Creative Destruction with Credit Inflation*

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Abstract

We model creative destruction as a channel via which credit inflation affects growth. With a demand function for real credit, there is a dynamically consistent revenue-maximizing rate of credit inflation. A higher semi-elasticity of real credit demand with respect to credit inflation yields a lower rate of credit inflation and lower revenue from credit inflation shared by the banks and the entrepreneurs. The revenue to entrepreneurship attracts more resources into R&D, promoting growth. The revenue to banks attracts more labor into intermediaries, decreasing the monopolistic profit of innovations. When the bargaining share of the banks is low, the former effect dominates and credit inflation promotes growth; when it is high, the latter effect dominates and credit inflation retards growth.

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"Only the entrepreneur then, in principle, needs credit; only for industrial development does it play a fundamental part,..." Schumpeter (1911, p. 105)

1 Introduction

One basic issue concerning production is why some countries persistently grow slower than others. For example, EU and US have an annual growth below 3% from 1995 to 2000, while Japan and South Korea have an annual growth above 4% from 1960 to 2000 (Heston, Summers and Aten, 2002). There are numerous theories tackling the basic issue (e.g., Aghion and Howitt, 2006). In this paper, we examine how credit inflation affects creative destruction and thereby long-run growth. That is, credit serves a medium of financing creative destruction, which links the credit/monetary side with the real economy. Our approach, like Jones and Manuelli (1995) and Gomme (1993), complements the static models on the role of money in the economy (e.g., Kiyotaki and Wright, 1989; 1993).

There is a long-standing debate on the effect of inflation on long-run growth. The controversy goes back to Tobin (1965) who argues that inflation is good for long-run growth.[1] In contrast, Sidrauski (1967) and Brock (1974) show that the stock of capital per worker is independent of inflation. Jones and Manuelli (1995) and Gomme (1993) find a significant negative effect of inflation on growth based on endogenous growth models. In contrast, we propose creative destruction (Schumpeter, 1911) as one channel via which inflation may have significant effects on growth. This is important as summarized by Khan and Senhadji (2001): "The negative and significant relationship between inflation and growth, ...does not provide the precise channels through which inflation affects growth — beyond the fact that, because investment and employment are controlled for, the effect is primarily through productivity." Therefore, within the literature between inflation and growth, our approach complements previous channels like capital accumulation (Stockman, 1981[2]) and intertemporal labor supply (Gomme, 1993; Jones and Manuelli, 1994).[3]

Our approach builds on the seminal work of Schumpeter (1911) on creative destruction that explains the long-run productivity growth in capitalist society, which is modeled by Aghion and Howitt (1992). We introduce banks into Aghion and Howitt (1992). To avoid further confusion, we study a pure credit economy as studied by Wicksell (1907). That is, we abstract from fiat money and all transactions are financed by bank credits (see

[1] Tobin argues that higher inflation increases the opportunity cost of holding cash balances, which results in a reallocation of saving from money into capital and thereby an increase in the stock of capital per worker. The empirical literature in the 1960s tries to find the positive effect of inflation on growth.

[2] Stockman (1981) studies a model with a cash-in-advance constraint. He shows that if the constraint applies to consumption, money is super-neutral. If investment purchases are subject to the constraint, there is a negative relation between the growth rate of money supply and the stock of capital per capita.

[3] Jones and Manuelli (1995) and De Gregorio (1993) point out that inflation is a tax on capital in models with cash-in-advance requirements for investment. In an endogenous growth model with a Lucas (1988) type production function for human capital investment, Jones and Manuelli (1995) show that inflation impacts the labor-leisure choice. Resultantly, inflation affects growth if and only if changes in the growth rate of money supply yield an adjustment in the asymptotic level of the labor supply.

Blanchard and Fischer, 1989, ch. 4). The price level would be determined by the nominal quantity of credit over the real output produced. In the pure credit economy, the credit is equivalent to money. Therefore, the credit means of payment is like a pure lump-sum transfer of newly-printed fiat money to the entrepreneurs. Therefore, our analysis holds with credit wholly replaced by fiat money or other forms of "credit". However, as in real society, only banks grant credit to the entrepreneurs. Government and the central bank never issues new money at the disposal of entrepreneurs. Therefore, credit is special because of the institutional feature of capitalist society. This supports the opening quote from Schumpeter. Therefore, we abstract from money. Moreover, unlike in the previous literature in which the source of inflation comes from monetary growth, which is controlled by the central bank, the source of inflation in our model comes from credit expansion, which is realized by the commercial banks.

All innovations are financed by the credit borrowed from the banks. Each bank needs only a fixed amount of labor to operate. There is free entry into the banking services. Creative destruction is achieved if the banks issue credit means of payment to the entrepreneurs to achieve the withdrawal of old uses of resources into new uses. However, the banks have the tendency to issue more credit (as pointed out by Schumpeter, p. 113 and Blanchard and Fischer, 1989, ch. 4). This is because the increase in credit will generate revenue (like seigniorage-revenue, see Blanchard and Fischer, 1989, ch. 4; Cagan, 1956; Obstfeld and Rogoff, 1996, ch. 8) to be shared by the banks and the entrepreneurs. Without a demand function for credit, it is hard to pin down a unique rate of credit inflation (see Blanchard and Fischer, 1989, ch. 4; Schumpeter, p. 115). To set a limit for the banks to create new credit, we borrow from the monetary approach and follow Bacchetta and Wincoop (2006) to get a demand for real credit. Therefore, in a no-bubble equilibrium, higher credit inflation would cause lower demand for real credit, acting as a penalty on the banks to issue more credit. Resultantly, there is an optimal revenue-maximizing rate of credit inflation that is positive, dynamically consistent, and uniquely pinned down by the semi-elasticity of real credit demand with respect to credit inflation.

The banks and the entrepreneurs share the revenue from credit inflation. The revenue to entrepreneurship attracts more resources into R&D, promoting long-run growth. The revenue to banks attracts more banks into intermediaries, which leaves less labor to manufacturing and thereby decreases the monopolistic profit of each innovation. When the bargaining share of the banks is low, the former effect dominates, so credit inflation promotes growth; when it is high, the latter effect dominates, and credit inflation retards growth. That is, credit is not superneutral. The higher the semi-elasticity of credit demand with respect to credit inflation, the lower the rate of credit inflation and the lower the revenue from credit inflation. Therefore, a higher semi-elasticity of credit demand with respect to credit inflation would be good (bad) for growth if the banks have a higher (low) bargaining power. A higher bargaining power of the banks always lowers growth.

Therefore, underlying cross-country differences in primitives such as the semi-elasticity of credit demand with respect to credit inflation and the relative bargaining power of the banks with respect to the entrepreneurs in credit contract would govern the relationship between credit inflation and long-run growth and offer one explanation for the observed substantive country-level growth differentials. Therefore, we have to be careful in taking the numerous cross-country empirical studies on the inflation-growth nexus.[4] Unless the countries have similar underlying primitives, it is groundless to pool the countries together in regressions on the inflation-growth nexus. Moreover, the source of inflation (whether it is monetary inflation or credit inflation) needs consideration.

The rest of the paper proceeds as follows. In section 2, we solve a basic model. Section 3 introduces credit inflation. Section 4 checks two situations. The first is that there is no micro-founded credit demand function and credit inflation depends on the bargaining power of the banks. The second involves inflation generated by the credit issued for consumptive ends. Section 5 concludes.

2 The Benchmark Model

The basic model is based on Aghion and Howitt (1992; 1998, ch. 2), in which we incorporate the demand for real credit. The reason to introduce the demand for real credit is discussed already. The economy is populated by a continuous mass L of individuals with linear intertemporal preferences: $u(c) = \int_0^\infty c_\tau e^{-r\tau} d\tau$, where r is the rate of time preference, which is also equal to the interest rate. Each individual is endowed with one unit of labor. Therefore, L is also equal to the aggregate labor supply. In the economy, the fixed stock of labor has two uses. It can be used in manufacturing, that is, to produce intermediate goods; it can also be used as the only input for the banks.

Aghion and Howitt (1992) abstract from considering the banking system. They, of course, implicitly assume there is a perfect financial system functioning in the background. We explicitly introduce the banking system into their model. Each bank needs only a fixed amount of labor, $\bar{l}$, with $0 < \bar{l} < L$, to operate. This concurs with the agency cost introduced into endogenous models by King and Levine (1993). Aghion and Howitt (1998, ch. 2) criticize that it is trivial to consider the agency cost from a banking sector in endogenous growth models. Nevertheless, we will see that, in section 3 in which credit inflation is considered, explicitly studying the banking sector is non-trivial.

The final output can be either used for consumption or used as research input. As in Aghion and Howitt (1992), it makes no essential difference whether technology progress

[4] Many empirical studies since the 1980s find a negative effect of inflation on growth (e.g., Kormendi and Meguire, 1985; Rubini and Sala-i-Martin, 1992), but there are critics of the findings. For instance, Khan and Senhadji (2001) have identified a threshold effect in the inflation-growth nexus. Barro (1995) finds that there is no relationship between pooled decade averages of growth and inflation in economies with annual inflation below 15%. Bruno and Easterly (1996) find that the results are sensitive and depend on outliers with episodes of high inflation. Fischer (1993) finds that, above the threshold, the negative relationship between growth and inflation is significantly non-linear.

at a steady state requires a constant amount of labor or an ever-increasing amount of the services of high-tech goods. In this paper, we assume the latter, that is, technology progress at a steady state requires an ever-increasing amount of the services of final goods (N_t). Therefore, the sum of consumption C_t and research input N_t is constrained by the amount of final output. To get a demand function for real credit, we follow Bacchetta and Wincoop (2006) to assume that production depends on real credit holding. As in Bacchetta and Wincoop, this avoids making real credit demand a function of consumption as in money-in-utility models. The production function for the final output is

$$C_t + N_t \leqq Y_t = A_t x_t^{\alpha} - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta, \tag{1}$$

where $\eta > 0$; $\widetilde{m}_t$ is real credit holding; x_t is the intermediate good; A_t is the productivity level associated with x_t, and $0 < \alpha < 1$. Each innovation (detailed in section 2.4) is an invention of a better quality of the intermediate good that replaces the old one. The use of the new intermediate good raises the technology parameter, A_t, by the constant factor, $\gamma > 1$ (i.e., $\frac{A_{t+1}}{A_t} = \gamma$). In other words, using the new intermediate good yields a higher level of productivity ($A_{t+1} > A_t$) for the final good producers (the quality ladder).

2.1 The Final Good Sector

Given the production function for the final good in equation (1), the producer in the final good sector takes the price charged by intermediate good firms, p_t, as given, and chooses her demand for the intermediate good, x_t, to maximize her profit. Therefore, we have the demand for the intermediate good: $x_t = \left(\frac{A_t \alpha}{p_t}\right)^{\frac{1}{1-\alpha}}$, which yields a profit for the final goods producer as $\Pi_t = \left(\frac{1}{\alpha} - 1\right) p_t x_t - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. The total final good produced in the economy, denoted by $\widehat{Y}$, is $\widehat{Y} = A_t x_t^{\alpha} - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$.

As stated, we study a pure credit economy following Wicksell (1907). We assume a no-bubble solution as in Bacchetta and Wincoop (2006). The monopolistic profit of final good producer, Π_t, will be distributed to the households. Basically, in the representative agent model, the banks will issue Π_t amount of credit and transfer it to the workers in a lump-sum manner. The mechanism will be described later.

2.2 The Intermediate Goods Sector

As described, some labor will be employed in the banking sector, while the rest is used in producing the intermediate good. The intermediate good sector is also referred to as the manufacturing sector. The technology of the intermediate good sector is that, it can transform one unit of labor into one unit of intermediate good. That is, by employing l_t units of labor, the manufacturing sector can produce x_t units of intermediate good, with $x_t = l_t$. After that, the pricing strategy of the intermediate good producer is as follows.

The intermediate good producer takes as given the demand x_t by the final good sector and the wage rate (W_t), and chooses her price charged on the final good sector, p_t:

$$\underset{P_t}{Max}: \pi_t = p_t x_t - W_t l_t = p_t x_t - W_t x_t$$
$$s.t.\ \ x_t = \left(\frac{A_t \alpha}{p_t}\right)^{\frac{1}{1-\alpha}}$$

Therefore, we have the optimal price mark-up as $\frac{1}{\alpha}$. The optimal price set by the manufacturing sector is $p_t = \frac{1}{\alpha} W_t$, which yields the monopolistic profit for each successful innovation (i.e., for the owner of each new intermediate good) as

$$\pi_t = \left(\frac{1}{\alpha} - 1\right) W_t x_t = A_t \left(\frac{1}{\alpha} - 1\right) \omega_t x_t \tag{2}$$

where $\omega_t = \frac{W_t}{A_t}$ is the productivity-adjusted wage rate. As stated, the intermediate good sector is the manufacturing sector that needs one unit of labor to produce one unit of intermediate good. The intermediate good sector is owned by an entrepreneur, who has to get credit/loan from a bank to get the means of production (i.e., the service of labor) as well as the means of innovation (i.e., the research input). That is, the entrepreneur borrows from the bank to finance the wage bills of their workers, the $W_t l_t$, and the cost of innovation. In so doing, she can produce $x_t = l_t$ units of intermediate good and sell them to the final good sector at price p_t. The monopolistic profit in equation (2) will be used to finance the R&D cost, which will be described in detail in section 2.4.

2.3 The Banking Sector

As argued by Schumpeter (1911), endogenous growth is achieved by creative destruction. Creative destruction needs a change in the relative purchasing power of individuals in favor of the entrepreneurs, which is made possible by the banking sector. As Schumpeter argues: "Credit is essentially the creation of purchasing power for the purpose of transferring it to the entrepreneur, but not simply the transfer of existing purchasing power." If credit — the new purchasing power — is created and placed at the disposal of entrepreneurs, then it will cause the withdrawal of goods and services from previous use into new and better uses, and creative destruction is achieved. Therefore, without a properly functioning banking system, creative destructions will be very hard to achieve. That is why many economists including Schumpeter argued that modern endogenous growth comes hand in hand with the appearance of a banking system. Concerning our model, with credit borrowed from the banks, the entrepreneurs can use the credit that has purchasing power to buy the means of production (the service of labor in our model, see section 2.2) and to finance R&D. Following Schumpeter, we consider the leading case in which there are no note-reserve regulations for the central bank or deposit-reserve regulations for the commercial banks (see Schumpeter, p. 112). The existence of those regulations may weaken our predictions, but we expect the main results to hold.

We assume that the creation of credit is achieved by a single bank (the entry of banks will be studied in section 3). In a mobile labor market, the wage rate of those working in the bank should equal that of those who are employed by the manufacturing sector. Schumpeter (1911, p. 98) cites Fetter: "A bank is 'a business whose income is derived chiefly from lending its promises to pay.'" Therefore, we assume that, by borrowing to finance their innovations, the entrepreneurs have to pay the service of the banks. In this situation, the amount is just the wage bills of the workers in the bank. Therefore, the entrepreneurs' net monopolistic profit would be the monopolistic profit from selling intermediate goods less the wage bills of the workers in the banking sector. Therefore, the adjusted profit of the intermediate good sector will be

$$\widehat{\pi}_t = \left(\frac{1}{\alpha} - 1\right) W_t x_t - W_t \bar{l} = A_t \omega_t \left[\left(\frac{1}{\alpha} - 1\right) x_t - \bar{l}\right]. \tag{3}$$

According to equation (3), the monopolistic profit from each innovation becomes lower comparing to that without the presence of a banking system. This, not against our intuition, is what is going on in the real world. A banking system makes creative destruction possible, but the economy has to cover the cost of financial intermediation.

The essence of capitalist society is detailed in figure 1, which describes our basic model based on Aghion and Howitt (1992). One can see that the capitalist society builds on the trust from credit. That is, in our pure credit economy, credit is acceptable to everybody in the economy. We follow Schumpeter and Wicksell to introduce credit via the banking system, which is like direct search by the entrepreneurs. This differs from the bilateral search in the monetary economics literature (see Kiyotaki and Wright, 1989; 1993) that has identified many fundamental roles of money. Unlike the essentially static models in monetary economics literature, in the pure credit model, credit plays a fundamental part for industrial development as stated in the opening quote of Schumpeter. Aghion and Howitt (1992) and Romer (1990) have shown that entrepreneurial innovations generate long-run growth. However, according to Schumpeter, only with credit can entrepreneurs achieve creative destruction. Therefore, credit helps to achieve the dynamic gains – the sustained long-run growth in per capita real output – in capitalist society. In other words, credit is like money when it can allow entrepreneurs to buy inputs for innovation and production. This function allows the banks to grant credit to the entrepreneurs to let them offer higher wages to workers and researchers, which would cause temporary inflation as discussed in Schumpeter. However, as new innovations are generated and applied to production, higher output will be realized. Then the price level would fall to the previous level. This would be discussed in detail in section 2.7.

[Figure 1 Here]

2.4 R&D

As in Aghion and Howitt (1998, ch. 2), we assume that when the amount N_t (in units of final output) is used in research, the Poisson arrival rate of innovation is λn_t, where $n_t = \frac{N_t}{A_t}$ is the "productivity-adjusted" level of research, and $\lambda > 0$ is a parameter indicating the productivity of the research technology. That is, when the amount of n_t is used in research, innovation arrives randomly with a Poisson arrival rate λn_t. The following argument helps to make the whole pieces come together. The entrepreneurs borrow credits from the bank. Some credits are used in the research sector that will generate new innovations at the disposal of the entrepreneurs. With successful innovations, the entrepreneurs will use the rest of the credit to achieve the withdrawal of stock of labor from existing manufacturing firms that have a lower productivity level A_t. That is, the entrepreneurs with the property rights on the successful innovations would set up manufacturing firms to produce new intermediate goods that embody a higher level of productivity A_{t+1}, given $A_{t+1}/A_{t+1} = \gamma > 1$. The final good firm will only demand the new intermediate good because it is more productive and brings a higher profit for the final good firm (see section 2.1).

As in Aghion and Howitt (1992), the research sector is portrayed as in the patent-race literature that has been surveyed by Tirole (1988) and Reinganum (1989). The amount of final good devoted to research (N_t) is determined by the research-arbitrage condition given in equation (4):

$$A_t = \lambda V_{t+1,} \tag{4}$$

where t is not time but the number of innovations that have occurred so far, A_t is the research cost, and V_{t+1} is the discounted expected payoff to the $(t+1)^{th}$ innovation. The marginal benefit of raising n_t is λV_{t+1}, while the marginal cost is A_t. The reason why the marginal cost is A_t is as follows. To raise the research intensity n_t by one unit, N_t must be raised by A_t units, which costs A_t units of final good.

The value V_{t+1} is determined by the following asset equation:

$$rV_{t+1} = \widehat{\pi}_{t+1} - \lambda n_{t+1} V_{t+1},$$

which yields

$$V_{t+1} = \frac{\widehat{\pi}_{t+1}}{r + \lambda n_{t+1}}. \tag{5}$$

Now combining equations (3), (4), and (5) yields

$$1 = \frac{\lambda \omega_t \gamma \left[\left(\frac{1}{\alpha} - 1 \right) x_t - \bar{l} \right]}{r + \lambda n_{t+1}}. \tag{6}$$

Equation (6) will be combined with labor market clearing condition to pin down the optimal amount of research, n, in the steady state.

2.5 The Labor Market

As already studied, the final good sector's only input is the intermediate good. That is, no labor is used in the final good sector. The research sector is financed by the final good, so labor is not used in research either. All labor is used in either manufacturing or banking. Therefore, we have the labor market clearing condition as

$$x + \bar{l} = L. \tag{7}$$

2.6 The Steady-State Growth Rate

Now it is time for us to rule out the bubble solution to make sure the credit issued by the banks would be accepted by everyone. The existence of credit granted by the banks still depends on people's expectations. If no one would accept the credit, the entrepreneurs would not be able to hire the workers with the borrowed credit from the banks. This is because the workers would not accept the credit as wage because they cannot buy final consumption with the credit if no one accepts credit. We would revert to a commodity economy (see the detailed discussion on bubble in Obstfeld and Rogoff, 1996, ch.8). Throughout this paper, we assume a no-bubble solution as in Bacchetta and Wincoop (2006). In so doing, one can show that the economy would have a steady state in which the consumption, the real credit holding and the final output would grow at the same rate as that of the nominal wage. Moreover, the real credit holding would be a constant fraction of the final output produced (see Blanchard and Fischer, 1989, ch. 4; Obstfeld and Rogoff, 1996, ch.8). In the following we will use the equilibrium conditions.

To get the expression for the average growth rate in the steady state, we plug equation (7) into equation (6):

$$1 = \frac{\lambda\omega\gamma\left[\left(\frac{1}{\alpha} - 1\right)\left(L - \bar{l}\right) - \bar{l}\right]}{r + \lambda n_{t+1}}. \tag{8}$$

Equation (8) pins down the optimal amount of research n in steady state. As shown in Aghion and Howitt (1998, ch. 2), the growth rate of social knowledge is governed by

$$\frac{\dot{A}_t}{A_t} = \lambda n_t \ln \gamma. \tag{9}$$

In a steady state, C_t, N_t, $\widehat{Y}$, real credit holding and nominal wage all grow at the same rate as that of A_t. That is, the steady-state growth rate is $g = \lambda n \ln \gamma$.

2.7 The Price Level in the Steady-State

A fixed amount of labor, $\bar{l}$, is employed by the bank, and the rest $l_t = L - \bar{l}$ is used in manufacturing. Figure 1 helps to illustrate the mechanism. In figure 1, the solid lines are the flows of credit, while the dashed lines represent the flow of real goods and services. As detailed in figure 1, each period the bank grants the credit/loan in the amount of $p_t x_t$ to the entrepreneur who has to repay the bank in the amount of its operating cost, $W_t\bar{l}$. The entrepreneurs use the credit to hire workers at the wage rate W_t. Since the production function of the intermediate good is $x_t = l_t$, the total wage bill is $W_t l_t = W_t x_t$. Given the mark-up pricing in section 2.2 of the intermediate goods firm, we have its sales value $p_t x_t = \frac{1}{\alpha} W_t l_t$. Therefore, the monopolistic profit is $\pi_t = \left(\frac{1}{\alpha} - 1\right) W_t l_t$. After repaying the bank in the amount of $W_t\bar{l}$, the remaining monopolistic profit $\widehat{\pi}_t = \left(\frac{1}{\alpha} - 1\right) W_t l_t - W_t\bar{l}$ would be used in research. That is, the entrepreneurs use this amount to buy the R&D input, which is final good. After consuming the amount of final good, the research lab could generate new innovations that follows the Poisson process as discussed above. Now, the total credit in the economy is still in the amount of $p_t x_t$.

As investigated in section 2.1, the final goods has to buy intermediate good in the amount of $p_t x_t$. Then it produces final output in the amount of $\widehat{Y} = A_t x_t^\alpha - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta = \frac{1}{\alpha} p_t x_t - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. In a no-bubble solution, the real credit holding $(\widetilde{m}_t)$ is a constant fraction (denoted by ϕ) of the final output $\left(\widehat{Y}\right)$ produced. Using $\widetilde{m}_t = \phi\widehat{Y}$ and the constant steady state growth rate of final output $g = \lambda n \ln\gamma$, we can solve for $\widehat{Y} = \frac{1}{\alpha} p_t x_t / \left(1 + \phi\frac{\ln\phi + t\lambda n \ln\gamma - 1}{\eta}\right)$. In cases in which the final goods production does not need the real credit holding, the real final output produced is $\frac{1}{\alpha} p_t x_t$. Here, the real final output produced can be seen as a constant fraction of $\frac{1}{\alpha} p_t x_t$ given that p_t would grow at an exponential rate of g in steady state. Therefore, the real final output here will also grow at the rate of nominal wage, given that $p_t x_t = \frac{1}{\alpha} W_t l_t$. The final goods firm has a profit in the amount of $\Pi_t = \left(\frac{1}{\alpha} - 1\right) p_t x_t - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. As discussed in section 2.1, to simplify discussion, in the representative agent framework, we assume that the bank issues the amount of Π_t credit to the representative worker who would spend the credit together with their wage bills in purchasing final goods for consumption. This mechanism allows the representative workers to own the profit of the final goods producer.

To determine the price level, we study the final goods firm. The order of the final goods firm (or the credit paid to the final goods firm) includes that from the workers in the amount of $W_t\left(l_t + \bar{l}\right) + \Pi_t$ and that from the entrepreneurs (the research input or the demand of the research lab) in the amount of $\widehat{\pi}_t = \left(\frac{1}{\alpha} - 1\right) W_t l_t - W_t\bar{l}$. Given that $p_t x_t = \frac{1}{\alpha} W_t l_t$, the total order/credit received is $W_t l_t + \Pi_t + \left(\frac{1}{\alpha} - 1\right) W_t l_t = \Pi_t + \frac{1}{\alpha} W_t l_t = \frac{1}{\alpha} p_t x_t - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. The last equality uses the definition for Π_t. The final output is $\widehat{Y} = A_t x_t^\alpha - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. Therefore, the price level P_t in the economy is 1 because $\frac{1}{\alpha} p_t x_t = A_t x_t^\alpha$. One can also think this way. The total amount of bank credit in the economy includes the credit granted to the entrepreneurs $(p_t x_t)$ and that transferred to the workers (Π_t). The whole credit is $\frac{1}{\alpha} p_t x_t - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. The final output is $\widehat{Y} = A_t x_t^\alpha - \widetilde{m}_t \left(\ln\left(\widetilde{m}_t\right) - 1\right)/\eta$. Therefore, the price level (P_t) is 1.

In is worthing noting that, each period both the amount of credit granted to the entrepreneurs ($p_t x_t$) and that transferred to the households (Π_t) grow at the rate of the steady state growth. The growth rate of credit supply equals that of the output produced, keeping the price level constant. This is like a Friedman's k-percent rule of credit growth.

3 The Model with Credit Inflation

By studying a pure credit economy with a banking sector, we link the credit/monetary side with the real economy. In so doing, we can model credit inflation and its implication on creative destruction and thereby long-run growth.

3.1 The Demand for Credit

We denote the wealth of workers that includes the wage income and the lump-transfer of credit from the banks as w_t. As in Bacchetta and Wincoop (2006), we assume the wealth yields a nominal return i_t. Therefore, the budget constraint for a worker would be

$$c_{t+1} = (1+i)(w_t - \widetilde{m}_t) + \widetilde{m}_t.$$

Using equation (1), we get the first-order condition for real credit holding:

$$\frac{M_t}{P_t} = \exp(-\eta i_t), \tag{10}$$

where M_t is the nominal demand of credit, which equals the nominal supply of credit in equilibrium.

3.2 The Dynamically Consistent Rate of Credit Inflation

As discussed above, this creative destruction is made possible by the banking sector. However, what amount of credit will the bank create in a laissez-faire economy?

As discussed in Schumpeter (1911, ch. III, p. 115), the unlimited power of the banks to create circulating media has been repeatedly quoted especially when there are no other legal barriers and rules for the gestation of banking business. Since this may not affect the essence of his new theory of credit, Schumpeter has not discussed the limit of the creation of purchasing power by the banks. Moreover, it is not clear whether the legal restrictions and special safety-valves are actually sufficient in practice to prevent all banks from collusively issuing more credit. For simplicity, we study the limit of the creation of purchasing power by the banks when there are no other legal barriers and rules for the gestation of banking business. It important for us to distinguish between consumptive credit issued by the banks and credit means of payment issued by them. Here we focus on the issuing of credit means of payment. The credit inflation from issuing more consumptive credit by the banks is discussed in section 4.2.

The limit of the creation of the credit means of payment will depend on how the profit of the banks changes with the creation of more credits. Suppose the banks overcome coordination problem (which is not very hard given the small number of giant commercial banks in capitalist society) and issue more credit means of payment to entrepreneurs. We assume that the banks and the entrepreneurs share the revenue from the credit inflation according to costless Nash Bargaining, with the share to the banks and the entrepreneurs being β and $(1-\beta)$ respectively. The banks will use the revenue from credit inflation to employ more workers, while the entrepreneurs would use the revenue from credit inflation to conduct more R&D (if it is used in increasing the nominal wage of the workers, it is similar to consumptive credit, which is discussed later). To make things easier to grasp, we refer to figure 2. The difference between figure 1 and figure 2 is that, now the banks issues more credit to the entrepreneurs, shown with thicker solid line in figure 2. The whole amount of credit issued is proportional to final output, as shown later. We assume that the rate of credit inflation is μ, with constant $\mu > 0$ that is endogenously determined. In a no-bubble solution, in steady state we have $(1+\mu) = \frac{M_t}{M_{t-1}} = \frac{P_t}{P_{t-1}}$ (see Obstfeld and Rogoff, 1996, ch. 8). Therefore, the price level will grow at a rate of $(1+\mu)$ as opposed to a constant price level of 1 in the benchmark model without credit inflation.

[Figure 2 Here]

We assume that the banks cannot issue more credit and keep the credit themselves (the case of consumptive credit will be discussed in section 4.2). That is, some credits go to the entrepreneurs. As stated, we assume the banks keep β share of the revenue from credit inflation, and entrepreneurs share $(1-\beta)$ of the revenue from credit inflation. The fact that the banks can share some of the revenue from credit inflation is to give the banks an incentive to issue more credit. Otherwise we end up with the benchmark case. Why would the banks prefer to keep some revenue from credit inflation? This is because we assume that the banks are self-interested and would like to use the revenue from credit inflation to employ workers. Given a demand function for real credit in equation (10), one can study the limit of the creation of credit means of payment, that is, the μ chosen by the banks. One can see that the revenue from credit inflation in period t is like seigniorage revenue (see Cagan, 1956; Obstfeld and Rogoff, 1996, ch. 8) on the whole economy:[5]

$$\text{Revenue from credit inflation in period } t = \frac{M_t - M_{t-1}}{P_t} = \frac{M_t - M_{t-1}}{M_t}\frac{M_t}{P_t}, \tag{11}$$

where M_t stands for the nominal amount of credit in the economy as stated.

Given the fisher equation $(1+i_t) = (1+r)\frac{P_{t+1}}{P_t}$, we have $i_t = r + \mu$. Now real credit

[5] This is not the same as giving subsidies to entrepreneurs. In this type of model, growth could be too much (see Aghion and Howitt, 1998, ch. 2), so there is no justification to subsidize R&D.

holding in equation (10) becomes $\frac{M_t}{P_t} = \exp\left(-\eta\left(r+\mu\right)\right)$. Therefore, we have

$$\text{Revenue from credit inflation in period } t = \frac{\mu}{1+\mu}\exp\left(-\eta\left(r+\mu\right)\right).$$

Maximizing with respect to μ yields the first-order condition

$$\eta\mu^2 + \eta\mu - 1 = 0. \tag{12}$$

This gives two optimal rates of credit inflation: one is positive and the other is negative.

Suppose μ^* is chosen in steady state. That is, μ^* is dynamically consistent. In the steady state, using equation (11), the revenue from credit inflation to the banking sector is equal to

$$\beta\frac{\mu^*}{1+\mu^*}\frac{M_t}{P_t} = \beta\frac{\mu^*}{1+\mu^*}\phi\widehat{Y}, \tag{13}$$

where the last equality uses the fact that, in a no-bubble solution, the real credit holding $\left(\frac{M_t}{P_t}\right)$ is a constant fraction (denoted by ϕ) of the final output $\left(\widehat{Y}\right)$ produced. Although we use the same notation $\widehat{Y}$, the level of technology A_t (and its growth rate) would be different from section 2. Nevertheless, one can see that the revenue from credit inflation is proportional to the real output produced in the economy. In a no-bubble solution, $\widehat{Y}$ woud grow at the rate of g (the steady state growth rate) in steady state. Suppose we begin at time 0 in a dynamically consistent situation. Given the constant rate of time preference r that equals the interest rate, the banks would get a discounted life-time revenue from credit inflation as $\sum_0^\infty \frac{(1+g)^t}{(1+r)^t}\beta\frac{\mu^*}{1+\mu^*}\widehat{y}_0 = \frac{1+r}{r-g}\beta\frac{\mu^*}{1+\mu^*}\widehat{y}_0$, where $\widehat{y}_0$ is a constant.

In a dynamically inconsistent situation, the banks would let μ go to infinity, in which case the banks can get one-period revenue from credit inflation. In the following periods, people would not accept credit and we revert to a commodity economy and growth is terminated. The limit revenue from credit inflation that the banks can get is β share of the total amount of output at period 0, $\beta A_0\left(L-\bar{l}\right)^\alpha$, given equation (7). Therefore, as long as $\frac{1+r}{r-g}\frac{\mu^*}{1+\mu^*}\widehat{y}_0 > A_0\left(L-\bar{l}\right)^\alpha$, the banks would always choose μ^*, which is dynamically consistent in steady state. In the following, we assume this inequality holds. Otherwise we revert to a commodity economy. Therefore, only a positive rate of credit inflation can be dynamically consistent. Therefore, we end up with one rate of credit inflation in the steady state, the positive root to equation (12), denoted by μ^*:

$$\mu^* = \frac{-\eta+\sqrt{\eta^2+4\eta}}{2\eta}, \text{with } \frac{\partial\mu^*}{\partial\eta} < 0. \tag{14}$$

where η is the semi-elasticity of real credit demand with respect to credit inflation. For example, $\eta = 10$ as in Bacchetta and Wincoop (2006), $\mu^* = 9\%$; $\eta = 20$, $\mu^* = 4.8\%$; $\eta = 40$, $\mu^* = 2.4\%$. A larger η will yield a lower rate of credit inflation. This is because a higher η means a larger elasticity of real credit demand with respect to credit inflation, yielding a larger penalty for the banks to issue more credit. Therefore, a lower rate of credit inflation would be optimal.

The existence of a demand function for real credit imposes a limit for the banks in choosing the rate of credit inflation. Without such a micro-founded mechanism, the banks would have unlimited power to create circulating media as pointed out by Schumpeter (1911, ch. III, p. 115): "Just as the state, under certain circumstances, can print notes without any assignable limit, so the banks could do likewise if the state — for it comes to this — were to transfer the right to them in their interest and for their purposes, and common sense did not prevent them from exercising it." That is why Blanchard and Fischer (1989, ch. 4) argue, as long as the bank profits by issuing money, it has the temptation to issue more until infinity that causes money to lose value. As also discussed in the introduction, if not for the particular institutional setup of capitalist society (banking credit is created by banks and granted to the entrepreneurs to achieve creative destruction/long-run growth, while money is created by the government and central bank and is never granted to the entrepreneurs for creative destruction), credit would be the same as money. In our pure credit economy, we can replace credit by money and everything holds. Therefore, it is reasonable for us to assume that there is a real demand for credit. Nevertheless, we will check the results in situation in which there is no such a demand for credit in section 4.1.

As β increases, the banks receive a large share of the revenue from credit inflation. We will consider two cases: the first involves free entry into the banking system; the second assumes that the entry into the banking system is prohibited. The first case is solved in the following section. The case of no free-entry will be discussed in section 3.6.

3.3 Free Entry into the Banking Sector

To follow the setup in section 2.3, we assume that the entrepreneurs repay the credit service of the banking system in the amount of the wage bills of the operating cost of one bank, which is $W_t\bar{l}$. This ensures that when the bank's own revenue from credit inflation is very low, the number of banks is always larger than 1. Now to solve the model, we need to consider one extra condition: the free entry of new banks, besides the research arbitrage condition. Given free entry into the banking sector, the existence of the revenue from credit inflation, given in equation (13), will incentize more banks to enter the banking business. The entry of new banks will stop when the expected profit of each bank equals its fixed set-up cost. This pins down the number of banks in the economy, denoted as m:

$$mW_t\bar{l} = W_t\bar{l} + \beta\phi\frac{\mu^*}{1+\mu^*}\widehat{Y}, \tag{15}$$

where the left-hand-side (LHS) is the set-up cost for all banks, while the right-hand-side (RHS) is the total revenue of the banking system. The LHS is easy to interpret: each new bank has a fixed setup cost, that is, each new bank needs a fixed amount of workers, $\bar{l}$, to operate. Each worker receives a wage rate W_t in the mobile labor market. The RHS can be interpreted as follows. We assume that the banks are symmetric and can coordinate without any cost. Therefore, the whole revenue of the banks should be the same as that of a single giant bank. We assume that the intermediate good sector (the entrepreneur) repays the service of banking that is $W_t\bar{l}$ as in section 2.3. Besides this, the banking system gets part of the revenue from credit inflation, which is the term $\beta\phi\frac{\mu^*}{1+\mu^*}\widehat{Y}$. In the steady state, free entry into the banking system stops whenever equation (15) holds.

As shown in sections 2.6 and 2.7, $\widehat{Y}$ would grow at the rate of nominal wage. Therefore, we define $\frac{\phi\widehat{Y}}{W_t} = \widehat{y}x_t$, where $\widehat{y}$ is a constant (we neglect all second-order effects). The free-entry condition of the banking sector in equation (15) can be simplified as

$$m = 1 + \frac{\beta\mu^*\widehat{y}x_t}{(1+\mu^*)\,\bar{l}}. \tag{16}$$

As in section 2.5, given that all labor is used in either manufacturing or banking and each bank needs a fixed amount of labor, $\bar{l}$, to operate, we have $x + m\bar{l} = L$. This equation combined with equation (16) yields the number of banks as

$$m = \frac{(1+\mu^*)\,\bar{l} + \beta\mu^* L\widehat{y}}{(1+\mu^*)\,\bar{l} + \beta\mu^*\bar{l}\widehat{y}}. \tag{17}$$

Equation (17) states that, the number of the banks (m), which is always larger than 1, positively depends on either β or μ^*. A higher bargaining power of the banks (i.e., a higher β) means the banks keep a larger fraction of the revenue from credit inflation. As the revenue from credit inflation to the banking system becomes higher, more banks will enter the intermediary service. A higher μ^*, which comes from a lower η, means a higher revenue from credit inflation, which would also cause the entry of more banks.

3.4 Research Arbitrage

Since entrepreneurs get $(1-\beta)$ share of the revenue from credit inflation, their profit will be the usual monopolistic profit from innovations plus the extra revenue from credit inflation. The profit of entrepreneurship, considering equation (3), becomes

$$\widehat{\pi}_t = \frac{1-\alpha}{\alpha}W_t x_t - W_t\bar{l} + \frac{(1-\beta)\,\phi\mu^*\widehat{Y}}{1+\mu^*} = A_t\omega_t\left[\frac{1-\alpha}{\alpha}x_t - \bar{l} + \frac{(1-\beta)\,\mu^*\widehat{y}}{1+\mu^*}x_t\right], \tag{18}$$

which says that, the entrepreneurs receive additional revenue from credit inflation, $(1-\beta)\,\frac{\mu^*}{1+\mu^*}\phi\widehat{Y}$, besides the monopolistic profit from a better quality of intermediate goods ($\frac{1-\alpha}{\alpha}W_t x_t$) less the repayment to the banking service ($W_t\bar{l}$). The additional revenue from credit inflation to entrepreneurship would attract more resources into R&D, which is good for growth.

The other opposing effect is reflected in the decreasing of x_t because more labor would be employed by the banking sector (see figure 2). The two opposing effects underpin our story of creative destruction with credit inflation, detailed in section 3.5.

Combining equations (4), (5), and (18) yields the research arbitrage condition:

$$1 = \frac{\lambda\omega\gamma\left[\left(\frac{1}{\alpha}-1\right)\left(L-m\bar{l}\right)-\bar{l}+(1-\beta)\frac{\mu^*}{1+\mu^*}\widehat{y}\left(L-m\bar{l}\right)\right]}{r+\lambda n_{t+1}}. \tag{19}$$

3.5 The Steady-State Growth Rate and Credit Inflation

The steady state growth rate is still governed by equation (9). Using equation (17) to substitute out m in equation (19), we get the steady-state amount of research, n, as a function of β and μ:

$$1 = \frac{\lambda\omega\gamma}{r+\lambda n}\left[\left(\frac{(1-\alpha)(1+\mu^*)+\alpha(1-\beta)\widehat{y}\mu^*}{\alpha(1+\mu^*+\beta\mu^*\widehat{y})}\right)\left(L-\bar{l}\right)-\bar{l}\right] \tag{20}$$

Equation (20) pins down the amount of research n in steady state, which is constant.

Proposition 1 *In the steady state with free-entry into the banking business, the growth rate is an increasing function of μ^* (the rate of credit inflation) if β (the bargaining power of the banks) is less than α; otherwise, the growth rate is a decreasing function of μ^*. Given that μ^* is a decreasing function of η (the semi-elasticity of credit demand with respect to the rate of credit inflation), in the former case, the growth rate is a decreasing function of η, while it is an increasing function of η in the latter case.*

Proof: We have shown that the steady state growth rate is $g = \lambda n \ln\gamma$. Since λ and γ are constant structural parameters, the steady state growth rate is linear in the steady-state amount of research, n. Therefore, the relationship between the steady state growth rate and μ^* will be the same as that between n and μ^*. According to equation (20), taking the derivative of the steady-state amount of research, n, with respect to μ^* yields

$$\frac{\partial n}{\partial\mu^*}\infty\widehat{y}(\alpha-\beta) \tag{21}$$

Therefore, we have

$$\begin{aligned}\frac{\partial n}{\partial\mu^*} &> 0 \text{ if } \alpha>\beta;\\ \frac{\partial n}{\partial\mu^*} &< 0 \text{ if } \alpha<\beta.\end{aligned}$$

Then from equation (14) we have $\frac{\partial n}{\partial\eta}<0$ if $\alpha>\beta$ and $\frac{\partial n}{\partial\eta}>0$ if $\alpha<\beta$. Q.E.D.

The mechanism can be seen from equations (18) and (16). According to equation (14), the optimal rate of credit inflation is independent of the bargaining power of the banks. Therefore, the revenue from credit inflation would be independent of the bargaining power of the banks. An increase in the rate of credit inflation, which is determined by an increase in the semi-elasticity of real credit demand with respect to credit inflation, yields larger revenue from credit inflation. This would have two opposing effects on the steady state growth. On the one hand, β share of the revenue from credit inflation goes to the banks, which would absorb more labor into the banking business. This is given in equation (16). Therefore, fewer workers will be employed in the manufacturing sector, which yields a lower monopolistic profit from innovations to entrepreneurs. This can be seen from equation (18), in which the monopolistic profit of entrepreneurs increases with x, and x is equal to the amount of labor used in manufacturing. On the other hand, $(1 - \beta)$ share of the revenue from credit inflation goes to the entrepreneurs, which increases the return to entrepreneurship and attracts more resources into R&D. This is captured by the last term in equation (18). This effect tends to increase the steady state amount of research n. When β is low, the latter effect dominates because the majority of the revenue from credit inflation goes to the entrepreneurs. Resultantly, the steady state growth rate would increase as the rate of credit inflation increases. In contrast, when β is high, the former effect dominates because the revenue from credit inflation mainly goes to the banks, and growth would be decreasing as the rate of credit inflation goes up. This is intuitive because the credit inflation would tax away some real resources from the economy. When it is used in the banking business that competes for labor services with the entrepreneurs, the growth would be retarded. When it is used in entrepreneurial R&D, more innovations would be forthcoming, which thereby yields higher steady state growth.

Equation (14) delivers $\frac{\partial \mu^*}{\partial \eta} < 0$. That is, in countries with a higher semi-elasticity of credit demand with respect to credit inflation, the optimal rate of credit inflation would be lower. Therefore, two factors determine the steady state growth rate across countries: the semi-elasticity of credit demand with respect to credit inflation (η) and the bargaining power of the banks (β). A higher semi-elasticity of credit demand with respect to credit inflation would be good for growth if the banks have a higher bargaining power. This is because when the banks have a higher bargaining power, a lower rate of credit inflation is good for growth. This is ensured by a larger η, which attaches more penalty on the banks to increase the rate of credit inflation. Similarly, a higher semi-elasticity of credit demand with respect to credit inflation would be bad for growth if the banks have a lower bargaining power. This is because when banks have a lower bargaining power a higher rate of credit inflation is desirable. A higher rate of credit inflation is achieved only when there is a lower semi-elasticity of credit demand with respect to credit inflation. Other cases can be similarly analyzed. Blanchard and Fischer (1989, p. 180) analyzed the role of the elasticity of money demand in the money growth and capital accumulation nexus.

In summary, one can see that, in our model, credit inflation works on growth through the channel of productivity, which confirms the aforementioned conjecture of Khan and Senhadji (2001). This complements previous studies that propose capital accumulation (Stockman, 1981) and intertemporal labor supply (Gomme, 1993; Jones and Manuelli, 1994) as the channels via which inflation may have negative effects on growth. Therefore, cross-country differences in the rate of credit inflation, which is in turn determined by the semi-elasticity of credit demand with respect to credit inflation, help to explain the cross-country differences in growth rates. Moreover, cross-country differences in the banking structure that may affect the bargaining power of the banks (but not the rate of credit inflation in our model here) would also help to explain the cross-country differences in growth rates. This is further shown in the following proposition.

Proposition 2 *In the steady state with free-entry into the banking business, the growth rate is a decreasing function of β (the bargaining power of the banks).*

Proof. This is obvious given equation (20). Observing equation (14), the optimal rate of credit inflation is not a function of β. Therefore, as β increases, the numerator in equation (20) decreases while the denominator increases. Resultantly, the steady state amount of research n increases, so does the steady state growth. Q.E.D.

The mechanism can be seen from equations (19) and (14). Equation (14) shows that the optimal rate of credit inflation is independent of the bargaining power of the banks, so is the revenue from credit inflation. Therefore, a larger share of the revenue from credit inflation goes to the banks would have two effects on the steady state growth, according to equations (19). First, more labor would be absorbed into the banking business. Therefore, fewer workers will be employed in the manufacturing sector, which yields a lower monopolistic profit from innovations to entrepreneurs. This can be seen from equations (3) and (18), in which the monopolistic profit of entrepreneurs increases with x (the amount of labor used in manufacturing). Second, according to equation (18), a larger bargaining power of the banks leaves a lower fraction of the revenue from credit inflation to the entrepreneurs, which tends to decrease the return to entrepreneurship. Therefore, both effects would lower the steady state amount of research n.

3.6 No Free Entry into the Banking Sector

Following the previous sections, we study what will happen if there is no free entry into the banking business. In this case, the labor market clearing condition is $x + \bar{l} = L$. Repeating similar steps yields the equilibrium condition:

$$1 = \frac{\lambda\omega\gamma\left[\left(\frac{1}{\alpha}-1\right)\left(L-\bar{l}\right)-\bar{l}+(1-\beta)\frac{\mu^*\widehat{y}}{1+\mu^*+\beta\mu^*\widehat{y}}\right]}{r+\lambda n_{t+1}}. \tag{22}$$

Equation (22) pins down the optimal amount of research n.

Proposition 3 *In the steady state with no free-entry into the banking business, the growth rate is an increasing function of μ^* (the rate of credit inflation). Given that μ^* is a decreasing function of η (the semi-elasticity of credit demand with respect to the rate of credit inflation), the growth rate is a decreasing function of η. Moreover, the growth rate is a decreasing function of β (the bargaining power of the banks).*

Proof. Now taking the derivative of the steady-state amount of research, n, in equation (22) with respect to μ^* yields $\frac{\partial n}{\partial \mu^*} > 0$. Given $\frac{\partial \mu^*}{\partial \eta} < 0$, we have $\frac{\partial n}{\partial \eta} < 0$. Because μ^* is not a function of β, it is obvious that the growth rate is a decreasing function of β. Q.E.D.

When the free entry into the banking business is not allowed, we actually eliminate the negative effect of credit inflation on growth. When there is free entry into the banking business, the revenue from credit inflation that goes to the banks would absorb more labor into the banking business. As a result, fewer workers will be employed in the manufacturing sector, which yields a lower monopolistic profit from innovations to entrepreneurs. But when the free-entry into the banking business is prohibited, such a effect would not exist. Meanwhile, the revenue from credit inflation that goes to the entrepreneurs would still attract more resources into R&D. Therefore, more innovations would be forthcoming, which thereby yields higher steady state growth. A lower semi-elasticity of credit demand with respect to credit inflation gives rise to a higher optimal rate of credit inflation as well as higher revenue from credit inflation. This would promote steady state growth, as the revenue from credit inflation distributed to the entrepreneurs would also increase.

Although in real economies there are legal restrictions on the entry into the banking business, the share of workers in existing banks may increase over time. Therefore, the prediction in proposition 1 is more likely to hold in the real world.

4 Extensions

In this section, we consider several other situations. The first involves no micro-founded credit demand function. Second, the credit inflation is purely a consumptive one.

In the previous literature, in order to introduce money in the economy, authors, for instance, model money as a medium of exchange (see Kiyotaki and Wright, 1989; 1993) or assume money-in-utility or cash-in-advance constraints (e.g., Sidrauski, 1967). In so doing, one can study the role of money, monetary inflation and other issues in the economy. When we study long-run growth generated by creative destruction, we already make credit essential in the dynamic capitalist society. This has been forcefully argued by Schumpeter (1911). In other words, we do not need a micro-founded credit demand function to introduce credit in the economy. The fundamental role of credit in financing entrepreneurs by creating new purchasing power already makes credit play an essential role in financing the development of capitalist society, as argued by Schumpeter. We introduce a micro-founded credit demand function in the previous sections just to set an upper limit for the banks to create new credit. Do the banks in the capitalist society behave this way in the real world? While we leave this to future studies, here we study what will happen if such a micro-founded credit demand function does not exist.

4.1 No Micro-founded Credit Demand Function

As Blanchard and Fischer (1989, ch. 4) argue, the more interesting and more difficult question is whether banks could try to issue their own fiat media of exchange. Blanchard and Fischer rule out the possibility that banks can issue their own fiat media of exchange by network externality and dynamic inconsistency (as long as the bank profits by issuing money, it has the temptation to issue more until infinity that causes money to lose value). In our pure credit economy following Wicksell (1907), we emphasize that the banks can issue their own "credit" media of exchange or credit means of payment. Otherwise, growth would not be possible as forcefully argued by Schumpeter and shown above. However, as discussed in Schumpeter (1911, ch. III, p. 115), the unlimited power of the banks to create circulating media has been repeatedly quoted, especially when there are no other legal barriers and rules for the gestation of banking business. As stated, whether our previous theory of credit demand is accepted or not, it is desirable to study the case where there is no such demand function for credit. Without a microfoundation for credit demand, in the following we rely on ad hoc assumptions.

4.1.1 The Benchmark Model

Now the final output production function would not depend on real credit demand. In the benchmark model, the existence of a single bank needs a fixed amount of labor to operate. The bank grants the credit/loan in the amount of $p_t x_t$ to the entrepreneur. The entrepreneurs use the credit to hire workers at the wage rate W_t. Total wage bill is $W_t l_t = W_t x_t$. The sales of intermediate good is $p_t x_t = \frac{1}{\alpha} W_t l_t$. This monopolistic profit less the service payment to the bank, $\widehat{\pi}_t = \left(\frac{1}{\alpha} - 1\right) W_t l_t - W_t \bar{l}$, would be used to buy the R&D input. The final goods firm buys intermediate good in the amount of $p_t x_t$. Then it produces final output $A_t x_t^\alpha = \frac{1}{\alpha} p_t x_t$. The final goods firm has a profit in the amount of $\left(\frac{1}{\alpha} - 1\right) p_t x_t$, that is distributed to the households by banks issuing the same amount of credit to the representative worker. The amount of total bank credit in the economy includes the credit granted to the entrepreneurs $(p_t x_t)$ and the lump-sum transfer of credit from the banks to the workers in the amount of $\left(\frac{1}{\alpha} - 1\right) p_t x_t$. The whole credit is $\frac{1}{\alpha} p_t x_t$. The final output is $A_t x_t^\alpha$. Therefore, the price level in the economy is $\frac{\frac{1}{\alpha} p_t x_t}{A_t x_t^\alpha} = 1$.

4.1.2 The Rate of Credit Inflation

As usual, we assume that the banks and the entrepreneurs share the revenue from the credit inflation according to costless Nash Bargaining, with the share to the banks and the entrepreneurs being β and $(1-\beta)$ respectively. We assume that the whole amount of credit issued is proportional to final output (which is $A_t x_t^\alpha$). That is, we assume that the banks, besides the original $A_t x_t^\alpha$ amount of credit, issue an extra $\mu A_t x_t^\alpha$ amount of credit with constant $\mu > 0$. The rate of credit inflation is μ. This is because now the total amount of credit in the economy is $(1+\mu) A_t x_t^\alpha$ and the real output is still $A_t x_t^\alpha$. Therefore, the price level increase to $(1+\mu)$ from the original level of 1. The revenue from credit inflation is also $\mu A_t x_t^\alpha$.

Now let us study the limit of the creation of credit means of payment, that is, the μ chosen by the banks. Suppose μ^* is chosen in steady state. That is, μ^* is dynamically consistent. In steady state, x_t remains constant at x and A_t grows at the rate of g. Given the constant rate of time preference r that equals the interest rate, the banks would get a discounted life-time revenue from credit inflation as $\sum_0^\infty \frac{(1+g)^t}{(1+r)^t}\beta\mu^* A_0 x^\alpha = \frac{1+r}{r-g}\beta\mu^* A_0 x^\alpha > 0$ (the interest rate is larger than the growth rate, which generally holds in endogenous growth models). In a dynamically inconsistent situation, the banks would let μ go to infinity, in which case the banks can get one-period revenue from credit inflation. In the following periods, people would not accept credit and we revert to a commodity economy. The limit revenue from credit inflation that the banks can get is $\beta A_0 x^\alpha$. Therefore, as long as $\frac{1+r}{r-g}\beta\mu^* A_0 x^\alpha > \beta A_0 x^\alpha$, that is, $\mu^* > \frac{r-g}{1+r}$, the banks would always choose μ^*, which is dynamically consistent in steady state.

Any μ with $\frac{r-g}{1+r} < \mu < \infty$ can be supported as a steady state. In contrast, in section 3 there is a demand function for credit. Then higher inflation would cause lower demand for real credit, acting as a penalty for the banks to issue more credit. This yields a revenue-maximizing rate of credit inflation. Here without a demand function for credit, to pin down μ, we ad hocly assume that the amount of credits issued by the banks and thereby the rate of credit inflation positively depend on the banks' bargaining power (share), β: $\frac{\partial\mu}{\partial\beta} > 0$. Therefore, there is a bijective mapping between β and μ. Unlike section 3.2 in which μ is uniquely pinned down by η, here μ is uniquely pinned down by β.

4.1.3 Free Entry into the Banking Sector and the Labor Market

Following the same argument in section 3.3, the free entry condition of the banking system becomes

$$W_t \bar{l} = \frac{\beta\mu A_t x_t^\alpha}{m-1}, \tag{23}$$

which pins down the number of banks (m) in the economy. As discussed, the free-entry condition of the banking sector in equation (15) can be simplified as

$$m = 1 + \frac{\beta\mu l_{t+1}}{\alpha^2 \bar{l}}. \tag{24}$$

Equation (24) states that, the number of banks, m, positively depends on the revenue from credit inflation to the banking sector. The higher bargaining power the banks (i.e., a higher β), the more credits the banks would issue to the entrepreneurs (given $\frac{\partial\mu}{\partial\beta} > 0$). Then the revenue from credit inflation of the banking system will be higher. More banks will enter into the banking business until equation (24) holds.

As in section 2.5, given that all labor is used in either manufacturing or banking, we have $x + m\bar{l} = L$. This equation combined with equation (24) yields the number of banks, which increases with either β or μ, as

$$m = \frac{\alpha^2\bar{l} + \beta\mu L}{\alpha^2\bar{l} + \beta\mu\bar{l}}. \tag{25}$$

4.1.4 Research Arbitrage and Steady-state Growth

Now the profit of entrepreneurs, considering equation (3) and $A_t x_t^\alpha = \frac{1}{\alpha^2} W_t l_t$, will be

$$\widehat{\pi}_t = \frac{1-\alpha}{\alpha} W_t x_t - W_t \bar{l} + (1-\beta)\,\mu A_t x_t^\alpha = A_t \omega_t \left[\frac{1-\alpha}{\alpha} x_t - \bar{l} + \frac{(1-\beta)\,\mu}{\alpha^2} l_{t+1}\right], \tag{26}$$

which says that, the entrepreneurs receive additional revenue from credit inflation, $(1-\beta)\,\mu A_t x_t^\alpha$, besides the usual monopolistic profit from a better quality of intermediate good.

Repeating similar steps yields the research arbitrage condition:

$$1 = \frac{\lambda\omega\gamma\left[\left(\frac{1}{\alpha} - 1\right)\left(L - m\bar{l}\right) - \bar{l} + \frac{(1-\beta)\mu}{\alpha^2}\left(L - m\bar{l}\right)\right]}{r + \lambda n_{t+1}}. \tag{27}$$

The steady state growth rate is still $g = \lambda n \ln\gamma$, which is linear in the amount of research n. Using equation (25) to substitute out m in equation (27), we get the steady-state amount of research, n, as a function of β and μ:

$$1 = \frac{\lambda\omega\gamma}{r + \lambda n}\left[\frac{\alpha(1-\alpha) + (1-\beta)\,\mu}{\alpha^2 + \beta\mu}\left(L - \bar{l}\right) - \bar{l}\right] \tag{28}$$

Proposition 4 *In the steady state with free-entry into the banking business, when the elasticity of μ (credit inflation) with respect to β (the bargaining power of the banks), $\varepsilon_{\mu\beta}$, is positive at $\beta = 0$, the growth rate is inverted-U related to β. The inverted-U shape is skewed to the left with higher $\varepsilon_{\mu\beta}$. Given that μ is monotone in β, the steady-state growth rate is also inverted-U related to μ.*

Proof: First, we have already shown that the relationship between the steady state growth rate and β is the same as that between n and β. According to equation (28), taking the derivative of the steady-state amount of research, n, with respect to β yields

$$\frac{\partial n}{\partial\beta} \propto \frac{\partial\mu}{\partial\beta}\alpha(\alpha - \beta) - \mu(\alpha + \mu) \tag{29}$$

Therefore, we have

$$\frac{\partial n}{\partial \beta}|_{\beta=0} = \frac{\alpha^2 \mu}{\beta}\left[\varepsilon_{\mu\beta}|_{\beta=0} - \frac{(\alpha+\mu)\beta}{\alpha^2}\right] = \frac{\alpha^2\mu}{\beta}\varepsilon_{\mu\beta}|_{\beta=0} \tag{30}$$

$$\frac{\partial n}{\partial \beta}|_{\beta=1} \infty \frac{\partial \mu}{\partial \beta}\alpha(\alpha-1) - \mu(\alpha+\mu) < 0. \tag{31}$$

Therefore, $\frac{\partial n}{\partial \beta}|_{\beta=0} > 0$ as long as $\frac{\partial \mu}{\partial \beta}|_{\beta=0} > \frac{(r-g)[\alpha(1+r)+r-g]}{\alpha^2(1+r)}$. The last inequality uses the fact that as β approaches 0, μ approaches its lower limit, $\frac{r-g}{1+r}$. We denote the elasticity of ϕ with respect to β when $\beta = 0$ as $\varepsilon_{\mu\beta}|_{\beta=0}$. Therefore, as long as $\varepsilon_{\phi\beta}|_{\beta=0}$ is greater than 0, $\frac{\partial n}{\partial \beta}|_{\beta=0} > 0$. Given this condition, n is inverted-U related to β, so is the steady-state growth rate. Observing equation (29), a higher $\varepsilon_{\phi\beta}$ makes the zenith point of the inverted-U shape emerge at a larger value of β (i.e., the inverted-U shape is skewed to the left). Last, given that $\frac{\partial \mu}{\partial \beta} > 0$, that is, μ is monotonically increasing in β, the steady-state growth rate is also inverted-U related to μ, the credit inflation rate. Q.E.D.

The economic mechanism is as follows. An increase in β (the bargaining share of the banks) has two effects on the steady state amount of research n. The first effect, through the term $-\mu(\alpha+\mu)$, tends to decrease n. All else equal, increasing the bargaining share of the banks will, first of all, leaves a lower share to the entrepreneurs. When entrepreneurs receive a lower profit, few resource would be devoted to research. Moreover, a larger share to the banks means the total profit of the banking system will be higher, and more banks will enter into the banking system. As a result, fewer workers will be employed in the manufacturing sector, which yields a lower monopolistic profit from innovations to entrepreneurs. Taken together, the first effect would decrease the steady state amount of research n. The second effect is reflected in the term $\frac{\partial \mu}{\partial \beta}\alpha(\alpha-\beta)$. This effect can be expressed, using $\varepsilon_{\phi\beta}$ to denote the elasticity of μ with respect to β, as $\frac{(\alpha-\beta)\mu}{\alpha\beta}\varepsilon_{\mu\beta}$. If the elasticity is positive, an increase in β incentizes the banks to issue more credits. When β is small, entrepreneurs keep a larger share of the revenue from credit inflation, which increases the return to entrepreneurship. Therefore, more resource will be devoted to research, which pushes up the growth rate. When β is low, this effect dominates the first effect, so growth increases with β (and μ). However, when β is very large, the revenue from credit inflation would not increase much. Moreover, a large chunk of the revenue goes to the banking sector, leaving a small share of the revenue to entrepreneurs. The banks employ more workers, which also decreases the monopolistic profit from innovations. Therefore, same as the first effect, the second effect tends to decrease n when β is very large, hence growth becomes a decreasing function of β.

One can see that, even if our assumption that the elasticity of μ with respect to β, $\varepsilon_{\mu\beta}$, is positive at low values of β does not hold, the model still predicts a negative effect of credit inflation on growth. In this case, the crowding out effect (that is, the banking sector compete for the service of labor) dominates the effect from the revenue from credit inflation. That is, the revenue from credit inflation to the banking sector causes more banks compete for the service of labor, which leaves less labor to manufacturing. The monopolistic profit from innovations will be lower. The decrease in the monopolistic profit from innovations will be larger than the revenue from credit inflation to the entrepreneurs, so growth is a decreasing function of credit inflation.

Our assumption that $\varepsilon_{\mu\beta}$ is positive when β is low can explain this observed positive relationship between growth and inflation when inflation is low (Khan and Senhadji, 2001) and the non-linear negative relationship between growth and inflation when inflation is high (Fischer, 1993; Khan and Senhadji, 2001). In other words, a predicted inverted-U relationship between growth and inflation matches previous empirical evidence. Moreover, proposition 4 offers some insights into the observed different threshold levels of inflation rate in the inflation-growth nexus by Khan and Senhadji (2001): the threshold level of inflation above which inflation significantly slows growth is estimated at 1-3% and 11-12% for industrial and developing countries respectively. Due to less strict legal regulations on the banking business in developing countries, $\varepsilon_{\mu\beta}$ could be larger in developing countries, increasing the threshold level of inflation above which inflation lowers growth.

4.2 Consumptive Credit Inflation

In this section, we first study the case in which there is only one giant bank in the economy (i.e., there is no entry into the banking business). As argued by Schumpeter (1911, ch. III, 114-115), banks could in principle give credits that really serve consumptive ends. If the banks only grant credit for consumptive ends, it is evident that the entrepreneurial activity is terminated in the economy. This is because entrepreneurs would not be able to get the service of labor from existing intermediate good firms. This is of course due to the fact that the banks can prevent the entrepreneurs from doing so. Otherwise, the usual creative destruction still exists. If people totally use the credit for consumptive use, would the bank agree to do so? The answer is yes if the banks can share the revenue from credit inflation with those who are granted the credit. Now, since there is no long-run growth, it boils down to a Cagan (1956) model (see Obstfeld and Rogoff, 1996, ch. 8), with negligible differences. If some people who are granted the credit become entrepreneurs, we will have long-run growth, although it is lower than that in previous sections.

If people use the credit only for consumptive ends, the situation would be even worse when there is free entry into the banking business. More banks would strive for the seigniorage-revenue, generating negative externalities on one another. This would result in hyperinflation. As Obstfeld and Rogoff (1996, p. 525) describe, a question that puzzled Cagan is governments let money growth exceed the rate that maximizes the seigniorage-revenue. If the commercial banks also issue credits purely for consumptive ends, the banks together with the government compete for the seigniorage-revenue. This would also push the government to further increase inflation. A hyperinflation is more likely to occur.

This even helps to understand the recent subprime mortgage crisis. In developed countries, although there are legal restrictions on the operation of banks, they may not be sufficient to prevent the banks from issuing more credits in the boom period either to more risky entrepreneurs or to consumptive uses. As consumptive credit issued by the banks in our model is obviously bad for growth, we are concerned with risky entrepreneurs. First, the banks may even get a larger share of revenue from credit inflation in negotiating with risky entrepreneurs. Second, a larger share of the revenue from credit inflation to the banking sector would cause the entry of more financial intermediaries. The financial intermediaries compete for the service of labor with the manufacturing sector, further decreasing the profitability of entrepreneurial innovations. It becomes less likely the entrepreneurs can succeed in producing commodities at least equal in value to the credit plus interest. Damped investment demand would contribute to the emergence of a liquidity trap that is emphasized by Krugman (2011). A recession is inevitable. This Schumpeterian growth and cycle interlink has been modeled by Francois and Lloyd-Ellis (2003), although with a different mechanism. Since our model is concerned with steady state growth, we leave the further study on the growth and cycle interlink in one general equilibrium framework to future research.

5 Conclusions

In this paper, we prove that productivity (i.e., creative destruction) is an important channel via which credit inflation has significant effects on long-run growth. In so doing, this paper contributes to the literature as follows. First, this paper gives a clear limit to the creation of credit means of payments that is not clearly studied in Schumpeter (1911). This is achieved by introducing a demand for real credit following Bacchetta and Wincoop (2006), which attaches a penalty for the banks to issue more credit. Second, this paper shows that, by affecting the amount of resources devoted to R&D, credit inflation significantly affects long-run growth. When the bargaining share of the banks is low, growth is an increasing function of credit inflation; when it is high, growth is an decreasing function of credit inflation. Moreover, a higher semi-elasticity of credit demand with respect to credit inflation would be good (bad) for growth if the banks have a higher (low) bargaining power. A higher bargaining power of the banks would always lower growth. This helps to explain substantial growth differentials across countries.

The economic mechanism is as follows. We introduce a banking system into Aghion and Howitt (1992). A bank needs a fixed amount of labor to operate. The financing of production and innovation are all through the banks. That is, the banks issue credits that are at the disposal of entrepreneurs to achieve the withdrawal of old uses of labor services into new uses — the creative destruction. However, the banks tend to issue more credits. But with a demand for real credit that attaches a penalty for the banks to issue more credit, there is an optimal revenue-maximizing rate of credit inflation that is positive, dynamically consistent, and pinned down by the semi-elasticity of real credit demand with respect to credit inflation. The higher the semi-elasticity of real credit demand with respect to credit inflation, the lower the rate of credit inflation and the lower the revenue from credit inflation. The banks and the entrepreneurs share the revenue from credit inflation. The revenue to entrepreneurship attracts more resources into R&D, promoting long-run growth. The revenue to banks attracts more banks into intermediaries, which leaves less labor to manufacturing, ending up decreasing the monopolistic profit of each innovation. When the bargaining share of the banks is low, the former effect dominates; when it is high, the latter effect dominates.

We also consider the case in which the banks grant credit for purely consumptive ends, discussed by Schumpeter (1911, 114-115). No creative destruction and thereby no growth will be possible, and hyperinflation is likely to occur. How to regulate the banking system without affecting its role in financing creative destruction needs further research.

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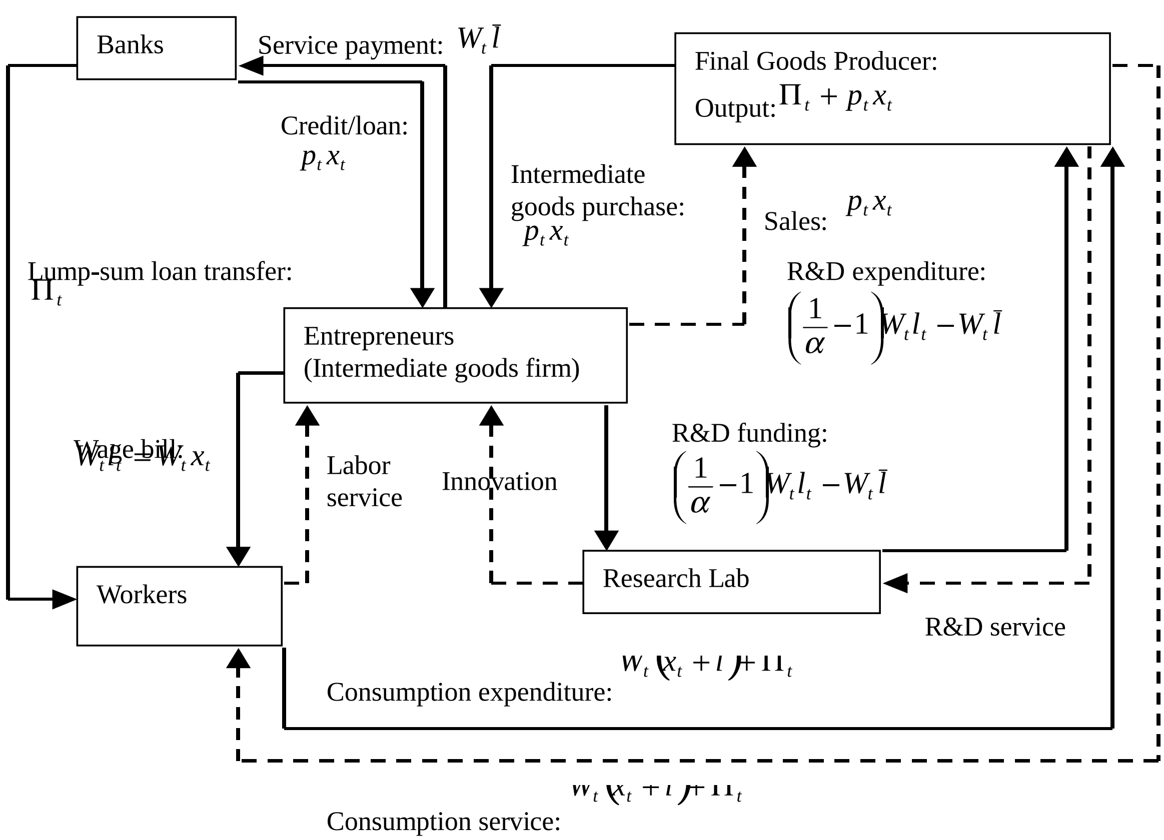

Figure 1. Benchmark Pure Credit Economy without Credit Inflation

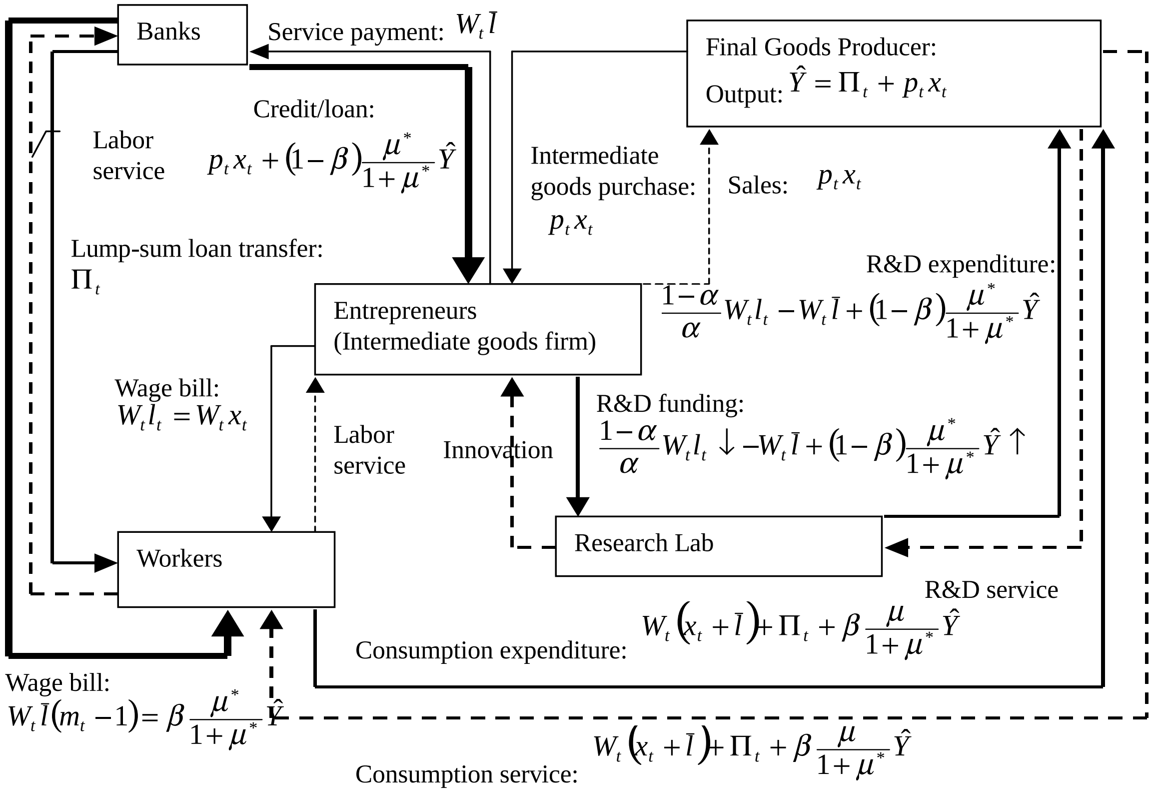

Figure 2. A Pure Credit Economy with Credit Inflation