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ADVANCING INFORMATION TECHNOLOGY

AND FINANCIAL INTERMEDIATION

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ABSTRACT: The whole financial sector has been under a remarkable structural change, and one of the major contributing forces has been the rapid advance in information processing based on digital technology. The purpose of this paper is to model the influence of advancing information and transaction technology on the financial markets and assess the consequent structural changes within the different forms of banking. The overall conclusion is that improving information technology increases the transparency of firms and the liquidity of capital market instruments. This development favors market-based finance at the cost of traditional financial intermediaries. Traditional bank lending will also benefit, but this benefit is not sufficient to compensate its losses to market-based finance. The welfare effects will be positive because now a smaller amount of profitable projects are rejected due to insufficient information and market transparency.

KEYWORDS: Financial intermediation, information technology, risk and liquidity

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Rahoitussektori kokonaisuudessaan on ollut voimakkaan rakennemuutoksen alaisena, jossa eräänä merkittävästi vaikuttavana taustavoimana on ollut digitaaliseen tietotekniikkaan perustuvan informaatioteknologian nopea kehittyminen. Tavoitteena on mallittaa informaatio- ja transaktioteknologian vaikutukset rahoitusmarkkinoille sekä arvioida tästä seuraavia rakennemuutoksia eri pankkitoiminnan muotojen suhteen. Yleinen johtopäätös tutkimuksessa on, että informaatioteknologia lisää yritysten läpinäkyvyyttä rahoitusmarkkinoilla sekä pääomamarkkinainstrumenttien likvidisyyttä. Tämä kehitys suosii markkinapohjaista rahoitusta perinteisen pankkitoiminnan kustannuksella. Myös tavanomainen pankkitoiminta hyötyy, mutta saavutetut hyödyt eivät riitä kompensoimaan sen menetyksiä markkinapohjaiselle rahoitukselle. Hyvinvointivaikutukset ovat positiivisia, koska nyt pienempi osa potentiaalisesti kannattavista projekteista tulee hylätyksi riittämättömän informaation ja markkinaläpinäkyvyyden vuoksi.

AVAINSANAT: Rahoituksen välitys, informaatioteknologia, riski ja likvidisyys

1 INTRODUCTION

The financial intermediation industry is essentially based on the production of information. The ongoing information revolution, which is based on the digital production and processing of financial data, has dramatically reduced information costs. We consider it self-evident that this technology shock has structural effects on the financial markets. This structural shift is to a great extent related to the roles of direct financial markets and indirect financial intermediaries in transmitting households' saving into firms' investments. Empirically, this process can be seen e.g. in the form of financial disintermediation and in the global spread of the so called Anglo-American type of financial systems, which stresses the role of markets in corporate finance. This evolution is not, by all means, solely the result of the information revolution. Financial deregulation and globalization as well as financial innovations have also had a significant role in this development. However, in this paper we focus strictly and only on the role of the information revolution. The natural framework in this subject is the theory of financial intermediation, which stresses the role of asymmetric information. In this theory the role of banks is to solve the information problems of financial contracting.[1]

Due to asymmetric information financial contracts are inherently incomplete. This causes agency costs, which are essentially information, incentive and transaction costs. Originally, financial intermediation and banks arose to mitigate theses costs. They could offer better contracts than were available directly in the market. As information technology improves, the quality of public market information increases and information costs generally decline. This downgrades the role of banks, whose very existence is based on producing information and on the imperfections of market information. The development of the whole financial structure can be seen as a dialectic interaction between conventional banks and direct financial markets. In this point we can quote Eichberger and Harper (1997), who have particularly well expressed the core idea:

> The evolution of financial systems is characterized by a continuing struggle between financial intermediaries and financial markets. As imperfections in the operation of markets recede with the development of new transactions technology and/or new ways of harnessing information, intertemporal trade on markets substitutes for financial intermediation.…. One can break into the history and observe both the phenomenal advance in the use of markets and also the considerable counter-reaction of financial intermediaries seeking to retain their *raison d'être* and to specialize in those services which, for the present at least, remain beyond the reach of financial markets.

In the theoretical extreme when market information is complete, and we know all future contingencies, contracts can be complete and there is no role for financial intermediaries such as conventional banks. Until we reach that point, there is a continuing struggle between direct and indirect financial intermediation. This issue is especially important now, when information and communication technology has advanced exceptionally fast, and the structure of financial markets is globally under a rapid change. This process changes the

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[1] See Bhattacharya and Tharkor (1993), Mayer (1994) and van Damme (1994) for good surveys of the related literature.

competitive status between different banks and different forms of finance. Our purpose is, to model the influence of advancing information and transaction technology on the structural change in the financial markets and on the competitive status of the different forms of banking.

In our model we focus particularly on two factors. These are liquidity and risk. It is our view that the core of banking can be boiled down to these factors. In producing information the main functions of banks are firstly, to ease the liquidity problems of households and secondly, to the reduce the risks involved in financing firms. As Rajan (1998) has argued: "I argue that banks arose historically to provide customers liquidity and a safe investment heaven. …". Firms invest in long term projects, and due to unexpected liquidity shocks, households cannot tie their purchasing power for such a long time. In addition, households do not have the ability and sufficient information to analyze the potential risks involved in the projects. With some simplification we can say that banks solve these problems and combine the conflicting interests of households and firms in order to mobilize savings for sufficient capital maintenance for the economy. By doing this they reduce the agency costs involved in financial contracting. We assume in our model that changes in information and transaction technology affect these agency costs, particularly those involved in the liquidity and risk management, and then assess, what kind of structural changes this development has in the financial market.

2 MODEL OF FINANCIAL INTERMEDIATION

We start by modeling financial intermediation, which consists of three sectors: households, firms, and banks.

I. The primary suppliers of finance (households)

Households or savers are the primary suppliers of finance. Their objective is intertemporal maximization of utility. Intertemporal trade implies that consumers do not instantly consume all the income they earn. They can postpone their consumption into the future. This requires that they must purchase some financial instruments in order to preserve their purchasing power, i.e. they must save. This in turn, presupposes that the yield on savings must equal the sacrifice of abandoning present consumption. This aspect is represented by the real interest rate. In addition, they demand liquidity and risk premiums, which are typically related to intertemporal trade. Consequently, the minimum required interest rate for the households' savings can be expressed as

$$i^H = r + l + s \tag{1}$$

where i^H is the yield expected from a certain financial asset by a household (*H*). r describes the time preference of a household or the real interest rate. l is the liquidity premium. Households demand liquidity in the secondary market in order to be prepared for unexpected liquidity shocks. An extra premium is required if an asset cannot be used as medium of exchange or converted into purchasing power without costs. s is the risk premium.

We assume two financial assets: banks deposits (D) and a capital market instruments (C), which could be bonds or stocks issued by firms. The yield required for a bank deposit is

$$i_D^H = r \tag{2}$$

Because bank deposits are actually money, they are completely liquid, and no liquidity premium is required for holding them. Diamond and Dybvig (1983) have modeled deposit taking banks as a liquidity pool of households, which is an insurance against unexpected liquidity shocks. In addition, we assume that neither a risk premium is required for a bank deposit. Leland and Pyle (1977) and Diamond (1984) have shown that banks diversify away the idiosyncratic risks, so that the agency costs between the depositor and the bank approach zero. Diamond and Dybvig (1983) have argued that a bank protects households from idiosyncratic risks and deposit insurance from systemic risks. So all in all, we can assume as a first approximation that relative to capital market saving, bank deposits are free from liquidity and risk premiums. Instead, capital market instruments are subject to these premiums. We assume that the advance of digital data processing technology affects both of these premiums. Consequently, the minimum required yield for capital market investments (bonds and stocks) can be expressed

$$i_C^H = r + l + s \tag{3}$$

where

$$l = 1 - IE \; ; \qquad 0 \le I \le 1, \; 0 \le E \le 1 \tag{4}$$

I describes the information and transaction technology that is used when converting capital market instruments into a medium of exchange. The advance in digital information and transaction technology makes the transformation of bonds and securities into purchasing power cheaper and more convenient, which decreases the liquidity premium. With complete information and transaction technology *I* is *1*. *E* describes the size of the emission of securities. Larger issues have deeper markets and are consequently more liquid. This limits the capital market finance of small firms. After a certain threshold, which we do not define here, *E* is *1*, and the size of the emission does not cause any increase in the liquidity premium. The equation (4) tells that in the theoretically extreme case with perfect information and transaction technology and with a sufficiently large emission size there are no differences in liquidity between bank deposits and capital market savings.

The risk premium is defined as follows bellow:

$$s = 1 - \lambda \left(Iq \right); \quad 0 \le \lambda \le 1, \; 0 \le I \le 1, \; 0 \le q \le 1 \tag{5}$$

were λ indicates the true quality of the firm. The quality of the firm is assumed here to capture all the relevant information (public and private) concerning the firm and its future projects. E.g. the ratings published by different rating agencies are based, to a great extent, on past performance and data and other public information of the firm. Consequently, the ratings reflect only market information processed by the rating agencies, and do not necessarily describe all the quality aspects of a firm. There is asymmetry of information in the sense that we assume that a firm knows its quality, but the primary savers must acquire information of it from the market. In addition, market information is imperfect. With perfect quality *λ=1*. *I* is the technology parameter as in equation (4) above. Improving information and transaction technology facilitates easier access to market information concerning firms, makes it cheaper, and increases the efficiency of information processing. This reduces risk. *q* describes the quantity or part of relevant information available for the financial market. In other words, *q* is the parameter of market transparency of a firm. If *q = 1* all the relevant quality aspects of a firm are transparent to the market. The equation (5) indicates that when the quality of a firm is perfect and we have complete information technology and market information contains all the quality aspects of a firm, there is no risk premium.

In summary, we can say that according to the equations above the development of information and communication technology decreases the premiums required for capital market savings (i.e. the agency costs becomes smaller). This increases the competitive edge of capital market instruments when competing about savings. Correspondingly the role of banks in reducing agency costs caused by information asymmetries diminishes with the improvement of common market information.

According to the above equations we can define the supply of savings:

$$S\left(\underset{+}{i_D^H},\underset{+}{i_C^H},\underset{-}{r},\underset{-}{l},\underset{-}{s}\right)=D\left(\underset{+}{i_D^H},\underset{-}{i_C^H},\underset{-}{r},\underset{+}{l},\underset{+}{s}\right)+C\left(\underset{-}{i_D^H},\underset{+}{i_C^H},\underset{-}{r},\underset{-}{l},\underset{-}{s}\right) \qquad (6)$$

The signs of the partial derivatives of the above equation indicate that the supply of savings depends positively on the relevant interest rates, and negatively on the increase of time preference, and on the increase of liquidity and risk premiums. The supply consists of bank deposits (*D*) and savings in capital market instruments (*C*). The fact that the supply of deposits depends positively on liquidity and risk premiums is derived from the feature that an increase in these premiums induces agents to shift part of their savings from capital markets into bank deposits because these premiums concern only capital market instruments as can be seen from equations (2) and (3).

II. The primary demand for finance (firms)

Firms are risk-neutral and their objective is to maximize its expected profit. Each entrepreneur invests in a project of fixed size, which for simplicity is normalized to 1. The projects yield a gross profit x, which varies as follows.

$$x=\begin{cases} Y \ \ \textit{with probability} \ \ p \\ 0 \ \textit{with probability} \ 1-p \end{cases}$$

so that the net profit of a project is

$$\pi^F = pY - R_i^F \qquad (7)$$

where R describes the financing costs. The superscript F symbolizes firm, and i indicates the forms of finance the entrepreneur is using ($i = C$, T or M). The entrepreneur has, thus, three ways in financing its projects (C = capital market finance, T = transaction bank loans, and M = monitored bank loans). The form of finance has an influence on both p and R. Let us fist examine the relationship between the probability of success and the form of finance.

Capital market finance and transaction loans:

$$p = \lambda \tag{8}$$

The probability of success depends only from the quality of the firm. As mentioned above, a firm knows its quality for certainty.

Monitored bank loans:

$$p = \lambda + \phi(1 - \gamma - \lambda); \qquad 0 \leq (\gamma + \lambda) \leq 1 \tag{9}$$

where ϕ represents the quality of the monitoring bank. A high quality bank can improve its customers' project choice more likely than a less qualified bank. γ describes the distance between the bank and the firm indicating that a local bank has better information in evaluating local enterprises. Long distance reduces a bank's capability to evaluate the firm's success probability giving an advantage to local banks. The success probability now depends on the quality of the firm and from the factor $\phi(1 - \gamma - \lambda)$, which is expected to be positive, and describes the bank's expertise in project evaluation or screening. Consequently, by monitoring (screening) banks can improve the success probability of projects. It is expected that through project screening a bank can obtain such private information on firms that cannot be observed in the market. In addition, as banks finance large numbers of investment projects in a specific sector or area in the economy, they collect experience and expertise which makes them well placed to appraise the potential performance of those projects. In many such cases banks may be equipped with even better information than firms themselves. Especially this may be the case with new and small enterprises. In other words, by screening banks mitigate the adverse selection problem of finance, and decrease the agency costs of financial contracting. On the other hand, banks cannot improve much the project choice of experienced high quality firms. Symbol λ within the brackets describes this idea.

III. Financial intermediaries (banks)

Banks are profit maximizers, and they can practice three forms of banking. firstly, in investment banking they can intermediate capital market finance. Secondly, they can collect deposits and grant transaction loans, and finally, they can grant monitored loans. In our analysis banks strategic choice implies that they choose between these three forms of banking activities. In addition, we assume that as institutional circumstances change (e.g. due to shifts in technology), this influences banks' strategy concerning the choice between the different forms of finance.

Banks may specialize exclusively in a certain form of banking. In this case technological shifts affect the competition between different types of banks. On the other hand, universal banks may practice all forms of banking. In this case, there is a choice concerning, which kind of activities the bank should most strongly emphasize. We start our analysis of banks by modeling the profit functions in the different forms of banking. As we want to keep the model as simple as possible without sacrificing our basic ideas, we firstly simplify our analysis by excluding potential economies of scope between the different banking activities. In the presence of significant economies of scope, a large universal bank is more efficient than a small and specialized bank. Another simplification is that we do not model the interbank market. This means that e.g. the lending of banks is constrained by the deposits they collect.[2] We also ignore possible economies of scale. There could be increasing returns to scale as the volume of the financial sector as a whole increases. This could be due to the effects stressed by the New Growth Theory. As a certain industry expands, there could be positive spillover effects of improving technology and human capital.[3] This increases efficiency and reduces the average fixed administration costs in banking. However, this feature is not essential to our subject, and consequently, we omit it from the model.

1. Investment banking and capital market finance

An investment bank buys securities from firms and sells them to households. When it buys bonds or stocks (i.e. grants finance to a firm) it gets a yield of R_C^F, and when it sells the securities, the interest rate households demand is i_C^H. In addition, the bank must pay administration costs of C_c^B. The net profit of an investment bank is

$$\pi_C^B = \left(R_C^F - i_C^H\right)Q_C - C_C^B\left(Q_C\right) \tag{10}$$

where Q_C is the volume of the bank's capital market transactions. According to equations (3, 4 and 5)

$$R_C^F = r_C^B + l + s = r_C^B + (1 - IE) + \left[1 - \lambda\left(Iq\right)\right] \tag{11}$$

$$i_C^H = r + l + s = r + (1 - IE) + \left[1 - \lambda\left(Iq\right)\right] \tag{12}$$

As we can see from equations (11) and (12) the valuation of capital market instruments are based on public market information about the quality of the firm issuing the securities. An investment bank does not create any new information concerning the firm.

When we subtract i_C^H from R_C^F in equation (10) the profit function is

$$\pi_C^B = \left(r_C^B - r\right)Q_C - C_C^B\left(Q_C\right) \tag{13}$$

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2 For this point see e.g. Jayaratine and Morgan (2000)

3 Becsi and Wang (1997) have introduced a model of the financial sector, which adapts the ideas of the New Growth Theory.

In other words, as the investment bank and the households require the same premiums from securities, they cancel out each other, the spread of the investment bank is reduced to the difference between the real interest rates demanded by the investment bank (r_C^B) and the time preference of the household (r). We get the gross income of the investment bank by multiplying the spread by the volume of the bank's transactions (Q_c). The net profit is then obtained by subtracting the administration costs [$C_C^B(Q_C)$] from this revenue. We can see from equation (13) that information technology has no influence on the spread of the investment bank.

2. Transaction loans

Like capital market finance, transaction loans are based on market information. They are typically granted to relatively large firms with good reputation. They differ, however, with respect to bonds and securities, in the sense that they do not have effective secondary markets (i.e. they are illiquid), and banks generally keep them in their balance sheets until the maturity day. This assumption imply that banks do not demand liquidity premium for these loans. In addition, we assume that they are financed mainly through collecting deposits. With these assumptions we get the following profit function for transaction loans:

$$\pi_T^B = \left(R_T^F - r\right)Q_T - C_T^B\left(Q_T\right) = \left\{r_T^B + \left[1 - \lambda\left(Iq\right)\right] - r\right\}Q_T - C_T^B\left(Q_T\right) \qquad (14)$$

We can see from the equations (11, 12, and 14) that, in principle, transaction loans could be more advantageous to firms than capital market finance, because their interest rate lacks the liquidity premium, and because they are financed through bank loans, which are cheaper than capital market savings.

3. Monitored loans

The prices of bonds and stocks are determined in the market because their prices are based on market information. Even when there are differences (as noticed above) transaction loans are close substitutes to capital market finance in the sense that their prices are based on market information. Instead, monitored loans or relationship loans are based also on unique private information that a bank produces itself. As discussed earlier and shown by equation (9) above by producing information banks can improve the probability of success of a firm's investment project under certain conditions. Monitoring can be seen to correspond product differentation in the goods market (Boot and Thakor, 1997). Banks can specialize in a specific branch of industry or a specific geographical area. In these areas they may have more expertise than more generally oriented banks have. This enables the monitoring banks to create extra value - or rents - that can be shared by the bank and the entrepreneur (Sharpe, 1990). James (1987) has provided empirical evidence indicating that a firm's announcement of a new bank loan leads to significantly positive abnormal stock returns. In other words, a bank loan is a positive signal to the market that even raises stock prices (reduces the costs of capital market finance). These findings can be interpreted (and often has) to indicate that markets consider bank loans to indicate an increase in the monitoring of the firm, which may improve the success probability of the firm' projects. In other words, markets consider that banks have some private information that they do not have, and interpret the granting of a bank loan as a signal of that information.

The factor $\phi(1-\gamma-\lambda)$ in equation (9) characterizes the above features of monitored loans. This factor can be also interpreted to represent a potential source of bank's monopoly power. Thus, markets for monitored credit are more monopolistic by nature than transaction or capital market finance. Because the latter forms of finance are based on market information, they are more characterized by Bertrand type of competition.

However, there are extra costs involved in monitoring. Average monitoring costs [M] may consist partly of project specific evaluation costs and partly of sunk-costs that the bank has invested in for a longer term. Such long-term costs may for example involve investments in branch networks and long term customer relationships.[4] We simplify our analysis by assuming that through sacrificing a certain average amount of the monitoring costs per a loan applicant the bank learns the quality of the firm (λ) for certainty. So, there are no risk premiums in the interest rates of monitored loans. This may be an oversimplification, but we believe this will not compromise the main points of our analysis. The central idea is that we want to emphasize the differences between the different forms of financing, and one major difference is in monitoring technology.

The role of monitoring technology:

We can describe the monitoring technologies for producing relevant financial information by the following production functions:[5]

$$Y^C = f\left(K, H, I, q^p\right)$$

$$Y^M = f\left(K, H, I, q^p, q^i\right)$$

where Y^C describes the information output for capital market savings may it be produced by individual investors themselves, rating agencies, financial analysts, investment banks, financial publications etc. Ultimately, every individual household makes the decisions according to its own judgments and risk profile, but it may exploit publicly available information, which is produced by some financial institutions or advisers. Y^M is the information output of a conventional bank. K describes physical capital, H is human resources, I is available information technology (as described earlier), q^p is available public market information and q^i is inside or private information concerning a firm an its projects. We can define the following differences in the monitoring technologies:

- Conventional banks may exploit both public and private information (q^p and q^i) whereas only public information is available for capital market savings.
- Transforming public data into relevant financial information is more routine-like than dealing with private proprietary information. Because of this, automatic data processing techniques can be more easily adapted in capital market finance.
- Producing private information requires more specialized human skills and even physical presence with the firm to be monitored.

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4 There is a considerable literature related to this issue. See Harris and Holmström (1982), Sharpe (1990), Von Thadden (1990), Caminal and Matutes (1996), Battacharya and Chiesa (1995), Manove, Padilla and Pagano (2000).

5 Also Emmons and Greenbaum have focused on the differences in the information production functions of the different types of financial intermediaries.

- Because of the above arguments conventional banks use proportionally more physical and human capital in monitoring. E.g. they may have a relatively large branch network and more personnel committed to these activities.
- The primary savers (households) - when investing in the capital market - exploit the information produced by different institutions, and they extensively survey and compare the whole spectrum of alternative firms in the market in order to choose where to invest. For this reason we assume that they do not monitor firms in the similar way that banks do in evaluating their loan applicants. Consequently, it is assumed that only conventional banks exercise actual project specific ex ante screening.

In summary, it can be concluded that both conventional banks and those who invest in capital market instruments benefit from improving information technology, but the benefit is asymmetric in the sense that capital market finance benefits relatively more. This is due to the fact that this form of finance is based solely on public information and to a greater extent on numerical data, which can be more easily processed digitally. We can describe the effects of improving information technology on the information production of the two forms of finance in following concave functions:

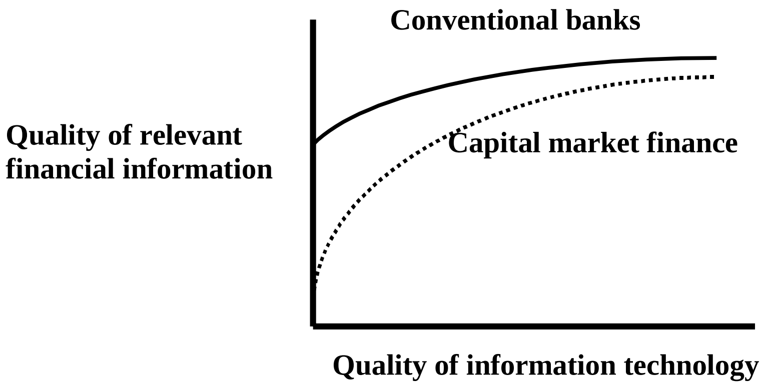

Figure 1: Information technology and quality of financial information

The concavities are such that the quality of capital market information approaches but never quite reaches the level, which prevails in the market for monitored loans. This is firstly based on the above argument that capital market finance benefits more from information technology, and secondly that capital market analysts has no access to private proprietary information. The latter point sets the ultimate limit to the quality of the market information. One additional conclusion of the above description of the monitoring technologies implies that the improvement of information technology decreases the average monitoring costs (M), which are necessary for a bank to learn the quality of a firm.

The profit function of conventional banks:

Taking into account these considerations, we can present the following profit function for a bank, which grants monitored credit:

$$\begin{aligned}\pi_M^B &= \left(R_M^F - r - M\right)Q_M - C_M^B\left(Q_M\right) \\ &= \left[r_M^B + \tau\phi\left(1-\gamma-\lambda\right) - r - M\right]Q_M - C_M^B\left(Q_M\right)\end{aligned} \tag{15}$$

We can see from the above equation that the interest rate for monitored loans (R_M^F) consists of the real interest rate the bank requires in order to cover its costs and normal profit (r_M^B) plus the contribution of the bank's monitoring efforts to the improved project choice. Parameter τ describes the part of the bank's contribution to the project choice that is transferred to the interest rate. If $\tau = 0$, the bank does not charge extra interest rate from its contribution, and consequently, all the benefits will go to the firm. If $\tau = 1$, the firm does not get any benefits from the improved project choice. Instead, they will go to the bank in form of higher interest rates. In this case the bank will loose its monopoly power, because firms will be indifferent with the bank and its competitors. Generally, $0 < \tau < 1$, so that the benefits of the improved project choice will be shared by the bank and the entrepreneur.

3 EFFECTS OF IMPROVING INFORMATION TECHNOLOGY ON THE DIFFERENT FORMS OF BANKING

In this part we examine the effects of improving information technology on the different forms of banking. For this purpose we first build a graphical supply and demand framework, in which we assess the changes that improving information technology has on the financial market. Then we calculate more exactly how the profits in the different banking activities are affected. We assume that in the initial equilibrium, the inter-mediation margins of each form of banking are equal, so that banks are indifferent with respect to the different banking activities. Then we assess, how the advance of information technology and consequent general improvement of market information affects this initial balance. The Framework consists of the following three curves, which differ in details between the different forms of finance.

1) The primary demand for finance by firms or the F-curve

This curve is based on equation (7) above. To be feasible an investment project of a firm must satisfy the condition: $pY \geq R_i^F$. In other words, firms invest up to a point, where the expected income on the project covers its financing costs. In addition we assume constant return to scale in the firm's cost function, so that the profit per unit does not depend on the quantity of production. Under this condition the F-curve is a horizontal line, where $pY = R$. It can be conceived to describe the expected average productivity of the investments to be financed. It is also consistent with the idea that the productivity of investments determines the real interest rate, and monetary policy can influence only nominal interest rates or inflation. We take the productivity of investments as exogenously given in our model. On the other hand, it could be more realistic to assume that e.g. the advance of information technology increases also the effectiveness of investments. This would raise the F-curve, increase market interest rates and the overall volume of transactions in the financial market. However, taking this into account would unnecessarily complicate the model without any additional contribution to our basic issues, which is to examine the relative shares of the different forms of finance.

2) The primary supply of finance by households or the S- curve

The behavior of that curve is based on equation (6) above. The intercept of that curve is formed by the minimum yield required by household on their savings [equation (1) above]. The curve is upward sloping because extra yield is required in order to induce the households save more as more capital is required for extra investments. For that purpose the equation (1) can be modified as follows:

$$i^H = r + l + s + cQ \tag{16}$$

Where Q is the quantity of finance and c is the coefficient, that indicates how much the interest rate must rise in order to induce the extra savings. We again simplify by assuming that c is linear. In practice, it could be convex describing the idea that as households are induced to save more the alternative cost of abandoned present consumption becomes increasingly higher. Because the supply of capital market savings and the supply of deposits are determined in a different way especially with respect to the liquidity and risk premiums, we must generate separate functions for them. Observing the contents of the premiums in equations (4 and 5), and their different signs (equation 6) with respect to deposits and capital market savings we can write:

The supply of deposits

$$i_D^H = r + \underset{-}{l} + \underset{-}{s} + cQ = r + (IE - 1) + [\lambda(Iq) - 1] + cQ \tag{17}$$

and the supply of capital market savings

$$i_C^H = r + l + s + cQ = r + (1 - IE) + [1 - \lambda(Iq)] + cQ \tag{18}$$

3) The financial intermediaries or the FI-curve

These curves differ between the different forms of banking and are based on equations (13, 14 and 15) above. The FI-curve is the interest rate a bank receives when it finances the firms' projects. The difference between the FI- and S curves is the intermediation margin. This margin can be calculated from the above equations. Basically it is the difference between the interest rate a bank receives from firms and the interest rate it must pay to the households. Consequently, this margin must cover a bank's profit (π) and administration costs (C) as well as potential monitoring costs (M) depending on the forms of finance. According to the above arguments concerning the monitoring technology of banks the monitoring costs are a decreasing function of the quality of the information technology.

With the above reasoning we can form the following graphical framework of the supply and demand conditions in the financial markets. The vertical axis (i, R) describes the interest rates received by households or banks and the costs of finance. The horizontal axis (Q) describes the quantity of finance. Equilibrium in figure 1 is determined in point A, where the expected gross returns of the investment (*pY*) equals the cost of finance required by the bank. The corresponding interest rate to savers is indicated by *i*.

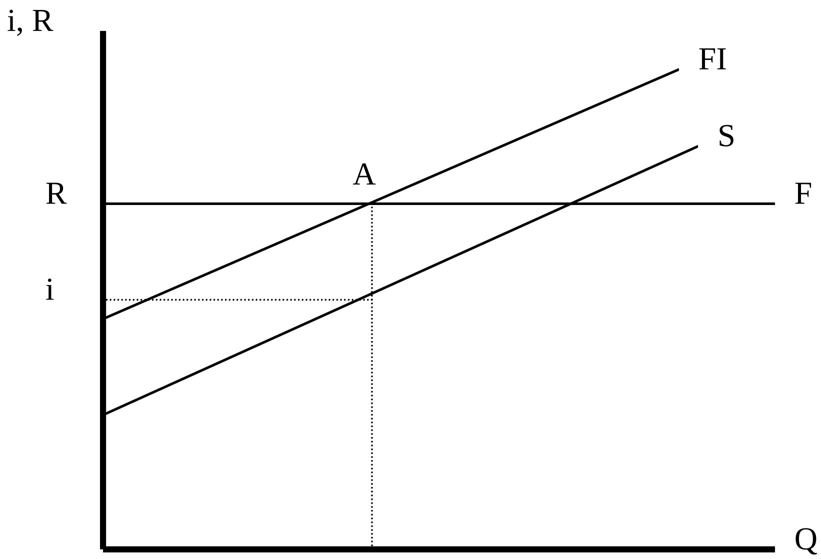

Figure 2: Supply and demand in the financial markets

Next, we examine the effects of improving information technology on each of the different forms of banking in the above framework. We assume that in the beginning there is an equilibrium in the sense that the intermediation marginal of banks is equal in each of the different forms of finance. Then we assess, how the change in the technology affects this balance and the market share of the different forms of banking.

3.1 Effects on the separate financial sectors

1. Capital market finance

Improving information and transaction technology will reduce the liquidity and risk premiums according to equations (4) and (5). According to equation (11) the FI-curve shifts rightwards. The supply of the capital market savings of households will be increased (equation 6), and the S-curve also shifts rightwards. The intermediation margin will be unaffected, but the volume of capital market finance will be increased from Q_0 to Q_1.

2. Transaction loans

According to equation (14) the FI-curve of transaction loans will shift rightwards because of improved market information, and the S-curve will shift leftwards because the supply of bank deposits is reduced as equation (6) indicates. The volume of transaction loans increases but the intermediation margin decreases as can be seen from figure 3 bellow.

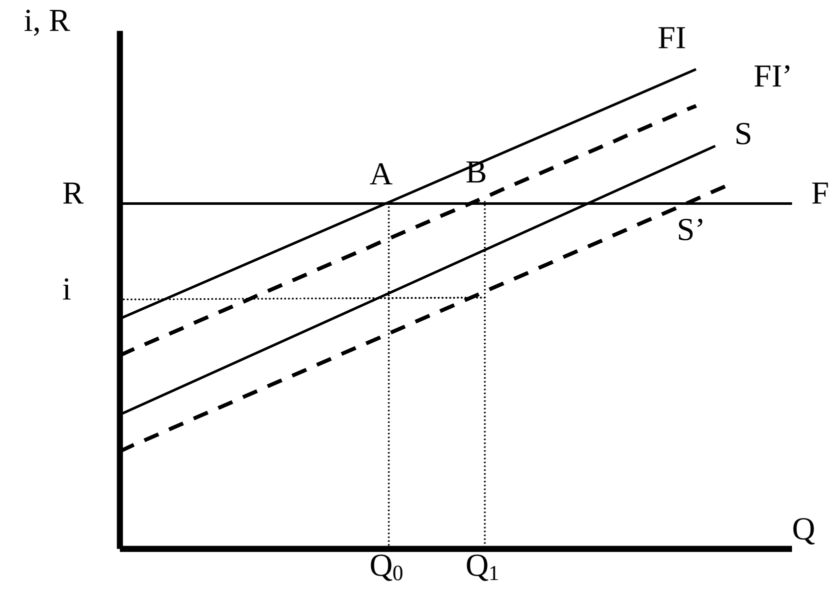

Figure 3: Supply and demand of capital finance

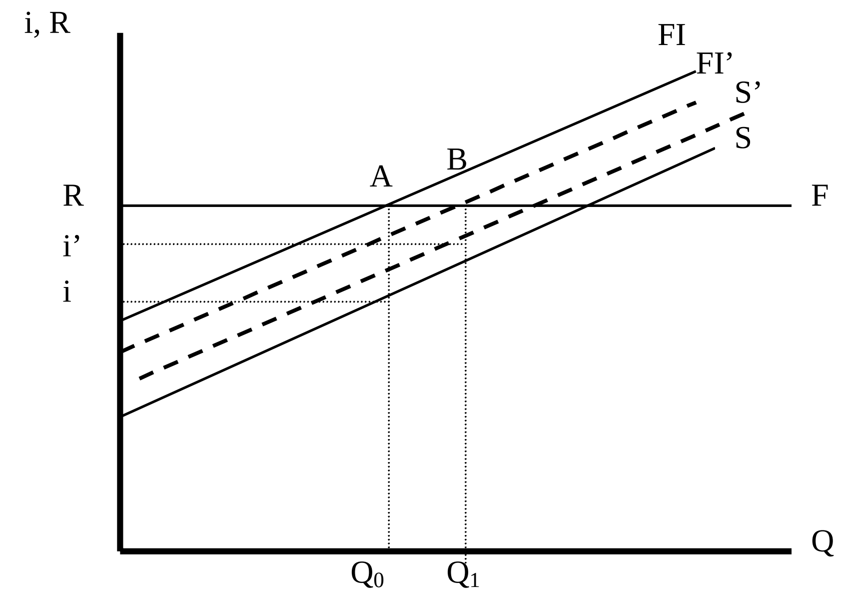

Figure 4: Supply and demand of transaction loans

3. Monitored loans

Improved market information does not immediately affect the FI-curve of monitored loans as can be seen from equation (15). Instead, the S-curve shifts left for the same reason as in the previous case. *Ceteris paribus*, the volume of monitored loans is unaffected, and the intermediation margin is decreased.

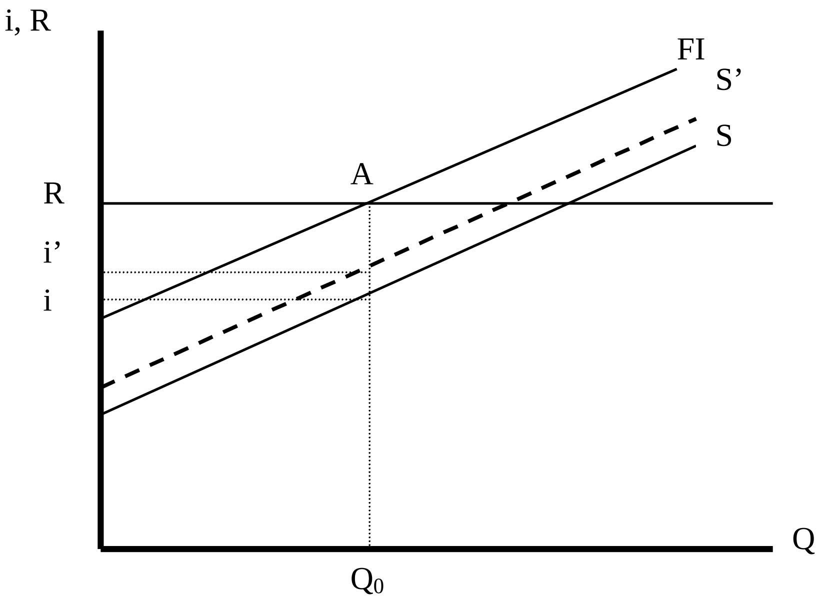

Figure 5: Supply and demand of monitored loans

3.2 Effects on the profits

The above figures already gave a rough idea how the advancing information technology influences the profitability of different types of banks. However, in the following we wish to have more explicit answers to this question. We modify bellow the profit functions of the different banking activities obtained in section two so that we are able to calculate the changes in the profits of the banks.

1. Capital market finance

Firstly, we must solve the volume of transactions or the quantity (Q), which is needed in the profit function. As has been shown previously, in equilibrium

$$pY = R_C^F \text{ or } pY - R_C^F = 0 \text{ or}$$

$$pY - r_C^B - (1 - IE) - (1 - \lambda Iq) - cQ_C = 0$$

and solving Q_C from the equation we get

$$Q_C = \frac{pY - r_C^B - 2 + IE + \lambda Iq}{c}$$

Substituting the solution for Q_C in equation (13) we the following profit function:

$$\pi_C^B = \left(r_C^B - r\right)\frac{pY - r_C^B - 2 + IE + \lambda Iq}{c} - C_C^B \tag{19}$$

Taking the first derivative of equation (19) with respect to *I*, we get the influence of information technology on the profits of an investment bank.

$$\frac{d}{dI}\left[\left(r_C^B - r\right)\frac{pY - r_C^B - 2 + IE + \lambda Iq}{c} - C_C^B\right] = \left(r_C^B - r\right)\frac{E + \lambda q}{c} \tag{20}$$

The first derivative is clearly positive. The intermediation margin has not changed, and the change in profit is the intermediation margin multiplied by the change in the volume of capital market finance. In other words, as can also be seen from figure 2, the net effect is that the volume of capital market finance increases. This can be interpreted from the welfare aspect so that the agency costs due to asymmetric information and undeveloped transaction technology and consequent excessive risk and liquidity premiums has caused previously a smaller than optimal supply of capital market finance. Correspondingly, the improvement of market information and communication technology diminishes this asymmetry and brings welfare gains as investments grow.

2. Transaction loans

In the same manner as above we first solve the quantity (Q_T). In equilibrium

$$pY = R_T^F \text{ or } pY - R_T^F = 0 \text{ or}$$

$$pY - r_T^B - \left(1 - \lambda Iq\right) - cQ_T = 0$$

and solving Q_T from the equation we get

$$Q_T = \frac{pY - r_T^B - 1 + \lambda Iq}{c}$$

Substituting the above solution for Q_T and i_D^H for r in equation (14), and observing from equation (17) that $i_D^H = r + (IE - 1) + \left(\lambda Iq - 1\right) + cQ_T$, we get the following profit function:

$$\pi_T^B = \left[r_T^B + \left(1 - \lambda Iq\right) - \left(r + (IE - 1) + \left(\lambda Iq - 1\right) + c\frac{pY - r_T^B - 1 + \lambda Iq}{c}\right)\right]\frac{pY - r_T^B - 1 + \lambda Iq}{c} - C_T^B \tag{21}$$

Taking the first derivative of equation (21) with respect to *I*, we get the influence of information technology on the profits from transaction loans.

$$\frac{d}{dI}\left\{\left[r_T^B+(1-\lambda Iq)-\left(r+\ (IE-1)+(\lambda\, Iq-1)+c\frac{pY-r_T^B-1+\lambda Iq}{c}\right)\right]\frac{pY-r_T^B-1+\lambda Iq}{c}-C_T^B\right\}$$
$$=\frac{5\lambda qr_T^B+Er_T^B-4\lambda qpY-EpY+7\lambda q-6\lambda^2q^2I-2E\lambda Iq+E-\lambda qr}{c} \tag{22}$$

The sign of the first derivative is indeterminate because the intermediation margin will be reduced but the volume of transaction loans will be increased. In addition, we can see form (22) that the second derivative is definitely negative.

3. Monitored loans

In the equilibrium of monitored loans

$$pY=R_M^F \text{ or } pY-R_M^F=0 \text{ or}$$
$$pY-r_M^B-\tau\phi(1-\gamma-\lambda)-cQ_M=0$$

and solving Q_M from the equation we get

$$Q_M=\frac{pY-r_M^B-\tau\phi(1-\gamma-\lambda)}{c}$$

Substituting the above solution for Q_M and i_D^H for *r* in equation (15), we get the following profit function:

$$\pi_M^B=\left[r_M^B+\tau\phi(1-\gamma-\lambda)-\left(r+\ (IE-1)+(\lambda\, Iq-1)+c\frac{pY-r_M^B-\tau\phi(1-\gamma-\lambda)}{c}+M\right)\right]\frac{pY-r_M^B-\tau\phi(1-\gamma-\lambda)}{c}-C_M^B \tag{23}$$

Taking the first derivative of equation (23) with respect to *I*, we get the influence of information technology on the profits from monitored loans.

$$\frac{d}{dI}\left\{\left[r_M^B+\tau\phi(1-\gamma-\lambda)-\left(r+\ (IE-1)+(\lambda\, Iq-1)+c\frac{pY-r_M^B-\tau\phi(1-\gamma-\lambda)}{c}+M\right)\right]\frac{pY-r_M^B-\tau\phi(1-\gamma-\lambda)}{c}-C_M^B\right\} \tag{24}$$
$$=-(E+\lambda q-M')\frac{pY-r_M^B-\tau\phi(1-\gamma-\lambda)}{c}$$

The volume of transactions is unchanged, but the factor $-(E+\lambda q-M')$ indicate a change in a bank's profit. The sign and magnitude of the change depends on the relative magnitude of the different effects. Factors *E* and λq reflect the effects of decreasing risk and liquidity premiums, which increases the attraction of capital market instruments, and consequently decreases the supply bank deposits. This increases a bank's costs of financing its loans decreasing the profits. Factor *M'* reflects the decrease of the monitoring costs of a bank, which increases profits. The bet effect is basically an empirical issue. However, it could be *á priori* expected that the latter effect is weaker as we have earlier defined that routing data processing and information technology have only a relatively minor role in the monitoring technology of a conventional bank.

4 STRUCTURAL SHIFTS WITHIN THE FINANCIAL INTERMEDIARIES

In this part we estimate the direct effects of the improving information technology on the structure of the financial markets. It can be expected that these effects will induce also secondary strategic responses by banks, when they adjust to the new situation. This will further reshape the financial structures. However, this issue requires another inquiry, and we do not explicitly address it here.

Our starting-point is that the advancing information technology influences the transparency of the different market segments in the financial market.[6] In addition, as discussed earlier, the digital information and communication technology affects the liquidity of financial instruments. We assume that there is a given set (Ω) of potentially feasible financial contracts concerning projects that each have the same expected positive project payoff (*pY*). However, they differ with respect to certain properties concerning their transparency and liquidity. We use the same transparency and liquidity concepts as defined earlier. Factor *Iq* describes the transparency of the firm to the market, factor *IE* is the liquidity factor, and *M* captures the idea that only by sacrificing certain monitoring costs a firm can be made transparent. The notation $\Omega\langle Iq, IE, M\rangle$ describes the properties of the potential contracts. This set can be divided into subcontracts, which consist of the different forms of finance discussed earlier. Consequently, the following financial subcontracts are offered in the market.

- $\Omega_C\langle Iq, IE\rangle$ describes those financial contracts, which are offered through capital market instruments. The actual contracting parties are households and firms. Investment bankers act only as brokers. As the notation and the earlier discussion indicates, the transparency and liquidity properties are essential in these contracts.
- $\Omega_T\langle Iq\rangle$ indicates transaction loan contracts offered by banks, and as mentioned above the liquidity properties are not important in these contracts, because banks are prepared to hold these items in their balance sheets until maturity. These contracts are available to those firms that are not so transparent and whose securities and bonds are not liquid enough so that they could contract in the capital market.
- $\Omega_M\langle M\rangle$ describes the contracts available to those firms that are so opaque that they have to be made transparent by banks through sacrificing a certain amount of monitoring costs.

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[6] For this point see also Emmons and Greenbaum (1998)

- Finally $\Omega_R\langle 0\rangle$ describes those potential contracts that are even rationed out by banks, because the monitoring costs to render them transparent would be excessive. These firms could still get finance e.g. by venture capital contracts, where the contractual asymmetries can be solved by some other means. This section also describes a welfare loss due to asymmetric information because, as defined above, also these projects are potentially feasible as their expected profit (*pY*) is similar to all other projects.

The relative shares of the different forms of finance can be described by the figure 6 bellow, where the most transparent and liquid instruments are on the left side. As these properties weaken we move leftwards. Sector $\Omega_C \rightarrow \Omega_T$ consists of capital market finance, sector $\Omega_T \rightarrow \Omega_M$ of transaction loans, sector $\Omega_M \rightarrow \Omega_R$ of monitored loans, and sector $\Omega_R \rightarrow$ of the part of potential projects, which cannot be financed either by capital market or banks.

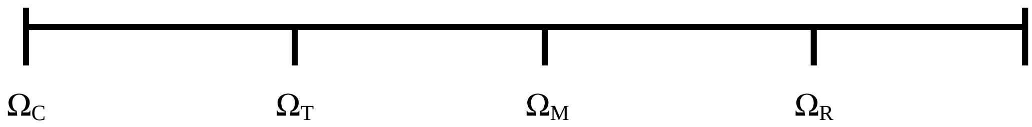

Figure 6: Transparency and liquidity and market shares of the different forms of finance

With reference to the earlier discussion in this paper we can appraise, how the digital information technology shock affects the above market structure. This can be seen in figure 7 bellow.

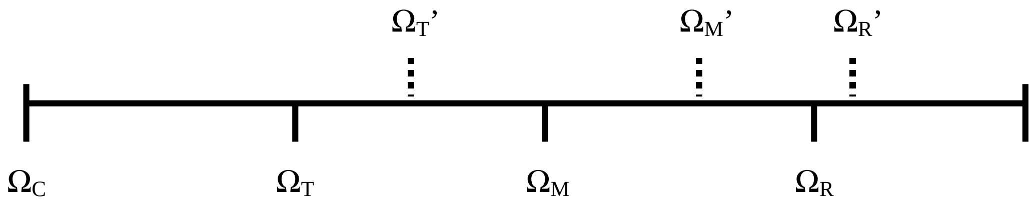

Figure 7: The effect of the information technology shock on the market shares

The market based finance benefits the most from the development in question, because the information technology affects both the risk (transparency) premium and the liquidity premium. Its relative share of the market will expand to Ω_T'. We see it quite realistic to assume that the increasing market share will be captured from the customer segment, whose transparency and liquidity properties are nearest to the gaining sector. For example, capital market finance cannot be immediately expanded to those firms, who are so opaque that even conventional bank loans are denied from them. So, in this case as some firms get more transparent, they go from transaction loans to capital markets. In a similar way, some loan applicants move from conventional bank loans to transaction loans.

The banks who grant monitored loans benefit the least. Their total market share can be even reduced as is seen in the figure 7. As the monitoring costs (M) will be reduced the costs, which are required to clarify the quality of the customer will be smaller. This enables banks to extend their monitored loans to some of those firms, which have earlier been rationed out, because now their quality can be revealed with reasonable monitoring costs. However, as discussed earlier in the context of the monitoring technologies, routine-like information technology plays only a relatively minor role in the monitoring exercised by traditional banks, and consequently, this effect will not be very strong. Thus, as an *á priori* assumption the gain from the most opaque sector is smaller than the banks' loss to transaction loans. In addition, it is probable that in the most opaque sector, which consists to a great extent from new and small entrepreneurs, conventional banks face an additional competition from venture capitalists, which is excluded from our model. The figure 7 also indicates that the improving information technology expands the whole financial sector to Ω_R', and the most opaque sector will be now smaller. Total welfare is increased because now a smaller amount of profitable projects are rejected doing to insufficient information.

The above considerations can be interpreted to be the immediate effects or structural market pressures. Secondary effects take place when the different banks start to adapt to the new situation. As seen in chapter 3.2 the profits of the banks will be affected, and it can be expected that there will be a reaction to the changing profitabilities within the different forms of banking. However, the strategic responses of banks require a more rigorous study, which is not possible within this context.

5 SUMMARY AND DISCUSSION

The whole financial sector has been under a remarkable structural change, and one of the major contributing forces has been the rapid advance in information processing based on digital technology. The overall conclusion of the analysis above is that improving information technology increases the transparency of firms and liquidity of capital market instruments. This development favors market based finance at the cost of traditional financial intermediation. Also traditional bank lending will benefit, but this benefit is not sufficient to compensate its losses to market based finance. The above changes will induce (in practice, has already induced) secondary strategic responses within the whole financial sector. The welfare effects will be positive because now a smaller amount of profitable projects are rejected doing to insufficient information and market transparency.

Our model is limited in the sense that it does not capture all the dynamics that are reshaping the financial service industry. Financial innovations such as securization of corporate loans increases the liquidity of small borrowers. This affects the parameter *E* in our model and decreases the size of firms, which can have access to the capital market. Venture capitalists can improve the project choice of small and new firms by providing expertise and even managerial help. This challenges further the role of traditional bank monitoring. All these bring forth further threats to conventional deposit taking financial institutions. A question then arises, where is the ultimate limit of market based finance, and where could we find those natural functions of traditional banks where markets cannot penetrate. One potential approach could be to look for the answers on the basis of the different monitoring technologies discussed earlier. Bank monitoring can have – at least in principle - access to such private information and even business secrets that are not transparent to markets even in the presence of the most efficient information technology. Banks can exploit this information in pricing their loans, whereas it is conceivable that markets cannot price them always correctly.

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