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Abstract

In this paper, financial infrastructures increase the efficiency of the banking sector: they decrease the market power (due to horizontal differentiation) of the financial intermediaries, lower the cost of capital, increase the number of depositors and the amount of intermediated savings, factors which in turn increase the growth rate and may help countries to take off from a poverty trap. Taxation finances financial infrastructures and decreases the private productivity of capital. Growth and welfare maximising levels of financial infrastructures are computed.

JEL classification: O16; E62; G21

Keywords: Endogenous growth; Imperfect competition; Financial infrastructures

Résumé

Dans cet article, les infrastructures financières accroissent l'efficacité du secteur bancaire: elles diminuent le pouvoir de marché des banques provenant de la différentiation horizontale, elles font baisser le coût du capital, elles élèvent la rémunération de l'épargne, et, par conséquent, le nombre des déposants et le montant de l'épargne intermédiée. Ces facteurs sont à l'origine d'une hausse

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du taux de croissance de l'économie et permettent à certains pays de sortir d'un piège à pauveté. Un financement par impôt des infrastructures financières conduit en revanche à une baisse du rendement net d'impôt du capital. On détermine la taille des infrastructures financières qui maximisent la croissance ou le bien-être.

Classification JEL: O16; E62; G21

Mots-clés: Croissance endogène; concurrence imparfaite; infrastructures financières.

1. Introduction

The need to build financial infrastructures is an important feature of Economies in transition, where banking practice was lost after several decades of central planning, and Less Developed Countries (LDC).[1] It is often held as a precondition for economic development, as financial intermediaries facilitate transactions, allocate capital and collect savings.[2] Financial infrastructures facilitate the collection of savings by banks, and channel more resources towards the modern sectors of the economy. When the financial system is rudimentary, some households may not have access to a bank or other institutions in which they could deposit savings. Moreover, a lack of confidence in the banking sector connected to failures to maintain property rights could make people wary of depositing, so that some kind of government action can lower the costs of intermediation and increase the collection of savings.[3]

Binswanger et al. [1993] show with the help of a panel data analysis for rural India that public infrastructures and financial intermediaries exercised a joint positive influence on agricultural investment and output and that *"bank expansion is greatly facilitated by government investment in roads and regulated markets which enhance the liquidity position of farmers and reduce transaction costs of both banks and farmers"*[4].

A distinction can be made between *general purpose public infrastructures*, such as roads and telecommunications, used for many transactions other than financial ones, and what can be called *financial infrastructures*. The role of these infrastructures for economic development is emphasized in this paper. The services provided by these financial infrastructures lower the costs of financial transactions. Many public goods are specific to the financial sector. First of all, there is a specific knowledge in both private and central banking practice (project appraisal, accounting, credit scoring,...). It requires the education of banks employees as well as the education of depositors[5]. Second, there exist a specific and common capital and technology shared

[1]See the special issue of the *Journal of Banking and Finance* [1993] (September) on Banking in transition economies and Fry [1995] for LDCs.

[2]On the role of financial intermediation in development, see the contributions in Hermes and Lensink [1996].

[3]A typical case study where defficiencies in the collection of savings is one of the most important factors limiting growth is Uganda in the recent years (Sharer et al. [1995]): few banks, including two large state owned bank which have acquired the bulk of the branch network, the larger one holding more than 40% of deposits, high intermediation margin, poor check clearing facilities and strong reluctance of the public to use checks, an economy where the use of money is not developed (a ratio of broad money to GDP of about 9 percent), with a large ratio of currency in circulation to deposits (more than 30%), inadequate prudential regulation and supervision of the central bank, lack of public confidence in the financial system, altogether with a short maturity and instability of deposits leading to frequent financial distress of banks.

[4]Binswanger et al. [1993] p.363.

[5]Mulligan and Sala-I-Martin [1996] found that the cost of adopting financial technology in the US

between banks for transactions purpose and the efficient working of the payment system[6]. Third, a specific authority must enforce banking laws and regulation in order to preserve the stability of property rights of banks and depositors' assets and provide other services (supervision and coordination of the payment system...).[7]

This paper presents a model of endogenous growth with local banking monopolises monopolies. Banks face spatial competition on the deposit market as in Salop's [1979] model, but depositors' transaction costs and banks' intermediation costs are endogenous and depend on financial infrastructures. We characterize financial infrastructures as a means to explicitly reduce transaction costs of depositors or fixed intermediation costs of banks and thus to foster saving. An increase in the number of banks will positively affect the level of aggregate savings.[8] Public intervention will determine the amount of financial infrastructures in the economy and thus indirectly influence the extent of imperfect competition in the banking sector, which will in turn affect economic growth and consumer welfare.[9] An adequate amount of financial infrastructures may also allow a country to take off from a poverty trap.

The paper follows the following progression. A second section describes the behaviour of firms, of households and of a banking oligopoly. A third section provides the equilibrium growth rate for given financial infrastructures. A fourth section computes the level of financial infrastructures that maximizes the growth rate or the aggregate welfare. Conclusion and possible extensions of the model are dealt with in section five.

2. The model

2.1. Firms

We consider a constant returns to scale production function for the private sector with capital K and labour N in a Cobb-Douglas specification.[10] Capital is entirely depreciated in one period.[11] The final good Y is produced under perfect competition ($0 < \alpha < 1$).

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is positively related to age and negatively related to the level of education of households.

[6] See Fry [1995], chapter 12.

[7] See Fry, Goodhart and Almeida [1996].

[8] The positive effect of a high number of bank branches on the private savings rate has been found to be significant in some applied studies for LDCs (Tun Wai [1972], Demetriadès and Luintel [1994]). Fry [1995] obtained that a ten per cent reduction in rural population per rural branch significantly increased the national saving rate on average by 0.16 of a percentage point for six Asian countries over the period 1961-1981.

[9] See Stiglitz [1995] and Levine [1996] for surveys on other types of public intervention in the financial system.

[10] In what follows, the time index t may be suppressed when not necessary.

[11] This widely held assumption in overlapping generation models does not affect the results of the model. Non depreciating capital may be introduced by assuming that workers purchase used capital from the elderly with their savings. Y_t is then re-interpreted as gross output, i.e. including the capital that is carried over between periods.

$$Y_t = A_t \cdot G_{1,t}^{1-\alpha} \cdot K_t^{\alpha} \cdot N^{1-\alpha} \tag{2.1}$$

Productivity incorporates a positive externality that is a function of "general purpose" public infrastructures G_1 as in Barro [1990]. Public capital, as well as private capital, is fully depreciated in one period.

Companies are facing perfect competition and maximize profits. Output is taxed at the rate τ. This rate is the sum of τ_{GP} which is needed to finance general purpose public infrastructure, of the rate τ_2 which finances financial infrastructures decreasing transactions costs on the depositors side and of the rate τ_3 which finances financial infrastructures decreasing operating costs on the banking side. Firms have to borrow the entire capital needed for production. The demand for credit is then derived from:

$$K_t \in ArgMax\left\{(1-\tau) \cdot A_t \cdot G_{1,t}^{1-\alpha} \cdot K_t^{\alpha} \cdot N^{1-\alpha} - r^c \cdot K_t - w_t \cdot N\right\}$$

and r^c is the interest factor on credit. One can then derive the following relationships between factor prices and demands:

$$\begin{aligned} r^c &= (1-\tau) \cdot \alpha \cdot A_t \cdot G_{1,t}^{1-\alpha} \cdot K_t^{\alpha-1} \cdot N^{1-\alpha} && (2.2) \\ w_t &= (1-\tau) \cdot (1-\alpha) \cdot A_t \cdot G_{1,t}^{1-\alpha} \cdot K_t^{\alpha} \cdot N^{-\alpha} && (2.3) \end{aligned}$$

In what follows, we normalise the population of each generation at $N = 1$.

2.2. Households behaviour and the deposit market

We consider a simple overlapping generations model. A fixed-size population of overlapping generations of agents live for two periods. There is a continuum of mass $N = 1$ of these agents. They are uniformly distributed on a circle of circumference equal to unity. This formalizes horizontal differentiation and/or spatial heterogeneity. During the first period, each agent inelastically supplies one unit of labour, saves a certain proportion of her earnings, and does not provide bequests to their offsprings. The agents can invest their savings either in a storage technology[12] or put them as deposits in banks. This assumption of no financial markets is justified on the grounds that in most LDCs it is statistically observed that direct financial claims, such as stocks and bonds, are unimportant compared with intermediated claims (such as deposits in banks and nonbank depository institutions included).

We assume that the utility function of an agent living in t and $t+1$ is log-linear and depends on the levels of consumption at the end of each of the two periods:

[12] For simplication purposes, we assume that investment in the storage technology does not contribute to national income. This is not strictly necessary, what matters is that non intermediated savings should not be as efficient as intermediated savings. We thus assume that only banks can channel saving resources to the 'modern' sector of the economy.

$$U = \log[C_t] + \frac{1}{1+\rho} \cdot \log[C_{t+1}] \tag{2.4}$$

ρ is the rate of time preference. First period's consumption is equal to the difference between wage income and savings, while second period's consumption is equal to the revenues derived from savings, thus:

$$U = \log[w_t - S_t] + \frac{1}{1+\rho} \cdot \log[z_{t+1} \cdot S_t] \tag{2.5}$$

where w is the real wage, S is the individual amount of savings and z the real return on savings on any assets (deposits or storage technology). From this specification follows an individual saving function inelastic to the real return:[13]

$$S_t = \frac{w_t}{2+\rho} \tag{2.6}$$

The assumption of savings function inelastic with respect to the interest rate is not that odd: Tun Wai [1972] noted that surveys in LDCs confirmed that the saving propensity does not seem to depend on the interest rate, but that rural households take into account the opportunity cost of deposits, the interest rate or the return on storable goods, in the decision on how to use savings (crops or money).

There is imperfect competition in the banking sector because of horizontal (spatial) differentiation as in Salop's [1979] model. We consider the existence of n banks indexed by i. Spatial competition takes place on a circle whose circumference is normalised to unity, over which banks are equidistributed. The lender deposits her money to bank i if it receives a return net of the transaction cost of the "trip to the bank" higher than the return from a storage technology μ, which can be negative.

$$r_{i,t}^d - d \cdot l \geq \mu \tag{2.7}$$

$r_{i,t}^d$ is the deposit rate of bank i at date t, l is the distance between a consumer's location and bank i's location, and $d \cdot l$ is the lender transportation cost per unit of saving. We adopt here a simple linear specification for this effect as is done in most of the literature on this topic.

$d \cdot l \cdot S_t$ the transportation cost factor, is assumed to be a decreasing function of the services provided by financial infrastructures G_2. There is a standard "free rider" coordination problem between financial intermediaries to pay for financial infrastructures, so that the government has to finance these public goods. It finances these infrastructures with an income tax on private firms. The budget constraint is $G_2 = \tau_2 \cdot Y$.

It is surely the case the transportation costs for trips to the banks affect much less savings in industrialised countries than in LDCs due to the existence of fully developed road infrastructures and networks of bank branches, as well as recent innovations such

[13] A linear utility function provides also a saving function inelastic to the real return.

as automated teller machines (ATM) networks and phone banking. But, if we do not stick to the literal explanation of transportation costs, we can relate this cost to a lack of confidence in financial intermediaries connected to defficiencies in the preservation of property rights of depositors.[14] Then one can assume that the cost is proportional to the amount left in the bank: this amount can be lost in a bankruptcy of the bank. The transaction cost (or distance) factor per unit of savings, d, is assumed to be a decreasing function of the services provided by financial infrastructures G_2, which fully depreciate after one period, as assumed for private capital. For homogeneity and simplicity, G_2 is divided by Y in the specification of d, so that the distance factor is $d\left(\frac{G}{Y}\right)$[15]. This way, the endogenous marginal transportation cost $d\left[\frac{G_2}{Y}\right]$ can be expressed as $d(\tau_2)$.

The farther the consumer is from the bank located at $l = 0$, the more costly it is for her to deposit her assets in that bank. A consumer keeps her assets with the storage technology when the return on deposits, net of transportation costs, available from the banks located on either side is lower than the return on the storable good. The marginal lender who is indifferent between depositing her money at bank i and holding it in the storage technology, is located at a distance l_m from the bank, defined by the following equation :

$$l_m = \frac{r_i^d - \mu}{d} \tag{2.8}$$

We will mainly assume that the number of banks (n) is always such that the distance between two banks is larger than $2 \cdot l_m$ so that the deposit markets of each bank do not overlap, which is a reasonable assumption for LDCs (the number of banks will be endogenously determined through a free entry condition, the growth rate in the case of "touching" markets will also be considered).

$$\frac{1}{n} \geq 2 \cdot l_m \tag{2.9}$$

The market area served by the bank i, located at $l = 0$, is therefore $2 \cdot l_m$. Given the density of depositors per unit of distance $N = 1$ and their unit supply of savings, the supply of deposit in bank i, D_i is equal to

$$D_{i,t} = 2 \cdot \frac{r_i^d - \mu}{d} \cdot \frac{w_t}{2 + \rho} \tag{2.10}$$

This equation shows that depositors reduce their deposits if the transportation rate of the trip to the bank d or the rate of return on the storable good μ increases

[14]See Barro and Sala-I-Martin ([1995] p. 159-160 for an identical interpretation of public infrastructures or public services as a mean to preserve property rights.

[15]See Barro and Sala-i-Martin [1995] for an exposition of the congestion effect incorporated as a negative effect of total infrastructure usage (taken to be represented by Y). They propose the typical example of public services as an influence on the preservation of property rights (p.159-160) and the theft probability. This is particularly relevant for the Russian banking sector in the 90's.

and if the deposit rate r^d decreases.

2.3. Banks behaviour

There is imperfect competition on both credit and deposit markets. Imperfect competition on the deposit market is the consequence of the spatial dimension, and banks behave *à la* Nash. We assume that banks compete on the credit market following a Cournotian imperfect competition.[16] Each bank incurs a fixed cost F at the end of each period. The bank chooses the amount of credit offered to firms and the amount of deposits taken from households. The index i is for a given bank. In the symmetric equilibria we consider, the credit market share of bank i is denoted $k_i = K/n$, and:

$$(D_{i,t}, k_{i,t+1}) \in ArgMax\ \Pi_i = r^c \cdot k_{i,t+1} - r_i^d \cdot D_{i,t} - F \tag{2.11}$$

subject to the balance sheet constraint of the bank, to the aggregate demand for credit and to the local monopoly demand for deposits:

$$\begin{aligned} k_{i,t+1} &= D_{i,t} \\ D_{i,t} &= \frac{2w_t}{2+\rho} \cdot \frac{r_i^d - \mu}{d} \\ r^c &= (1-\tau) \cdot \alpha \cdot A_t \cdot G_{1,t}^{1-\alpha} \cdot K_t^{\alpha-1} \cdot N^{1-\alpha} \end{aligned}$$

The equilibrium of imperfect competition is defined by the Cournot-Nash equilibrium of a game with n players (banks) where the strategies are the choice of deposit rates. The best response functions of banks are the first order conditions of the above program. The symmetric equilibrium of imperfect competition is characterised by deposit rates being identical for all banks, one obtains:

$$r^d = \frac{1}{2}\left[\mu + \left(1 + \frac{\alpha - 1}{n}\right) r^c\right] \tag{2.12}$$

The equilibrium deposit rate increases with the credit rate and the rate of return on the storable good. It lies between the credit rate and the rate of return on the storable good, as a weighted average of the two ($\frac{\alpha-1}{n}$ is related to the Cournotian mark-up on credit, which depend on the elasticity of demand and on the number of competitors). The spread between the credit rate and the deposit rate measures the extent of imperfect competition.

A higher level of financial infrastructure can lower the fixed operating costs in the intermediation activity. In so doing, it relaxes entry barriers and increases competition and efficiency in the banking sector. This is particularly relevant for the infrastructures specific to the payment system shared by banks. As observed recently in economies in

[16] See Bensaïd and De Palma [1995] for the general case of Cournotian competition mixed with horizontal differentiation.

transition (as well as OECD countries), the building of a good computerized telecommunication network between banks can help to develop the payment system such as check-clearing facilities, automated teller machines (ATM) networks, phone banking, and other tools reducing clearing time. Investment in these network infrastructures is generally financed both by the public and the private sector. The public sector finance G_3 which decreases the operating costs of banking. Banks pays the remaining fixed intermediation costs related to the network $F(G_3)$, with $F'(G_3) < 0$. The publicly provided part is financed by taxation, so that $G_3 = \tau_3 Y$.

We assume that the fixed investment in banking in the whole economy, $n_t \cdot F_t$, is a given share of the overall existing capital, i.e. $n_t \cdot F_t(G_3) = f(G_3/K_t) \cdot K_t$, with $f' < 0$ and $f'' > 0$. We define the ratio of fixed public investment in banking infrastructure with respect to overall investment by $\theta_3 = G_3/K_t$. This assumption is very widely held in endogenous growth models incorporating fixed costs so that they do not become negligible with respect to output in a growing economy. But it is much more than a technical assumption. It is empirically sound for numerous reasons. New technology in banking requires an increased amount of capital related to information technology.[17] For the particular case of the infrastructures pertaining to the payment system, the number of transactions grows faster than GNP, which increases the capital invested and the costs of the system. Fry ([1995] p. 322-327) surveyed that in some LDCs, bank operating costs do tend to rise at least as fast as GNP due to non price competition. Real wages of bank employees increase over time[18].

There is free entry in the banking activity, so that the long run equilibrium number of banks in the economy, n, is determined by the dissipation of profits. Ignoring the integer constraint, the equilibrium number of banks is then:

$$n^* = \frac{(1-\alpha) \cdot r^c}{2 \cdot f(\theta_3) + \mu - r^c} \tag{2.13}$$

It is straightforward to check that an increase in the tax rate (or the marginal productivity of firms) reduces the number of banks and thus aggravates the imperfection in competition in the banking activity. An increase in the level of fixed cost in intermediation reduces the number of banks at the equilibrium, as can be seen immediately from the expression for n^* above. Likewise, an increase in the return of the alternative assets (μ) modifies the decision to go to the bank and lowers financial intermediaries' profits. This effect decreases the number of banks at the equilibrium.

[17] See the Economist [1996]: "A Survey of Technology in Finance: Turning Digits into Dollars".

[18] We investigated an alternative assumption regarding these operating costs. The operating costs are $w_t \cdot f(G_3)$, with $f'(G_3) < 0$ where f is a fixed proportion of labour employed in each banks. Financial infrastructures decrease the number of workers necessary to run a bank. These workers are located at the same spot as the bank. Their savings are collected with no transaction costs and add to savings collected from the remaining part of the population, located uniformly on a circle. This assumption changes the expressions of the real wage, the return to capital and the number of banks. It complicates quite sensibly the mathematics of the model but does not alter the main arguments of the paper.

In what follows, we assume that some households do not deposit in banks, i.e. $0 < l^* < 1/2n^*$, and banks do operate ($n^* > 0$). Then, the return on capital r^c is bounded according to this condition: $f(\theta_3) + \mu < r^c < 2 \cdot f(\theta_3) + \mu$. Banks do exist, i.e. the economy is not stuck in a poverty trap due to too high banking operating costs. Substituting the equilibrium number of banks after free entry and the value of the marginal product of capital in the equilibrium deposit rate and collected savings by bank i, one has:

$$\begin{aligned} r^d &= r^c - f(\theta_3) && (2.14) \\ l^* &= \frac{r^d - \mu}{d(\tau_2)} = \frac{r^c - [f(\theta_3) + \mu]}{d(\tau_2)} && (2.15) \end{aligned}$$

3. Financing "General Purpose" Infrastructures

3.1. Growth

As Barro [1990], we assumed that the government runs a balanced budget financed by a proportional tax at rate τ on the aggregate of gross output.

$$G_1 = \tau_{GP} \cdot Y \tag{3.1}$$

From this equation and the production function, we get an expression for G_1:

$$G_1 = (\tau_{GP} A)^{1/\alpha} \cdot K \tag{3.2}$$

Therefore, the production function can be written as:

$$Y = (\tau_{GP})^{(1-\alpha)/\alpha} \cdot A^{1/\alpha} \cdot K \tag{3.3}$$

It follows that the share of financial infrastructure devoted to fixed investment in banking with respect to capital is a linear function of the tax rate τ_3. $\theta_3 = G_3/K_t = (\tau_{GP})^{(1-\alpha)/\alpha} \cdot A^{1/\alpha} \cdot \tau_3$. From now on, we use the simplified notation $f(\tau_3)$ for $f(\theta_3) = f\left((\tau_{GP})^{(1-\alpha)/\alpha} A^{1/\alpha} \tau_3\right)$.

We can substitute this expression of general purpose public infrastructures into the marginal conditions, in order to determine the macro-economic level of the interest rate and of the real wage:

$$\begin{aligned} r^c &= \alpha \cdot A^{1/\alpha} \cdot \tau_{GP}^{(1-\alpha)/\alpha} \cdot (1 - \tau_{GP} - \tau_2 - \tau_3) && (3.4) \\ w_t &= (1-\alpha) \cdot A^{1/\alpha} \cdot \tau_{GP}^{(1-\alpha)/\alpha} \cdot (1 - \tau_{GP} - -\tau_2 - \tau_3) \cdot K_t && (3.5) \\ &= \frac{1-\alpha}{\alpha} \cdot r^c \cdot K_t && (3.6) \end{aligned}$$

We recall that we assumed that borrowers (firms) can receive funds from financial intermediaries only. Aggregate capital investment, which is equal to the aggregate capital stock since capital entirely depreciates at each period, is equal to aggregate savings of the young generation collected by the banks.

We define "local monopolies" on the deposit market as the case where there remains a fringe of households who never deposit in a bank, and "touching markets" as the case where all households deposit in a bank, although, strictly speaking, both cases deals with "local monopolies". An intermediation fixed costs and imperfect competition on the credit side are necessary assumptions for the existence of "local monopolies" on the deposit side. Perfect competition on the credit market would imply that "touching markets" on the deposit market are the optimal long run behaviour of banks. Free entry would lead new banks to fill the gaps in the areas where households do not deposit.

In the case of "local monopolies" on the deposit market ($f(\tau_3) + \mu < r^c < 2 \cdot f(\tau_3) + \mu$), the growth rate is equal to:

$$\begin{aligned} g_t &= \frac{K_{t+1}}{K_t} = n^* \cdot (2 \cdot l^*) \cdot \frac{w_t}{(2+\rho) \cdot K_t} \\ &= \frac{2 \cdot (1-\alpha)^2}{\alpha \cdot (2+\rho)} \cdot \frac{(r^c)^2}{2 \cdot f(\tau_3) + \mu - r^c} \cdot \frac{r^c - [f(\tau_3) + \mu]}{d(\tau_2)} \\ &= g\left(\underset{+}{r^c}, \underset{-}{\rho}, \underset{-}{d}, \underset{-}{f}, \underset{-}{\mu}\right) \end{aligned} \tag{3.7}$$

One can see the influence of the financial intermediation sector on growth through the number of banks n^* and the market share of a bank measured by the distance $2 \cdot l^*$ which increases collected savings. The growth rate is constant over time, as is customary in $A.K$-type endogenous growth models, and depends positively on the saving rate (through the rate of time preference ρ) and on the productivity of capital, diminished by the marginal rate of unproductive taxation. Imperfect competition in the banking sector adds the two negative effects on growth of operating costs of banks $f(\tau_3)$ and of the return of the alternative assets for depositors μ. The positive effect of infrastructures on growth can appear clearly through the effect on d, as a decrease in the transaction cost incurred by the depositor d is beneficial to growth. Likewise, if infrastructures increase the level of private productivity A or decrease operating costs of banks $f(\tau_3)$, it is also beneficial to growth.

The growth rate in case of "touching" deposit markets (for $r^c > 2 \cdot f(\tau_3) + \mu$, where the fixed operating cost in banking is low enough so that local monopolies disappear) is such that all savings are collected by banks. It is simply given by:

$$g_t = \frac{w_t}{(2+\rho) \cdot K_t} = \frac{(1-\alpha)}{(2+\rho) \cdot \alpha} \cdot r^c \tag{3.8}$$

It can be computed without knowing the interest rate resulting from the banks' optimal program in the case of "touching markets". As the amount of individual savings does not depend on the interest rate, the growth rate is not affected by the price effect (mark-down on deposit) due to imperfect competition among intermediaries. In the case of touching markets, all savings are collected and horizontal differentiation does not affect the *number of depositors*.

In the case of touching markets, if the individual amount of savings is elastic to the interest rate, imperfect competition (with or without horizontal differentiation[19]) *affect growth* through a markup on *price*, which then decreases savings in the case of touching markets. This standard cournotian competition effect has already been modelled in endogenous growth.[20]

In the case of local monopolies that we emphasize in this paper, imperfect competition with horizontal differentiation decreases directly the *number of depositors*, and hence the amount of collected savings. An increase in the number of local branches (which is itself related to the markup), as well as a higher markup determines this quantity. Indeed a utility function which implies a dependance of the propension to save to the interest rate would mix the two effects in our model.

If the productivity level is so low that it is under the sum of the fixed cost per unit of deposit and the return of the non-productive asset ($r^c < f(\tau_3) + \mu$), then no savings are collected to finance the productive sector, intermediaries do not operate, and the economy remains stuck in a poverty trap, indeed connected to the fixed costs of intermediation. If no banks operate ($n^* = 0$, so that $r^c < f(\tau_3) + \mu$) due to high intermediation costs, high transaction costs for depositors and a high return on the storage technology, the economy is also stuck in a *poverty trap* with no growth. No savings are collected by banks and, therefore, the productive sector has no means of finance.

3.2. Optimal Level of "General Purpose" Infrastructures

We consider now welfare implications of our analysis. There are four sources of inefficiency in the model. First, there is the usual missing market for intergenerational trade that arises in overlapping generations models without bequests. Second, we have the Barro-style positive externality from capital formation. Third, there is the Hotelling distortion on the collection of savings due to horizontal differentiation with local monopolies. Fourth, we have the congestion externality that arises from financial infrastructures, because banks and firms ignore the impact of their decisions on the use of infrastructures on transaction costs.

[19] Horizontal differentiation of agents with an elasticity of demand different from zero leads to a mark-up which depends simultaneously on the elasticity of demand (as in the Lerner index) and on a parameter of horizontal differentiation (Bensaïd and De Palma [1995])

[20] The number of intermediaries affect growth with cournotian monopolistic competition between intermediaries but without horizontal differentiation in Berthélémy and Varoudakis [1996].

As a welfare measure for this population of heterogeneous agents, we consider the sum of utilities across agents in a representative generation.[21] Defining $s = 1/(2+\rho)$ the propensity to save out of wage income (which is constant with respect to the tax rate), and letting U_A denote this sum of utilities, we obtain:

$$\begin{aligned} U_A &= \log\left[(1-s)\cdot w_t\right] + \frac{\log\left[s\cdot w_t\right]}{1+\rho} \\ &\quad + \frac{2\cdot n^*}{1+\rho}\cdot\left\{\int_0^{l^*}\log\left[r^d - d\cdot i\right]di + \int_{l^*}^{1/(2\cdot n^*)}\log\left[\mu\right]di\right\} \end{aligned} \tag{3.9}$$

Households face heterogeneity of the return net of transportation cost on their savings. Maximising U_A with respect to the tax rate amounts to maximising:

$$\begin{aligned} &\frac{1}{s}\cdot\log\left[w_t\right] \\ &+2\cdot\frac{n^*}{d}\cdot\left\{r^d\cdot\log\left[r^d\right] - d\cdot l^* - \left(r^d - d\cdot l^*\right)\cdot\log\left[r^d - d\cdot l^*\right] - d\cdot l^*\cdot\log\left[\mu\right]\right\} \end{aligned} \tag{3.10}$$

Dividing the real wage by the capital of the preceding period in order to exhibit the steady state growth rate, substituting $d\cdot l^* = r^d - \mu$, $r^d = r^c - f$ and $w_t = \frac{1-\alpha}{\alpha}\cdot r^c\cdot K_t$, and eliminating "constants" with respect to the tax rates leads the "average" household to maximise:

$$U_B = \frac{1}{s}\cdot\log\left[g\cdot r^c\right] + \frac{2\cdot n^*\left(r^c\right)}{d}\cdot\left\{\left(r^c - f\right)\cdot\left[\log\left[\frac{r^c - f}{\mu}\right] - 1\right] - \mu\right\}$$

The average utility is proportional to U_B, a strictly increasing function of the growth rate g and of the net of taxation productivity r^c. The growth rate g is itself a strictly increasing function of r^c. Therefore, one has:

$$\begin{aligned} \frac{\partial U_A}{\partial \tau_{GP}} &= \frac{\partial U_B\left(g, r^c\right)}{\partial \tau_{GP}} = \left[\frac{\partial U_B}{\partial g}\frac{\partial g}{\partial r^c} + \frac{\partial U_B}{\partial r^c}\right]\frac{\partial r^c}{\partial \tau_{GP}} = 0 \Leftrightarrow \frac{\partial r^c}{\partial \tau_{GP}} = 0 \\ &\Leftrightarrow \frac{\partial g}{\partial \tau_{GP}} = \frac{\partial g}{\partial r^c}\cdot\frac{\partial r^c}{\partial \tau_{GP}} = 0 \end{aligned}$$

As a consequence, the growth maximising tax rate is equal to the (average) utility maximising tax rate as in Barro [1990]. The optimal tax rate is given by:

$$\frac{\partial r^c}{\partial \tau_{GP}} = 0 \Rightarrow (1-\alpha)\cdot(1-\tau_2-\tau_3) = \tau_{GP}^*. \tag{3.11}$$

[21] A social planner can also consider a discounted aggregate of the welfare of all generations, in order to tackle the intergenerational optimality condition, which is a general source of inefficiency for the overlapping generation model without bequests.

For the remaining part of the paper, we consider that this tax policy is implemented so that the net of tax rate of return is equal to:

$$r^c = \alpha^2 \cdot A^{1/\alpha} \cdot (1-\alpha)^{(1-\alpha)/\alpha} \cdot (1-\tau_2-\tau_3)^{1/\alpha} \tag{3.12}$$

The change with respect to Barro's [1990] result is only due to the financing of specific financial infrastructures ($\tau_2+\tau_3>0$). Indeed, an increase in the tax rate for financial infrastructures lower the net of tax aggregate return on capital r^c. But they are able to increase the growth rate and welfare through the fixed intermediation cost parameter (f) and the depositors transactions costs (d).

4. Financial Infrastructures and Growth

4.1. Financial Infrastructures and Banks Fixed Intermediation Costs

The welfare maximising tax rate is given by:

$$\begin{aligned}\frac{\partial U_A}{\partial \tau_3} &= 0 \Leftrightarrow 0 = \frac{d}{2\cdot s}\cdot\left[\frac{g_{\tau_3}}{g}-\frac{r^c_{\tau_3}}{r^c}\right]+ \\ &+n^*_{\tau_3}\cdot\left\{(r^c-f)\cdot\left[\log\left[\frac{r^c-f}{\mu}\right]-1\right]-\mu\right\} \\ &+n^*\cdot\left[r^c_{\tau_3}\cdot\log\left[\frac{r^c-f}{\mu}\right]\right]\end{aligned} \tag{4.1}$$

with $g_{\tau_3}=\partial g/\partial\tau_3$ and $r^c_{\tau_3}=\partial r^c/\partial\tau_3$. It is therefore necessary to compute g_{τ_3}. From (3.7), one obtains:

$$\frac{g_{\tau_3}}{g}=\frac{2\cdot r^c_{\tau_3}}{r^c}+\frac{r^c_{\tau_3}-2\cdot f_{\tau_3}(\tau_3)}{2\cdot f(\tau_3)+\mu-r^c}+\frac{r^c_{\tau_3}-f_{\tau_3}(\tau_3)}{r^c-f(\tau_3)+\mu} \tag{4.2}$$

A decrease in fixed intermediation costs due to financial infrastructures increases growth through an increase in the amount of savings due to a rise in the number of depositors for each bank and an increase in the number of banks. On the other hand, a rise in the tax rate τ_3 decreases the net of tax aggregate productivity r^c so that the wage income is reduced, as well as the number of banks and the market share for each bank. This trade-off leads to an interior solution if the marginal productivity of new investment in this kind of financial infrastructure is sufficiently high.

The first term on the right hand side is negative and represents the negative effect of taxation on wages through a decrease in the aggregate private productivity. The second term is the effect of financial infrastructures on the number of banks. When τ_3 is small, the marginal productivity of new investment in this kind of financial infrastructure $|f'(\tau_3)|$ is large so that the effect of an increased τ_3 is to augment the equilibrium number of banks. $f'(\tau_3)$ goes to zero as τ_3 increases, so that the positive effect is reversed, and the equilibrium number of banks eventually decreases when τ_3 is large. The third term represents the change in the market share of one bank l^* and thus a change in the number of depositors. For a small τ_3, $|f'(\tau_3)|$ is larger than $r^c_{\tau_3}$, and becomes smaller as τ_3 rises.

From equation (4.1), it is obvious to remark that the growth maximising tax rate, for which $g_{\tau_3} = 0$, is not in general equal to the utility maximising tax rate. A counter-example is provided with $A = 5.7$, $\alpha = 0.45$, $d = 1.75$, $\mu = 1.02$, $s = 0.5$ and $f[\tau_3] = 0.2 [\tau_3]^{-0.8}$, one obtains a growth maximising tax rate of approximately 2.46%, and an average utility maximising tax rate of approximately 2.36%.

The benefits of financial infrastructures as decreasing the fixed costs of intermediation are not equally shared by households. Only the agents going to the bank obtain a higher return (on their savings) due to a rise in the deposit rate. A few "marginal" households benefit from infrastructures and shift their savings from the storage technology to deposits (the effect on the number of banks and on l^* in the welfare function). But a range of households do not benefit from intermediation, and therefore from financial infrastructures. The average household put less weight on financial infrastructure than a growth maximising government so that welfare maximising tax rate is *lower* than the growth maximising one.

4.2. Foreign aid and poverty trap

The existence of this growth maximising level of financial infrastructures allows to consider the case of countries stuck in a poverty trap, if they invested a suboptimal level of financial infrastructures $\tau_3 < \tau_3^*$ such that $r^c(\tau_3) < f(\tau_3) + \mu$. The optimal level of financial infrastructures may verify the condition $r^c(\tau_3^*) > f(\tau_3^*) + \mu$. In these cases, a shift to the optimal level of financial infrastructures allows the country to take off from the poverty trap. Economies in transition are an example for such a shift from sup-optimal financial infrastructures to a higher level, as a precondition for economic growth.

In this model, we consider a closed economy, where government cannot rely on foreign capital. An extension can deal with foreign aid directed to financial infrastructures. If funds and transfers of banking technology are specifically directed, during a long enough period, to countries where the financial sector is rudimentary, this may increase internal savings and help to take off from a poverty trap. To rationalise a *temporary* foreign aid, one could assume for example that financial infrastructures are not fully depreciated at each period.

4.3. Financial Infrastructures and Depositors Transaction Costs

From now on, we consider that the optimal policy for the previous kind of financial infrastructure is implemented, so that $\tau_3 = \tau_3^*$. We study the effect of financial infrastructures through a decrease of depositors transaction costs on economic growth. The positive effect of infrastructures on growth comes through the effect of financial infrastructures on the distance $l^* = \frac{r^c(\tau_2)-(f+\mu)}{d(\tau_2)}$. The transaction cost d does not affect the number of banks or the real wage. l^* represents the number of people who will bring their savings to a bank. More precisely,

$$\frac{l^*_{\tau_2}}{l^*} = \frac{r^c_{\tau_2}(\tau_2)}{r^c(\tau_2)-(f+\mu)} - \frac{d_{\tau_2}}{d} \tag{4.3}$$

Collected savings increase with an increase of market share for banks l^* which increases with τ_2 as long as the marginal gain of transportation cost reduction $-d_{\tau_2}/d$ is greater than the marginal cost of the reduction of productivity of firms due to taxation (the first term of the right hand side expresssion). On the other hand, an increase of the tax rate τ_2 imply a decrease of the number of banks and a decrease of individual savings due to the decrease of net of tax productivity. The growth rate is balanced according to the same trade-off:

$$\frac{\partial g}{\partial \tau_2} = 0 \Leftrightarrow \frac{l^*_{\tau_2}}{l^*} + \frac{2r^c_{\tau_2}}{r^c} + \frac{r^c_{\tau_2}}{2\cdot f+\mu-r^c} = 0 \tag{4.4}$$

The first expression between square brackets above is decreasing with τ_2 whereas the second expression increases with τ. Under suitable conditions on the parameters such that the economy remains in the "local monopoly" regime on the deposit market ($f+\mu < r^c(\tau_2) < 2\cdot f+\mu$)[22] and such that the marginal productivity of new investment in this financial infrastructure is sufficiently high, $\frac{d_{\tau_2}}{d}$, there exists an interior solution τ_2^* such that the difference between the two expression vanishes and the growth rate is maximised.

We now consider welfare implications of our analysis. The "average" household maximises:

$$\log[r^c g] + \frac{2\cdot s\cdot n^*}{d}\cdot\left\{r^d\cdot\left[\log\left[\frac{r^d}{\mu}\right]-1\right]-\mu\right\}$$

Deriving the expression with respect to τ_2 gives the following expression:

$$\begin{aligned}\frac{\partial U_A}{\partial \tau_2} &= 0 \Leftrightarrow \frac{1}{2\cdot s}\left[\frac{g_{\tau_2}}{g} - \frac{r^c_{\tau_2}}{r^c}\right] + \\ &\quad \frac{n^*_{\tau_2}\cdot d - n^*\cdot d_{\tau_2}}{d^2}\cdot\left\{r^c - f\cdot\left[\log\left[\frac{r^c-f}{\mu}\right]-1\right]-\mu\right\} \\ &\quad +\frac{n^*}{d}\cdot\left[r^c_{\tau_2}\cdot\log\left[\frac{r^c-f}{\mu}\right]\right] = 0\end{aligned} \tag{4.5}$$

From this equation, it is obvious to remark that the growth maximising tax rate, for which $g_{\tau_2} = 0$, is not in general equal to the utility maximising tax rate. Taking a

[22] The regime with full collection of deposits over the circle implies the same welfare trade-off than the regime with local monopolies. The trade-off disappears for the growth rate.

numerical example with $A = 5.7$, $\alpha = 0.45$, $f = 1$, $\mu = 1.02$, $s = 0.5$ and $d[\tau_2] = 0.2 \cdot [\tau_2]^{-0.8}$, one obtains a growth maximising tax rate of approximately $6,2\%$, and a utility maximising tax rate of approximately $5,8\%$. This counter example shows that the welfare maximising tax rate can be *lower* than the growth maximising. The growth rate is given through the savings of households who provide deposit, as we assumed that only deposits are invested in accumulable and productive assets. The remaining part of savings are stored in non productive assets by the households for whom the "trip to the bank" remains too costly and *who do not benefit from the financial infrastructures.* Hence, the average household put less weight on public infrastructure than a growth maximising government.

5. Conclusion

This paper deals with the effect of financial infrastructures on economic growth, with financial intermediaries as local monopolies due to horizontal differentiation. Financial infrastructures decrease depositors transaction costs or fixed intermediation costs. They change consumer welfare through an increase of the proximity of financial services, which in turn increases savings and endogenous growth. Endogenous growth models have mostly stressed the effect of public capital directly inside the aggregate production function. To some extent, they neglected a *simultaneous* effect on the welfare of households caused by the use of public capital, which may be of the same order as the effect of infrastructure on the productive sector.

Assuming an elastic demand for deposit with respect to the interest rate is possible, albeit a complicated expression of aggregate deposit. First, the effect will be similar to standard cournotian imperfect competition models of intermediaries which have already been dealt with previous endogenous growth articles. Second, this assumption will not change the two basic points we wanted to stress: (i) local monopolies limit savings through the number of depositors, (ii) financial infrastructures help to relieve the transaction costs, and, as a consequence, the extent of imperfect competition.

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