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The dynamics of a banking duopoly with capital regulations

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ABSTRACT

This paper analyses the dynamics of a banking duopoly game with heterogeneous and homogeneous 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 tends to stabilise the market equilibrium (both with heterogeneous and homogeneous banks). Moreover, it is shown that 1) 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; 2) when the expectations are heterogeneous even the case of multi-stability may be present.
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.

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 foresight. 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 et al. (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 et al. (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 was 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

[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).

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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-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 caused by 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) analyses in particular the behaviour 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.

In order to model the banking duopoly, 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 – is used.[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 abstracts 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, the banking duopoly is analysed in accord with the recent strand of oligopoly literature in which firms' decisions are based on expectations different from the simple naïve expectations formation 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. Bischi et al., 2010; Fanti and Gori, 2012a, 2012b; Tramontana, 2010).[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 shown that when one or both firms competing à la Cournot have expectations different from the traditional Cournot (naïve) type, complex dynamics may occur, then we investigate the specific problem of the dynamical effects of a capital regulation in a fully micro-founded banking industry when such expectations do exist. 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.

The main result of the paper is that the introduction of sufficiently high capital requirements is effective for the purpose of keeping or restoring the banking industry stability, with heterogeneous as well as homogeneous banks' expectations.

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. Furthermore, a numerical analysis of the global behaviour has revealed that when banks are heterogeneous two stable attractors may co-exist (i.e. multistability) with their complicated basins of attraction. In such a case the implication for the regulation policy is that for identifying the effects of the policy on the long run evolution of the banking market criteria based on local stability are no longer sufficient and the market dynamics become dependent on the initial conditions (i.e. path-dependent), making difficult to predict which one of the multiple equilibria will be observed.

The paper is organised as follows. In Section 2 the model with the capital regulation is developed and the dynamical system of a duopoly game with heterogeneous expectations (one bounded rational bank and one naïve bank) is presented. In Section 3 the steady-state and the dynamics of the model are studied, 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 depending on the level of capital requirement through usual bifurcation diagrams; moreover, a numerical sketch of the global behaviour is also offered. Section 5 considers homogeneous expectations, comparing the results with those in Sections 3 and 4. Section 6 concludes.

2. The model

The model is a simplified duopolistic version of Klein's (1971) and Monti's (1972) models, which represent the standard models as regards

[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 by default.

[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 latter mainly interacts with the other competitors in the output market and have no or little interactions in the input market, the former *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 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 developed by Dermine (1986), who extends it with bankruptcy risk and deposit insurance, showing that the independence between deposit and credit rates (assumed, in line with the original Monti–Klein framework, in the present paper for simplicity) would be lost and the direction of causality between the two rates would depend on whether a deposit insurance mechanism is present or not.

[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.