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Financial stability, bank competition and consolidation:

Sources of asymmetry in the financial sector

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Para optar por el grado de Doctor por la Universidad de Granada dirigida por los Profesores Dr. Santiago Carbó Valverde y Dr. Francisco Rodríguez Fernández.

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Autorización para presentación de la tesis

El doctorando LUIS ENRIQUE PEDAUGA SÁNCHEZ y los directores de la tesis Dr. SANTIAGO CARBÓ VALVERDE, Catedrático de Fundamentos del Análisis Económico y Dr. FRANCISCO RODRÍGUEZ FERNÁNDEZ, profesor titular del Departamento de Teoría e Historia Económicas de la Facultad de Ciencias Económicas y Empresariales de la Universidad de Granada:

Garantizamos, al firmar esta tesis doctoral, que el trabajo ha sido realizado por el doctorando bajo la dirección de los directores de la tesis y hasta donde nuestro conocimiento alcanza, en la realización del trabajo, se han respetado los derechos de otros autores a ser citados, cuando se han utilizado sus resultados o publicaciones.

En tal sentido, AUTORIZAN la presentación y defensa pública de la tesis doctoral realizada bajo su Dirección, *"Financial stability, bank competition and consolidation: Sources of asymmetry in the financial sector*", de la que es autor D. LUIS ENRIQUE PEDAUGA SÁNCHEZ, puesto que reúne los requisitos formales y de contenido exigibles a un trabajo de esta naturaleza y es una investigación científica original, novedosa e innovadora.

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Resumen ampliado
Extended abstract

La crisis en el mercado de créditos hipotecario *subprime*, originada en Estados Unidos a mediados de 2007, ha ocasionado una de las mayores crisis financieras a nivel internacional, cuyo saldo más notable contabiliza numerosas quiebras bancarias, nacionalización de importantes instituciones financieras y múltiples intervenciones de los Bancos Centrales en su intento por calmar el pánico en los mercados financieros de los países más desarrollados

En las tres décadas anteriores al inicio de la actual crisis, la desregulación, la integración, la diversificación del negocio y la innovación tecnológica fueron los principales factores que determinaron los cambios en la estructura competitiva del sector bancario europeo. Estos factores promovieron un aumento de la rivalidad entre las instituciones financieras en distintos ámbitos territoriales (Carbó, López del Paso y Fernández, 2003; Bernad, et al., 2011). Con la crisis financiera, las presiones competitivas no han hecho sino aumentar en un entorno en el que tanto la demanda como la oferta de crédito se han contraído, la morosidad y el deterioro de activos han aumentado de forma considerable y la principal respuesta del sector han sido un conjunto de procesos de integración financiera que están elevando, en gran medida, el tamaño medio de las entidades financieras.

Dentro de esta grave situación, una de las medidas más discutidas para salir de la crisis ha centrado su atención en la necesidad de reestructuración del sector financiero a través de los procesos de consolidación financiera. Estos procesos suponen, que las fusiones y adquisiciones entre entidades financieras son necesarias para recuperar la salud del sistema financiero en el largo plazo. Sin embrago, ni la literatura teórica, ni la evidencia empírica han logrado ponerse de acuerdo en afirmar si los efectos de estos procesos de resultan positivos o negativos en términos de la estabilidad financiera, o si el desarrollo financiero promueve un mayor crecimiento económico en períodos de incertidumbre financiera.

En tal sentido, el propósito de esta tesis, estructurada en tres capítulos principales, busca dar respuesta de cuál es el impacto que la estabilidad financiera puede tener sobre el desarrollo financiero y su relación sobre el crecimiento económico, cuál es el efecto que la consolidación financiera tiene sobre la estabilidad financiera, y por último, tratar de conocer cómo los procesos de fusiones deterioran el grado de competencia bancaria.

En este sentido, el Capítulo 2 "*The finance growth nexus and the asymmetric effect of financial stability*", examina cómo la inestabilidad financiera puede afectar los canales por los que el desarrollo financiero puede fomentar el crecimiento económico pero visto desde un enfoque no-lineal. Los resultados en este capítulo contribuyen a la literatura financiera al mostrar que la relación inter temporal entre el desarrollo financiero y el crecimiento económico es de tipo no lineal, ya que es posible determinar empíricamente que el nexo entre finanzas y el crecimiento resulta ser asimétrico cuando la economía enfrenta períodos de inestabilidad financiera. Para lograr este objetivo de investigación, se propuso abordar el problema a través de un modelo autorregresivo de transición suave (STAR) siguiendo la propuesta de van Dijk, Teräsvirta, y Franses (2002), pero proponiendo utilizar el índice de estabilidad financiera Z-score como variable de transición entre umbrales. El modelo se aplica a países como España, Alemania y Noruega, y los resultados muestran que la inestabilidad financiera afecta no sólo la importancia económica de la relación entre el desarrollo financiero y el crecimiento económico, sino también el posible signo de esta relación.

Siguiendo la línea de investigación basada en las características no lineales de la estabilidad financiera el Capítulo 3 "*Another look at Bank Consolidation and Financial Stability*", presenta un estudio empírico en el que se intenta explicar las razones del porque la consolidación financiera no siempre tiene un efecto positivo sobre la estabilidad financiera. En este sentido, los resultados aquí presentados ofrecen evidencia que permiten conciliar las dos vertientes contrapuestas que existente en la literatura: una la fragilidad financiera asociada a la mayor concentración bancaria y el enfoque opuesto en el que es común considerar que a mayor concentración los mercados presentan una mayor estabilidad. En este sentido, el modelo empírico aquí propuesto permite mostrar cómo el número de bancos, el grado de expansión de oficinas y la productividad de empleados por oficina pueden ser las claves para explicar la relación asimétrica entre consolidación y estabilidad financiera. Estos resultados se obtienen luego de especificar una regresión de panel no dinámico con umbrales para una muestra de bancos de 23 países de la OCDE entre 1996 y 2010. Los resultados más relevantes señalan que las economías con un gran número de entidades financieras, un mayor grado de expansión de oficinas y un bajo número de trabajadores por oficina logran un menor riesgo en términos de inestabilidad financiera. Estos resultados resultan ser robustos midiendo la estabilidad a través del indicador Z-score, controlado por factores institucionales, macroeconómicas y específicos de cada sector bancario.

En el Capítulo 4 "*A stochastic conjectural approach to measure market power*", se propone un nuevo enfoque teórico para estudiar los efectos qué sobre el poder de mercado se derivan de un proceso de fusión y adquisición. Esta propuesta teórica está basada en un modelo de equilibrio parcial de tipo estocástico de variación conjetural (CVE) en el que se supone un comportamiento oligopólico. En este sentido, el marco teórico asume que el comportamiento del consumidor sigue una dinámica estocástica, en el que las empresas explotan las restricciones de movilidad del consumo entre empresas rivales a lo largo del tiempo. Por lo tanto, considerando un proceso markoviano que rige la trayectoria de cómo en la industria se reparten las cuotas de mercado hacia el equilibrio dinámico a largo plazo se deriva analíticamente un índice de

Lerner de poder de mercado dinámico dentro del marco de un modelo CVE. Una característica relevante de incorporar dentro de la literatura teórica esta propuesta, es que esta especificación posibilita introducir heterogeneidad entre las empresas dinámicamente, en el que es posible identificar un amplio conjunto de resultados de estructura de mercados no competitivos. Además, el modelo permite estudiar cómo los efectos de una concentración del poder de mercado, que considera el concepto de complementación estocástico, puede ser explicado como consecuencia de un proceso de fusión entre empresas rivales. En todo caso, la metodología que se propone en este capítulo tiene la ventaja de poder estimar cambios en la rivalidad entre entidades mediante simulaciones del efecto de las fusiones y adquisiciones sobre la probabilidad de que las cuotas de mercado de cada entidad cambien. En particular, la estrategia empírica sigue dos etapas. En primer lugar, se ofrece una metodología para medir los índices de rivalidad mediante variaciones conjeturales o lo que es lo mismo, mediante la medición de cómo las entidades reaccionan ante cambios en la cuota de mercado de otras entidades. En segundo lugar, se desarrolla un método (denominado de complementación estocástica) para estudiar cómo los procesos de integración pueden afectar a esos indicadores de rivalidad. De los resultados obtenidos pueden derivarse, principalmente, dos conclusiones: El proceso de reordenación bancaria en España ha propiciado un lógico incremento de la concentración de mercado-. En principio, la reducción en el número de operadores parece responder a los retos del entorno competitivo que se ha generado con la crisis en el sentido de que se ha evidenciado un exceso de capacidad en el sector financiero que ha debido corregirse en alguna medida mediante estrategias de integración. Segundo, los resultados de este artículo sugieren que la probabilidad de cambiar de que los clientes cambien de entidad financiera antes y después de la reordenación del sector no sólo no se ha reducido sino que ha aumentado. Estos resultados son consistentes a modelos alternativos de estimación y se obtienen controlando un amplio conjunto de factores de oferta y demanda.

Chapter – 1
Introduction

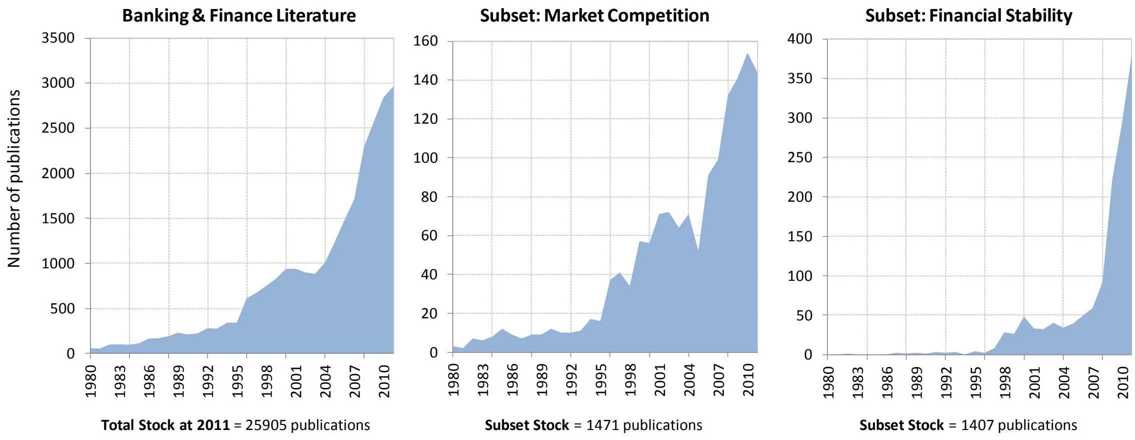
The collapse of the subprime mortgage lending market, which originated in the U.S. in mid-2007 was the beginning of a complex financial crises which considerably weakened macroeconomic conditions at both sides of the Atlantic. As in other historical experiences, the crisis can be considered to a large extent a banking crises, as it has been shown by a large number of bank failures, the nationalisation of large financial intermediaries and several bank bailout actions in many developed countries.

Although we have learnt that many of the causes and consequences of the crises are not new since the Great Depression in the 1920s, the remedies and courses of policy action have varied significantly in the different episodes of banking crises and the effects on the structure of these financial sectors have also been different. The way that financial instability may impact on the market structure and competition in financial systems remain largely unknown as it has been difficult to obtain the necessary data to capture the variety and complexity of linear and non-linear causality relationships involved.

Thus, the purpose of this doctoral thesis is to contribute to the knowledge on the relationships between financial stability, financial consolidation and market competition in the banking sector. The essays in this thesis pay special attention to econometric issues and other methodological contributions that aim at providing new insights and tools in the study of these relationships, as I will describe later on.

In the goal of trying to contribute to the relevant literature on issues such as financial stability and market structure/competition, an interesting point of reference could be a simple bibliometric study on the representatives of these topics in the banking and finance literature.

Figure 1.1
The growth trend of the banking & finance literature



Source: SciVerse Scopus considering author queries specifications.

Hence, a not necessarily comprehensive but hopefully illustrative bibliometric approach to know the state-of-the-art in the subject related to this research[1]. The main source is *SciVerse Scopus* provided by Science Direct, which gives direct access to one of the biggest journal databases in social sciences. The search undertaken considers a span of 30 years from 1970 to 2011 and provides us with 25,905 peer reviewed studies, in where the title 'Financial' or 'Bank' were the keywords considered. Using this bibliographic information the dataset was systematically narrowed by using the terms 'Stability' and 'Market/competition', obtaining 1,407 and 1,471 articles in each subset of topics, respectively (figure 1.1). Finally, we filtered the data by field of study and by author's citation to have an idea of the most recurring problems analyzed in this literature (table 1.1).

As shown in figure 1.1, prior to 1980, there were only written 50 financial articles found per year and this figure did not reach 500 until 1996, which means an

[1] Bibliometric analysis is a widely resources used to get a deeper understanding of the conceptual structure of a fragmented field of study whose intellectual bases could be unclear, or a often way to evaluate and compare the research outputs of individuals, institutions and fields of study (Cavenago, Marafioti, Mariani, & Trivellato, 2009)

average annual growth rate of 17% new articles in this field, a rate that has been pointed out in bibliometric-related studies as the normal growth trend in knowledge in financial economics (Heck & Cooley, 2009). As for the subset of articles on “competition” or “market power”, as well as on “financial stability”. However, as far as the literature on “financial stability” is concerned, there were almost no specific contributions prior to 1997, as pointed out by Chun-Hao & Jian-Min (2012). This pattern changed after the Asian financial crisis experienced in 1997 and 1998, which gave rise to an substantial growth in studies related to financial stability. In 1999, the number of tripled and the growth rate reached its peak in 2000 with 48 articles published. It was also because of the current crisis that started in 2007 that researchers paid increasing attention to the financial stability issue. In 2010, 294 related to financial stability were published in peer reviewed journals, which almost doubled the number of studies published on competition in that year (154 articles).

Table 1.1
Most cited financial classification-related literature

Author/year	Total cites	A	B	C	D	E	F	G	H	I
Levine and Zervos (1998)	660	●						●		
King and Levine (1993)	487	●								
Berger and Mester (1997)	459		●						●	●
Beck, Levine, & Loayza (2000)	409	●								
Berger and Udell (1998)	359		●	●	●					
Demirguc-Kunt and Maksimovic (1998)	328	●				●				
Berger et al. (1999)	286		●	●	●					
Beck, Demirgüç-kunt, & Levine (2000)	246	●					●			
Booth et al. (2001)	235	●				●	●			
Berger and Humphrey (1991)	234			●						

A: Economic Growth and Development, B: Monetary Policy, C: Industrial Organization, D: Mergers and Acquisitions, E: Law and Economics, F: Financial development, G: Economic Integration, H: Macroeconomic Policy, I: International Finance

Source: SciVerse Scopus considering author queries specifications.

In order to identify the most relevant topics –and based on the methodology suggested by Glanzel & Schoepflin (1999)- I identify the top-10 authors and look at the keywords of their published articles. The most common specific topic in was ‘Economic growth' and 'Economic development', followed by 'Monetary Policy' and 'Industrial Organization' issues.

As for the articles with more citations, Levine & Zervos (1998) with 660 citations and King & Levine (1993) with 487 were at the top of the list (see Table 1.1).

By looking at the list of most prolific authors and their research interests, we conclude that the financial literature has studied deeply the link between growth and financial development. However, the empirical evidence on the finance-growth nexus under periods of financial instability has been much more limited and less conclusive. In this respect, a possible reason arises from the fact that the standard literature has assumed that financial development and economic development are linearly related.

As we propose in Chapter-2 "*The finance growth nexus and the asymmetric effect of financial stability*", financial instability non-monotonically affect the channels through which financial development foster economic growth. In this respect, the results in Chapter 2 contribute to the finance literature by showing that considering a both a non-linear and an inter-temporal relationship between the financial development and economic growth, it is possible to empirically determine that the finance-growth nexus works asymmetrically during periods of financial instability. To achieve this goal, we introduce a smooth transition autoregressive (STAR) model specification *a la* Dijk, Teräsvirta, & Franses (2002) considering the financial stability index Z-score as the threshold variable. The model is applied to Spain, Germany and Norway and the results show that financial instability affects not only the economic significance of the relationship between financial development and economic growth but also the sign of this relationship.

Following the line of research based on the non-linear characteristics of financial stability Chapter-3 *"Another look at Bank Consolidation and Financial Stability"*, presents an empirical study showing that financial consolidation has an ambiguous effect on financial stability. This chapter offers evidence that may help reconcile two strands of the literature with opposite results: the *concentration-fragility* and the *concentration-stability* approach. The empirical model in this chapter allows us to show a number of non-monotonic key relationships affect the impact of banks' market structure on financial stability, including, *inter alia*, the number of banks, the degree of branching development or branch productivity. These results are shown using a non-dynamic panel threshold regression for a sample of banks from 23 OECD countries between 1996 and 2010. The results show that economies with a large number of financial institutions, a high branch development and a low number of workers per office achieve fewer risk of instability.

In Chapter-4 "*A stochastic conjectural approach to measure market power*", we rely on a partial equilibrium framework to study the effects on market power derived from a merger process under a stochastic Conjectural Variation Equilibrium (CVE) oligopolistic behaviour.

The theoretical frameworks assume stochastic consumer behaviour and allow firms to exploit consumer mobility restrictions among rival firms over time. Thus, considering a Markovian process that rules the trajectory of the industry's market-share towards the long-term dynamic equilibrium, we propose a novel way to analytically derive a Lerner index of market power. The model presented in this chapter shows that it is possible to embed a stochastic source of rivalry within a CVE model. A interesting feature in the specification relies on the possibility of introducing heterogeneity between firms in a dynamic sense and –as in other similar models in the literature- the methodology permit to identify a wide set of market structure outcomes. Additionally, the model allow us studying the effects of a merger on market power by proposing a theoretical framework that uses the idea of stochastic complementation and shows that a merger that exogenously occurs in a market of extreme rivalry, always reduce the level of competition. Additionally, it shows that mergers between clusters of firms which do not compete with each other do not, in any way, affect the market power of the entire industry. Finally to implement our framework, an empirical application to the bank merger processes recently observed in Spain was performed in particular, those affecting savings bank between 2007 and 2010.

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Chapter – 2
The finance growth nexus and the asymmetric effect of financial stability

Abstract

While the relationship between the size of a country's financial sector and its rate of economic growth has been extensively studied, the evidence on the finance-growth nexus during periods of financial instability is much more limited and not conclusive. A possible reason lies in that the standard empirical literature assumes –with very few exceptions- that financial development has a linear correlation with growth while some recent theoretical contributions suggest that non-linear relationship may also play an important role. We show that financial instability indeed affects economic growth in a non monotonic way. We use a Smooth Transition Vector Auto-regression (STVAR) model to test the hypothesis that the influence of financial development on economic growth behaves asymmetrically, depending on the state of the economy. Given this non-linear approach, we undertake an impulse-response analysis to simulate the potential effects of credit shocks on economic growth when the financial sector is subject to different degrees of financial instability. We the Z-score of financial instability as a threshold variable. The empirical analysis is applied to Spain, Germany and Norway and suggest that financial instability affects not only the economic significance of the effect of credit on economic growth but also the sign of this relationship.

Key words: Financial stability • Transition autoregressive model • Financial development • Economic growth.

JEL classification: G21 • G28

2. *The finance growth nexus and the asymmetric effect of financial stability*

2.1. Introduction

The importance of the financial system for economic growth has been intensively studied in the last three decades from an empirical perspective as cross-country databases and econometric techniques have made this analysis more suitable[2]. Starting with King and Levine (1993), a bunch of empirical studies has shown that well-developed financial systems foster economic growth. In one way, an increase in savings has a subsequent positive effect on capital accumulation. In another way, as financial intermediaries develop, savings are allocated more efficiently, intensifying productivity, and improving economic growth as a whole.

However, few studies have tried to explain how the link between financial development and economic growth works during periods of financial instability. Bauducco, Bulíř, and Čihák (2008), Hakkio and Keeton (2009) and Carlson et al (2009) have recently studied the effects of financial stress on economy performance. They have pointed out that there are three various channels through which financial instability can affect the relationship between finance development and economic growth. The first channel is an increase in uncertainty about the fundamental value of assets and the behaviour of investors during periods of financial instability. Since these two sources of uncertainty are frequently followed by increases in the volatility of asset prices, this makes firms more careful about investment decisions until the uncertainty has disappeared. Additionally, households use to cut back their spending with financial

[2] Some earlier contributions with some indirect but interesting insights on these features are Sims (1972) and Gupta (1984)

instability, since the uncertainty affects the expected value of their future wealth. As a consequence the reactions of these two agents produce a fall in economic output.

The second way in which financial instability can affect economic activity is by deteriorating borrowing conditions due to tightened credit standards (Lown, Morgan, and Rohatgi, 2000). When financial institutions raise their minimum credit standards it becomes harder for borrowers to get funding, consequently having a negative effect on economic growth.

Another channel through which financial instability can lead to a slowing of economic growth is through an increase in financing costs of firms and households. As Hakkio and Keaton (2009) have noted, instability increases interest rates on business and consumer debt in the capital markets, making it more expensive for firms to raise funds by issuing new equity. Such increase in the cost of finance can cause firms and households to cut back on their spending, thereby negatively affecting economic growth.

Overall, the relationship between the size of a country's financial sector and its rate of economic growth has been studied in depth but the empirical evidence on the finance-growth nexus in periods of financial instability is much more limited and not conclusive. Most of the previous approaches assume that financial development has a linear correlation with growth. However, several theoretical studies suggest that the dynamics of economic growth and the role of financial institutions as a determinant of this growth follow a nonlinear behaviour (Trew (2008) and von Peter (2009)). In this sense, nonlinearities may well be the reason for the failure to empirically and unambiguously validate specific aspects of the finance-growth nexus such as the relationship between the size of a financial sector and growth. The aim of this paper is to overcome these problems by considering how non-linear and intertemporal relationships between the main variables explaining how the finance-growth nexus works during periods of financial instability. To achieve this goal, we use a logistic smooth transition vector autoregressive (LSTVAR) model specification in line with the monetary policy approach proposed by Weise (1999) and theoretically developed by van Dijk and Franses (1999). A smooth transition autoregressive model is useful to identify the potential impact of three sources of asymmetry in the way that economic growth follows financial development: *i*) state of dependence, *ii*) size of the disturbance, where growth might react differently to different size shocks of financial development, and *iii*) the sign of the shock, where the impact on growth of financial development due to a positive shock is not necessarily equal to the effect of a negative shock. These three sources of asymmetry and/or non-linearity may be present in an economy, especially when typical market imperfections of financial markets such as incomplete information exist. Hence, the main contribution of this paper is showing the validity of a non- linear approach to test how financial instability affects the relationship between financial development and economic growth.

Section 2 summarizes some theoretical contributions and previous empirical evidence Section 3 describes the data. Section 4 introduces the methodology and explains the smooth transition VAR model with special emphasis on the modelling of non-linear effects of financial instability. Section 5 refers to the estimation procedure and presents the main results. The paper ends in Section 6 with a brief summary of conclusions and a discussion of policy implications.

2.2. Literature review

The theoretical analysis on how the financial sector –and, in particular, financial intermediaries- foster economic growth have been intensively studies over the last three decades with some seminal contributions to which many other studies have relied upon (see, for example, Greenwood and Jovanovic, 1990, Bencivenga et al.,1995, or Trew, 2008). Greenwood and Jovanovic (1990) develop a model that endogenously gives a role to financial intermediation on economic growth and explains the mechanisms through which financial intermediaries can invest more productively than individuals since they are able to better identify investment opportunities that promote economic growth. Similarly, Trew (2008) developed a parsimonious finance and endogenous growth model with microeconomic frictions in entrepreneurship and a role for credit constraints. In this model it is shown that while an efficiency–growth relationship will always exist, the efficiency–depth–growth relationship may not. This last result has important implications to establish a bridge between the theory and the empirics on the finance and growth nexus, since this relationship is not always supported empirically, especially in countries that have suffered repeated episodes of financial instability.

One way to try to deal with the impact of financial instability on growth is to assume a non monotonic relationship between financial development and economic growth. In this sense, Acemoglu and Zilibotti (1997) offer a theoretical framework that links the degree of market incompleteness to capital accumulation and growth. Similarly, Deidda and Fattouh (2002) offer a theoretical model which establishes a non-linear relationship between financial development and economic growth supporting their hypotheses by applying a threshold regression model.

Only some recent theoretical studies have specifically dealt with the non-linear relationship between financial instability and economic growth. Analyzing the connection between financial instability and economic activity, Bauducco, Bulíř, and Čihák (2008) developed a dynamic stochastic general equilibrium model which includes a financial system. Their model simulates how the central bank reacts to changes in the probability of default of the banking system, and their effects on economic growth.

Although their model is linear, they propose to include an arbitrary threshold used by the central bank to distinguish periods of financial instability, and in this way consider than the central bank response to changes in the probability of default is likely to be nonlinear.

In a similar way, von Peter (2009) develops an overlapping-generations model that links banking with asset prices to provide a characterization of how financial instability can affect economic activity. The model show how financial stability depends on bank behaviour in response to asset prices and bank losses. Their model specification results relevant since they propose that the optimal conduct of monetary policy change asymmetrically depending of a financial instability threshold, after which the credit contraction turns unstable and propels the system toward the collapse of the credit.

A recent work by Brunnermeier and Sannikov (2012), have developed a macro model that incorporates the behaviour of the financial system and its feedback effects on macroeconomic performance in a nonlinear way. A model is considered in which with financial frictions to show that due to highly non-linear amplification effects, the economy is prone to instability and occasionally enters volatile episodes. In this case, small shocks keep the economy near the long-run growth performances, but large shocks put the economy in the unstable crisis regime characterized by liquidity spirals in the financial sector.

As Ahmed (1998) has pointed out, most studies on the finance-growth nexus have not been able to show the non-linear relationships in the finance-growth nexus. In this sense, using time-series modelling in studies such as Demetriades and Hussein (1996), Demetriades and Luintel (1996), Arestis and Demetriades (1997) and Shan

(2005), it has been shown that a well developed financial system may stimulate economic growth in many different ways when *ad-hoc* nonlinearities are considered. Adrian and Song Shin (2008) studying U.S.' Fed Fund, present evidence about the financial stability role of monetary policy when this last is used to promote economic growth. Although this study employs a VAR linear approximation, it consider some dummy variables to control for crisis periods and the authors found a differentiated effect of monetary policy depending on whether the financial system is under periods of crisis or stability.

Recently, Chiou-Wei et al. (2008) investigated the influences of financial development on economic growth for South Korea using a univariate nonlinear smooth transition error correction technique, detecting periods of nonlinear behaviours when the dynamics of the aggregate output is considered as transition variable.

Of particular relevance to our research is the recent work of Mittnik and Semmler (2012). They estimate a two–regime VAR with the output–growth rate as the threshold variable and find evidence that a macroeconomic financial–stress index behaves asymmetrically depending whether the economy is in good or bad times, in term of the average growth rate defined by the threshold for the sample.

Although the results of Chiou-Wei et al. (2008) and Mittnik and Semmler (2012) prove the presence of non-linearity between financial development and growth, since these studies consider the dynamics of the aggregate output as the threshold variable, they are no capable to explain how under financial stability works the non-monotonic relationship between financial development and economic growth.

Table 2.1
Selected studies on the growth responsiveness finance hypothesis

Authors	Sample	Methods	Main findings
King and Levine (1993)	80 countries over the 1960-1989 period	Cross-sectional regression	Support the hypothesis that financial development affect or is affected by economic growth.
Levine and Zervos (1998)	Developed economies	Cross-sectional regression	Support the hypothesis
Rajan and Zingales (1998)	Developing and developed economies	Cross-sectional regression	Support the hypothesis.
Al-Taimi, Hussein, Al-Awad and Charif (2001)	Selected Arab countries	Cointegration, Granger causality, and impulse responses	No clear evidence that financial development affect or is affected by economic growth.
Shan and Morris (2002)	OECD and Asian countires	VAR and granger causality test	The bi-directional causality between finance and growth in some countries and the one-way causality from growth to finance in other countries.
Al-Yousif (2002)	30 Developing countries over the 1970–1999 period	Granger causality test	Causality is bi-directional; the finance-growth relationship between cannot be generalized across countries.
Deidda and Fattouh (2002)	80 countries over the 1960-1989 period	Threshold regression model	Non-linear and possibly non-monotonic relationship between financial development and economic growth.
Carbó, S., and Rodríguez, F (2004)	Spain	Dynamic panel data	Support the hypothesis in a regional perspective that financial development affect or is affected by economic growth.
Chiou-Wei et al (2008)	Korea	Threshold regression model	Support the hypothesis only in the long-run
Mittnik and Semmler (2012)	Germany, France, Italy, Spain, UK, and the U.S.	Trheshold VAR	Macro Financial stress shocks have asymmetric effects on economic growth, depending on the regime economy cycle.

Source: this research

2.3. Empirical model

This study uses time-series data to estimate non-linear dynamics between financial development and economic growth. To achieve this, the econometric approach estimates a vector auto-regression model that allows a logistic smooth transition (LSTVAR). The main purpose of this specification is to test the hypothesis that financial development's influences economic growth and if this relationship changes depending on the state of the economy – i.e. the link between financial and growth may significantly change in its economic impact and even in sign during periods of financial instability. As such, the LSTVAR is specified as:

$$X_t = \left[\Pi_1 + \sum_{m=1}^{q} \theta_{m,1} X_{t-m}\right] + \left[\Pi_2 + \sum_{m=1}^{q} \theta_{m,2} X_{t-m}\right] f(TV_{t-d}) + \varepsilon_t \qquad (2.1)$$

where $X_t = (\partial fin, \partial gdp, \partial inv, \partial lab, \partial open)$ is the vector of macroeconomic variables described soon in section 4.1, θ is the vector of coefficients and ε_t is the vector that contains linear combinations of random disturbances from each of the considered endogenous variables.

Since θ lies between the linear and the nonlinear component, this specification takes into account the possibility of a smooth transition in the estimated coefficients. In this sense, $f(TV_{t-d})$ is an indicator function set between zero and 1. In our case, we employ a logistic transition function as follows:

$$f(TV_{t-d}) = \{1 + exp[-\gamma(TV_{t-d} - c)/\hat{\sigma}_{TV}]\}^{-1}, \quad \gamma > 0 \qquad (2.2)$$

where TV_{t-d} denotes the transition variable, $\hat{\sigma}_{TV}$ is the standard deviation of the transition variable, c is the transition parameter and γ is a smoothing parameter or adjustment between regimes. Given that our aim is to examine if the relationship between financial development and economic growth varies depending on whether there is financial stability or instability, we test nonlinearities using ta set of transition variables that will be described in section 4.2 of this chapter.

Since the model is restricted to the existence of a single function of transition, it only allows a smooth transition between two regimes or states of the economy, associated with the extreme values of the transition function. For the identification of structural shocks, the Cholesky decomposition is used.

To estimate the responsiveness of economic growth to changes in the level of financial development, we follow the methodology proposed by Koop, Pesaran and Potter (1996) and Weise (1999) to calculate a generalized impulse-response. This is obtained as the expected values or means of the different trajectories of the cumulative impulse-responses of economic growth and financial development of period *H*, with an initial disturbance, u_0. The impulse-responses are generated from a given number of repetitions for each regime or state of the economy identified in the model. In this way, the responsiveness at horizon *H* can be expressed as:

$$IR_h = E\left[\sum_{h=0}^{H} \partial gdp_h / \partial u_0^{fin}\right] \qquad (2.3)$$

The procedure for estimating a LSTVAR model consists of three steps as suggested by Teräsvirta (1994) for auto regressive models, by Granger and Teräsvirta (1993) for multivariate cases and by Camacho (2004) for vector auto regressive models. These three stages are: *i*) estimating the linear model, *ii*) verifying the hypothesis of linearity against the alternative of a smooth transition with regressive specification and *iii*) identifying and estimating the regression model with smooth transition. In the case of this paper, the selection of a logistic model specification constitute the most common way of jointly the properties of the variables studied –i.e. presence of financial stability or instability cycles. The alternative approach, the exponential function was not considered that this model specification is used when the regimes are associated with small and large absolute values, not being that our case.

In the case of this paper, the selection between a logistic and a exponential model is not specifically addressed since according to the properties of the variables studied –i.e. presence of financial stability or instability cycles- a logistic specification is useful to investigate possible asymmetric effects on the dynamics of financial-growth nexus.

2.4. Data sources and variable definitions

In response to the financial market crises of the late 1990s the International Monetary Fund (IMF) intensified its effort in the area of financial system analysis initiating the Financial Soundness Indicator (FSI) project. Since this is a relatively new data set of economic statistics, a large data set is not yet available in the FSI Compilation prepared by the IMF. Nonetheless, following the guidelines laid out in the Compilation Guide on Financial Soundness Indicators (IMF, 2004) and using different sources, we compiled aggregate indicators for Germany, Norway and Spain, a set of developed countries which had experienced episodes of financial stress, and for which measures of financial stability were available.

In this sense, the sample period lies from the first quarter of 1980 to the first quarter of 2009. The macroeconomic time series were obtained from the IMF's International Financial Statistics and the DataStream database. The set of financial indicators used in this research was collected from central banks' statistic databases[3].

[3] The OECD database on *Bank Profitability - Financial Statements of Banks* was used to check homogeneity and comparability between countries.

2.4.1. Macroeconomic variables

The baseline VAR model and the LSTVAR model are derived from growth models and finance models. From growth theory, we assume that total output depends on investment, labor force and openness to international trade. In this sense, economic growth (∂gdp) is defined as the first difference of real gross domestic product (GDP); the change in real investment (∂inv) is measured as the first difference of gross fixed domestic capital formation corrected by the GDP deflator; the change in labor force (∂lab) is computed as the evolution in the number of workers; and the openness to trade ($\partial open$) is obtained as the change in the ratio of total imports and exports to nominal GDP. As for the financial variables, the total credit to GDP is used as an indicator of financial development. Like Levine and Zervos (1998), Beck and Levine (2004), and Shan (2005) we measure financial development (∂fin) as the changes in the ratio of creditcredit provided by all monetary financial institutions (MFIs) to the private sector as a proportion of GDP. Additionally we construct the same ratio considering credit provided by banks ($\partial bank$) and savings banks ($\partial saving$), to capture the specific effects of these two institutional sectors.

2.4.2. Financial stability indicators

To measure financial stability we first collect some macro prudential variables from consolidated balance sheet statements. These are classified in the core set of the Financial Soundness Indicators (FSIs) established by the International Monetary Fund (IMF). These variables comprise the average return on assets before taxes (***roa***), and the capital to assets ratio (***k***). Secondly, using these FSIs, we measure bank financial stability using the commonly known ***z–score*** as a proxy for financial insolvency. This indicator was constructed using aggregated data for all monetary financial institutions (MFIs) and for specific banking groups (commercial banks and savings banks) when the data was available.

Table 2.2
Definitions of variables to analyze finance-growth nexus

Variable		Definition	Source
VAR endogenous variables:	$X_t = (\partial fin, \partial gdp, \partial inv, \partial lab, \partial open)$		
Financial Development			
1. Monetary Financial institutions	∂fin	Changes (%) in the ratio of credit provided by all monetary financial institutions (MFIs) to the private sector as GDP proportion.	OECD Banking Statistics
2. Commercial Banks	$\partial bank$	Changes (%) in the ratio of credits provided by bank to the private sector as GDP proportion.	OECD Banking Statistics
3. Sanvings banks	$\partial saving$	Changes (%) in the ratio of credits provided by savings bank to the private sector as GDP proportion.	OECD Banking Statistics
Macroeconomic variables			
4. Economic growth	∂gdp	First difference of gross domestic product (GDP) in real terms (*log*)	International Financial Statistics (IMF)
5. Real investment	∂inv	First difference of gross fixed domestic capital formation (*log*) corrected by the GDP deflator.	International Financial Statistics (IMF)
6. Labor force	∂lab	Changes (%) in labor force	International Financial Statistics (IMF)
7. Openness to trade	$\partial open$	Changes (%) in the ratio of total imports and exports to nominal GDP	International Financial Statistics (IMF)
Smooth Transition variable:	$f(tv_{t-d})$		
Financial Stability			
8. Z-score	tv	Ratio of the sum of return on assets (RoA) and the equity capital (K) to the total assets, divided by the standard deviation of the return on assets modeled by a GARCH specification	Fitch-IBCA BankScope

The ***z-score*** is a widely used indicator of financial insolvency. Studies such as De Nicoló et al. (2004), Laeven and Levine (2007), Hesse and Čihák (2007), Uhde and Heimeshoff (2009), among others, have rellied on this index which is the sume ot the return on assets (***roa***) and the equity capital to the total assets (***k***) to the standard deviation of the return on assets ($\sigma_{roa,t}$), assuming that return on assets is normally distributed:

$$\boldsymbol{z_t} \equiv (roa_t + k_t)/\sigma_{roa,t} \tag{2.4}$$

However, as Engel (2001) points out, a large number of financial series are described by time-varying conditional variance. To account for this possibility, in this paper we introduce an GARCH type-model originally developed by Bolerslev (1986) that permits the return on assets to follow a generalized autoregressive conditional heteroscedastic process. In this context, the specification that allows us to construct a ***z–score*** ($\boldsymbol{z_t}$), which controls for changes in the $\boldsymbol{roa_t}$ variance was specified as follows:

$$\begin{aligned} &(5a) \quad roa_t = \sigma_t \varepsilon_t \quad \sim \quad \varepsilon_t \ i.i.d.N\,(0,1) \\ &(5b) \quad \sigma_t^2 = \phi + \alpha roa_{t-1}^2 + \beta \sigma_{t-1}^2 \end{aligned} \qquad (2.5)$$

Since ε_t is assumed to be normal, the ROA is normally distributed conditional to the variance which depends on the information up to the previous period. Although $\boldsymbol{roa_t}$ is modelled as being serially uncorrelated, its square can be expressed as an autoregressive process (specifically an ARMA (*p*,*q*)). The unconditional distribution is symmetric around a zero mean, with variance $\phi / (1 - \alpha - \beta)$ and kurtosis greater than 3 – i.e. leptokurtic distribution. Similar features apply to the generic ARCH (*p*) and GARCH (*p*,*q*) models.

Finally, it is clear that $\boldsymbol{z_t}$ will increase with the banks' profitability and capital ratio, and decrease with increases in the conditional volatility. Thus, from an economic perspective the index formulated in equation (2.4) shows the probability for a bank to become insolvent when the value of assets becomes lower than the value of debt. Hence, a higher ***z–score*** implies a lower probability of insolvency risk (Uhde and Heimeshoff, 2009).

2.5. Estimating the LSTVAR model

2.5.1. Specifying the baseline linear model

We first estimate a linear model as a benchmark using a VAR approach with a lag length chosen on the basis of conventional specification tests[4]. Importantly, the insignificant coefficients were eliminated using the modified version of the likelihood ratio test as suggested by Sims (1980), where the subsets VARs were estimated using a seemingly unrelated regression (SUR). We use SUR since it is more realistic to expect – as SUR does – that the equation errors are correlated. Additionally, the SUR improves estimation efficiency since it combines information on different equations. The baseline model for each country and banking sector are show in appendices A2.3 to A2.5.

2.5.2. Transition variable: Z–score's GARCH estimation

The return volatility of $\boldsymbol{roa_t}$ -which is needed to construct the ***z–score-*** was performed through a GARCH(p,q) process estimated by maximum likelihood, and generated through a forecast one-step-ahead through equation (2.5). The results for each country and sector are presented in Table 2.3. A correllogram of the $\boldsymbol{roa_t}$ series suggests the existence of autocorrelation and partial autocorrelation up to one lag, indicating a pattern of temporal dependence in the series in all sectors. Thus the inclusion of an ARMA (p,q) solve the problem of correlation and provide the volatility of return on assets needed in equation (2.4).

2.5.3. Linearity tests

We use the Lagrange multiplier linearity test described in Granger and Teräsvirta (1993) in a single-equation framework and the multiple-equation framework extended

[4] The data series used for each country are stationary according to augmented Dickey-Fuller test and in some cases Phillip-Perron test (the log levels of ***fin, gdp, inf*** and ***open*** contain unit roots, almost at 10%).

by Weise (1999) where the baseline is a VAR specification[5]. This test of linearity contrasts the null hypothesis H_0: $\gamma = 0$ against the alternative H_1: $\gamma > 0$ in equation (2.2). Table 2.4 reports the results of the linearity tests for each equation, the *F* statistic, and for the whole system, the *LR* statistic. The first ten columns show the linearity test statistics and their respective *p-values* for each dependent variable described at the top of the table. The last two columns contain information about the *LR* statistics for each transition variable and their respective *p-values*.

As a general result, these tests provide strong evidence against linearity and support a LSTVAR model specification. In the case of Germany and Spain the evidence against linearity when lags of ***z–score*** are used as the switching variable, appears to be weak when financial development for all MFIs are considered, and results strong in the case of Norway. Contrary to this, when the test is carried out for banking sectors, the result is more likely to reject linearity in Germany and Spain than in Norway.

In particular, the *LR* statistic reports *p-values* lower than 5% for delays between 1 and 4 in Germany and Norway, and between 2 and 4 in the case of Spain for models that consider all monetary financial institutions. When specific models for commercial bank and savings bank sectors are applied, all countries reject null hypothesis in all cases, except in the Norway savings bank sector, that only delays between 2 and 4 reject linearity.

Evaluated by equations, linearity is commonly rejected in the finance development and output equations for every considered single model (MFI, commercial banks and savings banks). By contrast, the control variables' equations are rejected in some cases. Germany and Spain in the savings bank sector and Norway in the commercial bank sector. Thus, nonlinearity results indicate that ***z-score*** could be considered as a transition variable, and the effects of the financial stability shocks could be determined by examining the dynamics in the LSTVAR model by financial sectors.

[5] For more details about how the linearity test is performed see the Appendix 2.

Table 2.3 GARCH estimation.
Dependent variable: ROA.
Method: ML - ARCH (Marquardt) - Normal distribution

Country: Germany
(1980Q3 2008Q4)

	MFIs			Commercial banks			Savings bank		
Variable	*Coef.*	*Std. Error*	*p-value*	*Coef.*	*Std. Error*	*p-value*	*Coef.*	*Std. Error*	*p-value*
C	0.006	0.000	0.000	0.006	0.000	0.000	0.009	0.000	0.000
AR(1)	1.002	0.014	0.000	0.747	0.075	0.000	1.019	0.010	0.000
MA(1)	0.765	0.084	0.000				0.608	0.115	0.000
Variance Equation									
ϕ	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.284
α	0.162	0.044	0.000	0.698	0.094	0.000	0.224	0.162	0.165
β	0.758	0.044	0.000	0.242	0.094	0.010	0.736	0.162	0.000

Country: Norway
(1990Q1 2009Q3)

	MFIs			Commercial banks			Savings bank		
Variable	*Coef.*	*Std. Error*	*p-value*	*Coef.*	*Std. Error*	*p-value*	*Coef.*	*Std. Error*	*p-value*
C	0.002	0.004	0.564	0.007	0.001	0.000	0.013	0.001	0.000
AR(1)	0.972	0.030	0.000	0.328	0.052	0.000	0.466	0.135	0.001
MA(1)	0.343	0.135	0.011	0.520	0.087	0.000			
Variance Equation									
ϕ	0.000	0.000	0.001	0.000	0.000	0.120	0.000	0.000	0.004
α	0.449	0.071	0.000	0.331	0.131	0.011	0.631	0.098	0.000
β	0.548	0.071	0.000	0.589	0.131	0.000	0.259	0.098	0.008

Country: Spain
(1980Q3 2008Q4)

	MFIs			Commercial banks			Savings bank		
Variable	*Coef.*	*Std. Error*	*p-value*	*Coef.*	*Std. Error*	*p-value*	*Coef.*	*Std. Error*	*p-value*
C	0.008	0.000	0.000	0.008	0.000	0.000	0.022	0.000	0.000
AR(1)	0.640	0.040	0.000	0.669	0.070	0.000	1.004	0.006	0.000
MA(1)							0.063	0.114	0.578
Variance Equation									
ϕ	0.000	0.000	0.010	0.000	0.000	0.027	0.000	0.000	0.000
α	0.250	0.091	0.006	0.247	0.043	0.000	0.432	0.069	0.000
β	0.695	0.091	0.000	0.693	0.043	0.000	0.450	0.069	0.000

Note: RoA is modeled as being serially uncorrelated; its square can be expressed as an autoregressive process.

Table 2.4

Lagrange multiplier test for linearity

Selected results for country and banking sectors

Transition variable	∂fin_t		∂gdp_t		∂inv_t		∂lab_t		$\partial open_t$		*System*	
	F stat	p-value	F stat	p-value	F stat	p-value	F stat	p-value	F stat	p-value	LR	p-value
Country: Germany (1980Q4 2009Q1)												
i) MFIs												
$z\text{-}score_{t-1}$	1.36	0.22	1.66	**0.08**	0.97	0.49	0.44	0.91	2.40	**0.01**	89.07	**0.00**
$z\text{-}score_{t-3}$	0.90	0.53	1.13	0.35	0.50	0.93	0.93	0.50	0.85	0.58	91.87	**0.00**
$z\text{-}score_{t-5}$	1.97	**0.05**	0.69	0.78	0.68	0.79	0.60	0.79	1.10	0.37	69.21	0.13
ii) Comercial banks												
$z\text{-}bank_{t-1}$	0.84	0.58	0.72	0.75	0.82	0.63	1.01	0.44	0.96	0.50	79.09	**0.04**
$z\text{-}bank_{t-3}$	1.10	0.37	1.42	0.16	1.24	0.27	1.04	0.41	1.58	0.11	112.49	**0.00**
$z\text{-}bank_{t-5}$	0.37	0.95	1.20	0.29	1.12	0.36	0.91	0.52	0.78	0.67	86.25	**0.01**
iii) Savings banks												
$z\text{-}saving_{t-1}$	2.49	**0.01**	1.98	**0.02**	1.96	**0.04**	0.71	0.71	1.63	**0.10**	88.35	**0.01**
$z\text{-}saving_{t-3}$	2.05	**0.04**	2.33	**0.01**	1.65	**0.09**	0.26	0.99	2.08	**0.03**	112.92	**0.00**
$z\text{-}saving_{t-5}$	1.80	**0.08**	2.36	**0.01**	1.67	**0.09**	0.95	0.49	1.35	0.21	109.58	**0.00**
Country: Norway (1990Q1 2009Q3)												
i) MFIs												
$z\text{-}score_{t-1}$	2.88	**0.01**	1.61	0.14	1.48	0.20	2.64	**0.02**	1.04	0.41	69.28	**0.00**
$z\text{-}score_{t-2}$	2.88	**0.01**	1.13	0.36	0.96	0.46	2.66	**0.02**	1.11	0.37	67.96	**0.00**
$z\text{-}score_{t-5}$	1.99	**0.06**	2.99	**0.01**	1.02	0.42	0.14	0.99	0.64	0.70	51.51	**0.06**
ii) Comercial banks												
$z\text{-}bank_{t-1}$	2.94	**0.01**	1.43	0.18	0.84	0.62	1.72	0.11	2.14	**0.04**	112.89	**0.00**
$z\text{-}bank_{t-2}$	2.92	**0.01**	1.88	**0.06**	1.09	0.39	2.15	**0.04**	2.20	**0.04**	124.03	**0.00**
$z\text{-}bank_{t-5}$	1.77	**0.09**	1.43	0.19	1.22	0.29	1.72	0.11	1.40	0.21	97.82	**0.00**
iii) Savings banks												
$z\text{-}saving_{t-1}$	0.59	0.74	1.22	0.30	1.26	0.28	0.94	0.51	0.60	0.77	51.32	0.18
$z\text{-}saving_{t-2}$	0.24	0.96	1.12	0.36	0.84	0.57	1.85	**0.07**	0.79	0.61	68.82	**0.01**
$z\text{-}saving_{t-5}$	0.90	0.50	1.38	0.22	1.43	0.20	1.32	0.24	1.18	0.32	58.18	**0.06**
Country: Spain (1983Q3 2009Q1)												
i) MFIs												
$z\text{-}score_{t-1}$	1.34	0.23	1.15	0.33	0.28	0.99	1.34	0.23	0.30	0.97	65.57	0.35
$z\text{-}score_{t-3}$	1.79	**0.09**	1.43	0.15	0.48	0.92	2.33	**0.02**	0.43	0.92	97.69	**0.00**
$z\text{-}score_{t-5}$	2.17	**0.04**	1.43	0.15	1.22	0.28	0.93	0.50	0.37	0.95	77.33	**0.09**
ii) Comercial banks												
$z\text{-}bank_{t-1}$	1.94	**0.04**	1.01	0.46	1.41	0.17	4.95	**0.00**	0.96	0.48	117.59	**0.00**
$z\text{-}bank_{t-3}$	1.74	**0.07**	1.12	0.35	1.62	**0.09**	4.92	**0.00**	0.88	0.55	142.58	**0.00**
$z\text{-}bank_{t-5}$	1.14	0.34	1.60	**0.08**	1.45	0.15	2.57	**0.01**	1.42	0.19	98.62	**0.01**
iii) Savings banks												
$z\text{-}saving_{t-1}$	2.99	**0.01**	1.96	**0.03**	1.94	**0.05**	2.11	**0.05**	0.68	0.73	108.43	**0.00**
$z\text{-}saving_{t-3}$	1.53	0.18	2.35	**0.01**	1.84	**0.06**	4.47	**0.00**	1.15	0.34	110.95	**0.00**
$z\text{-}saving_{t-5}$	2.95	**0.01**	2.55	**0.00**	2.05	**0.04**	5.34	**0.00**	0.68	0.72	144.63	**0.00**

Dependent variables: ∂fin_t, ∂gdp_t, ∂inv_t, ∂lab_t, $\partial open_t$, *System*.

Note: Null hypothesis is linearity and the alternative hypothesis is LSTVAR model. Computed *p-values* lower than 10% are reported in dark numbers.

2.5.4. Estimating the LSTVAR model

Given that the linearity test suggests that there are many candidates as possible transition variables, we can reduce the number of possibilities by conducting a two dimensional grid search for the transition parameters, *c*, and for the smoothing parameter, γ. The selection criteria respond to those specific values of *c* not placed at the ends of the search range, thus, to ensure a minimum number of observations in at least one of the regimes. Table 2.5 presents the optimal values of ***c*** and γ as observations in each regime, figure 2.1 presents graphical information on the evolution of transition variables over time, and Figure 2.2 estimated logistic functions and threshold between regimes for the three kind of model considered.

In Germany, the specification was of 1 lag for the z-score in the MFIs and 3 lags in the commercial banks and savings bank sector model. In Norway, the specifications were of 5 lags for the MFIs sector, 2 lags in the commercial bank sector and 1 lag in the savings bank sector. And in case of Spain, the specification considered was of 5 lags in the MFIs and commercial banks sector model, and of 1 lag for the savings banks sector model.

In Germany, the specification was of 1 lag for the ***z-score*** in the MFIs and 3 lags in the commercial banks and savings bank sector model. In Norway, the specifications were of 5 lags for the MFIs sector, 2 lags in the commercial bank sector and 1 lag in the savings bank sector. And in case of Spain, the specification considered was of 5 lags in the MFIs and commercial banks sector model, and of 1 lag for the savings banks sector model.

Table 2.5
Optimal values of smoothness and threshold parameters

Transition variable	Paramaters stimated			Obsertions in each regimen		
	c	γ	desv std.	Low	Transition	High
	Country: Germany (1980Q4 2009Q1)					
z score t-1	180.828	100.00	75.9595	59	0	55
z bank t-3	162.093	13.00	110.4022	67	12	35
z saving t-3	144.318	32.50	78.7825	25	3	86
	Country: Norway (1990Q1 2009Q3)					
z score t-5	47.448	57.50	37.3009	26	3	73
z-bankt-1	16.362	18.50	12.8497	31	4	41
z-savingt-2	27.492	38.50	34.4724	32	5	39
	Country: Spain (1980Q3 2008Q4)					
z score t-5	100.002	20.00	73.6783	67	8	39
z bank t-5	63.419	20.00	44.6803	61	6	47
z saving t-1	73.199	20.00	57.5062	31	8	75

Notes: Refers to the estimated value through the grid search of two dimensions. The low regime is defined for all *f(tv)* less than or equal to 0.1, *f(tv)* transition regime in the interval (0.1, 0.9) and high regimen *f(tv)* is between [0.9, 1] .

From Table 2.5 and Figure 2.1, we can conclude that when the ***z-score*** is used as a switching variable, the transition from one regime to the other is very fast in all sectors. This can be seen in the small volume of observations around the estimated transition parameters and the high speed of adjustment. This is because the given estimated smooth parameters and the transition function mainly take values of zero and one, indicating threshold specifications (see Figure 2.2).

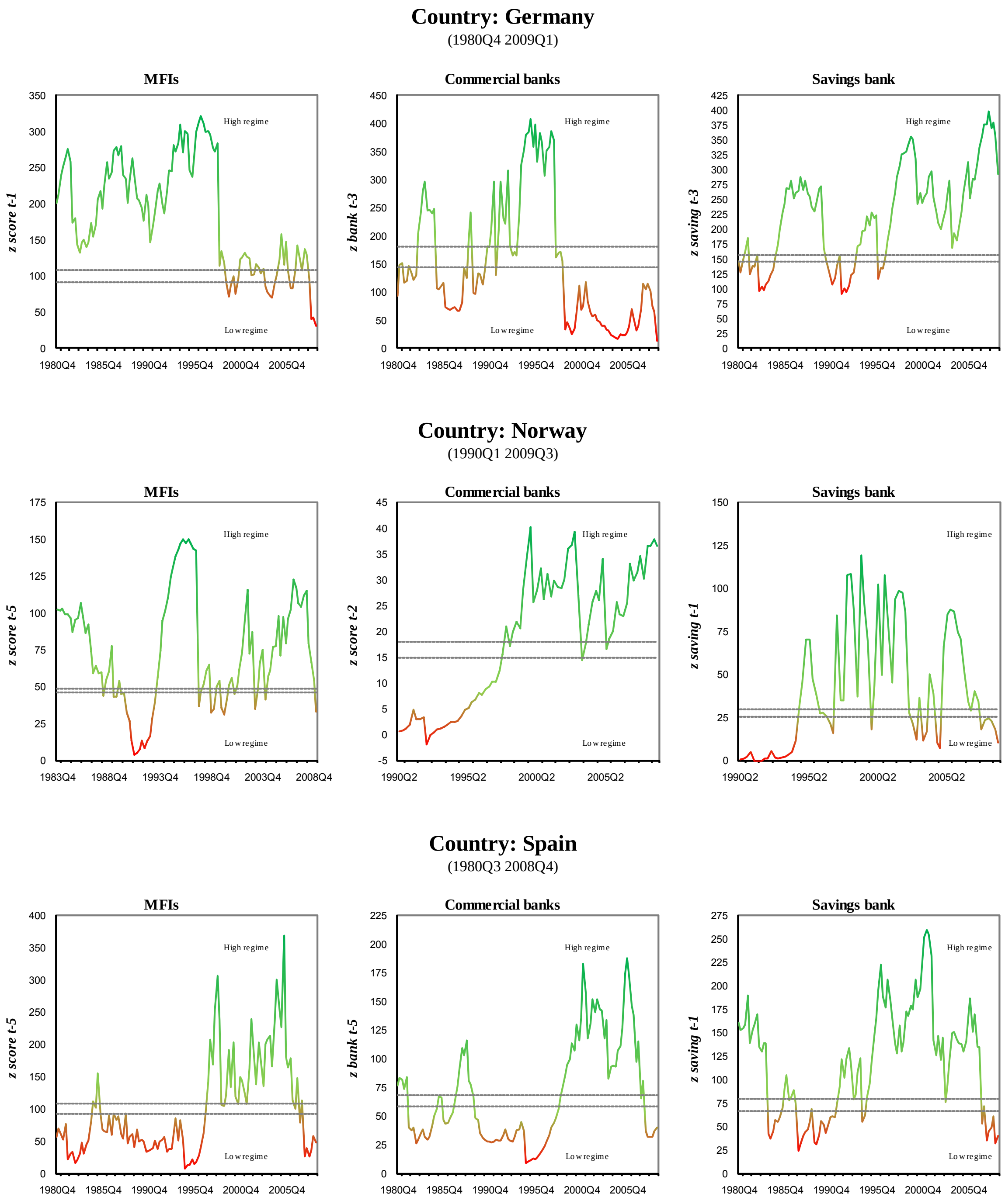
In the German MFIs specification, the estimated value of ***c*** = 180 allows the association of these two regimes of financial instability ($f(tv) = 0$) and financial stability ($f(tv) = 1$). However, this cannot be generalized to any specific sector since the *z*-score is constructed on a different scale for each of them. For instance, the estimated value of *c* presents values around 162 in the commercial banks sector and 144 in the savings banks sector. In the case of Norway, the estimated values in the MFIs sector for the ***c*** parameter are 47 and around 16 and 27 in the commercial bank and savings banks sector respectively. For Spain the estimated values are 100 for the MFIs sector, 63 for commercial banks and 73 for the savings banks sector. It should be noted that there are only a few cases of financial instability reported by the low regime observed in the savings banks sectors in Germany and Spain, demonstrating that the savings banks sector presents more periods of financial stability than the commercial banks sector in this two countries.

2.6. Results and dynamic behaviour:

This section employs the estimated LSTVAR model to explore the asymmetric effects of credit shocks on economic growth when the financial sector experiences different periods of financial instability. Since an impulse response function is a convenient way to respond to this question, once we obtained the nonlinear models, we proceed to estimate the impulse responses by setting a shock to the changes of total credit provided by all monetary financial institutions, commercial banks and savings bank institutions.

The results reported below are obtained using the bootstrapping technique recommended by Wiese (1999), where the impulse responses are obtained from the average of 50 repetitions in each of which a group of disturbances with replacement is randomly selected. This process is repeated 1,000 times for various periods in history within the same state of the economy –i.e. in periods of financial stability or instability.

Figure 2.1
Selected transition variables plotted against time



Note: Time-series plot of the selected transition variable ***z-score*** (solid line) by country and sector, together with thresholds at 0.1 and 0.9 percent (dotted line) defining transition regime interval. The transition variable colored in green refers to a high regime, *f*(***z-score***)=1 and in red the low regimen, *f*(***z-score***)=0.

The estimated impulse functions are the response of economic growth to Cholesky one S.D. credit innovation, by country. The size of the shock is set to the standard deviation of specific credit shocks for all monetary financial institutions, commercial banks and savings banks, calculated in the linear model. The graphs can be interpreted as the response of the log level of output to a permanent increase in total credit. From the various accumulated impulse response paths constructed, we obtain the median as an indicator of average value and build confidence bands using the 10th and 90th percentiles as lower and upper limits, respectively.

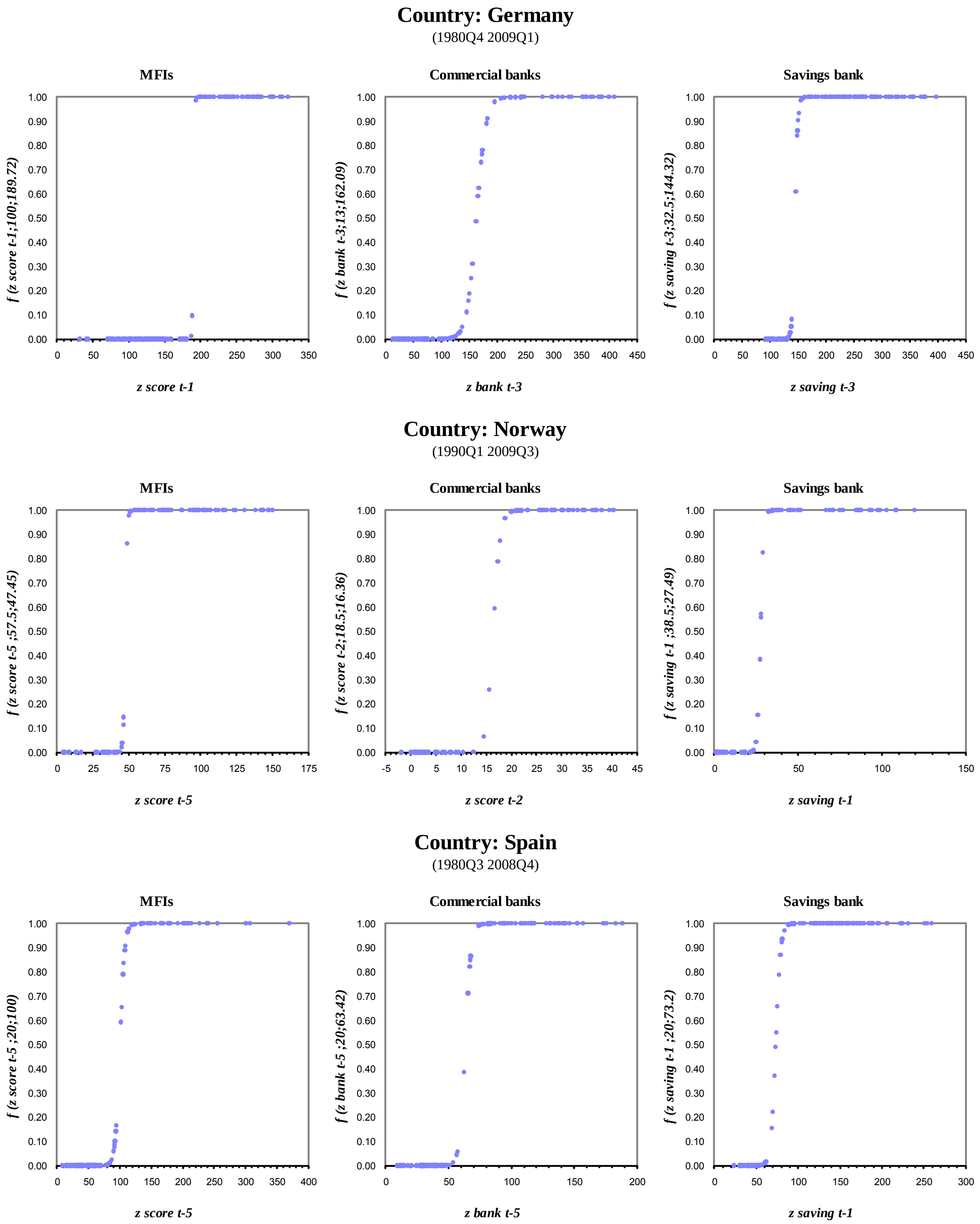
2.6.1 The asymmetry of the size: *German case*

Figure 2.3 shows evidence that for Germany a non-linear approach supports the hypothesis that financial development influence economic growth but the impact is different in periods of financial instability. This is reflected in the asymmetry of the size of the accumulative response of an economic growth as a result of a credit shock.

This can be particularly observed in the case of Germany when the economy begins in a high ***z-score*** state (financial stability), as an increase in credit is predicted to increase output by 8.73% over a four-year horizon, but if the economy begins in a low ***z-score*** state (financial instability), the increase will be less than half (3.97%). These results are similar to the models considering specific financial sectors. For example, in the case of the commercial banks' sector, the cumulative output response to a positive shock when the economy begins in a financial stability state is 6.29%, compared to 3.19% when the economy begins in a state of financial instability. In the model considering the savings bank's effect, the cumulative responses are 5.29% and 1.27% when the economy begins in a high and a low state respectively.

Figure 2.2

The transition function vs. the transition variable



Note: This figure plots the transition functions using the selected switching variable ***z-score*** index by country and sector.

2.6.2 Savings banks sector's asymmetric effect: *Norwegian case*

The impulse response analysis for the Norwegian models considering MFIs and commercial banks provides no evidence of asymmetry in the effects of positive credit shocks, since the responses estimated is virtually identical for all the time frames considered (second panel in Fig. 2.3).

However, as for the savings banks sector, we found some evidence of asymmetry, since a positive credit shock increases output regardless the state of financial stability or instability. What is interesting to note is the fact that the savings banks' sector responds better in periods of financial instability (2.48%) than in periods of financial stability (1.41%). This result seems consistent with the fact that Norway's savings banks hold a strong position in their market, with a deposit market share of around 70 per cent and they also maintain a high share of the retail market. Since savings banks in this country engage in all ordinary banking business and can provide the same services as commercial banks, the size of this sector could explain the asymmetries found.

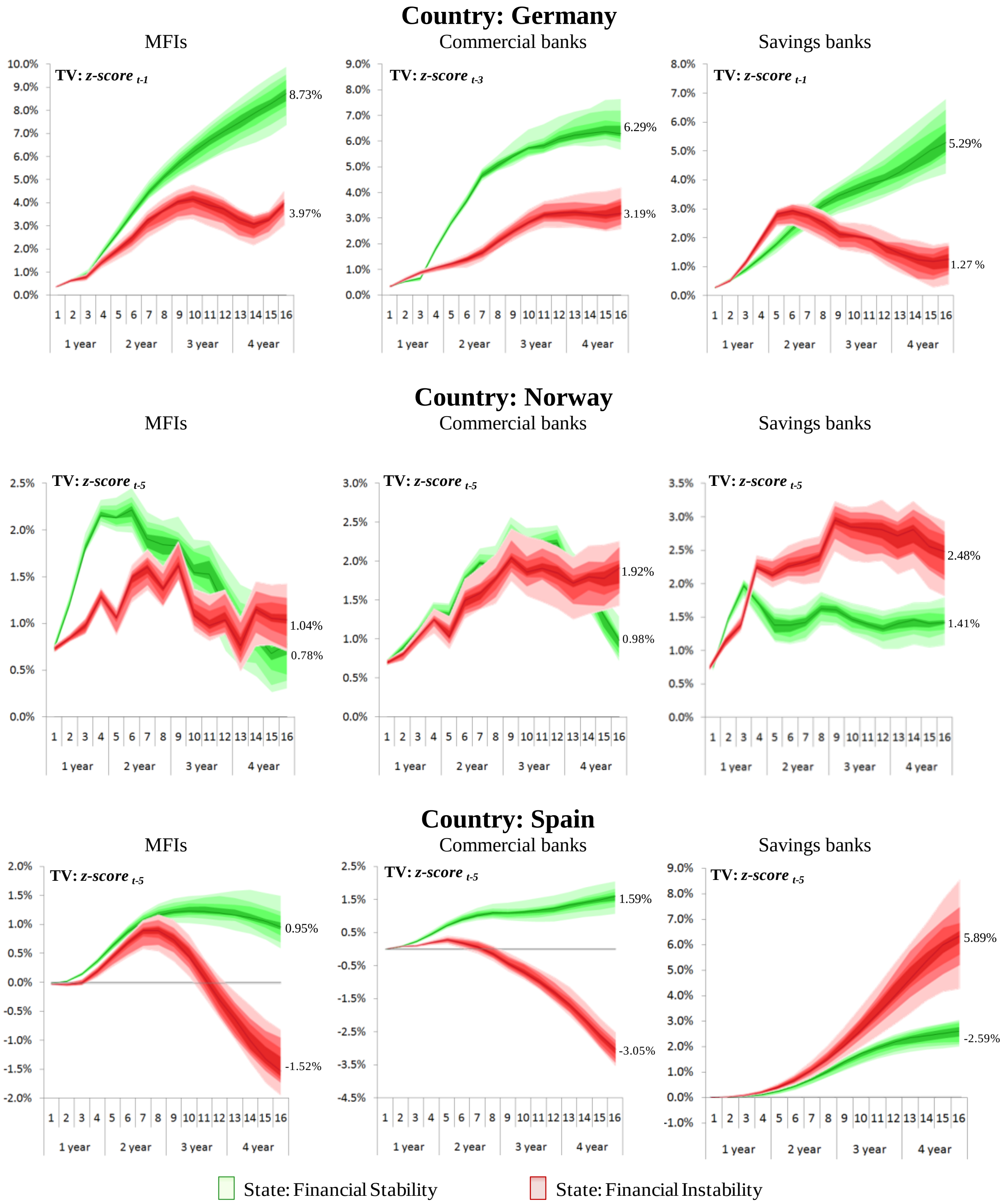
2.6.3 Banking sector's negative effect: *Spanish case*

Figure 2.3 (button panel) shows that the dynamic behaviour in Spain supports the hypothesis of asymmetries in the relationship between the size of a country's financial sector and its rate of economic growth, as it was also found in the German case. When the model that considers MFIs is employed, a positive credit shock has a positive effect on output when the economy begins to experience periods of financial stability. This means that when a high ***z-score*** state is observed, an increase in credit is expected to increase output over a four-year period horizon, as in the linear model.

Figure 2.3

Effect of positive financial development shocks by state of economy

Accumulated response of Growth to Cholesky one S.D. credit innovation



Note: The impulse responses are presented in a fan chart representation – in the form of a probability distribution. The central band, colored deep green/red, includes the central projection: there is judged to be a 10% chance that output growth will be within that central band at any date. The next deepest shade, on both sides of the central band, takes the distribution out to 20%; and so on, in steps of 10 percentage points.

However, when a low ***z-score*** state is observed, output is expected to fall considerably below its initial level within a two-year period horizon. This asymmetry is reflected in the cumulative output response to a positive shock over a four year horizon. When the economy is in a financial stability state, the effect is positive and reaches 0.95%, but the effect is negative and falls to -1.52% when the economy is in a state of financial instability.

As for the differences across different type of banks in Spain, while a positive credit shock from commercial banks in periods of financial stability increases output, output is expected to fall considerably in periods of financial instability, even within the one-year horizon. Cumulative output response is 1.6% when the initial ***z-score*** level is high, and it is negative and almost triple when the economy begins in a low ***z-score*** state (-3.06%).

In contrast, when the savings banks sector is considered, a positive credit shock increases output regardless of if the economy experiences periods of financial stability or instability as it also happened in the Norwegian savings bank sector, because the cumulative response is higher in periods of financial instability (5.89%) than in periods of financial stability (2.6%).

2.6. Concluding remarks

While the recent financial crisis has reshaped the debate on the adverse effect of financial instability on economic growth, it is important to understand how financial development affects growth in periods of financial instability which, in a way, may reveal the (hidden) inefficiencies of this link during stability periods.

This paper finds a differential effect of size and points at the responses of credit on growth in periods of financial instability. This result is supported by conducting a

Smooth Transition Vector Autoregressive model whose transition variable, the ***z-score*** index, is capable of estimating a nonlinear relationship in the financial development's influence on economic growth, in particular when the commercial banks and savings banks are studied. The study was performed independently for Germany, Norway and Spain, using quarterly data between 1980 and 2009.

In the case of Germany we find an asymmetric effect in the size of the impact of financial development on economic growth depending on the state of financial stability. The effects are found to be significantly larger in periods of financial stability than in periods of financial instability. As for the Norwegian case, asymmetric effects are only found when the savings bank sector is considered. For Spain, a positive credit shock in all monetary financial institutions or in the commercial banks' sector has been found to increase output when the economy begins to experience periods of financial stability, but decrease in periods of financial instability. However, this is not the case for the Spanish savings banks sector, where, regardless of the state of the economy, financial development always has a positive effect on economic growth.

These results are consistent with the non-linear relationship suggested by Bencivenga et al (1995), Trew (2008) and von Peter (2009) and contribute to the literature estimating the threshold of financial stability that changes the behaviour of the linkage between financial development and economic growth (Bauducco, Bulíř, and Čihák, 2008). There are extensions in this research such as the use of other financial soundness indicators than can provide a better understanding of the relationship between financial development and economic growth.

Appendix 2.1
Lagrange multiplier tests for linearity

This appendix describes a test for linearity where the baseline is a VAR model specification. This test of linearity contrasts the null hypothesis H_0, $\gamma = 0$ against the alternative H_1, $\gamma > 0$ in equation 1. We follow the three step procedure recommended by Teräsvirta and Anderson 1992. and Weise 1999.. The test is based on an approximation to the LSTVAR equation. In this sense, we test linearity establishing a k-variable VAR with a p lags through the vector of variables $X_t = X_{1t-1}$, X_{1t-2} ,…, X_{1t-p},X_{2t-1} ,…, X_{kt-p}. and assuming lags of the ***z-score*** index as transitions variable. Thus, we proceed as follows,

i) Run the restricted regression,

$$X_t = \left[\beta_0 + \sum_{m=1}^{q} \beta_{m,1} X_{t-m}\right] + \upsilon_t \qquad \text{(A2.1)}$$

collect the $SSR_0 = \sum \hat{\upsilon}_t^2$ and the variance-covariance matrix $\Omega_0 = \Sigma \hat{\upsilon}_t \hat{\upsilon}_t' / T$

ii) Run the unrestricted regression,

$$X_t = \left[\alpha_1 + \sum_{m=1}^{q} \alpha_{m,1} X_{t-m} + \sum_{m=1}^{q} \alpha_{m,2}\, z_t\, X_{t-m}\right] + \nu_t \qquad \text{(A2.2)}$$

collect the $SSR_1 = \sum \hat{\nu}_t^2$ and the variance-covariance matrix $\Omega_1 = \Sigma \hat{\nu}_t \hat{\nu}_t' / T$

iii) Calculate the test statistic F=[SSR_0-SSR_1./pk]/[SSR_0/T-2pk + 1..] to test linearity by equation, and the log-likelihood test LR=T$\{log|\Omega_0| - log|\Omega_1|\}$, to test linearity in the system as a whole. In this last case, the null hypothesis is that H_0, $\gamma = 0$ in all equations and the LR statistic is asymptotically distributed χ^2 with pk^2 degree of freedom.

Appendix 2.2

Table A2.1 - Subset VAR
Estimation Method: Seemingly Unrelated Regression
Country: Germany
Sample: 1980Q4 2009Q2

	MFIs					Commercial banks					Saving banks				
	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$
C	0.00397	-0.00274	-0.02285	0.00136	0.01591	0.02138	0.00049	-0.02067	0.00141	0.02297	0.00264	-0.00164	-0.01271	0.00141	0.01383
∂fint-1	1.07065				0.22356	0.99672					0.97471				
∂fint-2								0.07761				0.32580	0.67709		
∂fint-3		0.73493	1.74750		-1.43190		0.20222	0.45492		-0.41579					
∂fint-4	-0.51837	-0.61986	-1.29222		1.37108	-0.64190	-0.17811	-0.47203		0.30786	-0.33679				-0.59549
∂fint-5	0.41713		-0.38725			0.54449	0.04878				0.27153	-0.20333	-0.66390		0.71523
∂gdp-1	-0.21774	0.87140	0.53543			-0.46833	0.88782	0.67510		0.40820		0.88905	0.84754		0.28540
∂gdp-2				-0.08235					-0.08163					-0.08670	
∂gdp-3				0.07135	-0.65057				0.07150	-0.92712		0.15886		0.10142	-0.97663
∂gdp-4		-0.41492					-0.43287					-0.74680	-0.92741	-0.02980	0.35046
∂gdp-5		0.40886	0.59819		-0.41363	-0.34244	0.33151	0.39889		-0.33021	0.02143	0.45983	0.69493		-0.53987
∂invt-1	0.07621		0.68444			0.23037		0.62076					0.61401		
∂invt-2								0.07979							
∂invt-3			0.07499		0.19796		-0.03273			0.26478		-0.06170			0.20256
∂invt-4	-0.02231	0.08290	-0.28833				0.10425	-0.25417				0.17000			
∂invt-5	0.01245	-0.10455					-0.09625					-0.09669			
∂labt-1		0.22056		0.84185			0.20277		0.84451			0.27936		0.85212	
∂labt-2			0.93063					0.99138			0.29443		0.98166		
∂labt-3															
∂labt-4				-0.29792		-0.59080			-0.29603		-0.31831			-0.28089	
∂labt-5				0.21863					0.20605	-0.53635				0.20433	
∂opent-1		0.10816	0.13455		0.97626		0.06217			1.08771		0.07981			1.08794
∂opent-2		-0.06526								-0.16961			0.10797		-0.20731
∂opent-3				0.03468			-0.10185		0.03011			-0.06496		0.03364	
∂opent-4		-0.09050	-0.25787	-0.02723	-0.42995			-0.15492	-0.02331	-0.36173	-0.04410	-0.07077	-0.24645	-0.02837	-0.35156
∂opent-5		0.11165	0.18582		0.25315		0.05959	0.09201		0.26810		0.12918	0.18261		0.24930
R-squared	0.90141	0.84439	0.82663	0.68989	0.84193	0.80394	0.81695	0.80887	0.69025	0.84740	0.91381	0.79137	0.77183	0.69325	0.81495
Adjusted R-squared	0.89496	0.82608	0.80624	0.66961	0.82838	0.79112	0.79339	0.78846	0.66998	0.83110	0.90817	0.76216	0.74989	0.67010	0.79519
S.E. of regression	0.01079	0.01229	0.03620	0.00525	0.02901	0.03054	0.01340	0.03782	0.00525	0.02878	0.00872	0.01437	0.04113	0.00525	0.03169
Mean dependent va	0.02898	0.02029	0.01747	0.00625	0.01532	0.03660	0.02029	0.01747	0.00625	0.01532	0.02694	0.02029	0.01747	0.00625	0.01532
S.D. dependent var	0.03328	0.02947	0.08224	0.00913	0.07002	0.06682	0.02947	0.08224	0.00913	0.07002	0.02876	0.02947	0.08224	0.00913	0.07002
Sum squared resid	0.01245	0.01541	0.13367	0.00295	0.08836	0.09980	0.01813	0.14736	0.00295	0.08530	0.00813	0.02066	0.17592	0.00292	0.10344
Determinant resid covariance		9.58E-20				8.70E-19					7.05E-20				

Appendix 2.3

Table A2.2 - Subset VAR

Estimation Method: Seemingly Unrelated Regression

Country: Norway

Sample: 1983Q4 2009Q3

	MFIs					Commercial banks					Saving banks				
	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$
C	-0.01284	0.02463	0.00468	0.00015	0.00009						-0.00084	0.01694	0.00668	-0.00051	-0.00541
∂fint-1	1.04912	0.10873		0.06873		1.38888	-0.06571				0.80452	0.21967		0.03610	
∂fint-2						-0.70738		0.51220	0.01823		-0.19670			-0.03678	
∂fint-3		-0.17395		-0.07507			-0.09416	-1.02530		0.33681		-0.19785			
∂fint-4	-0.61810			0.06430	-0.24294			1.07841		-0.46535					-0.24098
∂fint-5	0.53341			-0.05216	0.24703			-0.51160		0.17782	0.27540				0.28498
∂gdp-1								0.59461	0.07364		0.30008		0.63240	0.06554	
∂gdp-2															
∂gdp-3				0.07812		-0.28640			0.06738			0.17786		0.08413	
∂gdp-4	0.26535	-0.29189		-0.06167			-0.36989		-0.05445					-0.07927	
∂gdp-5	0.30298	0.36738					0.28542					0.21778			
∂invt-1	0.04419		0.59231			0.07806	0.04280	0.55997					0.52724		
∂invt-2					0.09547	-0.09220									
∂invt-3	-0.04056					0.16551									
∂invt-4		-0.04978	-0.32712					-0.35791					-0.27907	0.01610	
∂invt-5			0.43241					0.32260					0.40575		
∂labt-1		0.65898		0.88588			0.72544		0.83078	0.84109				1.02959	1.52762
∂labt-2												1.30163		-0.23637	-1.34216
∂labt-3			2.49744		-0.58885			2.45959		-0.77787		-1.22164			
∂labt-4	-0.56422		-2.40795												
∂labt-5		-0.28467					-0.40509	-1.58450				-0.27829	-0.98116		
∂opent-1	0.14858	0.15973			0.56836		0.18746		0.03283	0.48405					0.48089
∂opent-2					0.38144					0.40230					0.44041
∂opent-3				0.04398		0.28118		0.40535					0.41895	0.04103	
∂opent-4	-0.13924	-0.23332			-0.39285	-0.16947	-0.22386	-0.51874		-0.46148					-0.46419
∂opent-5		0.16899					0.14728								
R-squared	0.92374	0.46760	0.48609	0.90256	0.69106	0.87979	0.44249	0.59377	0.90118	0.65973	0.72959	0.37213	0.52223	0.90505	0.65481
Adjusted R-squared	0.91334	0.40180	0.45904	0.89292	0.66420	0.86605	0.36051	0.51991	0.89294	0.62084	0.71414	0.30653	0.48008	0.89191	0.61875
S.E. of regression	0.02098	0.01945	0.07206	0.00579	0.03029	0.02671	0.01972	0.06905	0.00505	0.02867	0.02970	0.02071	0.06619	0.00493	0.02908
Mean dependent var	0.07428	0.02817	0.02476	0.00983	-0.00263	0.05579	0.02825	0.03389	0.01039	-0.00124	0.06283	0.02873	0.04227	0.01143	-0.00239
S.D. dependent var	0.07126	0.02515	0.09797	0.01769	0.05226	0.07298	0.02466	0.09966	0.01544	0.04656	0.05555	0.02487	0.09180	0.01501	0.04709
Sum squared resid	0.03873	0.03368	0.49328	0.00305	0.08438	0.04994	0.02643	0.31472	0.00184	0.05754	0.06176	0.02874	0.29791	0.00158	0.05664
Determinant resid covariance		1.14E-17				9.66E-18					1.19E-17				

Appendix 2.4

Table A2.4 - Subset VAR
Estimation Method: Seemingly Unrelated Regression
Country: Spain
Sample: 1980Q4 2009Q2

	MFIs					Commercial banks					Saving banks				
	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$	∂fin_t	∂gdp_t	∂inv_t	∂lab_t	$\partial open_t$
C	-0.04929	0.01556	0.32017	0.97589	-0.21614	0.00049	-0.70007	0.01243	0.36523	-0.40933	0.00379	0.08745	0.13019	-0.07985	-0.25912
∂fint-1	1.09418	0.03973	0.31224			1.00188	0.05274	0.46690			1.07584		-0.00859		
∂fint-2				0.02688			-0.05822	-0.24630							
∂fint-3		0.06710					0.06617					0.01862			
∂fint-4	-0.54121	-0.11157	-0.39453	-0.01506		-0.62197	-0.08351	-0.35583	-0.03771		-0.49427		-0.04656		
∂fint-5	0.33348					0.53890			0.04820		0.25846				
∂gdp-1		1.39178	2.44664		0.57279	0.78072	1.40239	2.23677		0.57070		1.25447	2.05710		0.52303
∂gdp-2		-0.44782	-2.36494			-1.34064	-0.53889	-2.78894				-0.36837	-2.24916		
∂gdp-3	0.51964	0.35246	0.94096			1.27804	0.39259	1.32683				0.33337	0.97217		
∂gdp-4	-0.51723	-0.84156		-0.12610		-0.78532	-0.89880		-0.11084			-0.81799		-0.08809	
∂gdp-5		0.47636			-1.33715		0.54908			-1.33763		0.42596			-1.32878
∂invt-1	0.05578		0.42797					0.38016	0.01539		0.06840	0.03911	0.60046		
∂invt-2			0.43511			0.17793		0.47699					0.46842		
∂invt-3															
∂invt-4		-0.02443	-0.48150			-0.10069		-0.41445				-0.03327	-0.54917		
∂invt-5		0.03298	0.21251	0.02052	0.17417		0.02587	0.23358	0.01907	0.17503		0.03187	0.20144	0.02276	0.17500
∂labt-1				0.97589			0.08534		0.99985		0.46962			0.96991	
∂labt-2															
∂labt-3		-0.16734					-0.21413		-0.17214			-0.16668			
∂labt-4		0.28397	0.32017	-0.51593			0.30187	0.42716	-0.39371			0.22411		-0.55814	
∂labt-5	0.33035	-0.12316		0.42242		0.32024	-0.10529		0.41121			-0.15303		0.45957	
∂opent-1			-0.07560	-0.01814	0.69770					0.69359					0.72516
∂opent-2		0.01556			0.25785		0.02550			0.27930		0.02086			0.23621
∂opent-3	-0.04929	-0.02792			-0.21614	-0.07137	-0.02423			-0.21526		-0.02287			-0.20645
∂opent-4					-0.33816					-0.35438					-0.30782
∂opent-5		0.01511	0.06218		0.37287		0.01479	0.06700	-0.01906	0.37689				-0.01896	0.33175
R-squared	0.95993	0.94674	0.82505	0.87132	0.66291	0.93517	0.94741	0.83809	0.87746	0.66260	0.94130	0.93526	0.81116	0.86865	0.66277
Adjusted R-squared	0.95691	0.93805	0.80447	0.86161	0.63747	0.92825	0.93819	0.81905	0.86567	0.63714	0.93858	0.92610	0.79482	0.86128	0.63708
S.E. of regression	0.01343	0.00416	0.02893	0.00453	0.04078	0.01795	0.00416	0.02783	0.00447	0.04080	0.01582	0.00455	0.02976	0.00452	0.04088
Mean dependent var	0.06757	0.02776	0.03721	0.01871	0.02012	0.05168	0.02776	0.03721	0.01871	0.02012	0.09865	0.02786	0.03739	0.01887	0.01967
S.D. dependent var	0.06471	0.01672	0.06543	0.01219	0.06773	0.06699	0.01672	0.06543	0.01219	0.06773	0.06382	0.01675	0.06569	0.01212	0.06785
Sum squared resid	0.01913	0.00170	0.08538	0.00218	0.17630	0.03317	0.00168	0.07902	0.00208	0.17646	0.02702	0.00205	0.09208	0.00218	0.17545
Determinant resid covariance		3.39E-20					4.95E-20					6.2E-20			

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Chapter – 3
Another look at bank consolidation and financial stability

Abstract

In this paper we show that a non-monotonic relationship links certain structural characteristics of the banking market to financial stability, including the number of banks in the market, the branching decisions and branch productivity. Using a non-dynamic panel threshold regression we explain how financial stability is affected by baking market power when market power is subject to one or more regime-switches that characterize a possible non-linear or a threshold effect. The results show that economies with a small number of financial institutions over branched but with a low number of employees per office achieve fewer risk of bank failure. However, such gains are absent in the case of economies with a large number of institutions, where decreases in competition produce a higher risk of financial instability.

Key words: Financial stability • Market power • Bank branches • Panel threshold regression

JEL classification: G21 • G33 • G34

3. *Another look at bank consolidation and financial stability*

3.1. Introduction

The international financial sector has been subject to substantial structural changes since the U.S. subprime credit crisis in mid-2007. The crisis has resulted in numerous bank failures, the nationalisation of many financial institutions, bailout and interventions by regulatory and supervision authorities and a considerable deterioration of economic output and employment at both sides of the Atlantic. In order to deal with this situation, many banking sectors have suffered important restructuring processes through mergers and acquisitions, implementing a set of related efficiency measures including the reduction of employees and branches at many banks.

Even if restructuring processes are common features following banking crises, there is no consensus as to whether the effects of these processes are positive or negative in terms of financial stability. One set of studies can be considered within the so-called *concentration-stability* approach. For example, in Allen and Gale (2004) or Boyd and Nicoló (2005), BDN henceforth, it is suggested that higher concentration of banking systems can generate greater economic value and reduce financial fragility. Opposite different view is provided by authors like Beck et al. (2006) and Uhde and Heimeshoff (2009) supporting the *concentration-fragility* approach, which holds that highly concentrated financial systems generate more systemic risk and financial instability.[6]

[6] For a detailed literature review of the different theoretical models, see for example Berger et al. (2008)

In this paper we hypothesize that the different findings under both approaches can be at least partially related to non-monotonic relationships between bank market power and financial stability. The aim of our paper is related to the theoretical findings of Martínez-Miera and Repullo (2010), MMR henceforth, who suggest that the link between bank competition and financial stability could turn negative if more competition reduces loan rates, which in turn leads to lower probabilities of default, and more financial stability. This response is referred to as the *risk-shifting effect* and was first identified by BDN under the assumption that loan defaults are perfectly correlated with the bank's probability of failure. However, in the case of imperfect correlation of loan defaults, more competition leads to lower loan rates, and consequently lower revenues from performing loans, and, less financial stability. This effect is known as the *margin effect*. Depending on which of the two effects (the "risk-shifting" or the "margin") dominates, the final effect of market competition on financial stability may have a different sign and significance.

Most of the existing literature dealing with banks' soundness have employed monotonic linear models. These studies have offered mixed or ambiguous results. For example, the findings reported by Boyd et al. (2006), De Nicoló and Loukoianoca (2006) Schaeck et. al. (2006) or Turk-Ariss (2010) show that higher bank competition is related to a lower risk of bank failure, in line with the *concentration-stability* approach. However, the findings of De Nicoló et al. (2004) and Uhde Heimeshoff (2009) Jiménez (2010), among others, support the *concentration-fragility* approach, since they suggest that bank risk decreases with bank market power. We hypothesize that both approaches may be reconciled to some extent by addressing the potential non-linearity of the relationship between bank competition and financial stability.

Some previous studies – including Liu et al. (2010) and Maudos and Fernández (2010) – tangentially deal with non-linearity by including a quadratic term in their bank market power explanatory variable, they find that the *risk-shifting effect* appears to dominate in more concentrated markets while the *margin effect* emerges dominant in more competitive banking markets. Although this solution results useful for testing the presence of non-linearity, it has the disadvantage of a priori imposing a U-shaped relationship which is not feasible to determine what the channel is or threshold that explains the non-monotonic connections between financial stability and bank competition. These relationships could change as a result of a stimulus which is triggered by exceeding a certain critical value, e.g. the number of banks as it has been proposed theoretically by MMR.

This study employs a non-dynamic panel threshold regression technique set out by Hansen (1999)[7], which allows us to test if the relationship between financial stability and market power, is conditional on one or more regime-switches or thresholds that characterize a possible non-linear effect. This approach has several advantages. First, the threshold value is estimated rather than being imposed a priori, and second, the changes in the number of banks, for example, can be assessed more easily since the variable is directly considered as an explanatory variable in the empirical model.

We apply this methodology on a panel of banks belonging to 23 OECD countries over 1996-2010. In addition we also consider using other transition variables besides the number of banks. In particular, we use bank branching decisions and the number of employees per branch, as a proxy of managerial office performance, providing a deeper

7 Hansen (1999) is who has further developed the statistical theory of threshold models.

understanding on what of the two effects – the *risk-shifting* or the *margin effect* – dominates.[8]

Since we find a U-shaped relationship our main contribution to current knowledge is that we reconcile diverse opinions as to whether processes of financial consolidation are positive or negative in terms of financial stability and show evidence of the channels through which the nonlinearity works. Thus, our results show that economies with a small number of financial institutions, over branched but with high level of managerial office performance achieve greater stability, measured by the Z-score indicator. However, such gains are absent in the case of economies with a large number of institutions, where increases in market power achieved by greater financial consolidation may actually produce financial instability.

The structure of the article is as follows. The next section briefly describes the main theories and empirical results in earlier contributions. The third section presents the model specification and the estimation methods. The fourth section describes the data and discusses the reasons for having selected the threshold variables in which we observe asymmetry in the relation between competition and stability. The fifth section presents the empirical results, and in the last section, some conclusions are drawn.

3.2 Literature review: a brief overview

3.2.1 *Concentration-stability* approach

The studies supporting the concentration-stability approach rely on four main type of findings related to bank concentration: *i*) enhanced ability to increase capital

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8 Managerial office performance is the systematic process by which a firm involves its employees, as individuals and members of a group, in improving organizational effectiveness in the accomplishment of firms mission and goals, e.g. revenue-maximizing firm’s strategy.

reserves; *ii*) constituted value; *iii*) enhanced ability to ration credit; and *iv)* enhanced monitoring and control.

According to the first hypothesis, large banks are more able to withstand liquidity shocks and macroeconomic instability; because they can increase their profits more easily by taking advantage of the benefits of greater concentration. Hence, financial fragility is reduced by the strengthening of *"capital reserves"*.

The theoretical work of Allen and Gale (2004) and BDN, considering different models of general equilibrium, show that financial crises are less likely in more concentrated banking systems. Their main argument is related to long-term dynamics, as it is theoretically proved that in the absence of competitions, banks have a greater capacity to absorb the deterioration of their assets, by appropriate management of their reserves in response in adverse situations. These findings have been also supported by empirical studies such as Paroush (1995) and Benston et al. (1995), which suggest that the increased market power obtained from the benefits of diversification following bank mergers leads to more bank stability. Furthermore, a detailed investigation of bank mergers in the U.S. has shown that the variance in pre-merger profits of the target bank and the corresponding covariance of the merging bank are negative with respect to the purchase price. Similar results were reported by Craig and Santos (1997), who analyse post-merger profitability and risk, and conclude that consolidation acts as a stabilisation mechanism. Finally, Schaeck et al. (2006) use cross section data for 38 countries and derive the Panzar-Rosse H-statistic providing empirical evidence that competition increases the probability of a banking crisis and that its duration is greater in more competitive environments. An important feature in many of these papers is that concepts of "concentration" and "competition" are sometimes unambiguously used.

The hypothesis of "*constituted value*" refers to the intangible value associated with the enhanced reputation obtained when a large bank is created. It is assumed that the increase in constituted value, arising from increased market power, discourages the bank's management from taking excessive risks that might threaten their own privileges. This is so because the higher is the value of an institution, the greater the opportunity cost of bankruptcy, which encourages banks to accept high-risk investments. This jeopardises their future profits but, at the same time, creates incentives to generate assets of higher quality.

As noted by Beck (2008), the question of constituted value in banking has been studied by Chan et al (1986), Keeley (1990) and Park and Peristiani (2007), under the theoretical assumption that banks choose the risk of their asset portfolio in terms of how to transfer it to depositors, so that in a world of limited liability, and where ever more competitive pressures to maximise profits are exerted, banks have greater incentives to take excessive risks – and thus the system becomes more fragile.

Another hypothesis in favour of the concentration-stability approach involves the economies of scale achieved when big banks diversify their investment portfolios. Authors such as Diamond and Dybvig (1983), Boyd and Prescott (1986) and Boot and Thakor (2000) have observed that large institutions tend to adjust better to the process of *"credit rationing"*; firstly, because the loans managed by these institutions are lower in volume but higher in quality, they are able to significantly increase their return on investment; secondly, these banks possess larger technological platforms and so, in general, they enjoy a comparative advantage in the provision of lending monitoring services. Additionally, because such banks usually have access to cross-border activities, they can geographically diversify the risk of their investments and thus improve their situation and financial strength (Méon and Weill, 2005).

The final hypothesis supporting the concentration-stability view is that a concentrated financial system, with just a few very large banks, is easier to control than one that is less concentrated but with many small banks. This means that, from a regulatory perspective, the supervision of this kind of financial institutions is more effective and the risk of contagion is better controlled (Allen and Gale, 2004).

3.2.2 *Concentration–fragility* approach

The concentration fragility approach also relies mainly on four different hypotheses: *i*) the aggravated problem of moral hazard; *ii*) increased interest rates; *iii*) the inefficiencies of risk diversification; *iv*) the complexity of processes and organisation.

The first hypothesis suggests that institutions in these markets suffer from the "too big to fail" effect (Mishkin, 1998), according to which regulators tend to grant big banks larger guarantees and subsidies, via a government-sponsored safety net, which encourages investment managers to take greater risks, thus aggravating the *"moral hazard problem"*.

Secondly, it is argued that the *"increased interest rates"* on loans from banks -a characteristic of more concentrated markets, in which financial institutions tend to act as monopolists- induce firms to take on greater investment risks in order to offset the loan repayments required. The theoretical models by Boyd and Nicoló (2005; 2006) predict that the higher the interest rates are, the greater is the likelihood that loans will become non-income-generating. Therefore, the risk of loan defaults in this context increases the likelihood of bank failures. In the same vein, Caminal and Matutes (2002) show that a lower degree of competition in the banking sector may lead to less credit rationing, larger loans and a higher probability of bank failure if these loans are subject to greater multiplicative uncertainty.

The third hypothesis states that more concentrated markets suffer from a greater degree of *"inefficiencies in the diversification of risk"*, since the increased size of banks, following mergers and acquisitions, generally leads to reduced administrative efficiency, less effective internal control and increased operational risks arising from failures of supervision, as shown by Cetorelli et al. (2007).

Finally, the argument of *"organisational complexity"* (Beck et al., 2006) is also in favour of the concentration-fragility approach. In particular, the size of a bank is positively correlated with a lower degree of transparency, as greater size allows the bank to expand operations across multiple geographic markets and lines of business, using sophisticated financial instruments. A complex corporate organisation makes the resulting structure much harder to monitor than in the case of a small bank.

3.3 The non-dynamic panel threshold regression method

3.3.1 The model specification

The systemic banking soundness has been usually studied through monotonic linear models that relate a financial stability dependent variable to a market competition measure (proxy by concentration indexes), as follows:

$$Z_{it} = \mu_i + \beta_1' c_{it} + \sum_j \psi_j' x_{j,it} + \sum_k \phi_k' y_{k,it} + e_{it} \qquad (3.1)$$

where Z_{it} represents the Z-score ratio as a measure of financial soundness, c_{it} as a measure of banking market competition, e_{it} as an error term, and μ_i and β_1 are the parameters to be estimated under the hypothesis that there exists only one regime (that is, there is no threshold). However, a more general model specification could be considered to test the hypothesis that financial stability could be affected by market power, as such power is subject to one or more regime-switches that characterize a possible non-linear effect. In this sense, the use of a non-dynamic panel threshold regression method provides useful according to the following specification (Hansen, 1999):

$$Z_{it} = \mu_i + \overbrace{\beta_1' c_{it} I(q_{it} < \gamma) + \beta_2' c_{it} I(q_{it} \geq \gamma)}^{\textit{Regime-dependent regressor}} + \underbrace{\textstyle\sum_j \psi_j' x_{j,it}}_{\substack{\textit{Financial soundness} \\ \textit{indicators}}} + \underbrace{\textstyle\sum_k \phi_k' y_{k,it}}_{\substack{\textit{Macro prudential} \\ \textit{indicators}}} + e_{it} \qquad (3.2)$$

where $I(.)$ is an indicator function. Where the observations are divided into two 'regimes' depending on whether the threshold variable q_{it} is smaller or larger than the threshold γ. Each regime is distinguished by the two regression coefficients β_1 and β_2, that capture possible asymmetric effects of market power on financial stability (positive or negative). In order to distinguish these coefficients, the elements of q_{it} must be non-time-invariant and the error term $e_{it} \sim N(0, \sigma^2)$. An alternative intuitive way of writing (3.2) is:

$$Z_{it} = \begin{cases} \mu_i + \beta_1' c_{it} + e_{it}, & q_{it} < \gamma \quad \textit{(low regime)} \\ \mu_i + \beta_2' c_{it} + e_{it}, & q_{it} \geq \gamma \quad \textit{(high regime)} \end{cases} \quad i=1,...,N; \quad t=1,...,T \qquad (3.3)$$

These equations include two set of control variables: *i*) bank-level *Financial soundness indicators* ($x_{j,it}$), and *ii*) country-level *Macro prudential indicators* ($y_{k,it}$), that are included to reduce the possibility of spurious correlations due to omitted variable bias. The expression (3.3) can be viewed as a special case of (3.1) by constraining the slope coefficients on this group of variables to be the same in the two regimes, which has no effect on the distribution. The reason why model (3.2) has a slope coefficient is that it switches between regimes (denoted by c_{it}). This isolates the so-called regime-dependent regressor.

3.3.2 Estimation and inference of threshold effects

Even though equation (3.2) is non-linear in the parameters, for any given threshold γ, the slope coefficients β_1 and β_2 can be estimated by using conditional least squares after a fixed-effects transformation, where the estimate of γ is the value that minimizes the residual variance obtained by a least square procedure:

$$\hat{\gamma} = \underset{\gamma \in \Gamma_n}{argmin}\, S_1(\gamma) \tag{3.4}$$

where $S_1(\gamma)$ is the sum of squared residuals from estimating (2) for a given threshold γ such that $\Gamma_n = \Gamma \cap \{q_1, \dots, q_n\}$. If n is very large, the minimization problem of (4) can be solved by a grid search by taking a certain percentage (η%) of observations out to ensure a minimum number of them in each regime. For some $N < n$, let $q_{(j)}$ denotes the (j/N) percentile of the sample $\{q_1, \dots, q_n\}$, and let $\Gamma_N = \Gamma \cap \{q_{(1)}, \dots, q_{(N)}\}$. Then the value of $\hat{\gamma}_N$ that minimizes $S_N(\gamma)$ could be considered as a good approximation of $\hat{\gamma}$, just requiring N function evaluations (Hansen, 2000). The main advantage of the threshold estimation technique is that the value of the threshold variable at which a significant change in coefficients occurs is endogenously determined in the estimation procedure.

An important question to be considered when a panel threshold regression model is specified is whether it is statistically significant to move from no threshold effect as in equation (3.1) to the non-linear expression in (3.2). Then, to test the hypothesis of a threshold effect we should impose the following linear constraint:

$$Ho: \beta_1 = \beta_2 \tag{3.5}$$

This expression shows that the relevant null hypothesis is that there is not an asymmetric pass-through from increases on banking market power to the stability of the financial sector. However, from an econometric standpoint the constraint in (3.5) results in a non-standard testing problem since under the null there are some parameters that are not identified[9]. Hansen (1999) shows that the likelihood ratio tests of Ho, with near-optimal power against the null alternatives, is a standard F-statistic based on:

$$F_1 = (S_0 - S_1(\hat{\gamma}))/\hat{\sigma}^2 \qquad (3.6)$$

where S_0 is the sum of squared error assuming a non threshold specification (3.1). Because the fixed-effects in (3.2) falls in the class of models considered by Hansen (1999), a bootstrapping procedure to simulate the first-order asymptotic distribution of the likelihood ratio test should be considered to obtain an asymptotically valid p-value[10.]

3.4 Data and variables

3.4.1 Sources and sample selection

Our empirical analysis is based on a sample of 23 OECD countries during 1996-2010. The set of Financial Soundness Indicators (FSIs) were obtained from the World Bank-FSB database of bank profitability, the balance sheets of firms reported in the Fitch-IBCA Bank Scope database, and the time series taken from the macroeconomic summaries of the International Financial Statistics database provided by DataStream. These indicators are based on an exhaustive measurement of the current conditions of financial health and soundness of a representative pool of banks in a given country.

[9] The so-called 'Davies' Problem (see Davies, 1977, 1987). For more details see Andrews and Ploberger (1994) and Hansen (1999).
[10] For further details on the implementation of the bootstrap see Hansen (1999)

Table 3.1
Definitions of variables to analyze financial stability

Variable	Definition	Source
Financial Stability		
1. Z-score	Ratio of the sum of return on assets (RoA) and the equity capital (K) to the total assets, divided by the standard deviation of the return on assets, considering a four year rolling window.	Fitch-IBCA BankScope
Competition measures		
2. C5	Concentration index	Fitch-IBCA / Own calculation
3. HHI	Herfindahl-Hirschman Index	
4. Lerner index	Banks' market price (P_{TA}) less marginal cost (C_{TA}) relative to their price	
5. Nimta index	Interest rate mark-up after controlling for different sized banks by deflating by total asset value.	
Threshold measures		
6. Number of MFI's	Number of Monetary financial institutions	OECD Banking Statistics
7. Ratio employees to branch	Number of employees per banks' branches	
8. Ratio branches to banks	Number of branch per banks	
Financial soundness indicators:		
9. Impaired Loans Ratio	Measure the impaired loans as a percentage of book value of total assets	Fitch-IBCA / Own calculation
10. Financial Leverage Ratio	One minus Shareholders' Equity relative to Total Liabilities	
11. Interest Margin Ratio	Net interest income relative to their Gross interest and dividen income	
12. Operating risk Ratio	Non interest expenses relative to their Net interest margin	
13. Commissions	Fees and commissions as a percentage of book value of total assets	
14. Spread Income	Difference between the assets it invests in loans and the cost of its funds (Short term and Long Term Funding).	
Macroprudential indicators		
15. Economic growth	Gross Domestic Product (GDP) growth rate	International Financial Statistics (IMF)
16. Inflation	Annual percentage change in the Consumer price index (CPI)	
17. Level of real interest rate	Lending interest rate adjusted by the GDP deflator	
18. Goverment debt to GDP	Debt owed by a central government as a percentage of the GDP	
19. Political Constrain	Captures how likely a change in preferences of any political actor translates into a change in the status-quo public policy	Heniz (2010)

3.4.2 Variable construction

3.4.2.1 Financial stability index (*dependent variable*):

As Boyd et al. (1993) we define instability as a state where $(RoA_t - K_t) \leq 0$, with RoA its return on assets and K is the bank's capital-asset ratio. Then, in line with the existing literature we construct the Z-score index by collecting information directly from the balance sheets of firms reported in the Fitch-IBCA Bank Scope database[11]. The index was computed for each bank by country and year by adding the average RoA to the average capital-to-asset ratio, and dividing this sum by the standard deviation of the return on assets ($\sigma_{roa,t}$) assuming normality in the distribution:

[11] For some recent papers using this methodology, see e.g. Nicoló et al. (2004), Laeven and Levine (2007), Hesse and Čihák (2007), Uhde and Heimeshoff (2009) and Carbó et al. (2011).

$$Z_t \equiv (RoA_t + K_t)/\sigma_{RoA,t} \quad \text{with} \quad \sigma^2_{RoA,t} \overset{i.i.d.}{\sim} (0, \sigma^2) \tag{3.7}$$

Accordingly, this indicator would rise with increases in bank profitability and fall with the proportion of capital to assets or with higher *RoA* volatility. Therefore, from an economic point of view, the Z-score reflects the probability of a bank becoming insolvent when its asset value is less than the value of its debt, and so a higher (lower) value implies a lower (higher) risk of default (see appendix for the probabilistic implications). Throughout the entire the sample, most observations of the Z-score are found within the range of 4 and 70; however, there are some extreme observations, resulting in the sample range being from -5 to 2,840 with an average of 28, which leads to the question of whether it is appropriate or not eliminate outliers from the distribution of the Z-score. On the one hand, we are interested in the events of financial instability, which makes it interesting to include extreme observations, but on the other hand, these outliers may be due to exceptional events or, simply errors in the data. In order to mitigate the effects of outliers and misreported data, the highest and the lowest 1% observations were winsorized. As for the distribution by country, Switzerland and Italy exhibit the highest average values (48.5% and 28.4%, respectively) while Estonia (7.5%) and the Finland (10.5) report the lowest. The overall probability of a bank becoming insolvent for the OECD sample is 20.3%.

3.4.2.2 Competition measures (*regimen-dependent regressor*):

Rather than using only concentration indices - as the N-firm ratio (C_N) or the Herfindahl-Hirschman Index (HHI) - to capture the effects of changes in competition on financial stability (measured at country-level), we propose to use of bank-level data to infer the competitive behaviour in the banking industry. We therefore use measures such as the Net interest margins ratio ($NIMTA$) and the Lerner index ($LERNER$), estimated in the same way as Schaeck et al. (2006) or Carbó et al. (2007).

Table 3.2
Financial stability and competition measures
(Mean values and ranks over 1996–2010)

Countrys	Financial Stability		Competition measures (*regime-dependent regressor*)									
	Z-score		Lerner		Nimta		C5		HHI		H-statistic	
	Index	Rank	(%)	Rank	(10 x %)	Rank	(%)	Rank	Index	Rank	Index	Rank
Austria	22.7	15	0.340	8	0.022	15	0.45	7	116.6	7	0.515	17
Belgium	16.5	9	0.341	9	0.017	8	0.69	17	215.0	16	1.274	23
Czech Republic	15.2	7	0.514	21	0.020	11	0.66	14	147.2	8	0.205	7
Denmark	18.6	10	0.508	20	0.035	23	0.67	15	178.8	13	0.307	9
Estonia	7.5	1	0.418	14	0.030	21	0.93	23	390.2	23	1.236	22
Finland	10.5	2	0.457	17	0.016	4	0.83	21	317.8	21	0.664	21
France	24.4	18	0.288	4	0.021	12	0.42	6	52.1	3	0.317	10
Germany	25.2	20	0.460	18	0.025	18	0.21	1	33.8	1	0.477	16
Ireland	23.0	17	0.690	23	0.006	1	0.53	8	97.6	6	-0.005	2
Israel	20.3	11	0.321	6	0.022	14	0.76	20	174.2	12	0.546	19
Italy	28.4	22	0.393	12	0.028	20	0.30	2	149.6	9	0.458	15
Japan	16.5	8	0.450	16	0.017	7	0.34	3	40.8	2	0.535	18
Korea Rep. of	11.1	3	0.283	2	0.016	6	0.41	4	70.1	5	0.189	5
Netherlands	26.4	21	0.307	5	0.014	3	0.66	13	195.5	15	0.284	8
Norway	23.0	16	0.253	1	0.019	10	0.85	22	289.7	20	0.201	6
Poland	14.2	6	0.382	11	0.032	22	0.57	10	321.7	22	0.441	14
Portugal	22.0	13	0.422	15	0.017	9	0.68	16	189.9	14	-0.053	1
Slovakia	11.2	4	0.597	22	0.022	16	0.74	18	165.9	11	0.381	12
Slovenia	14.1	5	0.372	10	0.023	17	0.61	12	216.8	17	0.647	20
Spain	24.8	19	0.487	19	0.021	13	0.41	5	264.7	19	0.322	11
Sweden	22.0	14	0.334	7	0.025	19	0.58	11	164.1	10	0.127	4
Switzerland	48.5	23	0.288	3	0.016	5	0.75	19	227.7	18	0.404	13
United Kingdom	20.5	12	0.394	13	0.014	2	0.54	9	64.9	4	0.110	3
Max	48.5		0.690		0.035		0.93		390.2		1.274	
Median	20.3		0.404		0.021		0.59		177.6		0.416	
Min	7.5		0.253		0.006		0.21		33.8		-0.053	

Source: author calculation

The $NIMTA$ ratio, has been widely used to capture the pricing ability of banks to raise spread between the interest revenues from bank assets (price loan, P_L) and the interest expense on bank liabilities (price deposit, P_D), since the seminal work of Ho and Saunders (1981). This measure, computed through the net interest margin (difference between interest income and interest expense) over total bank assets is also known as the bank's loan-deposit rate spread $(P_L - P_D)$ [12].

However, as it has been pointed out by Carbó et al. (2009) the Ho-Saunders model is based solely on pure intermediation activities. For this reason, we also consider the Lerner index, which allows us to complement our analysis by considering a multi-product framework thereby reflecting a more diversified bank output.

The latter is computed as $(P_{TA} - MC_{TA}/P_{TA})$, where P_{TA} is the price of total assets, which the ratio of total (interest and non-interest) income over total assets and MC_{TA} is the marginal cost of total assets. As in Carbó et al. (2009) we consider a standard trans-log function with a single output (total assets) and three input prices (deposits, labour and physical capital). The cost function is estimated as a panel data with fixed effects covering a sample of 23 countries over 1996–2010.

3.4.2.3 Threshold variables (*risk-shifting and margin effect*):

To account for potential nonlinear effects, three threshold variables were considered: *i*) the number of financial institutions, *ii*) bank branching expansion, and *iii*) the number of employees per branch. All these variables were computed using the Bank Profitability-FSB database published by the World Bank.

Given that main goal is try to solve the empirical puzzle on whether highly concentrated financial systems generate more systemic risk or not, we are going to use the intuition behind the U-shaped relationship proposed by BDN and extended by MMR, to analyze the effect of competition on the risk of bank failure (financial instability) as result of a potential combination of a negative risk-shifting effect and a positive margin effect.

[12] For an extended literature review about uses of this index and for extended studies for the European banking sector see for example Maudos and Fernández (2004) and Carbó and Rodríguez (2007).

The negative risk-shifting effect, identified by BDN, establishes that more market power leads to higher loan rates, which in turn lead to higher probabilities of default. As for the (positive) margin effect, it suggests that more market power leads to higher loan rates, and consequently to increases in revenues from performing loans, providing a buffer for loan losses (see figure 3.1).

Figure 3.1
Channels relating competition and financial stability

Concentration-Stability (*Margin effect*):					
↑ *Lerner index* ↓ *Competition*	↑ *Loan rates*	↑ *Revenues*	↑ *Buffer*	↑ *Z-score*	**(+) *if dominate***
Concentration-Fragility (*Risk shifting effect*):					
↑ *Lerner index* ↓ *Competition*	↑*Loan rates*		↑*Default*	↓*Z-score*	**(-) *if dominate***
		Channels			***Final effect***

The intuition to use the number of financial institutions (N_{it}) as threshold variables is based on the theoretical results presented by MMR, where it is shown that when the number of banks is sufficiently large, the margin effect dominates the risk-shifting effect, so any additional entry would increase financial instability. These results suggest that the risk-shifting effect tends to dominate in monopolistic markets, whereas the margin effect dominates in more competitive markets, which suggests that a U-shaped relationship between competition and financial instability is observed depending on the number of bank observed in a specific market.

The theoretical results suggest that the benefits of a margin effect will eventually be outweighed by the bankruptcy's costs (probabilities of default), once the number of banks in a specific market (N_{it}) pass some critical threshold (γ). Thus, under the MMR theoretical framework, under a dominant risk-shifting behaviour, the nexus between financial stability and market power could be non-monotonic in the following:

$$Z_{it} = \begin{cases} \beta_1' < 0, & N_{it} < \gamma_1 \\ \beta_2' > 0, & N_{it} \geq \gamma_1 \end{cases} \tag{3.8}$$

This hypothesis suggests that when a financial market is confronted with increased competition, if a banks' franchise value diminishing effect is observed, banks rationally choose more risky portfolios. However, as BDN point out, there exists a fundamental mechanism that reverses the risk-shifting effect when the choices on bank are size-dependent, causing that banks become more risky as their markets become less competitive, given that banks charge lower rates, and their borrowers have an incentive to choose safer investments, hence more safer institutions. However, this argument does not take into account the fact that lower rates also reduce the banks' revenues from performing loans, and this could be affected by other dimensions of the banking business, not considered in the theoretical framework established by BDN and MMR, such as the bank branching strategies and the number of employees per branch, dimensions that could directly affect revenues, and therefore the dominance mechanism between the margin effect and the risk-shifting effect.

The idea to use the bank branching strategy as a threshold variable is motivated by Berger (1997) and Carlson and Mitchener (2006), who find that branching expansion stabilizes banking systems given that a branching strategy enables banks to diversify geographically their risk and also access to a wider customer base. However, under certain circumstances, this could also lead to inefficiencies in the diversification of risk, because the increased size of banks may result in a less effective internal control and in increased operational risks arising from failures of supervision (Cetorelli et al., 2007).

Table 3.3
Number of banks, branches and offices
(Average values over 1996–2010) [/a]

Countrys	Number of Banks		Number of Branches	Number of employees	Threshold measures			
					Employees /		Branch / banks	
	Population	*Sample*	*Population*	*Population 10^3*	*Number*	*Rank*	*Number*	*Rank*
Austria	854	200	4463	69	15	7	5	2
Belgium	115	74	12172	72	8	2	160	23
Czech Republic	41	27	2147	45	21	15	52	18
Denmark	102	92	2065	44	21	14	20	8
Estonia	12	7	272	5	19	12	27	11
Finland	357	13	1255	27	21	16	4	1
France	987	336	29565	405	14	5	53	19
Germany	2480	1696	39500	689	18	9	17	6
Ireland	46	38	989	37	37	22	21	9
Israel	37	14	1132	43	38	23	36	15
Italy	841	322	29299	342	12	4	36	14
Japan	133	73	13967	370	26	17	100	20
Korea Rep. of	472	45	6969	99	15	6	117	21
Netherlands	111	54	4804	125	28	18	44	16
Norway	151	74	1342	23	18	10	9	4
Poland	868	31	4097	164	35	19	6	3
Portugal	214	25	5647	57	10	3	23	10
Slovakia	26	17	1138	21	19	11	46	17
Slovenia	34	18	726	12	16	8	35	13
Spain	283	88	40284	248	8	1	142	22
Sweden	123	77	2183	43	20	13	18	7
Switzerland	319	316	3259	116	36	20	10	5
United Kingdom	405	313	13380	488	37	21	32	12

Source: OECD (2010) "Structure of the financial system" OECD Banking Statistics (database), and authors calculation.
a/ Entries have been rounded and simplified to make the contrasts easier to see.

To explain this mixed result, authors like Carlson and Mitchener (2006) focus on the 'over branching' effects as an additional channel to affect banking stability, explaining that additional branches could attract extra customers, raising total bank output above the average cost-minimizing level. That is, banks could prefer to open extra branches and operate on the upward-sloping part of their average cost curve, if they experience scale economies. Then there might be some critical threshold on branching expansion (B_{it}) where competition increases financial stability:

$$Z_{it} = \begin{cases} \beta_1' < 0, & B_{it} < \gamma_2 \\ \beta_2' > 0, & B_{it} \geq \gamma_2 \end{cases} \tag{3.9}$$

Hence, over a certain number of branches per bank, the risk-shifting effect is dominated by the margin effect, given that the prevailing effect is the efficiency in the diversification of risk, as over-branch banking strategies increases financial stability in less competitive markets.

Finally, the third threshold variable considered is the ratio of employees per branch, which can be considered also as a proxy of the management capacity of firms to increase revenues and it also may diminish the negative risk-shifting effect that offset the positive margin effect. This idea is based on the efficient resource allocation perspective suggested by Hartman et al. (2001), where they show that small branches, though limited in human resources, tend to be the most efficient. Therefore, we also test if there is a critical level of employees per branch which determines an efficiency threshold (E_{it}) that changes the regime of the relationship between competition and financial stability in the following way:

$$Z_{it} = \begin{cases} \beta_1' > 0, & E_{it} < \gamma_3 \\ \beta_2' < 0, & E_{it} \geq \gamma_3 \end{cases} \quad (3.10)$$

The latter expression states that the gain of greater financial stability, promoted by higher market power, may depend also on the capacity of more productive branches to choose the right mix of human resources. As before, the effect on the risk of bank failure would result from the combination of a negative risk-shifting effect and a positive margin effect, with the margin effect dominating for a sufficiently small number of employees per branch (more productive).

3.4.2.4 Financial soundness and macroprudential indicators (*control variables*):

To mitigate the omitted-variable bias, we also consider measures that control for the financial health and soundness of a country's financial sector as a whole, as well as by other bank specific factors, which allows us to control some other effects of market competition, financial stability or both (Schaeck et al., 2006). As pointed out by Uhde and Heimeshoff (2009), the growth rate of real GDP should be considered as a control variable because the investment opportunities of banks may be correlated with economic cycles, and therefore the sign of this coefficient is expected to be positive. Additionally, we include inflation and interest rates, as their potential effects depend on whether or not they are anticipated by financial institutions during an economic downturn[13].

It is also important to identify the adjustment capacity of the institutional supervisory structure and the adaptation of the regulatory framework associated with consolidation processes, as these are key factors in determining stability. To reflect these institutional effects, we use the Political Constraints Index (Henisz, 2002), which measures how changes in the preferences of political actors lead to changes in public policies and in the status quo. In particular, it takes into account political constraints on executive discretion. The index ranges between 0 and 1, where higher values indicate greater limits on the discretional behaviour and higher acceptance of changes proposed by the government (greater political consensus), and lower values indicate greater executive discretion to implement its policies (associated with higher political risk). Studies like Henisz (2002), Jensen (2007) and Busse and Hefeker (2007) have found that lower political risk is correlated with higher investment flows. Therefore, the sign of this variable is expected to be positive, in the understanding that increased *stimuli* to economic growth produce positive returns on investment, and that this effect is directly related to greater financial stability.

[13] The use of macroprudential indicators has been frequently used in the efficiency literature, see for example Salas and Saurina (2003), Yildirim and Philippatos, 2007 and Uhde and Heimeshoff (2009).

3.5 Competition threshold and financial stability: empirical results

3.5.1 Competition-stability nexus at the country level

The first step is to test for the existence of a threshold (γ) using the likelihood ratio test, F_1, as discussed above. This involves estimating equation (3.2) by least squares, allowing for zero and single threshold (sequentially) and computing the residual sum of squares (S_1) for threshold levels, where the transition variable used is the number of financial institutions ($q_{it} \equiv N_{it}$) at the country level. Model *i*) and *ii*) consider the concentration ratio C_5, and the HHI as they have been generally used in previous studies as linear specifications, while in model *iii*) and *iv*) we propose consider other competition variables such as the $LERNER$ and the $NIMTA$ ratio. In all these models, the measure of financial stability is the *Z-score* computed for each country and year (see table 4).

The results show that bank C_5 concentration ratio and the Lerner index are statistically significant regardless of the regime examined. In the low regime, when the country has less than about 229 financial institutions, $I\ (N_{it} < \gamma)$, the estimated coefficient β_1 is positive, while in the high regime, with more than 229 institutions, $I\ (N_{it} \geq \gamma)$, the β_2 coefficient is negative, thus confirming the asymmetry of the sign in the relationship between market power and financial stability in the 23 countries included in the sample. A significant effect is also found for the HHI index. In this case higher market power is found to promote financial stability only when the country has less than 124 financial institutions, $I\ (N_{it} < \gamma)$, whereas above this threshold, $I\ (N_{it} \geq \gamma)$, an increase in competition leads to an increase in the risk of bank failure (see table 3.4)

Table 3.4
Financial stability - market power (*at country level*)
Model: Panel threshold regression
Dependent variable: Z-score

		Models:			
Coeficient estimates:		$Z_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} < \gamma) + \beta'_2 x_{it} I(q_{it} \geq \gamma) + \sum_j \psi'_j f_{j,it} + \sum_k \phi'_k m_t + e_{it}$			
		- *i* -	**- *ii* -**	**- *iii* -**	**- *iv* -**
Regimen-dependent regressors:		***Competition measures:***			
		C5	***HHI***	***Lerner***	***Nimta***
Low regime	β_1	**0.5853** **	**0.060** **	**0.2591** *	**-1.063**
		(0.22681)	(0.02423)	(0.15380)	(1.70956)
High regime	β_2	**-0.5061** **	**-0.066** ***	**-0.4367** **	**3.288**
		(0.25136)	(0.01869)	(0.21748)	(2.31319)
Threshold variable:					
Number of Banks	γ	**229**	**124**	**229**	**278**
Regimen-independent regressors:					
Financial soundness indicators					
Interest margin	ψ_1	**-0.1538**	**-0.2161**	**-0.0074**	**-0.1734**
		(0.16731)	(0.16718)	(0.19744)	(0.18492)
Non interest expenses	ψ_2	**0.0797**	**0.1479**	**-0.0486**	**0.1118**
		(0.15545)	(0.15523)	(0.18296)	(0.17270)
Commissions	ψ_3	**-26.0665** **	**-7.9317**	**-15.6734**	**-10.8359**
		(11.93317)	(12.29444)	(15.87000)	(14.73657)
Leverage	ψ_4	**1.4311**	**3.3001** **	**2.3438**	**2.2211**
		(1.35446)	(1.47033)	(1.54547)	(1.46430)
Spread	ψ_5	**-2.9848** ***	**-1.4894** *	**-2.9277** ***	**-2.8821** ***
		(1.04970)	(0.93697)	(0.93832)	(0.92064)
Macroprudential indicators					
Economic growth	ϕ_1	**0.0075**	**0.0096** *	**0.0079**	**0.0090**
		(0.00583)	(0.00623)	(0.00621)	(0.00596)
Inflation	ϕ_2	**0.0050**	**0.0111**	**0.0089**	**0.0126**
		(0.00817)	(0.00973)	(0.00932)	(0.00920)
Domestic real interest rate	ϕ_3	**-0.0086**	**-0.0143** **	**-0.0117** *	**-0.0163** **
		(0.00573)	(0.00704)	(0.00696)	(0.00691)
Goverment debt to GDP	ϕ_4	**0.0069** ***	**0.0054** ***	**0.0061** ***	**0.0073** ***
		(0.00132)	(0.00100)	(0.00178)	(0.00140)
Political Constraints	ϕ_5	**0.2123**	**-0.0397**	**0.1203**	**0.0988**
		(0.18236)	(0.14780)	(0.27760)	(0.27934)
Number of obs		271	305	260	271
Number of groups		21	21	21	21
First Stage F-test		6.74	7.12	3.79	5.33
Prob > F		0.00	0.00	0.00	0.00
$\chi2$ test of heteroskedasticity		4.24E+04	1.76E+04	6.92E+04	5.11E+04
P-value		0.00	0.00	0.00	0.00

Note: */**/*** Statistically significant at the 10/5/1% level. White SE are given in parentheses. Similarly to Hansen (1999), each regime has to contain at least 5% of all observations. Bootstrap replications (1000) were used to obtain p-values. Constant term included but not reported.

To provide some robustness to the threshold model results, we test for single threshold and their asymptotic 95% confidence intervals are reported in Table A2.3. The point estimates are the value of γ at which the likelihood ratio hits the zero axis, which is in near to the percentile 57 when the concentration ratio C_5 is considered, and 60% when the Lerner index is used as regressor. In these three cases, the 95% confidence intervals for the threshold parameters can be found beneath the dotted line, except for the use of the NIMTA index where the non-linearity at country level was rejected.

Table 3.5
Tests for single threshold effects *(at country level)*

Regimen-dependent regressors:	*Model*	*Threshold variable:*	*Threshold estimates*		*Ho: No threshold*	
			γ	95 % Conf. Interval	F-stat	p-value
C5	**- *i* -**	Number of Banks	229	[209 , 237]	5.78	0.045
HHI	**- *ii* -**		124	[107 , 126]	0.00	0.011
Lerner	**- *iii* -**		229	[223 , 281]	0.05	0.093
Nimta	**- *iv* -**		278	[52 , 609]	74352.64	0.535

Notes: Similarly to Hansen (1999), each regime has to contain at least 5% of all observations, where 1000 bootstrap replications were used to obtain the *p-values* to test for single thresholds in each model.

For the control variables, regardless of the model examined, the spread results significant and negative, indicating that increases in the difference between the assets invested by the banks in loans and the cost of funding (Short term and Long Term Funding) increase financial instability. The aggregated leverage ratio is found to be positive but only significant in the second model, indicating that increases in shareholders' equity relative to liabilities, promote financial stability. The coefficient representing fees and commissions is found negative, but only significant in the first model, showing with low evidence that an increase in fee revenues could be related to a higher risk of bank failure. Among the macro-prudential variables, domestic real interest rate is found to be negative and significant in most models, confirming that higher loan interest rates established by banks may induce borrowers to take on risky investments to compensate higher loan repayments. Finally as expected, the economic growth and government debt to GDP ratio were also significant, confirming the expected positive impact of these variables on financial soundness.

A relevant feature of these results is that they reconcile the diverse positions found in the literature. Thus, the results reported by De Nicoló et al. (2004) and Uhde and Heimeshoff (2009), who find evidence on the *concentration-fragility* approach, are similar to our estimates when consolidation processes take place in countries with a high number of institutions.

Table 3.6
Countries according to number of institutions (γ = 229)

	Low regime (+ *effects*)				High regime (- *effects*)				
$I(q_{it}<\gamma)$	Estonia	12	Denmark	102					$(q_{it}\geq\gamma)$
	Slovakia	26	Netherlands	111	Spain	283	Italy	841	
	Slovenia	34	Belgium	115	Switzerland	319	Austria	854	
	Israel	37	Sweden	123	Finland	357	Poland	868	
	Czech Republic	41	Japan	133	United	405	France	987	
	Ireland	46	Norway	151	Korea Rep. of	472	Germany	2480	
			Portugal	214					

Note: Refers to the average number of financial instutions reported on OECD Banking Statistics.

As for the theoretical arguments of Beck et al. (2006) and the empirical findings of Schaeck et. al. (2006), supporting the *concentration-stability* approach, they correspond to our results on financial consolidation in economies with a lower number of financial institutions. In this sense, policies oriented toward processes of financial consolidation should pay particular attention not only to the degree of concentration, but also to the number of financial institutions operating in those banking sectors.

Thus, countries such as Norway, Portugal or Spain, which are close to the threshold that we estimate, may also be close to the point at which the gains from a higher concentration of banking institutions could represent a reduction of financial stability (see table 3.6). Moreover, our results are in line with the theoretical general equilibrium prediction proposed by BDN, where the number of banks (N_{it}) in a market could affect the monotonic relationship between baking stability and competition in financial markets.

3.5.2 Competition-stability nexus at *bank level*

In order to check for the presence of thresholds effects at the bank-level, specifications (3.1) and (3.2) were estimated by least squares, allowing for zero and single threshold (sequentially). The test statistic F_1, along with the bootstrap p-values and 95% confidence intervals for each threshold variable considered are shown in table 3.7 where we find that the test for a single threshold is highly significant. Therefore, we find evidence at a bank-level that a nonlinear relationship between financial instability and market competition depends on banks' efficiency levels.

Table 3.7
Tests for single threshold effects (*at banking level*)

Regimen-dependent regressors:	*Model*	*Threshold variable:*	*Threshold estimates*		*Ho: No threshold*	
			γ	95 % confidence interval	F-stat	p-value
Lerner	***- i -***	Ratio employees to offices	17.21	[17.184 , 17.661]	323.69	0.016
Nimta	***- ii -***			[17.184 , 17.661]	237.35	0.003
Lerner	***- iii -***	Ratio branches to banks	16.58	[16.196 , 20.265]	240.49	0.001
Nimta	***- iv -***			[15.721 , 20.265]	284.16	0.001

Notes: Similarly to Hansen (1999), each regime has to contain al least 5% of all observastions. 1000 bootstrap replications were used to obtain the p-values to test for single thresholds in each model.

Table 3.8 show the results of the non-dynamic panel threshold regression, where two different efficiency ratios where considered as a transition variable: the ratio of employees to branches and the ratio of branches to banks, so that the threshold estimate γ indicates a shifting relationship between market power and financial stability (measured at bank level).

Table 3.8

Financial stability - market power (*at banking level*)

Model: Panel threshold regression

Dependent variable: Z-score

		Models:			
Coeficient estimates:		$Z_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} < \gamma) + \beta'_2 x_{it} I(q_{it} \geq \gamma) + \sum_j \psi'_j f_{j,it} + \sum_k \phi'_k m_t + e_{it}$			
		- i -	***- ii-***	***- iii -***	***- iv -***
Regimen-dependent regressors:		***Competition measures:***			
		Lerner	***Nimta***	***Lerner***	***Nimta***
Low regime	β_1	**-0.0748** ***	**-1.222** ***	**0.0650** ***	**0.657** ***
		(0.02144)	(0.24927)	(0.02080)	(0.22045)
High regime	β_2	**0.0673** ***	**0.745** ***	**-0.0501** **	**-1.006** ***
		(0.02080)	(0.21988)	(0.02086)	(0.23806)
Threshold variable:					
Ratio branches to banks	γ	**17.44**	**15.72**		
Ratio employees to offices				**17.211**	**17.211**
Regimen-independent regressors:					
Financial soundness indicators					
Impaired loans	ψ_1	**-0.0334**	**-0.0858**	**-0.0671**	**-0.0505**
		(0.06343)	(0.05351)	(0.06367)	(0.05333)
Interest margin	ψ_2	**1.1802** **	**0.1080**	**1.0739** *	**0.7597** *
		(0.57338)	(0.40744)	(0.57113)	(0.42553)
Non interest expenses	ψ_3	**-0.0082** *	**-0.0181** ***	**-0.0118** **	**-0.0203** ***
		(0.00479)	(0.00374)	(0.00486)	(0.00374)
Commissions	ψ_4	**1.3608**	**0.6687**	**1.7372** *	**0.8003**
		(0.99160)	(0.70990)	(1.00216)	(0.71865)
Leverage	ψ_5	**-0.9580** ***	**-0.9061** ***	**-0.9655** ***	**-0.8827** ***
		(0.08688)	(0.06645)	(0.08688)	(0.06527)
Spread	ψ_6	**-0.0924**	**-0.0962**	**-0.1698**	**-0.1163**
		(0.13765)	(0.12096)	(0.13571)	(0.12063)
Macroprudential indicators					
Economic growth	ϕ_1	**0.0008**	**0.0108** ***	**0.0007**	**0.0013**
		(0.00105)	(0.00097)	(0.00106)	(0.00097)
Inflation	ϕ_2	**0.0178** ***	**0.0276** ***	**0.0190** ***	**0.0238** ***
		(0.00245)	(0.00204)	(0.00246)	(0.00206)
Domestic real interest rate	ϕ_3	**-0.0737** ***	**-0.1206** ***	**-0.0850** ***	**-0.1091** ***
		(0.00905)	(0.00718)	(0.00847)	(0.00726)
Goverment debt to GDP	ϕ_4	**0.0631** ***	**0.0370** ***	**0.1660** ***	**0.1491** ***
		(0.01190)	(0.01027)	(0.01233)	(0.01012)
Political Constraints	ϕ_5	**-0.0094**	**0.0632** ***	**-0.0011**	**0.0476** ***
		(0.01369)	(0.01151)	(0.01354)	(0.01150)
Number of obs		24105	18663	24105	18663
Number of groups		4685	3958	4685	3958
First Stage F-test		83.74	86.61	106.44	82.61
Prob > F		0.00	0.00	0.00	0.00
$\chi 2$ test of heteroskedasticity		4.50E+37	6.20E+35	6.10E+37	6.20E+35
P-value		0.00	0.00	0.00	0.00

Note: */**/*** Statistically significant at the 10/5/1% level. White SE are given in parentheses. Similarly to Hansen (1999), each regime has to contain at least 5% of all observations. Bootstrap replications (1000) were used to obtain p-values. Constant term included but not reported.

In this sense, no matter the competition variable considered (Lerner index or NIMTA) the results are significant at both regimes, regardless of the model examined. In the low market power regime, when the country has less than about 16 branches per bank, $I\ (q_{it} < \gamma)$, the estimated coefficient β_1 is negative, while in the high number of branches regime, with more than 17 branches, $I\ (N_{it} \geq \gamma)$, the β_2 coefficient is positive, thus confirming that over-branch banking strategies increase financial stability in less competitive markets. These results confirm the asymmetry in the sign of the relationship between competitive behaviour and financial stability in the banking institutions considered for the 23 countries included in the sample.

Table 3.9
Countries according to bank level results

		Ratio employees to offices			
		Low regime (+ *effects*) $I(q_{1,it}<\gamma)$		High regime (- *effects*) $I(q_{1,it}\geq\gamma=17.21)$	
Ratio branches to banks	Low regime (-) $I(q_{2,it}<\gamma)$	Austria		Finland Norway	Poland Switzerland
	High regime (+) $I(q_{2,it}\geq\gamma=16.58)$	Belgium France Italy Korea Rep. of Portugal	Slovenia Spain	Czech Republic Denmark Estonia Germany Ireland Israel	Japan Netherlands Slovakia Sweden United Kingdom

Note: Refers to the average number of ratios.

Our finding is consistent with the hypotheses of Goodhart et al. (2006) and by Hesse and Čihák (2007), who conclude that in countries like the USA, Germany, Italy and Spain -where there is a strong presence of savings and cooperative banks- an increase in the bank competition is found to significantly reduce financial instability, as measured by the Z-score. As an additional robustness check for our threshold results, we also estimate a single threshold and their asymptotic 95% confidence intervals are reported in Table A.4. In the case when the ratio of employees per bank ratio is considered the estimation is around 17, which split the values in the empirical distribution in small (or large) number of employees' threshold variable (table 3.9).

3.6 Concluding remarks

The issue on whether a greater concentration of banking institutions improves or worsens financial stability has produced mixed results in previous empirical studies. We readdressed the question and try to reconcile the apparently conflicting results by considering the multifaceted nature of the relationship between the two key variables under study. To do so, we took a non-linear empirical approach, in the form of a non-dynamic panel threshold regression method, following Hansen (1999), for a sample of 23 OECD countries in the period from 1996 to 2010.

Our results offer robust evidence of asymmetries in the relationship between financial stability and bank competition, depending on the number of banks, the level of bank efficiency and the number of employees per branch. Our main contribution to current knowledge in this area is that we reconcile diverse opinions as to whether processes of financial consolidation are positive or negative in terms of financial stability. Our results show that those economies with a small number of financial institutions (less than about 229), over-branched (more than 15 branches per bank) and with a low number or employees per branch (less than 17) achieve greater stability, measured by the Z-score indicator. However, such gains are absent in the case of economies with a large number of institutions, where decreases in competition achieved by greater financial consolidation may actually produce financial instability.

Appendix 3.1
Lerner index of market power

We compute the Lerner index considering a multi-product framework (total assets) reflecting a diversified bank output as follows:

$$Lerner = (P_Q - MC_Q)/P_Q \quad \text{(A3.1)}$$

where P_Q is the price of total assets computed as the ratio of total (interest and non-interest) income as a proportion of total assets and MC_Q is the marginal cost of total assets. The index ranges from a high of 1 to a low of 0, with higher numbers implying greater market power. For a perfectly competitive (where $P_Q = MC_Q$), $Lerner = 0$; such a firm has no market power.

Similar like Carbó et al. (2009) we considered a standard translog function with a single output (total assets) and three input prices: labor (P_L), physical capital (P_K) and deposits (P_D). In this sense, we assume that production is characterized by constant returns to scale and that any technical change affecting factor prices are Hicks-neutral. For our three-input LKD model, we specify this cost function with symmetry and constant return to scale imposed as: λ

$$\begin{aligned} lnC_{it} = {} & \alpha_0 + \alpha_1 lnQ_{it} + \frac{\alpha_2}{2} lnQ_{it}{}^2 + \sum_j \beta_j \, lnP_{j,it} + \frac{1}{2}\sum_j \gamma_j \, lnP_{j,it}{}^2 + \sum_j \lambda_j \, lnQ_{it} lnP_{j,it} + \\ & + \sum_j \sum_h \varphi_{jh} \, lnP_{j,it} \, lnP_{h,it} + t + t^2 + t \, lnQ_{it} + \sum_j t \, lnP_{j,it} + \varepsilon_{it} \, , \; j,h = L,K,D \end{aligned} \quad \text{(A3.2)}$$

The specification includes a quadratic time trendr (t) as an approximation of technical progress. Since linear homogeneity in prices is imposed we established the following restrictions on (A3.1) assuming perfect competition in the input market, so that the input prices have been treated as fixed:

$$\beta_L + \beta_K + \beta_D = 1$$

$$\varphi_{KK} + \varphi_{KL} + \varphi_{KD} = 0$$

$$\varphi_{KL} + \varphi_{LL} + \varphi_{LD} = 0 \qquad \text{(A3.3)}$$

$$\varphi_{KD} + \varphi_{DL} + \varphi_{DD} = 0$$

Then given the level of output (Q), the cost minimizing input demand functions are derived thought the logarithmically differentiation of (A3.2), which using Shepard's Lemma, allow us to obtain the LKD input share of demand equations as follows:

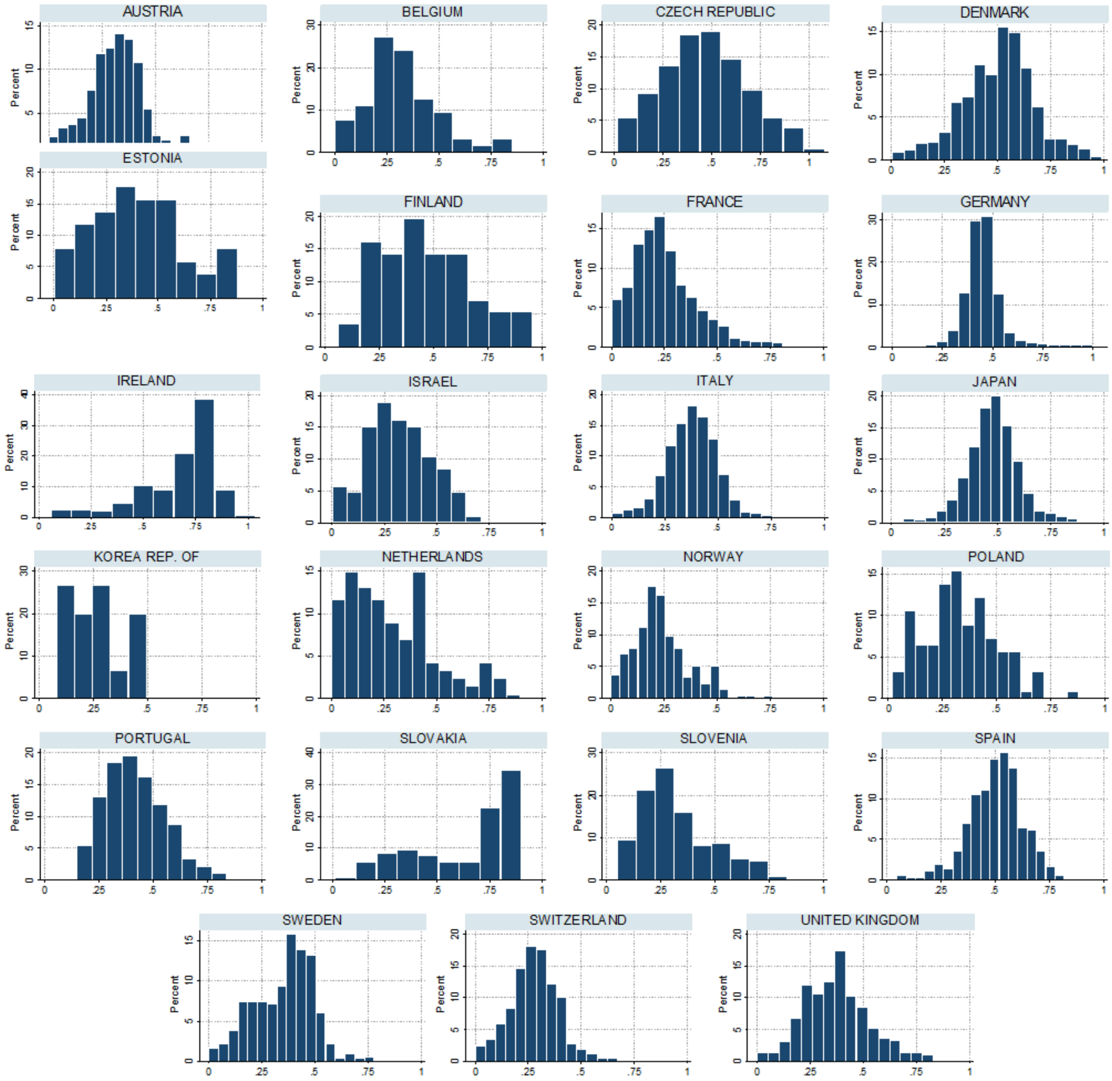
$$\frac{\partial lnC}{\partial lnP_i} = \frac{\partial C}{\partial P_i}\frac{P_i}{C} = \beta_j + \sum_j \gamma_j \, lnP_{j,it} \,, \qquad j = L, K, D \qquad \text{(A3.4)}$$

Finally, we then estimate simultaneously expressions (A3.2) and (A3.4), rewriting the former as:

$$P_Q = \frac{C}{Q}\left(\alpha_1 + \alpha_2 lnQ + \sum_j \lambda_j \, lnP_{j,it}\right) + t \,, \qquad j = L, K, D \qquad \text{(A3.5)}$$

where the first term of the right-hand side is the marginal cost, derived from equation (A3.2) establishing the corresponding first order condition. Finally, the Lerner index in (A3.1) is averaged over time for each bank and country.

Figure A3.1
Lerner index of market power
(Sample over 1996-2010)



Source: author calculation

Appendix 3.2
Z-score index of financial stability

As Boyd et al. (1993) we build the Z-score financial stability as aan indicator of the bank's probability of insolvency. Given the widespread measure of accounting profitability return on assets, RoA, and assuming this as a random variable with finite mean μ_{RoA} and variance σ^2_{RoA}, the Bienaymé-Chebyshev inequality allows us to state the probability of insolvency as:

$$p(\pi < -K) = p(RoA < K) = \int_{-\infty}^{K} f(RoA)dRoA \qquad \text{(A3.6)}$$

where p(.) is a probability and f(Roa) is the p.d.f. of return of assets. If RoA is normally distributed, we can rewrite (A3.6) as

$$p(RoA < K) = \int_{-\infty}^{Z} N(0,1)dZ$$

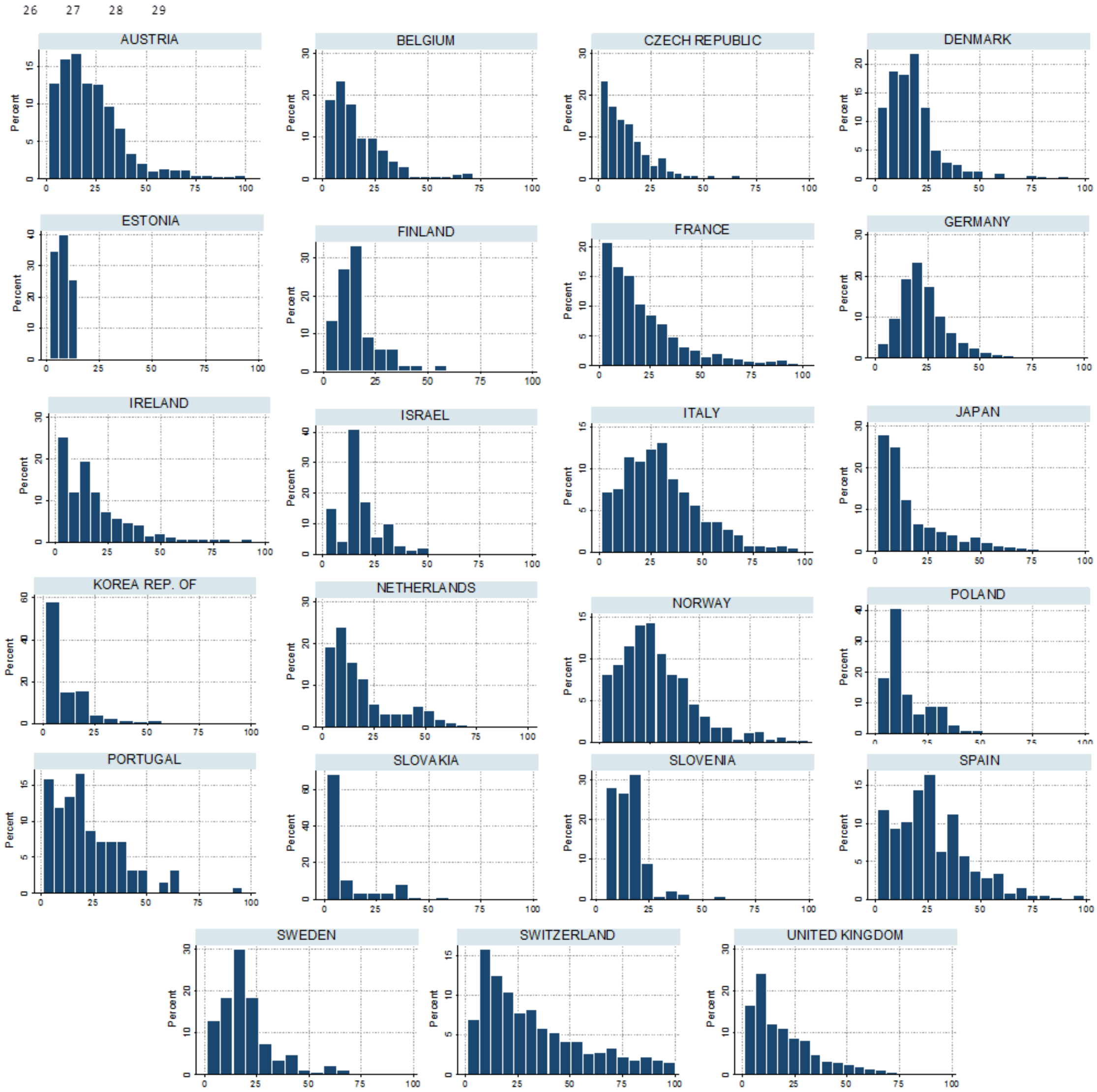
$$Z_t \equiv (RoA_t - K_t)/\sigma_{RoA,t} \quad \text{with} \quad \sigma^2_{RoA,t} \overset{\text{i.i.d.}}{\sim} (0, \sigma^2) \qquad \text{(A3.7)}$$

where the K_t is the true mean and σ_{RoA} the true standard deviation of the return of assets distribution. As a consequence, the Z_t could be interpreted as the number of standard deviations below the mean, by which profits must fall in order to reduce equity, $(RoA_t - K_t) \leq 0$.

Figure A3.2

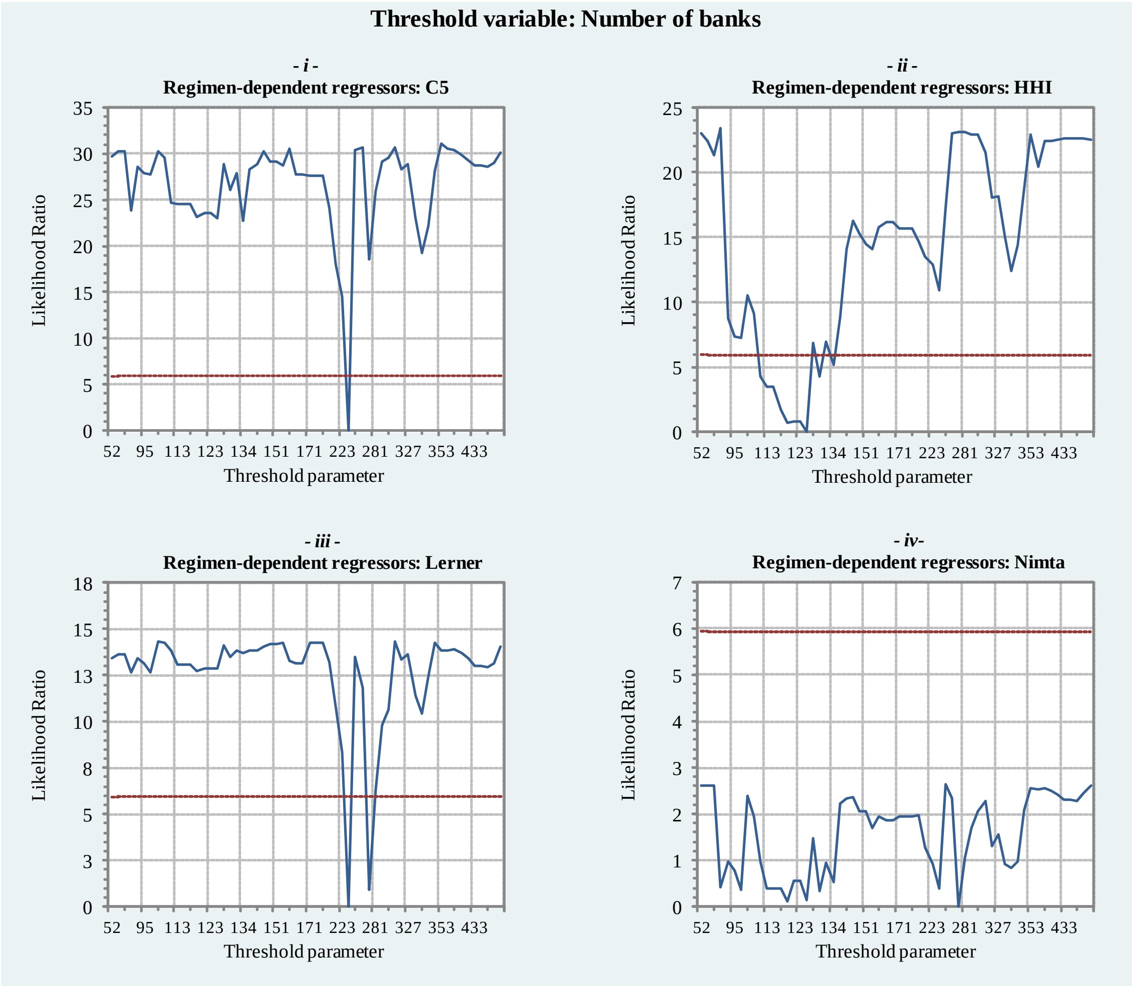
Z-score index of financial stability

(Sample over 1996-2010)



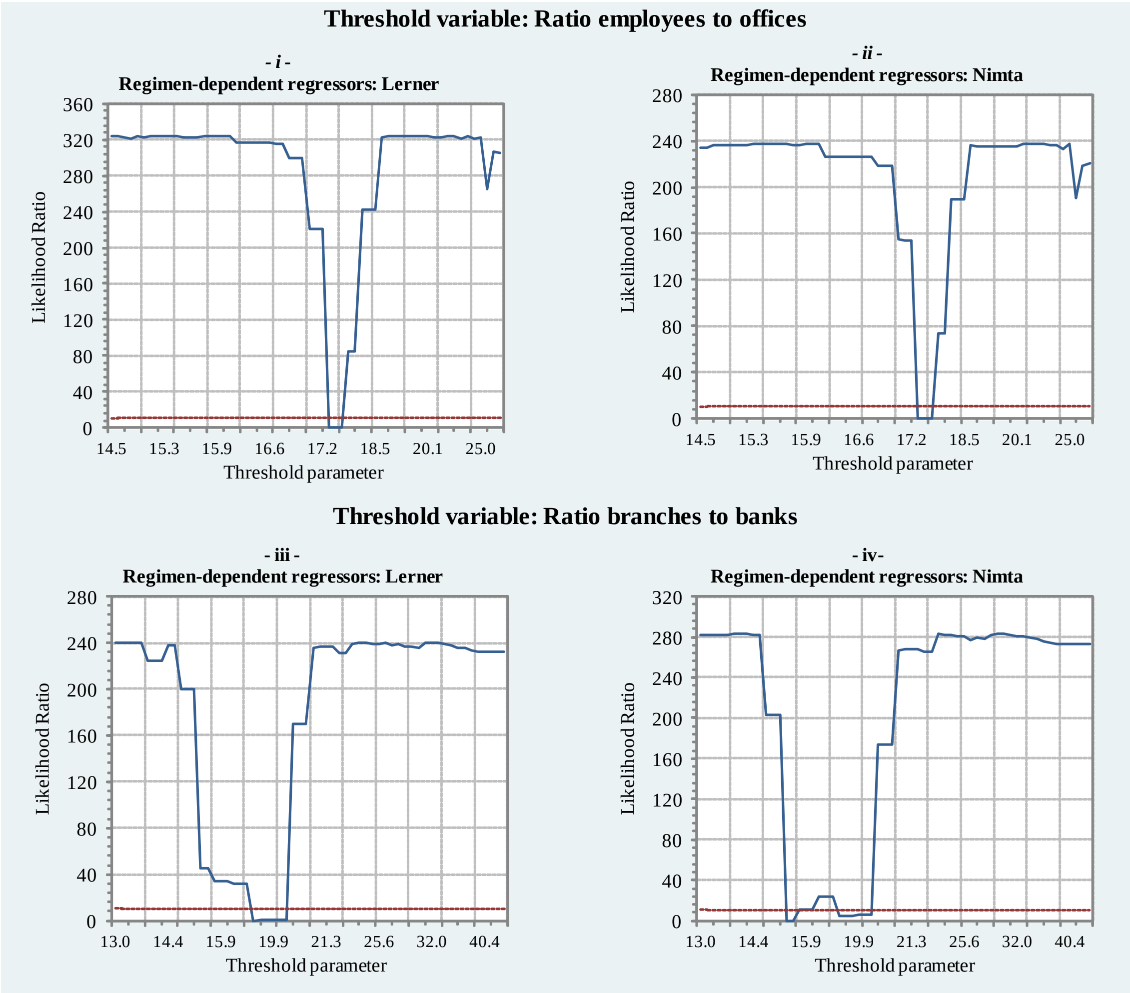
Source: author calculation

Figure A3.3
Confidence interval construction in single threshold models
(at country level)



Source: author calculation

Figure A3.4
Confidence interval construction in single threshold models
(at bank level)



Source: author calculation

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Chapter – 4
Measuring market power using a Stochastic Conjectural Equilibrium: An application for bank mergers in Spain

Abstract

This paper develops a Stochastic Conjectural Variation Equilibrium model by introducing a consumer switching costs behaviour which allows firms to exploit consumer mobility restrictions among rival firms over time. Considering a Markovian process that rules the trajectory of the industry's market-share towards the long-term dynamic equilibrium, we derive analytically a Lerner index of market power that allow us studying the effects of a merger on bank competition using stochastic complementation. Our theoretical approach suggests that mergers that occur in a market with extreme rivalry always reduce the level of competition. Additionally, we find that mergers between clusters of firms which do not compete with each other do not, in any way, affect the market power of the entire industry. Finally an empirical application to the bank merger processes recently observed in Spain was performed- as a numerical application..

Key words: Conjectural variation • Mergers • Switching costs • Stochastic complementation.

JEL classification: D43 • G34 • L11 • L13

4. *Measuring market power using a Stochastic Conjectural Equilibrium: An application for bank mergers in Spain*

4.1 Introduction

It is frequently assumed that firms operating in oligopolistic markets make their choices simultaneously. Theoretically, the reactions of rival firms are based on the subjective perception that there is a profit maximizing output (price) level, leading to the so-called Conjectural Variation Equilibrium (CVE)[14]. The CVE has been a popular approach to analyze market power in an oligopolistic competitive framework. As Figuières et al (2004) have pointed out, several studies have applied a CVE approach to predict the outcome of non-cooperative behaviour in Industrial Economics, in International Economics, in Macroeconomics or in Regional Economics[15].

However, as the CVE approach was emerging, two weaknesses of the earlier implementations were found and discussed of this approach (Dockner, 1992). The first one was that the CVE specification resulted in a static non cooperative setting, neglecting the dynamic features of competition (Friedman, 1977). Secondly, it was frequently observed that the choice of the conjectural variations, or conduct parameter, resulted inconsistent with unbounded rationality (Brenahan, 1981).

[14] Dockner (1992) quoted that this idea was introduced first by Bowley (1924), and extended by Frisch (1933).

[15] Recent examples are the study of Azzam and Andersson (2008) who measured market-power through the conjectural parameter in a mixed oligopoly for a specific Swedish food industry. Puller (2007) who characterized the oligopolistic behaviour in California's deregulated electricity market power; and Bikker (2003) and Uchida & Tsutsui (2005) who have studied the competitiveness of the different financial sectors estimating the average conjectural variation among banks. See Corts (1999) for a survey of older literature.

Nonetheless, as in a recent survey by Jin and Parcero (2010) there have been several recent dynamic CVE models with consistent conjectures, revitalizing the use of this concept in the last decade. Studies like Dixon and Somma (2003), Figuières et al. (2004), Jean-Marie and Tidball (2006) or Julien and Musy (2010) are some of the recent examples. In particular, they show how the long-run (steady state) equilibrium of a dynamic setting Figuières et al. (2004) suggest using the CVE as a shortcut for Nash equilibria in dynamic sets. As they have shown, taking the Nash Equilibrium as a benchmark, it is possible to analyze and compare conjectural behaviour when the agents interact in a symmetric strategic dynamic setting. Similarly. Julien and Musy (2010) considered a Stackelberg oligopoly model which allows mixed sequential and simultaneous strategic interactions. Additionally, Jin and Parcero (2010) introduce the case of asymmetry to rank different oligopoly market structures.

It is interesting to note that this analysis with CVE models has almost exclusively focused on the supply-side sources of rivalry, while demand-side sources have not yet been considered. For this reason, this research tries to complement the conjectural variation approach, introducing a stochastic consumer behaviour model, which assumes the existence of consumer mobility restriction among firms. To make this idea operational, the notion of switching costs in the spirit of Kim et al. (2003) and Dubé, Hitsch, and Rossi (2010) is used to assume the demand behaviour.

Linking the switching cost literature with the CVE is not exceptional, since it is well known that both, from different perspectives, have tried to analyze similar aspects of market power. In particular, the switching costs literature assumes the existence of a cost for consumers when they try to change their suppliers from one period to another, giving firms a degree of market power over their repeated-purchases (Klemperer, 1995). As a result -as it is also found in the CVE literature- firms’ current market shares become an important determinant of earning above-normal profits in oligopolistic markets.

Another contribution of this paper is to introduce firm heterogeneity in the model specification. As such, consumers' switching costs convert ex-ante homogeneous products into ex-post heterogeneous products (Kim, Kliger, and Vale, 2003). This way we characterize the beliefs of every firm when they act to maximize profit. In addition, since our model turns out to be stochastic - i.e. consumer behaviour is described by transition probabilities of switching between firms (like Gandhi et al. , 2008 and Dubé et al.,2010)) - a new method is provided to analyze the effects on market power derived from a merger process[16]. To develop this idea, the post-merger analysis using the stochastic dynamic response (Gandhi et al., 2008) is compared with the concept of stochastic complementation, proposed by Doğançay & Krishnamurthy (1999). This is carried out by considering that a combination of two or more independent firms to form is the result of a merger process. We analyze this stochastic process of aggregation as a Markov chain model that derives from another chain of smaller dimension. This process provides us with a methodology to establish the equivalence effects of an exogenous merger on market power within a dynamic context. Again, we propose a market power measure in which a considerable set of behavioural models are a priori possible.

The paper is organized as follows. Section 4.2 presents the stochastic conjectural variation model, introducing the switching cost demand framework into the conjectural variation approach. This section offers a dynamic measure of market power which is consistent with other different conjectural variation equilibrium models in the literature. Section 4.3 presents the concept of stochastic complementation theory and the analytical

[16] In this study's settings, the market share is established through a transition probability matrix, or a Markov chain model specification, which will define the equation of motion of the market's structure towards a steady state situation (Cesari, 2000).

implications for competition. An application to the bank merger processes in Spain -in particular, those affecting savings banks- is developed in Section 4. 4 (while some numerical examples are presented in the appendix). The Section 4.5 ends with the main conclusions.

4.2 Measuring market power: *Stochastic Conjectural Variation*

The effects on market power derived from a merger process under a stochastic conjectural variation oligopolistic behaviour is analyzed in a partial equilibrium framework. To get this, a stochastic consumer behaviour is assumed to allow firms to exploit consumer mobility restrictions among rival firms over time. For this purpose, it is assumed that the industry faces a demand mobility function in which each consumer is characterized by a switching cost associated with the decisions to select a firm j to buy from in each period[17]. Then, an exogenous merger process is considered to compare the effects on competition through a novel way to compute the Lerner index as a measure of market power.

4.2.1 Switching cost induced demand:

As a first assumption made we consider a demand behaviour in which consumers face different switching costs and make different choices. Thus, our aggregate consumer behaviour is assumed to follow a first-order Markov stochastic process that describes the shifting of individuals between firms, with a conditional probability such that:

$$m_{jt} = \Pr\left(M_{jt} = m_{jt} \middle| M_{jt-1} = m_{jt-1}\right) \tag{4.1}$$

[17] In our setting, it is proposed that $t = 1, \dots, T$ markets/periods are observed; each with $i = 1, \dots, I_t$ consumers and $j = 1, \dots, J_t$ firms, this last one considers the discrete states in this economy.

The expression above shows the rule which governs the trajectory of the firm's market-share towards the long-term dynamic equilibrium is given by:

$$m_{jt} = \sum_{i=1}^{J} \varphi_{ij} \cdot m_{j\,t-1} \qquad (j = 1, \dots, J) \qquad (4.2)$$

where m_{jt} determines the probability that a customer will be in state j at time t, and let φ_{ij} be the probability that a customer (or a group of consumers) will be a customer in firm j after having been a customer in firm i in the previous period[18]. The latter expression could be interpreted two ways: one related to the rivalry observed in the industry (customer mobility among firms), and the other involving the evolution of the industry's market structure.

The first interpretation considers the elements φ_{ij} as the parameters of the equations that show the dynamic demand structure. This idea is related with the constant changes observed in the market share in the short-term movements towards equilibrium – the firms' dynamic equilibrium, and the situation of steady-state corresponding to the long-term structure of the market – the industry's static equilibrium. In this sense, the notion of equilibrium means that the firms are in continuous competition to retain their customers and attract other customers from the rest of the firms. That is why a persistent mobility of customers among firms exists dynamically, but statically, this mobility is such that the market share over time, $m_{jt} = y_{jt}/\sum_{1}^{J} y_{jt}$, remains stable - i.e. the market share results stationary. The second interpretation focuses on the elements φ_{ij} to understand the effects of the

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[18] Defining $P \equiv [\varphi_{ij}]$ as a Markov Chain matrix of transition probabilities, it is assumed that the states are exhaustive (no other alternative firm exists) and mutually exclusive (customer can only interact with one firm at a time t), so the market share elements of m and the probabilities in the rows of φ_{ij} must sum to 1 in every period t: $\sum_{j=1}^{S} m_j(t) = 1$ and $\sum_{j=1}^{S} \varphi_{ij} = 1$.

process of rivalry in the industry. Since the probability φ_{ij} shows the degree of success of any firm j in attracting customers from any other firm i, each element φ_{ij} can be related to the idea of ex-post competition. This is because, in terms of customer mobility, the evolution of the industry's structure could be assumed as a multifaceted process of competition that takes into account different factors, as the multidimensional space, bounded rationality, heterogeneous customers, and a changing business environment (Gosh & Ortiz, 1997).

4.2.2 The firm maximization problem

As described above, competition can be captured by the firm's relative success in increasing its market share by exploiting the mobility restriction of customers among rival firms over time. Then considering this demand mobility behaviour, we propose to extend the Conjectural Variation Equilibrium model by introducing the idea that an oligopolistic group of firms, when choosing their output, take into account the reaction of rival firms, but that reaction is given by the mobility friction of customers. To achieve this, the industry structure, S firms, faces an inverse demand function as:

$$P = p(y,z) = p\left(\sum_j^S y_j , z\right) \qquad (j = 1,2, \dots , S) \tag{4.3}$$

where p is the market price of product y, z is a vector of exogenous variables affecting demand and y_i is the j firm's output. In addition, the firm's cost function is specified as $C(y_j, w_j)$, where w_j is a vector of input prices for firm j. Since the firm behaves as a profit maximizer the optimization function of firm j is:

$$\underset{y_j}{\text{Max}} \;\; p(y,z)y_j - C(y_j, w_j) \tag{4.4}$$

And assuming that the S firms operate in an intermediate oligopolistic structure, they would set their optimal quantities such that:

$$p + \frac{dp}{dy} \cdot y_j \cdot \varphi_j = C'(y_j, w_j) \tag{4.5}$$

where the parameter φ_j is an index of oligopoly conduct (or conjectural variation) parameter, capturing the deviation from competitive behavior. Since our proposal state that conjectures about competitors' reactions are modelled in terms of the rivalry intensity, this parameter is defined by:[19]

$$\varphi_j \equiv \varphi_{jj} = \Pr(m_{jt} \,|m_{j\,t-1}) \tag{4.6}$$

where φ_{jj} corresponds to the main diagonal of the stochastic process matrix that rules the evolution of market shares, as defined in (4.2). Thus, in (4.6) the conjectural variations parameter includes firm's heterogeneity, since this depends on firm *j*'s relative success in maintaining its own market share from one period to another, which could be different for each firm. Additionally, as in Berg and Kim (1994) and Cetorelli (1999), our theoretical model also embeds an ample set of oligopoly behaviour models, to be discussed later on.

Finally, since the aggregate consumer's behaviour is assumed to follow a Markovian process, the product market equilibrium expressed by (4.5) and (4.6) results in a pure strategic Nash equilibrium (PSNE) in output. This notion of long-run equilibrium in our specification is both stochastic and dynamic in nature. First, it is stochastic in nature for the industry since it requires that the forces acting to increase the size of the market share are on average counter-balanced by those tending to decrease it. Secondly, the concept of equilibrium is dynamic in nature for each firm given that it requires that customers of each firm move in and out of the steady state over time (Rojas, 1996). In this sense, as it has been demonstrated by Ghandi et al. (2010) the

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[19] In static CV models, the conjectural parameter φ_j is commonly interpreted as the perceived response in quiantities of the entire industry to a change in quantity operated by firm j.

PSNE of the underlying model could be found, since our Markov chain matrix specification exactly corresponds to the *stochastic dynamic response*. Hence, to numerically compute the PSNE of the underlying market structure, we only need to know the steady states of the dynamic process[20].

4.2.3 Market power from a rivalry perspective

To analytically derive an expression of the degree of market power of firm j using (4.5) we define market power as the relative mark-up of firm j as:

$$L_j = \frac{p - C'(y_j, w_j)}{p} = \frac{\Pr(m_{j\,t} | m_{j\,t-1})}{\varepsilon} \tag{4.7}$$

where $\varepsilon \equiv \frac{dy}{dp}\frac{p}{y}$ $(\varepsilon < 0)$ is the elasticity of demand.

Finally combining the definition of the firm's conduct parameter φ_j with equation (4.7) we define the degree of market power on the entire industry as a firm weighted average of the firms' market share in the steady state as follows:

$$L = \sum_j^S \left[\frac{p-C'}{p}\right] \widetilde{m}_j = \frac{\sum_{j=1}^S \varphi_{jj} \cdot \widetilde{m}_j}{\varepsilon} = \frac{\sum_{j=1}^S \Pr\left(m_j(t+1) \middle| m_j(t)\right) \cdot \Pr\left(m_j(t+1)\right)}{\varepsilon} = \frac{\varphi}{\varepsilon} \tag{4.8}$$

where the steady state vector $\widetilde{m}_j$ refers to the unique stationary distribution of the market share[21], and the parameter φ, is the stochastic conduct parameter. To the best of our knowledge this is the first contribution which assumes the existence of consumer mobility restriction to calibrate market power considering a stochastic component – .i.e. the market share dynamics through firm's rivalry. Hence we refer to our approach as Stochastic Conjectural Variation Equilibrium.

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[20] In order to avoid the difficulty involved in finding an analytical solution of the Nash equilibrium, the method proposed by Gandhi (2006) results useful to findthe PSNE in games with a continuum of actions and continuous payoff functions like our especification.

[21] The steady state vector corresponds to a Perron-Frobenius (PF) eigenvector to the unique stationary distribution vector, such that: $m_j^T = P_{ij}\, m_j^T$, where $p_{ij} > 0$, and $\sum_{j=1}^S p_{ij} = 1$, as have been required.

The main advantage of our proposal is that we provide a dynamic model to study the firm's market power under a dynamic behaviour, instead of a static one[22]. Another practical feature of introducing the rivalry intensity in the CVE model is to allow the possibility of heterogeneity between firms in a dynamic sense. It is not necessary to impose any ex ante restriction on φ, because by analyzing the conduct parameter element by element any rivalry's setting can be constructed (transition probabilities), and any behavioural model can be specified in terms of industry equilibrium conditions. Thus, we provide a measure of market power in which a considerable set of behavioural models are a priori possible: perfect competition at one end (high mobility, high rivalry) and a monopolistic structure at the other (high fidelity, low rivalry).

In this sense, considering the elements of the diagonal $i = j$, the firm's i relative success in maintaining its market share from one period to another can be determined by analyzing the off-diagonal elements $i \neq j$ we can observe the relative success of firm j in increasing its market share at the expense of a rival firm i. Furthermore, using the elements φ_{ij} and φ_{ji}, the results of bilateral rivalry between firm i and firm j can be analyzed. Finally, if there were many zero elements outside the diagonal this would show that the rivalry is fragmented, since some firms will not be competing with each other, a situation commonly associated with the existence of collusion. Additionally, because under this aggregate setting the parameter φ captures the average industry intensity of rivalry in a flexible way, we can deal simultaneously with different dimensions observed in the market structure, such as asymmetry, kurtosis, time dependence and firms' conduct heterogeneity.

[22] Our results also provide a theoretical framework for the index of rivalry that empirically proposed Rojas (1996) and statistically generalized by Cesari (2000).

Specifically, our conduct parameter lies between zero and one, showing the average probability in the steady state (long-run equilibrium) for customers to switch between firms between across time, which enable us to determine the proportion of customers in the industry that move across firms, and to compute the Lerner index in a dynamic probabilistic sense (see Table 4.1).

For example, a first case is observed with conjectures expressed as the firms' individual conditional probabilities φ_{jj} all being equal to zero, such that $\Pr\left(m_j(t+1)\middle|m_j(t)\right) = 0$, meaning that there is a perfect mobility of customers, and no market power is exerted by firms, consequently resulting in a perfectly competitive ($\mathrm{L} = 0$) market behavior.

On the other extreme, if φ_{jj} is equal to one, there is a situation of no changes in the market share or extreme fidelity, suggesting a lack of competition as customers do not shift from one firm to another which suggests a monopolistic market structure, in which the probability of staying with the same firm is near or equal to 1 (low rivalry, low competition).

A particular case results when φ is $1/S$ and, as a consequence, the conditional probabilities are all equal ($\varphi_{ij} = 1/S$), meaning that there is a collusion or a joint monopoly equilibrium where $\Pr\left(m_j(t+1)\middle|m_j(t)\right) = 1/S$.

Finally, there is a case of time independence in the probabilities, given by $\Pr\left(m_j(t+1)\middle|m_j(t)\right) = \Pr\left(m_j(t+1)\right)$, meaning that the market share of firm j at time $t+1$ is independent of the market share at time t, so that the φ conduct parameter is equivalent to the Herfindahl-Hirschman index:

$$L = \frac{1}{\varepsilon}\sum_{i=1}^{S} \Pr\left(m_j(t+1)\right) \Pr\left(m_j(t+1)\right) = \frac{1}{\varepsilon}\sum_{i=1}^{S} \widetilde{m}_j{}^2 = \frac{HHI}{\varepsilon} \qquad (4.9)$$

This case reduces the degree of market power to the very restrictive Cournot conjecture structure, commonly used to analyze the market structures in a static sense (Cetorelli, 1999).

Table 4.1
Stochastic conduct parameter under different market behaviour

Stochastic Conduct Parameter $\varphi = \sum_{j=1}^{S} \Pr\left(m_j(t+1) \middle| m_j(t)\right) \cdot \Pr\left(m_j(t+1)\right)$	**Lerner Index** $L = \varphi/\varepsilon$	**Market behaviour**
$\varphi = 0$ (extreme mobility of customers)	$L = 0$	Perfect competition
$0 < \varphi < 1$ (low rivalry or low mobility)	$L > 0$	Intermediate oligopoly structure
$\varphi = 1/S$ (invariant mobility of customers) /[a]	$L = 1/(S \cdot \varepsilon)$	Collusion or a joint monopoly equilibrium
$\varphi = HHI$ (time independence mobility)	$L = HHI/\varepsilon$	Cournot static conjecture equilibrium
$\varphi = 1$ (null mobility of customers)	$L = 1/\varepsilon$	Monopolistic structure

Note: a/ symmetric Markov chains shows the same results of collusion.

4.3 Measuring the competitive effect: *Stochastic complementation*

Another contribution of our theoretical specification is that we provide an additional way to study the effects on market power from a merger process by considering that a stochastic combination of two or more independent firms (a M&A) can be stochastically estimated. Thus, based in our theoretically setting, the parameters

φ_{ij} conform the stochastic matrix of equations that rule the dynamics of the industry market structure and we can study the post-merger effects on competition by considering that our specification is consistent to a *stochastic dynamic response* (Gandhi et al., 2008), meaning that we can link this response to the concept of *stochastic complementation*, proposed by Doğançay & Krishnamurthy (1999) - i.e. the stochastic process provides us a way to establish the equivalence effects on the market power of an exogenous merger process observed in a dynamic context.

In this sense, the above means that any M&A is treated as an exogenous process through the aggregation of Markov chain models, φ^P, estimated by replacing a finite-state Markov chain (merged firms) with another chain of smaller dimension, φ^C (post merger firms), and comparing the effects on competition dynamically using the variation observed in the Lerner index ($\Delta L = (\varphi^P - \varphi^C)/\varepsilon$)[23]

As the elements of the Markov matrix are the parameters of the equations of the change in the market structure, it is necessary to ensure that after a merger process, the new estimated transition probability matrix results also in a stochastic matrix (i.e., each entry of the matrix lies in the interval [0,1] and each row sums to one). To achieve this dynamic structure, adapting a *stochastic complementation* procedure (Meyer, 1989) for our purposes results valid for the analysis of the merger process. This, because our specification meets the requirement of a exact steady-state aggregation and, and in addition, has several important properties: first, the resulting aggregated matrix is stochastic and is irreducible if the original transition probability matrix is irreducible; second, for a completely decomposable Markov chain-which is characterized by a cluster of states into groups with strong coupling between the states in a group, and

[23] The subscripts *P* and *C* represent the pre-merger and post-merger behavior, respectively.

weak coupling between states in different groups, stochastic complementation is an accurate approximation for the state probabilities at any time t.

Consequently, a merger which yields a new market structure (new aggregated Markov chain) whose steady-state probability (as $t \to \infty$) is in a particular aggregated state is exactly equal to that computed using the original transition probability matrix. For our purpose, the three-step aggregation procedure based on the *stochastic complementation* theorem proposed by Doğançay and Krishnamurthy (1999) results useful to achieve an post merged aggregated Markov transition model, or a new market structure.

To do this, we assume that a matrix P containing al the possible combination of φ_{ij} – as have been defined in Eq. (4.2) – has the following K-*level* number of firm pre M&A:

$$\text{Pre M\&A: } P = \begin{bmatrix} \mathrm{P}_{11} & \mathrm{P}_{12} & \cdots & \mathrm{P}_{1\mathrm{K}} \\ \mathrm{P}_{21} & \mathrm{P}_{22} & \cdots & \mathrm{P}_{2\mathrm{K}} \\ \vdots & \cdots & \ddots & \vdots \\ \mathrm{P}_{\mathrm{K}1} & \mathrm{P}_{\mathrm{K}2} & \cdots & \mathrm{P}_{\mathrm{KK}} \end{bmatrix}_{\mathrm{S}\times\mathrm{S}} \tag{4.10}$$

where all diagonal blocks P_{ii} are square matrices of size $S_i \times S_i$ such that $\sum_{i=1}^{K} S_i = S$. The following lemma, based in Doğançay and Krishnamurthy's theorem, describes a method to study the effects on market power from a merger process by considering that a stochastic pre-M&A group firms, φ^P, stochastically complemented allow to reproduce the firms stochastic process of smaller dimension in a post-M&A situation, φ^C.

Lemma 1: *Let P be an $S \times S$ irreducible stochastic matrix with a K-level of firms as in Eq. (4.10). The $K \times K$ merged firms' matrix (or the consolidated matrix) C is obtained as follows*:

i) Compute the stochastic complements of P_{ii} (denoted by V_{ii}) using:

$$V_{ii} = P_{ii} + P_{i*}(I - P_i)^{-1}P_{*i} \quad (4.11)$$

where P_i is the principal block sub matrix of P obtained by deleting the i^{th} row and i^{th} column of blocks from P, P_{i*} is the i^{th} row of blocks where P_{ii} has been removed, and P_{*i} is the ith column of blocks where P_{ii} has been removed.

ii) Compute the $N_i \times 1$ PF eigenvector or the unique stationary distribution eigenvector $\lambda_i = [\lambda_{i1}, \dots, \lambda_{iN_i}]^T$ of the $N_i \times N_i$ stochastic complement V_{ii} defined by:

$$\lambda_i^T V_{ii} = \lambda_i^T, \quad v_{ij} > 0, \quad \sum_{j=1}^{S} v_{ij} = 1 \quad (4.12)$$

*iii)*Finally, the (i,j) th entry of the $K \times K$ aggregation matrix C is computed by:

$$c_{ij} = \lambda_i^T P_{ij} 1_{N_J}, \qquad i, j \epsilon \{1, \dots, K\} \quad (4.13)$$

where 1_{N_J} is the $N_j \times 1$ vector of ones, and meetings the requirement of an exact steady-state aggregation.[24]

Considering now the stochastic complementation Lemma 1 together with the stochastic model of consumer mobility behaviour as in Eq. (4.8), the following propositions, without loss of generality, could be made to characterize the effects of a merger process in a competition framework:

Corollary 1: *A market of perfect competition whose setting is the result of firm's strategies of extreme rivalry for customers, and no market power is exerted by firms in a dynamic probabilistic senses, any merger process always leads to a loss of competition.*

[24] The proof of this lemma can be found in Meyer (1989).

Let P be an $\mathrm{S} \times \mathrm{S}$ irreducible stochastic matrix with a K-*level* partition, characterized with values in the diagonal $i = j$ elements all equals to zero, indicating an extreme case of rivalry for customer or a case of perfect competition (L^P=0):

$$\text{Pre M\&A:}\ \ \mathrm{P} = \left[\begin{array}{ccc|c} 0 & \ldots & + & + \\ \vdots & 0 & + & + \\ + & + & 0 & \vdots \\ \hline + & + & \cdots & 0 \end{array}\right]_{\mathrm{S}\times\mathrm{S}} \qquad \text{where} \qquad \varphi^P = 0 \tag{4.14}$$

Any $\mathrm{K} \times \mathrm{K}$ merger process resulting in a new dynamic structure C, affects negatively the competitive behaviour ($L^C > L^P = 0$), since the elements c_{ii}^* representing the new aggregated state are always found to be strictly positive, i.e. the merged firm is able to maintain a captive's market share:

$$\text{Post M\&A:}\ \ C = \begin{bmatrix} c_{ii}^* & \ldots & + & + \\ \vdots & 0 & + & + \\ + & + & 0 & \vdots \\ + & + & \cdots & 0 \end{bmatrix}_{(S-K+1)\times(S-K+1)} \qquad \text{where } c_{ii}^* > 0, \tag{4.15}$$

Then $\varphi^C > \varphi^P = 0$

Proof. According to (4.7) the conjectural variation parameter could be expressed as $\varphi = \vec{\rho}\,'\vec{m}$, where $\vec{\rho}$ correspond to a vector containing the diagonal elements of P and $\vec{m}$ a vector containing the firms' market shares. Thus, under perfect competition $\vec{\rho}$ is a null vector $\vec{0}$, and the pre-merger parameter results in a scalar strictly equal to zero:

$$\varphi^P = \vec{0}\,'\vec{m} = 0 \tag{4.16}$$

Now, for a given index i, and assuming that P has been permutated and repartitioned following the Lemma 1 this leads to:

$$\hat{P} = \begin{bmatrix} \hat{P}_{11} & \hat{P}_{12} \\ \hat{P}_{21} & \hat{P}_{22} \end{bmatrix} \qquad \text{where } \hat{P}_{11} = P_{ii} \tag{4.17}$$

According to the stochastic complement theorem P_{ii} in P is the same as the stochastic complement of $\hat{P}_{11}$ in $\hat{P}$ ($\hat{P}_{11} = V_{ii}$), where the elements $\hat{P}_{11}$ are the result of computing $\hat{P}_{11} = \lambda_k^T P_{11} 1_K$. Then, it is straightforward to note that under extreme rivalry, the out off diagonal elements in the sub-matrix $\hat{P}_{11}$ are strictly positive, which combined with λ_k (also strictly positive) results in:

$$\hat{P}_{11} = \lambda_k^T P_{11} 1_K > 0 \qquad (4.18)$$

As a consequence, almost one of the elements in the vector $\vec{\hat{\rho}}$ containing the diagonal elements of $\hat{P}$ is not null, thus the post-M&A conduct parameter is also strictly positive ($\varphi^C = \vec{\hat{\rho}}'\vec{\hat{m}} > 0$).

■

Corollary 2: *In a market under oligopoly, if a group of firms (or cluster of firms) whose do not reflected rivalry for customers before merging, regardless of the rivalry observed with other non-merged firms, any merger process does not affect the level of competition in the industry.*

Let P be an $S \times S$ irreducible stochastic matrix with a K-*level* partition, characterized by a nonexistence of competition between a group of firms to be merged, defined by the sub-matrix P_{ii} with the off-diagonal elements $i \neq j$ equal to zero:

$$\mathrm{P} = \begin{bmatrix} + & 0 & 0 & + \\ 0 & \ddots & 0 & + \\ 0 & 0 & + & \vdots \\ + & + & \cdots & + \end{bmatrix}_{S\times S} \quad \text{where} \quad \varphi^P > 0 \qquad (4.19)$$

Any $K \times K$ merger process C between the states of this group does not affect the level of competition in the industry in any sense ($L^C = L^P$).

$$\mathrm{C} = \begin{bmatrix} + & + & \cdots & + \\ + & + & \cdots & + \\ \vdots & \cdots & \ddots & \vdots \\ + & + & \cdots & + \end{bmatrix}_{(S-K+1)\times(S-K+1)} \qquad \text{where } \varphi^C = \varphi^P > 0 \tag{4.20}$$

Proof. Assuming that P has been permutated and repartitioned following Lemma 1, and considering two groups of states: one containing the cluster of firms to be consolidated, and the other containing the rest of the firms, this matrix can be expressed as:

$$P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} \qquad \text{where } P_{11} = P_{ii} \tag{4.21}$$

where P_{11} and P_{22} are square matrices of dimension (K) and $(S-K)$, respectively; and P_{12} and P_{21} have the correct order to hold that P is a square matrix of dimension S. Then, according to the stochastic complement theorem P_{ii} in P is the same as the stochastic complement of P_{11} in P ($V_{11} = V_{ii}$).

In a case of non competition between a group of firms, the probability vector $\vec{\rho}$ containing the diagonal elements of P and the vector $\vec{m}$ containing the firms' market shares, are both strictly positive, hence:

$$\varphi^P = \vec{\rho}'\vec{m} > 0 \tag{4.22}$$

From equation (4.6), the degree of aggregate rivalry for the entire industry is the result of a firm's rivalry weighted by the firms' market share in the steady states. So equation (4.23) can be decomposed into two groups of vectors: one containing the cluster of firms to be consolidated, and the other containing the rest of the firms:

$$\varphi^P = \sum_{j=1}^{K} \left(\rho_{jj} \cdot \tilde{m}_j\right) + \sum_{j=K+1}^{S} \left(\rho_{jj} \cdot \tilde{m}_j\right) = \vec{\rho}^{(1)'}\vec{m}^{(1)} + \vec{\rho}^{(2)'}\vec{m}^{(2)} > 0 \tag{4.23}$$

That is, $\vec{\rho}$ and $\vec{m}$ could be partitioned as $\vec{\rho} = (\vec{\rho}^{(1)\prime}, \vec{\rho}^{(2)\prime})$ and $\vec{m} = (\vec{m}^{(1)\prime}, \vec{m}^{(2)\prime})$, respectively. Since by definition, the market share vector, $\vec{m}$, corresponds to a PF eigenvector from matrix P (the unique stationary distribution vector) it is shown that:

$$\vec{m} = P\,\vec{m}, \quad \vec{m} > 0, \text{ and } 1_S{}'\vec{m} = 1 \tag{4.24}$$

Given the properties of any PF eigenvector, any load vector, n_i, associated to each sub-vector can be expressed as:

$$n^{(i)} \equiv \frac{\vec{m}^{(i)}}{1'\vec{m}^{(i)}} \tag{4.25}$$

And the market share PF eigenvector for the large matrix P can be expressed in terms of smaller Perron-complements as:

$$\vec{m} = \begin{pmatrix} \xi^{(1)} n^{(1)} \\ \xi^{(2)} n^{(2)} \end{pmatrix} \tag{4.26}$$

where $\xi^{(i)}$ is the normalizing scalar, or the i^{th} coupling factor (Meyer, 1989 (2)). Then combining (4.23) with (4.26) results in:

$$\varphi^P = \vec{\rho}^{(1)\prime} \xi^{(1)} n^{(1)} + \vec{\rho}^{(2)\prime} \xi^{(2)} n^{(2)} > 0 \tag{4.27}$$

Now, following lemma 1, any $\mathrm{K} \times \mathrm{K}$ consolidation process on matrix P could be also being expressed in terms of a new matrix C:

$$C = \begin{bmatrix} c_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} \qquad \text{where } C_{11} = C_{ii} \tag{4.28}$$

From this last matrix, it can be first noted that, by definition, the elements in the diagonal sub-matrix C_{22} are exactly the same as the diagonal sub-matrix P_{22} in P, since they have not been complemented, and secondly, the individual conditional probabilities for the new consolidated firm is a scalar equal to $c_{11} = \vec{\rho}^{(1)} = \lambda_K{}' P_{11} 1_K$. Hence:

$$\varphi^C = [\lambda_K{}' P_{11} 1_K]' 1_K{}' \vec{m}^{(1)} + \vec{\rho}^{(2)\prime} \vec{m}^{(2)} \quad (4.29)$$

By uncoupling Perron vector properties, the unique corresponding eigenvector of sub-matrix c_{11} is actually the Perron complement eigenvector $n^{(1)}$, then substituting this in expression (4.28) holds that:

$$\varphi^C = \left[n^{(1)'} P_{11} 1_K \right]' 1_K \vec{m}^{(1)} + \vec{\rho}^{(2)'} \vec{m}^{(2)} \quad (4.30)$$

and by rearranging it:

$$\varphi^C = 1_K{}' P_{11}{}' n^{(1)} 1_K{}' \vec{m}^{(1)} + \vec{\rho}^{(2)'} \vec{m}^{(2)} \quad (4.31)$$

Given that no cluster rivalry exists between the firms that merge, this means that the out off diagonal elements in the sub-matrix P_{11} are equal to zero, so $1_K{}' P_{11}$ corresponds exactly to the definition of $\vec{\rho}^{(1)}$. Combining this observation with the definition for any load vector, it holds that:

$$\varphi^C = \vec{\rho}^{(1)'} \frac{\vec{m}^{(1)}}{1' \vec{m}^{(1)}} 1_K' \vec{m}^{(1)} + \vec{\rho}^{(2)'} \vec{m}^{(2)} = \vec{\rho}^{(1)'} \vec{m}^{(1)} + \vec{\rho}^{(2)'} \vec{m}^{(2)} = \varphi^P > 0 \quad (4.32)$$

■

4.4 Empirical extension: Spanish banks' M&As

4.4.1 Brief description of the Spanish consolidation process

A number of numerical examples of the procedures shown in Section 4.3 are provided in the appending while in this section we focus on an applied analysis with some illustrative cases from the banking sector. The Spanish banking industry is an interesting laboratory to analyze the impact of M&As on market power, since this sector has experienced a significant consolidation both following the deregulation process during the 1990s and as a consequence of the restructuring process following since 2009 within the context of the financial crisis.

Figure 4.1

Spanish savings banks' market share after M&A observed in 2010

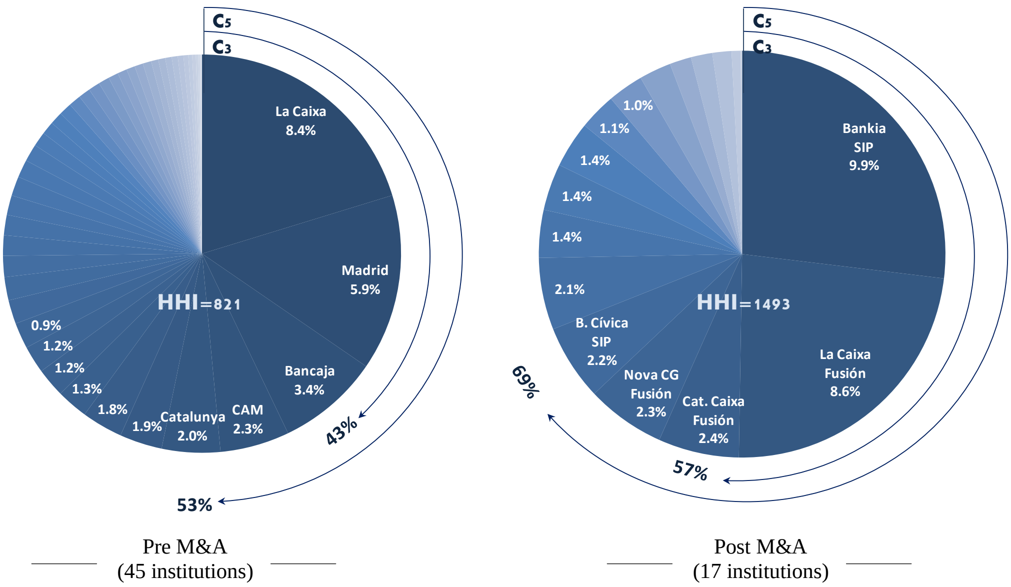
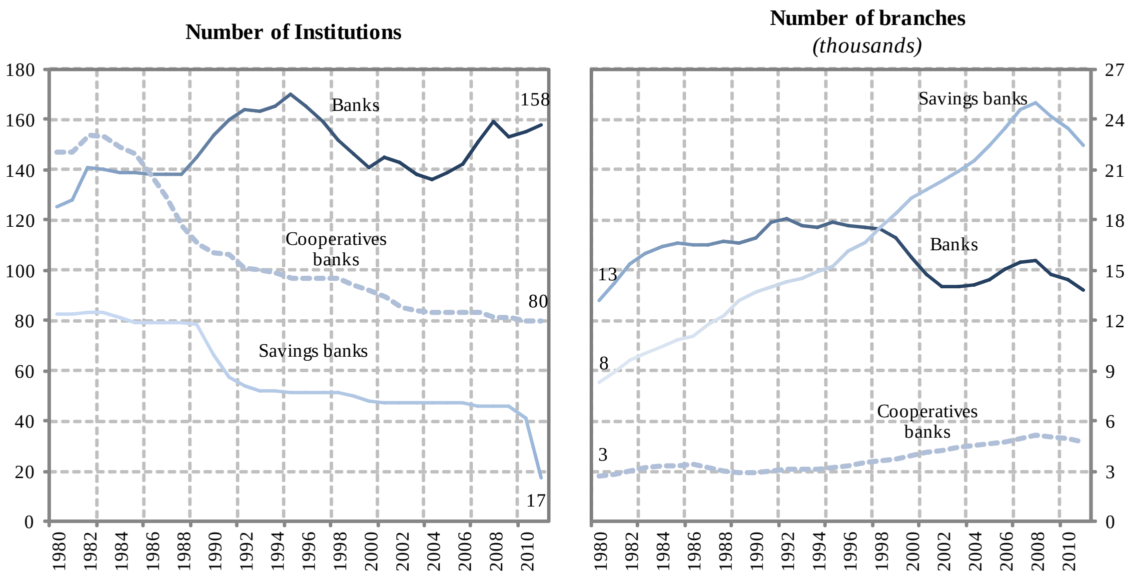


Figure 4.2

Spanish financial sector:

Number of institutions and branches (1980-2010)



Note: The specific market-shares are computed from the loans provided by all financial institutions in Spain. The measures of concentration ratios (C3 and C5) and the HHI index are correspond to the savings banks' sector.

Source: Bank of Spain and own calculations.

The mergers and acquisitions have led to a substantial reduction of 21% in the number of firms operating in the market between 1980 and 2009[25]. Savings banks have been the main actors in the consolidation process and, together with the increase in their number of branches they have gained significant market share over the last three decades (see figure 4.2).

The structure of the savings banks sector until 2009 was dominated by two large banks, La Caixa (SB_1) and Caja Madrid (SB_2), competing nation-wide with a joint market share[26] of 16% of the Spanish banking sector as of 2009; followed by three medium-sized savings banks: Bancaja (SB_3), Caja Mediterráneo (SB_4) and Caixa Catalunya (SB_5) with a joint market share of 10%; and 40 other smaller financial institutions representing 23% of the market. As a whole, savings banks have augmented their market share from 29% to 49% between 1980 and 2009 and increasing their concentration (see figure 4.1)

During the financial crisis, the Spanish banking sector is following an intense process of restructuring there were 13 mergers taking place as of December 2010, affecting more than 90% of assets in the sector and reducing the total number of savings banks (or groups of savings banks) from 46 to 17. This process has considerably changed the structure of the savings bank sector, with the assets' market share of the five larger savings banks increasing from 53% to 68%.

[25] In 1980 there were 57 savings banks and 45 in 2009.
[26] Measured in terms of total credit, respect to the total system at December 2009.

4.4.2 Econometric methodology

The most relevant data to estimate a Markov process in the Spanish banking sector is not available in the form of individual transitions probabilities[27]. For this reason we apply the widely empirical approach proposed by Lee, Judge, & Zellner (1970) and extended by MacRae (1977) to cover the limitation of using aggregate stock total asset data (proportion of individuals in each state at each moment of time).

Then, based on the stochastic model of consumers' behaviour expressed in the market share equation (4.2), the estimation of the transition probabilities consists of a stochastic specification that relates the actual and the estimated occurrence of $y_j(t)$ as follows:

$$m_j(t) = \sum_{i=1}^{S} \rho_{ij} \cdot m_j(t-1) + u_j(t) \qquad (j = 1,2,\ldots,S) \qquad (4.33)$$

Following MacRae (1977), without loss of generality, the Markov process could be described by an alternative system of $s-1$ equations:

$$m^*{}_j(t) = \sum_{i=1}^{S} \rho^*_{ij} \cdot m_j(t-1) + u_j(t) \qquad (j = 1,2,\ldots,S-1) \qquad (4.34)$$

Since the transition probabilities must be nonnegative and satisfy identity condition, we use a multinomial-logit formulation for the transition matrix P such that it can be expressed as the log of a ratio of probabilities as follows:

$$ln\left(\frac{\rho_{ij}}{\rho_{iS}}\right) = \beta_{ij} \qquad (j = 1,2,\ldots,S-1; i = 1,2,\ldots,S) \qquad (4.35)$$

Expression (4.35) comprises a transformation from the space of exogenous variables to the space of transition probabilities such that all elements of P are

[27] Commonly a Markov processes has been estimated following the behavior of individual economic actors who move among a number of discrete states over time (maximum-likelihood count method).

nonnegative and the rows of P sum to one. Rewriting (4.35) to express each probability separately as a function of coefficients gives:

$$\sum_{j=1}^{S-1} \rho_{ij} = P_{\ is}(t) \ \sum_{j=1}^{S-1} \beta_{ij}(t) = 1 - P_{iS}(t) \qquad (j = 1,2, \dots, S) \qquad (4.36)$$

and hence

$$P_{ij}(t) = \left[\exp \ \beta_{ij}\right] / \left[1 + \sum_{j=1}^{S-1} \exp\beta_{ij}(t)\right] \qquad (j = 1,2, \dots, S-1) \qquad (4.37)$$

$$P_{iS}(t) = 1 / \left[1 + \sum_{j=1}^{S-1} \exp\beta_{ij}(t)\right]$$

As can be noticed, all transition probabilities in a row of P depend exactly on the same set of parameters, which implies that the equations (4.36) and (4.37) should be jointly estimated by a method that allows dealing with nonlinear constraints. We employ the Maximum Likelihood Method (Marquardt algorithm). This procedure yields accurate results when the initial guess is not far from the global minimum. To avoid being trapped in a local minimum, a grid search was performed with many initial points over the whole search window, minimizing the log likelihood function.

4.4.3 Sample information

As the empirical goal is to evaluate the effects of M&A on market power in the savings banks' sector as a whole, we consider the savings banks as supplier of an aggregate product. In this sense, as in Angelini and Cetorelli (2003), we consider the total assets as the bank output, since this measure is commonly accepted as a valid proxy of the heterogeneous flow of services supplied by financial institutions. For this reason, this study get the monthly total assets from balance sheet information for virtually all Spanish savings banks for the period 2004:12-2010:05, provided by the Spanish Confederation of Savings Banks (CECA).

4.4.4 Empirical results

As the M&A and restructuring process in the Spanish banking sector during the financial crisis goes beyond the sample period, the empirical results should be considered only as a numerical example on how the "map of rivalry" in the Spanish savings banks changes when M&As take place. Figure 3 shows the main results [28]. The estimation considers a three-dimensional matrix in which each institution is compared with the rest of the top-ten savings banks and with the rest of the smaller institutions. In each case, the transition probability matrix was estimated using monthly total assets data (before M&As), and also using the stochastic complementation procedure to infer the effects of the consolidation process on competition (after M&As). To make the results comparable, the conditional probabilities are presented in annualized terms. Thus the transition probabilities matrices exhibit the outcome of rivalry between savings banks as supplier of an aggregate product from one year to another.

Additionally, we focus on three partial empirical examples of M&As observed during this period: one merger that involves two large savings bank, one involving a nation-wide with a small savings bank, as well as a merger for a medium sized firm with a group of small institutions. For each estimated matrix, the conduct parameter (φ), the Herfindahl-Hirschman Index (hhi) and the market share in the steady state (m_i) were computed to measure the effects on competition pre and post merger.

In June 2010 two Spanish savings banks announced a merger, Caja Madrid (SB_2) and Bancaja (SB_3). The first one was the second-largest savings bank at that time, after

[28] It refers to the results of the first row to the Markov chain, i.e. the likelihood of maintain their customers and its success to win customer from their rivals.

La Caixa (SB_1), while Bancaja ranked third. With that merger, the new institution became the country's biggest savings bank in Spain, with assets worth Eur 279 billion and a market share of 22% in the savings bank sector.

Table 4.2
Spanish savings banks: using total assets
Transition probabilities (annualized): before and after merger
(Sample 2004:12 – 2010:05)

Before M&A						After M&A					
Savings banks		Market share	Own transition probabilities			Savings banks		Market share	Own transition probabilities		
			Institution $\rho_{1,1}$	*Top 10* $\rho_{1,2}$	*Smalls* $\rho_{1,3}$				*Institution* $\rho_{1,1}$	*Top 5* $\rho_{1,2}$	*Smalls* $\rho_{1,3}$
La Caixa	1	20.3%	0.21	0.46	0.34	Bankia	1	26.9%	0.75	0.10	0.15
Madrid	2	14.3%	0.39	0.25	0.36	Caixa	2	23.4%	0.21	0.47	0.32
Bancaja	3	8.3%	0.28	0.31	0.41	Catalunya Caixa	3	6.4%	0.25	0.22	0.52
Mediterráne	4	5.6%	0.27	0.48	0.25	Nova Caixa Galicia	4	6.3%	0.26	0.25	0.49
Catalunya	5	4.7%	0.87	0.06	0.07	Banca Cívica	5	6.0%	0.23	0.27	0.50
Galicia	6	3.5%	0.93	0.03	0.04	Mare Nostrum	6	5.7%	0.17	0.66	0.17
Ibercaja	7	3.3%	0.31	0.33	0.36	BBK	7	3.8%	0.50	0.16	0.34
Unicaja	8	2.5%	0.16	0.44	0.41	Ibercaja	8	3.7%	0.31	0.33	0.36
Cajasol	9	2.4%	0.54	0.21	0.25	España.Salamanca	9	3.7%	0.42	0.13	0.45
Bbk	10	2.2%	0.58	0.20	0.23	Unicaja	10	3.0%	0.16	0.29	0.55

Ratios pre merger		Ratios post merger	
C_3	42.9%	C_3	56.7%
C5	53.3%	C5	69.0%
C_{10}	67.2%	C_{10}	88.9%
hhi	821	*hhi*	1,493
φ	0.3510	φ	0.3799

Case 1: Merger between a nation-wide savings bank and a medium-sized savings bank

Analyzing the characteristics of rivalry (Figure 4.3), we can identify a situation of monopolistic competition between SB_2 and SB_3 before the merger. We observe that there are several null off-diagonal transition probabilities out of this two, reflecting that for these savings banks is unlikely to lose customers with the rest of the institutions, whether large or small. Also, the probability that a customer will be a customer of this group (SB_2 and SB_3) after having been a customer in SB_2 is 0.79 and around 0.44 for SB_3.

Table 4.3
Transition probabilities matrices:
Merger between SB_2 and SB_4
(Sample 2004:12 - 2010:05)

		time: (t+1)							
		Before M&A					**After M&A**		
		Madrid	*Bancaja*	*Top 10*	*Smalls*		*SB 2-3*	*Top 10*	*Smalls*
	SB 2	0.62	0.18	0.05	0.16	*SB 2-3*	0.68	0.09	0.23
time:	*SB 3*	0.22	0.22	0.18	0.38	*Top 10*	0.12	0.63	0.25
(t)	*Top 10*	0.07	0.05	0.63	0.25	*Smalls*	0.04	0.44	0.51
	Smalls	0.02	0.02	0.44	0.51				
	φ^B	0.561				φ^A	0.603		
	HHI	0.341				*HHI*	0.362		
	Steady State	14.6%	6.9%	45.2%	33.3%	*Steady State*	21.5%	45.2%	33.3%

As a whole, the rivalry index pre-merger (φ^B) is 0.561, indicating a high average probability of success in maintaining its market share from one period to another.[29] When the market structure is analyzed after the merger, the transition probability matrix results in a post-merger rivalry index (φ^A) of 0.603, showing a lack of competition, in statistical terms, where the probability for a customer to switch savings bank increases by 4.1 percentage points after the merger, and the arrival of a new firm ($SB_{2\text{-}4}$) that will have a relative success in maintaining its customers with a 0.68 of likelihood from one year to another.

Case 2: A merger between a nation-wide savings bank and a small savings bank

The Spain's largest savings bank, “La Caixa” (SB_1), started at beginning of 2010 a process of acquisition over the smaller regional lender “Caixa Girona” (ranks 34), allowing to increase its market share to 20.3%. When the stochastic consumers' behaviour is analyzed in terms of rivalry (figure 4.4), we observe that the resulting

[29] Notice that in this case the Top 10 and the smalls groups of savings banks are considered as a single firm. Therefore, the mobility of customers within the rests of firms is not considered in the estimation of the rivalry index. See for example Rojas (1996) for more details.

market structure is very close to its steady state situation. This means that the market share covered by the SB_1 and SB_{34} is independent ofthe market share they both have in the year before. The "map of rivalry" supports the hypothesis that a cooperative solution exists between these two firms, in which SB_1 could be considered as a firm that maintains a degree of market power a la Cournot conjecture expression (Cetorelli, 1999).[30]

Table 4.4
Transition probabilities matrices:
Merger between SB_1 and SB_{34}
(Sample 2004:12 - 2010:05)

		time: (t+1)								
		Before M&A					**After M&A**			
		La Caixa	*Girona*	*Top 10*	*Smalls*		*SB_{1-34}*	*Top 10*	*Smalls*
time: (t)	*SB_1*	0.21	0.01	0.45	0.34	*SB_{1-34}*	0.21	0.45	0.34
	SB_{34}	0.22	0.01	0.43	0.35	*Top 10*	0.19	0.49	0.32
	Top 10	0.18	0.01	0.49	0.32	*Smalls*	0.22	0.44	0.34
	Smalls	0.21	0.01	0.44	0.34				
	φ^B	0.385				φ^A	0.387		
	HHI	0.366				*HHI*	0.368		
	Steady State	19.7%	0.6%	46.8%	32.9%	*Steady State*	20.3%	46.8%	32.9%

In this no common case, the effect of this M&A can be measured either through the index of rivalry (φ) or the HHI, and in both cases it does not represent a significant change in competition, given the limited presence of SB_{34} in the banking sector (only a market share of 0.6%).

Case 3: A merger between a medium-sized savings bank merger and 3 small savings banks

The latest emprical example corresponds to the merger started by Caja Mediterraneo savings bank (SB_4) in mid 2010 with other three institutions: Cajastur

[30] This result is valid when the rest of large and small savings banks are considered as single firms.

(SB_{13}), Castilla la Mancha (SB_{21}) and Extremadura (SB_{35}). Even if this merger finally failed, we consider here the potential implications that it could have had for illustration purposes.

Table 4.5
Transition probabilities matrices:
Merger between SB_4 SB_{13} SB_{21} SB_{35}
(Sample 2004:12 - 2010:05)

		year: (t+1)									
		Before M&A							**After M&A**		
		CAM	*CCM*	*Cajastur*	*Extrem.*	*Top 10*	*Smalls*		SB^{4-13}_{21-35}	*Top 10*	*Smalls*
	SB_4	0.23	0.01	0.00	0.00	0.55	0.21	SB_{1-34}	0.37	0.41	0.22
	SB_{13}	0.01	0.49	0.17	0.00	0.19	0.14	*Top 10*	0.07	0.63	0.29
year: (t)	SB_{21}	0.03	0.15	0.11	0.00	0.45	0.25	*Smalls*	0.05	0.62	0.32
	SB_{35}	0.05	0.01	0.01	0.01	0.63	0.30				
	Top 10	0.05	0.01	0.01	0.01	0.62	0.30				
	Smalls	0.04	0.01	0.01	0.01	0.62	0.32				
	φ^B	0.502						φ^A	0.515		
	HHI	0.460						*HHI*	0.466		
	Steady State	5.8%	2.0%	1.2%	0.8%	60.8%	29.5%	*Steady State*	9.7%	60.8%	29.5%

Analyzing the dynamic behaviour of this group, we observe a high level of competition, with different degrees of rivalry. Observing the diagonal elements for this group, we notice that a low market power to retain customers from one year to another. In the case of SB_4 the diagonal tranisition probability is 0.23, indicating that this firm does not have market power to retain its customers from one year to another, as SB_{21} with 0.11 and SB_{35} with almost none power. Only SB_{13} seems significant (0.49) but it is important to notice that compete againts the rest of the savings banks sector.

When the effects of this merger are considered, the rivalry index increases 1.3 percentage points, and this is explained by the considerable number of null off-diagonal transition probabilities for this four savings banks (there seems to be bilateral rivalry only between SB_{13} and SB_{21}) and there is a likelihood of 0.37 to success in maintaining the customer base for the new consolidated banking group (Figure 4.5).

4.4.5 Robustness checks

Using the firms' conjectural variation, $\varphi_j \equiv \Pr\left(m_j(t+1) \middle| m_j(t)\right)$, as our benchmark, several robustness checks of the empirical estimation were performed. First, we re-estimate our regressions considering the market share on deposits instead of total assets, as an alternative definition of the aggregate bank output. This change in our emprical setup is based in the long-running debate on whether deposits must be considered as an input or as an output (Angelini & Cetorelli, 2003). In this sense, the resutls obtained do not altered significatilly the terms of rivalry previously estimated.

Secondly, as for customers mobility, the evolution of the industry's structure could be assumed as a multifaceted process that consider other factors. We considere the relevance of the regional dimension of the Spanish's savings banks sector. This is based in the fact that there could be differences at the regional level in variables such as financial development, customer relationships, demand sophistication or financial exclusion that may affect competition outcomes (Carbó and Rodríguez & 2004). In this sense, if we consider a regional definition of customers – such as households, small and medium-sized firms – we could expect that they have a propensity to operate in local markets, where regional banks could tend to establish long-term lending relationships with their customers. Thus, through a regional perspective, we should expect a positive relatioship between firm's relative success in maintaining its customers and the savings banks' dominance of their bussines in their original regions.

Figure 4.6 illustrates this relathionship again using the ex-post estimated firms' conjectural variation and three measures of regional business' dominance: the presence of branches, the amount of loans and the amount of deposits as a percentage of the total firms in their original regions[31]. The evidence highligts the important role played by savings banks in their regions, where customers become more loyal (low rivalry) and regional dominance seems to be at work.

Table 4.6
Firm's relative success in maintaining its customer and savings bank's regional dominance
Dependent Variable: Conjectural Variation
Method: Least Squares (Sample 45 Savings *Banks)*

Variable	(I)		(II)		(III)		(IV)	
	Coef.	*p-value*	*Coef.*	*p-value*	*Coef.*	*p-value*	*Coef.*	*p-value*
Offices dominance	**0.8892** (0.3247)	0.0089						
Loans dominance			**0.7858** (0.3042)	0.0133				
Deposits dominance					**0.7572** (0.3051)	0.0171		
Overall dominance							**0.5382** (0.2072)	0.0128
Constan	**-0.3510** (0.4600)	0.4497	**-0.4004** (0.4909)	0.4192	**-0.5370** (0.4653)	0.2548	**-2.0402** (0.2549)	
Adjusted R-squared	0.2091		0.2221		0.1852		0.2132	
Observations	45		45		45		45	

Note: All variables expressed in logs. White heteroscedastic consistent standard errors in parenthesis.

4.5 Concluding remarks

The model presented in this chapter shows that it is possible to embed a stochastic source of rivalry within a CVE model. To do so, we use a discrete choice model of consumer behaviour with mobility restrictions. A significant feature in the specifications proposed relies on the possibility of introducing heterogeneity between

[31] For example, a savings bank that only operates in their original region will have a value of one hundred percent on the dominance measure observed through the number of offices, loans or deposits.

firms in a dynamic sense, and also, as other models found in the literature show, it provides a methodology to estimate market power in which an ample set of market structure outcomes are a priori possible.

The use of a Markov chain specification to introduce the rivalry behaviour makes it possible to incorporate the *stochastic complementation* theory within a M&A analysis. In this sense, it is demonstrated how a merger that exogenously occurs in a market of extreme rivalry, always reduce the level of competition. Additionally, it shows that mergers between clusters of firms which do not compete with each other do not, in any way, affect the market power of the entire industry.

Our empirical strategy follows two stages. First, it offers a methodology to measure levels of competition through a CVE stochastic perspective, by measuring how firms respond to changes in market share of other firms. Second, we develop a method (through the so called *stochastic complementation*) to study how M&A processes can affect the market power using a Lerner index.

We also offer a numerical example by analysing the bank merger processes recently observed in Spain -in particular, those affecting savings banks. From these numerical example we infer that the restructuring that the probability of switching customers to change their financial institution before and after the restructuring of the sector (as a measure of our conduct parameter) has increased from 35% to 38%. These results are consistent with alternative models and estimations obtained by controlling a wide range of supply and demand factors.

Appendix 4.1
Switching cost assumption

Each consumer is characterized by a switching cost, s_i, associated with the decisions to select a firm *j* to buy from in each period *t*. Additionally, it is assumed that switching costs among consumers are heterogeneous, thus consumers with different switching costs make different choices. In order to derive the aggregate demand system, the choice function is integrated out over the distribution of s in the population (Gandhi et al., 2008). Then assuming tails occur with zero probability, and considering that F(s) provides the density of the switching cost in the population, the size distribution of customers, or market share over time, $m_{jt} = y_{jt}/\sum_1^S y_{jt}$, results in a joint density function which is conditional on the state in which customers where located in the previous period, such that in each period:

$$m_{jt} = \int F(s,p)ds = \Pr\left(M_{jt} = m_{jt} \middle| M_{jt-1} = m_{jt-1}\right) = f(p_{jt}, p_{rt} + s_i) \quad \text{(A1)}$$

In simple terms, what the equation (A1) measures, given the existence of discrete states in this economy, is that the transition probabilities are functions of the price charged by firm, p_{jt}, and of the prices offered by alternatives purchases from the competing rival firms, p_{rt}, plus the cost of switching, s_i, to buy from a firm that a consumers did not buy in the previous period t.

Appendix 4.2
Numerical examples

In order to illustrate how changes in market concentration after a merger process not always provide accurate information about the effects on market power, four industries with similar number of firms and identical market-shares are characterized.

Examining the transition probabilities matrices that represent the equation of motion that governs the trajectory towards the long-term equilibrium, it can be shown that these probabilities are different in each case (see table A1). The merger between firms 1, 2 and 3 is considered as an example; computing the HHI to capture the concentration effect, and the Rivalry index, φ, to capture the market power effect[32].

The first case represents an industry with perfect customer mobility, described by all firms' individual conditional probabilities equal to zero before the merger (main diagonal). In this context, it is clear to note that no firm is successful in maintaining its market-share from one period to another, regardless of the elasticity that has been observed (perfect competition).

On the other hand, the second case characterizes a market with a considerable lack of competition, defined by the number of null off-diagonal transition probabilities being relatively high. In this case, the relative success in maintaining their customers, measured by the rivalry index, shows an average probability for firms to capture their customers equal to 0.898 before a merger process.

The third case represents a market with low relative success of firms to maintain their customers. This example is not as extreme as the case shown before, since the average probability to maintain customers are equal to 0.383 (relative high rivalry). Nevertheless, it is important to note that no level of rivalry exists between the firms that are going to be merged (non cluster rivalry between firms 1, 2 and 3).

[32] As we see before, this index correspond to the he numerator of the Lerner index, resulting valid if we assume that the demand elasticities remain identical after the merger process

Finally, case 4 shows a industry where the market structure does not present time dependence, since the market share of each firm, at any time, is exactly the same as the market share in the previous period (time independence rivalry).

Taking into account the concentration effect, measured by the HHI, it is evident that analyzing a concentration dimension is not a consistent way to determine the effects on market power resulting from a merger process. The concentration indexes are identical in all four cases, before and after any merger process, regardless of whether a more or a less competitive behaviour is considered (0.223 and 0.5 respectively). However, when the equation of motion that governs the trajectory of the market's structure towards a steady state situation is analyzed, through the rivalry index, the market power effect is captured, taking into account the dynamic component of competition.

The first example, shows how a merger between a group of firms in a competitive perfect behaviour, allows those firms to be merged, to unify customer preferences in order to counter balance their rivalry against the rest of the firms. In this particular situation, after a process of M&A, the average probability for a customer to switch becomes equal to 0.383 (loss of competition as predicted corollary 1.1).

The second and the third cases, represent markets with low rivalry in the industry. As a consequence, a merger could mean an increase in collusive trends. This happens in case 2, but not in case 3, because as predicted corollary 1.2, the merger occurs between a group of firms that do not compete at all with each other for customers, consequently, the final effect on market power is null (the market rivalry index results equal to 0.383 before and after the merger process).

Finally, case 4 represents a Cournot conjecture market, in which the probabilities are not conditional on time, and as pointed out before, the HHI and the rivalry indices are identical in a case like this.

Table A4.1

Transition probabilities matrices:

Numerical examples of pre and post mergers

Case 1: Extreme rivalry

	time: (t+1)								
	Pre-M&A						**Post-M&A**		
	Firm$_1$	*Firm$_2$*	*Firm$_3$*	*Firm$_4$*	*Firm$_5$*		*Firm$_{1-3}$*	*Firm$_4$*	*Firm$_5$*
time: (t) *Firm$_1$*	**0**	0.33	0.21	0.16	0.30	*Firm$_{1-3}$*	0.57	0.23	0.19
Firm$_2$	0.44	**0**	0.14	0.35	0.07	*Firm$_4$*	0.90	0.00	0.10
Firm$_3$	0.55	0.11	**0**	0.19	0.15	*Firm$_5$*	0.78	0.22	0.00
Firm$_4$	0.41	0.48	0.01	**0**	0.10				
Firm$_5$	0.42	0.26	0.10	0.22	**0**				
φ^P	0.00					φ^C	0.383		
HHI	0.22					*HHI*	0.500		
Market share	30.7%	24.3%	11.6%	18.7%	14.6%	*Market share*	66.6%	18.7%	14.6%

Case 2: Low rivalry

	time: (t+1)								
	Pre-M&A						**Post-M&A**		
	Firm$_1$	*Firm$_2$*	*Firm$_3$*	*Firm$_4$*	*Firm$_5$*		*Firm$_{1-3}$*	*Firm$_4$*	*Firm$_5$*
time: (t) *Firm$_1$*	**0.88**	0.02	0.02	0.03	0.05	*Firm$_{1-3}$*	0.93	0.03	0.04
Firm$_2$	0.04	**0.88**	0.02	0.04	0.02	*Firm$_4$*	0.12	0.86	0.02
Firm$_3$	0.04	0.05	**0.85**	0.02	0.04	*Firm$_5$*	0.17	0.03	0.80
Firm$_4$	0.07	0.04	0.02	**0.86**	0.02				
Firm$_5$	0.06	0.07	0.03	0.03	**0.80**				
φ^P	0.862					φ^C	0.90		
HHI	0.223					*HHI*	0.50		
Market share	30.7%	24.3%	11.6%	18.7%	14.6%	*Market share*	66.6%	18.7%	14.6%

Case 3: merger between non cluster-rivalry

	time: (t+1)								
	Pre-M&A						**Post-M&A**		
	Firm$_1$	*Firm$_2$*	*Firm$_3$*	*Firm$_4$*	*Firm$_5$*		*Firm$_{1-3}$*	*Firm$_4$*	*Firm$_5$*
time: *Firm$_1$*	0.62	**0**	**0**	0.28	0.10	*Firm$_{1-3}$*	0.57	0.24	0.19
Firm$_2$	**0**	0.67	**0**	0.27	0.07	*Firm$_4$*	0.88	0.00	0.12
Firm$_3$	**0**	**0**	0.27	0.07	0.66	*Firm$_5$*	0.81	0.19	0.00
Firm$_4$	0.38	0.28	0.22	**0**	0.12				
Firm$_5$	0.32	0.20	0.29	0.19	**0**				
φ^P	0.38					φ^C	0.383		
HHI	0.22					*HHI*	0.500		
Market share	30.7%	24.3%	11.6%	18.7%	14.6%	*Market share*	66.6%	18.7%	14.6%

Case 4: time independence rivalry

	time: (t+1)								
	Pre-M&A						**Post-M&A**		
	Firm$_1$	*Firm$_2$*	*Firm$_3$*	*Firm$_4$*	*Firm$_5$*		*Firm$_{1-3}$*	*Firm$_4$*	*Firm$_5$*
time: (t) *Firm$_1$*	0.31	0.24	0.12	0.19	0.15	*Firm$_{1-3}$*	0.67	0.19	0.15
Firm$_2$	0.31	0.24	0.12	0.19	0.15	*Firm$_4$*	0.67	0.19	0.15
Firm$_3$	0.31	0.24	0.12	0.19	0.15	*Firm$_5$*	0.67	0.19	0.15
Firm$_4$	0.31	0.24	0.12	0.19	0.15				
Firm$_5$	0.31	0.24	0.12	0.19	0.15				
φ^P	0.223					φ^C	0.50		
HHI	0.223					*HHI*	0.50		
Market share	30.7%	24.3%	11.6%	18.7%	14.6%	*Market share*	66.6%	18.7%	14.6%

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Chapter – 5
Summary and Conclusions

This thesis consists of three essays. Each of them focuses on a certain issue in the field of banking and financial stability, where competition features are studied as sources of asymmetry in the financial sector.

In the first essay, it is shown that financial instability plays a significant role in the relationship between the size of a financial sector and its rate of economic growth. The main contribution of this chapter is showing the validity of a non- linear approach to test the channels through which financial development foster economic output depending on the state of the economy. Here, the methodological approach considered was a Smooth Transition Vector Auto-regression (STVAR) specification with special emphasis on the modelling of non-linear effects of financial instability. Given this approach, we undertake an impulse-response analysis to simulate the potential effects of credit shocks on economic growth when the financial sector experiences different periods of instability, considering the Z-score as threshold variable and performed using quarterly data between the first quarters of 1980 to the first quarter of 2009 for Germany, Norway and Spain.

The empirical results reveal that in these countries financial instability has affected not only the economic significance of the effect of credit on output growth but even the sign of this relationship. Furthermore, the results are also consistent with the non-linear relationship suggested by Bencivenga et al (1995), Trew (2008) and von Peter (2009) and contributes to the literature as we estimate the threshold of financial stability that changes the linkage between financial development and economic growth.

The second essay also explores how a non-monotonic relationship plays a significant role in determining the stability of the financial sector. In this case we considered a panel of banks from 23 OECD countries from 1996 to 2010. The main contribution of this paper is that we use a non-dynamic panel threshold regression which is capable to explain how financial stability is affected by bank market power, but that market power is subject to one or more regime-switches depending on level of a three threshold variables: the number of banks, the over-branching characteristics and the managerial office performance.

The empirical evidence shows that economies with a large number of financial institutions, over branched institution but with a low number of employees per branch achieve fewer risk of instability. However, such gains are absent in the case of economies with a small number of institutions, where increases in market power achieved by greater financial consolidation may actually produce a greater risk of instability in their financial systems.

Finally, the third essay explores consumer switching costs behaviour within a Conjectural Variation Equilibrium (CVE) theoretical framework, where firms are allowed to exploit consumer mobility restrictions under a rival firms conduct parameter. The model contributes to the literature by deriving analytically a Lerner index expression that allows to study the effects of mergers and acquisitions (M&As) on market power within a CVE framework using stochastic complementation.

In this sense, the main contribution from this stochastic CVE model is to provide a methodology that establishes the equivalence effects on the market power of an exogenous merger observed in a dynamic context (pre and post-merger). Additionally, our theoretical results also demonstrate how a merger that exogenously occurs in a market of extreme rivalry, always reduces the level of competition; and shows that mergers between clusters of firms which do not compete with each other do not significantly affect the market power of the entire industry.

My future research will involve two strands. The first strand will be extending the empirical study of the relationship between financial development and economic growth by considering other group of countries and other financial soundness indicators, with the purpose to get a better the understanding of the role played by the financial stability in the real sector.

The second strand consists of embedding a capital asset pricing model (CAPM) and other standard pricing models within the Stochastic Conjectural Variation Equilibrium with the aim to incorporate firm's risk behaviour in explaining market instability and market power simultaneously as sources of asymmetry in the financial sector under a context of M&A.