Creative Destruction with Credit Inflation

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Abstract

In this paper we propose creative destruction as the channel for inflation to impact long-run growth. This is possible because inflation may affect the relative amount of resources allocated to entrepreneurs. The banks can reap revenue from a higher rate of credit growth (like seigniorage revenue), which attracts more labor into banks, decreasing the profit of entrepreneurs and thereby growth. But when the revenue is achieved by issuing more credit to entrepreneurs, part of the revenue goes to entrepreneurs, attracting more resources into R&D and promoting growth. When banks retain a larger share of the revenue, the former effect dominates and credit inflation retards growth. When entrepreneurs get the larger share of the revenue, the latter effect dominates and credit inflation increases growth. When the revenue is achieved by issuing more consumptive credit, growth will be retarded. The welfare implications are also analyzed. Empirical evidence from the U.S. and China is also provided.

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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

A continuing large literature assesses how inflation affects economic growth. Originally authors use a neoclassical setting (e.g., Tobin, 1965; Sidrauski, 1967; Stockman, 1981). Recent studies often use an endogenous growth framework (e.g., Jones and Manuelli, 1995; Ireland, 1994), but the source of growth there is not from deliberate entrepreneurs' innovations as in the new growth models (hereafter NGM) (Romer, 1990; Aghion and Howitt, 1992). In this paper we study how inflation affects growth in the NGM. This alternative approach is important for two reasons. First, how inflation affects creative destruction (the source of long-run growth) has received far less attention. Second, in reality inflation may affect the amount of resources allocated to entrepreneurs. Consequently, creative destruction may be one important channel for inflation to impact long-run growth.

The banking sector in NGM plays a passive role. The growth rate of credit supply equals that of output produced (like a Friedman's k-percent rule), keeping the price level constant – detailed later. In reality, the limit of credit creation by banks is a puzzling issue (Blanchard and Fischer, 1989, ch. 4; Schumpeter, 113-115). Recently authors argue that the credit creation by financial intermediaries contributes to the subprime-mortgage crisis (e.g., Brunnermeier, 2009). Therefore, it is very likely that the banks, for their own rational self-interest, may raise the growth rate of credit supply. This makes it important to study how credit inflation impacts long-run growth via its effect on creative destruction.

While we leave the detailed discussion of the data to Section 4.4, we show that there are large variations in the relative share of resources, either employment or total wages, allocated to the financial sector (see Figures 1 to 4). Figures 1 and 2 illustrate the effects of decreasing federal funds rates of the U.S. during 2001-2003 on the employment share, total compensation share and the relative compensation of the financial sector (i.e., the Finance and Insurance Industries classified by the Bureau of Economic Analysis (BEA)). One can observe that the expansionary monetary policy in the U.S. has initially caused an increase in the share of employees in the financial sector. As the federal funds rate increases since 2003, the share stays roughly constant during 2003-2006. Although the employment share of the financial sector remains constant, its relative compensation, as shown in Figure 2, increases rapidly, ending up with an increasing share of total compensation of the financial sector in all industries. In each year during 2003-2006, an additional 0.5% of total compensation in the U.S. has been absorbed into the financial sector.

[Figures 1 to 4 Here]

As China greatly felt the negative impact of the subprime mortgage crisis in 2008, Premier Wen Jiabao decided to pump 4,000 billion Yuan (the Chinese currency) into the economy starting from 2009. As illustrated in Figure 3, there was a large increase in the growth rate of M2 in 2009. Before 2009, China's M2 growth was relatively stable. Also shown in Figure 3, the employment share of the financial sector increased 0.3 percentage points in 2009 comparing to 2007. The increasing employment share coupled with the increasing relative wage of the financial sector (see Figure 4) caused the continuing increase of the share of total wages of the financial sector in all industries, despite of the adversity brought in by the subprime mortgage crisis. These important real world facts highlight the importance of the mechanism that we try to formalize in our paper – the relative amount of resources allocated to entrepreneurs and thereby creative destruction.

Before we get to the dry details, we present the findings. The banks can reap revenue from a higher rate of credit growth (like seigniorage revenue). When the revenue is achieved by issuing more credit to entrepreneurs, part of the revenue goes to entrepreneurs, attracting more resources into R&D and promoting growth. The remaining revenue to banks attracts more labor into banking business, decreasing the profit of entrepreneurs and thereby growth. When banks retain a larger share of the revenue, the latter effect dominates and credit inflation retards growth. When entrepreneurs get the larger share of the revenue, the former effect dominates and credit inflation increases growth. When the revenue is achieved by issuing more consumptive credit, growth will be retarded. The welfare implications and other results are discussed later.

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).[1] 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 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.

[1] For other ways to build banks and credit into the economy, please see Gertler et al. (2011).

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. Therefore, the role of credit is two-fold. First, it has an intertemporal role of financing entrepreneurs' innovations that determines long-run growth, as highlighted by Schumpeter (1911) in the opening quote. This intertemporal role of credit is similar to that of money in overlapping-generations models (e.g., Samuelson, 1958). The difference is that credit is used to finance entrepreneurs rather than purchase existing goods. Second, as entrepreneurs use the borrowed credit to purchase existing goods (as inputs for innovation and production), the role of credit is the same as that of money in the exchange economy – the medium of exchange – that has been studied in the monetary economics literature (e.g., Kiyotaki and Wright, 1989; 1993). As shown by Schumpeter, when entrepreneurs use the newly created credit to purchase inputs, the price level would temporarily increase. But after innovations are out, more output can be produced with the same amount of inputs, hence the price level falls to the previous level. Therefore, the rate of credit inflation would be zero on the balanced growth path.

The question is that the banks have the tendency to increase the rate of credit inflation (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) for the rational self-interested banks. 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 follow Bacchetta and Wincoop (2006) to assume that production depends on real credit holding. This yields a demand for real credit without making it a function of consumption as in money-in-utility models. This ensures analytical solutions. 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. We prove that 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.

When the revenue is achieved by issuing more credit to entrepreneurs, part of the revenue goes to entrepreneurs. Otherwise entrepreneurs would only borrow the amount in the benchmark case that yields zero rate of credit inflation. The main findings are already presented. That is, credit is not super neutral, and creative destruction is the channel via which inflation affects long-run growth. This complements previous channels like capital accumulation (Stockman, 1981) and intertemporal labor supply (Gomme, 1993; Jones and Manuelli, 1995). The welfare implications are as follows.

In the creative destruction model of Aghion and Howitt, the welfare-maximizing rate of growth may be greater or smaller than laissez-faire economy's growth (see Aghion and Howitt, 1998, 61-63 for details). When the laissez-faire growth is excessive (due to excessive research when the business-stealing effect dominates), a lower rate of laissez-faire growth resulted from credit inflation (when the share of entrepreneurs is low) is actually welfare-improving. In contrast, a higher rate of laissez-faire growth generated by credit inflation (when the share of banks is low) is welfare-improving only when the laissez-faire growth is less than optimal (due to too little research when the intertemporal-spillover and appropriability effects dominate).

Other results on comparative statics are as follows. 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 associated with higher (lower) growth if the banks have a higher (low) share in the revenue. Moreover, a higher share of banks in the revenue would always lower 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. This not only helps to solve the debate in the empirical inflation-growth nexus literature,[2] but offers one explanation for the observed substantial country-level growth differentials.[3]

The paper proceeds as follows. In Section 2 we present the benchmark model. Section 3 introduces credit inflation. Section 4 presents some discussions and the empirical evidence. Section 5 concludes.

2 The Benchmark Model

The basic model is based on Aghion and Howitt (1992; 1998, ch. 2). 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 c_τ is real consumption at period τ; 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 three uses. First, some labor is used in manufacturing (that is, in producing intermediate goods). Second, some labor is used as research input. Third, some labor is used as the only input for the banks. The first two uses are the same as in Aghion and Howitt (1998, ch. 2). The third use is new, as discussed below.

[2] Many empirical studies since the 1980s find a negative effect of inflation on growth (e.g., Kormendi and Meguire, 1985), 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.

[3] Previous studies on explaining the cross-country growth differentials include Hall and Jones (1999) and Aghion and Howitt (2006).

Aghion and Howitt (1998, ch. 2) 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 is only used for consumption. As discussed, the limit of credit creation by banks is a puzzling issue (Blanchard and Fischer, 1989, ch. 4; Schumpeter, 113-115). To set a limit for the banks to create new credit, we need a demand function for real credit that would impose a penalty for the banks to increase the growth rate of credit supply. To get a demand function for real credit, we follow Bacchetta and Wincoop (2006) to assume that the production of final output depends on real credit holding. This avoids making real demand for credit a function of consumption as in money-in-utility models, which ensures analytical solutions. Nonetheless, the general results are expected to hold with credit-in-utility preferences. Following Bacchetta and Wincoop, the production function for the final output is

$$Y_t = A_t x_t^{\alpha} - m_{t-1} \left(\ln \left(m_{t-1} \right) - 1 \right) / \eta, \tag{1}$$

which shows that final output production depends on the input of an intermediate good, x_t, and the real credit holding associated with the $(t-1)^{th}$ innovation, m_{t-1}. The real credit holding equals nominal credit holding M_{t-1}^d divided by the price level P_{t-1}. In (credit market) equilibrium, it would equal the nominal credit supply M_{t-1}^s divided by the price level P_{t-1} (i.e., $M_{t-1}^d / P_{t-1} = M_{t-1}^s / P_{t-1}$). And $\eta > 0$ measures the semi-elasticity of real credit holding with respect to credit inflation as shown later. 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., $\frac{A_{t+1}}{A_t} = \gamma$) (the quality ladder).

It is worth discussing the production function in equation (1). Bacchetta and Wincoop assume the money-in-production function to simplify their model, without offering details on the relationship between money and production. Since we focus more on credit in growth models that emphasize analytical solutions, understanding such relationship would be helpful. If we take the derivative of output Y_t with respect to m_{t-1}, we get

$$\frac{\partial Y_t}{\partial m_{t-1}} = -\frac{\ln \left(m_{t-1} \right)}{\eta} > 0, \text{ with } m_{t-1} \in (0, 1) .$$

That is, when the level of real credit holding lies in the range $(0, 1)$, holding more credit is good for production. Therefore, the way of introducing credit via the money-in-production function is similar to introducing money via the money-in-utility models in the sense that holding money/credit would be good for the agent, be it for the producer or for the consumer. Of course there is cost of holding money/credit, which would be the lost interest earnings from saving the same amount of money/credit in financial intermediaries (which applies to both the money-in-utility models and our model here), which will be pinned down in Section 3.2.1.

Will the the level of real credit holding be in the range $(0,1)$? In Section 3.2.2 that studies the market clearing of the credit market, we will prove that the equilibrium level of real credit holding in the economy would be pinned down by equation (15). This fact ensures that the equilibrium level of real credit holding lies in the range $(0,1)$.

2.1 The Final Output Sector

Given the production function in equation (1), the final output producer 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 $\Pi_t = \left(\frac{1}{\alpha} - 1\right) p_t x_t - m_{t-1}\left(\ln\left(m_{t-1}\right) - 1\right)/\eta$. This profit is neglected in Aghion and Howitt's model. In our pure credit economy, the monopolistic profit of final good producer will be distributed to the workers. The mechanism is described in Section 2.7.

2.2 The Intermediate Goods Sector

The intermediate goods sector is also referred to as the manufacturing sector. The technology of the intermediate goods 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 $x_t = l_t$. Then 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:

$$\underset{P_t}{Max} : \pi_t = p_t x_t - W_t l_t = p_t x_t - W_t x_t$$

$$s.t. \quad x_t = \left(\frac{A_t\alpha}{p_t}\right)^{\frac{1}{1-\alpha}}$$

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.

The intermediate goods sector is owned by a monopolistic entrepreneur who sells the intermediate good to the final good sector at price p_t. But first the entrepreneur has to borrow the credit from a bank to purchase the means of production (i.e., to finance the wage bills of their workers, the $W_t l_t$) and to finance innovation (i.e., the research input).

2.3 The Banking Sector

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 is created and placed at the disposal of entrepreneurs, then creative destruction is achieved. Therefore, without a properly functioning banking system, creative destructions will be very hard to achieve. Following Schumpeter, we consider the leading case in which there are no 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 up.

We assume that there is free entry into the banking business. The case of no free entry would be analyzed in Section 4.1. Since we are incorporating the banking sector into the Aghion and Howitt (1992) model, we study the simplest case where there is only one bank in equilibrium with free entry into the banking business. The credit contract between the bank and the entrepreneurs would be as follows. The entrepreneurs borrow newly-issued credit from the banks in the amount of $p_t x_t = \frac{1}{\alpha} W_t x_t$. In so doing, the entrepreneurs have to pay the service of the banks in the amount of d.

In a mobile labor market, the wage rate of those who work in the bank should equal that of those who are employed by the manufacturing sector. In the benchmark case with free entry into the banking business, we have

$$d = W_t \bar{l}, \tag{3}$$

which means the amount of service payment by entrepreneurs to the banks would equal the wage bills of the workers in the bank. This would leave the banking business zero profit under free entry.

Therefore, the entrepreneurs' net monopolistic profit would be the monopolistic profit from selling intermediate goods less the service payment to the banks. Therefore, using equations (2) and (3), the net profit of entrepreneurs is

$$\widehat{\pi}_t = \left(\frac{1}{\alpha} - 1\right) W_t x_t - d = A_t \omega_t \left[\left(\frac{1}{\alpha} - 1\right) x_t - \bar{l}\right]. \tag{4}$$

where $\omega_t = \frac{W_t}{A_t}$ is the productivity-adjusted wage rate. According to equation (4), 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.

2.4 R&D

We denote the amount of labor used in research as n_t. Following Aghion and Howitt (1998, ch. 2), when the amount n_t is used in research, innovation arrives randomly with a Poisson arrival rate λn_t, where $\lambda > 0$ is a parameter indicating the productivity of the research technology. As in Aghion and Howitt (1998, ch. 2), the research sector is portrayed as in the patent-race literature. The amount of labor devoted to research (n_t) is determined by the research-arbitrage condition:

$$W_t = \lambda V_{t+1}, \tag{5}$$

where t is not time but the number of innovations that have occurred so far, W_t the research cost, and V_{t+1} the discounted expected payoff to the $(t+1)^{th}$ innovation. Equation (5) states that value of working in the manufacturing sector should equal the value in research in a mobile labor market.

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

$$V_{t+1} = \frac{\widehat{\pi}_{t+1}}{r + \lambda n_{t+1}}. \tag{6}$$

Now combining equations (4), (5), and (6) yields

$$\omega_t = \frac{\lambda \gamma \omega_{t+1} \left[\left(\frac{1}{\alpha} - 1 \right) x_{t+1} - \bar{l} \right]}{r + \lambda n_{t+1}}. \tag{7}$$

Equation (7) 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 stated, all labor is used in manufacturing, research and banking. Therefore, we have the labor market clearing condition as

$$x + n + \bar{l} = L. \tag{8}$$

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 (see the detailed discussion on bubble in Obstfeld and Rogoff, 1996, ch.8). 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.

Throughout this paper, we assume a no-bubble solution. In so doing, one can show that the economy would have a steady state in which the consumption, the real credit holding, the final output, and the nominal wage would grow at the same rate. 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 (8) into equation (7):

$$1 = \frac{\lambda\gamma\left[\left(\frac{1}{\alpha}-1\right)\left(L-n-\bar{l}\right)-\bar{l}\right]}{r+\lambda n}. \tag{9}$$

Equation (9) 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

$$\frac{\dot{A}_t}{A_t} = \lambda n_t \ln\gamma. \tag{10}$$

In a steady state, the consumption, the real credit holding, the final output, and the nominal wage would grow at the same rate $g = \lambda n \ln\gamma$ (the steady state growth rate).

2.7 The Price Level in the Steady-State

Figure 5 helps to illustrate the mechanism. One can see that the capitalist society builds on the trust from credit. In Figure 5, the solid lines are the flows of credit, while the dashed lines represent the flow of real goods and services. 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 hire the R&D input, which is labor. Then the researcher would generate new innovations that follow the Poisson process as discussed above. Now, the total credit in the economy is still in the amount of $p_t x_t$.

The final good firm has to buy intermediate good in the amount of $p_t x_t$ (see Section 2.1). Then it produces final output in the amount of $Y = A_t x_t^{\alpha} - m_{t-1}\left(\ln\left(m_{t-1}\right)-1\right)/\eta = \frac{1}{\alpha}p_t x_t -$

$m_{t-1} (\ln (m_{t-1}) - 1) / \eta$. In a no-bubble solution, the real credit holding (m) is a constant fraction (denoted by ϕ) of the final output (Y) produced as discussed in Section 2.6:

$$m = \phi Y. \tag{11}$$

Using equation (11) and the constant steady state growth rate of final output $g = \lambda n \ln \gamma$, we can solve for $Y = \frac{1}{\alpha} p_t x_t / \left(1 + \phi \frac{\ln \phi + t\lambda n \ln \gamma - 1}{\eta}\right)$. The real final output produced is roughly a constant fraction of $\frac{1}{\alpha} p_t x_t$ given that p_t grows at an exponential rate of g in steady state and the denominator grows at a linear rate of g. 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 $\Pi_t = \left(\frac{1}{\alpha} - 1\right) p_t x_t - m_{t-1} (\ln (m_{t-1}) - 1) / \eta$. 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, one can 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 $\frac{1}{\alpha} p_t x_t - m_{t-1} (\ln (m_{t-1}) - 1) / \eta$. The final output is $Y = A_t x_t^{\alpha} - m_{t-1} (\ln (m_{t-1}) - 1) / \eta$. Therefore, the price level (P_t) is 1.

One can also determine the price level by studying the final goods firm. The order of the final goods firm (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 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 $W_t l_t + \Pi_t + \left(\frac{1}{\alpha} - 1\right) W_t l_t = \Pi_t + \frac{1}{\alpha} W_t l_t = \frac{1}{\alpha} p_t x_t - m_{t-1} (\ln (m_{t-1}) - 1) / \eta$. The last equality uses the definition for Π_t. The final output is $Y = A_t x_t^{\alpha} - m_{t-1} (\ln (m_{t-1}) - 1) / \eta$. Therefore, the price level P_t in the economy is 1 because $\frac{1}{\alpha} p_t x_t = A_t x_t^{\alpha}$.

[Figure 5 Here]

In is worth noting that, each period both the amount of credit granted to the entrepreneurs and that transferred to the households grow at the rate of the steady state growth. Here the price level of 1 is just normalization. The basic idea is that the growth rate of credit supply equals that of the output produced, keeping the price level constant in steady state (the price level may temporarily increase before innovations are realized).

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 study its effect on creative destruction and thereby long-run growth.

3.1 Credit Inflation Initiated by the Banking Sector

As shown above, the creative destruction is made possible by the banking sector. However, what amount of credit will the bank create in a laissez-faire economy? 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 (Schumpeter, 1911, p. 115). Moreover, it is not clear whether the legal restrictions and safety-valves are actually sufficient in practice to prevent the banks from issuing more credit. Some researchers have argued that the credit creation by financial intermediaries contributes to this recent subprime-mortgage crisis (e.g., Brunnermeier, 2009).

Therefore, it is very likely that the banks, for their own rational self-interest, may raise the growth rate of credit supply. Suppose the banks issue credit to entrepreneurs in the amount more than that in the benchmark case in Section 2.3. This would yield revenue – detailed below. As long as the banks can reap part of the revenue, the rational self-interest banks would initiate credit inflation.

For simplicity, we study the limit of the creation of purchasing power by the banks when there are no legal barriers and rules for the gestation of banking business. Here we focus on the issuing of credit means of payment – the credit issued to entrepreneurs. The credit inflation from issuing more consumptive credit will be discussed in Section 4.2.

3.1.1 Nash Bargaining

We assume that the banks are symmetric and can coordinate without any cost (which is not very hard given the small number of giant commercial banks in capitalist society). Now suppose the banks (collectively) issue credit means of payment to entrepreneurs in the amount more than that in the benchmark case in Section 2.3, and this credit inflation would yield revenue in the amount of R – detailed in Section 3.2.

Since our general results do not depend on the specific sharing rule between the banks and the entrepreneurs, we, for simplicity, assume that the banks and the entrepreneurs share the revenue from credit inflation using a costless Nash bargaining rule. In Nash bargaining, the bargaining power of the banks is β, and that of the entrepreneurs is $(1-\beta)$, where β is exogenously given. In the Nash bargaining, their reservation payoffs in sharing the revenue from credit inflation would be d (in equation 3) and zero for the banks and the entrepreneurs respectively in the benchmark case in Section 2.3.

With symmetry and no coordination cost, the whole revenue of the banks should be the same as that of a single giant bank. Now the single giant bank asks for the service payment in a higher amount D. Therefore, the banks and the entrepreneurs jointly maximize

$$(D-d)^{\beta}(E)^{1-\beta}$$
$$s.t.\ (D-d)+E=R.$$

where R is the credit-inflation-revenue (solved later), and E is the amount of credit-inflation-revenue that goes to the entrepreneurs. The Nash bargaining solution is

$$(D-d) = \beta \cdot R \tag{12}$$

$$E = (1-\beta) \cdot R. \tag{13}$$

The Nash bargaining solution states that the banking business gets β share of the credit-inflation-revenue (R) and the entrepreneurs gets the remaining. 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.

3.2 The Dynamically Consistent Rate of Credit Inflation

Now we try to pin down the optimal rate of credit inflation for the banks.

To make things easier to grasp, we refer to Figure 6. The difference between Figure 5 and Figure 6 is that, now the banks issues more credit to the entrepreneurs, shown with thicker solid line in Figure 6. Suppose the rate of credit inflation is μ (determined later). In a no-bubble solution, in steady state we have $(1+\mu) = \frac{M_\tau^s}{M_{\tau-1}^s} = \frac{P_\tau}{P_{\tau-1}}$. In contrast, the price level remains constant in the benchmark model without credit inflation.

[Figure 6 Here]

The revenue from credit inflation in period τ is fundamentally like seigniorage revenue (see Cagan, 1956; Obstfeld and Rogoff, 1996, ch. 8) on the whole economy. Denote the revenue from credit inflation in period τ as R_τ, we have

$$R_\tau = \frac{M_\tau^s - M_{\tau-1}^s}{P_\tau} = \frac{M_\tau^s - M_{\tau-1}^s}{M_\tau^s}\frac{M_\tau^s}{P_\tau}, \tag{14}$$

where M_τ^s stands for the nominal amount of credit supplied by banks.

Since credit inflation would yield positive revenue for the banks, what is the limit for the banks in increasing the rate of credit inflation? It is a puzzling issue according to Schumpeter (1911, p. 115) and Blanchard and Fischer (1989, ch. 4). To set the limit for the banks in increasing the rate of credit inflation, we need to have a demand function for credit that would impose a penalty on the banks to issue more credit.

3.2.1 The Demand for Credit

We denote the wealth of workers as w_τ. As in Bacchetta and Wincoop (2006), we assume the wealth yields a nominal return i_τ. At time $\tau+1$ the representative worker receives the return on their investments plus income $y_{\tau+1}$ from time $\tau+1$ final output production. Therefore, the budget constraint for a worker would be

$$c_{\tau+1} = (1+i)(w_\tau - m_\tau) + m_\tau + y_{\tau+1}$$

where $c_{\tau+1}$ is the worker's real consumption, w_τ the wealth of workers, m_τ the real credit demand/holding. Since the representative worker's preference is linear in consumption, her maximization problem would be maximizing $c_{\tau+1}$:

$$\max_{m_\tau} c_{\tau+1} = (1+i)\, w_\tau - i m_\tau + A_{\tau+1} x_{\tau+1}^{\alpha} - m_\tau \left(\ln(m_\tau) - 1\right)/\eta,$$

where we use equation (1). The above equation states that real credit holding is essential for the production of final output, but holding real credit incurs a loss of nominal return for the representative agent. The first-order condition for real credit demand is

$$m_\tau = \frac{M_\tau^d}{P_\tau} = \exp(-\eta i_\tau), \tag{15}$$

where M_τ^d is the nominal demand of credit, which equals the nominal supply of credit (M_τ^s) in equilibrium. According to equation (15), the real demand for credit only depends on the nominal return i_τ. That is why we follow Bacchetta and Wincoop (2006) to assume that production depends on real credit holding. In so doing, the demand for real credit is not a function of consumption as in money-in-utility models. This ensures analytical solutions. 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. Therefore, the existence of the demand function for real credit in equation (15) allows us to pin down the optimal rate of credit inflation chosen by the banks.

3.2.2 The Dynamically-Consistent Rate of Credit Inflation

In equilibrium, the credit market clears. That is,

$$\frac{M_\tau^s}{P_\tau} = \frac{M_\tau^d}{P_\tau} = \frac{M_\tau}{P_\tau} = m_\tau.$$

where m_τ is real credit holding. Given the fisher equation $(1+i_\tau) = (1+r)\frac{P_{\tau+1}}{P_\tau}$, we have $i_\tau = r + \mu$. Using the real credit demand in equation (15), we have $\frac{M_\tau^s}{P_\tau} = \frac{M_\tau^d}{P_\tau} = \exp(-\eta(r+\mu))$. Therefore, η is the semi-elasticity of real credit demand with respect to credit inflation. Now the revenue from credit inflation in period τ (R_τ) in equation (14) becomes

$$R_\tau = \frac{\mu}{1+\mu}\exp(-\eta(r+\mu)).$$

Maximizing R_τ with respect to μ yields the first-order condition

$$\eta\mu^2 + \eta\mu - 1 = 0. \tag{16}$$

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 (14), the revenue from credit inflation to the banking sector in equation (12) becomes

$$\beta R_\tau = \beta \frac{\mu^*}{1+\mu^*}\frac{M_\tau}{P_\tau} = \beta \frac{\mu^*}{1+\mu^*}\phi Y, \tag{17}$$

where the last equality uses the fact that, in a no-bubble equilibrium, the real credit holding $\left(\frac{M_\tau}{P_\tau}\right)$ is a constant fraction (denoted by ϕ) of the final output (Y) produced, using equation (11). Although we use the same notation Y, the level of technology A (and its growth rate) would be different from Section 2 (we use $\widehat{Y}$ in Figure 6).

Nonetheless, one can see that the revenue from credit inflation is proportional to the real output produced in the economy. In a no-bubble solution, Y would 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 $\sum_0^\infty \frac{(1+g)^\tau}{(1+r)^\tau}\beta\frac{\mu^*}{1+\mu^*}y_0 = \frac{1+r}{r-g}\beta\frac{\mu^*}{1+\mu^*}y_0$, where 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. In this case, the revenue from credit inflation that the banks can get is β share of the total amount of output at period 0, $\beta A_0\left(L-\bar{l}\right)^\alpha$.

Therefore, as long as $\frac{1+r}{r-g}\frac{\mu^*}{1+\mu^*}y_0 > A_0\left(L-\bar{l}\right)^\alpha$, 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 (16), denoted by μ^*:

$$\mu^* = \frac{-\eta+\sqrt{\eta^2+4\eta}}{2\eta}, \text{with } \frac{\partial \mu^*}{\partial \eta} < 0. \tag{18}$$

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 discussed in the introduction, if not for the institutional setup of modern capitalist society (banking credit is issued by commercial banks to the entrepreneurs to achieve creative destruction, while money is issued by the central bank and is seldom 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 4.3.

3.3 Free Entry into the Banking Sector

Here we study free entry into the banking system. Section 4.1 discusses no free-entry.

According to equation (12), the revenue of the banking business is $D = d + \beta \cdot R$. Using equations (3) and (17) to substitute out d and R, respectively, we have

$$D = W_t\bar{l} + \beta\frac{\mu^*}{1+\mu^*}\phi Y. \tag{19}$$

Given free entry into the banking sector, the existence of the revenue from credit inflation will incentize more banks to enter the banking business. The entry of new banks will stop when the expected profit of each bank ($\frac{D}{m}$, where m is the number of banks in equilibrium) equals its fixed set-up cost ($W_t\bar{l}$): $\frac{D}{m} = W_t\bar{l}$. This pins down m:

$$mW_t\bar{l} = W_t\bar{l} + \beta\frac{\mu^*}{1+\mu^*}\phi Y, \tag{20}$$

where we use equation (19).

The left-hand side of equation (20) is the set-up cost for all banks, while the right-hand side is the total revenue of the banking system. The left-hand side 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 right-hand side 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. It equals the reservation payoff in the benchmark case ($d = W_t\bar{l}$) in Section 2.3 plus the banks' share of revenue from credit inflation ($\beta R = \beta\frac{\mu^*}{1+\mu^*}\phi Y$). In the steady state, free entry into the banking system stops whenever equation (20) holds.

As shown in Sections 2.6 and 2.7, the real final output produced, Y, is roughly a constant fraction of $\frac{1}{\alpha}p_t x_t$, where x_t is the amount of intermediate good. And we have $p_t x_t = \frac{1}{\alpha}W_t x_t$. Therefore, $\frac{\phi Y}{W_t} = y x_t$, where y is a constant. The free-entry condition of the banking sector in equation (20) can be simplified as

$$m = 1 + \frac{\beta \mu^* y x_t}{(1+\mu^*)\,\bar{l}}. \tag{21}$$

As in Section 2.5, given that all labor is used in manufacturing, research and banking and each bank needs a fixed amount of labor, $\bar{l}$, to operate, we have $x + m\bar{l} + n = L$. This equation combined with equation (21) yields the number of banks as

$$m = \frac{(1+\mu^*)\,\bar{l} + \beta\mu^*\,(L-n)\,y}{(1+\mu^*)\,\bar{l} + \beta\mu^*\bar{l}y}. \tag{22}$$

Equation (22) states that, the number of the banks (m) 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

Section 3.3 has shown that the banks use their share of revenue from credit inflation to employ more workers when there is free entry into the banking business. In this section we show that the entrepreneurs would use their share of 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 in Section 4.2). Since entrepreneurs get $(1-\beta)$ share of the revenue from credit inflation, their profit will be the usual monopolistic profit from innovations (the $\widehat{\pi}_t$ in equation 4) plus the extra revenue from credit inflation (the E given in equation 13). Similarly, using equations (11) and (14) to rewrite equation (13) as $E = \frac{(1-\beta)\phi\mu^* Y}{1+\mu^*}$, the profit of entrepreneurship, $\widetilde{\pi}_t$, becomes

$$\widetilde{\pi}_t = \frac{1-\alpha}{\alpha} W_t x_t - W_t \bar{l} + \frac{(1-\beta)\,\phi\mu^* Y}{1+\mu^*} = A_t \omega_t \left[\frac{1-\alpha}{\alpha} x_t - \bar{l} + \frac{(1-\beta)\,\mu^* y}{1+\mu^*} x_t\right], \tag{23}$$

where y is a constant by defining $\frac{\phi Y}{W_t} = y x_t$. Equation (23) states that the entrepreneurs receive additional revenue from credit inflation, $(1-\beta)\,\frac{\mu^*}{1+\mu^*}\phi Y$, besides the monopolistic profit from a better quality of intermediate goods ($\widehat{\pi}_t$) in the benchmark case.

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 6). The two opposing effects underpin our story of creative destruction with credit inflation, detailed in Section 3.5.

Combining equations (5), (6), and (23) yields the research arbitrage condition:

$$1 = \frac{\lambda\gamma\left[\left(\frac{1}{\alpha}-1\right)\left(L-m\bar{l}-n\right)-\bar{l}+(1-\beta)\frac{\mu^*}{1+\mu^*}y\left(L-m\bar{l}-n\right)\right]}{r+\lambda n}. \tag{24}$$

3.5 The Steady-State Growth Rate and Credit Inflation

The steady state growth rate is still governed by equation (10). Using equation (22) to substitute out m in equation (24), we get the steady-state amount of research, n, as a function of β and μ:

$$1 = \frac{\lambda\gamma}{r+\lambda n}\left[\left(\frac{(1-\alpha)(1+\mu^*)+\alpha(1-\beta)y\mu^*}{\alpha(1+\mu^*+\beta\mu^* y)}\right)\left(L-n-\bar{l}\right)-\bar{l}\right] \tag{25}$$

Equation (25) 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 (25), taking the derivative of the steady-state amount of research, n, with respect to μ^* yields

$$\frac{\partial n}{\partial \mu^*} \infty y(\alpha-\beta), \tag{26}$$

where y is a constant defined in Sections 3.3 and 3.4. Equation (26) is easiest to derive by the implicit function theorem.

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 (18) 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 (23) and (21). According to equation (18), 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 (21). 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 (23), 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 (23). 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. Consequently, 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 R&D, more innovations would be forthcoming, which thereby yields higher steady state growth.

Equation (18) 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 penalties 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. 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 (25). Observing equation (18), the optimal rate of credit inflation is not a function of β. Therefore, as β increases, the numerator in equation (25) decreases while the denominator increases. Consequently, the steady state amount of research n increases, so does the steady state growth. Q.E.D.

The mechanism can be seen from equations (24) and (18). Equation (18) 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 (24). 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 (4) and (23), in which the monopolistic profit of entrepreneurs increases with x (the amount of labor used in manufacturing). Second, according to equation (23), 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.

In summary, we prove that creative destruction is one important channel for inflation to impact long-run growth. This is possible because inflation may affect the relative amount of resources allocated to entrepreneurs. The banks can reap revenue from a higher rate of credit growth (like seigniorage revenue), which attracts more labor into banks, decreasing the profit of entrepreneurs and thereby growth. But when the revenue is achieved by issuing more credit to entrepreneurs, part of the revenue goes to entrepreneurs, attracting more resources into R&D and promoting growth. When banks retain a larger share of the revenue, the former effect dominates and credit inflation retards growth. When entrepreneurs get the larger share of the revenue, the latter effect dominates and credit inflation increases growth.

3.6 The Welfare Implications of Credit Inflation

The basic model is similar to Aghion and Howitt (1998, ch. 2), which makes the welfare analysis much easier. To conduct the welfare analysis, we need to follow the similar approach in sticky-price open economy macroeconomic models (detailed in Obstfeld and Rogoff, 1996, p. 684). That is, we focus on the "real" component of the representative agent's utility. This is because in equilibrium the consumption will be equal to final output produced to clear the market for the final output. However, the final output production depends on real credit balances. Nonetheless, as long as the derived utility from real credit balances is not too large as a share of total utility, the welfare change from the "real" component of the representative agent's utility dominates. This is more likely with large values of η (the semi-elasticity of real credit holding with respect to credit inflation).

In the creative destruction model of Aghion and Howitt, the welfare-maximizing rate of growth may be greater or smaller than laissez-faire economy's growth (see Aghion and Howitt, 1998, 61-63 for details). A lower rate of laissez-faire growth resulted from credit inflation (when the share of entrepreneurs is low) is welfare-improving when the laissez-faire growth is excessive (due to excessive research when the business-stealing effect dominates), while it is welfare-decreasing when the laissez-faire growth is less than optimal (due to too little research when the intertemporal-spillover and appropriability effects dominates). In contrast, a higher rate of laissez-faire growth generated by credit inflation (when the share of banks is low) is welfare-improving when the laissez-faire growth is less than optimal, while the higher growth would decrease welfare when the laissez-faire growth is already excessive.

4 Other Issues and Empirical Evidence

In this section, we study several other cases. The first is that there is no free entry into the banking business, which is done in Section 4.1. The second involves consumptive credit – credit issued for pure consumptive ends. This is discussed in Section 4.2. The third investigates what will happen if there is no such a micro-founded demand function for credit. This is analyzed in Section 4.3.

4.1 No Free Entry into the Banking Sector

When there is no free entry into the banking business, the labor market clearing condition is $x + \bar{l} + n = L$. Repeating similar steps yields the equilibrium condition:

$$1 = \frac{\lambda\gamma\left[\left(\frac{1}{\alpha}-1\right)\left(L-n-\bar{l}\right)-\bar{l}+(1-\beta)\frac{\mu^* y}{1+\mu^*+\beta\mu^* y}\right]}{r+\lambda n}. \qquad (27)$$

Equation (27) 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 (27) 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 an 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.

Following the arguments in Section 3.6, the higher rate of laissez-faire growth generated by credit inflation with no free entry into the banking sector would be welfare-improving when the laissez-faire growth is less than optimal, while it decreases welfare when the laissez-faire growth is already excessive. Therefore, when the laissez-faire growth is already excessive, increasing the share of the banks in the revenue-from-credit-inflation would yield a lower growth, which is welfare-improving.

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.

4.2 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 (this includes the extreme case that the banks issue more credit and keep the credit themselves). 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 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 recession. 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. Nonetheless, we will link our model to empirical evidence in Section 4.4.

4.3 No Micro-founded Credit Demand Function

When we study long-run growth generated by creative destruction, we already make credit essential in the dynamic capitalist society (see 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? While we leave this to future studies, here we study what will happen if such a micro-founded credit demand function does not exist. Without a microfoundation for credit demand, we rely on ad hoc assumptions. The appendix presents the detailed proof the results:

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.*

We briefly explain the economic mechanism. The steady state growth linearly depends on the steady state amount of research n. An increase in the bargaining share of the banks (β) has two opposing effects on the steady state amount of research n. The first effect tends to decrease n. All else equal, increasing the bargaining share of the banks will, first of all, leave a lower share to the entrepreneurs. When entrepreneurs receive a lower profit, few resources 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 can be expressed, using $\varepsilon_{\mu\beta}$ to denote the elasticity of μ with respect to β, as $\frac{(\alpha-\beta)\mu}{\alpha\beta}\varepsilon_{\mu\beta}$, where α is the fixed parameter in the final good production function given in equation (1). When the elasticity is positive, an increase in β will incentize 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.

Moreover, 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 competes for the service of labor) dominates that from the extra credit-inflation-revenue to entrepreneurship. That is, the revenue from credit inflation to the banking sector causes more banks to 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, hence growth is a decreasing function of credit inflation.

4.4 Empirical Evidence from the U.S. and China

We have briefly discussed in the introduction that the mechanism that we try to formalize in our paper is supported by important real world facts (in the two most important countries, U.S. as the leading one, and China as the largest developing one). However, it is worth discussing several issues in detail. First, is the mechanism that we emphasize important in real world situations? Second, can our mechanism help to explain the stylized empirical facts in the U.S. and in China?

First of all, as illustrated in Figures 1 to 4, the financial sector is important in both countries. The share of employment in the financial sector is in the range 4.25%-4.4% in the U.S. (see Table 1), and that in China is in the range 3.1%-3.7% (see Table 3). Given the relative high compensation of the financial sector, its total compensative consists of 7.3 to 7.9% of total compensation of all industries in the U.S. (see Table 2). In China, the share is increasing over time and reaches 6.81% in 2010 (see Table 4). Therefore, the relative amount of resources allocated to the financial sector is large and varies over time, which may affect the relative amount of resources allocated to entrepreneurs and thereby economic growth.

[Tables 1 to 4 Here]

Second, we show that our model can help to explain the variations of the economic series, despite that it may not be the only explanation. The crucial linkage between the real world facts and the model is how the monetary policies (as reflected by the federal funds rate) would affect the credit expansion of the financial sector. That is, it is crucial to identify the parameters of our model that may be affected the changing economic environment. According to equation (18), the optimal rate of credit inflation is only a function of η (the semi-elasticity of real credit demand with respect to credit inflation), a parameter in the production function. Therefore, the optimal rate of credit inflation will not be affected by the changing economic policies. Therefore, it is hard to test Proposition 1. However, we argue that lax monetary policies may make the credit expansion by the financial sector easier. That is, one possible parameter of our model that may be affected the changing monetary policies is the relative bargaining power of the financial sector, β. Given Proposition 2, how β will be affected by monetary policies would determine whether our model can explain the facts.

We argue that the lax monetary policy during 2001-2003 would increase the bargaining share of the financial intermediaries. A larger share of the revenue from credit inflation to the banking sector would cause the entry of more financial intermediaries. Therefore, one can observe the increasing share of employment in the financial sector during 2001-2003 in the U.S. in Figure 1. The financial intermediaries compete for the service of labor with the manufacturing sector, decreasing the profitability of entrepreneurial innovations. As the Fed gradually tightens the monetary policy in 2003, the employment share of the financial sector decreases a little, but remains quite stable during 2003-2006. Although the Fed may be concerned with the overheating of the economy and has acted accordingly, the relative compensation of the financial sector starts to increase in 2003 (it is decreasing during 2001-2003) (see Figure 2). Therefore, we deem the counter-cyclical policy of the Fed to be insufficient or slow to decrease the relative bargaining power of the financial sector in the boom period when agents have optimistic moods.

To summarize, first, the share of labor in the financial sector increased during 2001-2003 due to expansionary monetary policy. Although the employment share of the financial sector stops to increase, its relative compensation starts to increase. Therefore, the total share of resources allocated to the financial sector began to increase in 2003. More shares of labor and more total resources absorbed by the financial sector would leave fewer resources to entrepreneurs. Economic growth would be decreased.

Moreover, with expansionary monetary policies, some credit of the financial sector may be issued to the consumers. As shown in Figure 7, starting in 2003, the U.S. has experienced a large increase in subprime mortgage lending by the financial intermediaries. The subprime share of mortgage originations more than doubled in 2004 (from 7.9% in 2003 to 18.5% in 2004). Section 4.2 shows that consumptive credit issued by the banks is bad for growth. This fact coupled with the fewer resources to entrepreneurs would predict a much lower growth, as confirmed by the U.S. subprime mortgage crisis.

[Figure 7 Here]

As showed in the introduction, feeling the negative impact of the subprime mortgage crisis in 2008, Premier Wen Jiabao decided to pump 4,000 billion Yuan into the economy starting from 2009. As argued in the U.S. case, we believe that the expansionary monetary policies would cause the relative bargaining power of the financial sector to increase. What happened in the U.S. almost all happened in China. The employment share of the financial sector increased by 0.3 percentage points in 2009 comparing to 2007, and stayed at the higher share. The relative wage of the financial sector continued to increase, causing the continuing increase of the share of total wages of the financial sector in all industries.

China has also implemented some other policies. For example, starting from October 2008, all consumers with mortgage payments have been given the 70% discount in interest rate comparing to 85% previously, which is still in effect today. Moreover, the government imposes various restrictions on housing transactions. China already felt the pressure of lower rate of economic growth. For instance, China anticipates 6.99 million university graduates nationwide in 2013, and these graduates are having problems finding a job, reported by The Wall Street Journal – China Real Time. Can China avoid a recession or a large decrease in the rate of economic growth? It remains to be seen.

Although there are numerous explanations for the subprime mortgage crisis (we do not cite them here), we can at least argue that our model and the mechanism that we are emphasizing are not rejected by the U.S. and the Chinese data.

5 Conclusions

In this paper we propose creative destruction as the channel for inflation to impact long-run growth. Inflation may affect the relative amount of resources allocated to entrepreneurs. The banks can reap revenue from a higher rate of credit growth, which attracts more labor into banks, decreasing the profit of entrepreneurs and thereby growth. But when the revenue is achieved by issuing more credit to entrepreneurs, part of the revenue goes to entrepreneurs, attracting more resources into R&D and promoting growth. When banks retain a larger share of the revenue, the former effect dominates and credit inflation retards growth. When entrepreneurs get the larger share of the revenue, the latter effect dominates and credit inflation increases growth. When the revenue is achieved by issuing more consumptive credit, growth will be retarded.

A lower rate of laissez-faire growth resulted from credit inflation (when the share of entrepreneurs is low) is welfare-improving when the laissez-faire growth is excessive (due to excessive research when the business-stealing effect dominates), while it is welfare-decreasing when the laissez-faire growth is less than optimal (due to too little research when the intertemporal-spillover and appropriability effects dominate). In contrast, a higher rate of laissez-faire growth generated by credit inflation (when the share of banks is low) is welfare-improving when the laissez-faire growth is less than optimal, while the higher growth decreases welfare when the laissez-faire growth is already excessive.

We also show that our model helps to explain the stylized facts in the U.S. during 2001-2007 and those in China during 2003-2011. Although it may not be the whole story, the mechanism – inflation can affect the relative amount of resources allocated to the entrepreneurs and thereby impact creative destruction – is important and helpful for us to appreciate the recent stylized facts in the U.S. and in China. We leave the rigorous quantifying of the importance of the mechanism to future work.

Appendix. No Micro-founded Credit Demand Function

A.1 The Benchmark Model

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 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 $\frac{\frac{1}{\alpha}p_t x_t}{A_t x_t^\alpha}=1$.

A.2 The Dynamically Consistent Rate of Credit Inflation

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 $A_\tau x_\tau^\alpha$). That is, we assume that the banks, besides the original $A_\tau x_\tau^\alpha$ amount of credit, issue an extra $\mu A_\tau x_\tau^\alpha$ amount of credit. Therefore, the price level increase to $(1+\mu)$ from the original level of 1. The revenue from credit inflation is also $\mu A_\tau x_\tau^\alpha$.

Now 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 $\sum_0^\infty \frac{(1+g)^\tau}{(1+r)^\tau}\beta\mu^* A_0 x^\alpha = \frac{1+r}{r-g}\beta\mu^* A_0 x^\alpha > 0$ (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 depends 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.

A.3 Free Entry into the Banking Sector and the Labor Market

Now the free entry condition of the banking system becomes

$$W_t\bar{l} = \frac{\beta\mu A_t x_t^\alpha}{m-1}, \tag{28}$$

which pins down the number of banks (m) in the economy. The free-entry condition of the banking sector can be simplified as

$$m = 1 + \frac{\beta\mu l_{t+1}}{\alpha^2\bar{l}}. \tag{29}$$

Equation (29) 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 (29) holds.

Given that all labor is used in manufacturing, research and banking, we have $x+n+m\bar{l} = L$. This equation combined with equation (29) yields the number of banks, which increases with either β or μ, as

$$m = \frac{\alpha^2 \bar{l} + \beta\mu (L - n)}{\alpha^2 \bar{l} + \beta\mu\bar{l}}. \tag{30}$$

A.4 Research Arbitrage and Steady-state Growth

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

$$\widehat{\pi}_t = \frac{1-\alpha}{\alpha} W_t x_t - W_t \bar{l} + (1-\beta)\mu A_t x_t^\alpha = A_t \omega_t \left[\frac{1-\alpha}{\alpha} x_t - \bar{l} + \frac{(1-\beta)\mu}{\alpha^2} l_{t+1}\right], \tag{31}$$

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:

$$1 = \frac{\lambda\gamma \left[\left(\frac{1}{\alpha} - 1\right)\left(L - m\bar{l} - n\right) - \bar{l} + \frac{(1-\beta)\mu}{\alpha^2}\left(L - m\bar{l} - n\right)\right]}{r + \lambda n}. \tag{32}$$

The steady state growth rate is still $g = \lambda n \ln \gamma$, which is linear in the amount of research n. Using equation (30) to substitute out m in equation (32), we get the steady-state amount of research, n, as a function of β and μ:

$$1 = \frac{\lambda\gamma}{r + \lambda n}\left[\frac{\alpha(1-\alpha) + (1-\beta)\mu}{\alpha^2 + \beta\mu}\left(L - \bar{l} - n\right) - \bar{l}\right] \tag{33}$$

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 (33), taking the derivative of the steady-state amount of research, n, with respect to β yields

$$\frac{\partial n}{\partial \beta} \propto \frac{\partial \mu}{\partial \beta}\alpha(\alpha - \beta) - \mu(\alpha + \mu) \tag{34}$$

Therefore, we have

$$\frac{\partial n}{\partial \beta}|_{\beta=0} = \frac{\alpha^2 \mu}{\beta}\left[\varepsilon_{\mu\beta}|_{\beta=0} - \frac{(\alpha+\mu)\beta}{\alpha^2}\right] = \frac{\alpha^2\mu}{\beta}\varepsilon_{\mu\beta}|_{\beta=0} \tag{35}$$

$$\frac{\partial n}{\partial \beta}|_{\beta=1} \infty \frac{\partial \mu}{\partial \beta}\alpha(\alpha-1) - \mu(\alpha+\mu) < 0. \tag{36}$$

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 μ with respect to β when $\beta = 0$ as $\varepsilon_{\mu\beta}|_{\beta=0}$. Therefore, as long as $\varepsilon_{\mu\beta}|_{\beta=0}$ 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. Using equation (34), a higher $\varepsilon_{u\beta}$ 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 $\frac{\partial \mu}{\partial \beta} > 0$, the steady-state growth rate is also inverted-U related to μ. Q.E.D.

The economic mechanism is presented in Section 4.3. Even if the 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. The explanation is given in Section 4.3.

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Table 1: Share of Employee in Finance and Insurance and Federal Funds Effective Rate (U.S.)

	Full-time and Part-time Employees (Thousands)		Share of Employee in	Federal Funds
	All Industries	Finance and Insurance	Finance and Insurance (%)	Effective Rate (%)
2001	137522	5843	4.25	3.88
2002	136578	5853	4.29	1.67
2003	136293	5950	4.37	1.13
2004	137812	5973	4.33	1.35
2005	139770	6067	4.34	3.22
2006	142241	6193	4.35	4.97
2007	143774	6159	4.28	5.02

Sources: Employee: U.S. Bureau of Economic Analysis, GDPbyInd_VA_NAICS_1998-2011_USA. Federal Funds Rate: Board of Governors of the Federal Reserve System (H.15).

Table 2: Relative and Total Compensation of Finance and Insurance in the U.S.

	Compensation of Employees (Millions of Dollars)		Share of Compensation of Finance&Insurance (%)	Relative Compensation between Finance&Insurance and All Industries
	All Industries	Finance and Insurance		
2001	5984534	442301	7.39	1.74
2002	6116389	447316	7.31	1.71
2003	6388293	467333	7.32	1.68
2004	6699555	497375	7.42	1.71
2005	7071450	541799	7.66	1.77
2006	7483609	584420	7.81	1.79
2007	7862992	610276	7.76	1.81

Notes and Sources: Relative compensation is calculated as follows. We first divide compensation of employees in Table 2 by the number of full-time and part-time employees in Table 1. Then we calculate the relative compensation. Source: U.S. BEA: GDPbyInd_VA_NAICS_1998-2011_USA.

Table 3: Share of Employee in Finance and Growth Rate of M2 in China

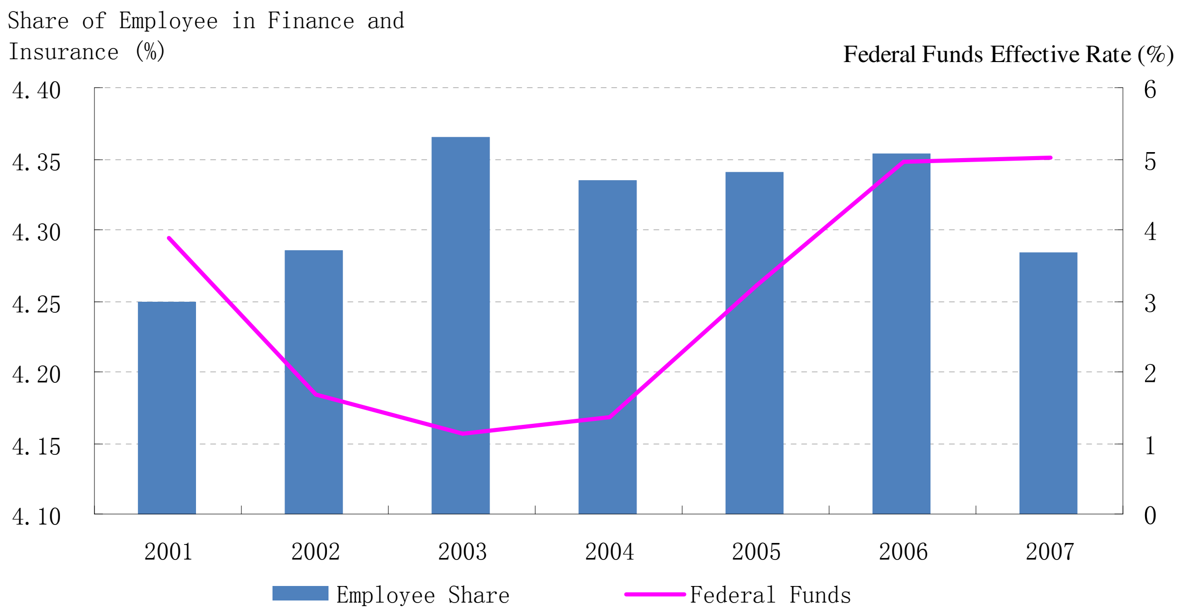
	Employment in Urban Units (10 Thousands)		Share of Employee in	Annual Growth Rate
	All Industries	Finance	Finance (%)	of M2 (%)
2003	10969.7	353.3	3.22	19.58
2004	11098.9	356.0	3.21	14.67
2005	11404.0	359.3	3.15	17.57
2006	11713.2	367.4	3.14	16.95
2007	12024.4	389.7	3.24	16.74
2008	12192.5	417.6	3.42	17.82
2009	12573.0	449.0	3.57	27.68
2010	13051.5	470.1	3.60	19.73
2011	14413.3	505.3	3.51	13.61

Sources: China Statistical Yearbook (2012) (Tables 4-5 and 19-4).

Table 4: Relative and Total Compensation of Finance in China

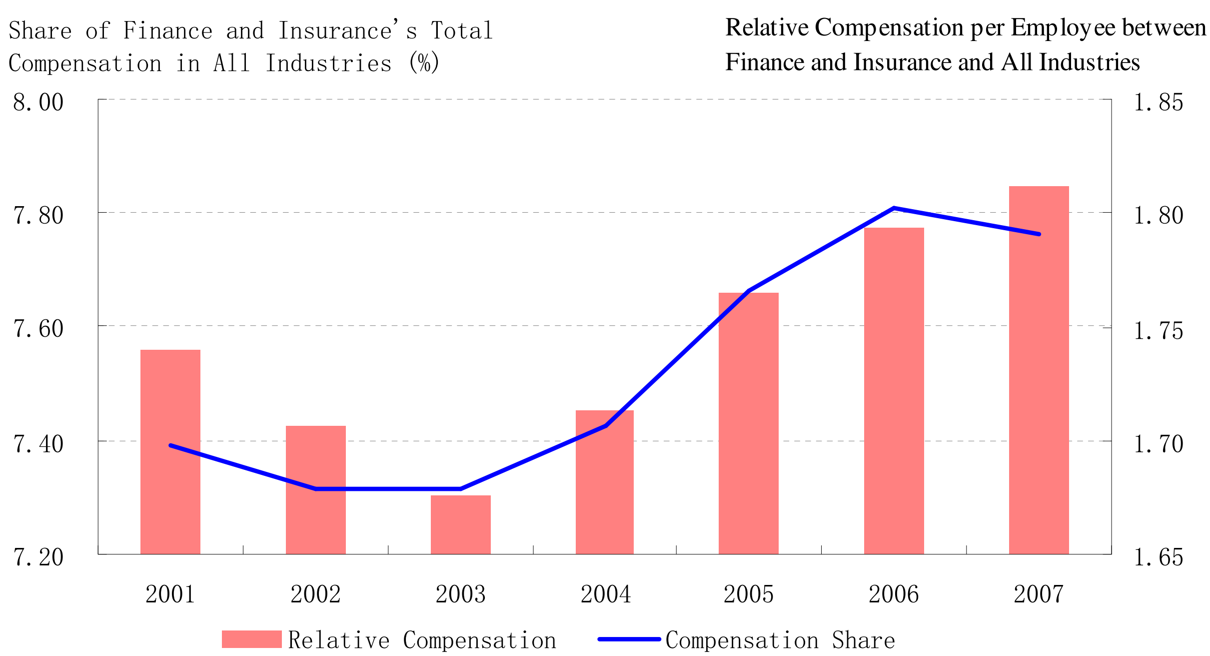
	Total Wages of Employees (100 Millions of Yuan)		Share of Wages of Finance (%)	Relative Wage between Finance and All Industries
	All Industries	Finance		
2003	15329.6	734.4	4.79	1.49
2004	17615.0	866.7	4.92	1.53
2005	20627.1	1047.7	5.08	1.61
2006	24262.3	1292.9	5.33	1.70
2007	29471.5	1670.3	5.67	1.78
2008	35289.5	2202.9	6.24	1.87
2009	40288.2	2658.8	6.60	1.87
2010	47269.9	3219.0	6.81	1.92
2011	59954.7	4007.0	6.68	1.94

Notes and Sources: China Statistical Yearbook (2012) (Tables 4-13 and 4-15). Relative wage is calculated using Table 4-15 that presents the average wage of each industry.



Sources: Employee Share: Bureau of Economic Analysis, GDPbyInd_VA_NAICS_1998-2011_USA.
Federal Funds: Board of Governors of the Federal Reserve System (H.15)

Figure 1. Federal Funds Rate Decrease and U.S. Financial Sector Employment Expansion



Sources: Bureau of Economic Analysis, GDPbyInd_VA_NAICS_1998-2011_USA.

Figure 2. Compensation Share and Relative Compensation of the U.S. Financial Sector

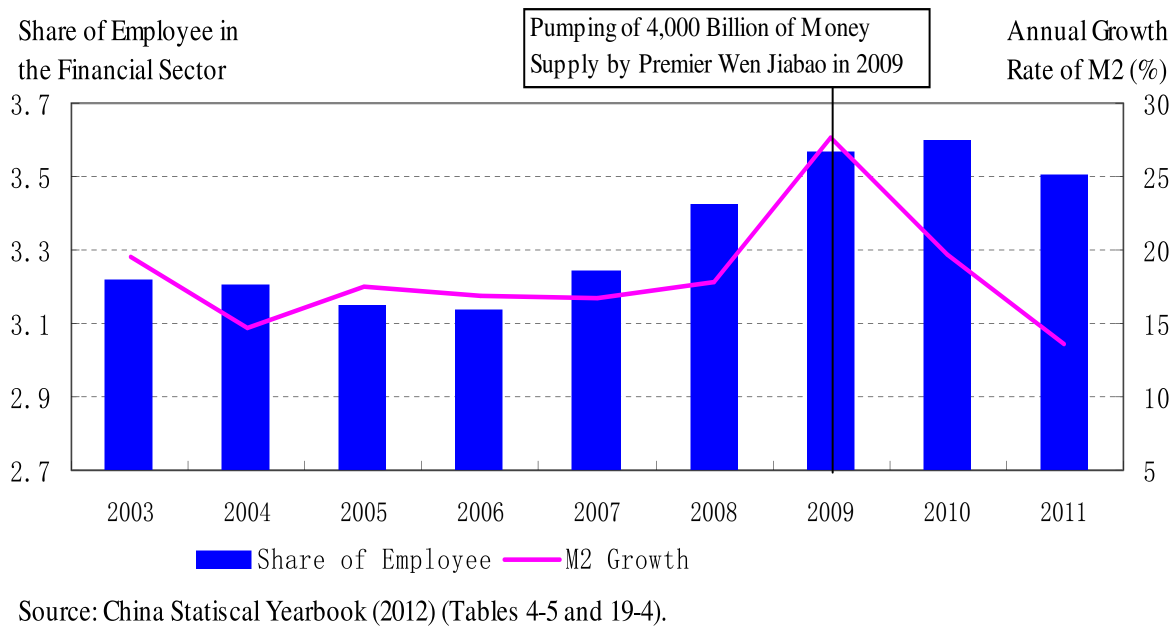


Figure 3. China's Monetary Expansion and the Financial Sector Employment Expansion

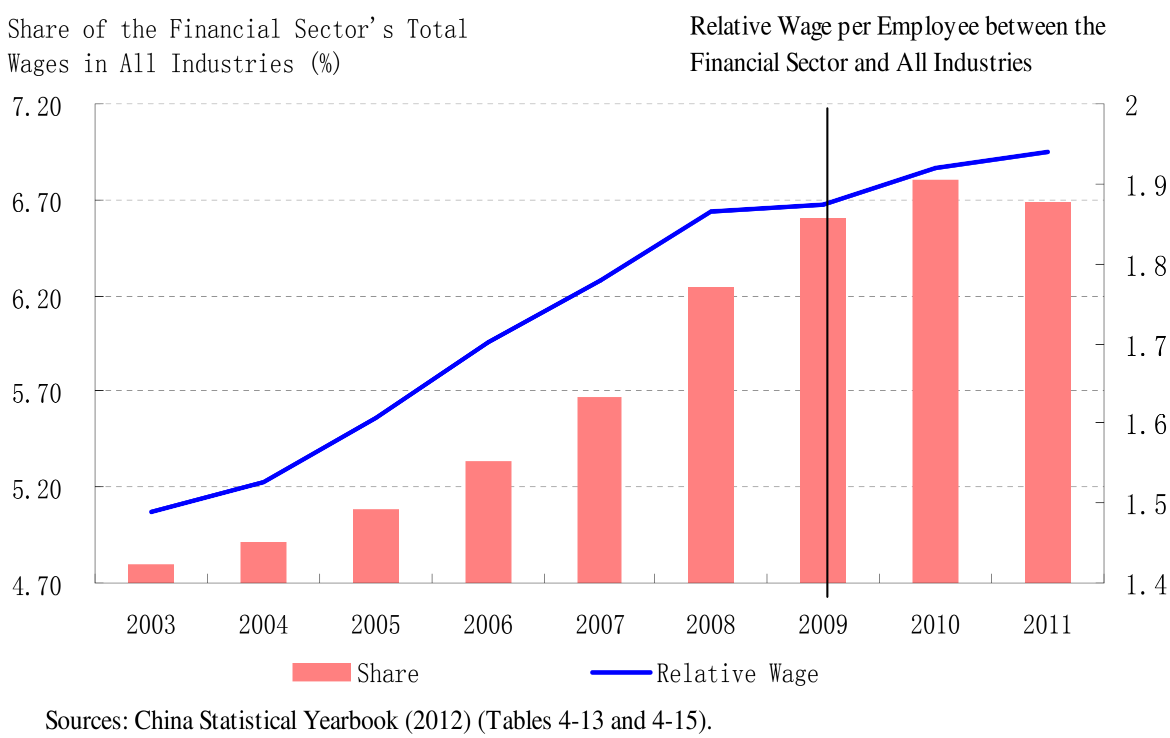


Figure 4. Wage Share and Relative Wage of the Chinese Financial Sector

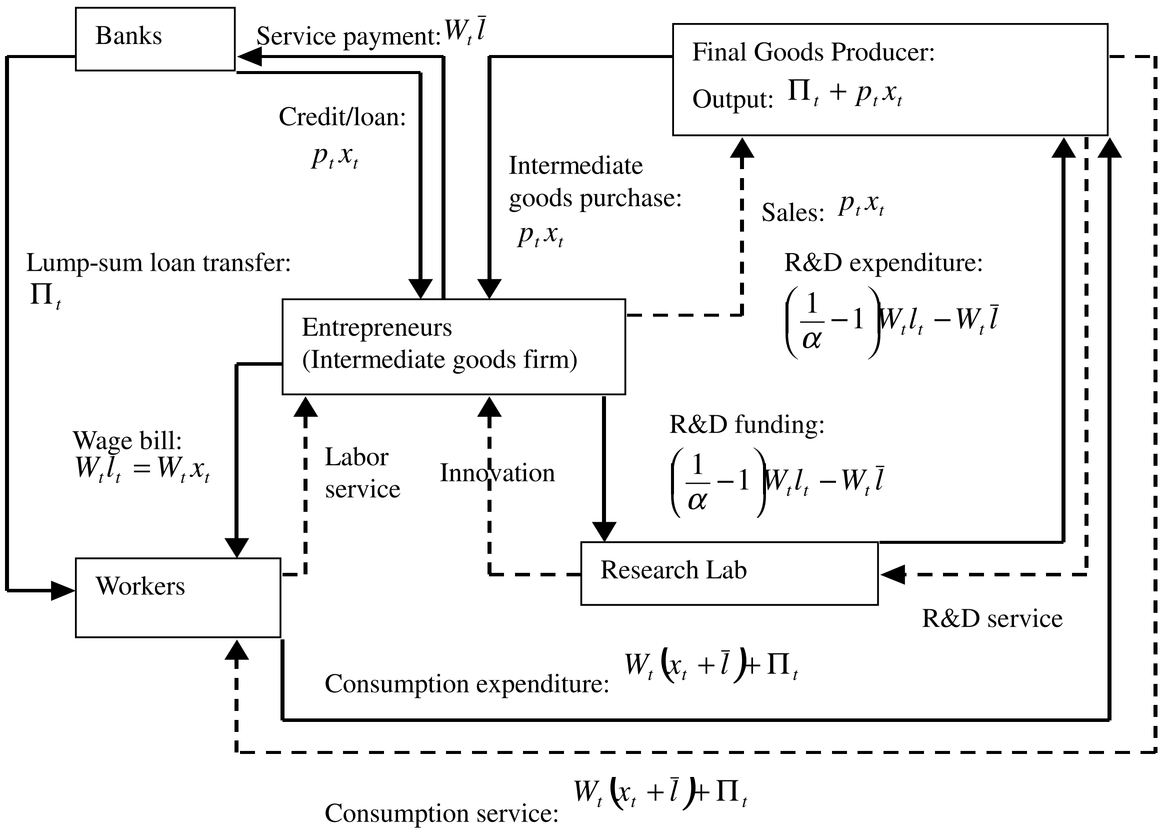


Figure 5. Benchmark Pure Credit Economy without Credit Inflation

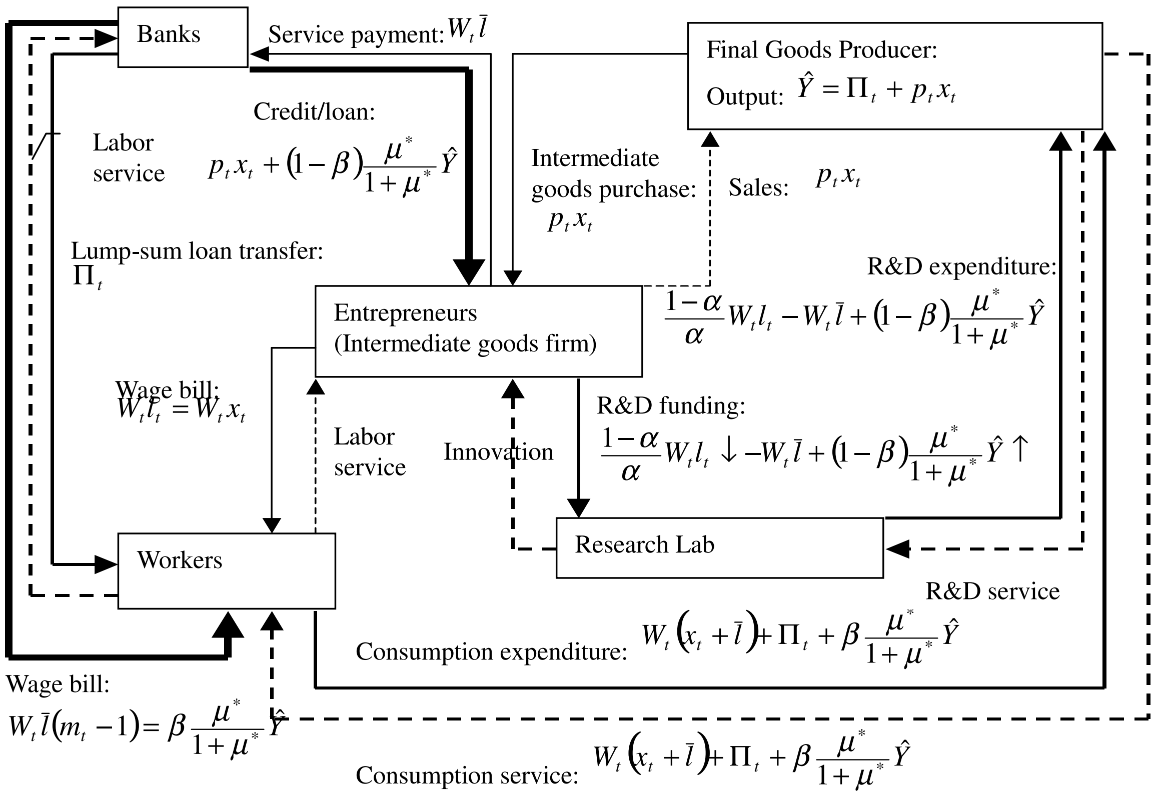


Figure 6. A Pure Credit Economy with Credit Inflation

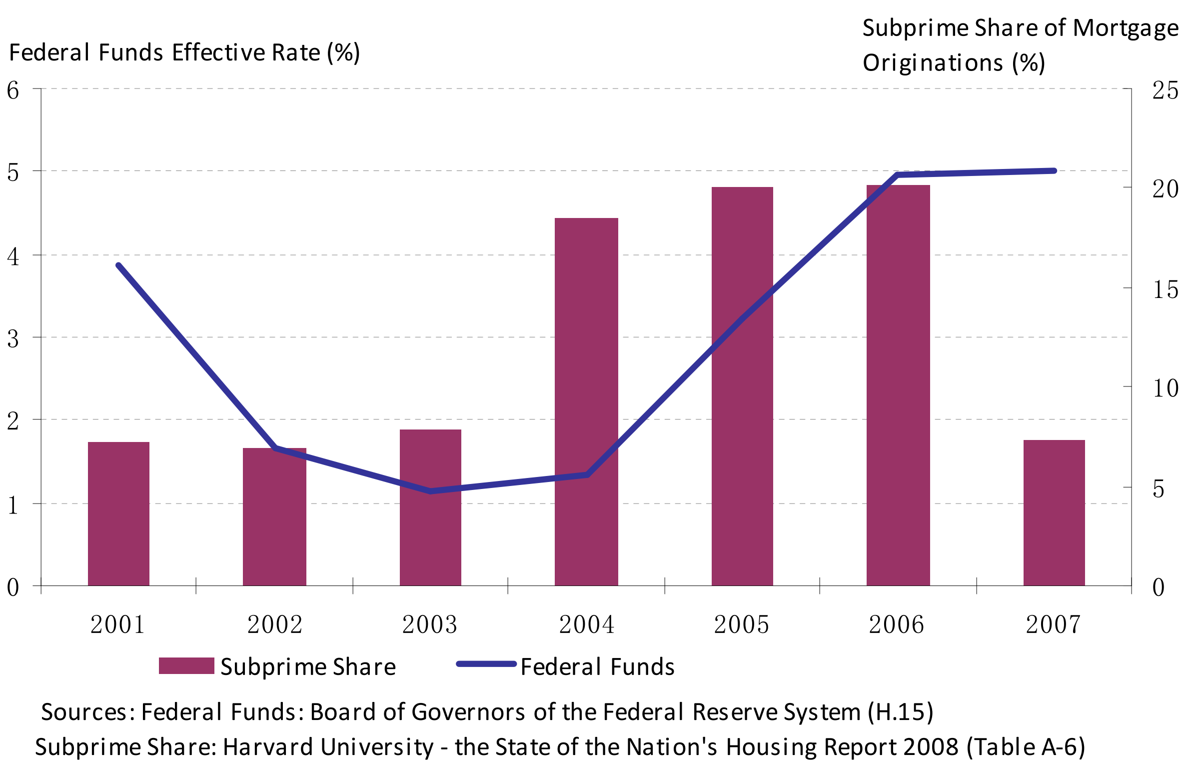


Figure 7. Federal Funds Rate Decrease and U.S. Subprime Lending Expansion