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Sectorial and qualitative differentiation for heterogeneous financial intermediaries

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”Diferenciación sectorial y cualitativa para intermediarios financieros heterogéneos ”

Resumen

Se estudia una variante del modelo de ciudad circular, en la que se analiza la competencia en los sistemas bancarios. Para este modelo, los intermediarios pueden diferir de dos maneras, primero en la calidad del servicio financiero ofrecido, la cual podría mejorar los beneficios percibidos por los agentes, y segundo de manera sectorial que representaría el conocimiento que tienen en un sector específico. Aquí se analiza la interacción de intermediarios financieros en el sistema, una fintech que tiene la capacidad de prestar a cada sector frente a los bancos especializados sectorialmente. El análisis encuentra la posibilidad de múltiples conjuntos de equilibrio de mercado y óptimos sociales. Este análisis se restrinje al rango de valores que otorgan mayor variabilidad en el análisis de falla de mercados.

Palabras clave:

Salop, Competencia bancaria, Bancos heterogéneos, Especialización, Fintech.

”Sectorial and qualitative differentiation for heterogeneous financial intermediaries”

Abstract

I study a variant of a Salop Circle, in which I analyze competition in banking systems. For this model, banks can differ in two ways, first in the quality of the financial service offered that could enhance the perceived benefits by the borrowers, and sectorally which could represent the knowledge that the banks have in a specific sector. Here, I analyze the interaction of heterogeneous lenders in the system, one bank that has the capacity of lending to each sector against business's specialized banks. The analysis finds the possibility of multiple sets of market equilibrium and social optima. I restrict the analysis to the set that allows me to analyze the market failures when all possible combinations of banks are allowed.

Keywords

Salop, Banking Competition, Heterogeneous banks, Specialization, Fintech.

Códigos JEL: D43; D53; G21; G28; G51

1 Introduction

Direct marketing represents a way in which businesses offer their products. Its attractiveness relies on the reduced effort brought to agents. While in the past direct marketing was not a threat to the business model due to its small size, the last thirty years shifted this up. This threat comes from the increasing penetration of the internet, which brought along digital platforms like Amazon and eBay, where people can find almost any product without even moving. This altered every aspect of the market, from pricing, quality, transaction costs, and delivery times (Cavallo (2018)).

As this change turned visible, diverse scholars came up with different methods to model this economic interaction. For example, Balasubramanian (1998) finds that the interaction increases competition in systems, forcing out the monopolistic competition state found in Salop. Then Bouckaert (2000) expands and finds that coexistence of more than one direct marketer is not the optimum scenario as severe competition implies the lowest income for firms. A central topic of interest in this field is to compare the market failures between decentralized and centralized economy. Research on market failures was limited to analyze retailers (Corchón and Zudenkova (2010)); until Madden and Pezzino (2011) analyzed both retailers and direct marketers; they found that a social planner will prefer that only direct market or retailers serve the market. Both of them implied a loss in welfare. This divergence of perfect competition models is product of transaction costs.

This increase in digitalization not only created a threat for retail stores. It also helped them with tools, automation, and lower transaction costs (Brynjolfsson and Hitt (2000)). Also, this brought digital businesses that served as good partners in any industry (Gajewski and Tran Dieu (2021)). One of these industries significantly impacted by these businesses is financial; here, banks became very profitable with these new services and are now at risk as fintech companies begin to offer loans to the same clients (Ferreira *et al.* (2022), Jagtiani and Lemieux (2017), Liao (2018)).

It is essential to research this interaction because the financial industry is a complex field with implications for economic growth (Gai *et al.* (2011)). Several scholars have analyzed financial systems on crisis-oriented regulations, optimal taxation policies, sectoral specialization (Schargrodsky and Sturzenegger (2000), Blickle *et al.* (2021)), screening (Marquez (2002)), Gehrig (1998)), impact on business development (Bonaccorsi di Patti and Dell'Ariccia (2004)), capital level (Almazan

(2002), VanHoose (2007)), collateral (Hainz *et al.* (2013), Andrés *et al.* (2013)), Monetary policy impact (Toolsema (2004)), and opacity (Ahnert and Martinez-Miera (2021)).

This paper aims to model the interaction between banks and fintech while contributing to the ongoing literature on the financial industry and technological innovations. The model is related to Madden and Pezzino (2011) and has the same setup. However, it differs by adding the specialization concept (Schargrodsky and Sturzenegger (2000)). In the model, the circle represents a set of different industries, where each point in the perimeter represents a specific sector. A mass of agents in the perimeter have a project with assured returns. The first banks are traditional banks specializing in a specific sector, while the other type is a digital firm (fintech) that does not specialize in any sector. Due to its channel, it can compete against all the traditional banks simultaneously.

This model consists of 2 subgames, the first is a competition just between banks, and the second includes the entry of a fintech. The structure of systems constrains competition between both. The specialization cost, Fixed Cost, and disutility of the alternative channel δ, mold the constraints .

The specialization cost refers to the unitary cost of specialization of each lender. Following Schargrodsky and Sturzenegger (2000), specialization implies the additional expertise of the bank in some industries, so their financial services provided will be helpful for the agents with projects developed there. In addition to that model, specialization now has a unitary cost related to the difficulty of adapting, developing, and employing new trends, tools, products, or technologies. It is supposed that this cost reflects the quality of the employed personnel in the firm. If they are qualified and have enough abilities, the cost will be low; otherwise, it will be high. For the case of Fintech is expected that BigTech has their specialization cost low as they have a rigorous selection process. In the case of local and small Fintech, this cost can take any value as its selection process can not confidently assess the existing skills of the personnel.

The fixed cost relates to the cost of operation of each lender. In big tech, fixed costs are high because they have to accomplish additional regulations to run business in other countries. Also, its entry supposes that the fintech directly engages in stricter competition because pilot programs or slow development in the market could expose the fintech to the copy of the strategies and products. The disutility δ complements the system and relies heavily on the agents' beliefs and preferences over this digital alternative. Although lenders can comprehend how δ affects customers, the parameter is invariant to a fintech's entry as this model focuses only on the short-run aspects.

The results follow a framework similar to the one found by Madden and Pezzino (2011). For the social optima, the planner discards the scenario in which both types of lenders provide loans as this implies a loss in welfare. Concerning specialization, it rises with lower costs. These costs affect the planner's choice; when perimeters cost is lower than fintech, the planner prefers provision by perimeters firm. The opposing argument follows for the election of the fintech as the provider. In decntralized economy, provision by both types of lenders occurs..

In the decentralized economy, the entry of the fintech diminishes rates of banks as it shifts competition from monopolistic to Bertrand. However, in the social optima, coexistence is not an optimal state, mainly for two reasons. First that in a range of values, welfare diminishes as banks increases. Second, when banks bring additional welfare, the planner assigns all the demand to the banks. Unluckily this level of welfare at the optimum of coexistence is lower than welfare with the same number of banks but without the interaction of the fintech. Further research could find the scenario in which provision by both lenders represents a social optimum.

The parameters of the model lead to multiple solutions for the analysis of Market-failures.When centralized and decentralized economies have provision only by banks, the specialization is the same. However, decentralized economy features twice the of banks. When fintech is the sole provider, the market and the planner reach the same specialization degree. An interesting find is that by reducing the level of δ to a minimum, fintech will not take all of the demand because banks can still compete by offering higher specialization in their products. This scenario could occur if the banks unitary specialization cost is lower than the fintech one.

The paper is organized as follows; Section 2 describes the circular city model and lender's structure, Section 3 develops the centralized economy, Section 4 develops the decentralized economy, Section 5 analyzes market failures, and Section 6 concludes.

2 Model

This model consists of a Salop circle with a perimeter equal to one, where each section in the perimeter represents particular activities that vary smoothly. Around this perimeter lies a unitary density of entrepreneurs who has an idea for an investment project. In autarky, these projects have a return of A; however, the entrepreneurs lack the funds to develop these projects, so they need to borrow from financial intermediaries, bank or fintech, characterized for being risk-averse.

The banks, homogeneous in nature, are traditional institutions located around the circle; their locations mean that their financial services are conveniently adapted to the activities in that sector. In the other hand the fintech is a non-traditional institution that uses alternative communication channels, and have different scorecards, departments, and costs. As new in the market, it does not have to comply with regulations pertinent to banks.Also it's versatility and it's lending channel allow it to treat any entrepreneur equally.

The decentralized economy feature free entry for banks; In the fintech case, only one is allowed, as the entry of another leads them without income (Bouckaert (2000)). The lenders have different fixed costs, these represents the cost incurred by lenders to operate, and can vary depending on the objective to characterize. For example, in a developed economy with appropriate conditions for financial institutions like an institutional framework, skilled personnel, and appropriate connectivity, the bank fixed costs F could be lower; on the other hand, in an underdeveloped economy with harsh conditions, fixed costs increase considerably. For the fintech, this cost G could be high in the case of a Big Tech, as it needs to comply with regulations to enter the economy and also has more staff; in a startup, the fixed cost could be assumed to be low as they have few employees, and lesser restrictions to enter the market. So whenever the agents decide for taking a loan he faces the following returns:

$$H_i = A\,(1 + \sqrt{\theta_i}) - r_i - \theta_i\, d_i \tag{1}$$

Where H_i is his net return of investment when he gets a loan from the lender i, being d_i its distance to the respective lender. As the entrepreneur being utility maximizing he will choose lender i, if

$S_i > S_{-i}$. For the lender, its income y follows the next structure:

$$y_i = (r_i - \tau_c\,\theta_c - \rho)\,D_i \tag{2}$$

Being D_i, the fraction of total demand achieved by the lender. For the banks, this demand will be noted as x, while for the fintech, it'll be $1 - 2\,N\,x$, being this the complementary of the circle. The distribution of the lenders in this circle constitutes an example of spatial product differentiation. The gap between an entrepreneur and a lender is understood as transaction costs; they can mean the asymmetry of information between the agents, and the entrepreneurs must incur a series of additional charges to diminish this asymmetry to be better assessed by the lenders.

The degree of specialization θ could be understood as a series of additional services brought by the bank to the entrepreneurs that can enhance the project's return. This specialization occurs under the main activities that the lender finances, from Eq. 1, the entrepreneurs will be benefitted by specialization if their activities are related to the lender. A higher specialization degree narrows the demand as borrowers' returns decrease linearly. Also, from Eq. 2, operating at a certain θ generates additional cost, determined by the type of lender. For banks, this marginal cost is τ_p, and for fintech is τ_c; this cost relates to the quality of the employed personnel in the firm. In the case of companies with a good selection process and training processes, the adaptation and development of new products will be easier than in places with low-quality personnel.[1]

The objective is to compare the model in a centralized economy against a decentralized one and describe the market failures. For the centralized, a social planner has complete control over the allocations in the economy and maximizes the economic welfare. For the decentralized case, the lenders enter whenever their profits are non-negative. Here the solution is found by simulating two games resembling a specific situation. In the first game, the banks compete by setting a degree of specialization and then offering a rate to the borrowers. The second game considers that a fintech suddenly enters at the end of the first game, thus reducing the number of banks in equilibrium and changing their specialization and rates.

[1]Further research on the specialization mechanism and utility brought to the entrepreneurs can be found in Schargrodsky and Sturzenegger (2000)

3 Centralized Economy

Theorem : The analysis of centralized economy results in 2 feasible equilibria based on the level of F and G, and under the condition $\tau_c + \delta \geq \tau_p$, In the first equilibrium S_1^P, the banks are the only ones in the economy, while in the second S_2^P, only the fintech is present
The resultant set of equilibria occur under these conditions:

$$S_1^P := \left[c^P = 0, N^P = \left(\frac{A - \sqrt{F}}{4\,\tau_p\,\sqrt{F}}\right)\right] \quad \text{if} \quad F \leq F_b \quad \text{or} \quad F \geq F_b \quad \text{and} \quad G \geq \Omega$$
$$S_2^P := \left[c^P = 1, N^P = 0\right], \quad \text{if} \quad F \geq F_b \quad \text{and} \quad G \leq \Omega$$

With $F_b = A^2 \left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c + \delta}}\right)^2$
Proof:
The social planner is an entity who has complete control over the production and allocation of the products in the economy. It has the objective to maximize the Economic Welfare which is the surplus of both demand (Consumer's surplus) and supply (Producer's surplus). Here sub-index C and P, represents fintech and perimeter respectively.
As this model features heterogeneous lenders, this section analyzes all the interactions between them, when only the banks provide, coexistence between lenders and the last the fintech as the only lender in the circle (This being an extreme case of coexistence).

3.1 Interaction of only banks

In the case where the fintech is not present in the economy, consumer and producer surplus are the same for all the borrowers and the banks, this is because the banks are homogeneous in nature, having the same profit structure.

Consumer surplus

$$CS_p = 2\,N\left(\int_0^{\frac{1}{2\,N}} A\,(1 + \sqrt{\theta_p}) - r_p - \theta\,x\,dx\right) \tag{3}$$

Producer surplus

$$PS_p = 2\,N\,(r_p - \tau_p\,\theta_p - \rho)\,\left(\frac{1}{2\,N}\right) - N\,F \tag{4}$$

Adding Eq. 3 with Eq. 4 brings the welfare of the economy.

$$W = A(1+\sqrt{\theta_p}) - \theta_p\,\left(\frac{1}{4\,N} + \tau_p\right) - N\,F - \rho \tag{5}$$

Planner observes that it can maximize its welfare by allocating the optimal degree bank's specialization θ_p and the number of banks N.

θ_p results:

$$\theta_p = \frac{A^2}{4\,(\frac{1}{4\,N^*} + \tau_p)^2} \tag{6}$$

Replacing Eq. 6 in Eq. 5 gives:

$$W = A + \frac{A^2}{4\,(\frac{1}{4\,N} + \tau_p)} - N\,F - \rho \tag{7}$$

With this planner can find the optimal number of banks:

$$N_P^* = \frac{A - \sqrt{F}}{4\,\tau_p\,\sqrt{F}} \tag{8}$$

3.2 Interaction between banks and fintech

In contrast with the previous interaction, now producer and consumer surplus changes as the fintech provides a different loan type than the banks; this results in a different set of surpluses. (*Superindex C means coexistence version for the surplus related to the bank*)

The consumer surplus when agents get a loan from banks is:

$$CS_p^C = 2\,N\,\left(\int_0^{\hat{x}} A\,(1+\sqrt{\theta_p}) - r_p - \theta\,x\,dx\right) \tag{9}$$

Where x, is the distance from the agent to the bank and $\hat{x}$ the optimal allocation for the bank

The banks surplus goes by:

$$PS_p^C = 2\,N\,(r_p - \tau_p\,\theta_p - \rho)\,(x) - N\,F \tag{10}$$

The consumer surplus when agents get a loan from the fintech is

$$CS_c = 2\,N \left(\int_{\hat{x}}^{\frac{1}{2\,N}} A\,(1+\sqrt{\theta_c}) - r_c - \theta_c\,\delta\,dx \right) \tag{11}$$

Fintech surplus is:

$$PS_c = 2\,N\,(r_c - \tau_c\,\theta_c - \rho)\left(\frac{1}{2\,N} - \hat{x}\right) - G \tag{12}$$

Adding Eqs. 12, 10, 11,9 together results in the welfare equation:

$$W = A(1+\sqrt{\theta_c}) - \theta_c\,(\tau_c+\delta) + 2\,N((A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) - \tau_p\,\theta_p + \tau_c\,\theta_c + \theta_c\,\delta)\,\hat{x} - \theta_p\,\frac{\hat{x}^2}{2}) - N\,F - G - \rho \tag{13}$$

Welfare depends on the optimal allocation of specialization degrees θ_p, θ_c, bank demand's allocation $\hat{x}$, and the number of banks. First maximizing with respect to $(\hat{x})$ results in:

$$\hat{x} = \frac{A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) - \tau_p\,\theta_p + \tau_c\,\theta_c + \theta_c\,\delta}{\theta_p} \tag{14}$$

Replacing Eq. 14 in Eq. 13, agent can optimize over both specialization degrees, θ_p and θ_c

$$\theta_c = \frac{A^2}{4\,(\tau_c+\delta)^2} \qquad \theta_p = \frac{A^2}{4\,\tau_p\,(\tau_c+\delta)} \tag{15}$$

With this value Welfare results:

$$W_C = A + \frac{A^2}{4\,(\tau_c+\delta)} + N\left(A^2\left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c+\delta}}\right)^2 - F\right) - G - \rho \tag{16}$$

In 16 . When $F \geq A^2\left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c+\delta}}\right)^2$, any level of N results in a welfare loss. So for this case, welfare is maximized at $N = 0$. In the system, this represents that fintech provides all the loans.

3.2.1 Welfare Analysis between coexistence and only banks

On the other hand, when the coefficient sign is positive, $F \leq A^2 \left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c+\delta}}\right)^2$, welfare increases as N rises. In this case, the planner set up the maximum number of banks allowed by the system demand. As the demand is unitary and each bank is assigned a constant portion of demand $2\,\hat{x}$, the total number of banks will be $N_C^* = \frac{1}{2\,\hat{x}}$.

$$N_C^* = \frac{1}{4\sqrt{\tau_p}\,(\sqrt{\tau_c+\delta} - \sqrt{\tau_p})} \tag{17}$$

The resultant number of banks for coexistence implies that banks are the sole providers of loans; however, welfare is affected by the presence of fintech. This condition leads the planner to decide if keeping a fintech that does not provide loans but affects its strategy is better than not having a fintech. For this, it compares the welfare of both states.

Welfare of coexistence W_C

$$W_C^* = A + \frac{A^2}{4\,(\tau_c+\delta)} + \frac{1}{4\sqrt{\tau_p}\,(\sqrt{\tau_c+\delta} - \sqrt{\tau_p})}\left(A^2\left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c+\delta}}\right)^2 - F\right) - G - \rho \tag{18}$$

Welfare of only banks W_P

$$W_P = A + \frac{(A-\sqrt{F})^2}{4\,\tau_p} - \rho \tag{19}$$

For the state of coexistence to be preferred over the one which only has banks, the welfare brought by the former must be greater than the brought by the latter..

Comparing both and reordering terms gives a rule of decision Υ over the level of G. If the fixed cost of the fintech is lower than the value of the rule, the planner will choose the coexistence.

Rule of decision Υ

$$G \leq \frac{A^2}{4\sqrt{\tau_p}\sqrt{\tau_c+\delta}} - \frac{F}{4\sqrt{\tau_p}\,\left(\sqrt{\tau_c+\delta} - \sqrt{\tau_p}\right)} - \frac{(A-\sqrt{F})^2}{4\,\tau_p} = \Upsilon_{(F,\tau_p,\tau_c,A,\delta)} \tag{20}$$

Then getting the first derivative Υ:

$$\frac{\partial \Upsilon}{\partial F} = \frac{-1}{4\sqrt{\tau_p}\,(\sqrt{\tau_c+\delta} - \sqrt{\tau_p})} - \frac{1}{4\,\tau_p} + \frac{A}{4\,\tau_p\sqrt{F}} \tag{21}$$

Then the second derivative[2]

$$\frac{\partial^2 \Upsilon}{\partial F^2} = -\frac{A}{8\,\tau_p\,(\pm\sqrt{F^3})} \tag{22}$$

Equating 21 to zero, brings the critical point of Υ.

$$F^* = A^2\left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c + \delta}}\right)^2 \tag{23}$$

At the same time, this critical point is also the end of coexistence, as from Eq. 18 a higher level of F means that the addition of banks reduces welfare.

Replacing F^* in Eq. 20 results:

$$\Upsilon(F^*) = 0 \tag{24}$$

And in Eq. 22:

$$\Upsilon''(F^*) = \frac{-\left(\sqrt{\tau_c + \delta}\right)^3}{8\,\tau_p\,A^2\,(\sqrt{\tau_c + \delta} - \sqrt{\tau_p})^3} \tag{25}$$

If Eq. 25 is negative, G = 0 represents the local máxima of Υ; otherwise, when positive is the local mínima. When the critical point is a local maximum, the planner will never choose the coexistence because the fintech fixed cost is always positive, so the cost will never be below Υ. With this, the entry of the fintech is restricted to the critical point being a local minimum.

Also, for being a feasible system, the optimum choice of planner must be consistent with the range of each variable, so for the case of the number of banks in coexistence, this number must be positive. Analyzing Eq. 17 results that parameters should meet the following condition in order to have positive banks :

$$\tau_c + \delta > \tau_p \tag{26}$$

With this, the sign of Eq. 25 can be found:

$$\Upsilon''(F^*) = \frac{-\left(\sqrt{+}\right)^3}{+\,.\,+\,.\,+\,.\,(+)^3} = - \tag{27}$$

[2]Note that square root of a value can be also negative, and with this, it can convert the critical from a maximum to a minimum

As the sign of Eq. 27 is negative, results impossible for the planner to choose coexistence because the critical point is a maximum, and all the feasible fixed cost G are above 0.[3].
Figure 1 illustrates.

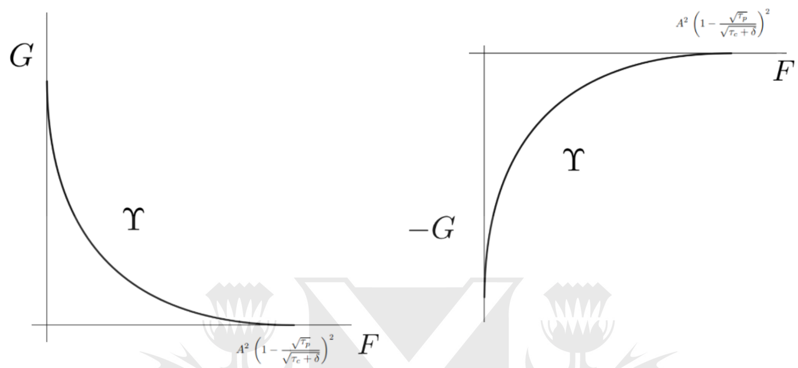

Figure 1: Function of decision Υ when $\tau_c + \delta \leq \tau_p$ and $\tau_c + \delta \geq \tau_p$

When the fintech's specialization cost τ_c added with the standard dis-utility of loaning from the internet δ is lower than the specialization cost of banks τ_p, the rule of decision allows positive values of G. However, the number of banks here would be negative breaking the restriction. Conversely, when $\tau_c + \delta > \tau_p$, Optimal banks will be positive, thus complying with the restriction, but the decision rule will not allow any fintech as its range is below zero.

3.2.2 Welfare Analysis between only banks state and only fintech state

This section analyzes the dynamic in the case of $F \geq A^2\left(1-\frac{\sqrt{\tau_p}}{\sqrt{\tau_c+\delta}}\right)$. For this, the planner analyzes Welfare brought by the system with only the fintech against the one with only banks.

Welfare of only Fintech (Extreme case of Eq. 18 with N = 0)

$$W_f = A + \frac{A^2}{4\left(\tau_c+\delta\right)} - G - \rho \tag{28}$$

Following the same reasoning, the planner must find higher welfare in fintech than only banks. Comparing Eq. 28 against Eq. 19, brings a rule of decision Ω over the level of G.

[3]This local maximum is at the same time the end of the rule

$$G \leq \frac{A^2}{4\,(\tau_c + \delta)} - \frac{(A - \sqrt{F})^2}{4\,\tau_p} = \Omega \tag{29}$$

With this, all the interactions of decisions rules with the levels of G and F could be calculated. Note that the equilibria that features only banks must comply with having at least one bank in the perimeter, as a fraction of bank in equilibria does not have any interpretability. Due to this, the equilibria is bounded at $F^C_{lim} = \frac{A^2}{(1+8\,\tau_p)^2}$, this number represents having one bank in the system. The resultant equilibrium states in the centralized economy are:

$$S_1^P := \left[c^P = 0, N^P = \left(\frac{A - \sqrt{F}}{4\,\tau_p \sqrt{F}}\right)\right] \quad \text{if} \quad F \leq F_b \quad \text{or} \quad F \geq F_b \quad \text{and} \quad G \geq \Omega$$

$$S_2^P := \left[c^P = 1, N^P = 0\right], \quad \text{if} \quad F \geq F_b \quad \text{and} \quad G \leq \Omega$$

Where $F_b = A^2 \left(1 - \frac{\sqrt{\tau_p}}{\sqrt{\tau_c + \delta}}\right)^2$

And are represented in the following graph.

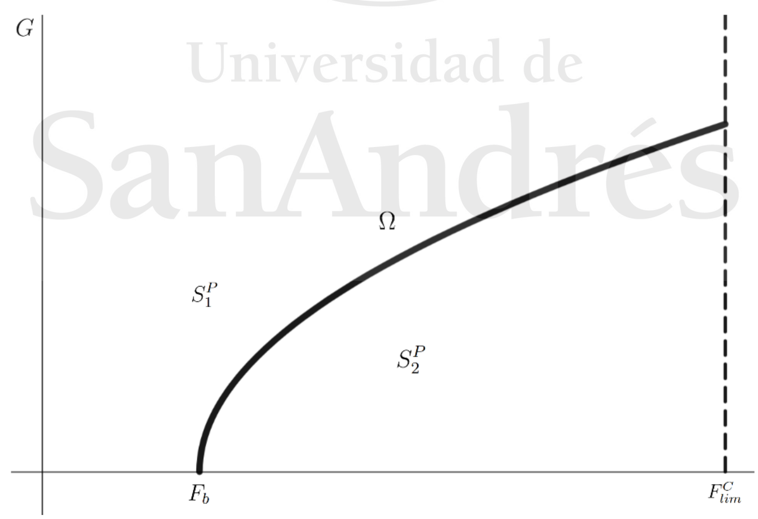

Figure 2: Centralized Economy

4 Decentralized Economy

Theorem : The analysis of decentralized economy results in three feasible equilibria based on the level of F and G. In the first equilibrium S_1^M, the banks offer all the loans, In the second S_2^M, only the fintech offer loans and in the third one S_3^M both lenders offer loans.
The resultant set of equilibria occur under these conditions

$$S_1^M := \left[c^M = 0, N^M = \frac{A - \sqrt{F}}{2\,\tau_p\,\sqrt{F}}\right] \quad \text{if} \quad G \geq \Psi \quad y \quad F \leq \bar{F} \quad \text{ó} \quad G \geq \lambda \quad y \quad F \geq \bar{F} \quad \text{ó} \quad F \leq \underline{F}$$

$$S_2^M := \left[c^M = 1, N^M = 0\right] \quad \text{if} \quad G \leq \lambda \quad \text{y} \quad F \geq \bar{F}$$

$$S_3^M := \left[c^M = 1, N^M = \frac{A^2}{2\left(A^2\,t_p - \left(A - \sqrt{\frac{9F}{2}}\right)^2 (\tau_c + \delta)\right)}\right] \quad \text{if} \quad G \leq \Psi \quad \text{y} \quad \underline{F} \leq F \leq \bar{F}$$

With $\bar{F} = \frac{2\,A^2}{9}\,\frac{\left(\sqrt{\tau_c+\delta} - \sqrt{\tau_p - \frac{1}{2}}\right)^2}{\tau_c+\delta}$ y $\underline{F} = \frac{2\,A^2}{9}\left(1 - \frac{3\,\tau_p}{4\,(\tau_c+\delta)}\right)^2$

Proof:

In the decentralized economy, the firms act in their own, here the number of lenders in the system is based on the assumptions of the model, in this case the model has two assumptions, the first one is the free entry conditions for banks, so they enter whenever their profits are non negative, and the second condition is that only fintech is allowed.
To find the set of equilibrium described in the theorem, each phase is solved by backward induction, following the steps describe in the model section.

4.1 Phase I

The first phase simulates a traditional banking system where the concept of fintech is unknown, in this phase bank i compete against adjacents banks by offering specialized loans with a rate r_i and a degree θ_i.
As the decentralized economy has free entry condition, and all the lenders being homogeneous, the

solution of the model in this phase results in a symmetric equilibrium in which all the banks set the same interest rate and specialization degree.

In this model, as agents face linear transport costs, the analysis is restricted to the case where banks locate symmetrically. [4].

Comparable to the logic developed in Hotelling (1929) there is an agent between banks i and j who is indifferent between them as their net benefit is the same for both. This agent is located at a distance $\hat{x}$ from bank i.

$$\hat{x} = \frac{A\,(\sqrt{\theta_i} - \sqrt{\theta_{i+1}}) - r_i + r_{i+1} + \theta_{i+1}\,\frac{1}{N}}{\theta_i + \theta_{i+1}} \tag{30}$$

This position $\hat{x}$, represents the maximum extend at one side of the demand of bank i, beyond this point the agents will prefer bank j

The banks being homogeneous, have the same strategy so then they finish with the same profit structure.

$$\pi_p = (r_i - \tau_p\,\theta_i - \rho)\,(2\,\hat{x}) - F \tag{31}$$

With these profits, lenders compete in their degree of differentiation and rates reaching the equilibrium determined by:[5]

$$\theta_p^* = \frac{A^2}{(\frac{1}{N^*} + 2\,\tau_p)^2} \tag{32}$$

$$r_p = \theta_p\left(\tau_p + \frac{1}{N^*}\right) + \rho = \frac{A^2\,N^*\,(\tau_p\,N^* + 1)}{(1 + 2\,\tau_p\,N^*)^2} + \rho \tag{33}$$

$$N_1^M = \sqrt{\frac{\theta_p^*}{F}} = \frac{A - \sqrt{F}}{2\,\tau_p\,\sqrt{F}} \tag{34}$$

Proof *See appendix A-I.*

[4] Linear transport costs imply that any position is profit-maximizing, instead of quadratic cost where symmetry results to be the best strategy. Economides (1993)

[5] This number of banks is twice that planner prefers, so this is excess in differentiation.

4.2 Phase II

The second phase attempts to characterize the entry of a fintech into an established economy. Here the banks cannot anticipate the entrance of this lender, so if the fintech enters, it alters the degrees and the rate of competition. In this dynamic, fintech offers the entrepreneurs a different source of financing; if this loan gives higher utility than the banks' one, the indifferent agent position will shift towards the bank position. This shift will alter banks' income, generating the exit of some banks and, in the extreme case, the exit of all of them, leaving the fintech as the only lender in the market.

When the fintech enters the indifferent agent choices will probably change from being between it's two adjacent banks to between the fintech and his closest bank. The new position of the indifferent agent will be at:

$$\hat{x} = \frac{A\left(\sqrt{\theta_p^*} - \sqrt{\theta_c^*}\right) - r_p^* + r_c^* + \theta_c^*\,\delta}{\theta_p^*} \tag{35}$$

Here both type of lender have income when $0 < \hat{x} < \frac{1}{2\,N^*}$.[6]

The location of the indifferent agent brings different outcomes of the dynamic that will be called Regimes. In the first regime, both types of lenders have income while in the second and the third, fintech has no income. The difference between these is that in the Second the presence of the fintech influence the strategy of the banks, not allowing them to set a monopolistic competition rate while in the Third, fintech presence does not alters banks behavior.

The characteristics and outcomes of the Regimes are:

Regime I[7], *Co-existence*

Regime one happens under the following condition, this condition could represent few banks in the

[6]If numerically $\hat{x} \leq 0$ this means that banks have no strategy in which they have demand, so even the agent at the same bank sector prefers a loan from the fintech. On the other hand, $\hat{x} \geq \frac{1}{2\,N}$ means a fintech with no possibility of lending, as all agents prefer banks. For both scenarios indifferent agent will be in $\hat{x} = 0$ and $\hat{x} = \frac{1}{2\,N}$, respectively

[7]These regimes imply that $0 \leq \hat{x} < \frac{1}{2\,N}$, as is the only set of parameters in which fintech has demand, Further explanation could be found in Appendix

system.

$$N^{*} \leq \frac{\theta_p^{*}}{A\,(\sqrt{\theta_p^{*}} - \sqrt{\theta_c^{*}}) + \theta_c^{*}\,(\delta + \tau_c) - \tau_p\,\theta_p^{*}} \tag{36}$$

The optimal degrees are:

$$\theta_p = \frac{A^2}{4\,(\tau_c + \delta)\,(\tau_p - \frac{1}{2\,N^{*}})} \quad \theta_c = \frac{A^2}{4\,(\tau_c + \delta)^2} \tag{37}$$

The rates of the bank and the fintech are:

$$r_p^{*} = \frac{A^2}{2(\tau_c + \delta)\,\sqrt{\tau_p - \frac{1}{2\,N}}} \left(\frac{\sqrt{\tau_c + \delta} - \sqrt{\tau_p - \frac{1}{2\,N^{*}}}}{3} + \frac{\tau_p}{2\,\sqrt{\tau_p - \frac{1}{2\,N^{*}}}} \right) + \rho \tag{38}$$

$$r_c^{*} = \frac{A^2}{2(\tau_c + \delta)\,\sqrt{\tau_p - \frac{1}{2\,N^{*}}}} \left(\frac{1}{4\,N^{*}\sqrt{\tau_p - \frac{1}{2\,N^{*}}}} - \frac{\sqrt{\tau_c + \delta} - \sqrt{\tau_p - \frac{1}{2\,N^{*}}}}{3} + \frac{\tau_c\sqrt{\tau_p - \frac{1}{2\,N^{*}}}}{2(\tau_c + \delta)} \right) + \rho \tag{39}$$

And by the free entry condition, firm profits are zero, so the number of resultant banks in this phase I is equal to:

$$N^{*} = \frac{A^2}{2\left(A^2\,t_p - \left(A - \sqrt{\frac{9F}{2}}\right)^2 (\tau_c + \delta)\right)} \tag{40}$$

Regime II *Entry's Barrier*

In this Regime fintech posses no demand as it marginal cost is relatively high w.r.t banks ones, that it cannot offer an attractive loan to the agents. Although in this Regime, banks share all demand, they cannot shift from this competition rate to a monopolist rate, because as soon they deviate to $r_p + \epsilon$ to achieve higher benefits, this deviation leaves a narrow margin in which fintech gains demand.

This regime occurs when the number of banks rise to an intermediate level:

$$\frac{\theta_p}{A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c(\delta + \tau_c) - \tau_p\,\theta_p} \leq N \leq \frac{3\,\theta_p}{2(A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c(\delta + \tau_c) - \tau_p\,\theta_p)} \tag{41}$$

The specialization degrees, rates[8] and profits are:

$$\theta_p = \frac{A^2}{4\,(\tau_p + \frac{1}{2\,N})^2} \quad \theta_c = \frac{A^2}{4\,(\tau_c + \delta)^2} \tag{42}$$

[8] Note how a high number of banks forced down the rates in the market, leaving fintech offering a marginal rate.

$$r_p = \frac{A^2\,(\frac{1}{2\,N} + 2\,\tau_p)}{4\,(\frac{1}{2\,N} + \tau_p)^2} + \theta_c\,(\tau_c + \delta) - A\,\sqrt{\theta_c} + \rho \tag{43}$$

$$r_c = \tau_c\,\theta_c + \rho \tag{44}$$

$$\Pi_p = \left(\frac{A^2}{4\,(\frac{1}{2\,N} + \tau_p)} + \theta_c\,(\tau_c + \delta) - A\,\sqrt{\theta_c}\right)\left(\frac{1}{N}\right) - F \quad \Pi_c = -G \tag{45}$$

Regime III *No menace*

In this Regime the marginal cost of the fintech are so big with respect to banks one, that the fintech is no longer perceived as a threat by the banks so they return to monopolistic competition. Also the number of banks in the system is big enough that even the farthest agent does not find benefit from choosing fintech.

This regime occurs when banks surpass the limit of regime II.

$$N \geq \frac{3\,\theta_p}{2(A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c(\delta + \tau_c) - \tau_p\,\theta_p)} \tag{46}$$

Specialization degrees, rates and profits are:

$$\theta_p^* = \frac{A^2}{(\frac{1}{N^*} + 2\,\tau_p)^2} \quad \theta_c^* = \frac{A^2}{4\,(\tau_c + \delta)^2} \tag{47}$$

$$r_p^* = \theta_p^*\,(\tau_p + \frac{1}{N^*}) + \rho = \frac{A^2\,N^{*2}}{(1 + 2\,\tau_p\,N)^2} + \rho \quad r_c^* = [\tau_c\,\theta_c^* + \rho, \infty > \tag{48}$$

$$\Pi_p = \frac{A^2}{(1 + 2\,\tau_p\,N)^2} - F \quad \Pi_c = -G \tag{49}$$

Proof *See appendix A-II.*

This regimes would be determinant in the entry of the fintech.

4.3 Bank' entry

First phase of the game results $N = \frac{A - \sqrt{F}}{2\,\tau\,\sqrt{F}}$, with their respective rate and specialization degree. Then fintech decides to enter the market based on two conditions. First when entering it must fall in Regime I, as this is the only one in which the firm as income [9]. Bank fixed cost should be at least $\underline{F}$ to enter the market:[10]

$$\underline{F} = \frac{2}{9} A^2 \left(1 - \frac{3\,\tau_p}{4\,(\tau_c + \delta)}\right)^2 \tag{50}$$

The second condition is that the fintech's profit must be positive; this is that its income must surpass the fixed cost G. For this, the fintech follows a rule of decision Ψ:[11]

$$\Psi = \frac{A^4}{9\,\left(A^2\,\tau_p - \left(A - \sqrt{\frac{9F}{2}}\right)^2\,(\tau_c + \delta)\right)} \left(\frac{3\,A\,\tau_p}{2\,\left(A - \sqrt{\frac{9F}{2}}\right)\sqrt{\tau_c + \delta}} - \sqrt{\tau_c + \delta}\left(\frac{\left(A - \sqrt{\frac{9F}{2}}\right)}{2} + 1\right)\right)^2 \tag{51}$$

From Eqs 34 and 40, higher levels of F result in a lower number of banks. Here coexistence happens until F is high enough that only one bank competes against the fintech, this occurs at:

$$\bar{F} \leq \frac{\left(A\,\left(\sqrt{\tau_c + \delta} - \sqrt{\tau_p - \frac{1}{2}}\right)\right)^2}{\tau_c + \delta}\,\frac{2}{9} \tag{52}$$

Going up from this level results in fintech having all the market. However, it will not set a monopolist rate as it has to avoid any possible entry of banks. If fintech is not in the system, the competition prevails up until fixed cost F allows two banks. This upper bound is :[12]

$$F^D_{lim} = \frac{A^2}{(1 + 4\,\tau_p)^2} \tag{53}$$

When the fintech is the only supplier of the loans, Its decision rule changes to λ as it has higher profit due to having all the market. Also, its strategy would remain the same as deviating to monopolist

[9] The fintech makes its income projection with the banks that will remain in the system.

[10] Below this bound, the number of banks in equilibria will be so numerous that even with fintech displacing with its entry some banks, no agent will find a relative benefit from borrowing from the fintech.

[11] Like the social optima, however, the decision of entry relies on the firm instead of the planner.

[12] For keeping variability of outcome, this limit will met certain criteria to be above of any other F.

rate could allow the entry of a bank.

$$\lambda = \frac{A^2\,\tau_p - \left(A-\sqrt{\frac{9\,F}{2}}\right)^2(\tau_c+\delta)}{4\,(\tau_c+\delta)^2\,\left(A-\frac{9\,F}{2}\right)^2} - \frac{A^2\sqrt{\frac{9\,F}{2}}}{6\,\left(A-\sqrt{\frac{9\,F}{2}}\right)(\tau_c+\delta)} \tag{54}$$

Proof: *See appendix A-III*

The resultant states of the decentralized economy are:

$$S_1^M := \left[c^M = 0, N^M = \frac{A-\sqrt{F}}{2\,\tau_p\,\sqrt{F}}\right] \quad \text{if} \quad G \geq \Psi \quad y \quad F \leq \bar{F} \quad \text{ó} \quad G \geq \lambda \quad y \quad F \geq \bar{F} \quad \text{ó} \quad F \leq \underline{F}$$

$$S_2^M := \left[c^M = 1, N^M = 0\right] \quad \text{if} \quad G \leq \lambda \quad \text{y} \quad F \geq \bar{F}$$

$$S_3^M := \left[c^M = 1, N^M = \frac{A^2}{2\left(A^2\,t_p - \left(A-\sqrt{\frac{9F}{2}}\right)^2(\tau_c+\delta)\right)}\right] \quad \text{if} \quad G \leq \Psi \quad \text{y} \quad \underline{F} \leq F \leq \bar{F}$$

With $\bar{F} = \frac{2\,A^2}{9}\,\frac{\left(\sqrt{\tau_c+\delta}-\sqrt{\tau_p-\frac{1}{2}}\right)^2}{\tau_c+\delta}$ y $\underline{F} = \frac{2\,A^2}{9}\left(1-\frac{3\,\tau_p}{4\,(\tau_c+\delta)}\right)^2$

The states are represented in the following graph:

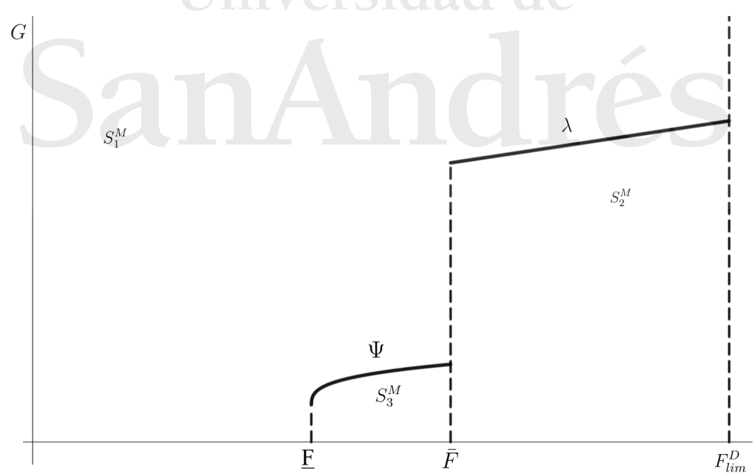

Figure 3: Decentralized Economy

5 Analysis of the market failures

Each equilibrium features a state where only the banks supply the loans. They differ in the number of banks, with decentralized having twice as centralized. This divergence is because banks decide their entry instead of the planner deciding. In free-market conditions, banks enter the system whenever they see an opportunity. However, the social planner finds a higher surplus with fewer banks, as its welfare function also considers fixed costs F.

Both economies find the equilibrium where only fintech is the sole provider. Here both have the same specialization degree. Above a level of bank fixed cost, the fintech's loan is qualitatively superior. It displaces all the banks in the decentralized economy, while in the centralized one, it brings alone the highest welfare.

Under a range of parameters, the decentralized economy brings the coexistence of lenders as a possible state. In this state, the competition shifts from monopolistic competition to aggressive competition. This state does not exist in the centralized because it does not represent a maximizing welfare option under feasible parameters. A possible mechanism to explain this is that the banks no longer compete against each other, so the planner can set up the degrees and number of banks that maximize its welfare. As this happens, the coexistence implies and sub-optimal state, as the planner had already found an optimized solution. For this is that the only scenario in which the coexistence exists implies having a negative level of G, which by definition will not be possible. For the social optima, the planner discards coexistence as a sub-optimal because having a fintech implies lesser welfare than not having it.

In the previous section, I bounded the analysis of both economies to compare both equilibriums simultaneously.

However, the research cannot find a single solution to market failure analysis. In this model, unlike Madden and Pezzino (2011), firms can specialize their products, but this comes to a variable cost defined by τ_c, τ_p. These parameters add more dimensions to the analysis, so the rules of decision $\Omega, \Upsilon, \lambda$ can have limitless analysis cases. For this reason, it seems reasonable to analyze only a subset of cases that could be deemed representative of the problem. The first selected is the one with the most variability. Then I adjusted the values of parameters to explain the other 3 cases.

5.1 Cases

First Case This case happens under the following assumptions:

1. $\Omega(\frac{A^2}{(1+8\,\tau_p)^2}) \geq \lambda(\frac{A^2}{(1+8\,\tau_p)^2})$
2. $\Omega(\bar{F}) \leq \lambda(\bar{F})$
3. $\Omega(\bar{F}) \geq \Psi(\bar{F})$.

This model features seven zones of analysis. First, for an intermediate level of G and high F ($S_1^M\ S_P^2$), the fintech does not enter as its profit is negative, even having all the market share. However, for the social planner, provision by the fintech brings higher welfare than offering differentiated products. Lowering F and G inverts the dynamic ($S_2^M\ S_1^P$); now, fintech moves out all banks; however, the planner finds more welfare by offering differentiated loans. Diminishing F and G ($S_1^M\ S_2^P$), the pair returns to the condition in which banks provide all loans in decentralized, and the planner prefers provision by fintech. With a low F or intermediate F level but high G ($S_1^M\ S_1^P$), banks are the sole providers in both economies. For an intermediate level of F but very low G ($S_3^M\ S_1^P$), coexistence arises in the free market, while the planner prefers bank provision. Increasing F ($S_3^M\ S_1^P$) changes the planner's optimal provider to fintech, as G falls under its decision rule. Rising F displaces all the banks in the free market ($S_3^M\ S_1^P$).

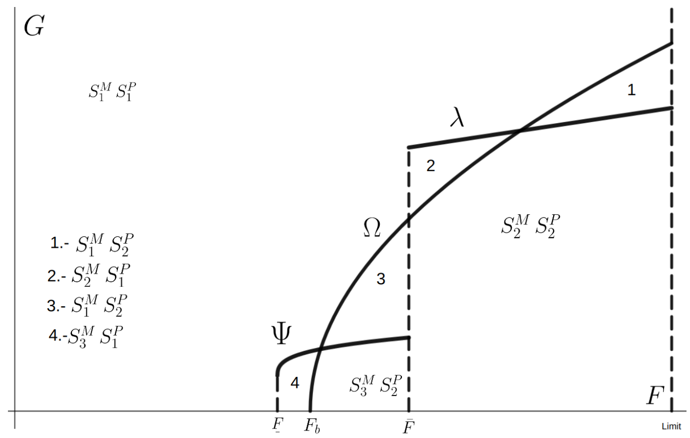

Figure 4: First Case

Second Case

In this derived case the value of planner's rule of decision does not surpass the value of the other rules in the delimiters. This is $\Omega(\bar{F}) \leq \lambda(\bar{F})$ and $\Omega(\bar{F}) \leq \Psi(\bar{F})$.

Here, the ranges of costs where the market prefers fintech provision but the planner prefers banks provision ($S_2^M\ S_1^P$) increases significantly, at the expense of reducing the zone where both equilibria have the fintech as the sole provider ($S_2^M\ S_2^P$).

Also, as the rule of decision, Ω no longer crosses Ψ or λ, the system lost the zone where the market results in banks' provision while the planner opts by fintech provision ($S_1^M\ S_2^P$).

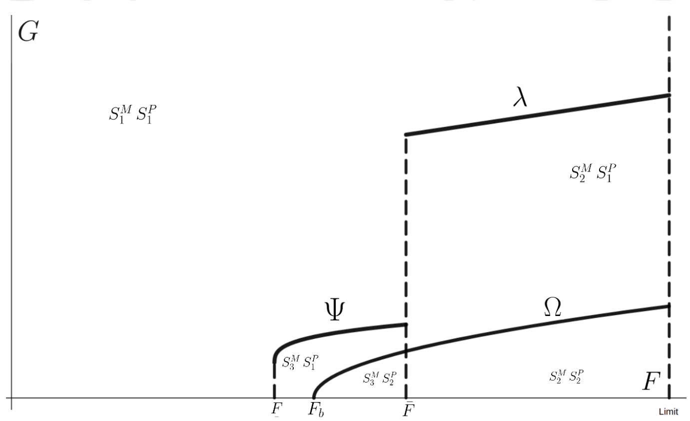

Figure 5: Second Case

Third Case

In this case, the delimiter of the social has optima is low than the lower free market delimiter: $F_b \leq \underline{F}$. This displacement expands the zone where decentralized have banks provision while centralized has fintech provision ($S_1^M\ S_2^P$). Also, this displacement makes Ω no longer cross Ψ, ruling out the zone where decentralized has coexistence of lenders and centralized just bank provision.

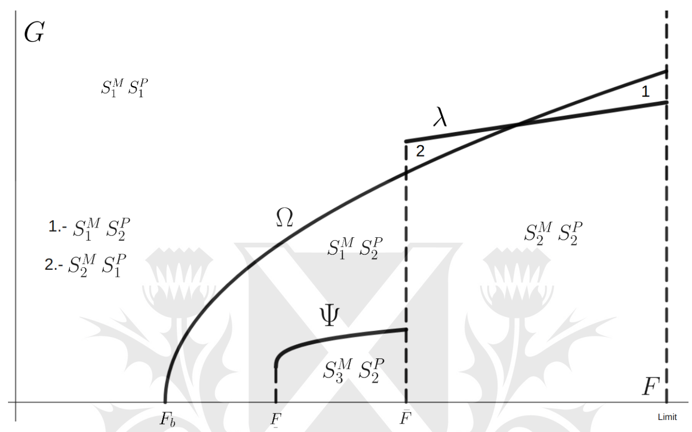

Figure 6: Third Case

Fourth Case

The fourth case keeps displacement of the third, but here Ω is lower than λ in all the span of the latter. This change expands the zone where decentralized has fintech provision, but centralized has banks provision ($S_2^M\ S_1^P$). Another change is that the state where centralized has bank provision and centralized fintech provision ($S_1^M\ S_2^P$), only occurs once, instead of the other cases where it also happened at higher F and G.

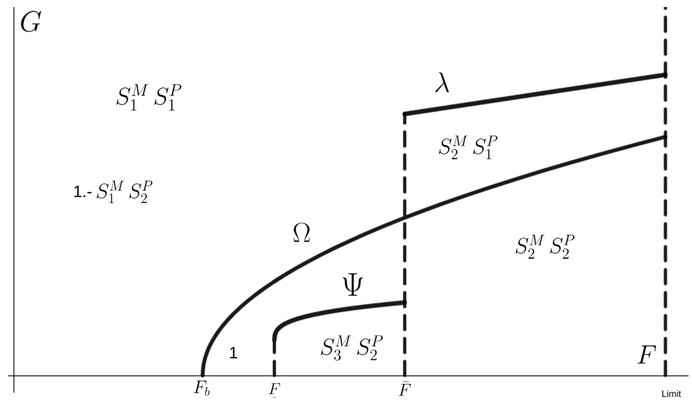

Figure 7: Fourth Case

As the case shows, market failures can be analyzed using certain assumptions about the relationship between delimiters and decision rules. While this impedes having a general analysis of the system, it permits at the same time the possibility of having different scenarios, enabling to characterize different situations of market failures. Also, this analysis can extend to enable different situations that could characterize some specific conditions of the market like zero transaction cost for borrowing of the center or same specialization unitary costs.

In the case of $\delta = 0$, all the entrepreneurs have fully adopted the technology in their lives, so they do not face any transaction cost of using fintech. Suppose the model does not feature specialization as a second channel. In that case, the only constraint that avoids the entry of the fintech is its fixed cost, as banks can not compete in prices (Madden and Pezzino (2011)). Here, however, fintech's entry will also be limited by the banks' strategy, as they specialize up until their variable cost allows them. Using $\delta = 0$ in Eq.40 gives the possibility of having a feasible number of banks in the system only if the ratio of marginal specialization cost is lower than a factor.

$$\frac{\tau_c}{\tau_p} < \frac{A^2}{\left(A - \sqrt{\frac{9\,F}{2}})^2\right)} \tag{55}$$

In Eq. 55 the right side is higher than one. This produces two outcomes; the first is when τ_p is higher than τ_c, which means that banks' specialization costs are higher than the fintech one; here the banks shift its strategy by offering a basic but very cheap loan, while of the fintech that keeps offering a highly specialized product.

In the second case, the bank's specialization costs are cheaper than the fintech, and banks stay in the market by offering a highly specialized product.
In the first case, banks try to expand their demands by lowering rates and transaction costs. In the second, they narrow their demands but increase rates and loan specialization.

6 Conclusions

This paper extends the literature on the financial markets, spatial competition, and heterogeneous firms. The motivation is to model the interaction of traditional banks and fintech in the lending sector and analyze the resultant market failures. I have developed a variation of the circular city model, where I added a fintech in the center and the possibility of endogenous specialization. While this concept is neither new nor welfare analysis, the paper expands the analysis possibilities by adding specialization as an additional channel of competition. Fintech competes by providing a financial service perceived as homogeneous by all the borrowers instead of traditional, where the perception of their services varies greatly. This model develops in 2 sub-games. The results of the sub-games find that competition is monopolistic when fintech do not participate, and a la Bertrand when fintech have a share in the market.
The specialization costs of each lender limits their competition. With lower, lenders compete more aggressively with each other. The analysis finds that in both scenarios, Social-Optima and Market Equilibrium, lower specialization costs for traditional banks lead to a higher number of their type. This result is consistent as specialization serves as an alternative channel of competition. This channel could explain why coexistence will perdure in the long term by showing that with a total adoption of the internet services by the population, people could still prefer traditional banks as they could bring additional surplus by specialization.

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Appendix

A.Proof

A-I: Proof of optimal degree

Recalling from each game structure, each lender competes in two stages. First, they compete in their degree of specialization and then in the rate offered. Deriving profits function for two lenders competing against each other leads to the equilibrium's rate functions, each depending on the degree of specialization. The equilibrium rate of bank i is:

$$r_i = \frac{A\,(\sqrt{\theta_i} - \sqrt{\theta_{i+1}}) + 2\,\tau_i\,\theta_i + \tau_{i+1}\,\theta_{i+1} + \frac{1}{N}\,(2\,\theta_{i+1}\, + \theta_i)}{3} + \rho \tag{56}$$

Then for the adjacent bank:

$$r_{i+1} = \frac{A\,(\sqrt{\theta_{i+1}} - \sqrt{\theta_i}) + 2\,\tau_{i+1}\,\theta_{i+1} + \tau_i\,\theta_i + \frac{1}{N}\,(2\,\theta_i\, + \theta_{i+1})}{3} + \rho \tag{57}$$

The election of the optimal degree of specialization implies an interior equilibrium; In this equilibrium the magnitude of the direct effect in the profit's function for changing the degree of specialization is neutralized with the strategic effect of the competitor's response to a degree of specialization.

$$\frac{d\,\Pi_i}{d\,\theta_i}\,(\theta_i, \theta_{i+1}) = \frac{\partial\,\pi_i}{\partial\,\theta_i} + \frac{\partial\,\pi_i}{\partial\,r_{i+1}}\,\frac{\partial\,r^*_{i+1}}{\partial\,\theta_i} = 0 \tag{58}$$

As banks are symmetric this rate will be:

$$\theta^* = \frac{A^2}{(\frac{1}{N} + 2\,\tau_p)^2} \tag{59}$$

Q.E.D

A-II: Proof of Regimes

The possible values of the position of the indifferent agent could lead to split-profit functions for both lenders.

Recalling

1. When $\hat{x} \leq 0$ only fintech has demand.
2. When $0 \leq \hat{x} \leq \frac{1}{2N}$ both share the market.
3. When $\hat{x} \geq \frac{1}{2N}$ only banks have demand.

So profit function for each type of lender results in:

Profit for fintech

$$\pi_c = \begin{cases} r_c - \tau_c\,\theta_c - \rho - G, & \text{if} \quad r_c \leq \text{lb}_c \\ \\ (r_c - \tau_c\,\theta_c - \rho)\left(1 - 2\,N\,\frac{A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + r_c - r_p + \delta\,\theta_c}{\theta_p}\right) - G, & \text{if} \quad \text{ub}_c \leq r_c \leq \text{lb}_c \\ \\ -G, & \text{if} \quad r_c \geq \text{ub}_c \end{cases} \tag{60}$$

With $\text{lb}_c = A(\sqrt{\theta_c} - \sqrt{\theta_p}) + r_p - \delta\,\theta_c$ and $\text{ub}_c = A(\sqrt{\theta_c} - \sqrt{\theta_p}) + r_p - \delta\,\theta_c + \theta_p\,\frac{1}{2\,n}$

Profit for bank

$$\pi_p = \begin{cases} (r_p - \tau_p\,\theta_p - \rho) - F, & \text{if} \quad r_p \leq \text{lb}_p \\ \\ (r_p - \tau_p\,\theta_p - \rho)\left(\frac{A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + r_c - r_p + \delta\,\theta_c}{\theta_p}\right) - F, & \text{if} \quad \text{ub}_p \leq r_p \leq \text{lb}_p \\ \\ -F, & \text{if} \quad r_p \geq A(\sqrt{\theta_p} - \sqrt{\theta_c}) + r_c + \delta\,\theta_c \end{cases} \tag{61}$$

With $\text{lb}_p = A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c\,\delta - \theta_p\,\frac{1}{2\,N}$ and $\text{ub}_p = A(\sqrt{\theta_p} - \sqrt{\theta_c}) + r_c + \delta\,\theta_c$

With this values the best responses of the lenders are

Best response of fintech rate

$$r_c = \begin{cases} A(\sqrt{\theta_c} - \sqrt{\theta_p}) + r_p - \delta\,\theta_c, & \text{if} \quad r_p \geq r_p^{\text{ub}} \\ \frac{\frac{\theta_p\,1}{2\,N} - A(\sqrt{\theta_p} - \sqrt{\theta_c}) + r_p + \tau_c\,\theta_c + \rho - \theta_c\,\delta}{2}, & \text{if} \quad r_p^{\text{lb}} \leq r_p \leq r_p^{\text{ub}} \\ [\tau_c\,\theta_c + \rho, \infty >, & \text{if} \quad r_p \leq r_p^{\text{lb}} \end{cases} \tag{62}$$

With $r_p^{\text{ub}} = A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c\,\delta + \theta_p\,\frac{1}{2\,N} + \tau_c\,\theta_c + \rho$ and $r_p^{\text{lb}} = A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c\,\delta + \tau_c\,\theta_c - \theta_p\,\frac{1}{2\,N}$
Best response of banks rate

$$r_p = \begin{cases} \theta_p\,(\frac{1}{N} + \tau_p) + \rho & \text{if} \quad r_c \geq r_c^{\text{ub}} \\ A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + r_c + \delta\,\theta_c - \theta_p\,\frac{1}{2\,N} & \text{if} \quad r_c^{\text{lb}} \leq r_c \leq r_c^{\text{ub}} \\ \frac{A\,(\sqrt{\theta_p} - \sqrt{\theta_c}) + \theta_c\,\delta + r_c + \tau_p\,\theta_p + \rho}{2} & \text{if} \quad r_c^{\text{zb}} \leq r_c^{\text{lb}} \\ [\tau_p\,\theta_p + \rho, \infty > & \text{if} \quad r_c \leq r_c^{\text{zb}} \end{cases} \tag{63}$$

With:

- $r_c^{\text{ub}} = 3\,\theta_p\,\frac{1}{2\,N} + A\,(\sqrt{\theta_c} - \sqrt{\theta_p}) - \delta\,\theta_c + \tau_p\,\theta_p + \rho$
- $r_c^{\text{lb}} = \theta_p\,\frac{1}{N} + A\,(\sqrt{\theta_c} - \sqrt{\theta_p}) - \delta\,\theta_c + \tau_p\,\theta_p + \rho$
- $r_c^{\text{zb}} = A\,(\sqrt{\theta_c} - \sqrt{\theta_p}) - \delta\,\theta_c + \tau_p\,\theta_p + \rho$

The sections of the best rate response of banks depend on the current value of the fintech's rate. So these sections can occur if their limit value is above the lowest value that r_c can take that is, its marginal cost $\tau_c\,\theta + \rho$ as this value is higher than the delimiters of banks best response, this generates the regimes, a set of configurations of degrees and rates.

The first Regime occurs when the fintech's marginal cost is relatively low, so it competes against the banks. [13] Then the marginal cost rises to a level where fintech lose demand, but banks can not change their rate to a monopolist one, as this could leave a narrow margin in which the fintech could enter again. Last when marginal cost is so high, the banks behave as the model without the fintech as any possible strategies of the fintech will not impact the proportion of shares.

So each Regime conditions are:

- Regime I: $\tau_c\,\theta_c + \rho \leq r^{lb}$
- Regime II: $r^{lb} \leq \tau_c\,\theta_c + \rho \leq r^{\mathrm{ub}}$
- Regime III: $\tau_c\,\theta_c + \rho \geq r^{\mathrm{ub}}$ Q.E.D

A-III : Proof of Lambda

Rule of decision lambda limits the entry of fintech when bank fixed costs are high enough that under competition, N is less than one so fintech provides all loans, So now fintech's profit function will be :

$$\pi_c = (r_c^* - \tau_c\,\theta_c^* - \rho)\,D \tag{64}$$

D equals one as it has all the market. Here the bank keeps its best response from the previous equilibrium, although now it is not competing with any bank. This strategy will give him profits while avoiding a bank's entry into the perimeter. Its profit will increase as F rises because it sets higher rates as bank will need to raise its rate so it can have a positive profit.[14]

So with Eqs 39 and 40 in 64 results in the profit function π_c, which could be re-ordered into rule λ:

$$\pi_c = \frac{A^2\,\tau_p - \left(A - \sqrt{\frac{9\,F}{2}}\right)^2\,(\tau_c + \delta)}{4\,(\tau_c+\delta)^2\,\left(A - \frac{9\,F}{2}\right)^2} - \frac{A^2\,\sqrt{\frac{9\,F}{2}}}{6\,\left(A - \sqrt{\frac{9\,F}{2}}\right)\,(\tau_c+\delta)} - G \tag{65}$$

[13] I leave the case where the fintech's rate leaves no demand to banks. Solving the model by backward induction only needs the fintech to have a positive income to decide its entry, and the coexistence of lenders meets this criteria.

[14] The range of fixed cost F analyzed occurs in a sub-space where they cannot reach the level in which fintech set monopolist rate.