causal. That is, low inflation rates foster financial market development, financial market development promotes economic growth and, hence, low rates of inflation promote economic growth (Altig, 2003). If so, then the empirical findings suggest that monetary policy can help financial market development, which in turn can increase economic growth. The competing interpretation is that the statistical relationships may not indicate any causality, because financial development is endogenous; in particular, a poorly developed financial sector may be a result of a weak real economy.[3]

In contrast to such ambiguity, a general equilibrium model makes the causality explicit. For this reason, it is useful to employ a general equilibrium model to quantify the effects of inflation and financial market development on economic growth. Moreover, the empirical literature cannot evaluate the welfare consequences of inflation and financial development. How large is the welfare cost of inflation? Does the cost depend on the degree of finan-

[1] To construct Table 1, we have used the same cross-country data as Levine et al (2000). The data range is 1960-1995. We sorted 63 countries for which all data was available into inflation tertiles (see the Appendix for the countries and their allocation into the three inflation baskets). For each country type, we then calculated the average inflation rate, the average real per capita growth rate, the average of bank credit, the average of liquid liabilities and the average of net interest rate margin.

[2] Bank credit and liquid liabilities have been used in many empirical studies as indicators of financial development (e.g., Levine et al, 2000). Interest rate spreads are used as proxies for the theoretical concept of the cost of financial intermediation, and the most common empirical measure of bank spreads is the net interest margin (e.g., Brock and Rojas-Suarez, 2000).

[3] See Levine (2004) for a discussion on this classic debate on whether financial development is a cause or simply a consequence of economic development.

cial development? These questions are important for designing policies, and they can be explicitly addressed with a general equilibrium model, as we do in this paper.

We construct a model of endogenous growth with microfoundations for money and financial intermediation. A search model with large households, as developed by Shi (1997), is used to give fiat money an essential role in the equilibrium. The model is extended to allow for financial intermediation and a balanced growth path. A representative household in the model consists of a continuum of members who are allocated to four activities: producing final consumption goods, innovating, working in the financial sector, and enjoying leisure. The innovation sector uses labor to produce innovation goods that are the input in the production of "knowledge capital", which in turn increases labor productivity in the final goods sector. As in a standard model of endogenous growth, non-diminishing marginal productivity of knowledge capital is the source of long-run growth.

Money and financial intermediation are both essential in the innovation sector. As a key departure from the literature, we model the market for innovation goods as a decentralized market where innovators are matched randomly and bilaterally. There is no double coincidence of wants between any two innovators and no record-keeping of innovators' transactions, and so immediate settlement is needed for exchanging innovation goods in this market. Moreover, in any given period, trading shocks generate a heterogeneous demand for liquidity among the innovators. Financial intermediaries emerge endogenously to reallocate liquid funds among innovators. As in Berentsen et al (2007), these intermediaries behave like banks since they take deposits and make loans. To simplify the analysis and to focus on the main mechanism of the paper, we assume that the market for final goods is centralized and perfectly competitive so that there is no need for a medium of exchange for trading those goods.[4]

We use the model to quantify the effects of inflation and financial development on growth and welfare. The model is consistent with the above mentioned stylized facts. First, an exogenous increase in the efficiency of financial intermediaries increases the financial sector size, the growth rate of per capita income, and welfare. Second, the model generates a negative relationship between inflation and the financial sector size. Third, the model displays a negative relationship between inflation and growth. To quantify the

[4] As a robustness check we depart from this assumption in Section 5.1 by introducing a need for a medium of exchange in the real goods sector as well and show that this reinforces our results.

welfare and growth effects of inflation and financial market development, we calibrate our model to the average low-inflation country (see Table 1) and perform several counterfactual experiments. For each of the three country types in Table 1, we ask how much the representative household would pay in terms of consumption for reducing inflation from the observed level to zero. Also, we calculate the welfare and growth effects of a financial reform that increases financial productivity by 100%. Table 2 reports our main simulation results:

(i) Inflation has a large and negative effect on the growth rate of per capita income. The average low-inflation country could increase its per capita growth rate by 0.295 percentage points by following a zero percent inflation rate, which is several times larger than the growth effect in the literature (see the later discussion). For the average high-inflation country, the growth gains from eliminating inflation are much larger. Such a country could increase its per capita growth rate by almost 1 percentage point by following a zero inflation policy.

(ii) Financial market reform has much smaller growth effects than zero inflation for all country types. Increasing financial productivity by 100% (see the definition in the text) could increase per capita growth rate by 0.032 percentage points for the average low-inflation country and by 0.025 percentage points for the average high-inflation country. Both numbers are one order of magnitude smaller than the growth gains from reducing inflation to zero.

(iii) Reducing inflation to zero or doubling financial productivity both have sizable welfare gains. For eliminating inflation, an average low-inflation country is willing to give up 1.42% of consumption and an average high-inflation country is willing to give up 5.32% of consumption. For doubling financial productivity, an average low-inflation country is willing to give up 0.33% of consumption and an average high-inflation country is willing to give up 0.29% of consumption.

Table 2 (Results): Price stability vs. financial market reform

	current annual inflation rate					
	Low (5.6%)		Middle (9.3%)		High (30.6%)	
	welfare gain[a]	growth gain[b]	welfare gain[a]	growth gain[b]	welfare gain[a]	growth gain[b]
zero inflation	1.421	0.295	2.212	0.448	5.316	0.998
financial reform	0.332	0.032	0.324	0.030	0.285	0.025

[a]Defined as the percentage increase in consumption permanently.

[b]Computed as the increase (in percentage points) in the net growth rate of income per capita.

These results suggest that inflation is an important cause of low growth in high-inflation countries. They support the theory that low inflation rates foster financial market development, financial market development promotes economic growth, and hence low rates of inflation promote economic growth (Altig, 2003). Moreover, financial market reform does not boost growth significantly, but it does increase welfare substantially.

1.1 Relationship to the Literature

There are numerous theoretical and empirical contributions that have investigated the relationship between finance and growth. A comprehensive survey is Levine (2004).[5] We focus on the role of financial intermediaries in providing liquidity to the innovation sector, which is intuitively important for growth. By integrating a financial sector into an environment that generates an essential role of money, we are able to study the effects of inflation on financial intermediation and growth.

Table 3: Welfare and growth gains of reducing inflation from 10% to 0%

	traditional[a]	Gomme[b]	Dotsey & Ireland[c]	our model
Growth gain (% pts)	-	0.056	0.05	0.475
Welfare gain (% of c)	0.3 - 0.45	0.024	0.915	2.359

[a]The traditional approach (e.g., Bailey, 1956, and Friedman, 1969) estimates the welfare cost by computing the area under the money demand curve. [b]Gomme (1993) considers a 10% money growth rate (8.5% inflation rate).

[c]The welfare cost is 0.92% of output per year if the model is calibrated to M0 and 1.7% if it is calibrated to M1.

[5]Early empirical studies on the relationship between finance and growth are Goldsmith (1969), Shaw (1973) and McKinnon (1973). More recent theoretical and empirical contributions are Greenwood and Jovanovic (1990), Levine (1991), King and Levine (1993a,b), Bencivenga and Smith (1993), Jones and Manuelli (1995), Acemoglu and Zilibotti (1997), Acemoglu et al (2006), Aghion et al (2005). It is not useful here to discuss the huge number of empirical papers on this subject. For a literature review, we refer the reader to Levine (2004) or Boyd and Champ (2003).

There is also a large literature that studies the effects of inflation on welfare and/or growth.[6] Traditional papers in this direction abstract from long-run growth, e.g., Fisher (1981) and Lucas (1981).[7] More recent models typically combine a variant of an endogenous growth model with the assumption of a cash-in-advance constraint or a shopping technology that requires money. The models are then used to quantify the cost of inflation and/or the effect of inflation on growth. Examples are Gomme (1993), Ireland (1994), Dotsey and Ireland (1996), and Chari et al (1996).[8] The common approach in this literature is to model financial intermediation as a provider of consumption loans.[9] The common result is that inflation has a negligible effect on the growth rate of per capita income (e.g., Gomme, 1993; Dotsey and Ireland, 1996; and Chari et al, 1996). Thus, this literature concludes that inflation is not quantitatively important for growth, although it may affect welfare significantly (e.g., Dotsey and Ireland, 1996).

In contrast to this literature, our model assumes that money is needed to finance the production of innovation goods rather than consumption. This modeling assumption not only is realistic but also gives a channel through which liquidity directly affects productivity and growth in the economy. As a result, inflation has a large and negative growth effect, which is consistent with the empirical evidence. Table 3 contrasts the growth and welfare gains from reducing inflation to zero in our model with the effects in the literature. First, reducing the inflation rate from 10% to 0% increases the net rate of growth in per capita

[6] Recent surveys on the cost of inflation are Craig and Rocheteau (2005) and Gillman and Kejak (2005a). Craig and Rocheteau focus on stationary models while Gillman and Kejak's interest is on models with a balanced growth path. Gylfason and Herbertsson (2001) and Chari et al (1996) compare various empirical studies. After reviewing the empirical evidence, Chari et al (1996) suggest that a 10 percentage point increase in the average inflation rate is associated with a decrease in the average growth rate between 0.2 and 0.7 percentage points. The robustness of this relationship is questioned though. In particular, Bruno and Easterly (1998) point out that a positive correlation between inflation and real growth depends on the inclusion of high inflation countries. To adress this valid criticism we perform robustness check by eliminating all countries that expericenced a hyperinflation and recalibrate the model in Section 5.2. We find that eliminating these countries does not affect our results, rather it reinforces them as discussed there.

[7] Fisher (1981) and Lucas (1981) estimate the cost of inflation by calculating the appropriate welfare cost under the money demand curve. Fisher (1981) estimates the cost of increasing the rate of inflation from 0% to 10% to be 0.3% and Lucas (1981) to be 0.45%. For a discussion of these estimation procedures and more recent estimates see Lucas (2000) or Craig and Rocheteau (2005).

[8] In a recent paper Gillman and Kejak (2005a) compare several models of endogenous growth and their ability to produce reasonable growth effects. They find that for some endogenous growth models, there exists parameterization that produces realistic growth effects of inflation.

[9] In a recent paper, Gillmann and Kejak (2009) introduce a cash in advance constraint for investment goods along the lines of Stockman (1981) into an endogenous growth model. They also find large and nonlinear growth effects of inflation.

income by 0.475 percentage points in our model, which is substantially larger than the growth effect in the literature (e.g., Dotsey and Ireland, 1996). Second, reducing inflation has a larger welfare gain in our model than in the literature. These contrasts between our results and those in the literature suggest that the key to understanding the effects of inflation and financial intermediation on growth is the role of liquidity and financial intermediation in the innovation sector rather than the final goods sector.

2 The model

A discrete-time economy is populated by a unit measure of households. A household has a unit of members who share consumption and regard the household's utility as the common objective.[10] The household divides the members into four groups: potential innovators (l), producers of final goods (h), financial intermediaries (k), and idle members ($1-l-h-k$), where the symbol in brackets denotes the fraction of each group in the household.

Each member is endowed with one unit of time per period which he can divide between work and leisure, the latter of which is denoted by n. If a member works in either the final goods production or the financial intermediation, the required time input is 1 and so $n=0$. An idle member's time input is 0 and so $n=1$. If a member is a potential innovator, his working time consists of the time searching and if matched, the time input in production. The time input required for search is $1-n_0$ and the time input required for producing Y units of innovation goods is $c(Y)$, where $n_0 \in (0,1)$ is a constant. Accordingly, leisure is n_0 for a member who searches but has no match, and $[n_0 - c(Y)]$ if he has a match.

The utility of enjoying n units of leisure is θn.[11] Thus, the household's total utility of leisure in a period is:

$$\sum_{t=1}^{\infty} \beta^{t-1} \left\{ u(q_t) + \theta(1-h_t-k_t-l_t) + \theta l_t (1-\sigma e) n_0 + \theta l_t (\sigma e) [n_0 - c(Y_t)] \right\}$$

Here q_t is the quantity of final goods consumed by the household, Y_t the quantity of innovation goods produced by the household, and $\sigma e \in (0,1)$ the probability that an innovator produces innovation goods (to be explained later). The discount factor is $\beta \in$

[10] The device of a household is used here to maintain tractability, as it enables us to smooth the matching risk within a household (to be described below) and hence to obtain a degenerate distribution of money holdings across households. See Shi (1997).

[11] We have also experimented with the more general specification $\Theta(n)$ with $\Theta'(n) > 0$ and $\Theta(0) = 0$.

$(0, 1)$ and the discount rate is $R \equiv \beta^{-1} - 1$. The second term in the brackets is the utility of leisure of the $1 - h_t - k_t - l_t$ idle members. The third term is the utility of leisure of the innovators who search but have no production opportunity and the last term is the utility of leisure of those innovators who search and produce innovation goods. This precise accounting of leisure time for each activity allows us to match the model to time use data as described later. Define the time input in search by potential innovators as $\rho \equiv 1 - n_0$. The household's preferences can be rewritten as follows:

$$\sum_{t=1}^{\infty} \beta^{t-1} \{u(q_t) + \theta(1 - h_t - k_t) - \theta l_t [\rho + \sigma e c(Y_t)]\}. \tag{1}$$

We pick an arbitrary household as the representative household and use lower-case letters to denote its decisions. The decisions of other households and the aggregate variables are denoted as capital-case letters. The representative household takes all capital-case variables as given. In particular, the quantity Y_t in the above utility function is chosen by the household's trading partners. For the remainder of the paper we suppress the time index t and indicate next period's variable by the subscripts $+1$.

A household uses labor h to produce final goods according to the production function, $q(h, a)$, where a is the household's productivity in the final goods sector. Productivity is determined by innovation as follows. A household has the technology to produce one type of innovation good, which has no use to the household but can be used by some other households as an input into the innovation process. The time requirement for producing Y units of innovation goods is $c(Y)$, as specified above. The household uses *other* households' innovation goods as the input in its innovation. If i is the amount of such input in the current period, then the household's productivity in the next period will be

$$a_{+1} = a [1 + f(i)].$$

Let us refer to the function $f(i)$ as the innovation function and to a as knowledge capital. Final goods and innovation goods are both perishable between periods.

For simplicity, we assume that the utility function, u, the disutility function of producing innovation goods, c, the production function of final goods, q, and the innovation function, f, have the following standard forms:

$$u(q) = \ln(q), \quad c(Y) = c_0 Y^{\alpha}, \quad q(h, a) = a h^{\eta}, \quad f(i) = f_0 i^{\chi},$$
$$\alpha > 1, \; c_0 > 0, \; \eta, \chi \in (0, 1), \; f_0 > 0. \tag{2}$$

The market for final goods is centralized and Walrasian. A producer can sell final goods in the market without transactions cost, and money is not needed for such transactions. This formulation helps us focusing instead on the need for liquidity in the market for innovation goods.[12] We will directly invoke the result that a household's consumption of final goods is equal to the quantity produced in a symmetric equilibrium. That is, $q = q(h, a)$.

The market for innovation goods, referred to as the innovation market, is decentralized. Individuals in the innovation market are randomly matched in pairs. In any given match, the first agent can make use of the innovation good produced by the second agent with probability $\sigma \in (0, 1)$; with the same probability, the second agent can make use of the innovation good produced by the first agent. No double-coincidence occurs. Let us label the agent who can use the other agent's innovation good as the buyer, and the other agent as the seller. The buyer makes a take-it-or-leave-it offer to the seller which consists of an amount of money to be paid by the buyer and a quantity y of the innovation good to be produced by the seller.

To capture the demand for and supply of liquidity in the innovation market, we make two additional assumptions on this market. First, at any given time, many people can have good ideas but they may not have enough liquid funds to finance the development of their ideas. More precisely, we assume that agents are anonymous and no form of record-keeping is feasible in the innovation market. For transactions to take place in this market, a medium of exchange is needed. This medium is fiat money, a perfectly storable object which is intrinsically worthless. Second, good ideas and the ability to use good ideas do not always arise easily, and so there is heterogeneity in the need for liquidity. More precisely, we assume that only a fraction e of a household's potential innovators can enter the innovation market in any given period and that a potential innovator realizes whether he can enter the market after he is given money.[13] As a result, those who cannot enter the innovation market have "idle" money which they would like to lend to earn interest, and those who can enter the market demand more liquidity and are willing to pay for it.

[12] In an early version of this paper, we explored the alternative assumption that the market for final goods is characterized as random, bilateral matches. In that formulation, inflation generates a welfare effect similar to that in the current formulation, but much smaller growth effect than in the current formulation.

[13] Rocheteau and Wright (2005) and Berentsen et al (2008) have used similar assumptions to model the liquidity demand and supply in the market for final goods.

Borrowing and lending is done through financial intermediaries that have free entry into the financial sector. We assume that financial intermediaries have no ability to keep records on transactions in the innovation market. This assumption prevents banks from issuing credit that supersedes money or directly intermediating the trade in the innovation market. However, banks are able to keep financial records on monetary loans and repayments, at a cost. So, borrowing/lending is in terms of money. If a buyer fails to repay a loan, the bank can confiscate money holdings of the buyer's household, which ensures that loans are always repaid. Banks take the deposit rate as given and compete in the loan market. Depositors have perfect information about the banks' financial state and trading histories, which induces the banks to always repay the depositors.[14]

The production function in the financial sector is such that labor input required to create and administer loans is proportional to the number of loans.[15] Since only a fraction e of the potential innovators can enter the innovation market, the number of loans is eL, where L is the aggregate measure of innovators per household. The aggregate measure of workers in the financial sector per household is K. Thus, the technology of financial intermediation requires:

$$eL = \phi K, \tag{3}$$

where $\phi > 0$ is a constant measuring financial productivity. We refer to the case $\phi \to \infty$ as a perfect loan market, i.e., one in which financial intermediation requires no resources.

Financial intermediaries take the loan rate, r_ℓ, the deposit rate, r_d, and the nominal wage rate, w, as given. There is no strategic interaction among financial intermediaries or between financial intermediaries and agents. In particular, there is no bargaining over the terms of the loan contract. Instead, these terms will be determined by free entry of intermediaries, which drives each financial intermediary's profit to zero.

For clarity, let us describe the sequence of events in a period as follows. First, at the beginning of the period, each household chooses the allocation of the members into the four groups, and divides its holdings of money among the innovators. Second, the innovators leave the household. Each innovator learns whether he can enter the innovation

[14] Our assumptions of perfect monitoring by the banks on the borrowers and by the depositors on the banks simplify the analysis and enable us to focus on growth. For a relaxation of this assumption, see Berentsen et al (2007).

[15] We can generalize this specification by adding a component of the labor requirement for financial intermediation that is proportional to the real stock of loans. However, the part of the cost that is independent of the size of the loan is important for the results.

market and decides whether to borrow from or lend to financial intermediaries. Third, after borrowing and lending, innovators are matched randomly and bilaterally, and they trade. Simultaneously, in the final-goods market, the producers produce and sell the final goods, and also purchase final goods for the household's consumption. Fourth, the members bring money and purchased goods back to the household. The household consumes the final goods and uses the innovation goods purchased from other households as the input in the innovation process to increase future productivity. Before the period ends, the household repays the loans, receives interest payments on deposit, and receives a lump-sum monetary transfer from the government.

Like many models of endogenous growth (e.g., Lucas, 1988), our model generates long-run growth through the non-diminishing marginal productivity of a in the innovation process. In particular, the law of motion and the production function $q(h, a)$ are both linear in a. The allocation of time between different sectors is an important dimension along which inflation affects economic activities in our model. The new feature of the model is decentralized exchange in the innovation market. This feature generates the demand for liquidity and the need for financial intermediation. It is an important channel through which inflation affects the resource allocation and growth.

2.1 The social planner's allocation

To provide a benchmark against which to measure the efficiency of the equilibrium, let us first consider the allocation of a social planner. Assume that the social planner can dictate all quantities, but is subject to the same matching frictions in the innovation process as the market is. The social planner does not need a credit market, and so $k = 0$. Denote the planner's allocation as $S = \{l, h, q, y\}$, where l the fraction of potential innovators, h the fraction of agents who produce final goods, $(1 - l - h)$ the fraction of agents who enjoy leisure, q the quantity of final goods produced and consumed by a household, and y the amount of innovation goods produced in each bilateral match. Denote the maximized social welfare function as $W(a)$. Then, the planner's allocation solves:

$$W(a) = \max_{S} \{u [q (h, a)] + \theta(1 - h) - \theta l [\rho + \sigma ec(y)] + \beta W(a_{+1})\}$$

subject to the following constraints:

$$a_{+1} = a[1 + f(i)] \tag{4}$$

$$i = \sigma e l y. \tag{5}$$

The first term in the welfare function is a household's total utility from consumption and leisure, where we have substituted the result that the quantity of final goods consumed is equal to the quantity produced. The difference between the second term and the third term is total utility of leisure in the household, where el is the fraction of agents who are innovators and σ is the probability that each innovator has a match in which the innovator produces. The law of motion of productivity is given by (4). The amount of input in the innovation process is given by (5), because σel is the fraction of agents who purchased innovation goods from other households and each purchased an amount y.

Denote the solution to the above problem by adding the superscript s to the variables. Define a balanced growth path of the social optimum as such that the growth rate of a is constant while the levels of (h, l, y) are constant. With the functional forms in (2), We can establish the following proposition (the proof of which is straightforward and, hence, omitted):

Proposition 1 *There exists a unique balanced growth path of the social optimum, which is the solution to (5), and the following equations:*

$$\eta / h^s = \theta \tag{6}$$

$$\rho = (\alpha - 1)\, \sigma e c(y^s) \tag{7}$$

$$R\left[1 + f\left(i^s\right)\right] = \frac{f'\left(i^s\right)}{\theta c'(y^s)} \tag{8}$$

The socially efficient rate of growth is:

$$g^s = 1 + f\left(i^s\right). \tag{9}$$

Equations (6) and (7) come from the first-order conditions of h and l, respectively; they say that the marginal cost of allocating an agent to produce the final good or the innovation good must be equal to the marginal utility of leisure. Equation (8) results from combining the envelope condition of a along the balanced growth path and the first-order condition of y.

3 Equilibrium and the Balanced Growth Path

3.1 The representative household's decisions

At the beginning of a period, the household chooses the division of the members into potential innovators, l, producers of final goods, h, financial intermediaries, k, and members who enjoy leisure, $1-l-k-h$. It allocates money evenly among the potential innovators, each getting m/l units of money. The household also chooses the quantity of final goods to be produced and purchased, q, and the offer that a buyer in the innovation market will make in a match. The offer consists of the amount of money to be given to the seller in the match, x, and the quantity of the innovation good to be asked from the seller, y. After leaving the household, potential innovators face the probability e of being able to enter the innovation market. Those who can enter may borrow money from the financial intermediary, and let b_ℓ be the nominal amount of borrowing. Those who cannot enter the market may lend money to the financial intermediary, and let b_d be the nominal amount of lending. Moreover, the household chooses future holdings of money, m_{+1}, and the future productivity, a_{+1}. The decision variables of the household are then:

$$z \equiv [q, l, k, h, x, y, b_\ell, b_d, m_{+1}, a_{+1}] .$$

Let m denote a representative household's holdings of money at the beginning of a period. The household's value function is $V(a, m)$. Define:

$$\omega \equiv \beta \frac{\partial V(a_{+1}, m_{+1})}{\partial m_{+1}} \quad \text{and} \quad \lambda \equiv \beta \frac{\partial V(a_{+1}, m_{+1})}{\partial a_{+1}}.$$

The variable ω is the shadow value of money next period and λ the shadow value of future productivity, both of which are discounted to the current period.

The representative household's problem is to choose z to solve the following problem:

$$V(a, m) = \max_z \{u[q(h, a)] + \theta(1-k-h) - \theta l [\rho + \sigma e c(Y)] + \beta V(a_{+1}, m_{+1})\}$$

subject to the following constraints:

$$
\begin{aligned}
b_d &\le \frac{m}{l}, & (10)\\
x &\le \frac{m}{l} + b_\ell, & (11)\\
\Omega x &\ge \theta c(y), & (12)\\
a_{+1} &= a + af(i), & (13)\\
m_{+1} - m &= \sigma el(X - x) + l[(1-e) b_d r_d - e b_\ell r_\ell] + wk + T. & (14)
\end{aligned}
$$

where $i = \sigma ely$. In the objective function, the first term is the utility of consuming final goods, where we have again used the result that $q = q(h, a)$. The difference between the second and the third terms in the objective function is the utility of leisure. As explained before, the household takes as given the quantity of production of the innovation goods, Y, because it is determined by other households' buyers who make a take-or-leave-it offer.

According to (10), a depositor cannot deposit more money than the amount he is given by the household. The next two conditions, (11) and (12), are the constraints on the offer that will be made by a buyer of the household in the innovation market. The constraint (11) specifies that such a buyer cannot offer more money than his money balance, which consists of the amount given by the household, m/l, and the amount borrowed, b_ℓ. The constraint (12) says that the offer must induce the seller to trade; that is, the value of the money received by the seller, Ωx, must be at least as high as the disutility of producing the proposed quantity y.[16]

The law of motion of productivity is (13), where the inputs are the amount of innovation goods that the household's buyers obtain from trade, $i = \sigma ely$. The law of motion of the household's money balance is (14). The term $\sigma el(X - x)$ is net money receipts from trading in the innovation goods market, since a fraction σe of potential innovators spend an amount x to buy innovation goods and a fraction σe of them receive an amount X when selling innovation goods. The term $l[eb_d r_d - (1-e) b_\ell r_\ell]$ is net money receipts from borrowing and lending since a fraction e of potential innovators borrow money and a fraction $1 - e$ of them deposit money, where r_d is the deposit rate and r_ℓ the loan rate. Finally, the household receives wage payments for workers in the financial sector, wk, and

[16] Note that it is the household that chooses the offer (x, y), taking into account all the constraints (i.e., (11) and (12)) that a buyer will face in a match. A buyer simply implements this offer. Thus, there is no need to specify a separate bargaining problem for each buyer.

lump-sum monetary transfers from the government, T.

We will examine an equilibrium in which the deposit rate is positive, i.e., $r_d > 0$. In this case, a lender will deposit all his money balance in the financial intermediary, and so (10) holds as equality. Moreover, if the loan rate is positive, a borrower will never borrow more than what he will need in a trade. As a result, a buyer in the innovation market will offer his entire money balance in a trade; that is, (11) holds as equality. The other constraint on the offer, (12), also holds as equality because it is not optimal for a buyer to leave a positive surplus to the seller under the assumption of take-it-or-leave-it offers. Since (10) through (12) all hold as equality, we can use them to solve for (x, b_ℓ, b_d). Substituting the solutions into the objective function and the other constraints, we can derive the following optimal conditions of (y, k, h, l) and the envelope conditions of (a, m):

(i) The optimal choice of the amount of innovation goods to be asked in a match, y:

$$\sigma\lambda a f'(i) = (\sigma + r_\ell)\,\theta c'(y) \tag{15}$$

This condition equates the marginal benefit of a unit of innovation good to the marginal cost. When the household instructs an innovator to ask the seller to produce an additional unit of innovation good, the household will obtain the additional unit with probability σ, because only with probability σ does an innovator have a match in which he is the buyer. The additional unit of innovation good increases the household's productivity next period by $af'(i)$, whose value is $\lambda af'(i)$ in terms of utility. Thus, the expected marginal benefit of asking for a higher y is $\sigma\lambda af'(i)$. In order to induce a seller to produce an additional unit of innovation good, a buyer needs to offer $\theta c'(y)/\Omega$ units of money. Carrying this additional amount of money has two costs. First, an innovator needs to borrow the additional amount of money, regardless of whether the innovator will be matched. The unit cost of borrowing is the loan rate r_ℓ. Second, once matched as a buyer (which occurs with probability σ), the innovator needs to pay the additional amount of money to the seller. In terms of utility, the marginal cost of increasing y is $\omega\theta(\sigma + r_\ell)c'(y)/\Omega$, which becomes the right-hand side of (15) in a symmetric equilibrium where $\Omega = \omega$.

(ii) Optimal choices of the number of financial intermediaries, k, and final-goods producers, h:

$$\omega w = \frac{\eta}{h} = \theta. \tag{16}$$

The terms ωw is the value of wages (in terms of utility) earned by a financial intermediary, and the term η/h is the marginal value of consumption goods produced by an additional producer. The above condition requires that the marginal benefit of increasing k or h should be equal to the marginal utility of leisure, which is θ.

(iii) Optimal choice of the number of innovators, l:

$$\lambda a f'(i)\, \sigma e y = \theta\left[\rho + (r_\ell + \sigma)\, ec(y)\right] \tag{17}$$

Allocating an additional member to be a potential innovator has the following benefits and costs. First, he has probability e to be able to enter the innovation market. Second, once in the market, he has probability σ to be a buyer, in which case he obtains an amount y of innovation goods which will increase the household's productivity next period by $af'(i)\, y$. Thus, the expected benefit of an innovator in the market is given by the left-hand side of (17). Third, with probability σ, the innovator in the market will be a seller in which case he incurs the time $c(Y)$ to produce the innovation good. Note that the value of money paid by a buyer cancels with the value of money obtained by a seller, because $X = x$ in a symmetric equilibrium. Since an innovator will become a borrower with probability e, the expected cost of borrowing incurred by an innovator is $e\omega r_\ell x$, which is equal to the second term on the right-hand side of (17) after substituting $x = \theta c(y)/\Omega$ and $\Omega = \omega$.[17] Finally, an innovator foregoes the value of leisure, which is $\theta\rho$.

(iv) The envelope conditions for a and m:

$$\frac{\lambda_{-1}}{\beta} = \lambda\left[1 + f(i)\right] + \frac{1}{a} \tag{18}$$

$$\frac{\omega_{-1}}{\beta} = \omega + \omega\left[(1-e)\, r_d + e r_\ell\right]. \tag{19}$$

These conditions state that the current value of an asset (a or m) is equal to the future value of the asset plus the additional value of the asset in the current exchange. According to (18), a marginal unit of productivity results in $[1 + f(i)]$ units of future productivity, the value of which is $\lambda\,[1 + f(i)]$. In addition, a marginal unit of productivity saves production cost of final goods, whose value in terms of utility is $u'(q)h^{\eta} = 1/a$. Similarly, in (19), an additional unit of money (in the hands of an innovator) allows the innovator to earn the deposit rate when the innovator cannot enter the innovation market, and to save the cost of borrowing when the innovator can enter the innovation market.

[17] Increasing l also reduces the amount of money each innovator has. However, the negative effect of this reduction cancels with the positive effect generated by the presence of more innovators.

3.2 Symmetric Equilibrium and the Balanced Growth Path

There is free entry of financial intermediaries. Let B_ℓ be the economy-wide average of the amount of borrowing per borrower and B_d the economy-wide average of the amount of lending per lender. Since a household has a measure eL of borrowers and a measure $(1-e)\,L$ of depositors, the aggregate amount of loans and deposits per household is LeB_ℓ and $L\,(1-e)\,B_d$, respectively. Since a financial intermediary hires a measure K of workers and pays the nominal wage w, the nominal cost of financial intermediation is wK. The intermediary covers this cost with a spread between the loan rate, r_ℓ, and the deposit rate, r_d. Therefore, the intermediary's profit is

$$L\,[r_\ell eB_\ell - r_d\,(1-e)\,B_d] - wK.$$

With free entry of intermediaries, the above profit is zero, and so

$$r_\ell eB_\ell - r_d\,(1-e)\,B_d = wK/L. \tag{20}$$

We focus on the monetary equilibrium which is symmetric in the sense that the decisions are the same for all households. Also, as stated earlier, we focus on the equilibrium where the deposit rate and the loan rate are both positive. Throughout this paper, monetary policy is such that monetary transfer maintains the gross rate of money growth at a constant level $\gamma \geq \beta$.

With the above focus, a *monetary equilibrium* consists of the representative household's decisions, z, other household's decisions, Z, and interest rates, $r_d > 0$ and $r_\ell > 0$, which meet the following requirements: (i) z solves the representative household's maximization problem above; (ii) the decisions are symmetric across households: $z = Z$; and (iii) the final-goods market clears and each financial intermediary makes zero profit.

We have already used the market clearing condition for final goods: $q = q(h, a)$. Note that, since the value of money in terms of utility is ω, the nominal price of final goods is:

$$p = \frac{u'(q)}{\omega} = \frac{1}{\omega q}. \tag{21}$$

Also, the intermediation technology, (3), implies that $K = eL/\phi$.

A *balanced growth path* is defined as an equilibrium in which productivity, a, grows at a constant gross rate g, and interest rates are non-negative and finite constants (i.e., $0 \leq r_d \leq r_\ell < \infty$). It is clear from (13) that

$$g = 1 + f\,(i)\,. \tag{22}$$

Lemma 1 *The balanced growth path has the following properties: (i) l, k and h are constants in $(0,1)$; (ii) q grows at rate g; (iii) the marginal value of money, ω, decreases at rate γ; and (iv) the marginal value of productivity, λ, falls at rate g. Moreover, interest rates, r_d and r_ℓ, satisfy:*

$$\frac{\gamma}{\beta} - 1 = er_\ell + (1-e) r_d \tag{23}$$

$$\phi\rho(r_\ell - r_d)(1-e) = e(\alpha - 1)(r_\ell + \sigma) \tag{24}$$

On the equilibrium balanced growth path, $\{h, y, l, k\}$ are determined by:

$$\theta = \frac{\eta}{h} \tag{25}$$

$$1 = \phi(1-e)c(y)(r_\ell - r_d) \tag{26}$$

$$R[1 + f(i)] = \frac{\chi f(i)}{\alpha\theta(\sigma + r_\ell)elc(y)} \tag{27}$$

$$\phi k = el \tag{28}$$

The proof of this Lemma (which is omitted here) involves straightforward manipulations of the equilibrium conditions derived earlier. Equation (23) comes from (19), which is the envelope condition of money holdings. Equation (24) comes from the first-order condition for l, (17). Equation (25) comes from the first-order condition of h stated in (16). Equation (26) comes from the zero-profit condition of intermediation, (20). Finally, (27) is derived from the envelope condition of a, (18), and (28) replicates the production function of the financial sector.

4 Quantitative Analysis

In this section we calibrate the model to quantify the welfare and growth effects of inflation and an improvement in the productivity of financial intermediation.

4.1 Calibration

The functions $u(q)$, $c(y)$, $q(h,a)$ and $f(i)$ have the forms in (2).[18] The parameters to be identified are as follows: (i) preference parameters: $(\beta, \theta, \rho, c_0, \alpha)$; (ii) technology parameters: $(\eta, f_0, \chi, \sigma, \phi, e)$; (iii) policy parameters: the money growth rate γ. To identify these

[18] Note that a slightly more general form of $q(h,a)$ is $q(h,a) = ah_0h^\eta$, where $h_0 > 0$. We set the scale parameter h_0 to one because it affects only the initial level of a which is irrelevant for what follows. In particular, a change in h_0 does not affect any of the ratios in the model as R&D expenditure over GDP or *priv*.

parameters, we calibrate the behavior of the equilibrium balanced growth path to the corresponding average statistics of low-inflation countries and, in particular, to the US data. The use of the balanced growth path in the calibration is reasonable, because low-inflation countries are typically developed countries. Table 4 lists the identification restrictions and the identified values of the parameters.

In the calibration, the inflation rate and per capita growth rate match the ones of the average low-inflation country (see Table 2). For the return on R&D investments we use a survey article by Nadiri (1993). In this article, Nadiri examined 63 studies and concluded that R&D activity renders, on average, a 20-to-30 percent annual return on private (industrial) investments. Since our R&D to GDP ratio also includes government spending on R&D we set the annual return to 20 percent for the baseline calibration. We also experiment with lower values in the robustness section.

In the empirical literature, various measures of bank spreads are used as proxies for the theoretical concept of the cost of financial intermediation (Brock and Rojas-Suarez, 2000). According to Brock and Rojas-Suarez, the most common empirical measure of bank spreads in panel data analysis is the net interest margin (nim). It is calculated by dividing the difference between interest income earned and interest income paid by total assets. The model equivalent of the net interest margin is the interest rate wedge, $r_\ell - r_d$. For the calibration we use the average net interest margin among low-inflation countries, nimlow $= 0.03$, the average net interest margin among medium-inflation countries, nimmid $= 0.035$, and the average net interest margin among high-inflation countries as targets, nimhigh $= 0.059$.[19]

As in King and Rebelo (1993), 20% of the total time is allocated to working which consists of producing final goods, producing innovation goods, and working for financial intermediaries. According to a report on occupational employment and wages by the Bureau of Labor Statistics (BLS, 2006), the fraction of loan officers to total employment in May 2005 was 0.0025.[20] According to the occupational employment statistics survey (OES: Table 788), the individuals employed in science and engineering occupations is 5.5% of the total workforce in May 2007. According to the report "Factbook 2008: Economic, Envi-

[19] To calculate the net interest wedge we use the data in Beck et al (2001).

[20] According to this report, in May 2005, 332690 people were working as loan officers and total employment in the economy was 130307850. The implied ratio 0.0025 is similar to the number 0.0028 used by Dotsey and Ireland (1996).

ronmental and Social Statistics" published by the Organization for Economic Cooperation and Development (OECD), the average of R&D expenditure as percentage of GDP for 1981-2006 for the US is 2.62%. Finally, a labor share of 0.64 is standard.

Table 4: Calibration and parameter values

parameters	values	identification restrictions
β	0.8899	return on R&D investments = 0.2
γ	0.0875	nimlow = 0.03
σ	0.0274	inflation rate = 0.056
α	1.1312	nimmid = 0.035
η	0.64	labor share = 0.64
ρ	0.0078	nimhigh = 0.059
c_0	1	set to 1
e	0.7345	working time/total time = 0.2
ϕ	580.127	loan officers / employment = 0.0025
θ	3.3952	R&D employment/total employment = 0.055
χ	0.36	R&D expenditure to GDP ratio = 0.0262
f_0	0.0423	per capita growth rate = 0.030

Table 5 compares the model's predictions on inflation, the growth rate, the size of the financial sector (FS) and the interest margin with the data. For low-inflation countries, the model's predictions on these variables are identical to those in the data because they are used as the targets in the calibration. We also set inflation rates of mid-inflation and high-inflation countries to match the data. In addition, we use data on interest margins for the three groups of countries. When inflation increases from low to high levels, the growth rate falls in the model as well as in the data, although in the data it falls more sharply. Similarly, the size of the financial sector falls in the model, but not as sharply as in the data.

Table 5: Calibration

	Inflation		Growth		Size of FS		Margin	
	Data	Model	Data	Model	Data	Model	Data	Model
Low	0.056	0.056	0.030	0.0300	1.00	1.00	0.030	0.030
Middle	0.093	0.093	0.019	0.0285	0.57	0.86	0.035	0.034
High	0.306	0.306	0.014	0.0230	0.37	0.46	0.059	0.060

4.2 Welfare analysis

We now quantify the cost of inflation and the benefit of an exogenous improvement in financial productivity. Denote the net rate of inflation as π. We focus on the balanced growth path.

Following the literature (e.g. Lucas, 2000, and Lagos and Wright, 2005), we measure the welfare cost of inflation at π relative to π' by asking how much consumption (in percentage) agents would be willing to give up in order to change inflation from π to π'. Similarly, we measure the welfare benefit of an exogenous improvement in financial productivity from ϕ to ϕ' by asking how much consumption (in percentage) agents would be willing to give up for the improvement. To express these measures formally, let π be any given inflation rate, ϕ any level of financial productivity, and Δ any fraction. Slightly abusing an earlier notation, we write the household's expected discounted utility under (π, Δ, ϕ) as:

$$V(\pi, \Delta, \phi) = \sum_{t=1}^{\infty} \beta^{t-1} \left\{ \ln(q\Delta) + \theta(1-k-h) - \theta l \left[\rho + \sigma ec(y)\right] \right\}$$

where the quantities (y, q, l, k, h) take their values on the equilibrium balanced growth path where $\Delta = 1$. Note that q is not stationary on the balanced growth path; rather, it grows at the gross rate g. Expressing $q_t = q_1 g^{t-1}$, we can rewrite the expected utility as

$$V(\pi, \Delta, \phi) = \frac{1}{1-\beta} \left[\ln(\Delta q_1) + \frac{\beta}{1-\beta} \ln(g) + \theta(1-k-h) - \theta l \left[\rho + \sigma ec(y)\right] \right]$$

For any fixed ϕ, the welfare cost of inflation at π relative to π' is the value of $(1-\Delta)$ that solves $V(\pi', \Delta, \phi) = V(\pi, 1, \phi)$. Similarly, for any fixed π, the welfare benefit of improving the exogenous component of financial productivity from ϕ to ϕ' is the value of $(1-\Delta)$ that solves $V(\pi, \Delta, \phi') = V(\pi, 1, \phi)$.

4.3 The growth and welfare effects of inflation

Consider the three groups of countries that differ in the inflation rate, i.e., the countries with low inflation (5.6%), medium inflation (9.3%), and high inflation (30.6%). For each of these groups, Table 6 reports the key variables on the balanced-growth path and compares this equilibrium to the equilibrium with zero inflation. Also, Table 6 reports the gains in welfare and the growth rate from moving to zero inflation.

As Table 6 shows, the quantity of innovation goods traded and the time spent in innovation both decrease significantly after an increase in inflation. As a result, the growth rate is decreasing in inflation, and this negative effect of inflation on growth is large. For the average medium-inflation country, reducing its inflation from the average (9.3%) to zero increases the long-run growth rate by 0.448 percentage points. For the average high-inflation country, reducing its average inflation to zero increases the long-run growth rate by 0.998 percentage points. These effects of inflation on growth fall into the range of empirical estimates obtained from cross-country studies (see the references in the Introduction). They are much larger than the growth effects of inflation found in the literature. In Gomme (1993) and Dotsey and Ireland (1996), for example, reducing inflation to zero in a similar experiment increases growth by only 0.05 percentage points, about one ninth of the growth effect obtained in our model.

Table 6: Effects of inflation in baseline model

	inflation			
	0%	5.6%	9.3%	30.6%
time innovating	0.01385	0.011	0.0097	0.00594
time in finance	0.00055	0.0005	0.00047	0.00038
time working	0.20289	0.2	0.19868	0.19482
net interest margin	0.024	0.03005	0.03417	0.05963
bank credit (priv ratio)	1.31009	1	0.85916	0.45785
innovation goods	1.1796	1	0.91187	0.62398
R&D / GDP	0.03432	0.0262	0.02251	0.012
growth loss (% pts)	0	0.29467	0.44756	0.99827
welfare loss (% of c)	0	1.42088	2.2121	5.31638

Higher rates of inflation also affect the financial market considerably. Table 6 shows that the size of the financial market relative to the economy decreases significantly with inflation, as indicated by the large reduction in the ratio of loans to GDP (i.e., the priv ratio). For the medium-inflation country, the ratio of loans to GDP is only 86% of the ratio for the low-inflation country, and for the high-inflation country this ratio is 46% of the ratio for the low-inflation country.

Inflation has large welfare effects. Even for the average low-inflation country, reducing inflation from the historical mean (5.6%) to zero increases consumption by 1.42%. For the medium-inflation country, the welfare gain from reducing inflation from the historical mean (9.3%) to zero is 2.21% of consumption. For the high-inflation country, the corresponding welfare gain is 5.32% of consumption. These welfare effects are considerably larger than the ones obtained in the literature (e.g., Dotsey and Ireland, 1996), partly because inflation has a larger negative effect on growth in our model than in the literature.

4.4 Decomposing the welfare and growth effects

In this subsection, we investigate how the distortions of inflation on various margins of the labor input in innovation contribute to the large welfare and growth effects of inflation reported in Table 6. We examine, in turn, the roles of the fraction of agents allocated to the innovation sector, l, and the quantity of innovation goods traded in a match, y. In both cases, we fix the variable under examination at the value calibrated under the low rate of inflation, and then change inflation from one level to another. Because the baseline model is calibrated to the statistics of the average low-inflation country, this experiment does not require recalibration of the model.

Table 7: Effects of inflation when l is fixed

	inflation			
	0%	5.6%	9.3%	30.6%
time innovating	0.01267	0.011	0.0102	0.0077
time in finance	0.0005	0.0005	0.0005	0.0005
time working	0.20167	0.2	0.1992	0.1967
net interest margin	0.02389	0.03005	0.03424	0.06
bank credit (ratio)	1.20366	1	0.9019	0.59033
innovation goods	1.18381	1	0.91063	0.62148
R&D / GDP	0.03154	0.0262	0.02363	0.01547
growth loss (% pts)	0	0.19033	0.29093	0.66743
welfare loss (% of c)	0	0.98789	1.53563	3.72252

First, let us examine whether the choice of the number of potential innovators, is important for the effects of inflation. For this purpose, we fix l at the baseline level and compute the effects of inflations which are reported in Table 7. Note that fixing l fixes only the extensive margin of the time input in innovation; the intensive margin is the amount of time each seller in the innovation market puts into production, which is $c(y)$ and can vary with the choice of y. Under the fixed l, the fraction of total working time is less elastic with respect to inflation than in the baseline model. Also, the reduction in the quantity of innovation goods traded in a match is only slightly higher than the reduction displayed by the baseline model. However, both the growth effect and the welfare effect are significantly smaller than those in the baseline case. From Tables 6 and 7, we infer that the endogenous response to inflation by the extensive margin of the labor input in innovation contributes to about 30% of the growth effect of inflation as well as the welfare effect of inflation. Note that even with the fixed l, growth and welfare effects of inflation are still much larger here than those reported in the literature.

Next, we fix the intensive margin of the labor input in innovation at the baseline level, which is equivalent to fixing the quantity of innovation goods traded in a match, y. Again, we compute the effects of inflation which are reported in Table 8. Under the fixed y, an increase in inflation reduces the time in innovation and the time in financial intermediation more significantly than in the baseline model. As a result, the negative effect of inflation on the growth rate is about 12% larger than in the baseline model. However, the negative effect of inflation on welfare is almost the same as that in the baseline model. The reason is that as total labor supply falls by more than in the baseline model, leisure increases by more than in the baseline model, which mitigates the negative welfare effect of inflation caused by the reduced growth rate. Thus, we infer that the endogenous response to inflation by the intensive margin of the labor input in innovation contributes moderately to the negative growth effect of inflation but very slightly to the welfare cost of inflation.

Table 8: Effects of inflation when y is fixed

	inflation			
	0%	5.6%	9.3%	30.6%
time innovating	0.01468	0.011	0.00936	0.00481
time in finance	0.00067	0.0005	0.00043	0.00022
time working	0.20384	0.2	0.19828	0.19352
net interest margin	0.02405	0.03005	0.03415	0.0595
bank credit (ratio)	1.32247	1	0.85425	0.44358
innovation goods	1	1	1	1
R&D / GDP	0.03465	0.0262	0.02238	0.001162
growth loss (% pts)	0	0.33266	0.50413	1.11336
welfare loss (% of c)	0	1.40872	2.21882	5.49087

4.5 Exogenous development in financial intermediary

In this subsection, we analyze how financial development affects growth and welfare. Levine et al (2000) find that an increase in the exogenous component of financial intermediary development increases growth significantly. We use the parameter ϕ in the intermediation technology to capture such an exogenous component of financial development.

Table 9 displays the effects of decreasing ϕ to $\phi/2$ for the average low-inflation country and the average high-inflation country. First, for each country type, lower efficiency in the financial sector increases the amount of working time in financial intermediation by a roughly 100%. As the cost of financial intermediation increases, the loan-deposit spread increases by roughly 100%, and bank credit decreases. Second, the time spent in innovation and leisure both decrease. Third, the amount of innovation goods traded in a match decreases. As a result of these changes, net growth rate decreases. However, because the decrease in the innovation time is very small, growth losses from the financial improvement are one order of magnitude smaller than the growth losses from inflation reported in Table 6. Welfare losses from this experiment are also much smaller to the ones reported in Table 6. Finally, note that at productivity $\phi/2$ the average low-inflation country has about the same interest rate margin as the average high-inflation country with productivity ϕ. This is another indication that financial development is much less important for welfare and growth than inflation. On the basis of this result, we suggest that a monetary institution that keeps inflation rate low should be the policy focus in development economics.

Table 9: Effects of financial productivity

	$\pi = 5.6\%$		$\pi = 30.6\%$	
	ϕ	$\phi/2$	ϕ	$\phi/2$
time innovating	0.011	0.01072	0.00594	0.0058
time in finance	0.0005	0.00099	0.00038	0.00076
time working	0.2	0.20021	0.19482	0.19506
net interest margin	0.03005	0.06109	0.05963	0.12095
bank credit (priv)	1	0.96823	0.45785	0.44291
innovation goods	1	0.98152	0.62398	0.61217
R&D / GDP	0.0262	0.02537	0.012	0.0116
growth loss (% pts)	0	0.03157	0	0.02473
welfare loss (% of c)	0	0.33153	0	0.28536

5 Robustness

We perform several robustness checks. First, we introduce a role of money in the final-goods market to show that the quantitative effects of inflation do not change much with this additional role of money. Second, we eliminate from our data set all countries that experienced hyperinflation between 1960-1995 and recalibrate the model. Third, we reduce the return on R&D investment from 20% to 15% in the calibration. Fourth, we use the relative *priv* ratios between different groups of countries instead of the relative net interest rate margins in the calibration. For each robustness check we recalibrate the model and perform the same counterfactual experiments as in the text.[21]

5.1 The model with cash-in-advance in the consumption-goods market

Let us assume that purchases of final (consumption) goods are subject to a cash-in-advance constraint.[22] As in the baseline model, we assume that the household needs to send only

[21] The parameter values resulting from the recalibration are available by request.

[22] Instead of using this shortcut to model the role of money in the final goods market, we have also introduced matching frictions and decentralized trades to generate a demand for money. In such an

one buyer and one seller to the consumption-goods market. In contrast to the baseline model, the household must choose the division of money between the innovators going to the innovation market and the buyer going to the final-goods market. Let m_i denote the total amount of money that the household allocates to the innovators. Then, the cash-in-advance constraint in the final-goods market is:

$$m - m_i \geqslant pq$$

With this additional constraint, the first-order condition for q is modified as

$$\frac{1}{q\omega p} = \frac{\gamma}{\beta}$$

Using the market clearing condition for consumption goods, the first-order condition for h becomes

$$\theta = \frac{\eta}{h}\frac{\beta}{\gamma}$$

None of the other first-order conditions is affected. However, the envelope condition for a after some manipulations changes to

$$Rg = \frac{(\beta/\gamma)\, f\chi}{\theta\alpha\,(\sigma + r_\ell)\, elc\,(y)}$$

Table 10 presents the simulation results for the model with a cash-in-advance constraint in the final-goods market.[23] A comparison with Table 6 shows that time allocation is more sensitive when money is required to buy final goods. The amount of innovation goods traded in each match is also more sensitive. Therefore, adding a cash-in-advance constraint in the final-goods market increases the negative growth effect of inflation. It also increases the negative welfare effect of inflation, since inflation reduces households' consumption not only through its effect on the growth rate but also through the cash-in-advance constraint. In terms of magnitude, however, the numbers reported in Table 10 are not substantially different from those in Table 6. Relative to the baseline case, the negative growth effect of inflation is 10% higher and the welfare cost of inflation is 15% higher.

alternative model and with the assumption that the buyer in a match makes a take-it-or-leave-it offer, the quantitative results are similar to the ones reported here.

[23] In order to create the simulation results presented in Table 10, we recalibrate the model for the same targets.

Table 10: Effects of inflation with CIA in final-goods market

	inflation			
	0%	5.6%	9.3%	30.6%
time innovating	0.01414	0.011	0.00957	0.00545
time in finance	0.00056	0.0005	0.00047	0.00035
time working	0.20563	0.2	0.19701	0.18488
net interest margin	0.02401	0.03005	0.03417	0.05961
bank credit (priv ratio)	1.32075	1	0.85463	0.44286
innovation goods	1.17966	1	0.91178	0.62344
R&D / GDP	0.0346	0.0262	0.02239	0.0116
growth loss (% pts)	0	0.3236	0.49215	1.10361
welfare loss (% of c)	0	1.63533	2.55427	6.26127

5.2 Eliminating hyperinflation countries

In this section we eliminate all countries that have experienced hyperinflation or very high inflation (episodes of inflation higher than 400% per year) within the sample period. The eliminated countries are: Argentina, Bolivia, Brazil, Chile, Israel and Peru. We regroup the resulting 57 countries in three groups of 19 countries whose average inflation rates are: 5.4%, 8.8% and 16.9%, respectively. We then recalibrate the model and perform the same simulation experiments as before. The simulation results are displayed in Table 11. In this version, growth effects are substantially larger than in the baseline model. An inflation equal to 30.6% yields a growth loss equal to 2.45 percentage points compared to 0% inflation, which is considerably higher than the loss presented in Table 6 (equal to 1 percentage point).

Table 11: Effects of inflation with different data sample

	inflation			
	0%	5.4%	8.8%	16.9%
time innovating	0.01602	0.011	0.00899	0.006
time in finance	0.00063	0.0005	0.00044	0.00034
time working	0.20515	0.2	0.19793	0.19484
net interest margin	0.02458	0.03081	0.03493	0.04536
bank credit (priv ratio)	1.50977	1	0.79678	0.36942
innovation goods	1.19636	1	0.90687	0.74396
R&D / GDP	0.03956	0.0262	0.02088	0.01312
growth loss (% pts)	0	0.83661	1.21551	1.84755
welfare loss (% of c)	0	4.70826	6.86527	10.4924

The key to understand the larger growth effects of inflation is the relative size of the financial sector (priv). For the average medium inflation country, the relative size in the basline calibration is 0.85916 vs 0.79678 in Table 11. For the average high inflation country, the relative size is 0.45785 vs 0.36942. In order to match our interest rate margin targets the model response to inflation has to be much more elastic which it achieves by making the size of the financial sector responding more elastic to inflation. Note that this comparison underestimates the change in the size of the financial sector because in the baseline model the size of the financial sector at 16.9% inflation is approximately 0.75 vs 0.36942 in Table 11.

5.3 Reducing the R&D return to 15%

In Table 12 we present simulation results when the model is recalibrated to match a R&D return of 15%, instead of 20% used in the baseline model. Since we use the average low-inflation country as the target in the calibration, such a country's main equilibrium variables do not change when the R&D return is lowered. For medium-inflation and high-inflation countries, the household puts more time in each of the three market activities and produces a higher amount of innovation goods than in the baseline model. The negative growth effect of inflation is only a third, and the negative welfare effect of inflation is less than a half, of that in the baseline model. However, these growth and welfare effects are still large relative to the literature.

Table 12: Effects of inflation with smaller return on R&D

	inflation			
	0%	5.6%	9.3%	30.6%
time innovating	0.01302	0.011	0.01005	0.00711
time in finance	0.00052	0.0005	0.00049	0.00046
time working	0.20204	0.2	0.19904	0.19607
net interest margin	0.02394	0.03005	0.0342	0.05963
change in bank credit (priv)	1.2351	1	0.88904	0.5483
innovation goods	1.1709	1	0.91624	0.64106
R&D / GDP	0.03236	0.0262	0.02329	0.01437
growth loss (% pts)	0	0.09282	0.14306	0.33956
welfare loss (% of c)	0	0.54959	0.8942	2.49574

5.4 Change in bank credit as target

In the calibration of the baseline model, we used the differences between the net interest rate margin in a medium- (high-)inflation country and a low-inflation country. Let us now replace these targets with the differences in bank credit (*priv*) between a medium- (high-)inflation country and a low-inflation country. This alternative calibration implies lower efficiency in financial intermediation than in the baseline calibration. As a result, a household has to spend more time in financial intermediation to obtain liquidity and less time in innovation and production. The economy produces a lower amount of innovation goods and the ratio of R&D to GDP is lower. Not surprisingly, inflation has larger negative effects on growth and welfare than in the baseline model. The magnitude of this difference is noteworthy. For each of the three groups of countries, the growth effect of reducing inflation to 0 is twice as large as in the baseline model; so is the welfare effect. In this sense, the baseline calibration gives conservative estimates of the growth and welfare effects of inflation.

Table 13: Effects of inflation with change in *priv* as target

	inflation			
	0%	5.6%	9.3%	30.6%
time innovating	0.01549	0.011	0.0091	0.0043
time in finance	0.00061	0.0005	0.00045	0.00029
time working	0.2046	0.2	0.19805	0.19309
net interest margin	0.02371	0.03005	0.03445	0.06217
change in bank credit (priv)	1.46515	1	0.80486	0.32669
innovation goods	1.20385	1	0.90086	0.58683
R&D / GDP	0.03839	0.0262	0.02109	0.00856
growth loss (% pts)	0	0.65226	0.96657	1.94699
welfare loss (% of c)	0	3.58511	5.36344	11.0861

6 Conclusion

In this paper, we integrated a microfounded model of money and finance into a model of endogenous growth to examine the effects of inflation and financial development. A novel feature of the model is that the market for innovation goods is decentralized, which requires the use of money. Financial intermediaries arise endogenously to provide liquid funds to the innovation sector. After calibrating the model, we found that inflation has large effects on both welfare and the long-run growth rate of per capita income. For example, reducing inflation from 10% to zero increases the annual growth rate by one percentage point, and the representative household in the economy is willing to give up five percent of permanent consumption for eliminating such inflation. We also found that an exogenous improvement in the efficiency of the financial sector also increases the growth rate and welfare, although such effects are much smaller than those of reducing inflation. Moreover, a sizable fraction of the welfare and growth effects of inflation comes from the endogenous response to inflation by the extensive margin of labor input in innovation as opposed to the intensive margin. Our results suggest that the need for liquidity and finance in the innovation sector is an important and, perhaps, the most important reason why reducing inflation and increasing the efficiency of the financial sector matter for long-run growth. It is time to shift research from the traditional focus in macro-finance on consumption loans to the study of the frictions that induce the need for liquidity and finance in the innovation market.

Appendix

The calibration procedure

Using the targets listed in Table 4, the following procedure identifies the model's parameters:

1) We set the model's net real growth rate, $g-1$, to be equal to the average per capita real growth rate among low-inflation countries. This yields g^*.

2) We calibrate the growth rate of the money supply as $\gamma^* = (1+\mu)g^*$, where μ is the average net inflation rate among low-inflation countries.[24]

3) We set the deposit rate equal to $r_d^* = 0.2$.

4) The average net interest rate margin among low-inflation countries, $nim = 0.03$, is then used to calculate the loan rate $r_\ell^* = r_d^* + nim$.

5) From (23), we use r_d^*, r_ℓ^*, and γ^* to get β^* as a function of e:

$$\beta^*(e) = \frac{\gamma^*}{er_\ell^* + (1-e)\, r_d^*}$$

The real interest rate is then $R^*(e) = (1-\beta^*(e))/\beta^*(e)$.

6) We then determine the allocation of time between goods production, innovation and working in the financial sector by using three targets: the fraction of total working time in total available time, 20%, the fraction of scientists and engineers in total employment, 5.5%, and the fraction of people working as loan officers in total employment, 0.0025. Working time in the financial sector is $k^* = 0.0025 * 0.2 = 0.0005$. Working time of scientists and engineers is $s^* = 0.055 * 0.2 = 0.0011$. Accordingly, the time worked in the goods sector is $h^* = 0.2 - k^* - s^*$.

7) We set the labor share equal to $\eta^* = 0.64$.

8) From the first-order condition for h, (25), we get $\theta^* = \eta^*/h^*$.

9) We define $\psi \equiv elc(y)$ and use the zero profit condition, (20), to write ψ as a function of e:

$$\psi^*(e) = k^*/\left[(1-e)\left(r_\ell^* - r_d^*\right)\right]$$

10) The average of R&D expenditure as percentage of GDP for 1981-2006 for the US is 2.62%. We set the ratio of nominal R&D expenditure to nominal GDP equal to its target

[24] Our calibration implies a money growth rate of 7.6%. For comparison, the US growth rate of $M0$ was 7.2% between 1960-1995, and the growth rates of $M1$ and $M2$ were 5% and 7%, respectively.

to get $\sigma^*(e)$:

$$0.0262 = \frac{\sigma}{\sigma + (1-e)(r_\ell^* - r_d^*) + 1/[\psi^*(e) * \theta^*]}$$

11) We then rewrite (27) as follows:

$$R^* g^* = \frac{\chi(g^*-1)}{\alpha^*(e)\,\theta^*[\sigma^*(e) + r_\ell^*]\,\psi^*(e)}$$

This equation yields $\chi^*(e)$ as a function of e.

12) We then rewrite (24) as follows

$$l^*\rho^*(e) = \psi^*(e)^*(\alpha-1)[r_\ell^* + \sigma^*(e)]. \tag{29}$$

In the model, time worked by scientists and engineers is $\sigma e l^* c(y^*) + \rho l^* = \sigma\psi + \rho l^*$. We set this equal to s^* to get:

$$\sigma^*(e)\,\psi^*(e) + \rho l^* = s^*$$

Use this equation to substitute ρl in (29) to get

$$s^* - \sigma^*(e)\,\psi^*(e) = \psi^*(e)^*(\alpha-1)[r_\ell^* + \sigma^*(e)].$$

This equation yields α^* as a function e, denoted $\alpha^*(e)$.

13) We normalize the time worked for producing innovation goods to 1, i.e., $c(y^*) = 1$. Then, from the definition of ψ, we can identify $l^*(e)$:

$$l^*(e) = \psi^*(e)/[ec(y^*)]$$

14) Given $l^*(e)$, we can identify $\rho^*(e)$:

$$\sigma^*(e)\,\psi^*(e) + \rho l^*(e) = s^*$$

15) From the production function of loans (28) we get productivity ϕ^* as a function of e:

$$\phi^*(e) = el^*(e)/k^*$$

We are left with two parameters to identify: c_0 and f_0.

16) We write the growth equation (22) as follows

$$g^* - 1 = f_0\{\sigma^*(e)\,el^*(e)\,y[\alpha^*(e), c_0]\}^{\chi^*(e)} \tag{30}$$

We rewrite it using the time spent for producing innovation goods $c(y) = c_0 y^{\alpha}$ to get

$$g^* - 1 = \tilde{f}_0 \left\{ \sigma^*(e)\, el^*(e) \left[c(y^*) \right]^{1/\alpha} \right\}^{\chi^*(e)}$$

where $\tilde{f}_0 \equiv f_0 c_0^{\frac{\alpha^*(e)}{\chi^*(e)}}$. This equation yields yields $\tilde{f}_0^*(e)$ as a function of e.

17) We use two equations: the time spent in producing innovation goods is $c(y^*) = c_0 (y^*)^{\alpha^*(e)}$, and the production function of innovation implies $\tilde{f}_0^*(e) = f_0 c_0^{\frac{\alpha^*(e)}{\chi^*(e)}}$. We can normalize either c_0 or y^*. Normalizing y^* yields a value of c_0 from the first equation and then a value of f_0 from the second equation. Since the values of c_0 and f_0 do not affect any of the values for the calibrated parameters derived in steps 1 - 15, the choice of y is irrelevant for the calibration. Along the same line, normalizing c_0 yields a value of y^* from the first equation and then a value of f_0 from the second equation. Again, these values do not affect any of the previous values of the calibrated parameters. We choose to normalize $c_0^* = 1$ which yields $y^* = 1$. With this normalization, we get $f_0^*(e) = \tilde{f}_0^*(e)$ as a function of e.

Finally, we are left with the task to identify e. For the baseline calibration, we use *nim* (see Table 1). As a robustness check we also use the change in *priv* as explained below.

Baseline calibration For the baseline calibration, we use the net interest rate margin, *nim*, to identify e as follows. We construct a grid for the parameter e. For each grid point, all parameters of the model are now determined and, therefore, we can simulate the model for different rates of inflation. We do this to calculate the model's *nim* for two inflation rates. Using the average inflation rate among medium-inflation countries we calculate $nimmid(e)$, and for the average inflation rate among high-inflation countries, we calculate $nimhigh(e)$ for each grid point. From Table 1, the average *nim* among medium-inflation countries is 0.035, and among high-inflation countries it is 0.059. We then choose the value of e that minimizes

$$\left[nimmid(e)/0.035 - 1 \right]^2 + \left[nimhigh(e)/0.059 - 1 \right]^2.$$

Alternative calibration For the alternative calibration we use *priv* to identify e as follows. In the model, *priv* satisfies

$$priv = \frac{1-e}{\sigma + (1-e)(r_\ell - r_d) + 1/\left[elc(y)\,\theta\right]}$$

We construct a grid for the parameter e. For each grid point, all parameters of the model are now determined and, therefore, we can simulate the model for different rates of inflation. We do this to calculate the model's *priv* for three inflation rates. Using the average inflation rate among low-inflation countries, we calculate $privlow(e)$, using the average inflation rate among medium-inflation countries we calculate $privmid(e)$, and for the average inflation rate among high-inflation countries we calculate $privhigh(e)$. For each grid point we then calculate the following ratios

$$\begin{aligned} privmidratio(e) &= \frac{privmid(e)}{privlow(e)} \text{ and} \\ privhighratio(e) &= \frac{privhigh(e)}{privlow(e)} \end{aligned}$$

From Table 1, the average *priv* among low-inflation countries is 0.48, among medium-inflation countries is 0.28, and among high-inflation countries is 0.18. Accordingly, $privmidratio = 0.57$ and $privhighratio = 0.37$.[25] We then choose the e that minimizes

$$\left[privmidratio(e)/privmidratio - 1\right]^2 + \left[privhighratio(e)/privhighratio - 1\right]^2.$$

[25] We use the measure of the size of the financial sector, *priv*, from Levine, Loayza and Beck (2000). The measure *priv* contains all claims on the private sector of banks that take deposits divided by GDP.

Country allocation

The data displayed in Table 1 contains 63 countries sorted into inflation tertiles. The data on inflation, growth, bank credit and liquid liabilities are based on the data set used by Levine et al (2000) which covers the period 1960-1995. The data on the net interest margin is from Beck, Demirgüç-Kunt and Levine (2001) and covers the period 1980-1995.

The basket of *low-inflation countries* contains the following 21 countries: Australia, Austria, Belgium, Canada, Cyprus, Denmark, France, Germany, Honduras, Japan, Malaysia, Malta, Netherlands, Norway, Panama, Papua New Guinea, Sweden, Switzerland, Taiwan China, Thailand, United States. The basket of *medium inflation countries* contains the following 21 countries: Barbados, El Salvador, Finland, Guatemala, Guyana, Haiti, India, Ireland, Italy, Kenya, Republic of Korea, Mauritius, Nepal, New Zealand, Pakistan, South Africa, Spain, Sri Lanka, Trinidad and Tobago, United Kingdom, Zimbabwe. The basket of *high-inflation countries* contains the following 21 countries: Argentina, Bangladesh, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Ghana, Greece, Israel, Jamaica, Mexico, Paraguay, Peru, Philippines, Portugal, Sierra Leone, Uruguay, Venezuela. Tables A1, A2 and A3 display annual inflation, net growth rate, bank credit, liquid liabilities and net interest margin for each country contained in the basket of low-inflation countries, the basket of medium-inflation countries and the basket of high-inflation countries, respectively.[26]

[26] As in Table 1, "bank credit" is defined as claims on private sector by deposit money banks, as share of GDP; "liquid liabilities" is defined as currency plus demand and interest-bearing liabilities of banks and nonbank financial intermediaries, as share of GDP; "net interest margin" is defined as interest income earned minus interest income paid divided by total assets.

Table A1: Low-inflation countries

	annual inflation (%)	net growth rate of real pc income (%)	bank credit	liquid liabilities	net interest margin
Australia	7.33	1.9751	34.01	51.73	0.0192
Austria	4.56	2.8892	62.30	67.50	0.0186
Belgium	5.28	2.6513	25.39	49.02	0.0233
Canada	5.95	2.3860	35.51	56.50	0.0175
Cyprus	5.33	5.3842	49.54	74.49	0.0665
Denmark	7.13	2.1794	42.13	49.48	0.0489
France	6.92	2.4313	55.36	63.37	0.0351
Germany	3.63	2.4537	71.00	57.46	0.0246
Honduras	7.12	0.5978	16.87	23.04	0.0693
Japan	5.38	4.3048	88.63	125.94	0.0175
Malaysia	3.89	4.1145	35.55	63.74	0.0247
Malta	3.98	6.6528	37.74	143.43	0.0234
Netherlands	4.81	2.2006	52.35	71.41	0.0146
Norway	6.93	3.1825	40.76	54.04	0.0313
Panama	3.79	2.0272	39.13	33.37	0.0204
P. N. Guinea	6.58	1.1204	20.84	31.05	0.0420
Sweden	7.18	1.8881	42.28	53.49	0.0266
Switzerland	3.95	1.4219	119.13	123.41	0.0155
Taiwan China	5.97	6.6247	53.72	66.97	0.0234
Thailand	5.87	4.8767	36.59	47.79	0.0298
United States	5.51	1.7123	58.42	62.12	0.0388

Table A2: Medium-inflation countries

	annual inflation (%)	net growth rate of real pc income (%)	bank credit	liquid liabilities	net interest margin
Barbados	8.72	2.6529	34.92	51.59	0.0334
El Salvador	10.80	-0.6076	22.71	26.94	0.0394
Finland	7.69	2.7985	51.71	45.35	0.0160
Guatemala	9.08	0.9292	11.99	20.22	0.0539
Guyana	10.17	-0.2806	15.12	52.96	0.0441
Haiti	7.89	-0.6579	7.15	22.60	0.0193
India	7.79	1.9152	17.01	32.95	0.0297
Ireland	9.08	3.2545	28.14	54.74	0.0161
Italy	9.57	2.9330	58.13	77.48	0.0360
Kenya	10.16	1.9625	16.95	35.74	0.0728
Rep. of Korea	10.44	7.1569	40.09	41.02	0.0229
Mauritius	9.63	3.0242	24.24	46.87	0.0324
Nepal	8.57	0.7672	6.92	20.27	0.0374
New Zealand	9.23	1.1241	25.44	49.63	0.0251
Pakistan	8.27	2.6982	20.76	38.68	0.0291
South Africa	9.97	0.3920	49.22	51.44	0.0388
Spain	10.41	2.8803	58.37	70.31	0.0376
Sri Lanka	8.55	2.7046	14.60	30.34	0.0509
T. & Tobago	9.55	1.1208	21.56	37.46	0.0368
United Kingdom	8.39	1.9622	45.55	48.63	0.0201
Zimbabwe	10.52	0.8382	12.97	46.92	0.0444

Table A3: High-inflation countries

	annual inflation (%)	net growth rate of real pc income (%)	bank credit	liquid liabilities	net interest margin
Argentina	90.78	0.6176	14.26	18.34	0.0824
Bangladesh	11.57	0.7083	13.69	24.69	0.0071
Bolivia	50.85	0.3551	10.80	16.39	0.0347
Brazil	77.2	2.9301	16.12	19.16	0.1204
Chile	45.47	1.4470	25.44	22.96	0.0453
Colombia	18.24	2.2270	12.51	22.41	0.0637
Costa Rica	13.80	1.6137	18.11	29.38	0.0515
Dominican Rep.	12.11	2.4988	12.09	20.58	0.0633
Ecuador	17.80	2.3881	13.49	20.05	0.0717
Ghana	31.81	-0.9632	5.07	17.58	0.0709
Greece	12.65	3.2241	20.78	53.34	0.0352
Israel	39.53	2.8110	37.41	51.95	0.0330
Jamaica	14.78	0.4178	20.89	36.85	0.0913
Mexico	24.76	1.9739	9.92	25.57	0.0535
Paraguay	12.67	2.3819	10.19	17.62	0.0651
Peru	59.96	0.0602	8.71	18.52	0.0716
Philippines	11.76	1.1587	20.64	27.50	0.0420
Portugal	13.72	3.6473	60.66	78.02	0.0346
Sierra Leone	24.72	-0.3398	5.07	16.83	0.0741
Uruguay	46.12	1.0253	21.20	29.47	0.0556
Venezuela	11.93	-0.8836	19.26	36.84	0.0781

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