# "The Role of Financial Sector Competition for Monetary Policy"

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**Abstract**

In this paper, we examine the impact of competition in the banking industry on financial market activity. In particular, we explore this issue in a setting in which banks provide risk pooling services and there is a well-defined transactions role for money. In our partial equilibrium benchmark, we demonstrate that the effect of monetary policy on deposit rates depends on the competitive structure of the financial system. By extending the model to include a credit market, we show that monetary policy can play a more significant role in regulating the extent of lending if the financial sector is less competitive. We conclude by illustrating the welfare costs of inflation under different degrees of competition in the banking system.

## 1 Introduction

Recent evidence demonstrates that the degree of financial sector competition varies significantly across countries. While the United States has a relatively competitive financial structure, the banking systems in a number of European countries are much more concentrated. Although the degree of concentration differs across economies, it is also clear that the industry is becoming less competitive over time. For example, there were around 19,000 different financial institutions in the United States in 1989. Nearly ten years later, only 10,000 were in operation.[1] Such developments clearly have an impact on financial market activity. Notably, Hannan (1991) and Neumark and Sharp (1992) find that monopolistic banks exercise their market power. In particular, they tend to pay lower rates on deposits and charge higher rates for loans.[2]

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[1]The Bank for International Settlements (2001) provides a detailed discussion of consolidation in the financial sector.

[2]See also Berger and Hannan (1989).

While empirical evidence identifies that greater concentration affects pricing in financial markets, it is also important to examine how the distortions *collectively* affect economic behavior. For example, do deposit market distortions exacerbate inefficiencies in the credit market? Surprisingly limited attention has been devoted to these issues – existing theoretical research generally focuses on either the deposit market or the credit market.[3,4] Consequently, we have little formal analysis that explores the impact of financial concentration from a general equilibrium perspective. Furthermore, does the degree of competition lead to different effects of monetary policy?

In an attempt to fill this gap, we develop a model of Bertrand competition to address the impact of market power on financial market activity and the effects of monetary policy. Interestingly, we construct our analysis in a setting where banks serve important economic functions. As in Diamond and Dybvig (1983), banks provide risk pooling services for depositors. Following Townsend (1987) and Schreft and Smith (1997), spatial separation and private information generate a transactions role for money. To examine the impact of banking structure, we compare economies with competitive banking systems to fully concentrated industries.[5] Although few, if any, banking industries are true monopolies or perfectly competitive, comparing these two extreme cases sheds light on how the degree of competition affects interest rates and interacts with monetary policy.[6]

As a benchmark, we begin our analysis by considering an economy in a partial equilibrium setting. We focus exclusively on activity in the deposit market by assuming that the rate of return to investment opportunities is exogenous. Based upon the available investment options, banks compete for funds by offering rates of return to potential depositors. We demonstrate that, for a given stock of money, the deposit rates offered by a perfectly competitive bank will be higher than a monopolist. Moreover, the impact of monetary policy depends on the competitive structure of the financial system. In particular, in a perfectly competitive industry, the nominal short-term interest rate is independent of monetary policy. However, under a monopoly bank, short-term interest rates will be higher in economies with higher

[3]Sharpe (1991) constructs a model with switching costs to determine the relationship between market structure and prices in retail bank deposit markets. In a partial equilibrium framework, Whitesell (1992) examines the deposit rates offered when banks experience competition for transactions services. Hutchison (1995) develops an intertemporal asset-pricing model with Cournot competition to study deposit rates.

[4]Pagano (1993) shows that distortions from market concentration have an adverse effect on economic growth. As a result of the higher rates on loans, Guzman (2000) finds that default is more likely to occur in an economy with a monopolistic banking industry.

[5]The framework that is closest to ours is Boyd, Nicolo and Smith (2004). They construct an overlapping generations model to study the impact of the degree of competition on the probability of a banking crisis. However, their model is partial equilibrium in the sense that they only consider the deposit market. Furthermore, they assume that monetary policy is established independently of the competitive structure of the banking industry. In contrast, we demonstrate that significant interactions may occur.

[6]Beck, Kunt and Levine (2003) report that over the period from 1990-1997, the average level of bank concentration across 99 countries was 0.72 but ranged from 1.0 to 0.2.

rates of money growth.

Furthermore, we develop important insights concerning the impact of financial market structure by extending the model to include credit market behavior. In contrast to the partial equilibrium version, the investments of each bank represent loans to potential borrowers. This allows the cost of obtaining funds to be determined endogenously. Consequently, we address how the amount of activity in the *deposit* market affects the interest rate in the *credit* market. As a result, there are additional transmission channels for monetary policy – they depend on the simultaneous interactions between both types of financial markets. Moreover, the degree of financial sector competition is critically important.

In order to gain deeper perspective, it is useful to understand the important economic functions of each type of financial market. As a result, the effects of concentration will be more apparent. While the deposit market promotes risk sharing in the economy, the credit market allows groups of individuals to improve their ability to smooth consumption. Since a monopoly bank distorts both the deposit and credit market, we first demonstrate that the amount of credit market activity is inefficiently low. That is, the interest rate in the credit market is higher in a fully concentrated financial sector than under perfect competition. In addition, the amount of lending will also be lower. Therefore, introducing the credit market demonstrates the welfare costs of *financial concentration* from less consumption smoothing.

Due to the different distortions in each market, there are interesting implications regarding the effects of monetary policy. Under perfect competition, a higher growth rate of money only affects the real short-term interest rate. It does not have any impact on the price of loans. However, in the fully concentrated banking system, higher rates of money growth will cause interest rates in the credit market to rise. In this manner, our model demonstrates that monetary policy may be more effective in regulating credit market activity if the financial sector is less competitive.

We also illustrate that the impact of monetary policy on *deposit* rates depends on the significance of credit market behavior and the competitive structure of the banking system. In a perfectly competitive economy, monetary policy has the same effect in both the partial and general equilibrium frameworks. This occurs because money growth only affects the return to money in the deposit market. In contrast, deposit rates offered by a monopolist will respond more to monetary policy when including activity in the credit market.

We conclude our analysis by examining the welfare cost of inflation in both the partial and general equilibrium settings. In particular, we illustrate that the cost of inflation depends on the combination of credit market conditions and market power. In the partial equilibrium model, the only negative effects from inflation occur under perfect competition. While perfectly competitive banks offer deposit rates to raise the expected utility of depositors, a monopoly bank extracts all gains from using the financial system.

Since monetary policy does not have any impact on credit market behavior under perfect competition, the welfare costs of inflation are the same in both the partial and general equilibrium frameworks. However, inflation leads to a higher price of loans under a monopoly bank. Since inflation reduces the ability of borrowers to smooth their consumption, the welfare costs of inflation are higher in the general equilibrium model. This reflects the importance of accounting for the effects of market power from a general equilibrium perspective.

The remainder of the paper is organized as follows. In section 2, we construct a model of banking in a partial equilibrium setting. As a benchmark, we initially consider an economy with a perfectly competitive banking industry. Next, we study an economy with a fully concentrated banking sector. We proceed by analyzing the impact of monetary policy in both economies. Section 3 extends the model to a general equilibrium framework. Including a credit market provides interesting insights regarding the interactions between monetary policy and the competitive structure of the financial system. Section 4 examines the welfare costs of inflation under different degrees of financial sector competition. Finally, Section 5 offers some concluding remarks. The proofs of major results are provided in the Appendix.

# 2 The Benchmark Model: A Partial Equilibrium Model of Banking Competition and Monetary Policy

We begin by studying a partial equilibrium framework in which the rate of return to investment opportunities in the economy is exogenous.

## 2.1 The Environment

We consider a discrete-time economy populated by an infinite sequence of two-period-lived overlapping generations, plus an initial old generation. In particular, the economy consists of two geographically separated islands. At the beginning of each time period, a new generation of individuals is born on each island with a population measure equal to 1. Although the population resides in two separate locations, there is a single consumption good available on both islands.

An individual's lifetime utility function is given by $U(c_1, c_2) = \ln(c_1) + \beta \ln(c_2)$. When young, agents are endowed with $x > 0$ units of the consumption good. While agents do not receive endowments in their old-age, they have access to a storage technology. For each of unit of goods allocated to the technology when young, agents receive $0 < s < 1$ units of consumption in the following time period.[7]

Private information serves as the primary trade friction in the economy. Although each island is characterized by complete information, communication across islands is not possible. Consequently, private liabilities do not circulate. Moreover, individuals in the economy are subject to relocation shocks. Each period, a fraction of young agents must move to the other island. The probability of relocation, $\pi$, is exogenous, publicly known, and the same in each island.

In contrast to standard random relocation models such as Schreft and Smith (1998), agents may carry goods across locations. However, transportation involves

[7] In the absence of alternative investment opportunities, the storage technology allows individuals to consume when old.

resource costs – a fraction of goods, $\tau \in (0,1)$, will depreciate during the relocation process.[8]

## 2.2 Consumption and Savings in an Autarky Economy

As a benchmark, we begin by describing the timing of events and actions in an autarky economy in which individuals do not have access to financial intermediation or a money market. We use superscripts to refer to the period of birth and subscripts to the time period of consumption. At the initial stage of period $t$, old relocated individuals carry the goods that they save from the previous period to the other location. Due to the transportation cost, they consume $s(1-\tau)(x-c_{t-1}^{t-1})$ units of goods. Individuals who do not experience relocation shocks, non-movers, consume the entire returns from storage, $s(x-c_{t-1}^{t-1})$. At the end of period $t$, old agents in generation $t-1$ die and the relocation shock occurs.

Since agents obtain utility from consumption in both their youth and old-age, they choose an amount of savings (deposits into the storage technology, $d_t$) to maximize expected lifetime utility:

$$\underset{d_t}{Max} \ln(x-d_t) + \beta[\pi \ln((1-\tau)sd_t) + (1-\pi)\ln(sd_t)]$$

subject to their budget constraint:

$$c_t^t + d_t \leq x$$

The lifetime-utility maximizing choice of savings is given by:

$$d_t = \left(\frac{\beta}{1+\beta}\right)x \tag{1}$$

The level of saving depends on both the amount of the endowment and the rate of time preference. When agents receive larger endowments, they will choose to save more in order to smooth consumption. If the rate of time preference is higher, future utility is more important. Consequently, agents deposit more goods in their storage technologies. Notably, the amount of saving is independent of the transportation and storage costs. This occurs because the income and substitution effects of returns to saving offset eachother.

The amount of consumption in each state and expected utility are shown in Figure 1. The horizontal axis represents different values of consumption while the vertical axis shows the corresponding amount of utility received. Since movers incur costs of transporting goods across islands, their level of consumption will be lower than non-movers. Consequently, individuals experience two different states in regard to their location – a good state in which agents continue to reside on their home island and a bad state in which they must move to the other location. We denote the respective levels of consumption as $c_N^A$ and $c_M^A$.

[8]This follows Samuelson's (1954) notion of "iceberg" transportation costs.

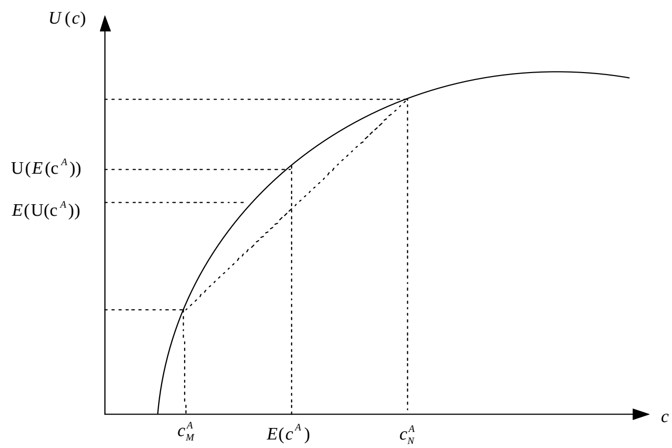


Figure 1: Expected Utility and Consumption in Autarky

As described in the Figure, the utility in the bad state will be lower than the utility in the good state. Therefore, an individual's expected lifetime utility, $E(U(c^A))$, is a probability-weighted average of the lifetime utility obtained across states.[9] To be specific, it is given by:

$$E(U(c^A)) = \ln(\frac{x}{1+\beta}) + \beta[\pi \ln(1-\tau)s(\frac{x\beta}{1+\beta}) + (1-\pi)\ln s(\frac{x\beta}{1+\beta})] \qquad (2)$$

Since agents are risk-averse, expected lifetime utility will be less than the utility received from expected consumption. This reflects that risk-averse individuals would prefer to face a consumption stream with less uncertainty.

### 2.3 An Economy with Financial Intermediation

We proceed by integrating financial markets into our framework. However, in contrast to standard random relocation models, agents have limited ability to participate in the financial system. Although one or many different financial intermediaries may be available, individuals only obtain access to financial markets indirectly through the services of banks.[10] With deposits received, banks can allocate funds to investment projects which yield $R > (1/\beta)$ for each unit of goods invested in the previous period.[11] Moreover, banks also have the ability to trade in a market for money balances.

[9] In the example in the Figure, the probability of a relocation shock is equal to 1/2. In this manner, $E(U(c^A)$ lies half-way between $U(c_M^A)$ and $U(c_N^A)$.

[10] See Grossman and Weiss (1983), Lucas (1990), Fuerst (1992), and Williamson (2005) for other models incorporating limited participation. In our framework, limited participation provides additional tractability. In particular, the level of expected utility in autarky only depends on exogenous parameter values.

[11] In contrast to Boyd et al, the returns to the economy's long-term investment opportunity must be sufficiently larger than 1. We discuss this in Section 2.3.2 below.

Although the investment opportunities generate higher returns than storage, private information across islands limits trading opportunities in the economy. That is, the trade friction of private information prevents movers from issuing claims to investments across islands. Consequently, as in autarky, only non-movers consume the full returns from investments.

Since movers would suffer from the costs of transporting goods across islands, the ability to receive fiat money from banks can lead to higher consumption. As emphasized in much of the literature on monetary theory, fiat currency involves lower costs of storage and transportation than a number of commodities. Thus, a market for money on each island helps individuals avoid trading frictions. However, constant growth of the money supply leads to inflation. Consequently, money will be dominated in rate of return. As a result, the relocation shocks in the model are similar to the liquidity shocks in Diamond and Dybvig (1983).

Next, we explain the timing of events compared to the previous section. At the initial stage of date $t$, banks announce the schedule of interest rates ($r_t^m$ for movers and $r_t^n$ for nonmovers) and young agents deposit $d_t$ units of goods. The bank decides how to allocate deposits to an investment project ($i_t$) and currency ($m_t$). Since money yields a relatively low rate of return, it will only be held to insure agents against relocation shocks.

The monetary authority gives currency to the bank at the rate $\sigma M_{t-1}$. The bank obtains additional currency through trade with relocated old agents. This occurs by providing the old with some of the deposits received from the current young. With the remaining amount of deposits received, the bank will allocate $i_t$ units of goods to the investment project. After the portfolio allocation is made, the bank receives returns from investment in the previous period and pays nonrelocated old agents $r_{t-1}^n d_{t-1}$.

At the end of period $t$, the relocation shock occurs. Young agents in period $t$ learn their location status. Those who relocate will go to the bank and withdraw currency. All old agents from the previous generation consume and die.

Based upon the returns offered by banks, young individuals seek to maximize their expected lifetime utility:

$$\underset{d_t}{Max} \ln(x - d_t) + \beta[\pi \ln(d_t r_t^m) + (1-\pi)\ln(d_t r_t^n)] \tag{3}$$

Notably, the amount of deposits is the same as the amount of savings in the autarky economy. This occurs since agents have log preferences in which the substitution and income effects of the rates of return to deposits offset each other.[12]

Next, we show how different degrees of banking competition affect economic outcomes and monetary policy. Banks compete by offering rates of return to deposits to individuals. Since banks are Bertrand competitors, we study two types of competitive structures – a perfectly competitive banking sector and a monopoly bank.

[12]Although the rates of return do not affect the amount of deposits, the degree of financial competition will have an important impact on the degree of risk sharing in the economy.

### 2.3.1 Perfectly Competitive Banks

In a perfectly competitive banking industry, banks compete against each other for deposits. Intermediaries are Nash competitors; that is, banks announce rates of return $(r_t^m, r_t^n)$, taking the announced rates of return of other banks as given. Then, each bank chooses a schedule $(r_t^m, r_t^n, m_t, i_t)$ to maximize the expected utility of a representative depositor. The bank's objective is given by:

$$\underset{r_t^m, r_t^n, m_t, i_t}{Max} \ln(x-d)+\beta[\pi\ln(dr_t^m)+(1-\pi)\ln(dr_t^n)] \tag{4}$$

subject to a balance sheet constraint:

$$d \geq m_t + i_t \tag{5}$$

Relocated agents cannot access their account in the other location due to limited communication. As a result, they must use money to trade for goods. Therefore, the payment to relocated individuals is given by the amount of reserves:

$$\pi r_t^m d \leq m_t \frac{p_t}{p_{t+1}} \tag{6}$$

Since movers receive payments at the end of their youth, we will also refer to $r_t^m$ as the short-term interest rate in the economy.

Agents who do not move can keep their funds in the bank. The rate of return will be determined by returns from the investment project:

$$(1-\pi)r_t^n d \leq R\ i_t \tag{7}$$

Following the discussion for $r_t^m$, we consider $r_t^n$ to be the long-term interest rate.

In addition, if the return of relocated agents is more than the return of nonrelocated agents, individuals will lie about their types. Consequently, they would all seek to withdraw deposits at the end of the period. For these reasons, the following self-selection constraint must also hold:

$$r_t^m \leq r_t^n \tag{8}$$

Finally, in order to induce individuals to deposit their funds in the bank, the expected utility of each depositor must satisfy a participation constraint. Instead of the bank, agents may choose to put funds in the storage technology. Consequently, individuals must obtain higher expected utility than the autarky level:

$$\ln(\frac{x}{1+\beta})+\beta[\pi\ln(r_t^m d)+(1-\pi)\ln(r_t^n d)] \geq E(U(c^A)) \tag{9}$$

To maximize the individual's expected utility, banks allocate funds to currency reserves such that:

$$m_t = \pi d \tag{10}$$

Since agents are risk averse, they obtain higher expected utility when they encounter less variable consumption streams. In particular, under logarithmic preferences, the income and substitution effects of deposit rates offset each other. Consequently, the optimal amount of insurance only depends on the probability of the bad state. Therefore, the bank's demand for money is pinned down by the probability of relocation.

It is easy to demonstrate that the rates of return for relocated and nonrelocated agents are:

$$r_t^m = \frac{p_t}{p_{t+1}} \tag{11}$$

$$r_t^n = R \tag{12}$$

Thus, the expected interest rate in the economy is:

$$r_{pc} = \pi(\frac{p_t}{p_{t+1}}) + (1 - \pi)R \tag{13}$$

In Figure 2 below, we show the consumption and expected utility of agents in the perfectly competitive banking system. As illustrated, the amount of consumption depends on the amount of the deposit and the return in each state. Although banks provide some degree of risk sharing to individuals, it is not efficient. As in autarky, the amount of consumption depends on an individual's location status. The consumption of movers, those who experience the bad state, is represented by $c_M^{PC}$. In contrast, consumption in the good state is $c_N^{PC}$.

Notably, consumption in either state is higher when individuals have access to the services of financial institutions. This results from the various functions of money and banks in our framework. First, money helps individuals avoid the resource costs of transferring goods across locations. As a result, consumption will be higher in the bad state, $c_M^{PC} > c_M^A$. Second, banks provide individuals with access to better financial opportunities. Since the return to the investment project exceeds the return to storage, $c_N^{PC} > c_N^A$. In this manner, banks simultaneously provide risk-sharing services and access to more profitable investment opportunities. Consequently, in the perfectly competitive financial sector, both expected utility $(E(U(c^{PC}))$ and expected consumption $(E(c^{PC}))$ are higher than the autarky level.

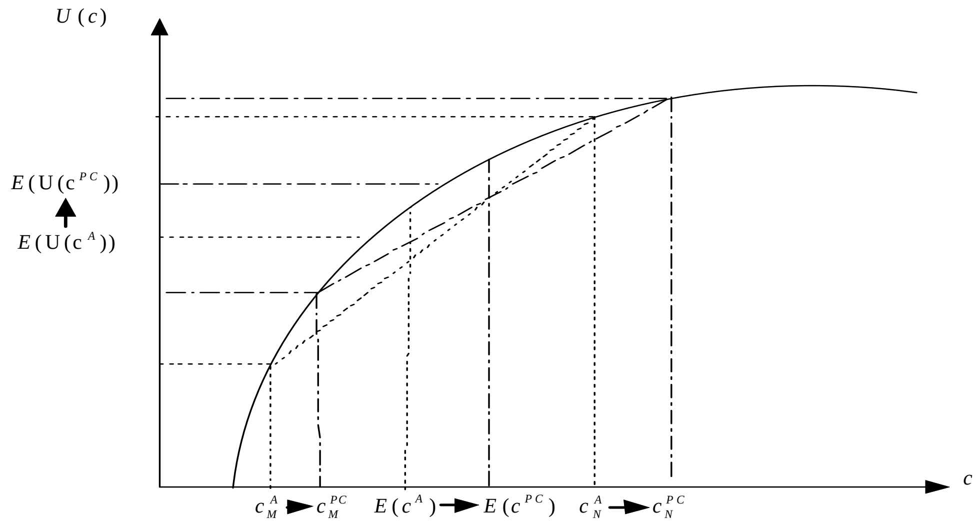


Figure 2: Consumption and Expected Utility under Perfect Competition

**Equilibrium** Now, we proceed to examine economic outcomes in the steady-state. Given the monetary authority's fixed money growth rule, it is easily shown that the gross inflation rate, $\frac{p_{t+1}}{p_t}$, is equal to $(1+\sigma)$.

**Definition 1.** *A steady-state equilibrium in a perfectly competitive banking industry is an economy such that:*

*1. depositors choose an amount of saving to maximize their expected lifetime utility, (3);*

*2. the bank's objective is to maximize the expected utility of an individual, (4);*

*3. the self-selection condition for depositors holds, (8), and*

*4. perfectly competitive banks satisfy the participation constraint of each depositor, (9).*

**Proposition 1.** *Suppose the return to investment opportunities is sufficiently high such that* $R \geq s^{\frac{1}{1-\pi}}\left[(1-\tau)(1+\sigma)\right]^{\frac{\pi}{1-\pi}}$. *Under this condition, a steady-state equilibrium in the perfectly competitive banking economy exists and is unique.*

In order to establish that the equilibrium exists, we must verify that three conditions are satisfied. First, the self-selection constraint must hold. Second, the participation constraint cannot be violated. Finally, since the sector is perfectly competitive, banks must not obtain any excess profits. We begin by discussing the self-selection constraint. In our partial equilibrium setting, it is easy to show that non-movers earn a higher rate of return than movers. The rate of return to investment is exogenous and larger than one. In addition, the money supply grows at a constant rate. Therefore, money is dominated in rate of return and agents reveal their location status honestly. Upon extending our analysis to the general equilibrium framework in Section 3, the constraint will be complicated by conditions in the credit market.

The second requirement is that the participation constraint holds. In order to induce individuals to deposit their funds in the bank, expected utility must be greater than the level in autarky. An individual's expected utility depends on the return to fiat money and the return to investment projects. Thus, if the value of currency is low, the return to investment opportunities must be sufficiently high to satisfy the participation constraint.[13] Finally, in the appendix, we demonstrate that banks do not earn any profits.

In steady-state equilibrium, it is easy to show that the expected interest rate is:

$$r_{pc} = \pi(\frac{1}{1+\sigma}) + (1-\pi)R \tag{14}$$

The expected interest rate is the weighted average between the rate of return to movers and the rate of return to nonmovers. The return to relocated agents depends on the return to money while the return to nonrelocated individuals is determined by the return to an investment project. When the growth rate of money increases, the value of currency decreases. As a result, movers receive lower returns while there is no change in the return for nonmovers. Thus, the expected rate of return to deposits decreases. The same argument is applied when the rate of return to an investment project is lower.

Figure 3 illustrates the effects of money growth. Due to the lower value of money, the consumption of relocated agents decreases from $c_M^{PC}$ to $\widehat{c_M^{PC}}$. In contrast, the rate of return to nonrelocated agents remains the same and does not respond to the change in monetary policy, $c_N^{PC} = \widehat{c_N^{PC}}$. As a result, the expected rate of return to deposits is lower. This makes expected utility decrease from $E(U(c^{PC}))$ to $E(U(\widehat{c^{PC}})$.

[13] In standard random-relocation models, agents do not have the ability to transfer goods across islands. Consequently, agents must hold some amount of money to insure against the possibility of relocation. However, in our framework, agents will not need to use money unless the costs of transporting goods are sufficiently high. As a result, an equilibrium may not exist.

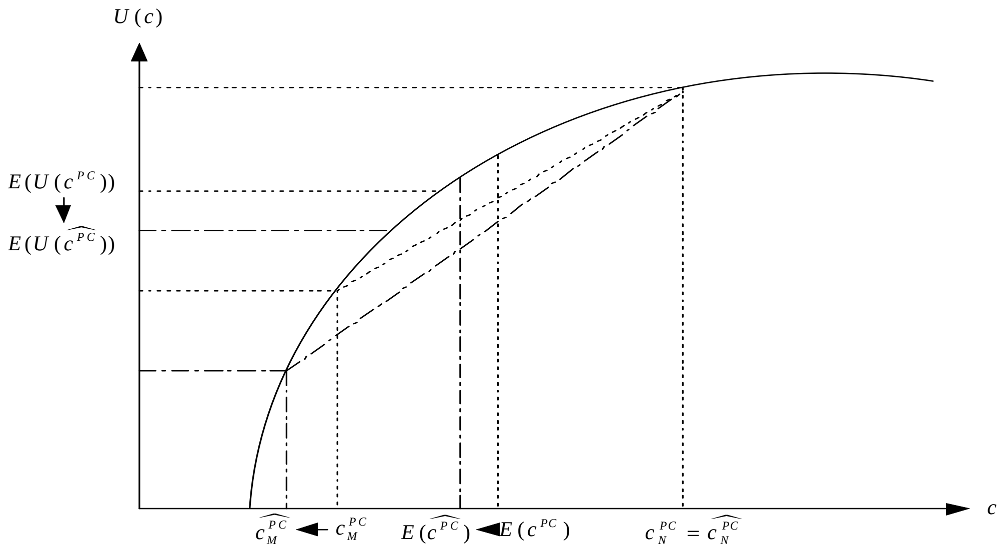

Figure 3: The Effect of the Growth Rate of Money in a Perfectly Competitive Banking Economy

If the probability of a relocation shock increases, banks must invest more funds in currency reserves and less in the investment project. Therefore, more funds are allocated to the asset that yields a lower rate of return. This causes the expected interest rate to fall.

### 2.3.2 A Monopoly Bank

We now study an economy in which the banking sector is fully concentrated. That is, there is only one bank available in the economy. In contrast to perfectly competitive banks, a monopolist chooses a schedule $(r_t^n, i_t, m_t)$ to earn the highest possible discounted profits:

$$\underset{r_t^n, i_t, m_t}{Max}\; d - m_t - i_t + \beta(R\, i_t - (1-\pi) r_t^n d) \tag{15}$$

The bank's profit comes from two sources. First, profits could be earned by taking the deposits received. Second, it obtains earnings from previous funds devoted to investment opportunities in an economy.

The return to fiat money is dominated by the return of long-term investment opportunities. Furthermore, if the bank sufficiently values second-period net revenues, it will choose to invest all of the deposits (after allocations to currency) in the investment projects. Thus, when the rate of return to investment opportunities is sufficiently high ($R > 1/\beta$), the monopolist earns all profits through long-term investments.

As in the economy with perfectly competitive banks, depositors must receive sufficient incentives to deposit funds in the bank. Since there is only one bank available, the monopolist can extract all of the gains from using the financial system. Therefore, it offers rates of return such that the expected utility from depositing funds is equal to the autarky level:

$$\ln(\frac{x}{1+\beta}) + \beta[\pi \ln(r_t^m d) + (1-\pi)\ln(r_t^n d)] = E(U(c^A)) \quad (16)$$

To maximize profits, the bank sets currency reserves equal to:

$$m_t(s, \tau, R, \frac{p_t}{p_{t+1}}, d, \pi) = \left( \frac{s(1-\tau)^\pi}{(R^{1-\pi})\left(\frac{p_t}{p_{t+1}}\right)^\pi} \right) \pi d \quad (17)$$

Interestingly, we find that the monopolist's demand for money is proportional to the amount held by perfectly competitive banks. Under perfect competition, since the income and substitution effects of deposit rates offset each other, the bank's demand for money depends only on the probability of the bad state (relocation). In contrast, the monopolist seeks to maximize profits. Consequently, the term $\frac{s(1-\tau)^\pi}{(R^{1-\pi})\left(\frac{p_t}{p_{t+1}}\right)^\pi}$ reflects the degree to which the bank's portfolio is distorted.

Given the bank's portfolio of assets, payments to relocated agents are limited by the return on money:

$$r_t^m = \frac{p_t}{p_{t+1}} \left( \frac{m_t(s, \tau, R, \frac{p_t}{p_{t+1}}, d, \pi)}{\pi d} \right) \quad (18)$$

While payments to movers are pinned down by the bank's earnings from money holdings, the constraint for non-movers (equation (7)) does not bind since the bank retains all excess earnings as profits. Instead, the monopolist extracts all of the gains from accessing the financial system. As a result, the rate of return to non-movers is determined by the participation constraint:

$$r_t^n = \left[ \left( \frac{(1-\tau)s^{\frac{1}{\pi}}}{(\frac{p_t}{p_{t+1}})} \right) \left( \frac{\pi d}{m_t(s, \tau, R, \frac{p_t}{p_{t+1}}, d, \pi)} \right) \right]^{\frac{\pi}{1-\pi}}$$

Therefore, the expected rate of return to deposits is:

$$r_{mp} = \pi \left( \frac{s(1-\tau)^\pi (\frac{p_t}{p_{t+1}})^{1-\pi}}{R^{1-\pi}} \right) + (1-\pi) \left( \frac{sR^\pi (1-\tau)^\pi}{(\frac{p_t}{p_{t+1}})^\pi} \right) \quad (19)$$

In order to better understand the rates of return offered by the monopoly bank, we begin by considering why individuals choose to access the financial system. In the absence of financial institutions, an individual's second-period consumption varies due to the realization of the relocation shock and costs of transporting goods. The principal economic function of banks is to provide opportunities for consumption insurance – since individuals are risk averse, they would prefer a consumption stream with less variability.[14] Perfectly competitive banks serve this role well – in standard random relocation models such as Schreft and Smith (1998), banks acquire a diversified portfolio of assets (money and long-term projects). Consequently, individuals obtain higher consumption in the bad state (when the liquidity shock occurs) in exchange for less consumption in the good state (when agents do not experience the liquidity shock, they are 'non-movers').

In contrast, incentives in the financial system are much different when the banking sector is fully concentrated. A monopoly bank takes advantage of the desire for consumption insurance when choosing deposit rates to maximize profits. In particular, the monopolist exploits depositors' degree of risk aversion. That is, it can significantly increase depositors' expected utility by promising a higher rate of return in the bad state. If individuals obtain slightly less consumption in the good state (than under autarky), they would experience a higher level of expected utility. However, in order to maximize profits, the bank can reduce consumption in the good state by a large amount – it can reduce consumption until individuals are indifferent between participating in the financial system or autarky.

We illustrate these ideas in Figure 4 below. Due to risk aversion, depositors would earn higher expected utility if consumption is higher in the bad state (if they become a mover). This is represented by $c_M^{MP}$ larger than $c_M^A$. Since individuals obtain some insurance against the possibility of relocation, they accept a lower rate of return if they do not move. As illustrated in Figure 4, the consumption of relocated agents increases from $c_M^A$ to $c_M^{MP}$ while the consumption of nonrelocated agents decreases from $c_N^A$ to $c_N^{MP}$. Notably, the expected utility in a fully concentrated banking economy, $E(U(c^{MP}))$, is the same as autarky, $E(U(c^A))$, but the expected consumption decreases from $E(c^A)$ to $E(c^M)$. The consumption of nonrelocated agents decreases more than the increase in the relocated agent's consumption but agents receive the same expected utility. In this manner, we demonstrate the profit-maximizing behavior of a monopoly bank.

[14]In addition, individuals face the problem of limited participation in financial markets. The bank provides depositors with access to the market for money and long-term investments.

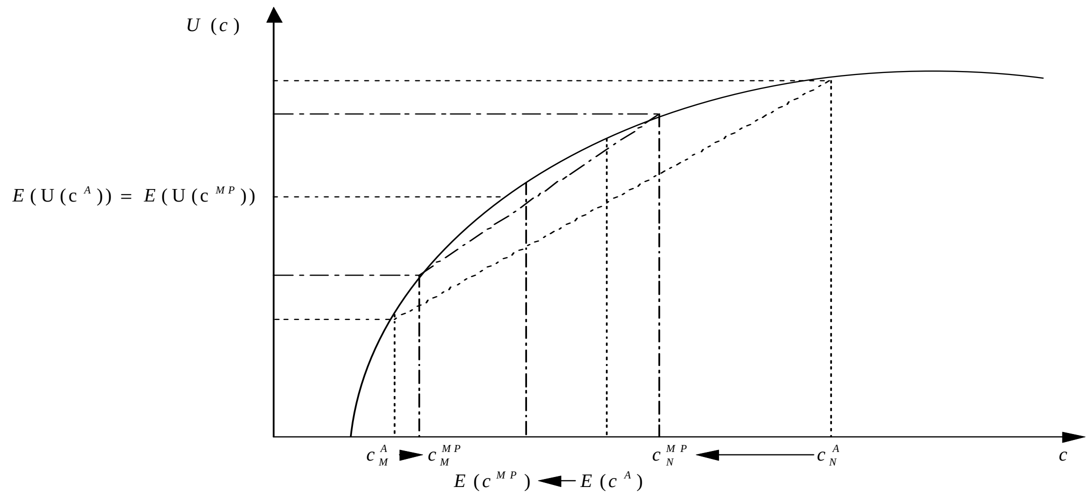


Figure 4: Expected Utility and Consumption in a Fully Concentrated Banking Economy

**Equilibrium** We now study the equilibrium in a fully concentrated banking sector.

**Definition 2.** *A steady-state equilibrium in a fully competitive banking sector is an economy such that:*

*1. depositors choose an amount of saving to maximize their expected lifetime utility, (3);*

*2. the bank chooses a schedule $(r^m, r^n, i, m)$ to maximize profits, (15);*

*3. the self-selection condition for depositors holds, (8);*

*4. the participation constraint for depositors is satisfied, (9), and*

*5. the bank earns positive profits.*

**Proposition 2**. *Suppose that $R \geq s^{\frac{1}{1-\pi}} \left[(1-\tau)(1+\sigma)\right]^{\frac{\pi}{1-\pi}}$. Under this condition, a steady-state equilibrium in the monopoly banking economy exists and is unique.*

As in the perfectly competitive economy, there are three conditions which must be satisfied in order for an equilibrium to exist. Obviously, the self-selection and participation constraints must hold. In contrast to the previous section, a monopoly bank must earn positive profits.

We begin by discussing the self-selection constraint. Under perfect competition, it is easy to show that non-movers earn a higher rate of return than movers. Since money is dominated in rate of return, perfectly competitive banks provide an amount of insurance that reflects the probability of the bad state to occur. In contrast, the monopolist provides an amount of insurance to maximize profits rather than a depositor's expected utility. As a result, the monopoly bank's demand for money will be inefficiently low – this causes short-term interest rates to be distorted. However, in order to induce individuals to deposit their funds, the amount of consumption in the good state must be sufficiently high. Consequently, despite the distortions in the deposit market, the self-selection constraint continues to hold.

Since the self-selection and participation constraints are satisfied, we only need to verify that the monopolist will earn positive profits. The monopoly bank must provide depositors with an expected schedule of consumption to induce individuals to deposit their funds. Any remaining income will count towards bank profits. If the return to long-term investment projects is not high enough, it will be difficult for the monopolist to provide depositors with a level of consumption insurance that generates excess revenues.

Interestingly, the conditions for existence in the monopoly economy are identical to the perfectly competitive industry. However, the allocations are much different. Under perfect competition, participation in the financial sector must increase the expected utility of depositors. In the monopoly economy, participation by depositors must allow the bank to generate enough second-period revenues to obtain positive profits. In Section 3 below, we demonstrate the conditions for existence are significantly different in a general equilibrium framework which includes credit market behavior. This occurs because of the additional distortions introduced through the market for loans.

In contrast to perfect competition, the returns to depositors in each state will depend on the bank's earnings from both money and investment opportunities. As an example, under perfect competition, the return to movers only depends on the return to money. However, the return to non-movers is completely independent of the money growth rate. Such independence does not occur in the fully concentrated banking system. In principal, the monopoly bank can provide insurance to its depositors – nevertheless, the gains in utility will be exactly offset by lower utility for non-movers.

Consequently, under the monopoly bank, the returns in each state are negatively correlated:

$$r^m = s(1-\tau)^\pi \left( \frac{1}{[R(1+\sigma)]^{1-\pi}} \right) \tag{20}$$

$$r^n = s(1-\tau)^\pi \left[ (1+\sigma)R \right]^\pi \tag{21}$$

Notably, the return to movers is decreasing in the money growth rate. However, the return to non-movers is increasing in the rate of money growth. As movers receive less consumption under higher inflation rates, their expected utility will also fall. In order to induce individuals to deposit their funds, the return to non-movers must increase. This leads to lower profits for the monopolist.

As a result of the different incentives of banks, we find that the impact of inflation on short-term interest rates depends on the competitive structure of the financial system:

**Lemma 1.** *The rate of return to movers is decreasing in the rate of money growth, regardless of the competitive structure of the financial system. However, the quantitative impact is stronger in an economy with a perfectly competitive banking system.*

In contrast to perfectly competitive banks, a monopolist seeks to maximize profits. For a given portfolio of asset holdings, the monopoly bank would need to raise the consumption of non-movers by a sufficient amount in order to offset the consumption loss from inflation. In order to minimize its earnings losses, a monopolist will choose to acquire greater money balances:

$$m = s(1-\tau)^{\pi}\left(\frac{(1+\sigma)^{\pi}}{R^{1-\pi}}\right)\left(\pi(\frac{\beta}{1+\beta})x\right) \tag{22}$$

In this manner, consumption in the bad state will not fall as much. As a result, the impact of inflation on short-term interest rates ($r^m$) is not as severe in comparison to the perfectly competitive economy.

While the preceding discussion relates the impact of monetary policy under different degrees of competition in the financial sector, existing empirical work on monetary policy is based upon nominal rates of return. Consequently, we offer the following corollary:

**Corollary 1**. *The nominal short-term interest rate is independent of monetary policy under perfect competition. However, it is increasing in the rate of money growth if the financial sector is fully concentrated.*

Under perfect competition, the return to movers is equal to $\frac{1}{1+\sigma}$. As a result, the nominal return is given by $(1+\sigma)r^m(\sigma) = 1$. However, the nominal short-term interest rate in the monopoly economy is $\left(\frac{s(1-\tau)^{\pi}}{R^{1-\pi}}\right)(1+\sigma)^{\pi}$. These results relate to recent research by Barnes, Boyd, and Smith (1999). In their paper, the authors study the impact of inflation on different measures of nominal short-term interest rates. Among 11 out of 23 countries, inflation was associated with higher interest rates for money market deposit accounts. In nearly all of the other 12 countries, there was no effect. Interestingly, our results suggest that the correlation should be stronger in countries with more concentrated financial systems.

From the rates of return to relocated and nonrelocated agents, the expected interest rate is given by:

$$r_{mp} = s(1-\tau)^{\pi}[\frac{\pi}{(R(1+\sigma))^{1-\pi}} + (1-\pi)\left(R(1+\sigma)\right)^{\pi}] \tag{23}$$

Due to the different incentives of banks, the effect of inflation on the expected interest rate depends on the degree of competition in the financial sector:

**Lemma 2**. *When the growth rate of money increases, the expected rate of return to deposits decreases in a perfectly competitive banking economy, but increases in a fully concentrated banking industry.*

In contrast to a perfectly competitive banking sector, the expected interest rate is increasing in the rate of money growth. In order to understand these differences, please refer to Figure 5. If the rate of money growth is higher, the rate of return in the bad state (as a mover) will be lower. As illustrated in the Figure, the consumption of relocated agents falls from $c_M^{MP}$ to $\widehat{c_M^{MP}}$ . Consequently, an individual's expected utility would be lower. However, in order to satisfy the participation constraint, the monopolist must compensate individuals with more utility in the good state. Thus, the bank must offer a much higher return to nonmovers from $c_N^{MP}$ to $\widehat{c_N^{MP}}$ . In this manner, expected utility is invariant to the inflation rate $(E(U(c^{MP})) = E(U(\widehat{c^{MP}}))$. Nevertheless, due to the lower rate of return to money, the expected rate of return will be higher. This is illustrated by the increase from $E((c^{MP}))$ to $E((\widehat{c^{MP}}))$.[15]

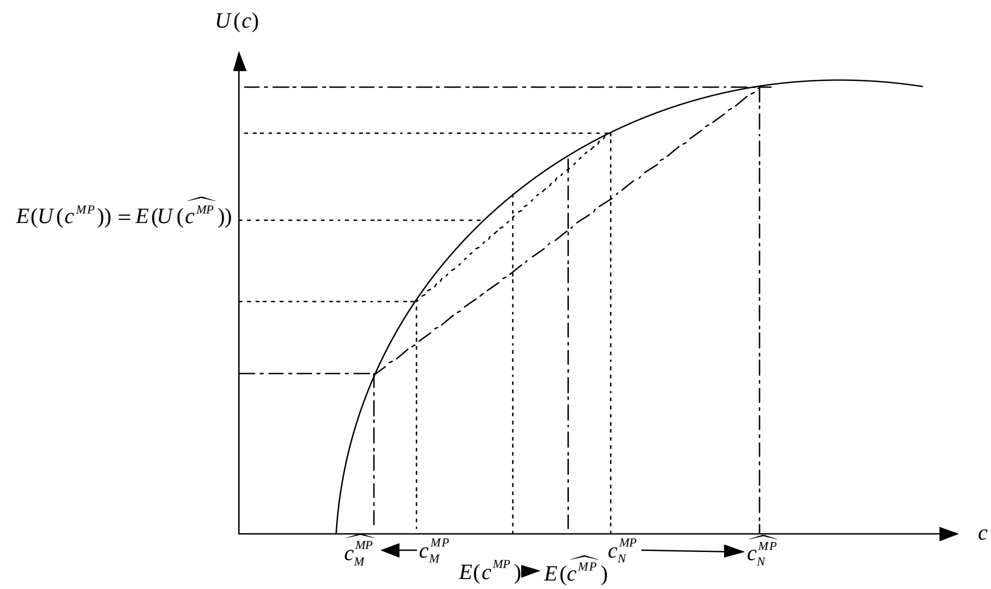


Figure 5: The Effect of the Growth Rate of Money in a Fully Concentrated Banking Economy

Finally, we turn to the impact of the return to storage and costs of transportation. While storage provides an alternative savings device compared to the bank, the transportation costs reflect the costs of alternative methods of payment besides money. Both alleviate the costs of limited participation in financial markets – as a result, the monopolist must provide individuals with additional incentives to deposit their funds. This leads to higher expected interest rates.

The preceding analysis describes how the effects of monetary policy can depend on the degree of competition in the financial sector. We conclude with the following observation:

[15] We may also compare the effects of $R$ on expected deposit rates in different financial systems. It is easily shown that higher returns to investment opportunities will generate an increase in the expected return to deposits. This occurs in both perfectly competitive and fully concentrated systems. Nevertheless, the impact is stronger under perfect competition. Our results are consistent with Neumark and Sharpe (1992). They find that an increase in open market rates leads to higher rates of return to bank deposits. However, the adjustment takes place more quickly in competitive deposit markets. In this sense, discounted interest income is positively associated with the degree of banking competition.

**Proposition 3**. *Suppose the steady-state equilibria in a perfectly competitive banking sector and a fully concentrated banking industry exist. In this setting, perfectly competitive banks offer higher rates of return to deposits than a monopolist.*

This occurs because of the distortions introduced by market power in the banking sector. As shown in equation (22) above, the level of money balances under a monopolist are inefficiently low. Consequently, the rate of return to movers (the short-term interest rate in the economy) is also inefficient. These distortions are reinforced through the participation constraint – a monopoly bank extracts all gains from using the financial system. As a result, the term structure of interest rates in a perfectly competitive economy dominates the fully concentrated economy. That is, both the short-term and long-term interest rates are higher under perfect competition.

# 3 A General Equilibrium Framework: Endogenous Rates of Return to Investment in the Economy

In this section, we extend our framework to a general equilibrium setting by including a credit market. In this manner, the return to banks' investments will endogenously respond to the different portfolio allocations of banks. In particular, we demonstrate that the price of loans will be inefficiently high under a fully concentrated banking system. Furthermore, there are interesting implications for the effects of monetary policy. Notably, in a monopoly banking economy, inflation affects interest rates in both the deposit market and the credit market. Under perfect competition, however, monetary policy only affects rates of return in the deposit market. Consequently, incorporating credit market behavior yields additional insights into the interactions between monetary policy and financial sector competition.

In this economy, there are two types of agents: borrowers and lenders. Lenders have the same preferences and endowments as in the previous section. Borrowers are endowed with $y_1$ units of goods when young and $y_2$ units of goods when old. In particular, the second period endowment is more than the first period endowment. It is assumed that borrowers have the same preferences and lifetime utility function as lenders. In contrast, they are not subject to the relocation shock. Since borrowers have income in both periods, the primary role of the credit market is to allow for consumption smoothing.

Next, we describe the timing and actions of agents and financial institutions in comparison to the partial equilibrium framework. After announcing rates of return in the deposit market, lenders deposit their funds. Next, banks receive transfers from the monetary authority. In addition, they obtain currency by trading some of the deposits from lenders to relocated old individuals. Instead of investment projects with a fixed rate of return, banks supply the remaining amount of deposits as loans in the credit market, $l_t^s$.[16] After bank portfolios for the current period are established,

[16] As in the partial equilibrium version, lenders have limited ability to participate in financial markets. While they can deposit their funds in the bank, they only obtain access to the credit market through the services of financial intermediaries.

old borrowers receive their endowments. With the newly acquired income, they pay back their loans along with interest to the bank. Banks use the funds to finance rates of return to non-movers or consume them directly as profits. At the end of the period, the relocation shock occurs and old borrowers die.

In an economy without financial intermediation, borrowers consume only their endowments in each period. In contrast, if borrowers have access to the financial system, they can smooth their consumption by obtaining loans. Specifically, they can maximize discounted lifetime utility by choosing the amount of loans:

$$\underset{l_t^d}{Max} \ln(y_1 + l_t^d) + \beta \ln(y_2 - R l_t^d) \tag{24}$$

Thus, loan demand is given by:

$$l_t^d = \frac{y_2 - \beta R y_1}{R(1+\beta)} \tag{25}$$

Loan demand is negatively related to the interest rate in the credit market, the rate of time preference and endowments in period $t$ but positively related to the amount of the endowment in period $t+1$ . When future utility is more important, borrowers want to consume more goods when old. Thus, loan demand decreases. If the young period endowment decreases or old period endowment increases, individuals want to obtain more loans in order to smooth consumption.

### 3.0.3 Perfectly competitive banks

Banks compete by offering rates of return to deposits. Thus, each bank's objective is to maximize the expected utility of a representative lender. In contrast to the partial equilibrium framework, the bank gives loans to borrowers instead of investing in projects with a fixed rate of return. That is, the rate of return to loans is determined by the interactions between loan demand and supply. Since the credit market is perfectly competitive, each bank takes the interest rate on loans as given.

Therefore, banks set the schedule $(r_t^m, r_t^n, m_t, l_t^s)$ to maximize:

$$\underset{r_t^m, r_t^n, m_t, l_t^s}{Max} \ln(x-d) + \beta[\pi \ln(r_t^m d) + (1-\pi)\ln(r_t^n d)] \tag{26}$$

The maximization problem is nearly the same as the partial equilibrium framework. However, we must verify that borrowers obtain higher lifetime utility from obtaining loans than autarky:

$$\ln(y_1 + l_t) + \beta \ln(y_2 - R_t l_t) \geq \ln(y_1) + \beta \ln(y_2) \tag{27}$$

As discussed earlier, the optimal amount of consumption insurance depends only upon the probability of the bad state to occur. Consequently, the loan supply of each bank is equal to the amount of deposits remaining after money holdings:

$$l_t^s = (1-\pi)d \tag{28}$$

Since the demand for money is independent of the return to loans, the loan supply curve is perfectly inelastic. Figure 6 illustrates the relationship between money holdings, loan supply, and equilibrium credit market behavior:

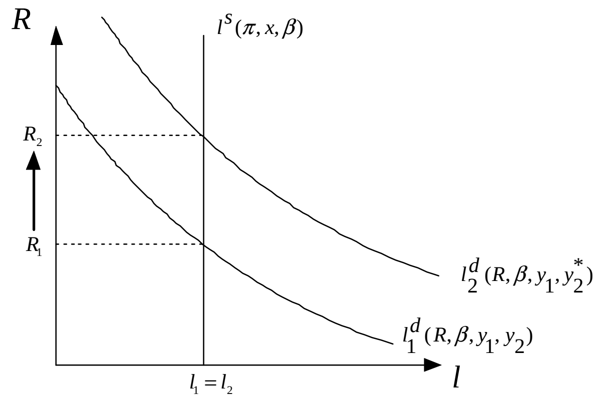


Figure 6: Credit Market Equilibrium under Perfect Competition

In particular, we obtain the following closed-form solution for the interest rate in the credit market:

$$R = \frac{y_2}{\beta[(1-\pi)x + y_1]} \tag{29}$$

To begin, when the old period endowment of borrowers increases, the interest rate on loans is higher due to higher demand for funds. Figure 6 illustrates the effect through loan demand. The shift in the loan demand curve will initially be associated with an excess demand for funds in the credit market. However, the supply of funds is completely inelastic and will not respond to an increase in the price of loans. Therefore, although the price of loans is higher when $y_2$ is higher, the extension of credit to borrowers remains the same. This is shown in the Figure by the increase from $R_1$ to $R_2$. The effect of $y_1$ works in a similar manner.

In contrast, the loan supply curve depends on the bank's demand for currency. For example, if the probability of a relocation shock increases, the loan supply curve will shift back and the price of loans will be higher. Although the lower amount of loans reduces payments to movers, there is an increase in bank earnings resulting from higher prices. Consequently, the net impact on the return to non-movers (the long-term interest rate in the deposit market) is ambiguous in the general equilibrium setting. In particular, it depends on the elasticity of the demand for funds by borrowers.

It is easy to show the expected deposit rate is:

$$r_{pc} = \pi(\frac{p_t}{p_{t+1}}) + \frac{(1-\pi)y_2}{\beta\left[(1-\pi)x + y_1\right]} \tag{30}$$

**Equilibrium** We now study outcomes in the steady-state:

**Definition 3.** *A general equilibrium steady-state in a perfectly competitive banking industry is an economy such that:*

*1. lenders choose an amount of saving to maximize their expected lifetime utility, (3);*

*2. borrowers determine the amount of loans to maximize their lifetime utility, (24);*

*3. the rate of return in the credit market is sufficiently high,* $R > (1/\beta)$*;*

*4. the bank's objective is to maximize the expected utility of a lender, (26);*

*5. the self-selection condition for lenders holds, (8);*

*6. banks satisfy the participation constraint of each lender, (9); and*

*7. borrowers obtain higher lifetime utility by receiving funds from the bank; that is, (27) is satisfied.*

**Proposition 4**. *Suppose the second period endowment of borrowers is sufficiently high. In particular, let* $y_2 > [(1-\pi)x + y_1]$*. If* $\frac{1}{1+\sigma} > (1-\tau)\, s$ *, then a steady-state equilibrium in a perfectly competitive banking economy exists and is unique.*

As in the partial equilibrium framework (Proposition 2), the interest rate in the credit market must be sufficiently high in order for a steady-state to exist. In contrast to the partial equilibrium setting, the loan price is determined endogenously by conditions in the credit market. If borrowers receive high levels of income in the second period, they will choose to borrow more when young. Consequently, if the demand for loans is sufficiently high, the return to non-movers will induce self-selection. This establishes the lower bound listed in the first condition for existence.

We next need to verify if the participation constraint is satisfied. Under the first condition in the Proposition, the return to non-movers exceeds the return to storage. Therefore, movers would obtain a higher amount of consumption through financial intermediation than under autarky. Finally, if the return to money exceeds the return to movers in autarky, lenders will deposit their funds in the bank.

The expected rate of return to deposits in the steady-state is:

$$r_{pc} = \frac{\pi}{1+\sigma} + (1-\pi)\left(\frac{y_2}{\beta[(1-\pi)x + y_1]}\right) \tag{31}$$

If the central bank expands the monetary base, the expected interest rate on deposits falls. As the supply of funds is inelastic, the effects of monetary policy are the same as the partial equilibrium framework.

#### 3.0.4 A Monopoly bank

Obviously, the monopolist's objective is to maximize discounted profits. However, the monopolist can distort both the deposit and credit markets in this economy. To be specific, the bank offers deposit rates such that lenders receive a level of expected utility equal to autarky. In addition, the monopolist exploits its market power in the credit market by setting the price of loans, $R_t$. In particular, it considers the effect of the interest rate on the amount of loan demand. Thus, its objective is given by:

$$\underset{r_t^n, m_t, R_t}{Max}\, d - m_t - l_t^d + \beta[R_t l_t^d - (1-\pi) r_t^n d] \tag{32}$$

The amount of credit market activity under the monopoly bank is shown in Figure 7:

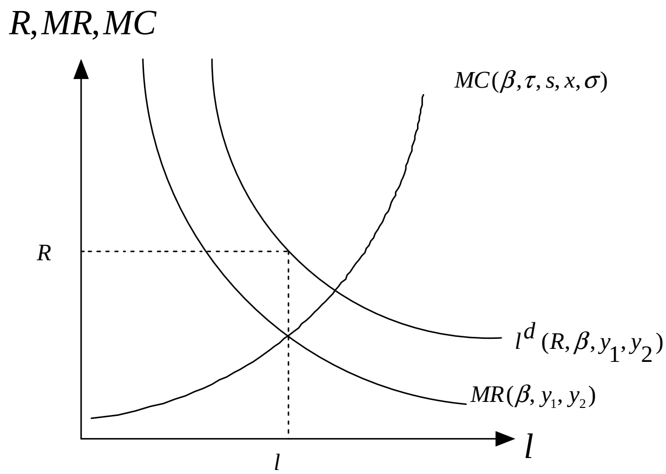


Figure 7: Credit Market Behavior under a Monopoly Bank

As illustrated above, the bank's marginal revenue curve is downwards-sloping. This occurs because borrowers receive less additional utility from higher amounts of consumption. Consequently, the additional revenue from extending credit will decline with the amount of loans issued. Moreover, the bank faces an upward-sloping marginal cost curve. Since all deposits are allocated between money holdings and bank loans, the cost of lending stems from higher payments to non-movers. For each additional amount of loans issued, lenders receive less consumption insurance. Due to the lower amount of utility received in the bad state, lenders require the same increase in utility in the event of the good state (when they are non-movers). Since the additional loans would require higher payments to non-movers, the cost of extending additional credit will be higher. As a result, the bank's marginal cost curve for loans is upward-sloping. The amount of lending occurs in which the marginal revenue of a loan is equal to the marginal cost. Consequently, the equilibrium interest rate in the credit market is determined by the demand for loans.

In order to make comparisons to the perfectly competitive financial market, we present a closed-form solution for the interest rate offered by the monopolist. For tractability, we assume that the probability of the relocation shock is equal to $\pi = \frac{1}{2}$. The profit-maximizing choice is given by:

$$R_{M,t}\left(y_1, y_2, s, x, \tau, \frac{p_{t+1}}{p_t}\right) = \frac{y_2 + \frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}\frac{p_{t+1}}{p_t}}}{\beta\,(x + y_1)} \tag{33}$$

We begin by discussing the impact of borrowers' endowments on credit market activity. As in the case of the perfectly competitive economy, higher second period endowments lead to an increase in demand for loans by borrowers. This is shown in Figure 8 by the upward-shift of both the demand and marginal revenue curves.

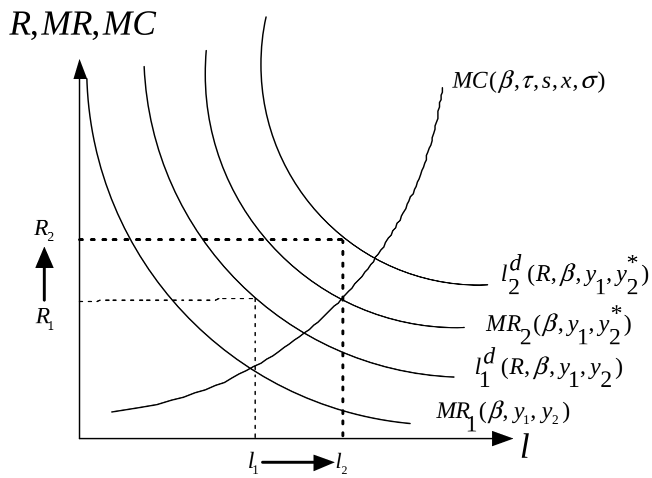


Figure 8: The Effect of Loan Demand on Credit Market Behavior under a Monopolist

The following lemma characterizes the resulting effects of an increase in the demand for loans:

**Lemma 3**. *An increase in* $y_2$ *is associated with a higher interest rate in the loan market regardless of the competitive structure of the financial system. However, the effect is stronger under perfect competition.*

Notably, the supply of loans in a perfectly competitive banking system is completely inelastic. An increase in demand does not generate additional lending – it only leads to higher interest rates in the credit market. In contrast, under the monopoly bank, the higher second period endowment increases both the demand for loans and the additional revenue. Consequently, both the price and amount of lending will be higher in the monopoly sector. As a result, the effect of $y_2$ on the interest rate in the credit market is stronger in the perfectly competitive economy.

Moreover, since the cost of lending depends on conditions in the deposit market, the interest rate in the fully concentrated banking economy will also depend on lenders' ability to use alternative methods of payment. This is most apparent by examining the effects of transportation costs. If transportation costs are higher, the transactions value of money balances will be more important. Thus, the monopolist can extract more gains from using the financial system by providing less insurance to its depositors through acquiring money balances. Since the bank does not need to obtain as much money, the marginal cost curve for loans will shift down. Therefore, it will have more funds available to lend to the credit market. As a result, the interest rate will be lower. We discuss the effects of monetary policy in the next section.

**Equilibrium** Now, we study economic outcomes in the steady-state:

**Definition 4.** *A steady-state equilibrium in a fully concentrated banking sector is an economy such that:*

*1. lenders choose an amount of saving to maximize their expected lifetime utility, (3);*

*2. borrowers determine the amount of loans to maximize their lifetime utility, (24);*

*3. the rate of return in a credit market is sufficiently high,* $R_M > (1/\beta)$*;*

*4. the bank chooses a schedule* $(r^m, r^n, m, R_M)$ *to maximize profits, (32);*

*5. the self-selection condition for lenders holds, (8);*

*6. the bank satisfies the participation constraint of each lender, (9);*

*7. borrowers obtain higher lifetime utility by receiving funds from the bank; that is, (27) is satisfied, and*

*8. the bank obtains positive profits.*

**Proposition 5**. *Let* $(1-\tau) > \left[\frac{2\beta(x+y_1)-2y_1(1+\sigma)}{\beta(1+\sigma)sx}\right]^2$ *and* $s > \frac{1}{\left[\beta^2 x-(1-\beta^2)y_1\right]\sqrt{y_1\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]}}$. *Also, setting* $\pi = \frac{1}{2}$ *and* $y_2 \in \left\{\frac{\left[s^2\beta(1-\tau)(1+\sigma)\right]\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]}{4}, (x+y_1) - \frac{\sqrt{(sx)^2\beta(1-\tau)(1+\sigma)(x+y_1)y_1}}{2y_1}\right\}$, *a steady-state equilibrium in a fully concentrated banking economy exists. This interval is non-empty as long as* $(1-\tau) > \frac{4(x+y_1)\left\{\sqrt{(x+2y_1)+2\sqrt{y_1^2+xy_1}+\frac{x^2}{y_1}}+\sqrt{\frac{x^2}{y_1}}\right\}}{\sqrt{(x+2y_1)+2\sqrt{y_1^2+xy_1}+\frac{x^2}{y_1}}\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]\left[s^2\beta(1+\sigma)\right]}$.

The rate of return to the investment project is exogenous in the partial equilibrium model. Thus, the existence conditions for a perfectly competitive banking sector and a fully concentrated banking industry are the same if $R$ is fixed. (See Propositions 2 and 4) However, the results are more stark in general equilibrium. In particular, the conditions for existence in the monopoly economy are significantly more complex than under perfect competition. As a benchmark, please refer to the graph of loan market behavior in Figure 6. Under perfect competition, the supply of loans is perfectly inelastic. As a result, it is easy to obtain a closed-form solution for the real interest rate in the credit market. Consequently, it naturally follows that the participation constraint depends on the return to money.

However, as can be observed in Figure 7, the supply of funds is elastic in the fully concentrated banking industry. In particular, the participation decisions by lenders affect the supply of funds through the bank's upward-sloping marginal cost curve. Since both the marginal cost and demand curves depend on the price of loans, the analysis of credit market behavior is more complicated than under perfect competition. As a result, it becomes more difficult to determine if the remaining conditions for existence are satisfied.

We conclude this section by comparing the price of loans in a perfectly competitive banking sector to the monopoly economy:

**Proposition 6.** *Suppose that the perfectly competitive banking and monopoly economies exist. Under these conditions, a monopolist charges a higher interest rate for loans than perfectly competitive banks.*

The credit market in a perfectly competitive banking economy is characterized by price-taking behavior. Specifically, the interest rate is determined by the demand and supply of loans. In contrast, a monopolist distorts the credit market. It considers the effect of the interest rate on the amount of loans and determines the price that maximizes profits. Thus, a monopolist can extract more surplus in the credit market than perfectly competitive banks. This results in the higher price of loans in a fully concentrated banking economy.

#### 3.0.5 Monetary Policy and the Degree of Financial Sector Competition

While the preceding analysis studies how the degree of financial sector competition affects credit market behavior, we continue by examining the impact of monetary policy on the price of loans:

**Proposition 7**. *There is no relationship between the interest rate in the credit market and the growth rate of money in a perfectly competitive banking economy. In contrast, the growth rate of money is positively related to the price of loans in a fully concentrated banking economy.*

Under perfect competition, the amount of consumption insurance provided to lenders only depends on the probability of the bad state. Given the inelastic demand for currency, the supply of loans is also independent of monetary policy in a perfectly competitive financial sector. Thus, in the absence of market power, inflation does not affect interest rates in the credit market. (See Figure 6)

However, in the case of the monopolist, monetary policy causes the bank's marginal cost curve to shift. For a given nominal amount of money holdings, the short-term interest rate will be lower under higher rates of money growth. Since the return in the bad state is lower when the inflation rate is higher, the required amount of compensation in the good state rises. As illustrated in Figure 9, this raises the marginal cost of bank lending.

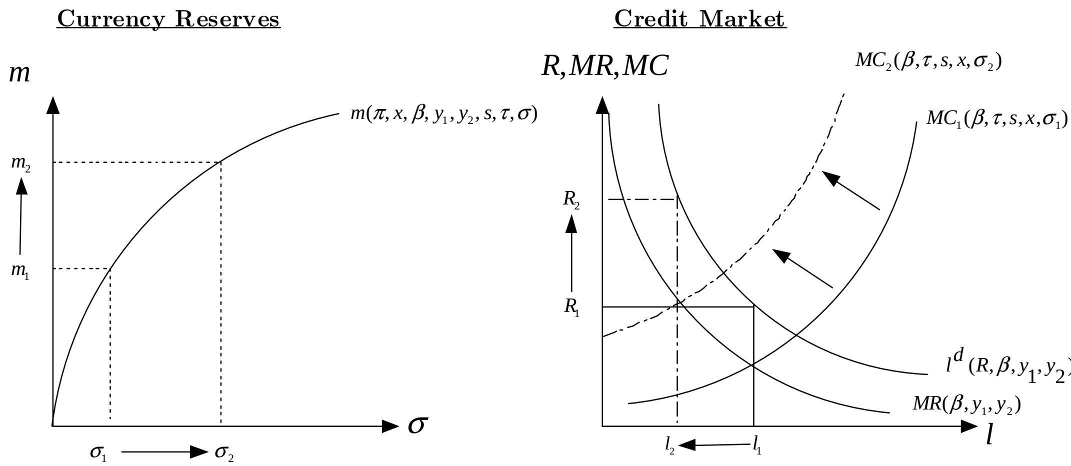


Figure 9: The Effect of Monetary Policy on the Price of Loans in a Fully Concentrated Banking Economy

As a result, the growth rate of money will be positively related to the price of loans in a fully concentrated financial sector.[17]

At this juncture, we discuss the impact of monetary policy and competitive structure on expected interest rates in both the partial and general equilibrium settings:

**Proposition 8**. *The effect of monetary policy on the expected deposit rate in a perfectly competitive banking economy is the same in both the partial and general equilibrium frameworks. In contrast, deposit rates offered by a monopolist respond more to monetary policy in a general equilibrium framework compared to a partial equilibrium setting.*

The credit market in a perfectly competitive banking economy is independent of the growth rate of money. When the monetary authority adjusts the monetary base, it only affects short-term interest rates. In this manner, in a perfectly competitive economy, the effect of monetary policy is the same in both the partial and general equilibrium settings. However, the effects of money growth are stronger due to the impact on *both* the bank's portfolio choice (for a given $R$) and the higher price of bank lending.

### 3.0.6 Relative Distortions in the Deposit and Credit Markets

At this point, we can examine the extent to which the distortions in the *deposit* market will affect the degree of inefficiency in the *credit* market. Recall that the efficient level of money holdings is given by:

$$m_{PC} = \left(\frac{1}{2}\right)\left(\frac{\beta}{1+\beta}\right)x \tag{34}$$

[17] In this manner, our model demonstrates that monetary policy is more effective in regulating credit market behavior if the financial sector is less competitive. Cechetti (1999) also argues that the impact of monetary policy depends on the degree of competition.

Under perfect competition, credit market conditions do not affect the bank's level of currency reserves. Recognizing that the bank's holdings of money are inefficiently low in the partial equilibrium framework, the inefficiency is reinforced in the presence of a credit market. The extent of the distortion is observed by examining the monopolist's money demand function:

$$m_M = \frac{s\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}}{\beta R_M\left(y_1, y_2, s, x, \tau, (1+\sigma)\right)}\left(\frac{1}{2}\right)\left(\frac{\beta}{1+\beta}\right)x \tag{35}$$

In both types of economies, loan demand is independent of monetary policy because borrowers do not experience relocation shocks. Therefore, they do not need to use fiat money. In contrast, loan supply depends on the level of banking competition and the growth rate of money. However, the following Lemma demonstrates that there exists a money growth rate in which the reserves held by a monopolist are the same as perfectly competitive banks:

**Lemma 4**. *If* $(1+\sigma) = \frac{\left(\left(\frac{1}{s}\right)\left(\frac{2y_2}{x+2y_1}\right)\right)^2}{\beta(1-\tau)\left(\frac{y_2}{y_1}\right)}$, *the level of money holdings will be the same as the perfectly competitive level.*

In this manner, we find that the monopolist provides the right amount of coverage against the bad state (the probability of relocation) if the inflation rate is high enough. However, this does not imply that the allocation is efficient – although movers receive the same amount of consumption as lenders under perfect competition, the rate of return to non-movers will be much lower.

Moreover, the higher amount of inflation further distorts the credit market and lowers the degree of consumption smoothing. Under perfect competition, interest rates and bank lending are unaffected by the economy's inflation rate. However, Figure 9 demonstrates that the credit market in a fully concentrated economy will be severely affected. Although the inflation rate instills the bank to hold the perfectly competitive level of money balances, the interest rate in the credit market will be higher. Due to the higher cost of obtaining credit, borrowers will obtain less second period net income. Furthermore, the higher amount of inflation also reduces the amount of lending. Both lower the amount of consumption smoothing among borrowers. Thus, in order to generate the efficient level of money holdings in the deposit market, the increase in inflation exacerbates inefficiencies in the credit market.

## 4 Welfare Costs of Inflation

In this section, we examine the interactions between the degree of banking competition and the welfare costs of inflation. In particular, we illustrate that the effects depend on the combination of credit market conditions and market power. To make clear comparisons, we use simple numerical examples.

As a benchmark, we start with the welfare costs in the partial equilibrium framework. Assuming that $EU(r_g)$ is the amount of expected lifetime utility under $g$ % money growth, our measurement of the welfare costs from an inflation rate of $r_0$ to $r_g$ are:

$$\triangle W = \frac{EU(r_g) - EU(r_0)}{EU(r_0)} \tag{36}$$

Following previous work such as Cooley and Hansen (1991), we present our analysis for the effects of 10% inflation relative to a constant money stock. As an example, consider the set of parameters: $x = 2$, $s = 0.8$, $\beta = 0.9$, $\tau = 0.8$, $R = 3$, and $\pi = 0.5$. The results are provided below:

| Money Growth | 0 | 2% | 4% | 6% | 8% | 10% |
|---|---|---|---|---|---|---|
| Perfectly Competitive Banks | 0 | -1.90% | -3.95% | -5.88% | -7.70% | -9.62% |
| Monopolist | 0 | 0 | 0 | 0 | 0 | 0 |

Table 1: Welfare Costs of Inflation in Partial Equilibrium

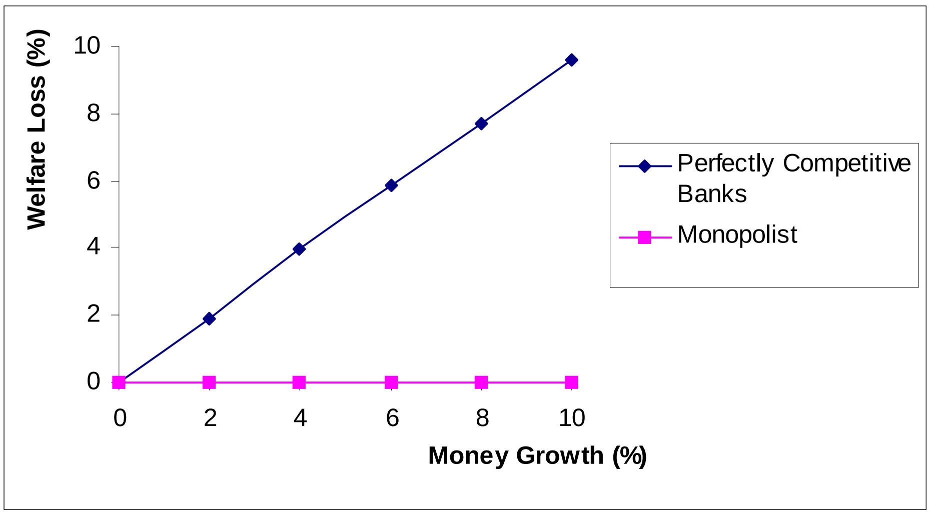


Figure 10: Welfare Loss in Partial Equilibrium

The Figure illustrates that the adverse effects of inflation only occur under perfect competition. As demonstrated in Lemma 6, the expected return to bank deposits increases with the inflation rate in the fully concentrated economy. However, expected utility will not be affected. Consequently, inflation will not have any impact on welfare in the presence of a monopoly bank.

We next explore the impact of inflation in the presence of both deposit and credit markets. In particular, we find that the additional costs of inflation only occur in the monopoly financial industry. Recall that in order to include credit market behavior, there are two types of agents: lenders and borrowers. Thus, the measure of welfare costs must account for the loss of lifetime utility by both groups of individuals:

$$\triangle W = \frac{EU(r_g) - EU(r_0)}{EU(r_0)} + \frac{U(R_g) - U(R_0)}{U(R_0)} \tag{37}$$

To be consistent with the partial equilibrium calculations, all benchmark parameters have the same values. In addition, $y_1 = 0.05$ and $y_2 = 2$. The impact of inflation under perfect competition is shown by:

| Money Growth | 0 | 2% | 4% | 6% | 8% | 10% |
|---|---|---|---|---|---|---|
| Partial Equlibrium | 0 | -1.90% | -3.95% | -5.88% | -7.70% | -9.62% |
| General Equilibrium | 0 | -1.90% | -3.95% | -5.88% | -7.70% | -9.62% |

Table 2: Welfare Cost in a Perfectly Competitive Banking Economy

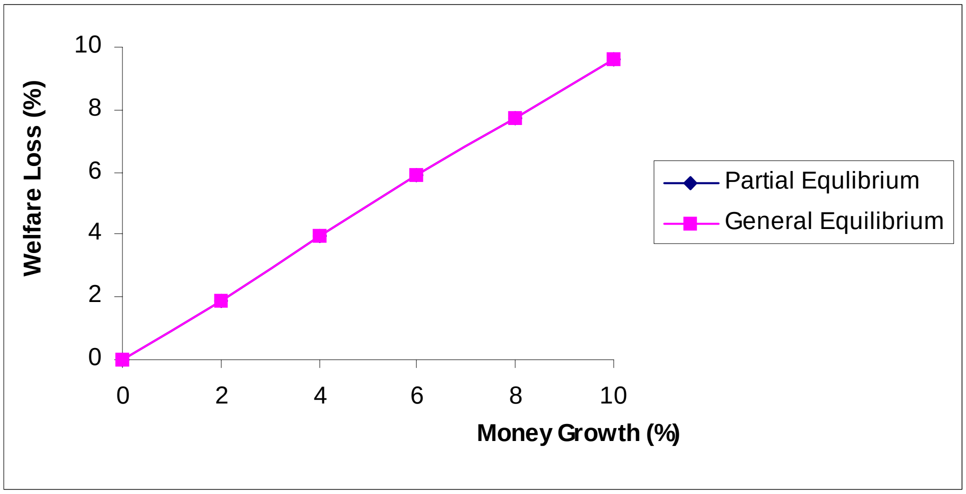


Figure 11: Welfare Loss in a Perfectly Competitive Banking Economy

The intuition follows from Proposition 14 – inflation only affects the real return to money.

Next, we consider the welfare costs of inflation in a fully concentrated banking economy:

| Money Growth | 0 | 2% | 4% | 6% | 8% | 10% |
|---|---|---|---|---|---|---|
| Partial Equlibrium | 0 | 0 | 0 | 0 | 0 | 0 |
| General Equilibrium | 0 | -0.65 | -1.3 | -1.93 | -2.56 | -3.18 |

Table 3: Welfare Cost in a Fully Concentrated Banking Economy

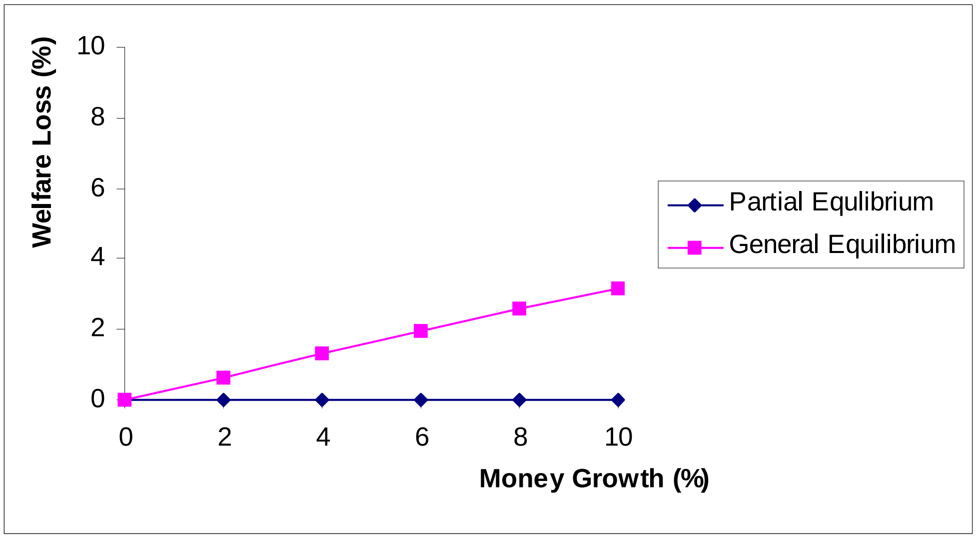


Figure 12: Welfare Loss in a Fully Concentrated Banking Economy

As in the partial equilibrium version, the expected utility of lenders does not depend on the rate of money growth. However, the price of loans is increasing in the inflation rate. Therefore, borrowers will have less ability to smooth consumption. As a result, the welfare costs of inflation are higher in the general equilibrium framework.

# 5 Conclusions

Recent evidence suggests that the banking industry is becoming less competitive over time. Such developments clearly have an impact on financial market activity. Moreover, the increasing degree of concentration is likely to lead to different effects of monetary policy. In order to explore the impact of competition in the financial sector, we develop a model of Bertrand competition. Our framework generates a number of interesting insights regarding the role of monetary policy under different degrees of concentration in the financial sector. In our partial equilibrium analysis, we demonstrate that nominal short-term interest rates do not depend on the rate of money growth if the deposit market is perfectly competitive. However, under a fully concentrated banking system, higher rates of money growth lead to higher short-term interest rates.

We continue by extending our analysis to a general equilibrium model which includes a credit market. Under perfect competition, the rate of money growth does not affect interest rates in the credit market or the amount of lending. However, in a monopoly banking system, monetary expansion reduces the real rate of return to money and lowers the supply of funds to the credit market. As a result, monetary policy plays a role in determining loan rates and the extension of credit in the economy. This leads to an interesting conclusion – although welfare is higher under perfect competition, monetary policy will have a more significant impact on credit market activity if the banking system is less competitive. Finally, we illustrate the welfare costs of inflation under different degrees of competition. Although welfare is inefficiently low under a monopoly banking sector, the welfare costs of inflation are highest if the financial sector is perfectly competitive.

# References


Bank for International Settlements, 2001. Report on Consolidation in the Financial Sector. January.

Barnes, M., J.H. Boyd, and B.D. Smith, 1999. Inflation and Asset Returns. European Economic Review 43, 737-754.

Berger, A. N. and T. H. Hannan, 1989. The Price-Concentration Relationship in Banking. Review of Economics and Statistics 24, 291-99.

Boyd, J. H., G. De Nicolo, and B.D. Smith, 2004. Crises in Competitive Versus Monopolistic Banking Systems. Journal of Money, Credit and Banking 36, 487-506.

Cetorelli, N., and M. Gambera, 2001. Banking Market Structure, Financial Dependence and Growth: International Evidence from Industry Data. Journal of Finance 56, 617-648.

Cechetti, S.G, 1999. Legal Structure, Financial Structure, and the Monetary Policy Transmission Mechanism. Federal Reserve Bank of New York Economic Policy Review, 9-27.

Cooley, T. and G. Hansen, 1991. The Welfare Cost of Moderate Inflation. Journal of Money, Credit, and Banking 23, 482-503.

Fuerst, T., 1992. Liquidity, Loanable Funds, and Real Activity. Journal of Monetary Economics 29, 3-24.

Hutchison, D.E., 1995. Retail Bank Deposit Pricing: An Intertemporal Asset Pricing Approach. Journal of Money, Credit and Banking 27, 217-231.

Diamond, D. and P. Dybvig, 1983. Bank runs, Deposit Insurance, and Liquidity. Journal of Political Economy 85, 191-206.

Gaetano, A., E. Huybens and T. Keister, 2001. Monetary Stability and Liquidity Crises: The Role of the Lender of Last Resort. Journal of Economic Theory 99, 187-219.

Grossman, S. and L. Weiss, 1983. A Transactions-Based Model of the Monetary Transmission Mechanism, American Economic Review 73, 871-880.

Guzman, M., 2000. Bank Structure, Capital Accumulation, and Growth: A Simple Macroeconomic Model. Economic Theory 16, 421-455.

Hannan, T.H., 1991. Bank Commercial Loan Markets and the Role of Market Structure: Evidence From Surveys of Commercial Lending, Journal of Banking and Finance 15, 133-149.

Lucas, R. , 1990. Liquidity and Interest Rates.Journal of Economic Theory 50, 237-264.

Neumark, D. and S.A. Sharpe, 1992. Market Structure and the Nature of Price Rigidity: Evidence From the Market for Consumer Deposits. Quarterly Journal of Economics 107, 657-680.

Pagano, M., 1993. Financial Markets and Growth: An Overview, European Economic Review 37, 613-22.

Petersen, M. and R. Rajan, 1995. The Effect of Credit Market Competition on Lending Relationships. Quarterly Journal of Economics 110, 407-443.

Rosen, R.J., 2003. Banking Market Conditions and Deposit Interest Rates. Federal Reserve Bank of Chicago Working Paper No. 2003-19.

Samuelson, P.A., 1954. The Transfer Problem and Transport Costs: Analysis of Effects of Trade Impediments. Economic Journal 64, 264-289.

Schreft, S.L. and B.D. Smith, 1997. Money, Banking, and Capital Formation. Journal of Economic Theory 73, 157-182.

Sharpe, S.S., 1991. Consumer Switching Costs, Market Structure, and Prices: Theory and Its Applications in the Bank Deposit Market, Finance and Economic Discussion Series, Board of Governors of the Federal Reserve System.

Thorsten, B., A. Demirguc-Kunt, and R. Levine, 2003. Bank Concentration and Crises. National Bureau of Economic Research Working Paper, No. 9921.

Townsend, R., 1987. Economic Organization with Limited Communication. American Economic Review 77, 954-971.

Whitesell, W.C., 1992. Deposit Banks and the Market for Payment Media. Journal of Money, Credit and Banking 24,. 483-498.

Williamson, S.D., 2005. Search, Limited Participation, and Monetary Policy. Forthcoming, International Economic Review.

# 6 Appendix

**1. Proof of Proposition 1.** By arguments in the text, the self-selection condition for depositors is trivially satisfied. The next step is to show that the participation constraint holds. Therefore, we must find that:

$$E(U(c^{pc})) = \ln(\frac{x}{1+\beta}) + \beta[\pi \ln(\frac{1}{1+\sigma}\frac{\beta}{1+\beta}x) + (1-\pi)\ln(R\frac{\beta}{1+\beta}x)] > E(U(c^{A}))$$

This condition easily holds *iff* $R \geq s^{\frac{1}{1-\pi}}\left[(1-\tau)(1+\sigma)\right]^{\frac{\pi}{1-\pi}}$. This completes the proof of Proposition 1.

**2. The profit-maximizing choices of the monopoly bank in partial equilibrium.** The monopolist allocates its funds and sets interest rates to maximize discounted profits. The objective problem is:

$$\underset{r_t^m, r_t^n, i_t, m_t}{Max} \; d - m_t - i_t + m_t \frac{p_t}{p_{t+1}} - r_t^m \pi d + \beta(Ri_t - (1-\pi)r_t^n d)$$

Since money is dominated in rate of return by the investment opportunities, $m_t \frac{p_t}{p_{t+1}} = r_t^m \pi d$. This reduces the bank's problem to:

$$\underset{r_t^n, i_t, m_t}{Max} \; d - m_t - i_t + \beta(Ri_t - (1-\pi)r_t^n d)$$

As $\beta R > 1$, the discounted value of investment earnings is greater than the value of bank deposits. Consequently, the monopolist allocates all deposits to money holdings and available investment opportunities. This reduces the number of choice variables from three $(r_t^n, i_t, m_t)$ to two $(r_t^n, m_t)$ since $i_t = d - m_t$.

$$\underset{r_t^n, m_t}{Max} R\,(d - m_t) - (1-\pi)r_t^n d$$

In order to maximize profits, the monopolist will choose $r_t^n$ and $m_t$ so that depositors do not experience any gains from using the financial system. Therefore, we may write $r_t^n$ as a function of $m_t$ from the participation constraint:

$$(r_t^n)^{\frac{1-\pi}{\pi}} = \frac{\pi(1-\tau)s^{\frac{1}{\pi}} d}{m_t(\frac{p_t}{p_{t+1}})}$$

Thus, the problem reduces to choosing the amount of money holdings to maximize profits:

$$\underset{m_t}{Max} R\,(d - m_t) - (1-\pi)\left(\frac{\pi(1-\tau)s^{\frac{1}{\pi}} d}{m_t(\frac{p_t}{p_{t+1}})}\right)^{\frac{\pi}{1-\pi}} d$$

which yields: $m_t = \left( \dfrac{s(1-\tau)^{\pi}}{R^{1-\pi}(\dfrac{p_t}{p_{t+1}})^{\pi}} \right) \pi d$. This completes the profit-maximizing choice of the monopoly bank.

**3. Proof of Proposition 2.**

As described in the text, we must first show that the self-selection constraint is satisfied, i.e., $r^n > r^m$. This is easily observed by comparing (21) to (20). We proceed to find conditions under which the monopolist earns positive profits. Using the implicit function theorem:

$$\Phi = d - m - i + \beta(Ri - (1-\pi)r^n d)$$

Recognizing that $d = m + i$, positive profits are realized *iff*:

$$R > \frac{(1-\pi)r^n d}{d-m}$$

Substitution yields the condition listed in Proposition 2. This completes the proof of Proposition 2.

**4. Proof of Proposition 4.** The remaining requirement for existence involves the participation constraint. Upon substitution for the rates of return offered by perfectly competitive banks, the constraint holds as long as:

$$\pi \ln(1+\sigma) + (1-\pi)\ln\left(\frac{y_2}{\beta\left[(1-\pi)x + y_1\right]}\right) \geq \pi \ln(1-\tau)s + (1-\pi)\ln s$$

Since $s < 1$, then $R = \frac{y_2}{\beta[(1-\pi)x+y_1]} > s$. As a result, $\frac{1}{1+\sigma} \geq (1-\tau)\, s$ is a sufficient condition for existence. This completes the proof of Proposition 4.

**5. The profit-maximization problem of the monoplist in the general equilibrium framework.** As in the partial equilibrium framework, the bank's problem may be reduced to three choice variables: $r_t^n$, $m_t$, and $R_t$ :

$$\underset{r_t^n, m_t, R_t}{Max}\ R_t l_t^d - (1-\pi) r_t^n d$$

Again, we can express $r_t^n$ as a function of $m_t$. This reduces the bank's problem to choosing a schedule $(m_t, R_t)$ to maximize profits. Upon substituting for the money demand function along with the demand for loans, the maximization problem is:

$$\underset{R_t}{Max} \frac{y_2 - \beta R_t y_1}{(1+\beta)} - (1-\pi)\left( \frac{\pi(1-\tau)s^{\frac{1}{\pi}}\left(\frac{x\beta}{1+\beta}\right)}{\left(\left(\frac{x\beta}{1+\beta}\right) - \dfrac{y_2 - \beta R_t y_1}{R_t(1+\beta)}\right)(\dfrac{p_t}{p_{t+1}})} \right)^{\frac{\pi}{1-\pi}} \left(\frac{x\beta}{1+\beta}\right)$$

In order to obtain a closed-form solution for the interest rate in the credit market, let $\pi = \frac{1}{2}$. This yields equation (33). This completes the proof of the maximizing choice of the interest rate by the monopoly bank.

**6. Proof of Proposition 5.**

1. We first need to find conditions in which the steady-state interest rate is sufficiently high. That is, $R > \frac{1}{\beta}$. Upon substitution from (33), this occurs if:

$$\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)} > (x+y_1) - y_2 \tag{38}$$

Assuming that $(x+y_1) > y_2$, the expression may be written as:

$$y_2^2 - \left[2(x+y_1) + \frac{(sx)^2\beta(1-\tau)(1+\sigma)}{4y_1}\right] y_2 + (x+y_1)^2 < 0$$

We next seek to find conditions under which this is true. Applying the quadratic formula establishes an upper-bound for $y_2$ :

$$y_2 < (x+y_1) - \frac{\sqrt{(sx)^2\beta(1-\tau)(1+\sigma)16(x+y_1)y_1}}{8y_1} \tag{39}$$

*This provides conditions in which the interest rate is sufficiently high.*

2. We also require that the self-selection constraint holds:

$$(x+y_1)\left(\sqrt{\frac{\beta y_2}{y_1(1+\sigma)}}\right) - y_2 < \frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)} \tag{40}$$

We note that both conditions involve the same upper bound. Therefore if (38) is satisfied, (40) holds if:

$$y_2 < \frac{y_1(1+\sigma)}{\beta} \tag{41}$$

*This provides conditions in which the self-selection constraint holds.*

3. We must next find conditions under which the borrowers choose to obtain some amount of loans:

$$\ln\left(\frac{y_1\left(2y_2+sx\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)+\left(2y_2-sy_1\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)\frac{x\beta}{(1+\beta)}}{y_1\left(2y_2+sx\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)}\right) \geq \beta\ln\left(\frac{y_2 2\beta(x+y_1)}{y_2 2\beta(x+y_1)-\left(2y_2-sy_1\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)\frac{x\beta}{(1+\beta)}}\right) \tag{42}$$

Since $\beta$ is less than one, the condition holds if :

$$y_2 \geq \frac{\beta(1-\tau)(1+\sigma)}{4y_1\left[\beta^2 x - (1-\beta^2)y_1\right]^2} \tag{43}$$

*This provides conditions under which the borrower's participation will be satisfied.*

4. We must verify that the bank earns positive profits. This occurs if:

$$d_t - m_t - i_t + \beta(R_t l_t^d - (1-\pi) r_t^n d_t) > 0 \tag{44}$$

Since the bank's balances sheet constraint binds, (44) reduces to:

$$R_t l_t^d > (1-\pi) r_t^n d_t \tag{45}$$

By substituting the values of $R_t$, $l_t^d$, $d_t$, $r_t^n$, and $\pi$, (45) becomes:

$$2\left[\frac{\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}+y_2}{\beta(x+y_1)}\right]\left[\frac{\left(2y_2 - sy_1\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)\frac{x\beta}{(1+\beta)}}{\left(2y_2+sx\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)}\right] > \left[\frac{(1-t)s^2x\left(2y_2+sx\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)}{2(x+y_1)(\frac{1}{1+\sigma})\left(sx\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)}\right]\frac{x\beta}{(1+\beta)} \tag{46}$$

This reduces to a lower-bound for the second-period income of the borrowers:

$$y_2 > \frac{\left[s^2(1-\tau)\beta\,(1+\sigma)\right]\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]}{4} \tag{47}$$

Therefore if old-age income is sufficiently high, borrowers will seek to obain loans. *This provides conditions for the borrower's participation constraint to hold.*

5. This leads to a total of four conditions which must hold in order for an equilibrium to exist:

a.

$$(x+y_1) - y_2 < \frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}\,(1+\sigma)}$$

This holds if:

$$y_2 < (x+y_1) - \frac{\sqrt{(sx)^2\beta(1-\tau)(1+\sigma)16(x+y_1)y_1}}{8y_1}$$

b.

$$y_2 < \frac{y_1\,(1+\sigma)}{\beta}$$

c.

$$y_2 \geq \frac{\beta(1-\tau)\,(1+\sigma)}{4y_1\left[\beta^2 x - (1-\beta^2)y_1\right]^2}$$

d.

$$y_2 > \frac{\left[s^2(1-\tau)\beta\,(1+\sigma)\right]\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]}{4}$$

We next note that if:

$$(1-\tau) > \left[\frac{2\beta\,(x+y_1) - 2y_1\,(1+\sigma)}{\beta\,(1+\sigma)\,sx}\right]^2 \tag{48}$$

, then the condition that $\beta R > 1$ is sufficient for the self-selection condition to hold.

Finally, we show that if the monopolist earns positive profits, then the borrower's participation constraint will be satisfied. This occurs if:

$$s > \frac{1}{\left[\beta^2 x - (1-\beta^2) y_1\right] \sqrt{y_1 \left[(x+2y_1) + 2\sqrt{y_1^2 + x y_1}\right]}} \tag{49}$$

The above analysis provides a lower bound and an upper-bound for $y_2$ :

$$y_2 \in \left( \begin{array}{c} \frac{\left[s^2(1-\tau)\beta(1+\sigma)\right]\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]}{4}, \\ (x+y_1) - \frac{\sqrt{(sx)^2\beta(1-\tau)(1+\sigma)16(x+y_1)y_1}}{8y_1} \end{array} \right)$$

Finally, we need to find conditions under which the above interval is non-empty. That is,

$$(x+y_1) - \frac{\sqrt{(sx)^2\beta(1-\tau)(1+\sigma)16(x+y_1)y_1}}{8y_1} > \frac{\left[s^2(1-\tau)\beta(1+\sigma)\right]\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]}{4} \tag{50}$$

This reduces to an upper bound on transportation costs:

$$(1-\tau) > \frac{4\,(x+y_1)\left\{\sqrt{(x+2y_1)+2\sqrt{y_1^2+xy_1}+\frac{x^2}{y_1}} + \sqrt{\frac{x^2}{y_1}}\right\}}{\sqrt{(x+2y_1)+2\sqrt{y_1^2+xy_1}+\frac{x^2}{y_1}}\left[(x+2y_1)+2\sqrt{y_1^2+xy_1}\right]\left[s^2\beta\,(1+\sigma)\right]} \tag{51}$$

Thus, if $(1-\tau)$ satisfies (51), there is a range of $y_2$ in which the fully concentrated banking economy exists. This completes the proof of Proposition 5.

**6. Proof of Proposition 8.** We first show the effects of money growth for perfectly competitive banks under the general equilibrium model:

$$\frac{\partial r_{pc}^{GE}}{\partial \sigma} = -\frac{1}{2\,(1+\sigma)^2} < 0$$

We next compare the impact to the monopoly banking economy:

$$\frac{\partial r_{mp}^{GE}}{\partial \sigma} = -\frac{(x+y_1)\left(\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}\right)\left(\frac{y_2}{2\sqrt{(1+\sigma)}}+\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}\right)}{x\left(y_2\sqrt{(1+\sigma)}+\frac{sx}{2}(1+\sigma)\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}\right)^2} + \frac{(1-t)s^2x\left(\frac{y_2}{2\sqrt{(1+\sigma)}}+\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}\right)}{4(x+y_1)\left(\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}\right)}$$

If

$$(x+y_1)\left(\sqrt{\frac{\beta y_2}{y_1(1+\sigma)}}\right) - y_2 < \frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)} \tag{52}$$

, then $\frac{\partial r_{mp}^{GE}}{\partial \sigma} > 0$. However, note that (52) is the same condition as the self-selection constraint. Therefore, if a monopoly banking economy exists, $\frac{\partial r_{mp}^{GE}}{\partial \sigma} > 0$.

We next seek to verify if expected interest rates respond more to monetary policy in the general equilibrium framework. First, we consider the expected rate of return to deposits in the partial equilibrium framework. Thus, the expected deposit rates in a perfectly competitive banking industry and a fully concentrated banking sector may be expressed as:

$$r_{pc}^{PE} = \frac{1}{2(1+\sigma)} + \frac{R}{2}$$

$$r_{mp}^{PE} = \frac{\left(\frac{sx}{2}\sqrt{\frac{\beta(1-\tau)\frac{y_2}{y_1}}{(1+\sigma)}}\right)}{x\beta R} + \frac{(1-t)s^2 x\beta R}{4\left(\frac{sx}{2}\sqrt{\frac{\beta(1-\tau)\frac{y_2}{y_1}}{(1+\sigma)}}\right)}$$

Assuming the price of loans is fixed, the effect of monetary policy on the expected rate of return to deposits will be:

$$\frac{\partial r_{pc}^{PE}}{\partial\sigma} = -\frac{1}{2\left(1+\sigma\right)^2} \tag{53}$$

$$\frac{\partial r_{mp}^{PE}}{\partial\sigma} = -\frac{1}{2}\left[\frac{\frac{sx}{2}\sqrt{(1-\tau)\frac{y_2}{y_1}}}{xR(1+\sigma)^{\frac{3}{2}}\sqrt{\beta}}\right] + \frac{1}{2}\left[\frac{(1-t)s^2 xR\sqrt{\beta}}{4\left(\frac{sx}{2}\sqrt{(1-\tau)\frac{y_2}{y_1}}\sqrt{(1+\sigma)}\right)}\right]$$

By substituting the price of loans in a general equilibrium setting, $\frac{\partial r_{mp}^{PE}}{\partial\sigma}$ becomes:

$$\begin{aligned}\frac{\partial r_{mp}^{PE}}{\partial\sigma} &= -\frac{1}{2}\left[\frac{\frac{s}{2}\left(x+y_1\right)\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}}{\left[y_2+\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right]\left(1+\sigma\right)^{\frac{3}{2}}}\right] + \\ &\quad \frac{1}{2}\left[\frac{s\sqrt{(1-\tau)}\left[y_2+\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right]}{2\left(x+y_1\right)\sqrt{\frac{y_2}{y_1}\beta(1+\sigma)}}\right]\end{aligned} \tag{54}$$

Recognizing that the interest rate in the credit market does not depend on the rate of money growth:

$$\frac{\partial r_{pc}^{GE}}{\partial\sigma} = \frac{\partial r_{pc}^{PE}}{\partial\sigma} = -\frac{1}{2\left(1+\sigma\right)^2}$$

Next, we consider a fully concentrated banking economy. We can rewrite $\frac{\partial r_{mp}^{GE}}{\partial\sigma}$ as:

$$\begin{aligned}\frac{\partial r_{mp}^{GE}}{\partial\sigma} &= -\frac{1}{2}\left[\frac{\left(\frac{s}{2}\left(x+y_1\right)\sqrt{\beta(1-\tau)\frac{y_2}{y_1}}\right)}{\left(y_2+\frac{sx}{2}\sqrt{\beta(1-\tau)\frac{y_2}{y_1}(1+\sigma)}\right)\left(1+\sigma\right)^{\frac{3}{2}}}\right] + \\ &\quad \frac{1}{2}\left[\frac{s\sqrt{(1-\tau)}\left(y_2+\frac{sx}{2}\sqrt{\beta(1-\tau)(1+\sigma)\frac{y_2}{y_1}}+\frac{sx}{2}\sqrt{\beta(1-\tau)(1+\sigma)\frac{y_2}{y_1}}\right)}{2\left(x+y_1\right)\sqrt{\beta(1+\sigma)\frac{y_2}{y_1}}}\right]\end{aligned}$$

Thus, $\frac{\partial r_{mp}^{GE}}{\partial \sigma}$ is reduced to:

$$\frac{\partial r_{mp}^{GE}}{\partial \sigma} = \frac{\partial r_{mp}^{PE}}{\partial \sigma} + \frac{sx\sqrt{(1-\tau)}}{4\,(x+y_1)}$$

Therefore, monetary policy has a more significant impact on expected deposit rates upon including credit market behavior. This completes the proof.