Imperfect Competition in the Banking System and Credit Market Activity in the Presence of Government Debt *

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Abstract

The recent financial crisis has drawn attention to the consequences of concentration in the financial system. Moreover, in the past few years, there has been an explosion in the level of government debt. To address these issues, this paper studies the implications of inflation-financed government debt in a model of imperfectly competitive financial institutions. In order to exploit their market power in private credit markets, banks hold excessive amounts of money balances and goverment debt. As a result, the interest rate on private sector loans will be higher than the interest rate on government bonds. In this manner, concentration in the banking system impedes interest rate arbitrage across different financial markets. Thus, our model offers insights into recent efforts by monetary authorities that focus on long-term yields of government debt.

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1 Introduction

The recent financial crisis has drawn attention to the consequences of concentration in the financial system. In fact, some institutions were so large that they were considered "too big to fail." Obviously, these large firms play a significant role in the financial system. For example, Janicki and Prescott (2006) observe that over 75% of assets in the banking system were held by less than 1% of banks prior to the crisis. With such a prominent role in economic activity, one must consider that these large institutions would attempt to exploit their market power in the financial system. Moreover,

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Gongloff et al. (2013) and Gandel (2013) point out the largest institutions were even bigger after the crisis. Therefore, their impact in the financial system became even more important. Similar observations about consolidation apply to the banking systems in Europe and the U.K.

At the same time that concentration increased, the debt burdens of countries have also increased appreciably. According to data from the International Monetary Fund, the debt to GDP ratio in the United States stood at 61.1% in 2006. After the crisis, the ratio climbed to almost 100% of GDP in 2011. As another example, the service burden of government debt in France increased from 63.6% to 84.1%. Fortunately, yields have also decreased. The 10-year yield in the United States fell from 4.8% in 2006 to 2.78% in 2011.

As a result, most economies are confronting two significant developments. First, the competitive structure of the financial landscape has considerably changed in recent years towards increasingly concentrated financial systems. Second, the amount of debt issued by countries has also grown significantly. As the recent financial crisis has demonstrated, monetary authorities and bank regulators cannot afford to overlook these structural changes in the financial system.

Furthermore, the conduct of monetary policy has fundamentally changed in the past few years. During the initial phase of the crisis, traditional monetary policy tools were relied upon in order to stimulate credit markets. For example, in the United States, the Federal Reserve aggressively lowered the federal funds rate from September 2007 through December 2008. After traditional remedies were exhausted, the central bank relied heavily on the size of its balance sheet to stimulate economic activity.

Fisher and Rosenblum (2009) and Rosenblum et al. (2010) argue that the high levels of concentration during the crisis "clogged" the standard transmission channels of monetary policy. As a result, unconventional policies to lower long-term interest rates were adopted. Large Scale Asset Programs, geared towards purchases of longer-dated government securities to lower their yields, have been increasingly utilized in order to promote private credit market activity. In particular, the Maturity Extension Program focused solely on long-term interest rates by shifting the composition of maturities held by the Federal Reserve.

What are the implications of the increasing concentration of the financial system for economic activity? How are they affected by the presence of government debt? How would consolidation in the banking system affect yields and interest rates across financial markets? How does the impact of inflation depend on the competitive structure of the banking system? These are important questions which must be addressed in order to implement effective public policy.

The objective of this paper is to study the behavior of imperfectly competitive intermediaries in the financial system where government bonds are an available asset. In order to address the consequences of distortions from imperfect competition, we view that it is particularly important that intermediaries play a non-trivial role in the financial system. That is, banks must perform important social functions that are difficult for individuals to achieve on their own. Consequently, as in Diamond and

Dybvig (1983), intermediaries help insure individuals against liquidity risk and provide risk-pooling financial services to depositors. Moreover, they also channel funds from depositors to borrowers and promote intertemporal consumption smoothing. As argued by Ghossoub and Reed (2013), Laosuthi and Reed (2013), and Vives (1991, 2010), intermediaries are imperfectly competitive firms that have strategic incentives and exploit their market power. It is also important that money provides an important transactions role so that the transmission channels of monetary policy are clearly understood. Following Schreft and Smith (1997, 1998), limited communication and restrictions on portability of government bonds generate a role for money as a means of payment.

In a production economy, Schreft and Smith study the impact of inflation-financed government bonds. In their framework, if the government runs a budget deficit, crowding out from higher inflation rates also occurs. In turn, investment and capital accumulation suffer at higher rates of inflation since inflation revenues promote the ability of the government to fund its borrowings. As a result, inflation leads to an increase in the severity of a crowding-out problem in financial markets.[1] However, in our framework, we model a private credit market which helps borrowers smooth consumption over time. Higher inflation rates and government debt crowd out funding in the credit market. Thus, following Schreft and Smith, the primary impact of inflation on economic activity is to finance government debt.

Moreover, in contrast to Schreft and Smith, we show that the impact of government debt depends on the degree of competition in the economy's banking system. Monetary authorities have long been aware of this problem. In 2001, the Bank for International Settlements warned: "Consolidation could reduce competition in these markets, increasing the cost of liquidity for some firms and impeding the arbitrage of interest rates between markets. In addition, consolidation could affect the performance of the market if the resulting large financial firms behave differently from their smaller predecessors."

Notably, the model demonstrates that distortions from market power in the credit market do indeed impede the arbitrage of interest rates between markets. Due to market power in the private credit market, the interest rate on private sector loans will be higher than the interest rate on government debt. This occurs even though both types of loans are risk-free in the model. In particular, the mark-up of private sector loans (over the yield on bonds) is higher in more concentrated markets.[2] In fact, interest rates in the private credit market would adjust more than one to one with changes in the rate of return to government debt as long as there are strategic incentives in the banking sector.

Similar to previous arguments by Ghossoub and Reed (2013) and Laosuthi and Reed (2013), intermediaries in concentrated financial systems have a tendency to hoard assets in markets where they have less market power in order to exploit their

[1] King and Levine (1993) discuss how public sector debt diverts funds away from the private sector.

[2] Hannan (1991) and Corvoisier and Gropp (2002) argue that borrowers in markets with higher concentration ratios face higher costs for loans. Moreover, they may also experience more difficulty obtaining access to credit – Beck, Demirguc-Kunt and Maksimovic (2003) document that credit rationing occurs more often in concentrated banking systems.

strategic incentives in the private credit market.[3] However, government bonds are not available in either of their frameworks. Thus, in contrast to both approaches, we show that banks with a lot of market power will tend to hoard government securities. In order to induce banks to switch from government bonds to private sector credit, monetary authorities in recent years have been forced to adopt unconventional monetary policies through Large Scale Asset Programs.

We argue that such a shift to large scale purchases of securities was in part due to the massive consolidation in the financial sector since the crisis occurred. At lower long-term interest rates on government debt, the incentives of banks to lend to private credit markets would improve. Thus, our model demonstrates that an increase in concentration would lower long-term government yields but lead to higher interest rates on private sector loans through its distortionary impact on interest arbitrage across markets. Consequently, we show the crowding-out problem from inflation is more severe in economies with concentrated banking systems.

The remainder of the paper is organized as follows. Section 2 provides a brief survey of recent work studying the role of the industrial organization of the financial system for economic activity. Section 3 presents the description of the physical environment in the model. Section 4 looks at activity in steady-state equilibrium. In particular, it studies the impact of the concentration of the financial sector for private credit market activity and long-term yields. It also discusses the effects of inflation. Section 5 makes some concluding remarks. Proofs of major results are presented in the Appendix.

2 Related Literature

Previous research demonstrates that the competitive structure of the financial system can have a significant impact on economic activity.[4] To begin, Ghossoub, Laosuthi, and Reed (2012) study how the effects of monetary policy vary between monopolistic and competitive banking systems. They show that in a perfectly competitive banking system, higher rates of money growth generate a Tobin-type effect in which inflation lowers interest rates and simulates lending activity. However, in a price-distorted monopolistic banking system, inflation generates the opposite effect. Building on the structure of Ghossoub, Laosuthi, and Reed, Matsuoka (2011) compares optimal monetary policy in a monopolistic banking sector to a competitive banking system. Ghossoub (2012) demonstrates how the industrial organization of the banking system affects prices in capital markets.[5] Boyd, De Nicolo, and Smith (2004) show that competitive banking systems are more fragile than monopolistic banking sectors.

[3] As documented by the Government Accounting Office, at the end of 2012, nearly half of all U.S. debt was held by international investors. Details are available at: www.gao.gov/special.pubs/longterm/debt/ownership.html.

[4] Tarullo (2011) challenges economists to devote more attention to the industrial organization of the financial system.

[5] Ruckes (2004) applies Bertrand competition in the presence of asymmetric information to study the interactions between the level of screening by banks and prices in the credit market. In their work, both papers principally focus on the financial contracts offered by banks. However, they do

As an alternative to price competition, other papers investigate the impact of imperfectly competitive behavior arising from quantity competition. Notably, Williamson (1986) assumes that financial intermediaries compete in terms of the quantity of loans they issue. Yet, in his framework, money is only a store of value. In addition, the economic functions of banks are quite different – while Williamson discusses the role of banks to alleviate costs of private information, we emphasize the risk pooling role of financial institutions. In a model of imperfectly competitive firms that differ in size, Ghossoub and Reed (2013) study the optimal size distribution of the banking system and the strength of monetary transmission to credit markets. However, in contrast to our work, government bonds do not compete with the private sector for funds. Finally, Laosuthi and Reed (2013) construct a framework with equilibrium entry into the banking sector and show that inflation magnifies barriers to entry in the banking system. Again, they do not include government bonds in their analysis.

3 The Model

We begin by considering an economy in the presence of non-cooperative behavior and limited banking entry. Following Schreft and Smith (1997) and Ghossoub, Laosuthi, and Reed (2012), banks compete by posting a schedule of interest rates in the deposit market. In contrast, competition in the credit market is characterized by quantity competition. In this manner, the degree of competition has a significant impact on the strategic behavior of banks.

3.1 Environment

The economy consists of an initial old generation and an infinite sequence of two-period-lived overlapping generations. At each date $t = 0, 1, ...$, young agents are born to one of two separate islands. Each island contains a continuum of young agents with unit mass. Although the two locations are separated, there is a single consumption good available on both sites. The price level for one unit of goods is common across islands and is defined as p_t at time t. For simplicity, the two islands are symmetric.

There are two types of ex-ante identical agents: depositors (which we also refer to as lenders) and borrowers. Young depositors are born with $x > 0$ units of the consumption good but do not receive endowments when old. They value consumption only in the last period (c_2) with preferences given by: $U(c_2) = \ln(c_2)$. In contrast, young borrowers are born without endowments but receive $y > 0$ units of the consumption good in their old-age. However, they derive utility from consumption in

not consider the effects of monetary policy. In contrast, Bagliano, Dalmazzo, and Marini (2000) propose that monetary policy can affect the ability of banks to collude in financial markets. While they demonstrate that the design of policy should account for strategic interactions among banks, depository institutions perform limited financial functions. In their framework, banks accept deposits and issue loans. That is, the primary function of banks is to promote intertemporal consumption smoothing. In contrast, following Diamond and Dybvig (1983), we incorporate that banks provide important risk pooling services to participants in financial markets.

both periods of their lives. The discounted lifetime utility function of borrowers is expressed by: $U(c_1, c_2) = \ln(c_1) + \beta \ln(c_2)$.

In this economy, there are N identical financial intermediaries on each island. Each bank's objective is to maximize profits in units of consumption goods. Banks have access to the financial system and can generate income by providing financial services to individuals in the economy. Specifically, banks offer a schedule of rates of return for each unit of deposits and charge prices for each unit of loans. With deposits received, banks can trade funds for two primary assets: fiat money and one-period, default-free loans. The return to fiat money depends on the total amount of currency in the economy. M_t denotes the per capita amount of the monetary base on each island and σ denotes the net growth rate of money. Therefore, the money supply for $t > 0$ evolves according to:

$$M_{t+1} = (1 + \sigma)M_t \tag{1}$$

Spatial separation and private information generate trade frictions in the economy. To be specific, there is no communication across islands. Consequently, private liabilities do not circulate between the two locations. Moreover, a relocation shock occurs on each island. In particular, a fraction of young depositors (π) must move to the other island. The probability of the relocation shock is exogenous, publicly known and the same in each site. Furthermore, fiat money is the only asset that agents can carry to the other location and exchange for goods. Therefore, the relocation shock plays the role of a liquidity preference shock in the Diamond-Dybvig model and fiat currency helps individuals avoid trading frictions. As a result, currency has an advantage over other assets in terms of liquidity. This allows fiat money to be dominated in rate of return.

Next, we explain the behavior of each group of agents. We proceed by studying the impact of competition and the effect of monetary policy on credit market activity.

3.2 Depositors

Depositors are born with endowments but derive utility from consumption only in their old-age. Due to the relocation shock and limited communication across locations, these young individuals deposit all of their endowments in banks. At the beginning of each time period, a unit mass of ex-ante identical workers and N financial intermediaries (or bankers) are born on each island. Each bank is indexed by j, where $j = 1, 2, ..., N$ and are risk-neutral agents. Therefore, the amount of deposits for each bank is given by:

$$d = \frac{x}{N}$$

3.3 Borrowers

Borrowers receive endowments when old and do not experience liquidity shocks. Furthermore, they value consumption during their youth and old-age. In order to smooth

consumption, they seek to obtain loans (l_t^d) from the credit market. Given R_t as the real interest rate for each unit of loans, a borrower's objective is:

$$\underset{l_t^d}{Max} \ln(l_t^d) + \beta \ln(y - R_t l_t^d) \tag{2}$$

Therefore, individual loan demand is given by:

$$l_t^d = \frac{y}{(1+\beta)R_t} \tag{3}$$

Obviously, individual loan demand is inversely related to the interest rate in the private credit market. When the endowment increases or the rate of time preference decreases, borrowers want to obtain more loans in order to smooth consumption. Furthermore, the total population of borrowers is equal to one in each location. Thus, the market loan demand (L_t) is the same as the individual loan demand.

3.4 The Government

Our framework follows Schreft and Smith (1997) in that the government issues inflation-financed government debt. All bonds are of one-period maturity and default-free. One unit of goods held in bonds at t constitutes a sure claim to R_t^b units of goods at $t+1$.[6] The government does not have any direct expenditures and does not levy direct taxes at any date. Thus, the government need only manipulate the supply of its liabilities to guarantee that it can meet its interest obligations in each period. The government budget constraint is given by:

$$R_{t-1}^b b_{t-1} = \frac{(M_t - M_{t-1})}{p_t} + b_t \tag{4}$$

Due to limited communication and spatial separation, agents cannot exchange privately issued claims across islands. Consequently, fiat money is the only asset that can be carried across locations.[7] Therefore, currency has an advantage over loans and bonds in terms of liquidity. This allows fiat money to be dominated in rate of return.

Next, we briefly describe the timing of actions in the economy. Banks announce deposit-return schedules that depend on depositor-withdrawal dates and depositors deposit their funds at banks. Based upon deposits received, banks choose portfolios that consist of currency reserves, loans, and government bonds. Money balances are obtained by receiving transfers of fiat money from the monetary authority and by trading some of the deposits to relocated old agents. The rest of deposits will be invested in the credit market and the bond market. After bank portfolios for the current period are established, old borrowers receive their endowments and pay back

[6] Alternatively, one unit of bonds held in period t yields I_t units of currency in period $t+1$. Thus, we can express the real return to bonds as $R_t^b = I_t \frac{p_t}{p_{t+1}}$.

[7] Government bonds cannot be used in interlocation exchange since they are issued in relatively large denominations.

their loans along with interest to the bank. Furthermore, intermediaries may receive additional income from the previous bond market if they are net lenders. However, if they are net borrowers, income from the previous loan market will be used to pay the principal and interest to the government. When the previous bond market is settled, banks use the funds to finance payments to nonrelocated individuals. At the end of the period, the relocation shock occurs and old borrowers die.

3.5 Banks

Banks engage in non-cooperative behavior and there is a fixed degree of entry in the financial industry. In particular, banks compete in terms of the quantity of loans they offer to borrowers in the credit market. However, they also choose an amount of bonds (b_t^d) and real money balances (m_t), to hold. In the deposit market, banks compete by offering rates of return to deposits. As a result, the deposit market is effectively a perfectly competitive market.

As a simple benchmark, we begin by studying the portfolio choice of a bank in the absence of government debt. As in Laosuthi and Reed (2013), banks maximize the expected utility of a representative depositor since the deposit market is perfectly competitive:

$$\underset{r_t^m, r_t^n, m_t, l_t^s}{Max} \pi \ln(r_t^m \frac{x}{N}) + (1-\pi) \ln(r_t^n \frac{x}{N}) \tag{5}$$

Furthermore, the bank's portfolio allocations must satisfy the balance sheet constraint:

$$m_t + l_t^s \leq \frac{x}{N} \tag{6}$$

Since currency is the only asset that can be transported across locations, the return to relocated agents is constrained by the amount of currency holdings and the inflation rate:

$$\pi r_t^m \frac{x}{N} \leq m_t \frac{p_t}{p_{t+1}} \tag{7}$$

In addition, money is dominated in rate of return. Therefore, intermediaries will not carry balances between periods. As a result, banks use the revenues from the credit market and the bond market to finance payments to nonrelocated agents:

$$(1-\pi) r_t^n \frac{x}{N} \leq R_t \; l_t^s + R_t^b b_t^d \tag{8}$$

Banks can prevent liquidity crises by offering a schedule of deposit rates so that nonrelocated agents receive higher returns than relocated agents:

$$r_t^m \leq r_t^n \tag{9}$$

Proposition 1 (Laosuthi and Reed 2013). *Suppose the borrower's endowment is sufficiently high such that* $y \geq \frac{N(1-\pi)(1+\beta)x}{[N-(1-\pi)](1+\sigma)}$. *Under this condition, a steady-state equilibrium exists and is unique. Each bank competes by allocating funds to portfolios such that* $m = \left(\frac{N}{N-(1-\pi)}\right)\pi\frac{x}{N}$ and $l^s = \left(\frac{N-1}{N-(1-\pi)}\right)(1-\pi)\frac{x}{N}$.

Based upon the above Proposition, in the absence of government debt, the portfolio choices of banks are primarily determined by conditions in the deposit market. That is, the individual loan supply of each bank only depends on deposits received and the degree of concentration in the financial sector.

With this background, we turn to the primary purpose of our work – portfolio allocations in the presence of government debt – and the role of concentration in the financial sector:

$$\underset{r_t^m, r_t^n, m_t, l_t^s, b_t^d}{Max} \pi \ln(r_t^m \frac{x}{N}) + (1-\pi)\ln(r_t^n \frac{x}{N}) \tag{10}$$

The balance sheet constraint must adjust for government bonds:

$$m_t + l_t^s + b_t^d \leq \frac{x}{N} \tag{11}$$

Banks obtain revenues from both the credit market and the bond market:

$$(1-\pi) r_t^n \left(\frac{x}{N}\right) \leq R_t \; l_t^s + R_t^b b_t^d \tag{12}$$

In order to maximize the expected utility of a representative depositor, banks allocate funds to money balances, loans, and government bonds:

Proposition 2. (Portfolio Allocations of a Typical Bank in the Presence of Government Bonds).

$$m_t = \pi\left(\frac{x}{N}\right) + \left(\frac{\pi}{N(1+\beta)R_t^b}\right)\left(\frac{y}{N}\right) \tag{13}$$

$$l_t^s = \left(\frac{N-1}{N}\right)\left(\frac{1}{(1+\beta)\,R_t^b}\right)\left(\frac{y}{N}\right) \tag{14}$$

$$b_t^d = (1-\pi)\left(\frac{x}{N}\right) - \frac{[N-(1-\pi)]}{N(1+\beta)R_t^b}\left(\frac{y}{N}\right) \tag{15}$$

While the portfolio choices of banks in the absence of government debt are primarily determined by conditions in the deposit market, the amount of funds lent by each bank depends on conditions in the private credit market and the interest rate on loans to the government in the presence of government bonds. In this manner, the results reflect that banks regard the rate of return on government bonds as given, but they take into account how the amount of loans offered affects interest rates in the private credit market.

The results suggest that the distortions from government participation in credit markets fundamentally change the behavior of private sector intermediaries. In the absence of the distortion from the availability of government bonds, lending by each institution only depended on their amount of deposit funding and the degree of concentration in the financial sector $\left(\frac{x}{N}\right)$. That is, the extension of credit depends in large part on the amount of deposit funding available to intermediaries to extend to borrowers.

However, in the presence of government bonds, banks more aggressively take into account how their actions affect the demand for funds facing each firm as exhibited by the term $\left(\frac{y}{N}\right)$. In fact, loan supply is entirely independent of deposit funding. Instead, the amount of deposits received only affects the demand for bonds. This takes place because intermediaries do not behave as if they have market power in the public debt market but they do have strategic incentives in the private credit market.

Interestingly, as we discuss in more detail below, a no-arbitrage condition between lending to the government and private sector loans also affects the availability of credit funding by each intermediary. Notably, higher real returns to government bonds (R_t^b) drive down loan supply. Moreover, the term $\left(\frac{N-1}{N}\right)$ reflects the degree of pricing distortions arising from imperfectly competitive behavior. As the degree of competition in the credit market is higher, $\left(\frac{N-1}{N}\right)$ goes to one and each bank lends relatively more funds to borrowers. In turn, banks demand less government bonds.

Money balances are increasing in the fraction of relocated agents. However, a bank's money balances are independent of the inflation rate. Thus, by construction, inflation only affects economic activity through the government's budget constraint and its ability to issue bonds.

In contrast to money balances, the amount of loans is independent of the liquidity shock. Banks can take advantage of the bond market by borrowing or lending additional funds. Therefore, banks can issue loans that maximize profits in the credit market regardless of the probability of the relocation shock. In this manner, government debt helps banks to exploit their market power in the credit market.

In particular, currency reserves are negatively related to the rate of return to government debt. This occurs because the return in the bond market reflects the opportunity cost of holding money. It also represents the opportunity cost of loans to the private sector. If government bonds yield a higher rate of return, these costs increase. As a result, banks hold less money balances and issue less loans to the private credit market.

Based on banks' portfolio allocations, the relationship between interest rates in the private credit market and the market for government bonds is:

Lemma 1. (The No-Arbitrage Condition Between Government Bonds and Private Sector Loans).

$$\left(\frac{N-1}{N}\right) R_t = R_t^b \tag{16}$$

Interestingly, the rate of return in the private credit market is higher than the rate of return in the bond market. Each bank realizes that its own decisions about loans affect the market interest rate. However, they take decisions of other institutions (especially the government) as given. Thus, banks issue loans such that the marginal revenue in the private credit market ($\left(\frac{N-1}{N}\right) R_t$) is the same as the marginal revenue in the public debt market (R_t^b).

That is, distortions from imperfectly competitive behavior lead to higher interest rates on private sector loans than government debt. As a result, the standard no-arbitrage condition between private and public credit markets breaks down under imperfectly competitive behavior. Thus, there are twin distortions affecting the availability of funding by each institution. The two distortions combine to affect the amount of loans to the private sector. Notably, the distortionary impact of higher returns to government debt (R_t^b) is stronger as the sector is more highly concentrated (N smaller). To be specific, the wedge $R_t - R_t^b$ is smaller as the number of banks is higher. In particular, under perfect competition, interest rates in both markets will be the same.

We view this finding to be particularly important in light of the aggressive actions of central banks that have been adopted since the financial crisis started. During the initial phase of the crisis, traditional monetary policy tools were largely utilized to promote credit activity. For example, in the United States, the Federal Reserve aggressively lowered the federal funds rate from September 2007 through December 2008. After traditional remedies were exhausted, the central bank relied heavily on the size of its balance sheet to stimulate economic activity.

Eventually, the Federal Reserve adopted Large Scale Asset Programs which were targeted towards purchases of longer-dated government securities to lower their yields and spur private credit market activity. In particular, the Maturity Extension Program focused solely on long-term interest rates by shifting the composition of maturities held by the Federal Reserve.

Moreover, during the crisis, the financial sector aggressively consolidated, reinforcing banks' market power. Fisher and Rosenblum (2009) and Rosenblum et al. (2010) argue that the high levels of concentration during the crisis "clogged" the standard transmission channels of monetary policy. As a result, unconventional policies to lower long-term interest rates were adopted.

Notably, our framework demonstrates that policies targeted towards long-term interest rates on government debt could be effective in promoting credit market activity. At lower long-term interest rates on government debt (R_t^b), the incentives of banks to lend to private credit markets would improve and individual loan supply (l_t^s) would increase. This is especially valuable in highly concentrated financial systems as the mark-up of private sector loans (over the yield on bonds) is higher in more concentrated markets. In particular, interest rates in the private credit market would adjust more than one to one with changes in the rate of return to government debt as long as there are strategic incentives in the banking sector.

Next, we examine interest rates offered to individuals in the deposit market. It is easy to demonstrate that the rate of return to relocated agents is:

$$r_t^m = \left(1 + \frac{1}{R_t^b(1+\beta)x}\frac{y}{N}\right)\frac{p_t}{p_{t+1}} \tag{17}$$

As in the benchmark framework, relocated agents can only carry fiat money to the other location. Thus, the short-term interest rate depends on the rate of inflation. In contrast to the benchmark model, the return to movers is independent of the probability of the relocation shock. This occurs because banks can receive or lend additional reserves through the bond market. For example, if the fraction of relocated agents is higher, banks acquire more money balances. However, money is dominated in rate of return. Therefore, banks do not hold excess reserves. As a result, the rate of return to movers is not affected by the liquidity shock.

In addition, the long-term interest rate on deposits can be expressed as:

$$r_t^n = R_t^b + \frac{1}{(1+\beta)x}\frac{y}{N} \tag{18}$$

As in the preceding section, the long-term interest rate depends on agents' endowments. In particular, when borrowers' endowments are higher, the demand for loans increases. Thus, banks can generate more income from the credit market. Consequently, the rate of return to nonmovers is higher. In contrast to the benchmark model, at a given interest rate on private sector loans (R_t^b) the return to nonmovers is independent of the fraction of movers. This occurs because the loan supply of each bank is independent of the liquidity shock. Next, we study outcomes in the steady-state.

4 Steady-State Equilibrium Activity

In equilibrium, three conditions must hold. First, the money market must clear. In particular, total money demand must be equal to money supply:

$$Nm = \frac{M}{p} \tag{19}$$

Second, the supply of bonds must satisfy the government budget constraint:

$$R^b b = \frac{(M - M_{-1})}{p} + b \tag{20}$$

Finally, interest rates between the private credit market and the market for government bonds require:

$$\left(\frac{N-1}{N}\right)R = R^b \tag{21}$$

Given I as the gross nominal interest rate on government debt, the supply of bonds can be obtained by imposing steady-state on the system and substituting the money demand function into the government budget constraint:

$$b = \frac{\sigma\pi x}{I - (1+\sigma)} + \frac{\pi(1+\sigma)}{[I-(1+\sigma)](1+\beta)I}\left(\frac{y}{N}\right) \tag{22}$$

Alternatively, one can apply the bank's balance sheet constraint (11) and express (22) as:

Lemma 3. (The Bond Market Clearing Condition)

$$L = x - \pi x \left(\frac{I-1}{I-(1+\sigma)} \right) - \frac{\pi(1+\sigma)}{(1+\beta)I} \left(\frac{I-1}{I-(1+\sigma)} \right) \frac{y}{N} \tag{23}$$

As stated in the Lemma, we refer to (23) as the bond market clearing condition. Notably, the last term represents distortions from market power and inflation. As the banking sector is more concentrated, each bank recognizes that its supply of loans has a more significant impact on interest rates in the private credit market. Moreover, inflation and public sector crowding out exacerbate distortions from imperfectly competitive behavior. At higher inflation rates, seigniorage revenues increase. This allows the government to issue more bonds. As a result, less funds are available for the private sector.

Furthermore, the inverse demand function for private sector loans (3) can be used to rewrite the relationship of interest rates between the credit market and the bond market from equation (21) as:

Lemma 4. (The No-Arbitrage Condition)

$$L = \left(\frac{N-1}{N} \right) \frac{(1+\sigma)y}{(1+\beta)I} \tag{24}$$

This equation represents the no-arbitrage condition between private sector loans and government debt. In particular, as the financial sector is less competitive, the interest rate on private sector loans exceeds the real interest rate on government debt. Under perfect competition, the amount of funds available in the private credit market is equal to $\frac{(1+\sigma)y}{(1+\beta)I}$.

In steady-state equilibrium, the bond market clearing condition and the no arbitrage condition must be satisfied. We proceed by describing the properties of these two conditions. First, we analyze the bond market clearing condition. Figure 3 illustrates combinations of loans and interest rates that clear the market for government

bonds.

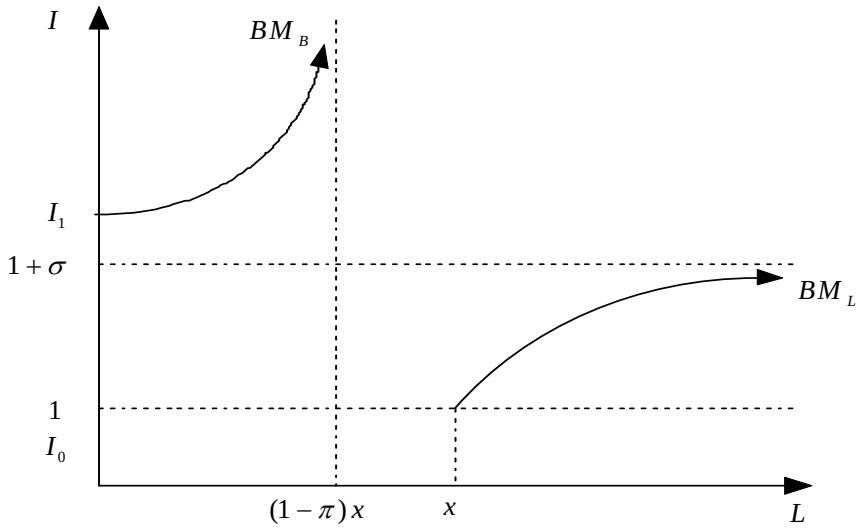

Figure 1: The Bond Market Clearing Condition

In the Figure, BM_B and BM_L are the bond market curves when the government is a net borrower and a net lender in the bond market respectively. To characterize the locus described in Figure 1, we first consider the level of the nominal interest rate when the amount of loans is equal to zero. If borrowers are born with sufficiently high endowments, (23) yields two loci, $I_0 < 1$ and $I_1 > 1 + \sigma$. However, money must be dominated in rate of return. Therefore, the locus I_0 is ignored.

We continue by studying the relationship between the nominal interest rate and the amount of loans. When $I > 1 + \sigma$, the government is a net borrower. If the nominal interest rate is higher, required interest payments are higher. Therefore, the government will not be able to issue many bonds and satisfy its budget constraint. In order for the bond market to clear, the amount of loans must increase. That is, banks must be willing to issue more loans and hold less government debt.

Moreover, the relationship depends upon the degree of competition in the financial sector. It can be shown that the bond market curve is steeper if the financial industry is more competitive. That is, under higher degrees of competition in the banking system, the nominal interest rate on government debt must rise more in order for asset markets to clear.

To gain deeper perspective, it is useful to refer to equation (22). Notably, the first term $\frac{\sigma\pi x}{I-(1+\sigma)}$ reflects the amount of bond holdings if financial markets are perfectly competitive. Under higher nominal interest rates, the government must pay a higher rate of return and cannot issue as many bonds. As a result, the amount of loans to the private sector must increase. The second term $\frac{\pi(1+\sigma)}{[I-(1+\sigma)](1+\beta)I}\left(\frac{y}{N}\right)$ represents the additional demand for government debt due to imperfectly competitive behavior. If there are more banks, the amount of bond holdings would be lower. Therefore, the nominal return to government debt must rise more if the banking sector is more competitive.

In addition, it is straightforward to demonstrate that $\lim_{I\to\infty} L = (1-\pi)x$. When the nominal interest rate approaches infinity, the government must pay a very high interest rate. Thus, the amount of bond supply must be very small. Moreover, from (16), we can observe that a higher interest rate in the bond market is associated with a higher interest rate in the private credit market. Therefore, banks are willing to issue more loans and hold less currency reserves. However, relocated agents need fiat money for transaction services. Furthermore, from (13), the smallest amount of money balances that banks hold is πx. As a result, the amount of loan supply is close to $(1-\pi)x$ when the nominal interest rate approaches infinity.

Next, we consider the steady-state in which the government is a net lender ($I < 1+\sigma$). First, when the nominal rate of return to bonds is equal to one, the amount of loans in the credit market is x. Intuitively, if government bonds yield the same rate of return as fiat currency, the cost of borrowing from the government is very low. Thus, banks use all deposits to issue loans. In order to acquire money balances, banks borrow funds from the government and trade with old relocated depositors.

Furthermore, it is easy to show that $\lim_{L\to\infty} I = 1+\sigma$. When the amount of loans approaches infinity, the government lends a large amount of funds to the private sector. This can only occur if the nominal interest rate is close to $1+\sigma$.

At this point, it is useful to compare our work on inflation-financed government debt with Schreft and Smith (1997). In a production economy, Schreft and Smith also incorporate inflation-financed government bonds. In their framework, if the government runs a budget deficit, crowding out from higher inflation rates also occur. In turn, the economy's level of development suffers at higher rates of inflation since less investment and capital accumulation occur.

There are two features that are distinct in our model. First, we model a private credit market which helps borrowers smooth consumption over time. Higher inflation rates and government debt reduce their ability to do so. Second, we show how this problem depends on the degree of competition in the economy's banking system.

We proceed by analyzing the conditions in which banks are indifferent between lending funds to the government or the private sector. If the nominal interest rate falls, the real return to government bonds will be lower. This provides banks with greater incentive to lend in the private credit market. In contrast to Figure 1, Figure 2 represents the combination of private sector loans and interest rates in the public

debt market that satisfy the no arbitrage condition.

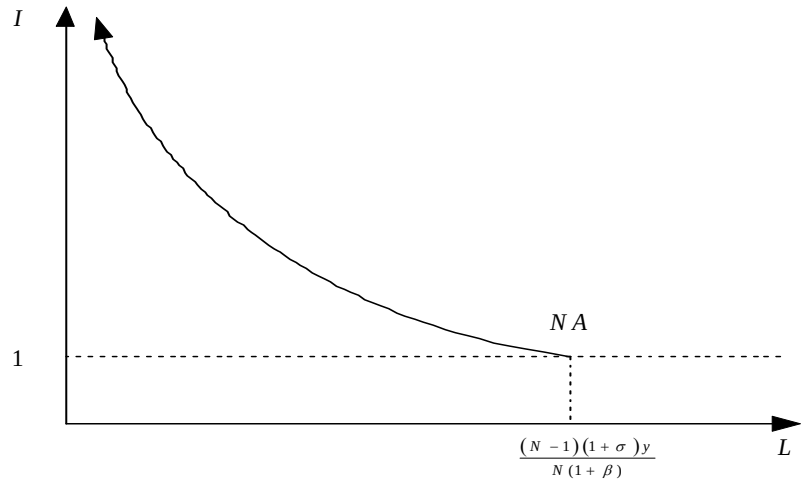

Figure 2: The No Arbitrage Condition

We refer to the NA curve in Figure 2 as the no arbitrage curve. Moreover, if the financial sector is more competitive, banks have less market power. Consequently, the amount of lending activity responds more to the nominal return to government debt if there are more banks. As a result, the no-arbitrage curve will be more flat if the financial sector is more competitive. Furthermore, as $I \to \infty, L \to 0$ and as $L \to \infty$, $I \to 0$. When the nominal interest rate approaches infinity, banks incur a significantly high opportunity cost by lending in the private credit market. Therefore, except for funds dedicated to currency reserves, they invest all funds in government bonds. Finally, if the amount of loans is close to infinity, the cost of borrowing must be extremely low. This implies that the nominal interest rate must approach zero.

In order to determine the steady-state amount of loans and nominal interest rates, we consider the interactions between the bond market clearing condition and the no arbitrage condition. Thus, we utilize Figure 3 to demonstrate the resulting steady-

state equilibria:

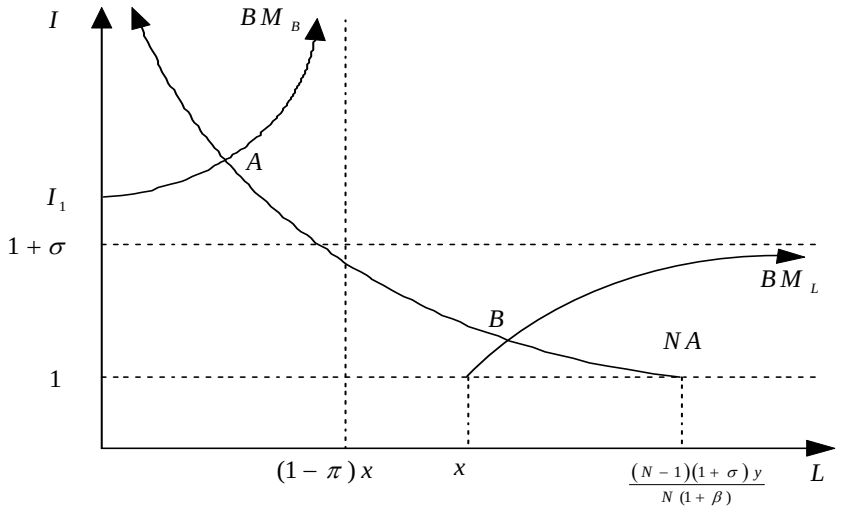

Figure 3: Steady-State Equilibria

The no arbitrage condition is a continuous function. Therefore, it passes through $I = 1 + \sigma$. As a result, we establish the first steady-state equilibrium at point A. Furthermore, at $I = 1$, if borrowers receive sufficiently high endowments, the demand for loans will be relatively high. As result, the effect of the no arbitrage condition on the amount of loans will be stronger than the bond market clearing condition. That is, the amount of loans implied by the no arbitrage condition will be higher than the bond market clearing condition. Consequently, we establish the steady-state equilibrium at point B.

Proposition 3: *Suppose borrowers receive sufficiently high endowments such that* $y > Max\left[\frac{1+\sigma-\pi-2\sigma\pi}{\pi}, \frac{1}{N-1}\right]\frac{N(1+\beta)x}{1+\sigma}$. *Under this condition, there are exactly two nontrivial steady-state equilibria with* $I > 1$.

From Figure 3, one steady-state occurs at a high nominal interest rate and a low amount of loans. In contrast, the other steady-state has a low nominal interest rate and a large amount of loans. The possibility of multiple steady-state equilibria arises because the government can act differently in the credit market. Specifically, when the government is a net borrower, government debt competes with private loans in banks' portfolios. Therefore, public sector crowding out diverts funds away from the private sector. Consequently, government debt exacerbates the distortions from imperfectly competitive behavior.

In contrast, if the government is a net lender, it transfers funds to banks. As a result, banks have more funds to invest in the credit market. In this manner, the actions of the government can alleviate credit market distortions. We proceed by studying the interaction between inflation and the degree of competition in the financial sector.

4.1 The Effects of Banking Competition

To understand the impact of banking competition in the presence of government debt, we focus on the impact of the degree of concentration in the banking sector through each transmission channel individually. That is, we study the impact of the competitive structure through the bond market and the no-arbitrage conditions in isolation. We conclude by studying their joint impact.

We start by investigating the effects of competition through the bond market clearing condition. The impact is shown by differentiating (23):

$$\frac{\partial L}{\partial N} = \left(\frac{\pi(1+\sigma)}{N(1+\beta)I}\right)\left(\frac{I-1}{I-(1+\sigma)}\right)\left(\frac{y}{N}\right) > 0 \text{ if } I > (1+\sigma) \tag{25}$$

As shown in Figure 6 below, the bond market clearing curve shifts out when the degree of competition is higher. From equation (25), at a fixed nominal interest rate on government *debt*, the amount of loans will be higher when there is more competition in the financial sector.

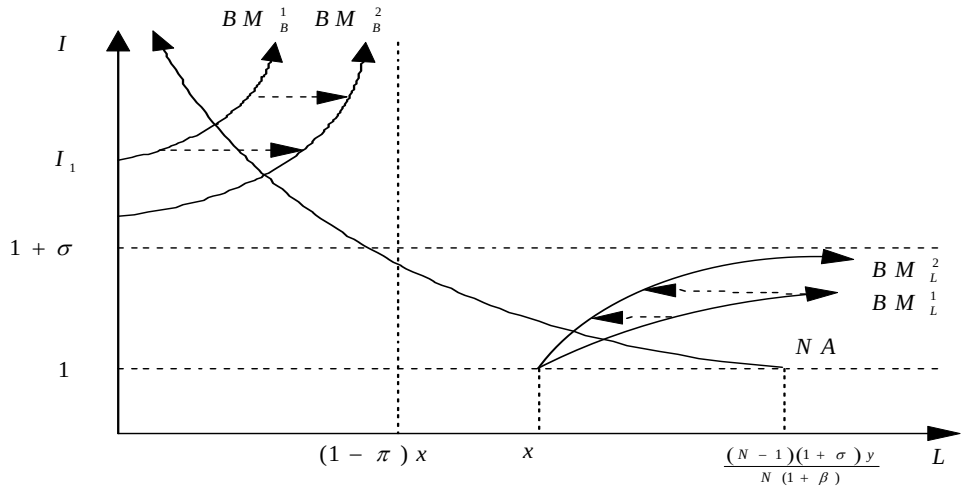

Figure 4: The Effect of Banking Competition on the Bond Market Curve

When there are more banks in the economy, each bank is willing to issue more loans since the individual institution has less influence on interest rates in the private credit market. Therefore, the demand for government bonds decreases while the amount of private sector loans increases. In turn, the interest rate on government debt must fall. In this manner, increased competition implies that the crowding out effect is less significant. However, if the banking sector is initially very competitive, increased entry in the financial sector will have less impact.

In contrast, when the government lends funds to banks, higher financial competition leads to the movement of the bond market curve from BM_L^1 to BM_L^2. If the degree of competition is higher, pricing distortions are lower and banks will seek to borrow more from the government in order to lend to the private sector. Consequently, the costs of obtaining funds must rise in order for financial markets to clear.

As a result, the total amount of funds devoted to the credit market actually falls when the sector is more competitive.

Next, we examine how competition affects financial market behavior through the no arbitrage condition. The effect of financial competition can be expressed by:

$$\frac{\partial L}{\partial N} = \left(\frac{(1+\sigma)y}{N(1+\beta)I}\right)\left(\frac{y}{N}\right) > 0 \tag{26}$$

We illustrate this impact in Figure 5:

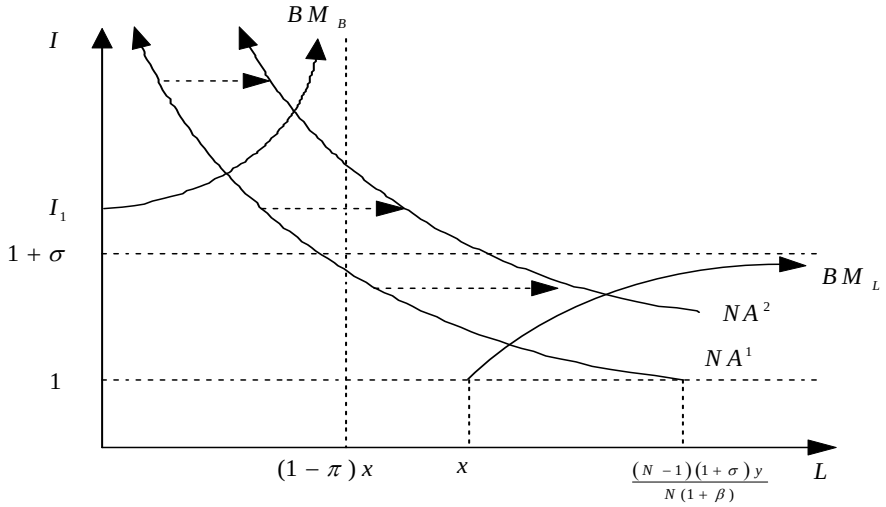

Figure 5: The Effect of Banking Competition on the No Arbitrage Curve

As shown in the Figure, when the degree of banking competition is higher, the no arbitrage curve moves from NA^1 to NA^2. This occurs because each bank understands that its market power is lower and the opportunity cost of issuing loans ($\left(\frac{N}{N-1}\right)R^b$) is lower in an economy with more banks. As a result, the volume of loans increases while the amount of government debt decreases. In turn, the nominal interest rate increases. Furthermore, as in the case of the bond market clearing condition, the effect on lending activity is less significant if the banking sector is more competitive. In this manner, the impact of competition on the credit market will be weaker if the credit market is initially competitive.

In summary, if the government runs a budget deficit, higher banking competition leads to a higher volume of private lending activity. Consequently, if the banking system is more competitive, the crowding out problem from inflation-financed government debt will be less severe. This occurs because the distortions from market power in the private credit market are not as strong. The impact of banking competition on government yields is explained in Lemma 5 below:

Lemma 5. (The Impact of Competition in the Banking System on Government Yields). *Suppose that the conditions in Proposition 3 hold. If the effect of competition through the no-arbitrage condition dominates the bond market clearing condition, an increase in banking competition is associated with a higher yield on government bonds.*

The results in Lemma 5 are quite interesting given the behavior of yields since the crisis began. If the banking sector is more competitive, the distortions from market power in the private credit market are lower. Consequently, each bank will issue more loans and buy less government bonds. As a result, the yields on government debt must rise if the no-arbitrage condition has a strong impact. The opposite results apply if concentration increases as observed since the beginning of the crisis. Due to the increase in concentration, the model predicts that banks would issue less loans and acquire more government debt. Thus, along with the Large Scale Asset Purchase Programs from the Federal Reserve, the decline in yields since the crisis began could also be due to the widespread consolidation observed in the financial sector as banks more aggressively assert their market power. The results for economies where the government lends funds to banks are analogous.

While the effects of banking competition on credit market activity might appear to be ambiguous, we are able to demonstrate that:

Proposition 4: *Suppose that both steady-state equilibria exist. Furthermore, let* y *satisfy* $(\left\{\frac{N(1+\beta)x}{(1+\sigma)}\left[\frac{(1+\sigma-\pi)}{\pi}, \frac{2(1+\sigma+\pi)}{(1+\pi)(N-2)}\right]\right\}$ *and* $N < 2\left(\frac{1+\sigma+\pi+2\sigma\pi}{1+\sigma+\sigma\pi-\pi^2}\right)$. *Under these conditions, a higher degree of financial competition leads to an increase in private sector loans.*

We offer some interpretation for the conditions in the Proposition. To begin, an increase in borrowers' endowments leads to higher demand for loans. This allows banks to exploit their market power in the credit market. Consequently, if banks lend funds to the government, the effect of the no arbitrage condition will be stronger than the effect of the bond market clearing condition. In contrast, if banks obtain funds from the government and borrowers receive very large amounts of endowments, the demand for loans will be relatively high. As a result, the effect of the bond market clearing condition may be stronger than the effect of the no arbitrage condition. That is, if more banks compete for funds from the government, higher levels of competition may actually lead to less credit market activity. This is due to the higher cost of funds from the government when the banking sector is more competitive. Yet, under the upper bound for borrowers' endowments stated in the Proposition, competition leads to increased lending activity.

Furthermore, the number of banks cannot be too high. When the banking sector is highly competitive, there are few distortions from imperfectly competitive behavior. Since banks do not have the ability to exploit their market power, the effect of N through the no-arbitrage condition can be dominated by the effect through asset market clearing.

Next, we proceed by considering the impact of banking competition on the real interest rate in the credit market. By following Proposition 4 and applying (3), we obtain Proposition 5:

Proposition 5: *Higher financial competition leads to a lower real interest rate in the private credit market.*

Interestingly, the results demonstrate that the impact of competition on interest rates varies across the private credit market and public debt market. It is natural to believe that interest rates in the private credit market would respond in the same manner. However, this ignores the pricing distortions from imperfectly competitive behavior in the private market for funds. For clarity, recall the no-arbitrage condition implies that the interest rate on private loans exceeds the interest rate on government debt: $R = \left(\frac{N}{N-1}\right) R^b$. Although the real interest rate in the private credit market is lower when the financial sector is more competitive, the change in the degree of pricing distortions also has an effect on yields as reflected by the term $\left(\frac{N}{N-1}\right)$. As a result, economies with more banks will have lower interest rates on private sector loans but the impact on yields depends on the strength of the no-arbitrage condition. Similar interpretation applies to the steady-state in which the government runs a budget surplus.

At this point, we have shown that the impact of inflation-financed government debt on private credit markets strongly depends on the degree of competition in an economy's banking system. Next, we examine how the impact of inflation depends on the competitive structure of the financial system and the government's position in financial markets.

4.2 The Effects of Inflation

Notably, in the presence of government debt, we have identified two additional transmission channels which affect the provision of funds to the private credit market. The first reflects pricing distortions from imperfect competition – the interest rate on private sector loans will be higher than the interest on government bonds. This occurs even though both types of loans are risk-free in the model. The second channel is the standard crowding-out problem – yet, here, the effect of fiscal policy clearly depends on the incentives of financial institutions to transfer funds to private borrowers. This exacerbates frictions from imperfectly competitive behavior. As demonstrated below, these transmission channels offer new mechanisms in which inflation affects financial market activity.

We begin by discussing the effects of inflation from the bond market clearing condition. Upon differentiating (23):

$$\frac{\partial L}{\partial \sigma} = -\left(\frac{\pi\left(I-1\right)}{\left[I-\left(1+\sigma\right)\right]^2}\right)\left(x+\frac{y}{N\left(1+\beta\right)}\right) < 0 \tag{27}$$

As observed, higher inflation rates lend to less lending activity in the private loan market. This reflects the standard crowding out problem from inflation-financed government debt. In Figure 6, the bond market curves shift from BM_B^1 to BM_B^2. The reduced availability of funds to the private sector comes from two sources.

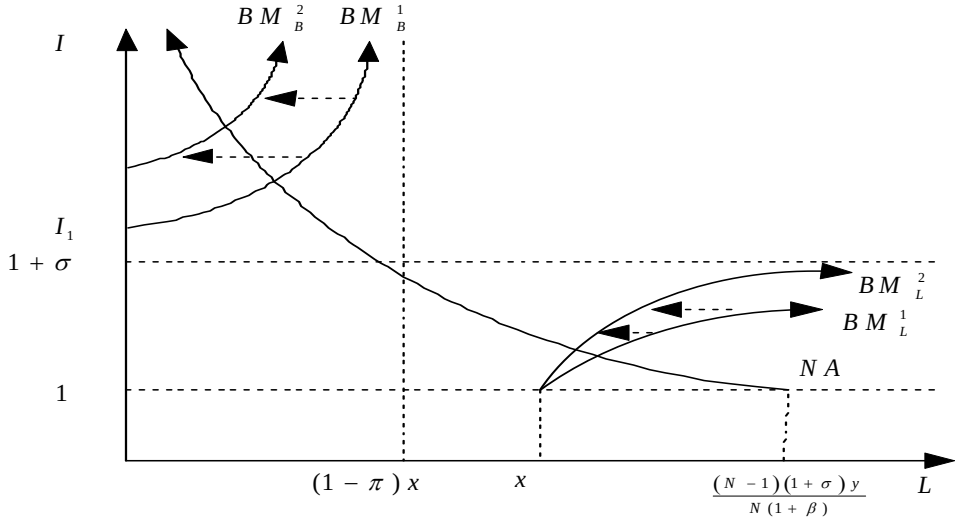

Figure 6: The Effect of Inflation on the Bond Market Curve

The first term, $-\left(\frac{\pi(I-1)}{[I-(1+\sigma)]^2}\right)x$, demonstrates how inflation affects the provision of funds under perfect competition. Under a higher rate of money growth, the real value of bonds decreases and the government can issue more debt. This leads to less lending activity in the private sector.

The second term, $-\left(\frac{\pi(I-1)}{[I-(1+\sigma)]^2}\right)\left(\frac{y}{N(1+\beta)}\right)$ shows the additional distortionary effect of market power. As the government seeks to obtain more funds from banks, this provides banks with additional investment opportunities and allows them to exploit their market power in the private credit market. This indicates that inflation-financed crowding out will have a stronger impact on the availability of funds to the private credit market if the banking system is more concentrated.

Inflation also affects the no-arbitrage condition across financial markets. These interactions can be observed by differentiating (24):

$$\frac{\partial L}{\partial \sigma} = \left(\frac{N-1}{N}\right)\frac{y}{(1+\beta)I} \tag{28}$$

The impact of inflation on the no arbitrage curve is illustrated in Figure 7:

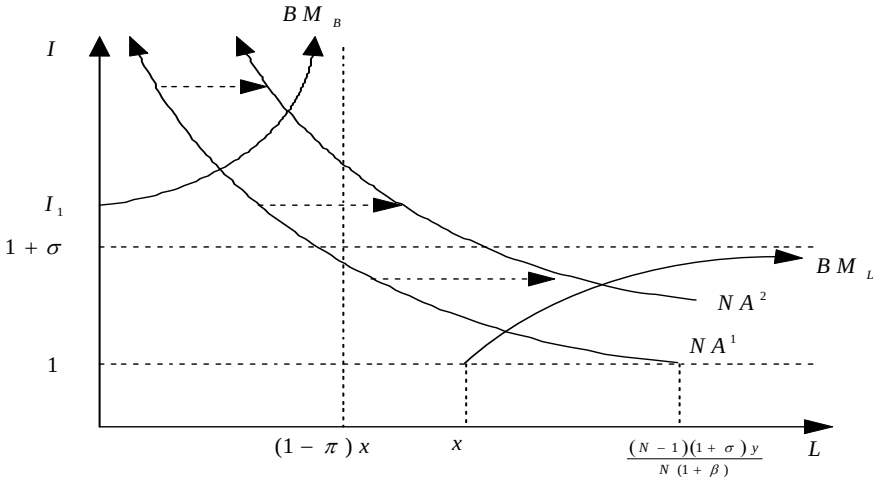

Figure 7: The Effect of Inflation on the No Arbitrage Curve

As shown in the Figure, the no arbitrage curve moves from NA^1 to NA^2. Intuitively, when inflation is higher, the real return in the bond market falls. Thus, the opportunity cost of issuing loans is lower. From this perspective, inflation may enhance welfare by lowering the real return to government debt and providing banks with less opportunities to exploit their market power in the private credit market.

As a result, the effects of inflation on credit market outcomes appear to be ambiguous. While the accompanying crowding out problem can be severe, inflation may alleviate pricing distortions from imperfectly competitive behavior. In order to obtain more insights, we look at some numerical illustrations. As an example, consider the following set of parameters: $x = 1.5$, $y = 10$, $\beta = 0.9$, $\pi = 0.5$, $N = 2$. Table 1 presents the results:

Growth Rate of Money	0.05	0.1	0.15	0.2
Rate of Return to Money	0.952381	0.909091	0.869565	0.833333
Equilibrium with Budget Deficit				
Nominal Interest rate in the Bond Market	5.608041	5.95192	6.29498	6.637365
Real Interest Rate in the Bond Market	5.340992	5.410836	5.473896	5.531138
Real Interest Rate in the Credit Market	10.68198	10.82167	10.94779	11.06228
Bonds	0.01093	0.02047	0.028874	0.036337
Loans	0.492714	0.486353	0.480751	0.475775
Equilibrium with Budget Surplus				
Nominal Interest rate in the Bond Market	1.018275	1.037554	1.057651	1.078424
Real Interest Rate in the Bond Market	0.969785	0.943231	0.919697	0.898687
Real Interest Rate in the Credit Market	1.939571	1.886462	1.839394	1.797373
Bonds	-3.320352	-3.434943	-3.542032	-3.642374
Loans	2.713568	2.789962	2.861355	2.928249

Table 1: Effects of Inflation

Moreover, the results are robust to different sets of parameters. As a result, we conclude:

If the government is a net borrower, inflation is negatively related to the amount of loans. In contrast, when the government is a net lender, higher inflation leads to a higher amount of loans.

Interestingly, these results relate to work by Boyd, Levine, and Smith (2001) who also find inflation is associated with a lower amount of credit market activity. They posit that the effects of inflation occur due to the presence of asymmetric information in the credit market. As inflation leads to lower real interest rates, both good and bad borrowers will seek to obtain funds. Consequently, banks respond by issuing less loans. By comparison, in our framework, inflation lowers the volume of lending activity because of pricing distortions from imperfect competition and public sector crowding-out effects.

How do the effects of inflation-financing of debt depend on the competitive structure of the banking system?

At this point, we have shown that both the inflation rate and the degree of competition have a significant impact on the credit market. Moreover, inflation can exacerbate distortions from imperfectly competitive behavior. We conclude the analysis by studying how the effects of inflation-financing depend upon the competitive structure of the financial industry. This is shown by differentiating (27) and (28) with respect to the number of banks:

$$\frac{\partial L}{\partial \sigma \partial N} = \frac{(I-1)\,\pi y}{(1+\beta)\,N^2\left[I-(1+\sigma)\right]^2} > 0 \tag{29}$$

$$\frac{\partial L}{\partial \sigma \partial N} = \left(\frac{N-1}{N}\right)\frac{y}{(1+\beta)N^2 I} > 0 \tag{30}$$

As illustrated by (29) and (30), the effects of inflation depend on the competitive structure of the financial system. In order to gain deeper understanding, we first provide economic intuition for (29). As previously discussed, inflation will cause the bond market curve to shift back. This results in a lower availability of funds to the private sector. Nevertheless, when the degree of competition is higher, banks are willing to issue more loans. In this manner, the decrease in funds will be lower if the financial sector is more competitive. This suggests that inflation-financing will have a stronger impact on credit market activity if the banking system is more concentrated.

We continue by explaining the interactions between the degree of competition and monetary policy through the no arbitrage condition. When inflation is higher, the real interest rate in the bond market decreases. Thus, the opportunity cost of issuing loans is lower. Furthermore, if the degree of competition increases, each bank perceives that the marginal cost for each unit of loans decreases even more. Therefore, an increase in the degree of competition results in a stronger impact of inflation through the no arbitrage condition.

As a result, inflation shifts the bond market curve and no arbitrage curves in different directions. Again, numerical examples offer some insight into the relationship

between the competitive structure of the financial system and the impact of inflation. We use the same set of parameters from Table 1, but the impact of inflation is illustrated by an increase in the growth rate of money from 5% to 10%. Table 2 shows the relationship between the inflation rate and the degree of financial competition:

Number of Banks	2	100	1000
% Change at Equilibrium with Budget Deficit			
Rate of Return in Credit Market	1.307706	0.718666	0.711842
Loans	-1.290826	-0.713538	-0.70681
% Change at Equilibrium with Budget Surplus			
Rate of Return in Credit Market	-2.738174	-0.735142	-0.70896
Loans	2.815261	0.740587	0.714023

Table 2: The Impact of Competition

From Table 2, we offer the following conjecture:

The effect of inflation on the credit market is weaker when the financial sector is more competitive. That is, inflation-financing of debt will have a stronger impact on credit market activity if the banking system is more concentrated.

As stated above, the effects of inflation on credit market activity appear to be weaker in more competitive financial systems. This reflects that the distortionary impact of the crowding out effect from inflation-financed government debt is less significant if institutions have less market power in private credit markets. In the previous discussion, we showed that if the government runs a budget deficit, higher inflation leads to a lower amount of loans. However, when the degree of competition is higher, each bank wants to issue more loans. Therefore, the effects of inflation are weaker when the financial sector is more competitive. Both yields and the amount of debt exhibit a weaker response to policy if the financial system is more competitive. Consequently, it appears that the impact of competition through the bond market clearing condition dominates the impact through the no arbitrage condition.

In addition to the degree of banking competition, the impact of monetary policy may depend on the initial level of inflation. In particular, Boyd, Levine and Smith (2001) and Boyd and Champ (2006) find evidence of threshold effects of inflation. In particular, they observe that the marginal effect of inflation decreases rapidly when inflation is above 15%.

While previous work investigates the impact of inflation on financial market outcomes, it emphasizes how the effects depend on the extent of information frictions in the credit market. In contrast, we aim to address this issue in a setting in which banks are engaged in strategic behavior due to market power. Interestingly, the numerical examples illustrate that the threshold effects from inflation may be determined by

the competitive structure of the financial system. Table 3 presents some examples:

Level of Inflation	0.1	0.15	0.2
% Change at Equilibrium with Budget Deficit			
Real Interest Rate in the Credit Market	0.013077058	0.011654355	0.010457275
Loans	-0.012908256	-0.011520096	-0.010349052
% Change at Equilibrium with Budget Surplus			
Real Interest Rate in the Credit Market	-0.027381742	-0.024950529	-0.022844645
Loans	0.02815261	0.025588988	0.023378723

Table 3: Sensitivity of Activity to Different Inflation Rates

The effects of inflation-financing are weaker at higher inflation rates. Moreover, the inflation threshold is lower in economies that have less competitive banking systems.

The numerical examples in Table 3 demonstrate that inflation has a less significant impact on credit market activity at higher inflation rates. Moreover, the analysis in Table 2 suggests that monetary policy has a stronger effect on lending if the banking sector is less competitive. Taken together, this implies that the inflation thresholds identified in Boyd, Levine, and Smith and Boyd and Champ are lower in economies that have more concentrated banking systems.

5 Conclusions

The recent financial crisis has drawn attention to the consequences of concentration in the financial system. Moreover, there has also been a surge in the level of government debt in most countries in the past few years. As the recent financial crisis has demonstrated, monetary authorities and bank regulators cannot afford to overlook these structural changes in the financial system. Our model demonstrates that there are two significant consequences from the recent developments.

First, banks will attempt to exploit their strategic advantages in credit markets by hoarding cash reserves and government securities. As a result, market power produces a distortionary impact on interest arbitrage across markets. As long as there are strategic incentives by intermediaries, there will be a markup of interest rates in private credit markets over yields on government debt. That is, the model demonstrates that there is a divergence between interest rates in the private credit market and government yields as the competitive structure of the banking system changes. Through the distorted interest arbitrage channel, as the financial sector becomes more concentrated, government yields will be lower but interest rates in the private credit would increase as banks acquire more government securities. In this manner, our framework provides insights into the motivation behind Large Scale Asset Programs that have been relied upon since the crisis. In order to induce banks to switch from hoarding government bonds to lending to the private sector, monetary authorities have aggressively targeted long-term yields in many countries.

Second, inflation exacerbates a crowding out problem from government debt in private credit markets. As banks have a tendency to hold excessive amounts of government debt in concentrated financial systems, the crowding out problem from inflation is more severe in economies with concentrated banking systems.

6 Appendix

1. Proof of Proposition 2.

Each bank maximizes the expected utility of a representative depositor by allocating funds to money, loans, and government bonds and setting the schedule of deposit rates:

$$\underset{r_t^m, r_t^n, m_t, l_t^s, b_t}{Max} \pi \ln(r_t^m \frac{x}{N}) + (1-\pi) \ln(r_t^n \frac{x}{N})$$

subject to:

$$m_t + l_t^s + b_t = \frac{x}{N}$$

$$\pi r_t^m \frac{x}{N} = m_t \frac{p_t}{p_{t+1}}$$

$$(1-\pi) r_t^n \frac{x}{N} = R_t l_t^s + R_t^b b_t$$

By defining $\gamma_t = \frac{N m_t}{X}$ and $\phi_t = \frac{N l_t^s}{X}$ and substituting the values of r_t^m and r_t^n, the maximization problem can be expressed as:

$$\underset{\gamma_t, \phi_t}{Max} \pi \ln(\frac{\gamma_t}{\pi} \frac{p_t}{p_{t+1}} \frac{x}{N}) + (1-\pi) \ln \left[(\frac{R_t \phi_t + (1-\gamma_t-\phi_t) R_t^b}{(1-\pi)}) \frac{x}{N} \right]$$

From the loan demand function, solve for R_t as a function of ϕ_{it}, $R_t = \dfrac{Ny}{(1+\beta)x \sum \phi_{it}}$. Then, upon the substitution of R_t and deleting the constant terms, the objective function is:

$$\underset{\gamma_t, \phi_t}{Max} \pi \ln \gamma_t + (1-\pi) \ln(\frac{Ny\phi_t}{(1+\beta)x \sum \phi_{it}} + (1-\gamma_t-\phi_t) R_t^b)$$

By solving for γ_t and ϕ_t, the amount of money balances and loans is:

$$m_t = \pi \frac{x}{N} + \frac{\pi y}{N^2 (1+\beta) R_t^b}$$

$$l_t^s = \frac{(N-1) y}{N^2 (1+\beta) R_t^b}$$

This completes the proof of the profit-maximization choices of the bank in the model with government bonds.

2. Proof of Proposition 3.

In order to establish the existence of steady-state equilibrium, the following conditions must be satisfied:

1. The total money demand must be equal to money supply:

$$Nm_t = \frac{M_t}{p_t}$$

2. The amount of bond supply must satisfy the government budget constraint:

$$R^b_{t-1} b_{t-1} = \frac{(M_t - M_{t-1})}{p_t} + b_t$$

3. Interest rates between the credit market and the bond market require:

$$\left(\frac{N-1}{N}\right) R_t = R^b_t$$

By imposing the steady-state, we substitute the money demand function into the government budget constraint and derive the bond market clearing condition:

$$L = x - \left(\pi x + \frac{\pi(1+\sigma)y}{N(1+\beta)I}\right)\left(\frac{I-1}{I-(1+\sigma)}\right)$$

Furthermore, we can use the inverse demand function for loans and rewrite the relationship of interest rates between the credit market and the bond market as the no arbitrage condition:

$$L = \left(\frac{N-1}{N}\right)\frac{(1+\sigma)y}{(1+\beta)I}$$

In this manner, economic outcomes in the steady-state must satisfy the bond market clearing condition and the no arbitrage condition.

Next, consider the relationships between the amount of loans and nominal interest rate in the bond market that satisfy the bond market clearing condition. When the amount of loans is zero, there are two nominal interest rates, I_0 and I_1. It is easy to show that I_0 is less than one. In contrast, we impose the condition on the amount of depositor's endowments such that $I_1 > 1 + \sigma$:

$$y > \frac{[(1-\pi) + \sigma - 2\sigma\pi]\, N\,(1+\beta)\, x}{\pi\,(1+\sigma)}$$

Next, we find the condition such that the amount of loans and nominal interest rate in the bond market meet the requirements in both the bond market clearing condition and the no arbitrage condition. The no arbitrage curve is continuous. Thus, we establish the first steady-state in which the government is a net borrower. To establish the second steady-state, note that if the nominal interest rate in the bond market is equal to one, the amount of loans implied by the no arbitrage condition must be more than the amount of loans in the bond market clearing condition. This holds if:

$$y > \left(\frac{N}{N-1}\right)\frac{(1+\beta)x}{(1+\sigma)}$$

This completes the proof of Proposition 3.

5. Proof of Proposition 4.

We demonstrate the effect of banking competition on economic outcomes by differentiating the bond market clearing condition and the no arbitrage condition respectively:

$$\frac{\partial L}{\partial N} = \left[\frac{\pi\left(1+\sigma\right)y}{N^2\left(1+\beta\right)I}\right]\left[\frac{I-1}{\left(I-\left(1+\sigma\right)\right)}\right]$$

$$\frac{\partial L}{\partial N} = \frac{\left(1+\sigma\right)y}{N^2(1+\beta)I}$$

The effect of financial competition on the amount of loans in the bond market clearing condition depends on the government's net position in the bond market. In contrast, more financial institutions lead to an increase in the amount of loans from the no arbitrage condition. As a result, we begin by considering the economy in which the government is a net borrower in the bond market. In this economy, the effect of banking competition on the no arbitrage condition dominates the effect of banking competition on the bond market clearing condition if:

$$y > \frac{N\left(1+\beta\right)x\left[\left(1-\pi\right)+\sigma\right]}{\pi\left(1+\sigma\right)}$$

In contrast, when the government is a net lender in the bond market, the effect of banking competition on the no arbitrage condition is greater than the effect of banking competition on the bond market clearing condition if depositors receive endowments such that:

$$y < \frac{2N(1+\beta)x\left(1+\pi+\sigma\right)}{\left(1+\pi\right)\left(N-2\right)\left(1+\sigma\right)}$$

In this manner, we establish the lower bound and the upper bound for the amount of lender's endowments. Thus, this interval is non-empty if:

$$N < 2\left[\frac{1+\sigma+\pi+2\sigma\pi}{1+\sigma+\sigma\pi-\pi^2}\right]$$

This completes the proof of Proposition 4.

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