Imperfect Competition, Electronic Transactions, and Monetary Policy*

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Abstract

In recent years, electronic financial transactions have increased significantly. At the same time, financial systems in many countries have also become more concentrated. In this paper, we construct a model of imperfectly competitive behavior to study the provision of financial services. Notably, in our framework, financial institutions can alleviate information frictions by providing individuals with remote access to their deposits. As a result, electronic financial transactions reduce the cost of liquidity risk. Consequently, the degree of financial competition and the cost of processing transactions generate important real outcomes. In particular, due to strategic interactions among financial institutions, productivity gains are more significant if the sector is highly concentrated. Introducing a role for monetary exchange into the framework allows us to study the demand for electronic and monetary means of payments. In turn, monetary policy affects agents' incentives to use different payments instruments.

1 Introduction

In recent years, the financial systems of many countries have experienced significant technological change. In particular, financial transactions and methods of settlement have progressed towards electronic-based methods. For example, Gerdes and Walton (2002) report

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that the share of credit cards in retail noncash payments in the United States increased from 13.83% in 1979 to 20.9% in 2000.[1] Furthermore, debit cards experienced even more significant growth. At the same time, automated teller machines (ATMs) have become increasingly available. Hayashi, Sullivan, and Weiner (2006) report that while only less than 50,000 terminals were in operation in the United States in 1983, there were almost 400,000 in 2006. In Europe, similar trends have occurred – in fact, the share of electronic transactions in noncash payments increased from 43% in 1987 to nearly 80% in 1999.[2] These developments have lowered transactions costs in the economy and improved individuals' access to funds. Moreover, technological progress has promoted the ability of the financial sector to manage various types of risk.[3]

However, financial systems have also become more concentrated. In 1989, around 19,000 different financial institutions were active in the United States. By 1999, there were only about 10,000 in operation. This has raised public concern about the pricing of financial services. To begin, Hannan, Kiser, Prager, and McAndrews (2003) find that banks are more likely to impose surcharge fees on the use of ATMs if they represent a significant share of the local ATM market. In addition, Stavins (2000) argues that large banks impose higher surcharges than small institutions after controlling for the number of ATM machines and operating costs.

As the financial system continues to evolve, it is important to consider how these developments will affect the conduct of monetary policy. Will technological progress in the financial sector leave monetary policy with little impact on the economy? How does the industrial organization of the financial system matter? While these are obviously important questions, little formal analysis has been devoted to studying them. In order to fill this gap, we construct a model of imperfectly competitive behavior within the banking sector to address the provision of electronic financial transactions. Notably, in our framework, financial institutions alleviate information frictions by providing individuals with remote access

[1] Gerdes and Walton (2002) define retail noncash payments as check, debit card, credit card, and retail ACH transactions.

[2] See Humphrey et. al. (2006).

[3] Berger (2003) provides a wide array of evidence on the impact of technological progress in the banking sector. In particular, he demonstrates that productivity improvements have been associated with increased provision of payments services. In addition, technological change has produced better risk management tools.

to their deposits. As a result, the availability of electronic transactions reduces the cost of liquidity risk. Consequently, the degree of financial competition and cost of processing transactions generate important real outcomes.[4] In particular, due to strategic interactions among banks, productivity gains (as exhibited by lower costs of processing transactions) are *more* significant if the sector is *highly concentrated.* In this manner, the impact of technological progress depends on the industrial organization of the banking system. Interestingly, the effects of increased market power may be offset by technological change.

Introducing a role for monetary exchange into the framework allows us to study the demand for money and electronic transactions. In turn, monetary policy affects agents' incentives to hold a liquid portfolio. As a benchmark, higher rates of money growth induce individuals to reduce their use of cash. Moreover, inflation erodes the gains from technological advance in the financial system.[5] That is, transactions services offered by banks are less responsive to changes in costs in economies with high inflation rates. However, the availability of transactions services depends *more* on the competitive structure of the financial system if inflation is higher.

To better understand these results, we proceed by outlining the details of our framework. Section 3 presents the benchmark model. In the economy, there are two different geographically separate locations. Within each location, individuals have complete information so that transactions are costless. However, across locations, limited communication inhibits trade. While individuals do not have the ability to issue private claims to their portfolios, banks can route information so that agents can obtain access to their funds and make payments.[6] Though financial institutions can process these transactions, there are

[4]For example, Humphrey, Pulley, and Vesala (1996) determine that the cost of processing electronic transactions can be as low as one-third of the amount of paper-based transactions. Berger (2003) observes that improvements in information technologies lead to productivity gains in the banking sector and lower costs of processing transactions. Moreover, Humphrey, Willesson, Bergendahl, and Lindblom (2006) estimate the savings in bank operating costs from the adoption of new electronic transaction technologies. Overall, they conclude that operating costs fell by 24% among European banks from 1987-1999. There is also evidence that fees charged by ATM network providers have fallen in recent years. For more discussion, see Hayashi, Sullivan and Weiner (2003).

[5]Numerous studies have pointed out that inflation reduces the amount of financial market activity. In particular, Boyd, Levine, and Smith (2001) find that inflation is association with a lower volume of loans. Using a model of Bertrand competition, Ghossoub, Laosuthi, and Reed (2007) demonstrate that the impact of monetary policy depends on the industrial organization of the financial sector. Under perfect competition, money growth leads to a higher amount of loans. However, if the banking sector is monopolistic, the effects of inflation are consistent with Boyd, Levine, and Smith.

[6]The role of spatial separation and limited communication follows Townsend (1987). In contrast to

costs associated with this activity. In order to study pricing decisions among banks, the model posits that banks engage in Cournot competition by offering quantities of transactions services.[7]

In Section 4, we introduce a role for monetary exchange. In addition to the two different locations, there are two different types of goods on each island. We refer to these goods as general goods and special goods.[8] General goods are homogeneous consumption goods that have the same characteristics in either location. In contrast, special goods are unique depending on the location in which they are available. In the process of obtaining special goods, a coincidence of wants problem emerges which requires money for exchange. Since general and special goods are substitutes, monetary policy affects agents' demand for each type of good. As a result, monetary policy will have an impact on the use of electronic and monetary payments methods. In particular, inflation raises the costs of monetary exchange and leads individuals to consume more general goods. In this manner, inflation distorts agents' desired consumption bundles.

Section 5 provides some concluding remarks. The proofs of major results are provided in the Appendix.

2 Related Literature

Our work is related to two different literatures in monetary economics. The first studies how the impact of monetary policy depends on the transactions role for money. Notably, Schreft and Smith (2000) consider the impact of monetary policy in an economy in which the reliance on cash evolves over time. In addition, Lacker and Schreft (1996) construct a

our model, Townsend illustrates that *fiat money* can overcome information frictions and act as a medium of exchange. Schreft and Smith (1997) introduce liquidity risk into a model of spatial separation. As in Diamond and Dybvig (1983), banks arise endogenously to insure individuals against idiosyncratic shocks.

[7] The notion of quantity competition has been widely used to address the impact of market structure on financial market activity. For example, Hutchison (1995) employs Cournot competition in deposit quantities to study the effect of imperfectly competitive behavior on deposit rates. In addition, Sharpe (1991) constructs a model with switching costs to determine the relationship between market structure and prices in retail bank deposit markets. Furthermore, in a partial equilibrium framework, Whitesell (1992) examines the deposit rates offered when banks experience competition for transactions services. Unlike our framework, these papers do not formally model the role of banks to avoid information frictions. Williamson (1986) studies the effects of banking competition on the credit market. He assumes that financial intermediaries compete in terms of the quantity of loans they issue.

[8] This terminology follows Lagos and Wright (2005).

model in which individuals choose between using cash or credit as a means of payment.

There is also a growing literature that emphasizes the role of imperfect competition in the banking sector and the impact of monetary policy. Notably, Ghossoub, Laosuthi, and Reed (2012) study how the effects of monetary policy vary between monopolistic and competitive banking systems. They show that in a perfectly competive banking system, higher rates of money growth generate a Tobin-type effect in which inflation lowers interest rates and simulates lending activity. However, in a price-distorted monopolistic banking system, inflation generates the opposite effect. Building on the structure of Ghossoub, Laosuthi, and Reed, Matsuoka (2011) compares optimal monetary policy in a monopolistic banking sector to a competitive banking system. Ghossoub (2012) demonstrates how the industrial organization of the banking system affects prices in capital markets.[9]

As an alternative to price competition, other papers investigate the impact of imperfectly competitive behavior arising from quantity competition. Notably, Williamson (1986) assumes that financial intermediaries compete in terms of the quantity of loans they issue. However, in his framework, money is only a store of value. In addition, the economic functions of banks are quite different – while Williamson discusses the role of banks to alleviate costs of private information, we emphasize the risk pooling role of financial institutions.

A majority of previous work in the area studies the impact of the industrial organization of the banking sector through credit markets. By comparison, our framework emphasizes how imperfect competition affects market outcomes through the demand for transactions-based services.

[9]Ruckes (2004) applies Bertrand competition in the presence of asymmetric information to study the interactions between the level of screening by banks and prices in the credit market. In their work, both papers principally focus on the financial contracts offered by banks. However, they do not consider the effects of monetary policy. In contrast, Bagliano, Dalmazzo, and Marini (2000) propose that monetary policy can affect the ability of banks to collude in financial markets. While they demonstrate that the design of policy should account for strategic interactions among banks, depository institutions perform limited financial functions. In their framework, banks accept deposits and issue loans. That is, the primary function of banks is to promote intertemporal consumption smoothing. In contrast, following Diamond and Dybvig (1983), we incorporate that banks provide important risk pooling services to participants in financial markets.

3 The Benchmark Model

We begin by constructing a benchmark model in which banks offer two different types of financial services. In particular, individuals can save by establishing deposit accounts with banks. Based upon account balances with one financial institution, depositors may also gain access to their funds from any bank in the financial system. That is, banks are able to verify accounts of depositors from competing institutions. Consequently, they have the ability to provide withdrawal services based upon requests of customers. However, depositors pay service fees for processing these transactions. In this manner, the provision of payments services is effectively similar to electronic financial transactions such as ATM transactions or online debit card services.

3.1 The Environment

We consider a discrete-time economy populated by an initial old generation and an infinite sequence of two-period-lived overlapping generations. At the beginning of each period, a new generation of individuals is born with unit mass on each of two identical islands. Although both locations are separate, there is a single consumption good available on both islands.

Agents are endowed with $x > 0$ units of goods when young but do not receive endowments when old. They value consumption (c) only in the last period with preferences given by:

$$u(c) = \frac{c^{1-\theta}}{1-\theta} \text{ for } \theta \neq 1 \tag{1}$$
$$u(c) = \ln c \text{ otherwise}$$

In addition, there are N identical banks in operation on each island. A bank's objective is to maximize profits in units of consumption goods. Financial institutions earn income by allocating received funds to investment opportunities. In particular, depository institutions compete for deposits by offering a schedule of interest rates. With deposits received, banks

devote funds to investment. If funds are available until the beginning of the following period, investments yield $R > 1$ units of the consumption good. On the other hand, if funds are withdrawn at the end of the current period, banks will only receive their principal in return so that the investment yields $r = 1$ units of the consumption good.

On each location, individuals are subject to a relocation shock. Specifically, a fraction of young agents (π) must move to the other island. In the event of relocation, they cannot carry goods between locations. The probability of the relocation shock is exogenous, publicly known, and the same at both places. Furthermore, agents cannot communicate with individuals who reside on the opposite island. Due to this problem, individuals cannot verify information about people who move from the other location. For this reason, private liabilities do not circulate.

In contrast to individuals, banks in both locations have the ability to communicate with each other. Thus, they can verify the account balance of agents who move from the other island. Consequently, financial institutions are able to provide withdrawal services based upon requests of depositors of other banks. In particular, relocated customers can access their account and withdraw their funds from banks at different locations.[10] Banks in turn charge relocated depositors the service fee, P units of goods, for processing their requests of withdrawals.[11] In this manner, payments services operated by financial institutions allow agents to access returns from their accounts at any location.

From the perspective of relocated individuals, withdrawal services offered by each bank are the same. As a result, the service fee per unit of payments will be the same across banks. In this manner, if a mover obtains q units of goods from a participating bank, a total of $(1 + P)q$ units of goods will be immediately debited from an agent's account balance. Although banks have the ability to conduct transactions, it is not costless for them to perform these services. In particular, when an agent seeks to acquire q units of

[10] There are a number of ways to interpret the communications infrastructure between banks. One possibility is that banks have the ability to transfer goods between locations at lower cost than individual depositors. However, the transfer of account balances in the model operates as a net settlement system. At the end of the period, each bank has a zero net account balance with other banks. As a result, goods are not transferred between them. Each financial institution experiences the same total costs of processing transactions and provides the same amount of payments services.

[11] The service fee in the model is comparable to the surcharge fees in ATM services or PIN fees in the debit card industry. For more discussion, see Hayashi, Sullivan and Weiner (2003).

goods, the costs of processing transactions are equal to cq units of goods.

Next, we describe the timing of events and actions. In the economy, there are two types of depositors: movers and nonmovers. To be specific, nonmovers deposit and withdraw funds from their own bank. On the other hand, relocated depositors (movers) must access their account through a bank at the alternative location. Consequently, at the initial stage of the current date, banks offer the rate of return r^m to movers and the rate of return r^n to nonmovers. Based upon the schedule of interest rates, young agents decide whether to deposit their funds in banks. Given the amount of deposits received, banks allocate funds to investment opportunities. Furthermore, they receive returns from previous investment projects. Some fraction of income from investment is used to finance withdrawal services to old relocated depositors from the other island.[12] Banks use the remaining amount of funds and the profits from operating transactions services to pay returns to their own nonrelocated old depositors. At the end of the current period, the relocation shock occurs. Young agents who are subject to the shock move to the other island. All old agents from the previous generation consume and die.

We proceed by explaining the behavior of depositors and financial intermediaries in more detail.

3.2 Depositors

Agents are born with endowments but derive utility from consumption only in their old-age. Due to the relocation shock and limited communication across locations, they deposit all of their funds in banks. The population of young individuals has unit mass. Therefore, the total amount of deposits (d) in each location is given by:

$$d = x \tag{2}$$

In addition, if agents experience the relocation shock, they must travel to the other

[12] Alternatively, one can view that financial institutions use funds transferred from relocated depositors' banks to finance withdrawal services. However, our model posits that the two locations are identical and symmetric. Consequently, the transfer of income among banks operates as a net settlement system. Thus, the account balances among banks are always zero. In this manner, depository institutions do not actually move funds across locations.

location. Consequently, relocated depositors seek to access their accounts through banks on the other island. In this manner, financial institutions provide transactions services to movers. Furthermore, from the perspective of movers, withdrawal services performed by banks are the same. Therefore, each bank supplies a homogeneous service. Moreover, there is no notion of 'switching' costs in the model – individuals have equal access to each bank in the opposite location.[13] As a result, relocated depositors can withdraw funds from any depository institution.

Given the rate of return to relocated depositors (r^m) offered by banks in the home location, relocated agents' account balances will be equal to $r^m x$. The demand for transactions services, q^d units of goods, represents the amount of funds that movers seek to obtain from financial institutions in the other location. In this manner, if the service fee per unit of payments services is P, an individual's demand curve will be generated by his budget constraint, $q^d + Pq^d = r^m x$. It follows that an individual's demand for withdrawal services is:

$$q^d = \frac{r^m x}{1+P}. \tag{3}$$

Since the fraction π of depositors will be forced to relocate, the market demand for transactions services (Q^d) is given by:

$$Q^d = \frac{\pi r^m x}{1+P} \tag{4}$$

Therefore, the inverse demand curve for the total amount of withdrawals is:

$$P = \frac{\pi r^m x - Q^d}{Q^d} \tag{5}$$

Notably, the service fee is negatively related to the total amount of transactions. Furthermore, when the account balance or the probability of a relocation shock is higher, relocated depositors seek to withdraw more funds from their accounts. As a result, banks can collect a higher service fee.

[13] One may perceive that there are transactions costs in switching between two different banks. Although incorporating such costs as in Klemperer (1987) is likely to affect the strategic behavior between banks in the framework, our setting provides a useful benchmark. Moreover, the tractability in our model renders it useful for discussing the links between monetary policy and imperfect competition in the banking sector.

3.3 Banks

In the deposit market, banks offer two types of rates of return to deposits. In particular, if depositors have an account with a bank but seek to obtain withdrawal services from other financial institutions in the new location, they receive the rate of return r^m for each unit of deposits. On the other hand, when depositors withdraw funds from their own bank, the rate of return will be r^n for each unit of deposits. Since banks compete for deposits by posting the schedule of interest rates, each bank acts as a Bertrand competitor in the deposit market.

In contrast to the deposit market, each bank provides transactions services to customers of other banks by offering access to their depository accounts. From the perspective of each relocated depositor, all financial institutions perform the same type of services. In this manner, competition in the market for electronic transactions services is characterized by Cournot competition.

We begin by considering the deposit market.

3.3.1 The Market for Bank Deposits

As mentioned, banks compete for funds by offering a schedule of rates of return to deposits. Thus, a set of actions is a Nash equilibrium if a bank cannot increase its profits in the deposit market by choosing a term structure to deposits other than its equilibrium action. Since financial intermediaries offer identical services, individuals will establish their accounts with the bank offering deposit rates that lead to the highest expected utility. Consequently, depository institutions have an incentive to offer slightly more favorable rates of return until profits in the *deposit* market are eliminated. Therefore, when the economy consists of more than one financial institution, the deposit market is effectively perfectly competitive. In this manner, if there are $N > 1$ identical depository institutions in the economy, each financial intermediary chooses rates of return to deposits to maximize the expected utility of a representative depositor. As a result, the amount of deposits per bank is equal to $\frac{x}{N}$ units of consumption goods.

Depository institutions perform transactions services and collect a service fee from de-

positors who move from the other location. Therefore, if each financial intermediary offers payments equal to q units of goods, the amount of relocated depositors' consumption will be $r^m \frac{x}{N} - P(Q^d)q$. In contrast to movers, nonrelocated agents directly access their accounts at their own bank. Thus, their consumption is equal to the account balance, $r^n \frac{x}{N}$. In this manner, the bank's objective is:

$$\underset{r^m, r^n}{Max} \pi \frac{\left[r^m \frac{x}{N} - P(Q^d)q\right]^{1-\theta}}{1-\theta} + (1-\pi)\frac{\left(r^n \frac{x}{N}\right)^{1-\theta}}{1-\theta} \tag{6}$$

All depositors access their funds in old-age. Therefore, banks allocate all deposits received to investment opportunities. Earnings from previous investment will be paid to old depositors. Some of the payments will be provided to relocated old agents. In particular, there is a fraction π of depositors who move from the other island. Thus, the returns to relocated individuals are constrained by the fraction π of income from bank earnings:

$$\pi r^m \frac{x}{N} \leq \pi R \frac{x}{N} \tag{7}$$

By processing transactions for customers of other banks, financial institutions generate some profits. Specifically, if each bank provides q units of payments to relocated depositors, they receive revenues from the service fee, $P(Q^d)q$, and incur costs, cq. In this manner, depository institutions use profits from performing transactions services along with earnings from investments to pay returns to their own customers:

$$(1-\pi) r^n \frac{x}{N} \leq (1-\pi) R \frac{x}{N} + P(Q^d)q - cq \tag{8}$$

In order to maximize the expected utility of a representative depositor, banks offer rates of return to deposits such that:

$$r^m = R \tag{9}$$

$$r^n = R + \frac{\left(P(Q^d)q - cq\right) N}{(1-\pi)x} \tag{10}$$

Interestingly, the rate of return to relocated depositors is always equal to the rate of return to investment opportunities. On the other hand, the rate of return to nonrelocated depositors

depends on returns from investment opportunities and profits from performing payments services. Thus, nonmovers always receive a higher rate of return to deposits than movers.[14]

3.3.2 The Market for Electronic Transactions Services

In contrast to the deposit market, we posit that banks compete in the market for electronic payments by offering quantities of withdrawal services. Thus, they act as Cournot competitors. In this manner, each depository institution's objective function is:

$$\underset{q}{Max} P(Q^d)q - cq \tag{11}$$

However, the amount of funds that relocated depositors can withdraw must satisfy the account balance:

$$\left[1 + P(Q^d)\right] q \leq \pi r^m \frac{x}{N} \tag{12}$$

In order to maximize profits, each bank offers the amount of transactions such that:

$$q = \left(\frac{N-1}{N}\right)\left(\frac{\pi r^m}{1+c}\right)\left(\frac{x}{N}\right) \tag{13}$$

When the probability of a relocation shock is higher or a bank receives more deposits, the account balance of movers increases. Thus, financial institutions are able to process a higher amount of transactions. Furthermore, an agent's account balance is positively related to the rate of return to deposits. As a result, when relocated individuals receive a higher interest rate, they utilize a higher amount of electronic payments. Moreover, when the cost of processing withdrawal services (c) decreases, banks can perform transactions services more efficiently. Therefore, they offer a higher volume of withdrawal services.

[14] The provision of electronic means of payments allows banks to allocate all deposits received to investment opportunities. Consequently, banks in this model can offer higher rates of return to deposits compared to banks in standard relocation models such as Schreft and Smith (1997). In this manner, the market for transactions services benefits depositors by enhancing the degree of risk pooling services.

Interestingly, the degree of financial competition (N) has a significant impact on a bank's supply of transactions services. Specifically, the term ($\frac{N-1}{N}$) reflects the fraction of account balances that will be paid to relocated depositors. When the banking sector is more competitive, banks posses less market power. As a result, given the account balances of movers, each bank offers a high volume of payments.

However, an increase in competition leads to a lower amount of deposits per bank ($\frac{x}{N}$). Thus, each depositor allocates less income to an account at a particular depository institution. Moreover, the effect of financial competition on the amount of deposits dominates the impact of banking competition from less market power. In this manner, a higher degree of competition causes each bank to provide a lower amount of payments.

Next, we proceed by characterizing economic activity in equilibrium.

3.4 Equilibrium

Thus far, we have studied behavior in the market for bank deposits and the market for transactions services separately. In particular, we stated that interest rates in the deposit market depend on the rate of return to investment opportunities and the banks' profits from providing payments services. In order to characterize equilibrium activity, we begin the analysis by considering the market for electronic means of payments.

Given the account balance of depositors from other financial institutions, each bank offers the amount of withdrawal services that maximizes its profits. However, the account balance depends on the rate of return to deposits. Thus, in equilibrium, relocated agents have funds in their account equal to $\pi R \frac{x}{N}$. Based upon each banks' supply of transactions services and the assumption that all financial intermediaries are identical, the aggregate volume of withdrawal services and the service fee are:

$$Q = \left(\frac{N-1}{N}\right)\left(\frac{\pi R x}{1+c}\right) \tag{14}$$

$$P = \left(\frac{N}{N-1}\right)(1+c) - 1 \tag{15}$$

Notably, the total amount of transactions services depends on the total account bal-

ance of movers (πRx) in the economy. In contrast, the withdrawal fee is independent of depositors' account balances. If aggregate account balances are higher, relocated agents seek to withdraw more funds. Consequently, the market demand for transactions services is higher. At the same time, higher account balances cause banks to offer more payments services. This results in an increase in the market supply of available funds. Furthermore, the change in the market demand is the same as the change in the market supply. As a result, an increase in aggregate account balances leads to a higher market quantity of electronic payments. However, banks collect the same fee for providing withdrawal services.

Interestingly, operating costs and the degree of banking competition yield significant implications for payments services activity:

Lemma 1. *A decrease in the unit cost of processing transactions leads to a higher market quantity of payments and a lower service fee.*

When banks have a lower cost of performing withdrawal services, they are able to provide transactions services more effectively. Consequently, the total amount of withdrawal services increases. This also results in a decrease in the service fee. In this manner, productivity growth in the financial sector leads to higher expected utility among depositors.

Lemma 2. *When the degree of financial competition is higher, the total volume of withdrawal services increases. Furthermore, banks collect a lower service fee.*

The effect of banking competition can be seen by considering the terms $(\frac{N-1}{N})$ and $(\frac{N}{N-1})$ on the expressions for the market quantity of payments and the service fee respectively. As in the standard Cournot model, market supply is higher when there are more firms. Similarly, as there are more banks in operation, the availability of transactions services will be higher. Furthermore, individuals incur a lower fee for electronic payments.

Corollary 1. *In a perfectly competitive banking industry, the total quantity and the unit price of payments services are* $Q_{pc} = \frac{\pi Rx}{(1+c)}$ *and* $P_{pc} = c$ *respectively.*

When the financial sector is perfectly competitive, banks cannot exploit market power. Therefore, they takes prices as given. As a result, all depository institutions receive ser-

vice fees equal to the marginal cost of processing transactions. Thus, the total volume of withdrawal services is high and the transaction fee is low compared to an economy under imperfect financial competition.

Next, we study the effects of technological change under different degrees of banking competition:

Lemma 3. *Consider the impact of productivity improvements on the market for transactions services. Although a lower cost leads to a higher volume of electronic payments and a lower service fee, the effect is stronger when the banking sector is more concentrated.*

If the intensity of competition in the banking sector is high, banks have little influence over the total amount of transactions services that are supplied. In contrast, if there are relatively few banks, each financial institution has a large impact on market availability of transactions services. In the former setting, the equilibrium availability of withdrawal services will be high. Consequently, productivity gains in the banking industry will have a relatively minor impact since total output is close to the perfectly competitive level. In contrast, if the banking sector is highly concentrated, lower costs from processing payments will lead to a significant increase in the availability of electronic transactions.

Based upon the total amount of payments and the service fee, the equilibrium rate of return to nonrelocated depositors is:

$$r^n = R + \frac{\pi}{(1-\pi)}\frac{R}{N}$$

Notably, when the financial sector is more competitive, banks receive lower profits from providing withdrawal services. Therefore, they offer nonmovers a lower rate of return to deposits. In contrast, the amount of consumption among movers improves since account access is cheaper. In this manner, the financial sector provides a higher degree of risk sharing if it is more competitive.

3.5 The Efficient Provision of Payments

Banks compete by offering the schedule of interest rates in the deposit market. Due to the strategic nature of price competition, all bank revenues are transferred to depositors. Therefore, social welfare depends on the expected utility of depositors in the economy. In this manner, the efficient provision of payments is determined by:

$$\underset{Q}{Max}\pi\frac{[r^m x - P(Q)Q]^{1-\theta}}{1-\theta} + (1-\pi)\frac{(r^n x)^{1-\theta}}{1-\theta}$$

When relocated individuals obtain a higher amount of electronic financial transactions, their expected utility increases. However, an increase in the amount of withdrawal services leads to a lower service fee. Consequently, financial institutions earn lower profits from performing payments services. As a result, nonrelocated depositors receive a lower rate of return to deposits. In this manner, the efficient volume of payments will be such that the marginal utility of relocated depositors is equal to the marginal loss of utility of nonrelocated depositors.

From the social welfare problem, we derive the expression for the efficient total amount of payments:

$$Q = \frac{\left[\pi^{\frac{1}{\theta}} - (1+c)^{\frac{1}{\theta}}(1-\pi)^2\right] Rx}{(1-\pi)(1+c)^{\frac{1}{\theta}} + \pi^{\frac{1}{\theta}}(1+c)} \tag{16}$$

Notably, the cost of processing transactions has a significant impact on the efficient provision of payments services. To be specific, as banks obtain productivity improvements, financial institutions can provide transactions services more efficiently. Moreover, depositors are risk averse. They want to receive less variability in their returns. In this manner, the total volume of transactions services must increase in order to provide higher consumption to individuals who experience liquidity shocks (i.e., movers).

Furthermore, by comparing (14) and (16), we obtain the following observation:

Lemma 4. *If* $N < \frac{\pi\left[(1-\pi)(1+c)^{\frac{1}{\theta}} + \pi^{\frac{1}{\theta}}(1+c)\right]}{\pi\left[(1-\pi)(1+c)^{\frac{1}{\theta}} + \pi^{\frac{1}{\theta}}(1+c)\right] - \left[\pi^{\frac{1}{\theta}}(1+c) - (1+c)^{\frac{1+\theta}{\theta}}(1-\pi)^2\right]}$, *the efficient amount of payments is higher than the equilibrium volume of transactions services.*

Banks compete in the transactions services market on the basis of quantities. When the

level of financial competition is fairly low, depository institutions can exploit more market power. As a result, the equilibrium volume of withdrawal services is lower than the efficient amount of payments.

Corollary 2. *Assume that* $\theta = 1$. *Furthermore, define* $N^* = \frac{\pi}{(1+c)(1-\pi)^2}$ *as the degree of competition that leads to the efficient provision of payments services. That is, suppose that each bank processes its equilibrium volume of transactions. In this setting, the availability of transactions coincides with the socially optimal level if* $N = N^*$. *Obviously,* N^* *is higher if the cost of processing withdrawal services decreases or the probability of relocation increases.*

If banks incur lower processing costs or agents seek to obtain more withdrawal services, the efficient provision of transactions services increases. In this manner, the number of banks in equilibrium must increase in order to make the amount of withdrawal services equal to the efficient volume of transactions services.

We continue by analyzing the economy under equilibrium entry.

3.6 The Endogenous Degree of Banking Competition

In this setting, we are interested in characterizing equilibrium outcomes when depository institutions are able to enter the market for electronic financial transactions. In order to address this issue, we utilize a free-entry condition to determine the number of financial institutions in the economy. Furthermore, we aim to demonstrate how technological change and investment returns affect the degree of competition in the market for transactions services.

Notably, our framework features two different financial markets – a deposit market and a transactions services market. While banks offer relocated depositors an amount of withdrawal services, they post the schedule of interest rates in order to induce agents to deposit their funds. As a result, the deposit market is characterized by perfect competition. In this manner, all bank profits from operating withdrawal services are transferred to finance payments in the deposit market. Therefore, depositors are the residual claimants of banks' earnings. Alternatively, one could interpret that depositors are stockholders of banks which pay dividends.

Based upon this interpretation, the number of depository institutions is determined by a free entry condition. Specifically, depositors have incentive to establish more financial institutions if they can obtain more surplus from participating in the banking system. In this manner, if the alternative use of funds provides depositors with an income level equal to U, the equilibrium number of banks will be such that each depositor's expected utility from using banks is equal to the utility from alternative use of funds, $\frac{U^{1-\theta}}{1-\theta}$:

$$\pi \frac{\left[r^m \frac{x}{N} - P(Q)q\right]^{1-\theta}}{1-\theta} + (1-\pi)\frac{\left(r^n \frac{x}{N}\right)^{1-\theta}}{1-\theta} = \frac{U^{1-\theta}}{1-\theta} \tag{17}$$

By substituting the values of r^m, r^n, $P(Q)$ and q, (17) becomes

$$\pi \left[\frac{(1-\pi)}{N} + \frac{\pi}{(1+c)}\left(\frac{N-1}{N^2}\right)\right]^{1-\theta} + (1-\pi)\left[\frac{1}{N} + \frac{\pi}{(1-\pi)N^2}\right]^{1-\theta} = \left(\frac{U}{Rx}\right)^{1-\theta} \tag{18}$$

As a result, an equilibrium number of banks exists when N satisfies (18).

Proposition 1. *Let $\theta < 1$. Furthermore, suppose that the rate of return to investment opportunities and the cost of processing transactions are sufficiently high. Under these conditions, an equilibrium number of banks exists and is unique.*

Interestingly, from (18), the cost of processing transactions and the rate of return to investment opportunities have a significant impact on the degree of competition. Thus, we offer the following:

Lemma 5. *Assume that $\theta < 1$. A lower cost of providing withdrawal services leads to a higher level of banking competition. Consequently, when an economy is characterized by endogenous entry, productivity improvements have a greater impact on the amount of payments and the service fee compared to the economy with a fixed number of banks.*

Under endogenous entry, the cost of operating transactions affects the market for electronic payments in two different ways. First, a decrease in the unit cost of processing withdrawal services directly leads to a higher amount of payments. Second, it also results in a higher degree of banking competition. In particular, as banks achieve productivity

gains, they earn more profits for performing transactions services. In turn, financial institutions can offer higher rates of return to deposits. In this manner, individuals receive a greater level of risk pooling services from depositing their funds with banks. Therefore, they have incentive to establish new depository institutions. As a result, the degree of banking competition increases. Thus, the total amount of payments further increases and the service fee falls even more.

Lemma 6. *Suppose that $\theta < 1$. A higher rate of return to investment opportunities results in an increase in the level of competition. In this manner, the returns to investment opportunities have a greater impact compared to an economy with a limited number of banks.*

If banks receive a higher rate of return to investment opportunities, they have more funds to finance payments in the deposit market. As a result, the rates of return to deposits increase. In this manner, individuals seek to obtain additional surplus by establishing more banks. This leads to a higher degree of financial competition in the economy. Thus, an increase in the rate of return to investment opportunities not only directly causes the amount of payments to increase but leads to a greater level of banking competition. In this setting, the effect of a change in the rate of return to investment opportunities under equilibrium entry is stronger than under a fixed number of banks.

3.7 Efficient Level of Banking Competition

As in the efficient provision of payments, social welfare depends on the expected utility of all depositors in the economy. Therefore, the efficient degree of financial competition will be set such that:

$$\underset{N}{Max}\pi\frac{[r^m x - P(Q)Q]^{1-\theta}}{1-\theta} + (1-\pi)\frac{(r^n x)^{1-\theta}}{1-\theta} \tag{19}$$

Notably, relocated depositors obtain returns through transactions services. In contrast, the utility of nonrelocated depositors depends on each banks' profits from providing electronic means of payments. Furthermore, at higher degrees of banking competition, banks provide more payments to movers but obtain lower profits. Consequently, when the banking sector is more competitive, relocated agents are better off while nonrelocated individuals are worse

off. As a result, the efficient degree of financial competition will be such that the marginal utility of movers is equal to the loss in marginal utility of nonmovers.

To maximize social welfare, the efficient number of banks should be set such that:

$$N = \frac{\pi^{\frac{1+\theta}{\theta}} (1+c)^{\frac{\theta-1}{\theta}} + \pi(1-\pi)}{\left[(1-\pi)(1+c) + \pi - \pi^{\frac{1}{\theta}} (1+c)^{\frac{\theta-1}{\theta}}\right](1-\pi)} \tag{20}$$

Interestingly, the unit cost of processing transactions has a significant impact on the efficient level of banking competition:

Lemma 7. *Suppose that $\theta < 1$. A decrease in the cost of performing withdrawal services leads to a higher efficient degree of financial competition.*

When each bank realizes productivity improvements, they offer a higher amount of payments. Furthermore, depository institutions also earn more profits from providing transactions services. Consequently, relocated depositors and nonrelocated depositors receive higher rates of return to deposits. However, depositors are risk averse. Thus, they want to obtain less variation in their returns. In order to decrease the gap between the returns to movers and nonmovers, the amount of electronic means of payments must increase. In this manner, more financial institutions must participate in the banking system. As a result, the efficient degree of banking competition increases.

At this juncture, we have demonstrated the effects of financial competition and the cost of processing transactions on the market for electronic payments. Next, the study proceeds by introducing fiat money into the model. In this manner, we can investigate how monetary policy affects the provision of electronic transactions services. Furthermore, we are able to examine the impact of monetary policy in response to technological progress, depending on the competitive structure of the financial system.

4 The Model with Fiat Money

In order to address the effect of monetary policy on the market for transactions services, we posit that the economy consists of two types of agents: natives and depositors. Furthermore,

we assume that there are two kinds of goods: general goods (g) and special goods (s). General goods are the same across islands. In contrast, special goods are unique depending on the location in which they are available.

At the beginning of every period, a unit mass of one-period lived natives is born on each location with y units of special goods. Though they are endowed with special goods, natives only obtain utility from consumption of general goods.

Following the benchmark model, depositors are endowed with $x > 0$ units of general goods when young but do not receive endowments when old. However, their tastes are subject to uncertainty. In particular, with probability π, some depositors experience preference shocks such that they would like to consume both general goods and special goods of the *other* island. As a result, they must move to the opposite location to obtain special goods. The utility functions of these agents (movers) are given by:

$$u(c_g, c_s) = \alpha \frac{(c_g)^{1-\theta}}{1-\theta} + \phi \frac{(c_s)^{1-\theta}}{1-\theta} \text{ for } \theta \neq 1 \tag{21}$$
$$u(c_g, c_s) = \alpha \ln(c_g) + \phi \ln(c_s) \text{ otherwise}$$

In this manner, α and ϕ reflect the relative importance of general goods and special goods in the preferences of relocated depositors, respectively.

In contrast to movers, other depositors (non-movers) only want to consume general goods:

$$u(c_g) = \frac{(c_g)^{1-\theta}}{1-\theta} \text{ for } \theta \neq 1 \tag{22}$$
$$u(c_g) = \ln c_g \text{ otherwise}$$

Since general goods are homogeneous across islands, agents who value general goods do not need to move to find consumption opportunities.

Young depositors deposit their endowments of general goods into their accounts. With the amount of deposits received, banks devote some funds to local investment opportunities

which only yield payoffs in units of general goods. Depository institutions use returns from investment opportunities to provide transactions services. This allows relocated depositors to obtain general goods from their account through withdrawal services performed by banks. On the other hand, depositors do not have accounts with balances of special goods. Therefore, they need currency to trade for special goods.[15] The price level for one unit of special goods is common across locations and is defined as $\widehat{P}_t$ at time t.

Next, we explain the timing of events and actions. At the initial stage of date t, banks announce the schedule of interest rates and young depositors deposit their general goods. Furthermore, financial institutions receive money transfers from the monetary authority at the rate σM_{t-1}.

Given the amount of funds received, banks choose an amount of currency reserves (m_t). In addition to the money balances received from the monetary authority, banks obtain currency from natives in the following manner. First, old depositors who have acquired a taste for special goods must travel to the opposite island with cash. Once they arrive, they meet natives who are carrying units of special goods. Natives do not have bank accounts, but will accept cash from relocated depositors. Upon trade between movers and natives, natives take their cash balances to banks. Banks are able to acquire money balances from natives by giving up some of the deposits of general goods that they received from young individuals. The remaining amount of general goods (i_t) is devoted to investment opportunities on the local island.

In the second-stage, banks receive returns from investment opportunities from the previous period. As in the benchmark economy, a fraction of income from investment opportunities are used to process withdrawal services for old relocated depositors. With the remaining amount of funds and the profits from performing transactions services, banks pay returns to nonrelocated old depositors. At the end of period t, young depositors realize their taste status. Those who want to consume both general goods and special goods will go

[15] To study retail bank deposit pricing, Hutchison (1995) applies an asset pricing model that incorporates cash-in-advance liquidity constraints. In particular, buyers can obtain goods by withdrawing funds from their account. However, in some situations, sellers cannot verify buyers' account balances. Therefore, buyers need to hold currency in order to trade for goods with sellers.

to the bank and withdraw currency. All old agents from the previous generation consume and die.

Next, we consider the behavior of a representative bank.

4.1 Banks

The preferences of depositors depend on the realization of their utility function. In particular, movers need currency to trade for special goods. Therefore, relocated depositors must withdraw currency from their account at the end of current period and leave the remaining deposits until next period. In addition, money is dominated in rate of return. As a result, banks offer two types of rates of return to relocated depositors. Specifically, if movers withdraw currency, they receive the rate of return r_t^s per unit of deposits. Furthermore, when they access their account at the other island, the rate of return is r_t^g per unit of deposits.

In contrast to relocated depositors, nonmovers only value general goods from their own location. Moreover, they withdraw funds from their own bank. Consequently, banks offer the rate of return r_t^n per unit of deposits to nonmovers. Due to price competition in the deposit market, each bank chooses a schedule $(m_t, i_t, r_t^s, r_t^g, r_t^n)$ to maximize the expected utility of a representative depositor:

$$\underset{m_t, i_t, r_t^s, r_t^g, r_t^n}{Max} \pi \left\{ \alpha \frac{\left[r_t^g \frac{x}{N} - P(Q^d) q \right]^{1-\theta}}{1-\theta} + \phi \frac{(r_t^s \frac{x}{N})^{1-\theta}}{1-\theta} \right\} + (1-\pi)\alpha \frac{\left(r_t^n \frac{x}{N}\right)^{1-\theta}}{1-\theta} \tag{23}$$

Financial institutions allocate deposits to currency reserves and investment opportunities. Therefore, the bank's balance sheet must satisfy:

$$m_t + i_t \leq \frac{x}{N} \tag{24}$$

Relocated depositors use currency to trade for special goods. Therefore, the consumption of special goods depends on the amount of currency holdings and the rate of inflation:

$$\pi r_t^s \frac{x}{N} \leq m_t \frac{\widehat{P}_t}{\widehat{P_{t+1}}} \tag{25}$$

In addition, the population of movers (with mass π) seek to obtain general goods from banks

at the new island. Consequently, the amount of withdrawal services offered by depository institutions is constrained by the portion π of earnings from investment opportunities:

$$\pi r_t^g \frac{x}{N} \leq \pi R i_t \tag{26}$$

For nonrelocated depositors, their returns depend on the remaining income from investment opportunities and bank profits from performing transaction services:

$$(1-\pi) r_t^n \frac{x}{N} \leq (1-\pi) R i_t + P(Q^d) q - cq \tag{27}$$

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

$$m_t = \frac{\pi \frac{x}{N}}{\pi + \left(\frac{\alpha}{\phi}\right)^{\frac{1}{\theta}} \left(R \frac{\widehat{P_{t+1}}}{\widehat{P_t}}\right)^{\frac{1-\theta}{\theta}} \left\{ \pi \left[(1-\pi) + \frac{\pi}{(1+c)} \left(\frac{N-1}{N}\right) \right]^{1-\theta} + (1-\pi)^{\theta} \left[1 - \frac{\pi(N-1)}{N} \right]^{1-\theta} \right\}^{\frac{1}{\theta}}} \tag{28}$$

If $\theta < 1$, currency balances are negatively related to the rate of return to investment opportunities. As discussed by Tobin (1956), higher returns to interest-bearing assets raise the opportunity cost of holding money. Thus, banks want to minimize the amount of currency holdings when investment opportunities yield a higher rate of return. The same arguments apply to the effects of inflation. Specifically, when inflation increases, the value of real money balances decreases. In turn, the bank allocates less funds to currency holdings.

Interestingly, the cost of processing transactions has a significant impact on the amount of currency balances. Therefore, we offer the following observation:

Lemma 8. *Suppose that $\theta < 1$. A decrease in the cost of processing electronic means of payments leads to a lower amount of currency holdings.*

When the cost of processing transactions is lower, financial institutions can perform withdrawal services more efficiently. Consequently, depository institutions receive higher profits. In this manner, given the same amount of deposits received, productivity improvements lead to less currency holdings and a higher amount of investment.

Based upon the amount of money balances, each bank offers the quantity of payments

to movers such that:

$$q = \left\langle \frac{R^{\frac{1-\theta}{\theta}} \left\{ \pi \left[(1-\pi) + \frac{\pi}{(1+c)} \left(\frac{N-1}{N} \right) \right]^{1-\theta} + (1-\pi)^{\theta} \left[1 - \frac{\pi(N-1)}{N} \right]^{1-\theta} \right\}^{\frac{1}{\theta}}}{\pi \left(\frac{\phi}{\alpha} \right)^{\frac{1}{\theta}} \left(\frac{\widehat{P}_t}{\widehat{P}_{t+1}} \right)^{\frac{1-\theta}{\theta}} + R^{\frac{1-\theta}{\theta}} \left\{ \pi \left[(1-\pi) + \frac{\pi}{(1+c)} \left(\frac{N-1}{N} \right) \right]^{1-\theta} + (1-\pi)^{\theta} \left[1 - \frac{\pi(N-1)}{N} \right]^{1-\theta} \right\}^{\frac{1}{\theta}}} \right\rangle \left(\frac{N-1}{N} \right) \left(\frac{\pi R}{1+c} \right) \left(\frac{x}{N} \right) \tag{29}$$

As in the previous section, an individual bank's supply of payments services is positively related to the rate of return to investment opportunities but negatively related to the degree of banking competition. Furthermore, when the cost of performing transactions decreases, banks provide more electronic payments. Notably, inflation also has a significant effect on the amount of electronic transactions. Thus, we continue our study by demonstrating how monetary policy affects the market for transactions services in equilibrium.

4.2 Equilibrium

Given the monetary authority's fixed money growth rule, it is easily shown that the gross inflation rate in equilibrium is equal to $(1 + \sigma)$. Consequently, we obtain the equilibrium market quantity of payments and the service fee:

$$Q = \left\langle \frac{R^{\frac{1-\theta}{\theta}} \left\{ \pi \left[(1-\pi) + \frac{\pi}{(1+c)} \left(\frac{N-1}{N} \right) \right]^{1-\theta} + (1-\pi)^{\theta} \left[1 - \frac{\pi(N-1)}{N} \right]^{1-\theta} \right\}^{\frac{1}{\theta}}}{\frac{\pi \left(\frac{\phi}{\alpha} \right)^{\frac{1}{\theta}}}{(1+\sigma)^{\frac{1-\theta}{\theta}}} + R^{\frac{1-\theta}{\theta}} \left\{ \pi \left[(1-\pi) + \frac{\pi}{(1+c)} \left(\frac{N-1}{N} \right) \right]^{1-\theta} + (1-\pi)^{\theta} \left[1 - \frac{\pi(N-1)}{N} \right]^{1-\theta} \right\}^{\frac{1}{\theta}}} \right\rangle \frac{\pi R x}{(1+c)} \left(\frac{N-1}{N} \right) \tag{30}$$

$$P = (1 + c) \left(\frac{N}{N-1} \right) - 1 \tag{31}$$

Interestingly, monetary policy has a significant impact on the volume of withdrawal services. Therefore, we offer the following observations:

Lemma 9. *Assume that $\theta < 1$. Higher rates of money growth lead to an increase in the use of electronic payments. However, monetary policy does not affect the degree of pricing distortions. That is, there is no relationship between inflation rates and the fee for electronic payments.*

When the monetary authority adopts a higher rate of money growth, the real value of each unit of currency decreases. As a result, banks hold less currency and allocate more

funds to investment opportunities. Furthermore, financial institutions use returns from investment to finance payments in the transactions services market. In this manner, when the rate of inflation is higher, depository institutions have more funds to provide withdrawal services. In turn, the volume of electronic payments increases.

In contrast to the market quantity, the withdrawal fee is independent of monetary policy. When the rate of return to currency decreases, banks allocate more funds to investment opportunities. Thus, the account balance of relocated depositors (in units of general goods) increases. Consequently, movers seek to withdraw more funds from banks in the other location. However, a higher account balance also leads to an increase in the supply of transactions services. As a result, an increase in market supply is offset by higher market demand and inflation does not have any impact on the price of electronic payments.

Corollary 3. *If* $\frac{1}{2} < \theta < 1$, *the effect of monetary policy on the provision of transactions services is less significant at higher inflation rates.*

At a relatively high rate of inflation, there is a comparatively large demand for electronic payments. This causes bank revenues to increase. However, since the service fee is constant, the cost of processing transactions is high. Financial institutions would suffer from lower profits if they process very high volumes of transactions. Furthermore, risk averse depositors want to have some money holdings in case they acquire a taste for special goods. As a result, the impact of monetary policy on non-cash transactions is less significant in high inflation environments.

4.3 Transactions Costs, Banking Competition, and Monetary Policy

At this point, we would like to consider how inflation distorts the impact of technological change in the financial sector. To address this issue, we consider some numerical illustrations. As an example, we assume that the cost of performing withdrawal services decreases from 0.04 to 0.035. Furthermore, we utilize the following set of parameters: $x = 10$, $R = 2$, $\pi = 0.5$, $\theta = 0.6$, $\phi = 0.5$, $\alpha = 0.5$, $N = 2$. Table 1 presents the results:

Growth Rate of Money	0.05	0.1	0.15	0.2
% Change in Transactions	3.668807	3.667985	3.667216	3.666495
% Change in Service Fee	-6.759259	-6.759259	-6.759259	-6.759259

Table 1: The Impact of a Lower Cost of Transactions under Different Inflation Rates

From Table 1, we obtain the following observation:

When the cost of processing transactions is lower, the increase in the amount of electronic transactions is lower at higher inflation rates. However, inflation does not affect the relationship between banking productivity and the price of financial transactions.

In the previous section, when banks achieve productivity gains, relocated depositors obtain more withdrawal services. However, fees for electronic transactions are constant. Therefore, banks earn lower profits if inflation is higher. In this manner, if the cost of processing transactions falls in high inflation environments, banks have less incentive to offer more transactions services. As a result, the impact of productivity improvements is less pronounced at higher money growth rates. In other words, inflation erodes the gains from technological change in the banking industry.

Next, we continue by investigating how the competitive structure of the banking sector affects financial market outcomes at different inflation rates. We use the same set of parameters from Table 1 and assume that the cost of processing transactions is 0.04. Moreover, the impact of banking competition is shown by increasing the number of depository institutions from 2 banks to 10 banks. Table 2 shows the effect of financial competition under different inflation rates:

Growth Rate of Money	0.05	0.1	0.15	0.2
% Change in Transactions	79.30944	79.32737	79.34414	79.35987
% Change in Service Fee	-85.59671	-85.59671	-85.59671	-85.59671

Table 2: The Effect of Higher Competition at Various Inflation Rates

Based upon Table 2, we make the following observation:

The effect of banking competition on the use of electronic means of payments is stronger at higher rates of inflation. Nevertheless, monetary policy does not influence how the degree of financial competition affects the withdrawal fee.

When the banking sector is more competitive, banks have less impact on the total supply of financial services. Consequently, they have less market power. Furthermore, banks earn lower profits if inflation is higher. Therefore, in economies with a high degree of financial concentration, banks reduce their availability of transactions services. However, there is less incentive to do so if more banks are active in the economy. In this manner, the competitive structure of the financial system has a stronger impact on financial outcomes in high inflation economies.

5 Conclusions

In recent years, electronic financial transactions have increased significantly. At the same time, financial systems in many countries have also become more concentrated. In this paper, we construct a model of imperfectly competitive behavior to study the provision of financial services. Notably, in our framework, financial institutions can alleviate information frictions by providing individuals with remote access to their deposits. As a result, electronic financial transactions reduce the cost of liquidity risk. Consequently, the degree of financial competition and the cost of processing transactions generate important real outcomes. In particular, due to strategic interactions among financial institutions, productivity gains are more significant if the sector is highly concentrated.

Introducing a role for monetary exchange into the framework allows us to study the demand for electronic and monetary means of payments. In turn, monetary policy affects agents' incentives to use different payments instruments. As a benchmark, higher rates of money growth induce individuals to reduce their use of cash. In addition, inflation erodes the gains from technological advance in the payments system. In contrast, the availability of transactions services responds more to the competitive structure of the financial system in economies with high inflation rates.

Appendix

1. Proof of Proposition 1.

In order to establish the existence of an equilibrium number of banks, the following condition must be satisfied:

$$\pi\left[\frac{(1-\pi)}{N}+\frac{\pi}{(1+c)}\left(\frac{N-1}{N^2}\right)\right]^{1-\theta}+(1-\pi)\left[\frac{1}{N}+\frac{\pi}{(1-\pi)N^2}\right]^{1-\theta}=\left(\frac{U}{Rx}\right)^{1-\theta}$$

Given $f(N)=\pi\left[\frac{(1-\pi)}{N}+\frac{\pi}{(1+c)}\left(\frac{N-1}{N^2}\right)\right]^{1-\theta}+(1-\pi)\left[\frac{1}{N}+\frac{\pi}{(1-\pi)N^2}\right]^{1-\theta}$ and $g(N)=\left(\frac{U}{Rx}\right)^{1-\theta}$ and the assumption that $\theta<1$, we have:

1. At $N=1$, $f(N,\pi,c)>g(U,R,x)$ if:

$$R>\frac{U}{x\left[\pi[(1-\pi)]^{1-\theta}+(1-\pi)^{\theta}\right]^{\frac{1}{\theta}}}$$

2. It is easy to show that $f(N,\pi,c)$ is a decreasing function of N if $c>\frac{2\pi-1}{(1-\pi)}$. On the other hand, there is no effect of N on $g(U,R,x)$.

3. When N approaches ∞, $f(N,\pi,c)$ converges to 0.

From conditions 1 - 3, when the rate of return to investment opportunities and the cost of processing transactions are sufficiently high, an equilibrium number of banks exists and is unique.

This completes the proof of Proposition 1.

2. The Maximization Problem of the Bank in the Model with Fiat Money.

Each bank wants to maximize the expected utility of a representative depositor. Furthermore, money is dominated in the rate of return. Thus, each banks' balance sheet constraints bind. The maximization problem of a bank becomes:

$$\underset{m_t,i_t,r_t^s,r_t^m,r_t^n}{Max}\ \pi\left\{\alpha\frac{\left[r_t^m\frac{x}{N}-P(Q^d)q\right]^{1-\theta}}{1-\theta}+\phi\frac{(r_t^s\frac{x}{N})^{1-\theta}}{1-\theta}\right\}+(1-\pi)\alpha\frac{\left(r_t^n\frac{x}{N}\right)^{1-\theta}}{1-\theta}$$

subject to:

$$m_t + i_t = \frac{x}{N}$$

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

$$\pi r_t^m \frac{x}{N} = \pi R i_t$$

$$(1-\pi) r_t^n \frac{x}{N} = (1-\pi) R i_t + P(Q^d) q - cq$$

By substituting the bank's constraints into the objective function, the optimization problem is simplified. Therefore, the bank maximizes depositors' expected utility by choosing portfolio allocations (m_t, i_t):

$$\underset{m_t, i_t}{Max}\pi \left\{ \alpha \frac{\left[Ri_t - P(Q^d)q\right]^{1-\theta}}{1-\theta} + \phi \frac{(\frac{m_t}{\pi}\frac{\widehat{p_t}}{\widehat{p_{t+1}}})^{1-\theta}}{1-\theta} \right\} + (1-\pi)\alpha \frac{\left[Ri_t + \frac{P(Q^d)q - cq}{(1-\pi)}\right]^{1-\theta}}{1-\theta}$$

From the bank's problem in the transactions services market, we can rewrite the expressions of market quantity and price as $P = (1+c)\left(\frac{N}{N-1}\right) - 1$ and $q = \frac{\pi R i_t}{(1+c)}\left(\frac{N-1}{N}\right)$. Therefore, upon substituting the values of P and q into the bank's objective function, a few lines of algebra yields:

$$\underset{m_t, i_t}{Max}\pi \left\{ \alpha \frac{\left\{ Ri_t \left[(1-\pi) + \frac{\pi}{(1+c)}\left(\frac{N-1}{N}\right)\right]\right\}^{1-\theta}}{1-\theta} + \phi \frac{(\frac{m_t}{\pi}\frac{\widehat{p_t}}{\widehat{p_{t+1}}})^{1-\theta}}{1-\theta} \right\} + (1-\pi)\alpha \frac{\left\{ Ri \left[\frac{1-\pi\left(\frac{N-1}{N}\right)}{1-\pi}\right]\right\}^{1-\theta}}{1-\theta}$$

From the bank's balance sheet constraint, we can write i_t as a function of m_t; $i_t = \frac{x}{N} - m_t$. Consequently, the bank's optimization reduces to:

$$\underset{m_t}{Max}\pi \left\{ \alpha \frac{\left\{ R(x-m_t) \left[(1-\pi) + \frac{\pi}{(1+c)}\left(\frac{N-1}{N}\right)\right]\right\}^{1-\theta}}{1-\theta} + \phi \frac{(\frac{m_t}{\pi}\frac{\widehat{p_t}}{\widehat{p_{t+1}}})^{1-\theta}}{1-\theta} \right\} + (1-\pi)\alpha \frac{\left\{ R(x-m_t) \left[\frac{1-\pi\left(\frac{N-1}{N}\right)}{1-\pi}\right]\right\}^{1-\theta}}{1-\theta}$$

As a result, the bank chooses the amount of money balances to maximize the expected

utility of a representative depositor. The expression for money holdings is provided in the main text.

This completes the maximization problem of the bank in the model with fiat money.

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