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Are Banks Too Many? A Theoretical Possibility and a Policy Issue

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ABSTRACT

Motivated by the Blackorby-Schworm (1993) observation that market outcomes may differ from those originating in market-actor optimization, this paper claims that the number of banks in the market is larger than the number justified by bank profit maximization alone or in combination with bank depositor welfare maximization. This claim is made within the context of bilateral monopoly banks and intertemporal utility maximization by bank depositors. The basic policy implication towards bank population rationalization is a minimization of the deviation away from the optimal interest rate margin at every stage of the business cycle. It is meant to be an acyclical policy though the target of optimal bank population is attainable by active countercyclical policy as well. The nature of this policy issue makes the use of macroprudential measures imperative, jointly perhaps with a fiscal-monetary policy mix. A dynamic version of the model in a Cournot environment is akin to the modeling of Minsky's hypothesis of financial fragility.

KEYWORDS

Bank competition; Business cycles; Macroeconomic policy

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1. Introduction

The differing empirical findings of the voluminous banking literature make one think that one reason for the differences may be the neglect of some notion of socially optimal bank population as the basis for discussion. Such a study task may appear to be superfluous when urgent policy issues are debated in view of bank markets with a limited number of sizeable banks, and when even then competition among them may be fierce given the multiproduct character of this market. For example, Bikker and Spierdijk (2010) report that market structure itself does not harm competition. However, the keyword here is a "socially optimal" number of banks independently of the matter of competition: Which should bank population be if market tendencies were shaped by bank profit maximization alone or in combination with bank depositor-consumer utility maximization, instead of the opposite; that is, instead of having banks and depositors running after market developments. The answer might be any specific number depending on model assumptions rather than readily refutable empirical evidence trying to detect whether there is some specific concentration-competition pattern that is consistent with efficiency.

More precisely, this paper elaborates upon the bare essentials of such a model. The key observation is that bank-borrower relations are mostly personal, and the market loan demand and supply do not coincide with those coming out of some notion of representative bank/borrower supply/demand (Blackorby and Schworm, 1993). Can it be said that the market thus corrects for the "personal" element, that the optimal bank population is then the one implied by the market, and that banks should be chasing after market outcomes instead of having banks molding the market? The answer would be in the affirmative if banks and borrowers were identical, which in reality is not true. Since in this paper banks are assumed to be identical but no particular assumptions about borrowers are made except for simplicity that only businesses, no households, borrow, the real issue is if the number of banks is the one that bankers and their input suppliers, not the market, would wish.

The optimality of competition intensity comes as a by-product of this optimal number, which is also the optimal concentration. Any discussion of the banking sector is made within this strictly microeconomic framework, assuming away the industrial economics of the topic under investigation (factors like those associated with financial market failures). There is much literature on this economics but with no point of reference for the arguments advanced. The proper questions that should be raised methodologically are: Given this or that difference between the actual and socially desirable number of banks, what does this or that industrial economics hypothesis implies about it?[1] How sensitive are these implications to alternative model assumptions and/or extensions of the basic modeling? Which of these implications are validated or refuted by empirical evidence? An extensive line of research may thus be put forward in the expectation of obtaining a better policy-related understanding of the behavior of the banking system.

Indeed, the focus is not on microeconomics and industrial economics *per se* but on using them to arrive at a set of policy measures compromising macroeconomic performance (including income and wealth redistribution) with free banking efficiently. This is at least the mindset characterizing this article; more so when it is the macroeconomic repercussions of banking that make it different from the rest of the industry and worthy of special investigation. For example, large-scope economies would be welcome both micro- and macro-economically; but it is also a factor posing barriers to new entry, and the costs and benefits of the pros and cons have to be assessed before any definite conclusions are reached. They would be conclusions that if they were pointing to policy intervention, not only competition but also macroeconomic authorities would be called forth to intervene. Should the matter be seen within the broader context of financial system diversity with a mix of small and large institutions? What do large-scope economies imply for the relative size of the financial system compared to the real economy? What is the right

[1] Microeconomics is quite clear on how to handle the difference in causality between market agents and market outcomes. Industrial economics, and more so empirical industrial economics, is not. The structure-conduct-performance paradigm wants by its very definition the market to be dictating behavior, while the hypothesis of quiet life forgets depositors and wants bankers dancing on the beat of the markets dazzled by the success of their businesses. The "new" industrial organization wants firms in general to be shaping the market but in terms of entry competition on incumbent firms preferably within a game-theoretic setting. The efficient-structure hypothesis according to which superior efficiency including efficiency in monopoly-seeking activities, increases market concentration even to the point of ending up to "socially desirable" monopolies, while according to the contestability hypothesis, monopolies may still opt to have this social profile in fear of new entry (Shepherd 1990). And, finally, there is empirical industrial economics based on econometric modeling tailored to the question and industry being studied. It is clear that although each of these strands in industrial economics has its own merit, none of them starts from the basics of whether firm behavior shapes or is shaped by market outcomes and of comparing these outcomes in line always with standard microeconomics. The non-price factors that industrial economics is supposed to introduce into the microeconomics of the firm and the market may be contemplated once this comparison has been made.

balance between bank size on the one hand and bank soundness and proneness to propagating instability on the other? These are examples of questions that the authorities would have to deal with before policy intervention, and their type is decided in response to only one issue, namely that of large-scope economies. It is evident that the banking system is pervaded by much complexity with profound consequences for the course of the overall economy.

The next section combines the typical textbook approach to the loan market with bank profit maximization in an imperfectly competitive banking system, which is also a monopsonist of bank deposits; that is, the system is modeled as a bilateral monopoly. Each individual bank is a monopsonist too, given that deposits are homogeneous goods and all banks provide typically the same deposit rate regardless of the bank market structure (Adams et al., 2002). This would be true for regulated deposit rates too if this rate was close to that set by unregulated monopsony (Mingo, 1980); unless off-balance sheet competition takes place, in which case monopsony becomes a feature of individual banks but does not extend to the industry (Zephirin 1994). The presence of non-bank thrift institutions, interest-bearing saving accounts, investment funds and life insurance policies (such as annuities) do provide a source of competition, which may be the reason for the limited attention that this matter has received by the literature, But, again, the elasticity of residual demand, which dictates the attractiveness of unilateral price change, is very small for each of these products, because substitutability among them holds only in principle; in practice, their characteristics differ (Bikker and Spierdijk 2010). The differences in the rates across institutions are negligible, and individual banks may very well be monopsonies. Another feature of the analysis in this section is the acknowledgment of the presence of non-performing loans, which is a factor becoming important when policy is introduced in the discussion of section 3. The analysis is a static one but predisposes the dynamic investigation in section 4. The main result of section 2 is that banks in the market are too many relative to those justified either by bank profit maximization alone or in combination with depositor-consumer welfare maximization.

Section 3 points to the procyclicality of the banking system, which in the context of the analysis of section 2 is attributable to the large number of banks. It next contemplates upon the policy implications of the discussion in section 2 or the same, of procyclicality, by arriving at an acyclical interest-rate-spread rule as a means of fostering acyclical bank population, that is, a bank number at each stage of the business cycle that does not exceed the socially optimal one, the number justified by optimization on the part of banks and depositors. The spread rule towards the rationalization of bank population might be pursued by the central bank either directly, by imposing to the market the bank profit margin dictated by the national income statistics of the particular moment of the business cycle, or indirectly, by adopting the tax rate and money supply policy that will induce the market to the desirable profit rate. The efficacy of this fiscal-monetary policy mix is influenced by the fraction of nonperforming loans. For the same reason, efficiency, this policy mix should be combined with macroprudential measures as well, given the large information requirements upon which the fiscal-monetary policy mix has to be based. The introduction in the discussion of a balanced government budget elucidates this policy mix even further. Section 3 also discusses the attainment of the goal of bank population rationalization as a by-product of broader counter-cyclical policy.

Section 4 presents a dynamic version of the basic equation for bank population, complete with a second one about national income, as it comes out of a dynamic variant of the Cournot theorem for the banking sector. That is, there is a system of two differential equations, acknowledging the influence that loan market concentration and competition can exert on bank numbers and vice versa. According to the theoretical and empirical literature on concentration & competition, the standard thesis is that bank competition is conducive to growth, but the stability of the banking system is better served by market power (Vives, 2001). To overcome this trade-off, the concept of contestability, one akin to the dominant bank-firm market, has been proposed: competitive behavior, with any outstanding market demand satisfied by bank-firms with market power (Northcott, 2004); which does show to be more competitive in practice relative to what the Cournot oligopoly would imply (Coccorese, 2005). However, contestability is a framework acknowledging the role factors like competition-promoting regulation, extent of financial system development, effects of branch networks, and influence by technological progress, can have in shaping contestability beyond the factors of the number of banks and the degree of concentration. Therefore, this article abides by the standard practice of following the Cournot approach as an intermediate case between monopoly and perfect competition, given that the examination of factors unrelated to pricing is not of concern here.

To sum up other noteworthy results, a key condition, in order to have a positive number of banks in the market, is that loan supply should be more sensitive than loan demand to lending rate changes. Increased sensitivity of loan supply to output fluctuations relative to the sensitivity of loan demand is also found. Bank population increases/decreases during output expansion/contraction, enhancing/diminishing thereby bank competition and lessening/rising, in turn, the interest rate margin. Banking is procyclical because of the presence of too many banks. There is a sharp increase and decrease in bank numbers during the course of the business cycle, but there are banks at the trough of the cycle that refuse to leave the industry. The fiscal-monetary policy mix towards bank population rationalization by minimizing the interest rate margin deviation away from its optimal value, involves an inverse co-movement in the tax rate and money supply, whose prerequisite is (i) a minimum loan performance rate, and (ii) a minimum quantity of money below which borrowers may not be able to continue servicing their loans. In the dynamic analysis, the fixed point is consistent with at least three banks, and once the long-run equilibrium is disturbed, anything can happen. Finally, the Cournot approach to the dynamic version of the model is akin to the modeling of Minsky's hypothesis of financial fragility. Section 5 concludes this paper by looking at the intertemporal aspect of the policy, possible extensions of the model, and prospects for empirical work.

2. Theoretical Considerations

The premises of the theoretical discussion are quite simple in comparing loan market quantities consistent first with bank profit maximization, and then with depositor-consumer welfare maximization. Let $\varkappa$ be the fraction of borrowing businesses from banks servicing their loan(s) as prescribed by the loan agreement. That is, if total business loan demand is $L^d = bY - \beta r$:

$$\varkappa L^d = \varkappa(bY - \beta r) \tag{1}$$

Given that modeling loan demand in terms of the output level, Y, and the lending rate, r, is commonly accepted (Calza et al., 2003); b and β are positive coefficients. Even if borrowing firms are identical, bank-borrower deals are made on a case-by-case basis, the personal element is involved, and hence, the community loan demand does not correspond to the summation of representative-firm loan demand *à la* Blackorby and Schworm (1993). The presence or not of $\varkappa$ does not affect the interest elasticity of loan demand:

$$e_r^d = \frac{\partial \varkappa L^d}{\partial r}\frac{r}{\varkappa L^d} = -\frac{\beta r}{(bY - \beta r)} = \frac{\partial L^d}{\partial r}\frac{r}{L^d} \tag{2}$$

Consider also the following empirically-valid *ad hoc* formulation of loan supply according to which supply depends on money holdings, M, and the interest rate spread, $(r - \rho)$, so that:

$$L^s = hM + c(r - \rho) \tag{3}$$

where ρ is the deposit rate, h and c are some positive constants, and M is nominal money supply (Huelsewig et al., 2005). The Blackorby-Schworm argument made in connection with market loan demand might as well apply to market loan supply in the face of identical banks. In any case, the loan supply elasticity with respect to deposit rate is:

$$e_\rho^s = \frac{\partial L^s}{\partial \rho}\frac{\rho}{L^s} = -\frac{c\rho}{hM + c(r - \rho)} \tag{4}$$

which, given that loan supply is a multiple of bank deposits, is equal to the elasticity of deposit supply with respect to ρ but with opposite sign. Market equilibrium occurs when $L^s = L^d$: $hM + c(r - \rho) = (bY - \beta r) \Rightarrow$

$$r' = \frac{bY + c\rho - hM}{\beta + c} \tag{5}$$

where $bY + c\rho > hM$. To find the number of banks, N, needed to sustain this equilibrium when the banking system is imperfectly competitive and the single buyer of deposits with all the bargaining power on its side, and when subsequently the equality between marginal revenue and marginal cost takes for each bank the form:

$$r^* = \rho \frac{1 - \frac{1}{Ne_\rho^s}}{1 + \frac{1}{Ne_r^d}} \tag{6}$$

We insert Eqs. (2) and (4) in Eq. (3), and solve for r:

$$r^* = \frac{c\beta\rho(N - 1) + \beta hM + cbY}{c\beta N} \tag{7}$$

equate next Eq. (5) with Eq. (7) and solve for N:

$$N' = \frac{(\beta + c)(\beta hM + cbY - \beta c\rho)}{\beta c(bY - hM - \beta\rho)} \tag{8}$$

Eq. (6) captures the quantities desired by the typical bank, whereas Eq. (3) is an *ad hoc* formulation describing what actually happens in the loan market, given anyway that a supply curve under imperfect competition cannot be defined. Specifically, what banks experience in the market, the "empirical" equilibrium is $L^s = \varkappa L^d$: $hM + c(r - \rho) = \varkappa(bY - \beta r) \Rightarrow$

$$r'' = \frac{\varkappa bY + c\rho - hM}{\varkappa\beta + c} \tag{5'}$$

where $\varkappa bY + c\rho > hM$. When Eq. (5') is equated to Eq. (7), and the resulting expression is solved for N, gives:

$$N'' = \frac{(\varkappa\beta + c)(\beta hM + cbY - \beta c\rho)}{\beta c(\varkappa bY - hM - \varkappa\beta\rho)} < N' \Rightarrow \tag{8'}$$

$\varkappa(\beta hM + cbY - \beta c\rho) < (\beta hM + cbY - \beta c\rho)$, which is true given that $\varkappa < 1$. That is, the number of banks that could satisfy $\varkappa L^d$ in a profit-maximizing way for the banks is less than the actual number that has come up under market equilibrium. Consequently, the banking system is subject to default losses, especially when $r' < r'' \Rightarrow \varkappa < 1$ as well.

Note that having equated the profit-maximizing loan rate to the market ones, quantities r', r'', N', and N'', capture the adjustment of banks to market conditions so as to make the most out of these conditions in terms of profitability. It is the market circumstances not the desires of the banks that shape the loan market. To see the compatibility of this behavior with the welfare of bank depositors, let ϱ be the rate of return on saving by assuming that depositors-consumers maximize utility, U, form consumption, $\mathbb{C}$, according to the utility function: $U(\mathbb{C}) = \mathbb{C}^\zeta + \mathbb{C}_1^\zeta + G^\xi$, subject to the budget constraints: $\mathbb{C} = (1 - t)Y - S$ and $\mathbb{C}_1 = \varrho(1 - t)S$, where S is saving, G is a public good, t is the proportional income tax rate levied to cover the production cost of G, subscript "1" denotes next time period, and coefficients $\zeta, \xi \in (0,1)$, reflecting decreasing marginal utility. Substituting the constraints into the utility function, the solution to the maximization problem gives that:

$$\varrho^* = \frac{S^\varepsilon}{(1 - t)[(1 - t)Y - S]^\varepsilon} \tag{9}$$

where $\varepsilon = (1 - \zeta)/\zeta$.[2] Letting $S = \gamma Y$, with constant $\gamma \in (0,1)$, (9) becomes:

$$\varrho^* = \frac{\gamma^\varepsilon}{T} \tag{9'}$$

where $T = (1 - t)(1 - t - \gamma)^\varepsilon$. Certainly, $\varrho^* < 1 \Leftrightarrow \gamma^\varepsilon < T$. Such a treatment of consumers is consistent with the assumption of profit-making banks. They are owned by the current generation, which saves by both depositing and purchasing equity shares of banks. Loan supply is based on these deposits and this equity capital as part of the overall money reserves of the banks. Arbitrage equates the rates of return to deposit and equity. When the current generation becomes old in the next period, its consumption in that period will consist of bank profit as well. And, of course, the optimum, welfare-maximizing deposit rate should satisfy: $\rho^* = \varrho^*$.

Now, noting that all quantities are in current prices, one might set: $M = \mu Y$, $\mu > 0$, which when it along with Eq. (9') are inserted in Eq. (7) given $\rho^* = \varrho^*$, one may subsequently obtain the bank-consumer welfare-maximizing equilibrium interest rate margin:

$$r^* - \rho^* = \frac{T(\beta h\mu + cb)Y - \beta c\gamma^\varepsilon}{c\beta TN} \tag{10}$$

which when in turn is solved for N, gives:

[2] The associated saving supply elasticity with respect to ρ is $\eta = 1/\rho\varepsilon\{1 - [\rho(1 - t)]^{1/\varepsilon}\}$. If saving is wholly deposited with the banks, this is also the deposit supply elasticity. Equating it with the loan supply elasticity, one obtains that $L^s = c\varepsilon\rho^2\{1 - [\rho(1 - t)]^{1/\varepsilon}\}$ provided that loan supply is a multiple of deposits.

$$N^* = \frac{T(\beta h\mu + cb)Y - \beta c\gamma^\varepsilon}{c\beta T(r^* - \rho^*)} \tag{11}$$

Social welfare maximization follows intuitively from the fact that although bank-depositor deals are taking place within a bilateral monopoly environment, banks are owned by depositors and have to satisfy their owners. But, when Eq. (9') is inserted as ρ^* to market equilibrium r's given by Eqs. (5) and (5'), one obtains that:

$$\bar{r}' = \frac{c\gamma^\varepsilon + T(h\mu - b)Y}{(\beta + c)T} \tag{12}$$

$$\bar{r}'' = \frac{c\gamma^\varepsilon + T(h\mu - \varkappa b)Y}{(\varkappa\beta + c)T} \tag{12$'$}$$

While as far as Eqs. (8) and (8') are concerned, they become:

$$\bar{N}' = \frac{(\beta + c)[T(\beta h\mu + cb)Y - \beta c\gamma^\varepsilon]}{\beta c[T(h\mu - b)Y - \beta\gamma^\varepsilon]} \tag{13}$$

$$\bar{N}'' = \frac{(\varkappa\beta + c)[T(\beta h\mu + cb)Y - \beta c\gamma^\varepsilon]}{\beta c[T(h\mu - \varkappa b)Y - \varkappa\beta\gamma^\varepsilon]} < \bar{N}' \tag{14}$$

or, in view of Eq. (11):

$$\bar{N}' = \frac{(\beta + c)(r^* - \rho^*)}{[(h\mu - b)Y - \beta\rho^*]} N^* > N^* \tag{13$'$}$$

$$\bar{N}' > \bar{N}'' = \frac{(\varkappa\beta + c)(r^* - \rho^*)}{[(h\mu - \varkappa b)Y - \varkappa\beta\rho^*]} N^* > N^* \tag{14$'$}$$

Given that $h\mu > b$ and $h\mu > \varkappa b$ so as the first derivatives of the $\bar{N}$'s with respect to Y to be positive. The bar (¯) above the r's and N's indicate quantities consistent with profit-maximizing bank behavior, shaped not only by market circumstances but by deposit rate "demands". The number of banks is excessive relative to the social welfare maximizing one, which implies that the industry is always in disequilibrium. Noting that all quantities depend ultimately on Y − which is known to be subject to cyclical fluctuations − it appears that during a recovery, the number of banks entering the market to satisfy the increasing banking needs is excessive, and during a recession, banks hesitate to leave the market.

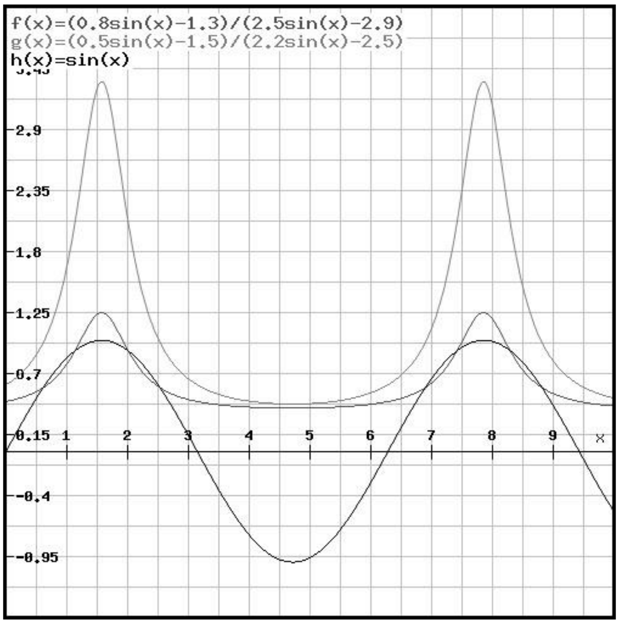

Figure 1. The cyclical relationship between $N, sin(Y)$ (vertical axis), and Y (horizontal axis).

The example of uniform fluctuations is illustrated in Fig. 1, where Y, along the horizontal axis, has been set equal to $sin(Y)$, appearing jointly with N on the vertical axis, as N is described by (13) or (14). To be more precise, consider the two inequalities: $c > \beta$ and $c > \varkappa\beta$, which should hold in order to have positive N's (see Appendix). They make clear that in order to have positive N's in the market, and to have actually banks in a market economy, one key condition is that loan supply in the market should be more sensitive than market loan demand to lending rate changes. Intuitively, lender sensitivity is one way of self-protection from lending- and thereby default-rate fluctuations as the reduced sensitivity reflected by inequality $c > \varkappa\beta$ relative to sensitivity under inequality $c > \beta$ suggests; contrary to the latter inequality, the former one does take into account the default rate. There is also, increased sensitivity of loan supply to output fluctuations relative to the sensitivity of loan demand: $h\mu > b$ and $h\mu > \varkappa b$. These exact considerations surrounding the positiveness of N's explain: (i) why it is the case of having too many banks in the market relative to what bank profit maximization indicates, and not the opposite case of not having enough banks under profit maximization relative to the needs of the market, (ii) why from the above relationships $\partial(r^* - \rho^*)/\partial Y > 0$, $\partial(r^* - \rho^*)/\partial N < 0$, and $\partial N/\partial Y > 0$, viz. that bank population increases/decreases during output expansion/contraction, enhancing/diminishing thereby bank competition, and lessening/rising, in turn, the spread, and (iii) why according to (13') and (14'), these cyclical trends are realized in the market more intensively.

3. Policy Implications

The higher steepness of the supply curve in the loan market relative to the slope of the demand curve suggests the presence of Marshallian, short-run quantity stability, despite the assumption of imperfect competition (Davies 1963, Purcell et al. 1999). Yet, the matter of medium- and long-term stability does pose a policy problem. Fig. 2, where $Y = sin(Y)/Y$ so that output fluctuations can be damped, does produce convergence for the number of banks too, but at again a large number of banks.

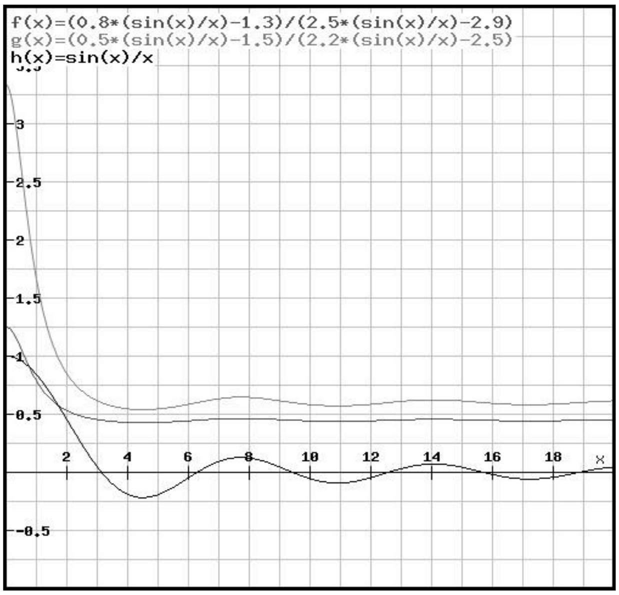

Figure 2. The cyclical relationship between $N, sin(Y)/Y$ (vertical axis), and Y (horizontal axis).

Equally disturbing are the trends in banking numbers depicted by Fig. 3, which has been generated by the complicated configuration $Y = 0.6cos(3Y) - 0.3cos(7Y)$.

Trends in all three diagrams are in line with the stylized fact of procyclical banking (Huizinga and Laeven, 2019); one reason for the procyclicality is the excessive number of banks. Furthermore, it is noteworthy that there is a sharp increase and decrease in bank numbers during the course of the business cycle, but there are banks at the trough of the cycle that refuse to leave the industry. Although identical banks and identical subsequently bank behavior have been assumed, exit at a certain moment does not apply to all banks instantly; the remaining ones manage thus to survive the next moment under the new market conditions exit has induced as described by the total differential of N'' in (14) with respect to $\varkappa, Y$, and ρ^* (see Appendix). This is what the diagrams presume and explains why some banks manage to survive during a trough.

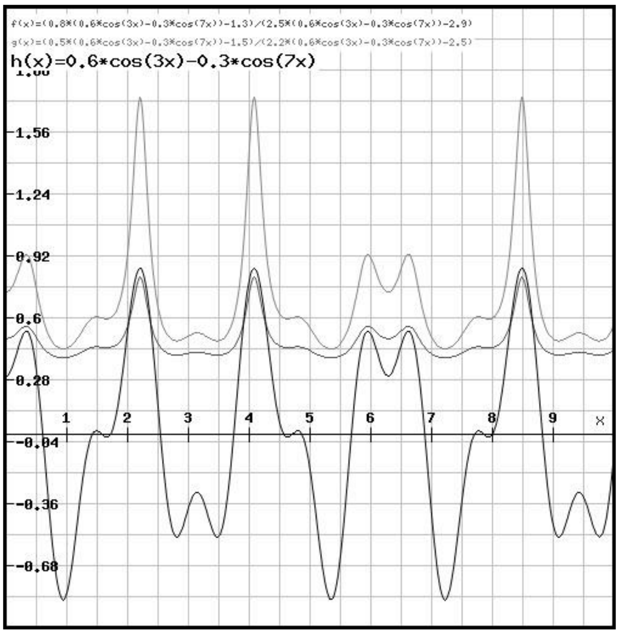

Figure 3. The cyclical relationship between $N, [0.6cos(3Y) - 0.3cos(7Y)]$ (vertical axis), and Y (horizontal axis).

In general, short-run quantity stability in the loan market does not necessarily connote optimality of the number of banks, because presumably of interest rate instability. Our algebra above suggests that the problem with bank numbers might be tackled by trying to have $N^* = N''$ along the business cycle through the interest rate rule, emerging by equating Eq. (11) with Eq. (14'), that is, through the rule:

$$(r^* - \rho^*) = (\mathcal{B} - \mathcal{F}\mu Y + \mathcal{H}Y^2)^{\frac{1}{2}} \tag{15}$$

or since $M = \mu Y$:

$$(r^* - \rho^*) = \left(\mathcal{B} - \mathcal{F}M + \mathcal{H}\frac{M^2}{\mu^2}\right)^{\frac{1}{2}} \tag{16}$$

where:

$$\mathcal{B} = \frac{\varkappa\beta\gamma^{2\varepsilon}}{(\varkappa\beta + c)T^2} = \frac{\varkappa\beta\rho^{*2}}{(\varkappa\beta + c)}$$

$$\mathcal{F} = \frac{\gamma^{\varepsilon}h}{cT} = \frac{h\rho^*}{c}$$

$$\mathcal{H} = \frac{(\beta h\mu + cb)(h\mu - \varkappa b)}{\beta c(\varkappa\beta + c)}$$

The general rule to reduce the part of procyclicality coming out of the presence of too many banks is that the spread should be in tune with the course of national income and money, or with a combination of the two, like the one given by Eq. (17):

$$(r^* - \rho^*) = (\mathcal{B} - \mathcal{F}M + \mathcal{H}Y^2)^{\frac{1}{2}} \tag{17}$$

It is a rule that prescribes direct intervention to the spread driven by the momentum of the cycle, *ceteris paribus*. The presence of Y in Eqs. (15) and (17) and M in Eq. (16) or (17) serve as a national accounts statistic that should be taken into account when calculating the proper spread given that neither the tax rate nor the behavioral parameters of the model change throughout the cycle.

These parameters are those related to loan demand and supply, and to consumer preferences, which and thereby t are subject to the pattern implied by:

$$\frac{d\rho^*}{dt} = \frac{\gamma^\varepsilon[\varepsilon(1-t)+(1-t-\gamma)]}{(1-t)^2(1-t-\gamma)^{\varepsilon+1}} > 0 \tag{18}$$

ρ presumably has to increase to compensate for a reduction in consumption and utility brought about by an increase in the tax rate. This is a conclusion that greatly affects the policy if the target of $N^* = N''$ is to be pursued not through direct intervention to the spread but by using t and M rather as policy means. Totally differentiating the square root of spread in Eq. (16), equating it to zero, and solving from dM/dt, one obtains that:

$$\frac{dM}{dt} = -\left\{\frac{(1-t-\gamma)^\varepsilon[2(\beta h\mu + cb)(h\mu - \varkappa b)M - \beta h(\varkappa\beta + c)\mu^3\rho^*]}{\beta\mu^2[2\varkappa\beta\gamma^\varepsilon c - (\varkappa\beta + c)h]}\frac{1}{d\rho^*/dt}\right\}^{\frac{1}{2}} \tag{19}$$

According to Eq. (19), the response of M to a tax-rate change, which is necessary to have a spread consistent with $N^* = N''$ at a certain point along the business cycle, depends certainly on the deposit rate and the effect of the altered t on this rate. The Appendix shows that Eq. (19) is indeed negative; M's response to a change in t changes in the opposite direction as it should be. For example, an increase in the tax rate raises the deposit rate in order to compensate for the reduction of after-tax income, but lowers the interest rate spread, which decrease may be confronted by lessening money supply according to the standard proposition that smaller money supplies tend to raise the lending rates. Nevertheless, prerequisites for the pursuit of such policy are (i) the minimum loan performance rate that makes the denominator of Eq. (19) positive:

$$\varkappa > \frac{h(\varkappa\beta + c)}{2\beta c\gamma^\varepsilon} \tag{20}$$

since the fraction in Eq. (20) is less than 1 (see Appendix), (ii) the minimum quantity of money below which borrowers may not be able to continue servicing their loans, as one might infer from the condition related to the positiveness of the numerator of Eq. (19):

$$\varkappa < \frac{2(\beta h\mu + cb)h\mu M - c\beta h\mu^3\rho^*}{2(\beta h\mu + cb)bM + \beta^2 h\mu^3\rho^*} \tag{21}$$

As follows: $\varkappa$ in Eq. (21) will be less than one when the denominator exceeds the numerator, which is the case when there is a minimum quantity of money in the economy:

$$M > \frac{\beta^2 h\mu^3\rho^*(1+c)}{2(\beta h\mu + cb)(h\mu - b)} \tag{22}$$

Now, given the stage of the business cycle, Eq. (22) suggests quite schematically that equal-spread loci in the positive quadrant generated by t (horizontal axis) − M (vertical axis) might look as in Fig. 4: Successive increments in the tax rate should be met by increasingly less money supply reductions along a given locus, and the slope of this locus turns positive after the level of M in Eq. (22) is reached, implying a critical level for t as well. Put differently, a government budget cannot consist only of tax revenue or *seigniorage*, which is made quite explicit by the very fact that Eq. (19) is a square root, too. And, the lower the spread, the further a locus lies from the origin of the axes, reflecting general expansion trends in line with empirical findings according to which bank profitability is related inversely to the business cycle due to predatory pricing during expansion and exit that helps remaining banks sustain higher profit margins during recessions (Mandelman, 2011). The positive relationship between credit growth and loan losses during boom periods because of softer credit standards in terms of screening of borrowers and collateral requirements (Jimenez and Saurina, 2006), corroborates this description of the equal-spread loci map, too. Nevertheless, it should be remarked again that in view of Eqs. (19) and (19'), Fig. 4 is only suggestive in illustrating an important point of the policy discussion.

More insight into policymaking may be gained by introducing into the discussion the government budget constraint;

$$G = tY + M \Rightarrow M = \frac{\mu G}{(\mu + t)} \tag{23}$$

given $M = \mu Y$. This is a balanced-budget constraint under which the proposed fiscal-monetary mix becomes feasible at every single stage on the oscillation of the output.

At a given stage, it is a rectangular hyperbola whose slope, $-\mu G/(\mu + t)^2$, has to be equal to Eq. (19) if the policy mix is to be feasible. Tangency point E in Fig. 4 reflects such an equality. But, given the budget line passing through this point, the spread consistent with E may be, say, high relative to that corresponding to a point like Γ on a lower spread locus, (i) because of improper budget drafting, being overly pessimistic about the state of economic activity, or (ii) because the spread at Γ is the one that policy has to rise to the level indicated by point E. In the former instance, the composition of this budget must change; M has to be higher and t lower than at E. Or, both M and t are lowered, shifting the budget line towards the origin of the axes until tangency at point E' is attained. The opposite should be done when E is the correct target. These rules of thumb rather, of what to do once for some reason E is unattainable, are important, given that the synchronization of policy intervention with the stage of the business cycle is practically impossible. Much more so when according to Eq. (19), the equal-spread loci are anything else but the smooth ones depicted in Fig. 4.

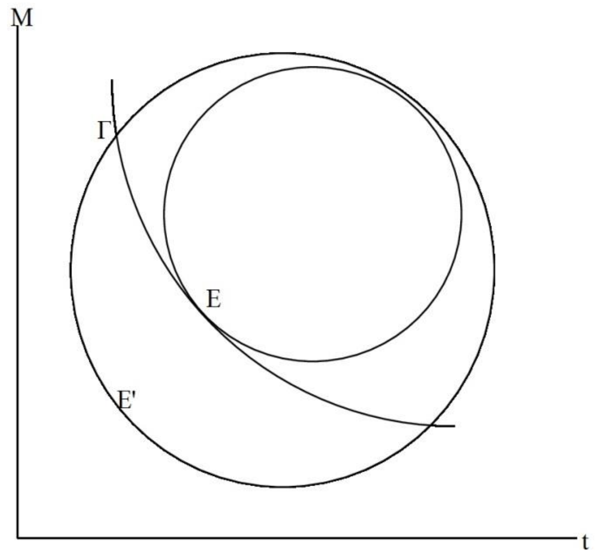

Figure 4. Equal-spread Loci and the Government Budget.

The design of the proper fiscal-monetary policy mix towards the desirable policy-wise spread can prove to be quite a formidable task, because it stumbles on the many information details it presupposes; and if it is not successful, it will strengthen instability. At least medium-term instability will always be present, and improper policymaking can reinforce it, prolong it, and perhaps, perpetuate it. The same destabilizing can be the policy mix if there are other competing policy goals, whose presence is almost certain. For example, the average long-term loan rate has been found to be less volatile than the average deposit rate in the US (Andreasen et al., 2012). According to this paper, this situation does not help synchronize N and N^*, or in general, "rationalize" the number of banks in the system along the business cycle, but it is prone to alleviating consumption and investment reaction to an exogenous shock.

Note that the above interest-rate rule is not a policy against this cycle, but one that takes the cycle for granted and seeks to downsize bank population to the benefit of banks and its customers. The analysis has been static and hence, without explicit reference to the time considerations that would allow feedback on the state of economic activity on the number of banks. Such feedback is made explicit through the dynamics attempted in the next section given the business cycle context within which the main arguments of the present discussion are being advanced. Bearing this in mind, one can still note from now about policy that the target of bank population rationalization might be tackled successfully, indirectly as a by-product, so to speak, of a more general counter-cyclical policy as follows.

What is sought policy-wise is the counter-cyclicality of money supply and at least acyclicality of tax policy, as these would be conducive to, among other things, bank-numbers rationalization along with some macroprudential policy, targeting the number of banks directly. Although knowledge of the macroprudential tools is still limited, and there may be coordination problems with microprudential policies, evidence suggests that these tools do reduce procyclicality (Claessens, 2015), that at least a combination with monetary policy whenever circumstances require so in the Swedish fashion of "leaning against the wind" is welcome (Svensson, 2018), and that from an Austrian-School perspective, the destabilizing role of central banking can be minimized (Facchini, 2015). But again, the current view about prudential policies is linked to financial crises, while herein, they are invoked as a systematic policy means against procyclicality. For example, bailouts are meaningless within the context of the view of macroprudential policy held here, and some financial fragility may be desirable to the extent banks engage in maturity transformation (Diamond and Rajan, 2001). The term macroprudential policy is used here in the old sense of up to the 1970s government stance of targeting a specific sector, which in our case is banking; "the name is different, but the policies are similar... [or,] old wine in new bottles" in many instances as Shin (2016 [2015, 1]) puts it.

Such macroprudence can complement a fiscal-monetary policy mix against procyclicality in general and not against particularly banking procyclicality. In industrial economies at least, tax policy is already acyclical and in many instances countercyclical (Vegh and Vuletin, 2014). Fiscal rules for government expenditure can make this trend robust (Nerlich and Reuter, 2015). The fact that fiscal policy in general remains procyclical in developing countries gives us the opportunity here to point out that what is of concern for this paper is the cyclicality of tax-only policy. The general remark is that it can be at least acyclical and is compatible with a macroprudence seeking to "rationalize" the number of banks in the system. Money supply too, and the overall monetary policy, can act counter-cyclically depending again on the quality of political economy (Calderón et al., 2012), and as cautioned, for instance, by Ireland (1996). Alternatively, it might be those jointly optimal monetary and prudential policies, set the interest rate and bank-capital requirements, respectively, to deal the former with the business cycle and the latter with inefficient risk-taking by banks (Collard et al., 2017). In any case, special features of banking like the procyclical or counter-cyclical character of equity issuance (Baron 2015), the role of public banks (Capeleti et al., 2018), or the size distribution of banks (Aiyar et al., 2018), are certainly expected to influence the performance of any policy and have to be addressed by the policymaker explicitly.

4. Market Concentration, Competition, and Dynamics

In order to have a glimpse of the dynamics associated with the topic under examination, market concentration and competition have to be introduced in the discussion as follows. To account for the role of the loan performance rate too, the expression of $\bar{N}''$ in Eq. (14) is considered, with Y being replaced by its time derivative, $\dot{Y}$. Solving the resulting relationship for $\dot{Y}$ yields the following nonlinear differential equation:

$$\dot{Y} = \frac{\beta c\gamma^{\varepsilon}[\varkappa\beta N - (\varkappa\beta + c)]}{\beta cT\mathbb{Z}N - (\varkappa\beta + c)T\mathbb{Q}} \tag{24}$$

where: $\mathbb{Q} = (\beta h\mu + cb)$ and $\mathbb{Z} = (h\mu - \varkappa b)$. This is a lagged, so to speak, ad hoc version of Eq. (14) susceptive to dynamic analysis. The derivative:

$$\frac{\partial\dot{Y}}{\partial N} = -\frac{\beta^2 c\gamma^{\varepsilon}(\varkappa\beta + c)[2\varkappa cb - h\mu(c - \varkappa\beta)]T}{[\beta cT\mathbb{Z}N - (\varkappa\beta + c)T\mathbb{Q}]^2} < 0$$

specifies an inverse relationship between output growth and the number of banks in the system. This is because increased bank competition reduces profitability, while increased loan losses make banks vulnerable to bankruptcy. More bank competition lessens market power, diminishes profit margins, and encourages at the same time risk-taking, extending loans on "easier" terms during upturns in economic activity and coming back to trouble banks as precarious loans during downturns (Berger et al., 2017).

To obtain a similar differential equation for the time derivative of $\bar{N}''$, $\dot{N}$, in terms of Y, we introduce the element of market concentration as derives from a dynamic version of the Cournot theorem according to which:

$$L^{ind} = \frac{\dot{N}}{\dot{N} + 1} L^{mkt} \Rightarrow \dot{N} = \frac{L^{ind}}{(L^{mkt} - L^{ind})} \tag{25}$$

where L^{ind} are total Cournot bank-sector loans in a market that clears with quantity L^{mkt}, i.e., with the quantity of loans emerging by solving Eq. (5) for Y, inserting this solution along with Eq. (5) in Eq. (1), (with $\varkappa = 1$), and replacing ρ in the resulting expression by Eq. (9'):

$$L^{mkt} = \frac{T\mathbb{Q}Y - \beta c\gamma^{\varepsilon}}{(\beta + c)T} \tag{26}$$

The discrepancy$(L^{mkt} - L^{ind})$ in Eq. (25) gives the extent of market concentration: The larger the discrepancy, the fewer the banks that service the loan market. Hence, the satisfaction of a need for increased L will induce bank entrance into the market according to the rate implied by the reduction of the denominator of Eq. (25) and the increase of the numerator in response to the higher loan demand.

Next, inserting Eq. (26) in Eq. (25) and solving for $\dot{N}$, yields:

$$\dot{N} = \frac{L^{ind}(\beta + c)T}{Y\mathbb{Q}T - L^{ind}(\beta + c)T - \beta c\gamma^{\varepsilon}} \tag{27}$$

L^{ind} is determined in the Appendix under the simplifying assumption that $\dot{N}$ is some constant percentage, λ, of N, so that $\dot{N} = \lambda N = \lambda\left[L^{ind}/\left(L^{mkt} - L^{ind}\right)\right]$; when this value of L^{ind} is inserted in Eq. (27), yields:

$$\dot{N} = \frac{(\varkappa\beta + c)[T\mathbb{Q}Y - \beta c\gamma^{\varepsilon}]^2}{[\mathbb{Z}\beta c(T\mathbb{Q} - \beta c\gamma^{\varepsilon}) - \mathbb{Q}(\varkappa\beta + c)(T\mathbb{Q}Y - \beta c\gamma^{\varepsilon})]TY - c(\beta c\gamma^{\varepsilon})^2} \tag{28}$$

The derivative:

$$\frac{\partial\dot{N}}{\partial Y} = \frac{(\varkappa\beta + c)(T\mathbb{Q}Y - \beta c\gamma^{\varepsilon})[2T\mathbb{Q}\mathbb{Z}\beta c(T\mathbb{Q} - \beta c\gamma^{\varepsilon}) - 2T\mathbb{Q}c(\beta c\gamma^{\varepsilon})^2]}{\{[\mathbb{Z}\beta c(T\mathbb{Q} - \beta c\gamma^{\varepsilon}) + \mathbb{Q}(\varkappa\beta + c)(\beta c\gamma^{\varepsilon} - T\mathbb{Q}Y)]TY - c(\beta c\gamma^{\varepsilon})^2\}^2} + \frac{(\varkappa\beta + c)T(T\mathbb{Q}Y - \beta c\gamma^{\varepsilon})^2\{\mathbb{Q}(\varkappa\beta + c)[T\mathbb{Q}Y - \beta c\gamma^{\varepsilon}] - \mathbb{Z}\beta c(T\mathbb{Q} - \beta c\gamma^{\varepsilon})\}}{\{[\mathbb{Z}\beta c(T\mathbb{Q} - \beta c\gamma^{\varepsilon}) + \mathbb{Q}(\varkappa\beta + c)(\beta c\gamma^{\varepsilon} - T\mathbb{Q}Y)]TY - c(\beta c\gamma^{\varepsilon})^2\}^2} > 0$$

specifies the rate of increase of the number of banks as a positive function of the level of output. The argument is that during the upturn of economic activity, an increasingly more optimistic outlook prevails, encouraging, among other things, entry into the banking industry.

Eqs. (24) and (28) form a system of two nonlinear differential equations. Setting the former equal to zero, yields:

$$\widehat{N} = \frac{(\varkappa\beta + c)}{\varkappa\beta} > 2 \tag{29}$$

since $\varkappa\beta/\varkappa\beta = 1$ and $c/\varkappa\beta > 1$. The fixed point is consistent with at least three banks. Similarly, Eq. (28) becomes zero when:

$$\hat{Y} = \frac{\beta c\gamma^{\varepsilon}}{T\mathbb{Q}} = \frac{\beta c}{\mathbb{Q}}\rho^* \tag{30}$$

Eqs. (29) and (30) define the only fixed point of the system, $(\widehat{N}, \hat{Y})$. From the Jacobian of the system evaluated at the fixed point:

$$J_{(\widehat{N},\hat{Y})} = \begin{bmatrix} \frac{\partial\dot{N}}{\partial N} = 0 & \left.\frac{\partial\dot{N}}{\partial Y}\right|_{(\widehat{N},\hat{Y})} < 0 \\ \left.\frac{\partial\dot{Y}}{\partial N}\right|_{(\widehat{N},\hat{Y})} > 0 & \frac{\partial\dot{Y}}{\partial Y} = 0 \end{bmatrix}$$

one concludes that the linearization is a center (stable but not asymptotically stable), and the nonlinear system might be either stable or unstable, given $tr(J) = 0, det(J) > 0$ (Teschl, 2012). Once the long-run equilibrium is disturbed, anything can happen, but it is noteworthy that this is a result that one might expect from a Minsky-type limit-cycle approach too, simply because the system Eqs. (24)-(28) is in this spirit as reflected, for instance, by the system (Stockhammer and Michell, 2017):

$$\dot{\mathcal{M}} = \mathcal{M}(-\delta + \varpi Y) \tag{31}$$

$$\dot{Y} = Y(\delta - \mathcal{M}) \tag{32}$$

where $\mathcal{M}$ is financial fragility, while δ and ϖ are some positive coefficients. Replacing $\mathcal{M}$ by N, one obtains a simplified version of the system given by Eqs. (24)-(28).

The empirical evidence that bank concentration & competition affects financial fragility is thus corroborated. One link between the two is the influence of competition on bank liquidity. Of course, the hypotheses about this link are two opposing ones (Horvath et al., 2016). According to the "fragility channel view", increased competition increases fragility by reducing profits, which ordinarily safeguard banks against unwelcome shocks. As a result, banks are motivated to lessen liquidity creation (loan provisions and acceptance of deposits). At the other end, the “price channel view” postulates that more competition leads to diminished loan rates and increased deposit rates, encouraging, in turn, liquidity creation. In any case, the point is that competition influences fragility. From the viewpoint of the link between concentration and fragility, Marshy and Sengupta (2017) show that competition within a dominant bank-firm context can potentially increase fragility to the point of endangering the overall stability of the banking sector. The general conclusion is that bank concentration & competition might be used to complement the set of financial fragility indicators though the matter needs further investigation, given those like Koskela and Stenbacka (2000), who claim an absence of a trade-off between competition and financial fragility in banking. More so when as Zigraiova and Havranek (2015) show, definitions play a critical role in establishing the link between the two quantities.

As far as the impact of policy on bank concentration & competition is concerned, the policy combination discussed in the last section towards bank population rationalization is either "business-cycle neutral", that is – acyclical, or counter-cyclical. In the former instance, the macroprudential-fiscal-monetary policy is not supposed to influence the trends in market concentration and competition accompanying the course of the cycle, only to alleviate them. This is a policy alternative regardless of the fact that it has been advanced through an analytical framework in which market structure considerations have been assumed away. Such considerations become meaningful only as a result of the dynamics of the present section. Note, in particular, that any equation describing bank population is of the same format, which implies that the derived Minsky-like cyclical pattern of the system should be attributed to the Cournot modeling of the loan market. In any case, countercyclical policymaking is sensible methodologically only within a dynamic environment. And, as far as policymaking is concerned, the impact of macroprudential and fiscal-monetary policies will be in the same direction by policy design.

For example, capital buffers are characterized by counter-cyclicality over the business cycles, and they are related inversely to market concentration, implying that a decline in market concentration would strengthen the countercyclical operation of capital buffers (Xu, 2016). Consequently, since monetary policy affects the cost of capital, encouraging thereby concentration in loan markets, a countercyclical response to the state of economic activity by raising the interest rate will increase market concentration (Schinkel, 2018), weakening, in turn, the countercyclical behavior of capital buffers. Of course, higher minimum capital requirements may always be set by the central bank to offset the declining capital buffers. There ought to be a combination of monetary policy with prudential measures.

Yet, the monetary authority comes to compete with banks in terms of stabilization, which would be welcome only if it was more effective than banks in pursuing this goal; and, it does so at the expense of market concentration and competition, which might be against growth (Northcott, 2004). The matter becomes even more complicated when the role of variables like the distribution of weak- versus well-capitalized banks needs to be contemplated before decision-making by the authorities (Paries et al., 2019). And, again, what if banks are indeed too many? Therefore, to the extent competition is seen as a welfare-enhancing *modus vivendi*, the interest rate rule examined in the last section is superior to anti-cyclical policy intervention as an alternative means towards the rationalization of bank numbers; much more so in view of the practically limited information upon which policy should be based.

5. Concluding Remarks

A summary of the results has been already provided in the last paragraph of the introductory section. Here, the intertemporal aspect of the proposed policy, possible extensions of the model, and directions for empirical work are being discussed. The intertemporal utility, assumed for simplicity is strongly additive, and hence, with zero intertemporal risk aversion and substitution elasticity. Also, a unit discount rate has been assumed; tomorrow's utility is the same as the present utility. Under these circumstances, no further remarks than those made earlier as to the welfare consequences of policy may be advanced. But, in general, a change in the deposit rate can induce, as a matter of straightforward logic, more or less consumption during this period depending on the direction of change, the value of the non-unit discount rate, and how risks at different times interact. This is something that the bank population rationalization policy has to offset. Moreover, if money enters the utility function for the current period, say, the decline of it, that would accompany a tax rate increase within the context of the proposed fiscal-monetary policy mix will reduce present utility, and there ought to be policy provision against this reduction.

These remarks predispose how the model above can be qualified and/or extended, and there can certainly be many. For example, intertemporally dependent preferences dampen consumption volatility, facilitating the operation of the proposed policy. In any case, the aspect of household borrowing, borrowing constraints, and (in) voluntary bequests, could alter results significantly. The incorporation of public debt and optimal intertemporal taxation would be a more realistic approach, too. Optimal policymaking is greatly influenced in the presence of debt because it can substitute for taxes or money supply (Crettez et al., 2002). Another important avenue of model change would be the adoption of a dominant bank-firm approach to market structure as a more realistic one nowadays. One more important extension of the model would be in the direction of heterogeneous depositor-consumer preferences, given that representative consumer models cannot capture adequately important traits of multi-consumer economies (Blackorby and Schworm, 1993).

Finally, empirical work might be motivated by the dynamics examined above as one more version of Minsky's financial instability hypothesis, especially when not much of such work has been undertaken on the subject (Nishi, 2019). According to Falahati (2019), bank system characteristics do cause financial instability in a Minsky fashion, and one important characteristic is the market concentration of the industry. For example, the empirical rejection of the paradox of debt− that the presence of debt takes away the leveraging-deleveraging which is behind "Minsky-instability"−is made on the grounds that during, for instance, the upward phase of the cycle, new borrowers enter bank market and there is no further leveraging for those firms that have already borrowed (González and Pérez-Caldentey, 2018): How does concentration-competition influences this finding? In any case, it would be important to see how the nexus between concentration/competition-financial innovation fits to a "Minsky-oscillations environment" given the rapid expansion of the so-called Financial Technology (FinTech). The new forms of lending and shadow banking prompted by this technology improve banking, inducing at the same time financial fragility as a source of bank-like operations (Lai and Van Order, 2017). Applying Minsky's hypothesis to the context of Neo-Schumpeterian financial production contingent on concentration-competition can offer useful insights to financial sector and instability.

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The authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Appendix

The derivative:

$$\frac{\partial \bar{N}'}{\partial Y} = \frac{\gamma^{\varepsilon}(\beta + c)(1-t)(1-t-\gamma)^{\varepsilon}[h\mu(c-\beta) - 2cb]}{c[(1-t)(1-t-\gamma)^{\varepsilon}(h\mu - b)Y - \beta\gamma^{\varepsilon}]^2} > 0$$

will be positive if $h\mu(c-\beta) > 2cb$, and hence, if $c > \beta$, because only a positive number can be greater than another positive number as $2cb$ is. Similarly, one obtains in connection with $\partial N''/\partial Y > 0$ that $c > \varkappa\beta$:

$$\frac{\partial \bar{N}''}{\partial Y} = \frac{\gamma^{\varepsilon}(\varkappa\beta + c)(1-t)(1-t-\gamma)^{\varepsilon}[h\mu(c-\varkappa\beta) - 2cb]}{c[(1-t)(1-t-\gamma)^{\varepsilon}(h\mu - \varkappa b)Y - \beta\gamma^{\varepsilon}]^2} > 0$$

Now, the total differential of $\bar{N}''$ in (14) with respect to $\varkappa, Y$, and ρ^*, is:

$$d\bar{N}'' = \frac{[(\beta h\mu + cb)Y - \beta c\rho^*](\beta h\mu Y + cbY + c\beta\rho^*)}{\beta c\{[(h\mu - \varkappa b)Y - \varkappa\beta\rho^*]\}^2} d\varkappa + \frac{\beta(\varkappa\beta + c)[2\varkappa bc - h\mu(c - \varkappa\beta)]\rho^*}{\beta c\{[(h\mu - \varkappa b)Y - \varkappa\beta\rho^*]\}^2} dY - \frac{\beta(\varkappa\beta + c)[h\mu Y(c + \varkappa\beta) - \beta c\rho^*(1+\varkappa)]}{\beta c\{[(h\mu - \varkappa b)Y - \varkappa\beta\rho^*]\}^2} d\rho^*$$

In so far as the sign of Eq. (19) is concerned, its denominator will be positive if:

$$\varkappa > \frac{h(\varkappa\beta + c)}{2\beta c\gamma^{\varepsilon}} \quad (A1)$$

Applying to this inequality the rules of proportions, if $\epsilon/\hbar \geq \sigma/\omega$, then:

$$\frac{\epsilon + \hbar}{\epsilon - \hbar} \geq \frac{\sigma + \omega}{\sigma - \omega}$$

we obtain that:

$$\frac{\varkappa + 1}{\varkappa - 1} > \frac{h(\varkappa\beta + c) + 2\beta c\gamma^{\varepsilon}}{h(\varkappa\beta + c) - 2\beta c\gamma^{\varepsilon}}$$

where the left-hand side is negative given $\varkappa - 1 < 0$. It follows that $h(\varkappa\beta + c) < 2\beta c\gamma^{\varepsilon}$, i.e., that the fraction in (A1) is one less than 1.

To find L^{ind}, equate $\lambda N = \lambda\left[L^{ind}/\left(L^{mkt} - L^{ind}\right)\right] \Rightarrow N = \left[L^{ind}/\left(L^{mkt} - L^{ind}\right)\right]$ with Eq. (14)

$$\frac{L^{ind}}{(L^{mkt} - L^{ind})} = \frac{(\varkappa\beta + c)[T\mathbb{Q}Y - \beta c\gamma^{\varepsilon}]}{\beta c[T(h\mu - \varkappa b)Y - \varkappa\beta\gamma^{\varepsilon}]} \quad (A1)$$

Next, insert Eq. (26) in$\left[L^{ind}/\left(L^{mkt} - L^{ind}\right)\right]$:

$$\frac{L^{ind}}{(L^{mkt} - L^{ind})} = \frac{(\beta + c)TL^{ind}}{T\mathbb{Q}Y - \beta c\gamma^{\varepsilon} - (\beta + c)TL^{ind}} \quad (A2)$$

equate (A1) and (A2), and solve for L^{ind}:

$$L^{ind} = \frac{(\varkappa\beta + c)[T\mathbb{Q}Y - \beta c\gamma^{\varepsilon}]^2}{\beta c[T\mathbb{Z}Y - \varkappa\beta\gamma^{\varepsilon}](\beta + c)T}$$

Finally, insert L^{ind} in Eq. (27), Eq. (28) is obtained:

$$\dot{N} = \frac{(\varkappa\beta + c)[T\mathbb{Q}Y - \beta c\gamma^{\varepsilon}]^2}{[\mathbb{Z}\beta c(T\mathbb{Q} - \beta c\gamma^{\varepsilon}) + \mathbb{Q}(\varkappa\beta + c)(\beta c\gamma^{\varepsilon} - T\mathbb{Q}Y)]TY - c(\beta c\gamma^{\varepsilon})^2}$$

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