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The dynamics of a banking duopoly with capital regulations.

Abstract

We analyse the dynamics of a banking duopoly game with heterogeneous players (as regards the type of expectations' formation), to investigate the effects of the capital requirements introduced by international accords (Basel-I in 1988 and more recently Basel-II and Basel-III), in the context of the Monti-Klein model. This analysis reveals that the policy of introducing a capital requirement may stabilise the market equilibrium. Moreover, we show that when the capital standard is reduced the market stability is lost through a flip bifurcation and subsequently a cascade of flip bifurcations may lead to periodic cycles and chaos. Therefore, although on the one side the capital regulation is harmful for the equilibrium loans' volume and profit, on the other side it is effective in keeping or restoring the stability of the Cournot-Nash equilibrium in the banking duopoly.

Keywords: Bifurcation; Chaos; Cournot; Oligopoly; Banking; Capital regulation.

JEL Classification: C62; G21; G28; D43; L13.

1. Introduction

As noted by Vives (2010b, p. 1) "the recent history of the financial sector can be divided into two periods. The first, from the 1940s up to the 1970s, was characterised by tight regulation, intervention, and stability, while the second was marked by liberalisation and greater instability."

The recent financial turmoil 2008-2009 has made high in the current political agenda the importance of a regulation of the banking industry, having stressed the threat of a systemic risk due to a bank run and the inability of depositors to monitor banks.

In particular, the ongoing financial crisis has sparked a debate about the need for a profound shake-up of financial regulation. Admittedly, most of discussion grounds on well-established and sophisticated microeconomics of banking, which however is prevalently either in a static context or assumes banks' perfect foresightness. Since the crisis represents "intrinsically" an out-of-equilibrium market behaviour as well as causes per se a more unpredictable environment for banks' decisions, we investigate the banking market stability under the assumption of bounded rationality rather than of perfect foresight.

The predominant instruments employed in the regulation of banking, aiming to prevent banks in investing in too risky projects and to render more safe the banking system for depositors, may be considered 1) a deposit insurance contract offered by the government (e.g. Chan, Greenbaum and Thakor (1992); 2) a capital requirement (e.g. Kim and Santomero (1988), Rochet (1992)); 3) a joint use of deposit insurance and capital requirements (e.g. Giammarino, Lewis and Sappington (1993)).

While each of these instruments has been largely studied in its pro and cons, we only focus on the second one, because the international accords of the last decades as regards the banking industry regulation (namely Basel I, II and very recently III) are substantially based on it.[1]

Another reason why the imposition of some capital standard is important concerns the problem of corporate bank governance. This is because the regulation through capital requirements may be optimally used to establish a threshold of corporate control between bank's owners and regulators (which represent the interests of depositors who are unable to monitor management) (e.g. Dewatripont and Tirole, 1993).

In a nutshell, the capital to asset ratio imposed under Basel-I Norms (1988) by the regulator is fixed at 8 %, while the new banking capital regulation (Basel II) prescribes a similar capital adequacy ratio which is, however, risk weighted. The idea underlying Basel II is to calibrate the capital requirement so that it covers the Value at Risk (expected and unexpected) from the loan under some assumptions.[2] More theoretically, the risk calibration of the capital requirement is due to the fact that when banks are regulated by a flat-

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[1] The evolution of political debate about the banks' regulation may be so resumed: "the general trend in banking regulation has been to control risk-taking through capital requirements and appropriate supervision. Both risk-based (deposit) insurance and disclosure requirements have been proposed to limit risk-taking behaviour. ……..Capital requirements, supervision, and market discipline are the three pillars on which the Basel II regulatory reform was based." Vives, (2010b, p.12).

[2] More technically, in order to fix the capital requirement under Basel-II, banks can choose between a "standardised" approach in which external rating agencies set the risk weight for the different types of loans (say corporate, banks, and sovereign claims) or an internal-rating-based approach in which banks estimate the probability of default and also the loss given default.

capital requirement, this may lead to an increase in the bank's probability of failure because the banker may choose to compensate the loss in utility from the reduction in leverage with the choice of a riskier portfolio. Therefore the regulator can eliminate this adverse effect by using a risk–based capital requirement approach (Kim and Santomero (1988)).

As regards Basel III, the main content of such an accord – only focusing on the issue of capital requirements (which is crucial in this paper) – is a further increase of the capital requirements: in particular it will require banks to hold *1)* 4.5% of common equity (up from 2% in Basel II), *2)* 6% of Tier I capital (up from 4% in Basel II) of risk-weighted assets, *3)* a mandatory capital conservation buffer of 2.5% plus a discretionary countercyclical buffer (up to another 2.5% of capital during periods of high credit growth).

The literature on banking and regulation is fairly vast (see, for a review, Santos (2000) and very recently Vives (2010a,b), to which we refer to)). Only to mention someone, Blum and Hellwig (1995) discuss the macroeconomic implications of bank capital regulation, while, as regards particularly emerging economies, Vives (2006) discusses the role of banking capital regulation and Nieto-Parra (2005) analyzes in particular the behavior of regulated foreign banks. As regards, more specifically, the assumption of non-competitive banking market Matutes and Vives (2000), among many others, consider an imperfect competition model where banks are differentiated, have limited liability and there are social costs of failure, and Allen and Gale (2004) consider banks competing à la Cournot in the deposit market and choose a risk level on the asset side, showing that, as the number of banks grows and depositors are insured, banks have maximal incentives to take risk on the asset side.

Despite the progress in the theory of banking regulation in the last two decades, there are still many relevant issues that are not fully investigated: for example, the theoretical research on the effects of banks' capital regulations on the dynamics of an imperfect competition banking industry is still limited.

For modelling our banking duopoly, we use a simplified version of the models of Klein (1971) and Monti (1972), which are the standard models of the neoclassical theory of firm applied to the banking industry.[3] In particular the model is adapted for banks' capital regulation, with the assumption that banks are risk-neutral. For the sake of precision, we recall that this model abstract from the uncertainty,[4] and thus from both default risk (both for borrowers and banks) and risk for depositors (with corresponding insurance deposit mechanisms).

As to the dynamical context, we analyse our banking duopoly in accord with the recent strand of oligopoly literature in which firms' decisions are based on expectations different from the simple naïve expectations formation

[3] Indeed, a part from the further differences arising with uncertainty, there is a significant difference between bank and ordinary firm. In fact, while the former mainly interact with the other competitors in the output market and have no or little interactions in the input market, the latter *i)* interacts in both the deposit (input) market, and the loan (output) market, and *ii)* lends (borrows from) to other banks.

[4] In the presence of uncertainty, another – and more important - difference between banks and ordinary firms arises. Indeed, in contrast with the ordinary firms, banks have to face with the problem of loans default risk (i.e. credit risk) and the own possible default risk. An important model embodying uncertainty in the Monti-Klein framework is Dermine (1986), who expands it with bankruptcy risk and deposit insurance, showing that the independence between deposit and credit rates (i.e. assumed in the present paper, for simplicity and in line with the original Monti-Klein framework,) would be lost and the direction of causality between the two rates would depend on the presence or the absence of a deposit insurance mechanism.

implicit in the original model by Cournot (1838) (according to which in every step each firm assumes the last values taken by the competitors without estimation of their future reactions).

In fact, more recently, several works, in particular following Dixit (1986), have considered more realistic mechanisms through which bounded rational players form their expectations on the decisions of the competitors and have shown that the Cournot model may lead to complex behaviours such as periodic cycles and chaos (e.g. Leonard and Nishimura, 1999; Den Haan, 2001; Agiza and Elsadany, 2003; Zhang et al., 2007; Tramontana, 2010, Fanti and Gori, 2012).[5] However, at the best of our knowledge, the issue of the dynamical relationship between capital regulation and stability in a banking duopoly has not been so far explored. Since the above mentioned papers on dynamic duopoly have largely shown that when firms competing à la Cournot have heterogenous expectations, complex dynamics may occur, then we only investigate the specific problem of the dynamical effects, when such expectations do exist, of a capital regulation in a fully micro-founded banking industry. This fills the gap in the literature on dynamic Cournot duopolies. Moreover we note that the issue of the effects of capital regulations on stability takes on a greater importance when the banking industry is in peril of instability as in the current European situation.

[5] Note that we assumed an informative context of bounded rationality instead of perfect foresight also because in the latter case the dynamic analysis is less interesting (broadly speaking, any market adjustment dynamics would tend to be prevented “by construction”). However, we recall, for the sake of precision, that Dana and Montrucchio (1986) showed that a complex trajectory can be an admissible solution to discounted dynamic optimization problems in a dynamic duopoly game with complete information and rational agents.

The main result of our paper is that the introduction of sufficiently high capital requirements is effective for the purpose of keeping or restoring the banking industry stability.

The policy implication is that while on the one hand a banks' capital regulation induces a reduction in equilibrium profits and in the volume of loans, on the other hand it may prevent undesirable and unpredictable fluctuations and even a shrinking of the loans market.

Moreover, from a mathematical point of view, it is shown that the loss of the market equilibrium stability may occur through a flip bifurcation and that a cascade of flip bifurcations may lead to periodic cycles and chaos.

The paper is organised as follows. In Section 2 we develop the model with the capital regulation and present the dynamical system of a duopoly game with heterogeneous expectations (bounded rational and naïve). In Section 3 we study the steady-state and the dynamics of the model, showing explicit parametric conditions of the existence, local stability and bifurcation of the market equilibrium. In section 4 the results of the previous section are numerically illustrated and complex dynamic behaviours are shown to occur in dependence of the level of capital requirement through usual bifurcation diagrams. Section 5 concludes.

2. The model

The model is a duopolistic simplified version of Klein's (1971) and Monti's (1972) models, which represent the standard models as regards the microeconomic view of the banking industry (see for more detailed comments the textbook of Freixes and Rochet, 1997). This model is extended to embody a capital requirement, in line with the Basel-I, II and III international accords.

Since we assume, for simplicity, that there are no open positions between banks in the interbank market, the balance sheet of each bank is composed only of loans *L* on the asset side and of capital *K* and deposits *D* on the liability side. Again for simplicity, it is also assumed the same constant marginal costs *c* for deposits and loans. By contrast with the standard Monti-Klein model, there is no remuneration for deposits (however the marginal cost for deposits could be interpreted as the interest on deposits).[6]

As usual, a linear demand function for loans is assumed:

$$r_L(L_i + L_j) = a - b(L_i + L_j) \qquad (1)$$

where $a, b > 0$ and r_L is the inverse demand function for loans.

Consequently, the profit function is as follows:

$$\pi_i = \lfloor a - b(L_i + L_j) \rfloor L_i - r_K K - c(D_i + L_i) \qquad (2)$$

where r_K is the capital remuneration determined exogenously by the equilibrium in the capital markets.

By matching assets and liabilities in the balance sheet, we have:

$$L = K + D \qquad (3)$$

and by denoting the capital requirement per unit of loans by γ, we have:

$K \geq \gamma L$ where γ is a fixed percentage determined by the regulator.

We assume, for simplicity, that the capital requirement is binding, i.e.

[6] Since we assume a capital regulation based on the supply of loans, then the minimum capital requirements do not depend on the level of deposits and thus the presence or the absence of deposit remuneration is not relevant for our purposes. The alternative view about capital requirements linked with deposits is left for further research.

$K = \gamma L.$ (4)

Therefore, by using (3) and (4), the profit function becomes:[7]

$$\pi_i = [a - b(L_i + L_j)]L_i - L_i[(2c + (r - c_K)\gamma] \quad (5)$$

We assume, as usual in literature, that $a > 2c$ and that capital remuneration is higher than marginal cost, i.e. $r_K > c$.

From the profit maximisation by firm $i = \{1,2\}$, the marginal profits are obtained as:

$$\frac{\partial \pi_1(L_1, L_2)}{\partial L_1} = a - b(2L_1 + L_2) - 2c - \gamma(r_K - c), \quad (6.1)$$

$$\frac{\partial \pi_1(L_1, L_2)}{\partial L_2} = a - b(L_1 + 2L_2) - 2c - \gamma(r_K - c) \quad (6.2)$$

The reaction or best reply functions of firms 1 and 2 are computed as the unique solution of Eqs. (6.1) and (6.2) for q_1 and q_2, respectively, and they are given by:

$$\frac{\partial \pi_1(L_1, L_2)}{\partial L_1} = 0 \Leftrightarrow L_1(L_2) = \frac{1}{2b}[a - 2c - bL_2 - \gamma(r_K - c)], \quad (7.1)$$

$$\frac{\partial \pi_1(L_1, L_2)}{\partial L_2} = 0 \Leftrightarrow L_2(L_1) = \frac{1}{2b}[a - 2c - bL_1 - \gamma(r_K - c)] \quad (7.2)$$

Following a vast recent dynamic oligopoly literature, (e.g. Leonard and Nishimura (1999), Den-Haan (2001), Agiza and Elsadany al. (2003), Zhang et al. (2007), Tramontana (2010), Fanti and Gori, 2012), we assume

[7] Since capital requirement is binding and deposits are not remunerated, banks compete by only choosing loans, while in the original Klein-Monti framework they choose loans, deposits and capital.

heterogeneous expectations: i.e., firm 1 is bounded rational and firm 2 is naïve. [8]

As suggested, for instance, by Dixit (1986), the bank has bounded rational expectations about the level of loans that should be set in the future, and, as a consequence, uses the information on the current profit in such a way to increase or decrease loans at time $t+1$ depending on whether marginal profits are either positive or negative. Therefore, the adjustment mechanism of loans over time of the ith bounded rational bank is described by:

$$L_{i,t+1} = L_{i,t} + \alpha_i L_{i,t} \frac{\partial \pi_i}{\partial L_{i,t}}, \tag{8}$$

where $\alpha_i > 0$ is a coefficient that captures the speed of adjustment of bank i's loans with respect to a marginal change in profits when L_i varies.

The second duopolist, instead, is - in line with the traditional Cournot's assumption - a naive player which expects a level of loans of the rival equal to the last period's one.

Therefore, given these types of expectations formation, the two-dimensional system that characterises the dynamics of a differentiated Cournot banking duopoly is the following:

$$\begin{cases} L_{1,t+1} = L_{1,t} + \alpha L_{1,t}\left[a - b(2L_1 + L_2) - 2c - \gamma(r_K - c)\right] \\ L_{2,t+1} = L_{2,t} = \dfrac{1}{2b}\left[a - 2c - bL_1 - \gamma(r_K - c)\right] \end{cases}. \tag{9}$$

3. Local stability analysis of the unique positive Cournot-Nash equilibrium

[8] We note that the main result of this paper (i.e. the efficacy of the capital requirement in stabilising the Cournot-Nash market equilibrium) qualitatively holds even by assuming both bounded rational banks as well, but in such a case the algebraic work would be more cumbersome.

From an economic point of view we are only interested to the study of the local stability properties of the unique positive output equilibrium, which is determined by setting $L_{1,t+1} = L_{1,t} = L_1$ and $L_{2,t+1} = L_{2,t} = L_2$ in (9) and solving for (non-negative solutions of) L_1 and L_2, that is:

$$L^*_1 = L^*_2 = L^* = \frac{1}{3b}\left[a - 2c - \gamma(r_K - c)\right], \tag{10}$$

where $a > a - 2c - \gamma(r_K - c)$ should hold to ensure $L^* > 0$.

The equilibrium profit is

$$\pi^* = \frac{\left[a - (2c + (r_K - c)\gamma)\right]^2}{9b} \tag{11}$$

It is easy to see that both equilibrium loans and profits are reduced with an increasing capital requirement, γ.

The Jacobian matrix evaluated at the equilibrium point (10) is the following:

$$J = \begin{pmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{pmatrix} = \begin{pmatrix} -\dfrac{2\alpha\left[a - 2c - \gamma(r_K - c)\right] - 3}{3} & -\dfrac{\alpha\left[a - 2c - \gamma(r_K - c)\right]}{3} \\ -\dfrac{1}{2} & 0 \end{pmatrix} \tag{12}$$

The trace and determinant of the Jacobian matrix (12) are respectively given by:

$$T := Tr(J) = J_{11} + J_{22} = -\frac{2\alpha\left[a - 2c - \gamma(r_K - c)\right] - 3}{3}. \tag{13}$$

$$D := Det(J) = J_{11}J_{22} - J_{12}J_{21} = \frac{-\alpha\left[a - 2c - \gamma(r_K - c)\right]}{6}, \tag{14}$$

so that the characteristic polynomial of (12) is:

$$G(\lambda) = \lambda^2 - tr(J)\lambda + \det(J), \tag{15}$$

whose discriminant is $Q := \left[Tr(J)\right]^2 - 4Det(J)$.

We now study the local stability properties of the Cournot-Nash equilibrium (Eq. (10)) by means of well-known stability conditions for a system in two dimensions with discrete time (see, e.g., Medio, 1992; Gandolfo, 2010), which are given by:

$$\begin{cases} (i) \quad F := 1 + T + D > 0 \\ (ii) \quad TC := 1 - T + D > 0 \\ (iii) \quad H := 1 - D > 0 \end{cases} . \tag{16}$$

The violation of any single inequality in (16), with the other two being simultaneously fulfilled leads to: (*i*) a flip bifurcation (a real eigenvalue that passes through -1) when $F = 0$; (*ii*) a fold or transcritical bifurcation (a real eigenvalue that passes through $+1$) when $TC = 0$; (*iii*) a Neimark-Sacker bifurcation (i.e., the modulus of a complex eigenvalue pair that passes through 1) when $H = 0$, namely $Det(J) = 1$ and $|Tr(J)| < 2$. For the particular case of the Jacobian matrix (12), while it can easily be seen that conditions (*ii*) is always fulfilled, conditions (*i*) and (*iii*) can be violated, as it can be easily ascertained from the following (17):

$$\begin{cases} (i) \quad F = \dfrac{-5\alpha[a - 2c - \gamma(r_K - c)] - 12}{6} > 0 \\ (iii) \quad H = \dfrac{-\alpha[a - 2c - \gamma(r_K - c)] - 6}{6} > 0 \end{cases} . \tag{17}$$

Therefore, the Cournot-Nash equilibrium L^* can loose stability through either a flip or Neimark-Sacker bifurcation. The stability condition (*i*) in (17) represents a region F in the (α, γ) plane, i.e., the speed of adjustment and the level of capital requirement, bounded by the economic model assumption $\alpha > 0, 0 < \gamma < 1$. Therefore, the following equation $\mathrm{B}(\alpha, \gamma)$, i.e. the numerator of

F in (17), represents a bifurcation curve at which the positive equilibrium point $L^*_1 = L^*_2 = L^*$ looses stability through a flip (or period-doubling) bifurcation, that is:

$$\mathrm{B}(\alpha,\gamma) := -5\alpha[a-2c-\gamma(r_K-c)]-12=0\,. \tag{18}$$

A simple inspection of Eq. (18) leads to the following remark.

Remark 1. *The bifurcation curve* $\mathrm{B}(\alpha,\gamma)$ *intersects the horizontal axis at*

$$\alpha=\alpha^F := \frac{12}{5[a-2c-\gamma(r_K-c)]} \text{ or, alternatively, at } \gamma=\gamma^F := \frac{5\alpha(a-2c)-12}{[5\alpha(r_K-c)]} \tag{19}$$

Furthermore, the market equilibrium L^* *is stable (* $\mathrm{B}(\alpha,\gamma)>0$ *) when* $\alpha<\alpha^F$ *or, alternatively, when* $\gamma>\gamma^F$ *.*

Moreover, the following equation $N(\alpha,\gamma)$, i.e. the numerator of H in (17), represents a bifurcation curve at which the positive equilibrium point L^* looses stability through a Neimark-Sacker bifurcation, that is:

$$N(\alpha,\gamma) := -\alpha[a-2c-\gamma(r_K-c)]-6=0\,. \tag{20}$$

A simple inspection of Eq. (20) leads to the following remark.

Remark 2. *The bifurcation curve* $N(\alpha,\gamma)$ *intersects the horizontal axis at* $\alpha=\alpha^H := \dfrac{6}{[a-2c-\gamma(r_K-c)]}$ *and the market equilibrium* L^* *is stable (* $N(\alpha,\gamma)>0$ *) when* $\alpha<\alpha^H$*.*[9] (21)

[9] Alternatively, it can be easily shown, by solving $N(\alpha,\gamma)>0$ for γ, that the market is stable when $\gamma>\gamma^H$.

Given that the Nash equilibrium may become unstable either via flip or via Neimark–Sacker bifurcation (as shown in Remark 1 and 2)), we have to check which one occurs before the other one, starting from a stability situation and increasing the value of α (decreasing the value of γ).

Then the following Remark holds:

Remark 3: *the equilibrium market L* may loose stability only through a flip bifurcation.* This Remark straightforwardly follows from the simple observation that $\alpha^F < \alpha^H$.[10]

Once established that only a flip bifurcation may occur, we focus on our parameter of interest, i.e. the capital requirement γ. In particular, we must investigate whether the solution for $\gamma = \gamma^F$ is feasible from an economic point of view. Therefore the following holds:

Remark 4: *A flip bifurcation value of the capital requirement does exists, provided that the following threshold values of the speed of adjustment hold:*

$$0 < \gamma^F < 1 \Leftrightarrow \frac{12}{5(a-2c)} < \alpha < \frac{12}{5(a-c-r_K)}. \quad (18)$$

Therefore, provided that the speed of adjustment is not too small (too high), in which case the market is always stable (unstable) independently of the level of the capital standard, the regulation through the choice of an appropriate level of capital requirement is feasible and effective in stabilising the banking duopoly.

Moreover, from the simple observation of the effects of parameters c and r_K on the flip bifurcation value of γ (i.e. $\frac{\partial \gamma^F}{\partial c} < 0, \frac{\partial \gamma^F}{\partial r_K} < 0$) we may see that both

[10] Of course, the proof of Remark 3 could be alternatively formulated in terms of γ, showing that $\gamma^H > \gamma^F$.

higher marginal costs and higher exogenous capital remuneration (a higher opportunity-cost of capital) favour the stabilising effect of the capital requirement.

4. A numerical illustration

The main purpose of this section is to show that the dynamic system (9) can generate, in addition to the local flip bifurcation and the resulting emergence of a two-period cycle analytically shown in section 3, complex behaviours. According with the aim of the paper, we take the capital requirement parameter γ as the bifurcation parameter, and choose the following parameter set only for illustrative purposes: $\alpha = 1.35$, $a = 3$, $r_K = 2.5$ and $c = 0.1$. To provide some numerical evidence for the dynamical chaotic behaviour of system (9), we resume several numerical results in a bifurcation diagram.

Figure 1 depicts the bifurcation diagram for γ. The figure clearly shows that a decrease in the capital requirement implies that the map (9) converges to a fixed point for $1 > \gamma > 0.4259$. Starting from this interval, in which the positive fixed point (10) of system (9) is stable, Figure 1 shows that the equilibrium volume of loans undergoes a flip bifurcation at $\gamma^F = 0.4259$. Then, a further decrease in implies that a stable two-period cycle emerges for $0.4259 > \gamma > 0.11$. As long as the parameter γ reduces a four-period cycle, cycles of highly periodicity and a cascade of flip bifurcations that ultimately lead to unpredictable (chaotic) motions are observed. Therefore it is clearly illustrated that the banking industry is stable (unstable) for sufficiently high (low) levels of capital requirement.

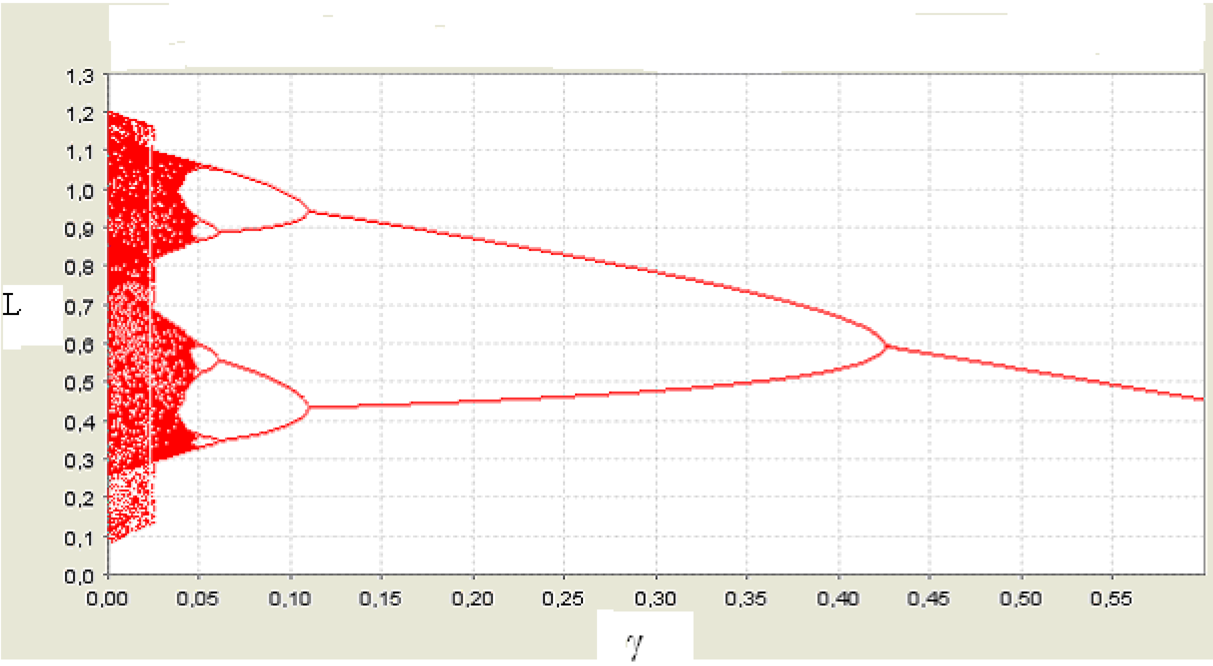

Figure 1. Bifurcation diagram for γ . Initial conditions: $L_{1,0} = 0.3$ and $L_{2,0} = 0.31$.

5. Conclusions

Motivated by the important debate on banks' capital regulations, we analysed the dynamics of a Cournot banking duopoly game with firms' heterogeneous expectations, and investigated the effects of the presence of capital requirements. For doing this, a simplified version of the Monti-Klein approach to the banks' behaviour is adopted, extended to embody a capital requirement, in line with the Basel-I, II and III Norms.

The main result is that such a capital regulation is effective for the purpose of stabilising the market equilibrium, and, under appropriate economic conditions, a reduction of the capital standard is responsible for the stability loss of the market equilibrium, through a flip bifurcation, and consequent complex dynamic events.

In conclusions, we have shown that, although, on the one hand, capital regulation reduces the equilibrium loans' volume and profit, on the other hand it may keep or restore the banking market equilibrium, and, furthermore, the latter result may constitute a warning for policy-makers as regards the possible effects of de-regulation policies.

Two remarks are appropriate to conclude, as a note of caution and as insights for future directions of research. Since the aspect of defaults and the security for depositors is important, at the light of the present debate about the banks' capital adequacy, the present model should be extended for embodying uncertainty and default risks.

Moreover, according to Matutes and Vives (2000), the capital requirement level should be – rather than an exogenous constant as in the present model (and in the Basel-I accord) - an increasing function of the intensity of competition (i.e. a decreasing function of the degree of product differentiation between banks, which would requires that the solvency requirement be tightened in a less products differentiated environment). A model's extension following the suggestions in Matutes and Vives (2000) is left for future research. Finally we note that dynamical analyses of the effects of banking regulations such as the present one may be of interest for the public policy responses to the recent banking industry crisis, especially in Europe.

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