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DEPARTMENT OF ECONOMICS

Financial Intermediation and the Great Recession: Microeconomic and Macroeconomic Issues

Tommaso Oliviero

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

Florence, March 2014

European University Institute
Department of Economics

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Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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Abstract

This thesis consists of three manuscripts that analyze the role of financial intermediation in the Great Recession from both a microeconomic and macroeconomic perspective. Although these papers differ in the adopted methodologies, they share the substantial idea that, to evaluate the real effects of the last recession, we need a deeper study of the role of the financial intermediation sector.

The first chapter of this thesis is joint work with L. D'Aurizio and L. Romano. It documents the credit allocation by Italian banks following the failure of Lehman Brothers. The empirical analysis reveals that Italian family firms experienced a significantly smaller contraction in granted loans than non-family firms. It is showed that the difference in the amount of credit granted to family and non-family firms is related to an increased role for soft information in Italian banks' operations.

The second chapter, joint work with D. Menno, quantifies the welfare effects of the drop in aggregate house prices for leveraged and un-leveraged households in the Great Recession. It features a dynamic general equilibrium model calibrated to the U.S. economy and simulates the 2007-2009 Great Recession as a contemporaneous shock to the financial intermediation sector and aggregate income. The estimates show that borrowers lost significantly more in terms of welfare than savers. In counter-factual experiments it has showed that this loss is larger the higher the households' leverage.

The third chapter documents the relation between bank performance in the 2007-2008 financial crisis and CEO monetary incentives in a cross-country analysis. Results suggest that the sensitivity of CEOs' stock-option portfolios to share prices (option delta) in 2006 have strong predictive power for ex-post bank performance. By exploiting the cross-country variability in financial regulation, results show that incentives to take risk

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

given by stock options are stronger in countries with explicit deposit insurance and weaker in countries with highest monitoring by outside stakeholders.

Contents

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

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Preface

I started my graduate studies in September 2008, at the time of the failure of Lehman Brothers. This event, together with the collapse of the US and many European economies, fostered my curiosity of young researcher in studying the causes of the crisis and its consequences on households and firms. The three papers that follow are meant to contribute in this respect, offering the reader some new findings with a clear empirical and quantitative flavor.

Chapter 1, entitled *"Family firms, soft information and bank lending in a financial crisis"* documents the credit allocation by Italian banks following the failure of Lehman Brothers using very detailed data about firm-bank credit relations. The analysis reveals that family firms experienced a significantly smaller contraction in granted loans than non-family firms. Results are robust to different specifications of the econometric model, which aimed to exclude plausible confounding factors related to family firm status and to time-varying bank fixed effects. By exploiting banks' heterogeneity in lending practices, it is showed that the difference in the amount of credit granted to family and non-family firms is related to an increased role for soft information in Italian banks' operations. Finally, by identifying a match between the banks that increased the role of soft information and family firms, it has been controlled for firms' time-varying unobserved heterogeneity and validated the hypothesis that the results are supply driven.

Chapter 2, entitled *"Financial Intermediation, House Prices, and the Welfare*

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Effects of the U.S. Great Recession" quantifies the welfare effects of the drop in aggregate house prices for leveraged and un-leveraged households in the US Great Recession. To address the research question, it is showed a dynamic general equilibrium model calibrated to the U.S. economy. Consistently with empirical evidence, the 2007-2009 Great Recession has been simulated as a contemporaneous shock to interest rate spreads and aggregate income. The estimates show that borrowers lost significantly more in terms of welfare than savers. In counter-factual experiments it has been found that this loss is larger the higher the households' leverage. This last effect comes from non-linearity that is absent in a model with an always binding collateral constraint (i.e. constant leverage).

Chapter 3, entitled "*CEO compensation, credit crisis and financial regulation: a cross-country analysis*" documents the relation between bank performance in the 2007-2008 financial crisis and CEO monetary incentives in a cross-country analysis. CEO incentives have been measured by their compensation at the onset of the crisis (2006). Results suggest that the sensitivity of CEOs' stock-option portfolios to share prices (option delta) in 2006 have strong predictive power for ex-post bank performance; higher option delta is in fact related to a reduced stock return and higher stock return volatility. The sample allows the study of the interaction between CEO monetary incentives and financial regulation at country level. The evidence suggests that the risk-shifting incentives given by stock options are stronger in countries with explicit deposit insurance and weaker in countries with highest monitoring by outside stakeholders. It is finally showed that a better alignment between CEO and shareholder incentives, through insider ownership, is related to lower stock return volatility.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Chapter 1

Family firms, soft information and bank lending in a financial crisis

with Leandro D'Aurizio (Bank of Italy) and
Livio Romano (Confindustria)

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

1.1 Introduction

The global financial crisis in 2008 and the subsequent recession in the world economy highlighted that capital markets can represent an important source of business cycle fluctuations.[1] Adverse shocks hitting the banking sector propagate to the real economy through a reduction in credit supply. In particular, an increase in asymmetric information problems in the bank-firm relationship tend to amplify negative shocks, by disproportionately affecting some types of borrowers more than others (Bernanke *et al.* (1996)). Problems of moral hazard (Holmstrom and Tirole (1997)) and adverse selection (Stiglitz and Weiss (1981)) make lenders less willing to supply credit to firms facing high agency costs.

Information asymmetry in the borrower-lender relationship is typically lower for banks than for public debt-holders; while the latter must rely mostly, if not exclusively, on publicly available information (balance-sheets, ratings, etc., the so-called hard information), the former have access to "inside" information, which is transmitted through repeated interactions between the loan officer and the firm's manager (Fama (1985); Diamond (1989); Petersen and Rajan (1994)). Such information relates to the lending officer's subjective evaluation of the firm's creditworthiness and is commonly labeled as soft (Berger and Udell (2002); Petersen (2004)). Soft information is an important determinant of corporate lending, especially for small businesses (Garcia-Appendini (2011)). In addition, it has been recently shown that it helps to mitigate the adverse consequences of aggregate credit contractions (Jiangli *et al.* (2008); De Mitri *et al.* (2010)). The reason is that hard information, such as past results and standardized risk measures, are less powerful in predicting firm risk profiles during a crisis. Soft information about a firm's pending results and future plans can reduce this uncertainty, as it is continuously updated and more targeted to the characteristics of the borrower.

[1] See Quadrini (2011) for a review.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

However, despite the interest of scholars in examining the importance of soft information in banks' lending decisions, it is still unclear which types of firms can benefit most from an established relation with a bank. In this paper, we address this issue by focussing on firms' heterogeneity in corporate ownership structure, namely the existence of a family block-holder within the company. In particular, we address the following empirical question: does the existence of a family block-holder mitigate bank-firm agency conflicts during a financial crisis? The answer is strongly related to differences in the incentive structures of family and non-family firms, and thus to the problem of risk-shifting potentially faced by banks (Jensen and Meckling (1976)).

Burkart *et al.* (2003), and more recently Bandiera *et al.* (2012), highlighted the fact that family block-holders attach a value to firm control which is not only represented by the monetary return of their investment, but also includes an amenity component, that is, utility gained though control *per se*. This amenity component can be thought as the personal status acquired thanks to the identification of the family name with the firm's success, or as the desire to transfer the firm to descendants. It translates into higher non-monetary costs of default that lowers the incentive to strategically default (Anderson *et al.* (2003)). On the other hand, as pointed out by Villalonga and Amit (2005), Ellul *et al.* (2009) and Lins *et al.* (2013), family block-holders may have a higher incentive to extract private benefits from the firm at the expenses of the other shareholders and of the stakeholders[2]. In fact, in contrast to the case with non-family block-holders, the gains from misbehavior are concentrated in the hands of a single family group.

In a financial crisis, a lower expected return to investments can exacerbate the incentive to divert resources out of the company, thus reducing a

[2]All these papers focus their empirical investigation on listed firms, which are characterized by the existence of agency conflicts between controlling and minority shareholders. Our analysis, instead, regards firms that are smaller in size and very few went public. Accordingly, this type of agency conflict is less of a concern in the present context.

family firm's investment in the future, and lowering the probability that it will repay its loans. On the other side, family firms may be perceived as more creditworthy by banks because of the lower incentive to default in the future. The evaluation of the overall impact of family ownership on credit allocation will depend on the distribution of "good" and "bad" family firms relative to non-family ones. Therefore, even if the family status of firms is observable to all banks, only soft information, collected through personal interactions with firms' managers, can enable a loan officer to assess whether, given the same publicly available characteristics, a family firm is more creditworthy than a non-family one. In other words, soft information complements hard information by revealing the different objective functions of family and non-family firms.

We answer our research question by using highly detailed data from the Credit Register (CR), which covers all loans granted to non-financial firms by the universe of banks operating in Italy. This information is matched with firm-specific data, including the identification of family status. In our analysis we are able to include family firms of different sizes, including SMEs (small and medium sized enterprises), for which detailed information on corporate structure is not typically available. We cover the 2007-2009 period, which enables to compare results before and after the Lehman Brothers bankruptcy. The choice of October 2008 as the start of the financial crisis is driven by the nature of the shock represented by the Lehman Brothers failure. This event was exogenous and largely unexpected by Italian banks, inducing a lower propensity to lend (Albertazzi and Marchetti (2010)). At the same time, capital shortages characterizing the onset of the financial crisis of many OECD economies, were not a major concern for Italy (but also Japan), where banks relied primarily on resident deposits and less on wholesale funding[3].

For the purpose of our analysis, Italy represents an ideal laboratory. Firstly,

[3]See Panetta *et al.* (2009) for a cross-country comparison and the Financial Stability Assessment of the IMF (2013) for a focus on the Italian banking system during the crisis.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

bank lending represents the most important category of debt for firms in the sample (85% of total debts) both for family and non-family firms. Moreover, there was substantial heterogeneity in the use of soft information by Italian banks following the crisis. By exploiting the information provided by a special survey conducted by the Bank of Italy in 2009, we find that about 35% of surveyed banks (representing about 36% of total aggregate credit) increased the relative weight given to qualitative information and direct knowledge of the borrower in the lending decision, as a result of the financial crisis.

The empirical analysis reveals that both family and non-family firms, one year after the failure of Lehman Brothers, experienced a decline in the aggregate growth rate of loans. However, the contraction was statistically significantly lower for family firms by around 5 percentage points. This result is robust to the inclusion of a rich set of observable characteristics aimed at excluding the correlation of family-ownership with other firm characteristics. By exploiting the presence of multiple lending relationships, we also control for time varying bank fixed effects. We show that this differential effect is not driven by the controlling shareholder's nationality, nor by firms' group affiliation, nor by different concentrations of share ownership. We find no differences between family and non-family firms in the interest rates on their loans and in the amount of physical collateral provided by the companies (these two results are shown in section 1.7 - Appendix). The economic interpretation of these findings is that the existence of a family block-holder in the firm reduced the expected risk of default borne by banks, all other things being equal. Given that family firms are, on average, of smaller size, this alternative flight to quality mechanism towards family firms is consistent with recent findings by Presbitero *et al.* (2012) who show that, in Italy, in the 2007-2009 financial crisis, smaller firms experienced lower contractions in loan availability relative to larger ones.

By exploiting the information on bank lending practices provided by the special survey by the Bank of Italy (previously mentioned), we also show that the banks that increased the role of soft information accounted for the observed difference between family and non-family firms. Starting from this finding, we estimate a time varying firm fixed-effect model in which a family firm dummy interacts with an identifier of those banks that increased the use of personal information in their lending practices. This empirical strategy enables us to control for unobserved heterogeneity between firms (e.g. demand shocks) and validate the hypothesis that results are driven by changes in credit supply. The results suggest that banks, conditional on having increased the relative weight given to soft information, re-allocated credit towards family firms.

The relevance of our results is twofold. Firstly, family firms are widespread all around the world, among SMEs and also among big listed companies[4] (Bertrand and Schoar (2006)). Therefore, their ability to access financial markets has a potentially significant impact on the real economy, as financially constrained firms tend to reduce investments and employment levels (Campello *et al.* (2010)), exacerbating the negative effects of a credit supply shock[5]. Accordingly, in the last section of the paper, we show to what extent the different access to bank lending has been mirrored by differences in real outcomes in the 2007-2009 period. We do not find significant differences in terms of capital expenditure, while we do find that the employment policies of family and non-family firms were substantially heterogeneous. In particular, the reduction in the total workforce was 2.6 percentage points lower for family firms. Finally, we find evidence that profitability, as measured by the ROE, declined less in family firms. Taken together, these results suggest that the credit re-allocation towards family firms has had significant effects for the real economy and appears to have been ex-post efficient from the perspective of the banking system.

[4] In our representative sample of Italian firms, family firms represent about 60% of the total population and about 40% of total sales in 2008.

[5] See also Kahle and Stulz (2013) for a review of the empirical literature on the effects of the recent financial crisis.

A second contribution relates to the debate in the banking literature about the efficiency of relationship lending. In the last two decades, hard information has had an increasingly important role in lending practices due both to regulatory pressure and to the diffusion of information technologies in the financial sector. However, this paper shows that soft information can mitigate the negative effects of an aggregate credit contraction, being a valuable resource for banks in times of increased uncertainty.

The rest of the paper is organized as follow: section 1.2 presents the data used for the analysis and provides some descriptive statistics of the sample of firms under investigation; section 1.3 analyzes the trends in aggregate granted loans, showing how they differ depending on firm corporate structure; section 1.4 looks at bank-firm relationship, focusing on the interaction between bank lending technologies and family firm status; section 1.5 documents the ex-post differences in real outcomes between family and non-family firms; section 1.6 concludes.

1.2 Data sources and descriptive statistics

In this paper we exploit information about bank-firm relationships, firm corporate governance, firm balance-sheet data and bank organization. Accordingly, our dataset comes from four main databases: Invind, Cerved, Centrale dei Rischi (CR) and a special survey on the Italian banks, that was run by the Bank of Italy in 2009. Each observation is therefore a firm-quarter-bank triplet, for the years 2007-2009.

The Invind survey is conducted yearly by the Bank of Italy (Bank of Italy (2011)), on a representative sample of Italian non-financial companies with more than 20 employees[6]. It collected information on the variables con-

[6]This cut-off is set by the Bank of Italy in order to collect information for a representative sample of firms belonging to the industrial and service sectors: firms above this threshold represent 70.5 and 59.2 % of the total payroll employment in the industrial and non-financial service sectors respectively.

cerning the family status of the firms for three consecutive waves in the years 2007-2009[7]. The family firm status is attributed on the basis of the following question:

"Is the firm controlled (directly or indirectly) by a single individual or a group of persons linked by family relationships?"[8]

This approach to the definition of family firms relies on self-reported information and can overcome the typical identification problem in which the stake of each shareholder must be measured in order to determine who controls the firm (see Ellul *et al.* (2010)). Additionally, for a sub-sample of observations (industrial firms with at least 50 employees) we are also able to assess the stakes of controlling shareholders quantitatively. In order to recover balance-sheet data (total assets, leverage, and ROE among others), we used the local Italian Chambers of Commerce's official information collected in the CERVED archives.

We match our firm-level information with the Centrale dei Rischi (CR) database, containing observations on all loans granted by the Italian banking system to firms, with quarterly frequency. These data enable us to construct unique variables based on each bank-firm relationship, with quarterly frequency. In the empirical analysis, we focus on revocable credit lines. This choice is due to the homogeneity underlying this type of contract and because this form of credit can be renegotiated unilaterally by banks.[9] Thus, the loans under scrutiny exclude long-term, collateralized

[7]When the information for a firm was not available in all the waves of the survey, we check the information from previous years, using Amadeus and on-line search from the company's websites. Amadeus is a European database that provides qualitative and quantitative information on firm ownership structure.

[8]Translated from Italian.

[9]The CR database distinguishes between call loans and term loans. When call loans are granted, banks can call them unilaterally at any moment in time, while with term loans the bank typically has to wait until the end of term before renegotiation occurs. Thus, when using the term "revocable credit lines", we are implicitly referring to call loans only,

loans. As argued by Sapienza (2004), borrowers may have contemporaneous relations (deposits, personal loans) with their bank that could affect the lending decision and for which we can't control by using the credit lines[10].

Finally, we integrated the above firm-year-bank observations with the information provided by a special survey conducted by the Bank of Italy's regional branches in 2009 on about 400 banks, accounting for 80% of outstanding bank credit to Italian firms. This survey contains a variable referred to the relative change in the use of soft information in the lending decision as a result of the financial crisis. In particular, banks were asked the following question:

"Starting from October 2008, as a result of the economic and financial crisis, indicate whether the importance accorded to qualitative information and direct knowledge of the borrower increased, decreased or remained the same " [11]

After removing state-owned companies and those firms for which we were unable to recover the structure of the corporate ownership, we were left with 1,808 family firms and 1,101 non-family firms. Panel A of table 1.1 provides a summary description of the characteristics of our sample, with family and non-family firms presented separately. We notice that family firms were much smaller on average at the end of 2008 (a result well known in the literature), slightly older and had a lower penetration in the North of Italy (and conversely a higher penetration in the South) compared to non-family firms. Moreover, family firms were more indebted on

because lines of credit within the term loans group are not considered. However, in order to be sure that results are not driven by the specific nature of the financial instrument considered, we also re-estimated all of the empirical models with the call and term loan data summed together. Results are qualitatively the same, and statistically significant

[10] Unfortunately, this information is never observable, and all the results must be interpreted under this *caveat*.

[11] Translated from Italian.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

average prior to the crisis, suffered slightly more from the contraction in sales relative to non-family firms [12] and generated less cash-flow for each euro earned (the last two differences are weakly significant). Family and non-family firms, on the contrary, did not differ significantly in terms of profitability as measured by the ROE.

Panel B of table 1.1 provides summary statistics regarding firm-bank relationships. We notice that family and non-family firms had similar risk profiles, as measured by the Altman Z-score[13] (the difference in rating is statistically significant but economically negligible). In line with other works using Italian data (Detragiache *et al.* (2000) and Ongena and Smith (2000)), multiple lending is a common phenomenon within our sample, with more than 87% of firms having relations with at least three different banks. Family firms have a higher average number of relationships with banks than non-family firms, a result which is in line with with recent findings by Guiso and Minetti (2010)[14]. This finding explains a different degree of loan concentration for family firms, as measured by the Herfindal index and also by the relative share of each bank financing the firms' activity (in particular the first bank).

Insert Table 1.1 here

[12] The difference in sales contraction between family and non-family firms is not statistically significant once we control for sector, size, year of foundation and geographical area.

[13] This index is built on balance-sheet figures and can take integer values between 1 and 9. Higher values imply a higher probability of default.

[14] The authors use concentrated ownership as a proxy for the degree of informational opacity and the debt restructuring costs for banks in case of corporate reorganization. With both types of interpretation, ownership concentration predicts a positive probability of engaging in multiple lending.

1.3 Bank lending and corporate ownership

In this section we establish whether the degree to which firms suffered a contraction in bank lending was affected by their corporate ownership structure. In order to address this empirical question, we first look at the overall exposure of the firms to the banking sector, in terms of the total amount of credit lines they have been granted. In particular, we aggregate data from each firm's banking relationships into a single observation.

1.3.1 Graphical inspection

Figure 1.1 examines the bank lending channel non parametrically by plotting the dynamics of average granted loans for FF and NFFs separately. Specifically, we take the mean of the logarithm of the outstanding loans granted to family and non-family firms in each quarter, from September 2007 up to September 2009[15], and we normalize to zero the observations, using the end of the third quarter of 2008 as a base. The y-axis can then be interpreted as the growth rate of outstanding loans relative to that quarter.

The figure confirms that the choice of Lehman Brothers' bankruptcy for the identifying date of the credit shock in Italy is reasonable, as the average growth rates in outstanding loans started to decline during the third quarter 2008. Moreover, the figure shows that, before and immediately after the sudden drop occurred in October 2008, there was no significant difference in the dynamics of loans granted between family and non-family firms. An important divergence between the two types of firms began after the first quarter of 2009.

[15]In each quarter we excluded the first and last percentile of the distribution of the relative change in the logarithm of loans, in order to control for extreme observations.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Figure 1.1: Bank lending before and after the Lehman Brothers' bankruptcy: overall adjustments

1.3.2 Econometric analysis

In this subsection we test whether the different patterns observed in figure 1.1 can be rationalized by differences in *ex-ante* characteristics between family and non-family firms. Given the nature of the exogenous shock we are analyzing in this paper, we estimate the following model:

$$\triangle_t logLoans_i = \alpha + \beta_0 Family_i + \beta_1 X_i + \epsilon_i \tag{1.1}$$

where subscript i refers to the firm, and X_i is a vector of controls. The set of control variables captures possible channels which have been identified in the literature as determinants of bank lending behavior, and that could be correlated with the family-firm status. Given that family firms are, on average, smaller than non-family ones, we include the firm size (expressed by the *log* of the number of employees) at the end of 2008, as this characteristic may explain a difference in access to the credit market. We also control for the geographical area of the firm's headquarters by using three geographical dummies, corresponding to the North, the Center and the South of Italy. This is justified by the uneven geographical diffusion of family and non-family firms: a factor that could result in different demand shocks, and in different conditions for the access to credit, due to differences in the distances between firms' headquarters and their financing banks.

We also include the share of credit granted by the first bank (evaluated at the third quarter of 2008), as it can potentially affect the capability of a company to substitute across banks and, consequently, to hedge bank-specific shocks. For each firm, we construct the weighted average length of the relationship with its financing banks (up until October 2008), weighted by the share of each banking relationship in total borrowing. In such a way, we control for the average intensity of the bank-firm relationships, which may not be fully captured by the share of credit granted by the first bank. Firm's year of foundation, sector of activity, level of total leverage, cash-flow over sales, risk (captured by the Z-score being greater than 5) are also included as natural controls. Finally, we include the change in sales that occurred between 2008 and 2009 to control for any different change in the demand for loans resulting from differences in the impact of the crisis on family and non-family firms.

Our dependent variable is the *log* difference of average granted loans between two time windows: the 1st of October 2007 - 30th of September 2008 and the 1st of October 2008 - 30th of September 2009. Within the 'pre-crisis' and a 'post-crisis' windows, we summed up each firm's loans. The two time windows have the same length in order to avoid problems of seasonality, as loan applications may vary during the year for economic and fiscal reasons. We have selected the last quarter of 2008 as the beginning of the post-crisis period both because Lehman Brothers' default occurred at the very end of the third quarter of 2008, and because by doing so we avoid an arbitrary choice of the time windows to compare. An observation period immediately "after the Lehman Brothers event" helps us capture mostly supply-side effects in the dynamics of granted loans, since credit lines respond rapidly to a change in bank portfolio composition. Our results are derived after excluding the top and the bottom percentiles of the distribution of the dependent variable, in order to control for outliers and to increase the accuracy of the estimations. Summary statistics of the change in *log* of loans are reported in the first line of table 1.2

Insert Table 1.2 here

Column (1) estimates the basic model without controls; column (2) includes the basic set of controls; column (3) adds the share of the first bank as a bank-firm characteristic; column (4) looks at the sample of small and medium-sized firms (SMEs) only[16]. Results are shown in table 1.3.

Insert Table 1.3 here

Table 1.3 shows that family firms experienced a 5 percentage points lower decline in the growth rate of loans than non-family firms. The coefficient is robust to different specifications of the model, and is both highly statistically significant and economically relevant. We notice that the β_0 estimates in column (1), without controls, and column (3), with the complete set of controls, are close. This confirms that the observed differences in the amount of granted loans for family and non-family firms cannot be fully explained by standard mechanisms and require further investigation. Moreover, our results are not driven by the change in granted loans for very large firms (where the comparability between family and non-family firms is lower, as shown in Table 1.1): the coefficient of β_0 is almost unchanged in column (4), where the sample is restricted to SMEs only.
A higher risk (measured by the Z-score) is associated with a lower amount of granted loans, as theory predicts. Moreover, the growth of loans is lower when borrowing is more concentrated in the first bank. The negative sign of this coefficient, as previously discussed, may be explained

[16]SMEs are defined as having no more than 250 employees and 50 millions euro of annual sales. This definition is commonly used not only in Italy but also in the rest of the European Union.

by the fact the higher concentration of borrowing in the first bank negatively affects the firm's ability to hedge bank specific shocks. It is also consistent with the empirical evidence that the first financial institution more frequently belongs to the major five Italian banking groups, which cut their credit, on average, more than the other banks (see Albertazzi and Marchetti (2010)).

We argue that the estimated difference between family and non-family firms is mostly driven by a change in the supply of credit. It is true that the change in outstanding loans derived from the financial crisis cannot be directly interpreted as the effect of a credit supply contraction, but the coefficient β_0 of the regression model captures any additional difference on top of that observed for non-family firms. Therefore, we could interpret the difference between family and non-family firms as a supply-driven effect, assuming that the rich set of observable characteristics included in the analysis captures firms' demand for credit[17].

1.3.3 Robustness checks

We have documented so far the existence of divergent patterns in the aggregate dynamics of credit for family and non-family firms. We have also controlled for a set of observable characteristics, potentially correlated with the existence of a family block-holder, able to influence the dynamics of credit. However, some concerns must still be addressed.

Foreign firms

The first relates to the foreign status of the firm. In fact, the large majority of foreign firms (they account for around 8% of our sample) are controlled by non-family block-holders and could follow patterns of credit different

[17]The following results are robust to i) the inclusion of the interaction term between the family firm dummy and the change in sales; ii) the inclusion of the square of *log* size; iii) measuring size in terms of total assets, instead of number of employees.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

from those observed for Italian companies. Foreign firms may in principle substitute domestic credit with foreign credit by exploiting their multinational group affiliation, or may be systematically discriminated against by local banks. In order to be sure that our results are not driven by a difference in the nationalities of the companies, column (1) of table 1.4 adds a dummy for the firm's foreign status to the full specification in column (3) in table 1.3. Reassuringly, our family dummy is still statistically significant, even if the magnitude of the coefficient is slightly lower than before (the foreign status is negatively correlated with the change in loans, but the difference is not significant).

Insert Table 1.4 here

Group affiliation

A second concern, partially related to the first one, arises because of the possibility that firms could substitute bank credit with intra-group financing transactions. If group affiliation is negatively correlated with family firms status, then our results could be explained by a lower demand for bank loans by non-family firms. In order to control for that, column (2) of table 1.4 adds to the full specification of column (3) in table 1.3 a dummy to distinguish group-affiliated and independent firms. Again, our previous results are robust to this additional control and the group dummy has the expected negative sign, which is also statistically significant.

Ownership concentration

Furthermore, we want to be sure that our results are not driven by a difference in the ownership concentration of the controlling shareholder, which has been found to play an adverse effect on the risk of default (see Aslan and Kumar (2012)) and may vary between family and non-family firms. The cleanest available information is the fraction of shares held by the first shareholder; unfortunately this information is only available for relatively

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

large firms (with 50 employees or more). This reduces the number of observations by more than half. Column (3) of table 1.4 adds the ownership concentration of the first shareholder to the full specification in column (3) in table 1.3. In line with theory, higher degrees of ownership concentration in the dominant shareholder reduce the amount of loans granted (even if the coefficient is only weakly significant), but the existence of a family block-holder (*ceteris paribus*) significantly reduces this negative effect (the coefficient associated with family firm status is positive and around 6 percentage points).

Lock-in effects

The last hypothesis we want to test is whether the observed difference between family and non-family firms can be simply explained by *ex-ante* matching with different types of financial institutions. In other words, because it is costly to switch banks, and the switching costs may be proportional to loans concentration, non-family firms might have been "locked-in" with those banks that cut down more during the crisis. In order to address this issue, we need to check whether family and non-family firms have been treated differently by the same bank. By exploiting information at the level of individual bank-firm relationships we can compare the change in *log* loans for family and non-family firms, controlling for bank fixed-effects (thus for time-varying bank fixed effects)[18]. We estimate the following model:

$$\triangle_t logLoans_{ij} = \alpha + \beta_0 Family_i + \gamma X_{ij} + f_j + \epsilon_{ij} \tag{1.2}$$

where $\triangle_t logLoans_{ij}$ is the *log* difference in the average value of loans granted (the averaging procedure is identical to the one used before) for firm *i*, by bank *j*. X_{ij} includes not only the firm-specific characteristics used in the previous analysis, but also the share of loans from bank j to firm i, relative

[18]Summary statistics of the change in *log* loans at the individual bank-firm level are reported in the second line of table 1.2.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

to total loans for firm i and the length of the bank-firm relationship, both measured at the third quarter of 2008. The addition of these two variables is important, as they control for very large percentage variations in the dependent variable, induced by loans of a small size. Finally, f_j represents the bank *j* fixed effect. Results are reported in column (4) and (5) of table 1.4. In column (4), we report the analog of the aggregate results presented in column (3) of table 1.3 at the individual bank-firm level. Column (5) adds bank fixed effects.

The estimates of β_0 in the specifications with and without bank fixed-effects are almost identical and very similar to those obtained at the aggregate level. They confirm that divergent trends in the amount of loans granted for family and non-family firms are not driven by "lock-in" effects induced by an *ex-ante* sorting of family firms with particular banks.

1.4 Heterogeneity among banks in lending practices

In the previous section we observed that, following October 2008, the credit contraction was significantly lower for family firms, after controlling for a rich set of observable characteristics, hence conditioning on hard information. This finding is consistent with the idea that an additional piece of information, namely soft information acquired through the personal interaction of the firms' managers with loan officers, played a substantial role in explaining the observed difference[19]. In particular, it might have allowed banks to better assess the borrower's risk, revealing that it was lower, on average, for family firms.

To test for this hypothesis, we rely on a special survey conducted by the Bank of Italy in 2009 (see section 1.2), and in particular on a variable referred to the change in the use of soft information in the lending decision

[19]Examples of soft information comprise the degree of cohesiveness among firm's shareholders, their personal history, or the existence of hidden personal assets.

after September 2008. We find an increase in the relative importance of soft information for around 35% of surveyed banks (representing about 36% of total aggregate credit), while a decrease in less than 5% of the cases. The increased importance of this type of information following an adverse aggregate shock is consistent with the idea, recently formalized by Bolton *et al.* (2013), that soft information collected at the branch level can partially substitute hard information in the assessment of borrower's risk, as it is continuosly updated thanks to frequent contacts with the firm. At the same time, the degree of such change over time in the screening technology depends on the existing bank's organizational structure. In particular, soft information is costly to collect: in the extreme case of a bank that only processed hard information before the crisis, a sudden shift to soft information-based screening technologies would probabily be unfeasible. Regulatory interventions played a role in shaping the optimal mix of hard and soft information adopted by banks before the crisis; for instance, the Basel II reform in 2004 recommended an expansion in the use of standardized criteria for company default risk evaluation in order to increase the transparency and comparability of national banking sectors. For the Italian case, Albareto *et al.* (2008) show that hard-information based practices have been consequently adopted by almost all larger Italian banks, and by the majority of all other banks.

Table 1.5 shows that when the sample of banks is split between those that increased the use of soft information, labeled as "soft-type" banks, and those that did not, labeled as "non soft-type" banks[20], no difference in the pre-crisis levels of capitalization (measured as the ratio of total equity over total asset) is observed. Similarly, results reveal that the weighted averages

[20] It is important to remind that we are measuring changes in the relative importance of soft information, not absolute levels. Hence, "non soft-type" banks could be those that were attaching, already before October 2008, a high value to soft information in their lending decision. However, the estimates of the Z-score variable in table 1.6 suggest that there is a strong positive association between the relative and the absolute measures of soft information.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

of the net interest rates and of the length of the bank-firm relationships do not differ between the two types of banks[21].

Finally, and most importantly for our purposes, the last two lines of the table 1.5 report the pre-crisis share of credit granted to family firms by the two groups of banks[22]. In particular, the ex-ante share of credit granted to family firms is not statistically different both considering revocable loans only and the overall financial exposure. Family firms have a relatively high share of total credit granted, both by "soft" and "non-soft" banks, primarily because they represent about 60% of our sample and are, on average, more leveraged. This last piece of evidence supports the assumption that the magnitudes of banks' shocks, which are likely correlated with the endogenous choice of increasing the importance of soft information in the screening process, are invariant to the family firm characteristic.

Insert Table 1.5 here

By splitting the sample of surveyed banks between those that increased the use of soft information and those that did not, we replicate the graphical analysis of figure 1.1. This is shown in figure 1.2; the dashed line refers to non-family firms, the other to family firms.

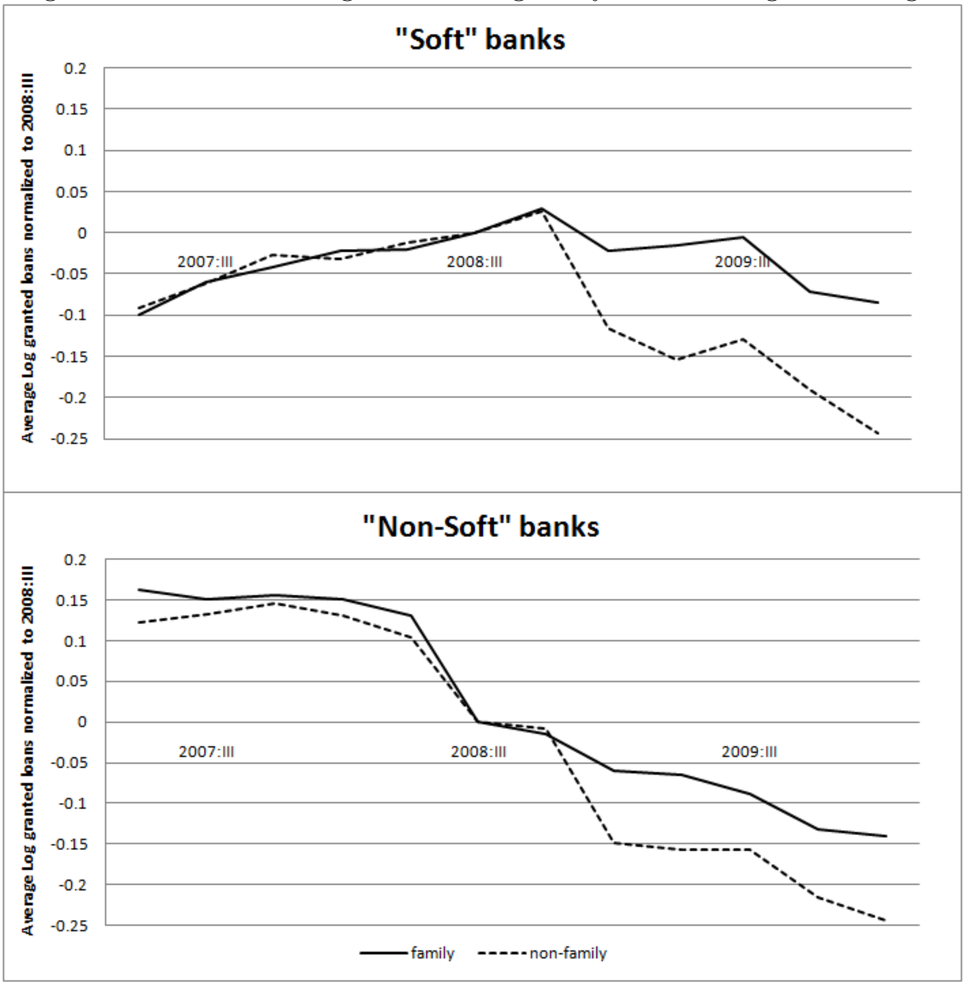
The growth rate of credit appears very different before and after the crisis for the two types of banks. This implies that the decision to change lending technology is likely correlated with the severity of the shock suffered by those banks. While the credit granted by "non-soft" banks was already declining in the period preceding October 2008, the growth rate of credit granted by "soft" banks was increasing until the end of 2008 and then, at the onset of the recession, started shrinking. In particular, we can observe that for the latter banks, there was no difference between family

[21] Weights are equal to the relative share of credit granted to firm i by bank j over the total amount of credit granted to that firm, in the time window 1st of October 2007 - 30th of September 2008

[22] The first of the two lines considers revocable loans only, while the second lines sums up revocable loans with term loans

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Figure 1.2: Bank lending and heterogeneity in screening technologies



and non-family firms before the Lehman brothers bankruptcy shock; following October 2008, the difference emerged. For the "non-soft" group, it seems that a difference between family and non-family firms already existed before the crisis and that, following the shock, the difference weakly started to widen.
To test whether the differences in figure 1.2 are statistically significant after controlling for observed heterogeneities between family and non-family firms, we can re-estimate equation (1.1), splitting the total amount of loans granted for each firm into two groups, corresponding to loans from "soft" and "non-soft" banks. Results are reported in table 1.6.

Insert Table 1.6 here

Results suggest that the difference between family and non-family firms is statistically significant only for those banks that reported an increase in the use of soft information, following October 2008. In particular, family firms experienced a drop in the growth rate of credit that was of about 6 percentage points lower than for non-family firms, *ceteris paribus*. This result validates the prior that soft information played a crucial role in explaining the observed difference in access to bank lending for family firms. Consistently with the previous discussion, we find that high values of the Z-score, captured by the risk dummy, negatively (and significantly) affect the dynamics of credit granted for "non-soft" banks, while it plays no role in explaining the lending decision of banks that rely more on soft information. This last piece of evidence is also in line with Garcia-Appendini (2011), showing that, for banks that do not have access to soft information, the propensity to grant a loan is more sensitive to changes in the values of publicly available variables.

1.4.1 Controlling for unobserved firm heterogeneity

The final set of results fully controls for unobserved time-varying heterogeneity at the firm level, and in particular for demand-side effects. We ex-

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

ploit the existence of multiple lending within our sample and we include firm fixed-effects in the following regression model:

$$\triangle_t logLoans_{ij} = \alpha + \beta_0 \triangle_t Soft_j + \beta_1 Family_i \triangle_t Soft_j + \gamma Z_{ij} + f_i + \epsilon_{ij} \quad (1.3)$$

where $\triangle_t logLoans_{ij}$ is the change in *log* loans for firm i from bank j; $\triangle_t Soft_{ij}$ is a dummy equal to one if bank j increased the importance attached to soft information after October 2008; Z_{ij} includes the share of loans from bank j to firm i, relative to total loans for firm i and the length of the bank-firm relationship, both measured at the end of September 2008 and controls for loan-specific demand effects that may vary between banks for family and non-family firms, due to heterogeneity in the banks' screening processes; f_i is the firm fixed-effect. This estimation strategy is analogous to that proposed by Khwaja and Mian (2008), as the firm fixed-effect controls for demand effects that are invariant with respect to bank characteristics.
Our estimate of interest is now represented by the coefficient β_1, which identifies the interaction between the family firm dummy and $\triangle_t Soft_{ij}$. This parameter captures whether, after controlling for unobservable firm characteristics, banks' use of soft information affected the supply of credit to family and non-family firms. Intuitively, the coefficient β_1 measures whether the difference in the family firm dummies between the two columns of table 1.6 is supply-driven. Given the evidence in table 1.5, the identifying assumption, similar in spirit to that of Rajan and Zingales (1998), is that the different lending behavior of the two types of banks to family and non-family firms is caused by the change in the use of soft information. Results are shown in table 1.7.

Insert Table 1.7 here

Results in columns (1) and (2) show that, for those banks that increased the importance attached to soft information, family firms experienced a relatively smaller credit contraction compared to non family firms. The effect is statistically significant and economically relevant (the difference is around 8 percentage points). Therefore, we can credibly argue that soft information, by uncovering their higher degree of reliability, helped family firms mitigate the adverse consequences of the financial crisis.

1.5 Investments, employment and economic performance

In this last section we analyze the real effects of the financial crisis to see whether differences arise between family and non-family firms in the 2007-2009 period. As highlighted in the introduction, we relate our results to the growing literature, that followed the 2008 financial crisis, about the effects of bank lending shocks to the real economy. Specifically, in table 1.8, columns (1) to (4), we use as dependent variable the log difference in physical capital expenditures, in intangible asset investments, in the number of employees and in the average wage respectively; in column (5), instead, the dependent variable is the absolute difference in the return on equity (ROE). We use balance sheet figures at the end of 2007 and of 2009, that is the year the preceded and the one that followed the bankruptcy of Lehman Brothers. We control for the sector of activity, the geographical area where headquarters are established, the year of foundation, the size and the total leverage of the firm. Unfortunately, due to missing balance-sheet data on the dependent variables for some firms, the number of observations is not constant throughout the analysis.

Insert Table 1.8 here

Results show that while family and non-family firms did not differ significantly in terms of investments (both in tangible and intangible assets), a negative and significant difference emerges in terms of the change in the number of workers. In particular, the reduction in the number of employees has been 2.6 percentage points lower for family firms compared to non-family ones. This difference is not mirrored by a change in the average wage, suggesting that the reduction in the employment levels was homogenous across classes of workers. These results are consistent with recent findings by Sraer and Thesmar (2007), Bassanini *et al.* (2013) and D'Aurizio and Romano (2013), showing that workforce levels in family firms tend to be less sensitive to negative shocks. Finally, the reduction in ROE was less severe for family firms by 2 percentage points, and this difference is statistically significant at conventional levels. These results tend to corroborate the hypothesis that the credit re-allocation towards family firms has been ex-post efficient from the banks perspective, rejecting the alternative explanation of a matching between family owners trying to tunnel resources out of the company and opportunistic loan officers gaining private benefits at the expense of bank's shareholders[23].

1.6 Conclusions

In this paper we have studied the credit allocation decisions of Italian banks following Lehman Brothers' failure. We have found that corporate ownership is an important source of firm heterogeneity. In particular, the presence of a family block-holder had a positive effect in mitigating the agency conflict in the borrower-lender relationship. This effect was strongly related to an increase in the use of soft information by Italian banks in their lending practices following October 2008. The main result is robust to different specifications of our empirical model. We have been able to control for *ex-ante* observable differences between family and non-family firms and also to exclude the existence of significant "lock-in" effects that could potentially reduce the capabilities of firms to hedge bank specific shocks, thanks to the highly detailed data available on bank-firm relations. Finally we controlled for unobserved heterogeneity, confirming

[23]We also checked that the *ex-post* ratio of delinquent loans over total granted loans and the default rate between family firms and non-family firms were not significantly different.

that the credit allocation was driven by a change in the credit supply. At the same time, this difference in credit availability was not mirrored by a contenporaneus difference in capital investments, while it was associated with a lower contraction in the total workforce for family firms.

Our results indicate that it is crucial to look at heterogeneity on both sides of the borrower-lender relationship when studying the propagation of adverse shocks through bank lending. Moreover, our paper, in line with other recent contributions in the literature, highlights the importance of soft information during crises in mitigating the negative effects of a credit crunch.

Finally, notice that our results are not inconsistent with the standard flight-to-quality of credit from smaller (and relatively more opaque) firms to larger (and relatively more transparent) ones as a result of negative shocks hitting the banking sector. We complement the existing evidence (including the recent contribution by Iyer *et al.* (2014)) showing that, within the same firm size class, there is a difference in the dynamics of credit supply depending on the corporate ownership structure. Nonetheless, our analysis primarily concerns the effects of an uncertainty shock hitting the Italian banking sector at the end of 2008 that did not involve also a negative liquidity shock (except for some larger banks). Therefore, a natural extension of our analysis is to explore whether the different lending behavior to family and non-family firms is observed also in times when the financial stability of the banking sector gets weakened. In this case, the demand by financial markets and regulators for more transparency into the banks' operating performances may induce a higher reliance on hard information in the screening process, lowering the relative advantage of family firms in accessing bank lending in times of crisis.

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Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

1.7 Appendix

1.7.1 Data construction

The CR database records all the loans granted by Italian banks that exceed a minimum threshold. The threshold is determined by summing up all the types of loans granted to an individual firm by a bank into three main categories:

1. short-term lines of credit (analyzed in this paper),
2. collateralized credit lines, mortgages, etc.,
3. advances, etc.

The threshold changed over time: it was 75,000 euros up to September 2008 and then reduced to 30,000 euros. For missing observations we proceed as follows:

- when an observation for a specific line of credit at the bank-firm level is missing in some of the quarters between 1st October 2007 and 30 September 2009, we consider the total value of loans issued by the individual bank,
- if the total amount of loans is above the threshold, we assign zero to that observation,
- if the total amount of loans is below the threshold, we compute its expected value (37,500 before October 2008 and 15,000 afterwards) and divide it by three (the number of components in the total amount) and assign the resulting value to the observation.

The inclusion of zeros poses a problem when we estimate the *log* difference in loans granted at the individual bank-firm level. We therefore exclude these observations from the sample, instead of arbitrarily changing their values to a positive integer. However, the occurrence of these observations

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

is limited both in terms of their number and their economic relevance, as table 1.9 clearly shows.

Insert Table 1.9 here

1.7.2 Collateral channel

The observed differences in the change of credit granted to family and non-family firms could also be the result of the different abilities of these two types of firms to provide hard and verifiable collateral to banks. Although our analysis is conducted on call loans only (not directly affected by the ability of firms to provide collateral assets), some degree of substitutability with collateralized term loans could exist. To overcome this type of concern, we confirmed our findings by re-estimating the empirical models in the paper, using the sum of call and term loans as dependent variable. As already outlined in section 1.2, the estimates were qualitatively similar and statistically significant. An alternative hypothesis is that a certain degree of complementarity could exist between call loans and collateralized term loans. In particular, a bank may be more willing to grant call loans to firms that have already pledged collateral on their term loans. Given that we cannot insert the change in collateral for each firm as regressor in the analysis due to endogeneity issues, we address this concern by estimating a model where the dependent variable is the *log* difference of the average amount of collateral pledged for each firm between two time windows: the 1st of October 2007 - 30th of September 2008 and the 1st of October 2008 - 30th of September 2009. Results from table 1.10, columns (1) and (2), clearly show that the family firm dummy has no explanatory power on the change in the dependent variable. This finding reassures us that the results outlined in the paper are not driven by systematic differences between family and non-family firms in the elasticity of collateral provision.

Insert Table 1.10 here

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

1.7.3 Interest rate

In table 1.10, columns (3) and (4), we analyze the cost of borrowing, to check whether differences in the change in the (net) interest rate charged to family and non-family firms exist. In order to do so, we exploit the information contained in a special survey conducted by the Bank of Italy on a subsample of Italian banks (about 200). Unfortunately, this comes at the cost of reducing significantly the number of observations we can include in our estimation. In the regression analysis, the dependent variable is the difference of average interest rates charged on outstanding loans between two time windows: the 1st of October 2007 - 30th of September 2008 and the 1st of October 2008 - 30th of September 2009. Interest rates are weighted by the relative amount of granted credit for each bank-firm relationship. Results show that interest rates went down in the period under consideration (as a result of ECB interventions in the interbank market), but no differences emerged between family and non-family firms.

1.7.4 Other financing channels

Given that family and non-family firms differ on average in terms of size, it is possible that the biggest firms may finance their activities by directly accessing the capital market through equity or bond issuance. Therefore, despite we already control for size in our analysis, for the sake of completeness, we re-estimate the main model, excluding firms that in the period 2008-2009 proceeded with equity or bond issuances/payouts. This is the most precise information that we can obtain from the dataset Invind regarding all the firms in the sample. We find that 16% of the firms in our sample changed at least 0.1% of their capital financing structure; in particular the percentage of family firms is 14.5% while for non-family firms it is 20%. By re-estimating equation 1.1 and by excluding those firms that accessed the capital market directly, we find that our findings are still robust; the significance and the magnitude of the family dummy is always strong

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

for all the specification of the model. This finding further reassures us that the size of the firms is not the main driving force behind our findings.

1.8 Tables

Table 1.1: Summary Statistics for family and non-family firms, prior to the shock

	Non-Family			*Family*			*Mean Diff.*	
	Mean	St. Dev.	Median	Mean	St. Dev.	Median		Obs.
Panel A:*Firm characteristics:*								
Foundation	1976.88	22.79	1981.00	1973.88	24.20	1979.00	3.00***	2909
Employees (2008)	421.63	1324.20	100.00	170.06	422.20	60.00	251.60***	2909
SMEs (%)	.63	.48	1	.78	.41	1	-0.15***	2909
North (%)	.46	.50	0	.39	.49	0	0.07***	2909
Center (%)	.24	.43	0	.22	.41	0	0.02	2909
South (%)	.31	.46	0	.40	.49	0	-0.09***	2909
Roe (2007)^a (%)	6.25	6.97	4.9	6.40	6.13	5.26	-0.15	2741
Leverage (2007)^a (%)	.44	.49	.31	.51	.51	.40	-0.07***	2200
Cashflow/Revenues (2008)	.06	.12	.05	.04	.42	.05	0.02*	2781
Change in sales$_{2008-09}$ (%)	-.14	.29	-.09	-.16	.27	-.12	0.02*	2909
Panel b:*Bank-Firm relation:*								
Zscore (2008)	4.50	1.82	4	4.30	1.76	4	0.20***	2641
Bank Leverage (2007)§ (%)	.39	.46	.27	.44	.42	.35	-0.05**	1710
N° bank relations	6.64	5.01	5.00	7.60	5.03	6.00	-0.96***	2848
Share first bank (%)	.56	.24	.51	.48	.21	.44	0.08***	2909
Share second bank (%)	.22	.11	.21	.22	.09	.22	-0.00	2763
Share third bank (%)	.12	.07	.12	.13	.06	.13	-0.01***	2535
Share fourth bank (%)	.08	.05	.08	.09	.05	.09	.01***	2253
Herfindal index	.45	.21	.30	.36	.23	.32	0.09***	2909

Robust standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. SMEs are defined as having 250 employees or less and annual sales less than 50 millions euro. Rating takes values between 1 and 9, increasing in the borrower's risk. ^{a} extreme values were recoded at the 1^{th} e 99^{th} percentiles because of outliers in these variables. Leverage is measured as total debt over total assets in 2007; ROE is calculated as net profit over total equity in 2007. N° of bank relations and Herfindal index (measured in terms of loans concentration at the firm level) measured at the end of September 2008.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 1.2: Summary statistics of the change in *log* lending

$\mathbf{log(loans)_{09}}$-$\mathbf{log(loans)_{08}}$:	Mean	St. Dev.	Median	Observations
aggregated at the firm level	-.08	.42	-.03	2851
at the bank-firm level	-.15	1.01	0	15212

$\log(\text{loans})_{09}$-$\log(\text{loans})_{08}$ is the log difference of the average granted loans in the time windows 1st October 2007 - 30th September 2008 and 1 October 2008 - 30 September 2009. When aggregated at the firm level, it implies that in each quarter all bank loans for each firm are summed, and then the *ex-ante* and *ex-post* averages computed. When considered at the bank-firm level, it implies that, for each loan from a single bank to a single firm, the ex-ante and ex-post averages are computed. At the aggregate level, we cut the distribution at the 1^{th} e 99^{th} percentiles of the distribution to control for outliers. At the bank-firm level we consider only those observations relative to firms analyzed at the aggregate level.

Table 1.3: Granted loans and corporate structure

	Dependent variable: $\Delta_t logLoans_i$			
	(1)	(2)	(3)	(4)
Family	0.0577***	0.0625***	0.0481**	0.0514**
	(0.0168)	(0.0204)	(0.0203)	(0.0234)
log(Size)		-0.0206**	-0.0203**	-0.0196
		(0.0093)	(0.0092)	(0.0174)
Risk		-0.0416**	-0.0543***	-0.0323
		(0.0190)	(0.0189)	(0.0203)
Leverage		0.0110	0.0132	0.0005
		(0.0185)	(0.0186)	(0.0016)
% Change in $\text{sales}_{2008-09}$		0.0584	0.0643	0.0694
		(0.0449)	(0.0450)	(0.0513)
Year of foundation		0.0001	0.0001	0.0009**
		(0.0004)	(0.0004)	(0.0004)
Share first			-0.2585***	0.2119***
			(0.0483)	(0.0549)
Constant	-0.1180***	-0.2190	-0.1568	-1.7296
	(0.0139)	(0.8890)	(0.8770)	(0.9545)
Other controls	No	Yes	Yes	Yes
Observations	2851	2026	2026	1473

Robust standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Leverage is measured at the end of 2007. Share first measured at the end of Sep. 2008. Other variables are measured at Dec. 2008. Other controls include 11 sector dummies, 3 geographical dummies, cash-flow over revenues and weighted length of the relations. SMEs are defined as having 250 employees or less and annual sales less than 50 millions euro. For all the specifications we cut the 1^{th} e 99^{th} percentiles of the dependent variable to control for outliers.

Table 1.4: Robustness checks

Dependent variable	$\Delta_t logLoans_i$			$\Delta_t logLoans_{ij}$	
	(1)	(2)	(3)	(4)	(5)
Family	0.0447**	0.0451**	0.0578*	0.0416**	0.0446***
	(0.0201)	(0.0204)	(0.0340)	(0.0197)	(0.0164)
Foreign	-0.0338				
	(0.0569)				
Group affiliation		-0.0451**			
		(0.0211)			
Concentration			-0.0009*		
			(0.0005)		
Controls	Yes	Yes	Yes	Yes	Yes
Bank fixed-effects	No	No	No	No	Yes
Observations	2026	2009	911	15212	15212

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. For columns (1) and 3: Robust standard errors in parentheses. Controls are those included in column (3) of table 2.3. We cut the 1° and 99° percentile of the dependent variable to control for outliers. For columns (4) and (5): controls are those included in column (3) in table table 2.3, plus the share of loans from bank j to firm i, relative to total loans for firm i, and the length of the bank-firm relation, both measured at the end of September 2008. In column (4) we compute robust standard errors clustered at the firm level, while in column (5) clusters are derived at the bank level.

Table 1.5: Summary Statistics for Non-Soft and Soft banks

	Non-Soft		*Soft*		*Difference*
	Mean	Obs.	Mean	Obs.	
Pre-crisis capital ratio	.126	210	.120	117	.006
	[.062]		[.0.05]		
Pre-crisis weighted average length of the bank-firm relationship (measured in years)	7.353	213	6.852	119	.501
	(3.334)		(3.720)		
Pre-crisis weighted average net interest rate (%)	2.882	213	3.127	119	-.245
	(4.836)		(4.458)		
Pre-crisis share of granted credit to family firms (1)	.614	213	.649	119	-.035
	(.352)		(.326)		
Pre-crisis share of granted credit to family firms (2)	.606	213	.626	119	.020
	(.345)		(.316)		

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Granted credit amounts are labeled with (1) or (2). (1) refers only to revocable loans. (2) refers to the sum of revocable loans plus term loans. Pre-crisis period refers to average values in the time window: 1st of October 2007 - 30th of September 2008. Capital ratio is defined as total equity over total assets for each banks; it is measured at the second quarter of 2008. % of big banks is the share of big banks as defined by the bank of Italy. Weighted average length of credit relation is measured as the number of years of each bank-firm relationship at October 2008. Weights are equal to the relative share of credit granted to firm i by bank j, over the total amount of loans granted to that firm, in the time window 1st of October 2007 - 30th of September 2008. Weighted average net interest rate is the average interest rate in the time window 1st of October 2007 - 30th of September 2008 for each bank-firm relationship which it is observable; weights are constructed as explained above. Standard deviations in square brackets.

Table 1.6: Estimation results: Soft information and family firms

	Dependent variable: $\Delta_t logLoans_i$	
	"Non-Soft"-type banks	"Soft"-type banks
	(1)	(2)
Family	0.0046	0.0731**
	(0.0343)	(0.0344)
log(Size)	-0.0679***	-0.0072
	(0.0149)	(0.0156)
Risk	-0.0804***	-0.0088
	(0.0295)	(0.0293)
Leverage	-0.0003	-0.0122*
	(0.0050)	(0.0069)
% Change in $\text{sales}_{2008-09}$	0.1078*	-0.0597
	(0.0646)	(0.0719)
Year of foundation	-0.0004	-0.0003
	(0.0006)	(0.0009)
Share first	-0.2925***	0.0318
	(0.0810)	(0.0920)
Constant	1.1092	0.6528
	(1.2401)	(1.7806)
Other controls	Yes	Yes
Observations	1970	1827

Robust standard errors in parentheses, clustered at the firm level.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Length of the relation and Share of the bank measured at the end of Sep. 2008. Other controls include 11 sector dummies, 3 geographical dummies, cash-flow over revenues and weighted length of the relations.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 1.7: Banks' heterogeneity in the screening process

	Dependent variable: $\Delta_t logLoans_{ij}$	
	(1)	(2)
Δ_tSoft	0.0995***	0.0642*
	(0.0353)	(.0352)
Δ_tSoft x Family	0.0797*	0.0845**
	(.0424)	(0.0420)
Share of the bank		-1.0583***
		(0.0773)
Length of the relation		-0.0094***
		(0.0030)
Constant	-0.1804***	-0.0530**
	(0.0082)	(0.0240)
Firm fixed-effects	Yes	Yes
Observations	12864	12864

Robust standard errors in parentheses, clustered at the firm level.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Length of the relation and Share of the bank measured at the end of Sep. 2008.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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Table 1.8: Estimation results: Real outcomes

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	$\Delta_t logTang.Inv_i$	$\Delta_t logIntang.Inv_i$	$\Delta_t logEmploym._i$	$\Delta_t logWage_i$	$\Delta_t ROE_i$
Family	-0.0690	-0.0364	0.0259***	0.0128	2.028*
	(0.0830)	(0.108)	(0.00998)	(0.0134)	(1.113)
log(Size)	-0.0837	-0.363*	0.0955***	0.0149	-1.114
	(0.178)	(0.217)	(0.0213)	(0.0367)	(2.720)
Leverage	-0.0995	-0.0413	0.00376	-0.00184	0.381
	(0.0889)	(0.0777)	(0.00773)	(0.0114)	(0.950)
Year of foundation	-0.00181	-0.000439	0.000414***	0.000227	0.0126
	(0.00158)	(0.00206)	(0.000158)	(0.000249)	(0.0248)
Constant	3.999	1.966	-1.116***	-0.436	-25.17
	(3.253)	(4.242)	(0.313)	(0.499)	(49.32)
Other controls	Yes	Yes	Yes	Yes	Yes
Observations	1801	1046	2037	1395	1833

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Other controls include 11 sector dummies, 3 geographical dummies, and the square of log(size).

Table 1.9: Appendix - Comparative statistics for the bank-firm loan observations (euro)

	Mean	Median	Obs.
Before October 2008:			
Bank-firm relations disappeared after Sept. 2008	247,692	11,267	458
Bank-firm relations considered in the analysis	710,715	100,000	19,722
After October 2008:			
New bank-firm relations appeared after Sept. 2008	178,746	6,250	438
Bank-firm relations considered in the analysis	672,147.8	100,000	19,722

Table refers to bank-firm loan averages either for the period 1st October 2007 - 30th September 2008 (Before October 2008) or for the period 1st October 2008 - 30th September 2009 (After October 2008)

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 1.10: Appendix - Collateral channel, Interest rates

Dependent variable:	$\Delta_t Collat.ratio_i$		$\Delta_t Netinterestrate_i$	
	(1)	(2)	(3)	(4)
Family	-0.0359	-0.0822	0.0019	-0.0023
	(0.0636)	(0.0727)	(0.0080)	(0.0087)
log(Size)		-0.0124		-0.0098*
		(0.0235)		(0.0056)
Risk		-0.0670		0.0051
		(0.0625)		(0.0108)
Leverage		0.136		-0.00917*
		(0.0827)		(0.00514)
Cashflow/Revenues		0.0148		-0.0013
		(0.0297)		(0.0010)
% Change in sales$_{2008-09}$		-0.0665		-0.0132
		(0.0881)		(0.0119)
Share first		-1.028*		-0.0440
		(0.571)		(0.0764)
Constant	0.154***	-2.700	-0.0291***	-0.4100
	(0.0524)	(1.865)	(0.0067)	(0.4550)
Other controls	No	Yes	No	Yes
Observations	1182	841	998	863

Robust standard errors in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Leverage is measured at the end of 2007. Share first measured at the end of Sep. 2008. Other variables are measured at Dec. 2008. Other controls include 11 sector dummies, 3 geographical dummies, firm's year of foundation and weighted length of the relations. For columns (1) and (2) we cut the 1^{th} e 99^{th} percentiles of the dependent variable to control for outliers.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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Chapter 2

Financial Intermediation, House Prices, and the Welfare Effects of the U.S. Great Recession

with Dominik Menno (RWTH Aachen University)

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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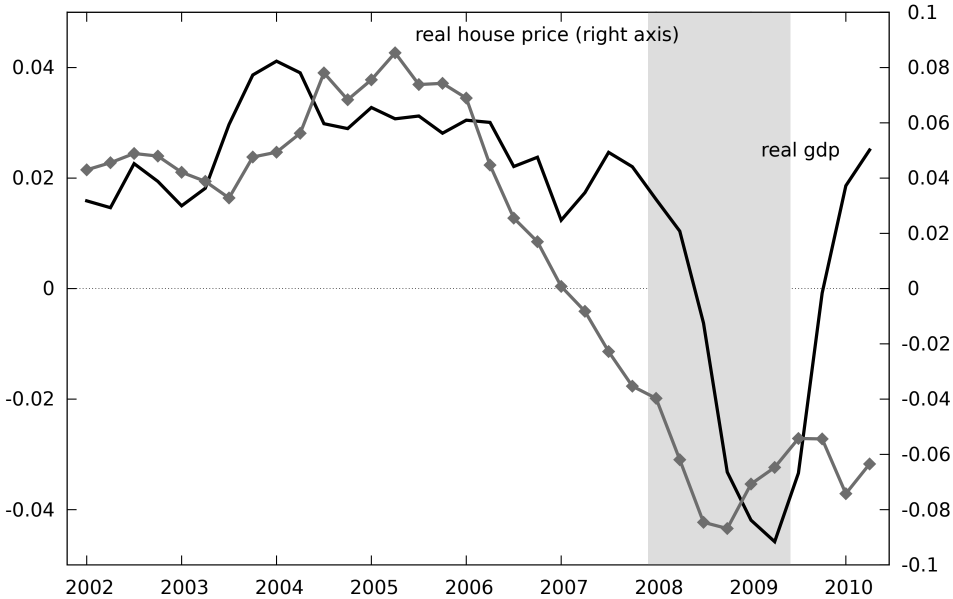
2.1 Introduction

The U.S. Great Recession was characterized by a large fall in GDP coupled with an unprecedented collapse in the housing market. This drop in aggregate house price between 2007:IV and 2009:II deeply affected a great number of U.S. households. [1] Figure 2.1 shows the de-trended quarterly series of US GDP and aggregate house prices. We observe a large drop of around 5.4% between the NBER recession dates, and a collapse in aggregate house prices of about 11%.

Figure 2.1: GDP growth vs. house price growth



Notes: Shaded areas are NBER recession dates. The grey dotted-line is the Y2Y-growth rate of All-Transactions House Price Index for the United States deflated by CPI (less shelter); the black line is Y2Y growth of U.S. real GDP. For a detailed data description see appendix 2.6.1

The recession has also been linked turbulence in the financial markets and, in particular, the banking system. This fact has triggered a debate among economists and policy-makers about the welfare consequences of the fi-

[1] Iacoviello (2011b) shows that housing wealth represents about half of total household net worth in 2008 and almost two third of median household total wealth

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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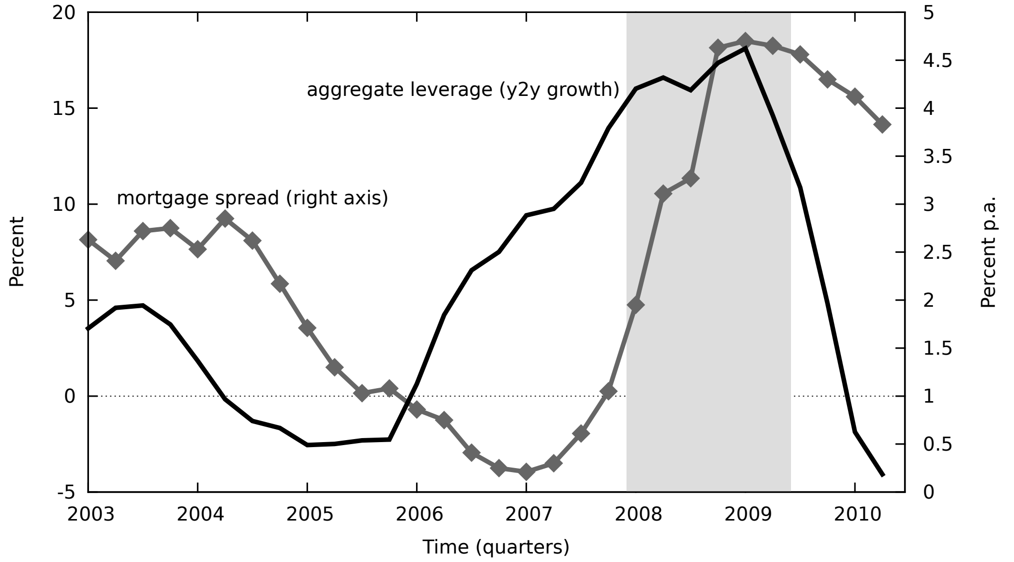
nancial innovation process that preceded the crisis and that possibly exacerbated the effects of the economic collapse. In fact, the last decade witnessed an increase in household indebtedness that coincided with a period of relaxing credit conditions. Both microeconomic and macroeconomic evidence show an increase in household leverage in the years preceding the recession. On the micro side, an analysis of Survey of Consumer Finance (SCF) data reveals that aggregate mortgage debt expanded by 59% between 2001 and 2007, despite a 19% increase in housing wealth. On the macro side, we observe around ten quarters of growth in leverage followed by sharp fall during the NBER recession dates, as seen in the mortgage to real estate ratio. Figure 2.2 plots the year-to-year growth rate of leverage and the spread between the mortgage interest rate and the federal funds rate. These two series show a negative correlation at the onset, and in the last quarters of the Great Recession. During the quarters preceding the crisis, spreads were particularly low and leverage was rising at an unprecedented rate. In mid-2008 however, interest rate spreads jumped to a level of about 4.5% while household leverage started to decline. Our interpretation is that, in the period of credit expansion (low spreads), the mortgage growth rate was faster than real estate inflation and leverage was increasing; the opposite happened in a period of credit contraction (high spreads).

In the current paper we examine the effects of exogenous changes in interest rate spreads and aggregate income on endogenous aggregate house prices and, ultimately, on households' welfare. In this respect, we share the view that fluctuations in spreads largely reflect disturbances in the financial markets' assessments of credit risk Bordo (2008). Furthermore, we share the view of Adrian and Shin (2010) that variations in the price of default risk reflected variations in the effective risk-bearing capacity of the financial sector, which has been ultimately affected by aggregate portfolio losses.

The stylized facts highlighted in figures 2.1 and 2.2 motivate our interest

Figure 2.2: Mortgage spread vs. Leverage



Notes: Shaded areas are NBER recession dates. The grey dotted-line shows the spread between the one-year amortizing adjustable mortgage rate (ARM) and the federal funds rate from 2002:I to 2010:II. Spreads of ARM over Fed Funds rate are shown in levels (percent p.a.). The black line is Y2Y growth of U.S. leverage defined as the ratio between mortgage and real estate series (taken from the balance sheet of U.S. households and nonprofit organizations). For a detailed data description see appendix 2.6.1.

in quantifying and isolating the impacts of financial and income shocks on aggregate house prices and, consequently, on households' welfare. In particular we address this question within a stochastic dynamic general equilibrium model with heterogeneous households and endogenous collateral constraints. In our model, households differ in their level of patience. This heterogeneity results into two types of agents: borrowers, who are potentially financial constrained, and savers, who are unconstrained.[2] Within this framework, we study the welfare effects of an endogenous drop in housing wealth for these two groups of households. The data in table 2.1 motivate the choice of this cross-sectional heterogeneity across house-

[2]The structure of the economy is similar to Iacoviello (2011a) and Justiniano *et al.* (2013) who present a quantitative analysis of the US Great Recession

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Table 2.1: Summary Statistics from SCF panel 2007-2009

Household type$_{2007}$	*Savers*	*Borrowers*	*All households*
$\Delta_{07,09}$housing wealth	-9.2%	-16.6%	-12.9%
Leverage$_{2007}$	*< 43%*	*43 - 67%*	*>67%*
$\Delta_{07,09}$housing wealth	-12.9%	-16.5%	-23.5 %

holds. Using panel data from the Survey of Consumer Finance (SCF) for the period from 2007 to 2009, the table shows that households with a positive net savings position (*savers*) show an average drop in housing wealth of 9.2% between 2007 and 2009. This is significantly lower than the equivalent number for households with a negative net savings position (*borrowers*, -16.6%).[3]

Moreover we show that the drop in housing wealth for borrowers is increasing in the level of leverage in 2007:[4] while borrowers with initial levels of leverage greater than or equal to 67% show a drop of 23.5% in housing wealth, households that entered the recession with a lower level of leverage (less than 43%) show a much smaller drop in housing wealth.

In the model economy, agents are fully rational and derive utility from both the consumption of perishable goods and of housing services coming

[3]In table 2.1, saver and borrower status refers to home owners in 2007. Savers and borrowers are defined here - and throughout the paper- as households that show respectively a positive or a negative net asset position. A net asset position is defined as the sum of savings bonds, directly held bonds, the cash value of life insurances, certificates of deposits, quasi-liquid retirement accounts and all other types of transaction accounts minus the debt secured by primary residence, the debt secured by other residential property, credit card debt and other forms of debt. For a detailed description of data please refer to Appendix 2.6.1.

[4]Leverage is defined here - and thorough the remaining sections- as the ratio between net asset position and total housing wealth.

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from housing stock. Housing is the only physical asset in the economy and it is fixed in supply. This is motivated by the fact that previous and during the Great Recession, house prices were most volatile in geographical areas where the supply of houses was relatively fixed.[5] The financial friction arises because agents have to collateralize short positions of one-period financial asset by a fraction of the expected value of their available housing stock.

In this otherwise standard model, we introduce a competitive financial intermediation sector. All saving and borrowing is conducted though this sector, which faces exogenous shocks to its technology.[6] These shocks give rise to a spread between borrowing and lending such that the collateral constraint does not necessarily bind. In other words, it generates endogenous changes in the households' leverage. The second source of aggregate disturbance comes from standard aggregate income shocks that directly affect the households' endowment of the perishable good. This may be interpreted as a reduced form way to capture the cyclical behavior of productivity shocks.

We calibrate the model to the US economy and simulate the Great Recession as a contemporaneous negative income and financial shock that follows a period of moderate economic, credit expansion and increasing leverage. This characterization is due to the empirical observation that both income and financial intermediation were above (below) the long run trend before (after) the recession. To calibrate our key parameters we consider moments from both micro and macro data. In particular, we were able to match the leverage and the wealth share of borrowers relative to savers using from the Survey of Consumer Finances (SCF, waves 1998 -

[5]See figure IV in Mian and Sufi (2009).

[6]We consider a simple model for the financial intermediation in the spirit of Cooper and Ejarque (2000) and Curdia and Woodford (2010). Otherwise, the link to these studies is limited as the former looks at the business cycle properties of financial shocks within a representative agent framework, while the latter studies the implications of spread shocks for the optimal conduct of monetary policy.

2007). This calibration strategy, although different from the approach of most papers in the existing literature which target macro moments only, results in calibrated parameters that are compatible with recent contributions (Iacoviello and Guerrieri (2012)).

A very delicate issue for the calibration exercise is what time frame to use, and in particular, whether to incorporate a recession or not. We take the following stance. Our main goal is to maintain a close link between the model and the research question. We study the Great Recession as a state-contingent exogenous event that hit the US economy in late 2007, following a period characterized by banking innovation and increasing household leverage. Therefore, we consider the Great Recession as a low probabilistic event embedded in a business cycle framework. For this reason, we calibrate the model to data including the quarters of the recession until 2009:II.[7] The structural nature of our exercise allows us to conduct counterfactual experiments in order to disentangle the quantitative effects of income and intermediation shocks on aggregate house prices and agents' welfare.

We have three major findings. First, we find that our benchmark model quantitatively explains the observed drop in house prices during the Great Recession. The majority of the effect is attributed to real income shocks. Financial intermediation shocks explain only a small percentage of the observed drop. This finding confirms that the observed behavior of aggregate house prices, before and after the Recession, could be partially related to changes in fully expected shocks. More importantly, we find that, in contrast to the widespread view, shocks in the financial sector have very limited quantitative effects on aggregate house prices.

Second, we find that borrowers significantly lost more than savers in the Great Recession. In particular we highlight a significant difference in the

[7]For the micro data, SCF is run every three years. We decided to include the 2009 wave and not to include the 2010 wave of the survey in the analysis in order to be consistent with the other calibrated parameters in the model. However, even when including the 2010 wave, the targeted values are very similar.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

welfare effects of income and financial intermediation shocks. In the Great Recession, the negative income shock was the main driver behind the absolute drop in house prices and the absolute level of agents' welfare losses. The financial intermediation shock is instead the main determinant of changes in households' leverage before and after the house price drop.[8] We show that increasing interest spreads had distributive effects, with savers gaining at the expense of borrowers. Accordingly we show that an increase in interest rate spreads forced borrowers to de-leverage and amplified their welfare losses of house price drop by 37.5% while causing a 66.7% welfare gain for savers. Moreover, counterfactual experiments show that the high leverage previous to the crisis made borrowers' welfare losses 25% bigger than if it would have occurred in a state of low leverage.

Third, we find that if we restrict the collateral constraint so that it always binds, the amplification effects given by leverage and de-leverage would have been underestimated; a model with always binding collateral constraint which reduces in fact the volatility of the aggregate leverage to zero. This is an important finding as previous studies (notably, Iacoviello (2005)) usually assume that the constraints are always binding. The intuition for this result is that when the growth rate of the borrowers' debt is forced to be proportional to changes in expected housing wealth, borrowers leverage up more slowly in expansions and de-leverage more slowly in contractions when compared to our benchmark model. This implies that when the crisis hits, borrowers have more outstanding debt in the benchmark model that they need to roll-over. In a recent paper, Iacoviello and Guerrieri (2012) explore the quantitative properties of occasionally binding collateral constraints and the relative non-linear effects coming from changes in the demand for housing.

[8]This mechanism is in line with the microeconomic evidence of Mian (2010), who found that an increase in credit supply, coupled with the effect of collateralized debt on increasing house prices, created an unprecedented increase in household leverage in the quarters preceding the crisis

The mechanism behind the three findings is the following. First, a negative realization of one or both of the exogenous shocks leads to credit contractions. In a credit contraction - given that it is more costly to roll over existing debt - borrowers choose optimally to reduce their indebtedness. If the reduction in debt is sufficiently large, borrowers need to reduce their housing stock. For a given supply of housing, house prices must therefore decrease. This causes borrowers to suffer in terms of both wealth and expected lifetime utility. On the other hand - because of the lower demand for debt - savers potentially face a lower interest rate on savings. This potentially hurts them by raising the price of future consumption. However, savers expecting house prices to rise again in the next period - can smooth their consumption by buying houses when their prices are depressed. Finally, savers gain in terms of wealth and do not suffer much in terms of expected lifetime utility. The size of this distributive effect depends crucially on how interest rates move. In this paper we quantitatively show what exactly distinguishes financial shocks from income shocks. Another important remark concerns the non-linearity generated by the collateral constraint. In states of the world where borrowers choose optimally to move away from the constraint, it becomes slack. That is, borrowers can choose the pace at which to reduce their debt, unlike the case in models with an always-binding constraint. This implies a change in the elasticity of the demand for debt and housing with respect to changes in house prices that could have non-negligible quantitative effects.

The present study is related to two important strands of literature. First, we relate to the recent literature that studies the financial sector as an autonomous source of macroeconomic fluctuations Jermann and Quadrini (2012) and the literature that claims that financial frictions played a preeminent role in explaining the observed drop in US aggregate economic activity Hall (2011). Recently, Guerrieri and Lorenzoni (2011) find that a shock to the spread between the interest rate on borrowings and the interest rate on savings - in the presence of a collateral constraint that links

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

debt to the level of durables - generates a decrease in the borrowers' demand for durables that grows stronger as agents get closer to the credit constraint. While their analysis abstracts from aggregate house prices and endogenous changes in wealth, we explicitly emphasize the channel that goes through the endogenous change in house prices.

Second, our analysis relates to recent studies on the distributive effects of the Great Recession. Compared to Glover *et al.* (2011) - a study on intergenerational redistribution during the Great Recession - we focus on a different dimension of agent heterogeneity and welfare, namely, redistribution between constrained agents (borrowers) and unconstrained agents (savers). Similar to Hur (2012), we find that the constrained agents always lose more than unconstrained agents.[9] Both of the aforementioned studies are silent about the inherent redistributive nature of financial shocks, the focus of this paper.[10]

The rest of the paper is structured as follows: In the following section we present the model. Section 2.3 presents the quantitative analysis. In section 2.4 we compare the predictions of the benchmark model to alternative specifications, including the case of an always binding constraint. Section 2.5 concludes.

[9] Hur (2012) considers an overlapping generations model with collateral constraints; he finds that the constrained agents are mostly from the young cohort, and that those agents suffer the most during a recession.

[10] Another distinguishing element of our analysis to Hur (2012) and Guerrieri and Lorenzoni (2011), is that they consider the recession as an unanticipated event while, in our economy, agents take into account the probability of negative aggregate shocks when making decisions about the future.

2.2 Model

2.2.1 The physical economy

Uncertainty. Time is discrete and denoted by $t = 0, 1, \ldots$. In each period t, the world experiences one of Z possible exogenous events $z \in \mathcal{Z} = \{1, \ldots, Z\}$. The resolution of uncertainty is represented by an event tree Σ with root σ_0, which is given by a fixed event z_0 in which the economy starts at time 0. Each node is characterized by a history of events, denoted by $\sigma^t = (\sigma_0, \ldots, \sigma_t) \in \Sigma^t = \times_{k=0}^{t} \Sigma_k$. Each node has Z immediate successors ($\sigma_t z^+$) and a unique predecessor (σ_t^-). The exogenous events follow a Markov process with transition matrix Π.

Agents and Endowments At each node σ_t there are two types of agents, borrowers (denoted by a subscript b) and savers (denoted by a subscript s). Borrowers and savers differ in their rates of time preference, in the sense that borrowers discount the future more than savers. Formally, we have $\beta_s > \beta_b$, where $\beta_i \in (0, 1)$ for $i = s, b$. Each group consists of infinitely many agents but the group size differs: denote by n_b and n_s the relative size of the borrower and saver groups. Note that we choose the normalization $n_b + n_s = 1$.

At each node σ_t, there is a perishable consumption good (non-durable consumption good). The total endowment of the perishable good is stochastic and depends on the realization of the shock alone, that is, $y(\sigma_t^-) = y(z)$, where $y : \mathcal{Z} \to R_{++}$ is a time-invariant function. Note that there is no idiosyncratic uncertainty, the endowment of the perishable good is the same for both types of households. In addition to the non-durable consumption good, agents trade houses. Houses are the only physical asset in the economy and are in fixed net supply. This is motivated by the fact that house prices were most volatile in counties where the supply of houses remained relatively fixed as shown by Mian (2010). At period 0, agent $i = b, s$ owns a stock $h_i(\sigma_0^-) \geq 0$ of houses. We normalize $\sum_{i=b,s} h_i(\sigma_0^-) = 1$.

At node σ_t let $h_i(\sigma_t)$ denote agent $i's$ end-of-period stock of houses. We assume that houses are traded cum services. That is, buying a house allows the agent to enjoy the housing services in the same period: if agent i owns $h_i(\sigma_t)$ houses then he receives a service stream of $1 \cdot h_i(\sigma_t)$. Other than the service stream, houses do not yield any dividend payments.[11]

Markets. At each node, spot markets open and agents trade the perishable consumption good. We choose the perishable good as the numeraire and - without loss of generality - normalize its price to be equal to 1. Agents can trade housing in every period; that is, agents $i = s, b$ can buy a unit of housing at node σ_t at price $q(\sigma_t)$. As long as $h_i \geq 0$, there is no possibility of default since no promises are made when agents hold a positive amount of the physical asset. In addition to houses, there are two financial assets, debt and savings, both one-period securities. We denote agent i's end-of-period debt holdings by $d_i(\sigma_t)$ and end-of-period savings by $s_i(\sigma_t)$, respectively. Denote the prices of the respective securities by $p_j(\sigma_t)$ for $j = d, s$. We distinguish these two assets because their effective returns differ. Debt is assumed to be a security for which only negative (short) positions are allowed, that is, $d_i(\sigma_t) \leq 0$. For savings, agents can only take positive (long) positions, such that $s_i(\sigma_t) \geq 0$, for $i = b, s$ and all σ_t. Asset $j = d, s$ traded at σ_t promises a nominal pay-off $b_j(\sigma_t z)$ at any successor node $\sigma_t z$. We normalize $b_j(\sigma_t z) = 1$ for all $\sigma_t, \sigma_t z$. For the remainder of the paper, we will discuss pay offs in in terms of real interest rates: denote by $R_D(\sigma_t) = \frac{1}{p_d(\sigma_t)}$ the real interest rate on debt and $R(\sigma_t) = \frac{1}{p_s(\sigma_t)}$ the real interest rate on savings. We also restrict borrowers to hold zero savings and savers to hold zero debt. Formally, for all nodes σ_t, we have $d_b(\sigma_t) \leq 0$, $s_b(\sigma_t) = 0$, $d_s(\sigma_t) = 0$, and $s_s(\sigma_t) \geq 0$.[12]

[11]These assumptions are for simplicity. We could allow the service stream of houses to depend on the realization of the shock z or on the identity of the agent.

[12]This is only for the ease of exposition. When computing the equilibrium policy functions, we allow borrowers and savers to trade both assets, debt and savings. Borrowers will only want to take long positions in savings for high relative wealth shares. In the

Collateral Requirements and Default. Similar to Kiyotaki and Moore (1997) we assume limits on debt obligations. Houses are distinguished from other assets by the fact that they are widely used as collateral for debt obligations (mortgages). As in Iacoviello and Neri (2010), the theoretical justification for collateral constraints is the ability of borrowers to default on their debt promises. If the borrowers default in some successor node $\sigma_t z^+$, lenders can seize the borrowers' assets, $q(\sigma_t z^+)h_b(\sigma_t)$ by paying a proportional transaction cost of $(1-m)E[q(\sigma_t z^+)|\sigma_t]h_b(\sigma_t)$ that is not redistributed. This transaction cost can be thought of as a loss associated with bankruptcy. Lenders will therefore never accept a debt contract where the borrowers' promises exceed the expected collateral value of housing. Formally, in each node σ_t, promises made by the borrower have to satisfy

$$R_D(\sigma_t)d(\sigma_t) + mE[q(\sigma_t z^+)|\sigma_t]h_b(\sigma_t) \geq 0. \tag{2.1}$$

Note that in some successor node $\tilde{z} \in \sigma_t z^+$ it might still be optimal for the borrowers to default ex-post. We assume throughout the analysis, however, that m is small enough that borrowers will never default in equilibrium:

ASSUMPTION 1

$$m \leq \frac{\min\left(q(\sigma_t z^+)\right)}{E[q(\sigma_t z^+)|\sigma_t]} \qquad \textit{for all } \sigma_t.$$

There is no default in equilibrium if and only if this condition is satisfied.[13] When solving the model equilibrium numerically, we assume that

calibrated economy, this never occurs along the equilibrium path unless the initial wealth share of the borrowers is very high.

[13]Assuming default costs equal to zero, borrowers default in some successor node $\tilde{z} \in \sigma_t z^+$ iff

$$-mE[q(\sigma_t z^+)|\sigma_t]h_b(\sigma_t) + q(\tilde{z})h_b(\sigma_t) < 0,$$

That is, whenever the realized value of housing is smaller than the maximum amount promised. Since in any financial market equilibrium, house prices and - by the Inada this condition holds and verify ex post that it is indeed satisfied for all prices along the equilibrium path. This allows us to treat debt as risk free.[14]

Utilities and budget constraints Agents $i = s, b$ maximize a time-separable utility function

$$U_i(c_i, h_i) = E_0 \sum_{t=0}^{\infty} \beta_i^t \, u(c_{s,t}, h_{s,t}) \tag{2.2}$$

where E_0 is the expectation operator at the the starting date $t = 0$. We consider period-by-period utility functions $u(c,h) : \mathbb{R}_{++} \times [0,1] \to \mathbb{R}$ characterized by constant elasticity of substitution.

$$u(c,h) = \frac{\Psi(c,h)^{(1-\gamma)}}{1-\gamma}, \qquad \text{and} \qquad \Psi(c,h) = [\phi c^\rho + (1-\phi)h^\rho]^{\frac{1}{\rho}}$$

Note that this class of preferences is strictly monotone, continuously differentiable, strictly concave, and satisfies the Inada conditions for both c_i and h_i.

At each node, the savers' budget constraint is given by

$$c_s(\sigma_t) + q(\sigma_t)h_s(\sigma_t) + s_s(\sigma_t) \leq y(\sigma_t) + s_s(\sigma_t^-)R(\sigma_t^-) + q(\sigma_t)h_s(\sigma_t^-) + \Upsilon(s^t). \tag{2.3}$$

conditions - h_b are strictly positive for a small enough m, this condition does not hold. As an alternative to a condition on m, we could just assume default costs are sufficiently high that it is never optimal for the borrowers to default.

[14]We evaluated the robustness of our results by replacing equation (2.1) by the following collateral requirement:

$$R_D(\sigma_t)d(\sigma_t) + m \cdot \min\left(q(\sigma_t z^+)\right) h_b(\sigma_t) \geq 0.$$

This is a tighter constraint and ensures that there is no default in equilibrium, independent of the value of m. While the qualitative implications remain unaffected, this specification implied slightly smaller quantitative effects on house prices and welfare. The intuition for the smaller quantitative effects is that leverage in states of high intermediation is lower compared to the benchmark model and the wealth distribution is therefore less sensitive to price changes. We stick to the collateral constraint as outlined in the main text because it has became standard in macroeconomic models with mortgage debt and thus increases the comparability of our results.

The right hand-side is the savers' available income. It consists of the endowment of the perishable good $y(\sigma_t)$, the gross return on savings, and the housing stock carried over from the previous period. Finally, $\Upsilon(s^t)$ are resources that are redistributed in a lump-sum fashion from the financial sector to the households, of which savers receive a share n_s, representing their share in the population. The reason why we need this re-distribution will be explained in detail below.
Analogously, the borrowers' budget constraint reads as

$$c_b(\sigma_t) + q(\sigma_t)h_b(\sigma_t) + d_b(\sigma_t) \leq y(\sigma_t) + d(\sigma_t^-)R_D(\sigma_t^-) + q(\sigma_t)h_b(\sigma_t^-) + \Upsilon(s^t). \tag{2.4}$$

The right hand-side is the borrowers' available income. It consists of the endowment of the perishable good $y(\sigma_t)$, the value of housing stock net of the debt burden from the previous period plus resources being redistributed from the financial sector to the households, of which borrowers receive the amount $\Upsilon(s^t)$.

Financial Intermediaries. Intermediaries demand aggregate deposits $S(\sigma_t)$ and supply aggregate debt $D(\sigma_t)$. The real pay-offs for each unit lent are given by the real interest rates, $R_D(\sigma_t)$ and $R(\sigma_t)$, respectively. The collateral constraints and assumption 1 make sure that debt is risk free. The key distortion in the intermediation sector is similar to that in Cooper and Ejarque (2000).[15] We assume that in each node σ_t only a fraction of savings can be transformed into debt. This fraction is stochastic and depends on the realization of the current shock only. That is, $\theta(\sigma_t^- z) = \theta(z)$ and $\theta(z) : \mathcal{Z} \to (0, 1]$ is a time-invariant function.
This exogenous financial shock represents a reduced form way to model the risk-bearing capacity of the financial sector. In particular, changes in the intermediation technology θ potentially reflect changes in the value of equity associated with a risky asset portfolio or changes in monitoring by

[15]Another example for the inclusion of a supply-sided friction in the banking sector into an international macro model is Kalemli-Ozcan *et al.* (2012).

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the bank managers as a consequence of changes in risk aversion. Consequently, while we remain agnostic about the exact foundation of the θ, we point out that the observed variations in the spread series in the period 2005-2009 mainly reflect changes in the households' price for risk rather than changes in the default risk.[16]

Financial intermediaries are otherwise risk neutral and maximize expected profits on their portfolio, that is,

$$\max_{D(\sigma_t),S(\sigma_t)\geq 0} R_D(\sigma_t)D(\sigma_t) - R(\sigma_t)S_i(\sigma_t) \tag{2.5}$$

subject to the constraint

$$D(\sigma_t) \leq \theta(\sigma_t)S(\sigma_t). \tag{2.6}$$

Because intermediaries operate in competitive markets with free entry, equilibrium interest rates are such that intermediaries make zero profits:

$$R_D(\sigma_t)\theta(\sigma_t) - R(\sigma_t) = 0. \tag{2.7}$$

This last relation implies that there is a spread between loan and deposit rates in this economy . In particular, the interest rate on debt is always at least as big as the interest rate on savings, or $R_D(\sigma_t) \geq R(\sigma_t)$.

Transfers from the Banking sector to the Household sector. Completing the description model, we specify the re-distribution function $\Upsilon(s^t)$. The intermediation process as outlined above implies an aggregate intermediation loss in terms of real resources that, in equilibrium, is given by $(1-\theta(\sigma_t))S(\sigma_t)$. This can be easily verified by combining the households budget constraints, using market clearing conditions in the debt and savings markets, and the zero profit condition of financial intermediaries. The aggregate resource constraint, then, reads as:

$$n_b c_b(\sigma_t) + n_s c_s(\sigma_t) + (1-\theta(\sigma_t))S(\sigma_t) = y(\sigma_t) + \Upsilon(s^t)$$

[16] The inclusion of a more detailed micro-founded banking sector is an interesting avenue that we leave for future research.

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On the left hand side, we have the borrowers' and savers' consumption plus the resources 'eaten up' by the financial sector. On the right hand side we have aggregate income plus total transfers. In order to keep the intermediation process as a purely redistributive distortion, we choose $\Upsilon(s^t)$ such that all resources 'lost' in the intermediation sector are redistributed back to the agents, so that aggregate consumption is a function of aggregate income only. Therefore, aggregate transfers are defined as follows:

$$\Upsilon(s^t) \equiv (1 - \theta(\sigma_t))S(\sigma_t) \tag{2.8}$$

We interpret this transfer as income generated by the intermediation sector that is redistributed back to the households because they are either the managers of the bank or the residual claimants on the portfolio revenues of the bank. The inclusion of the transfer function has two advantages. The first is that any effect of a θ shock on house prices and welfare comes through the effect on interest rates, and is not generated by an aggregate loss of resources. The second advantage is computational, as the re-distribution of resources makes sure that aggregate consumption is a function of aggregate endowment only, an essential requirement for the application of the concept of wealth recursive equilibria proposed by Kubler and Schmedders (2003) to our framework.

2.2.2 Financial Market Equilibrium with Intermediation and Houses as Collateral

The economy is a collection of period-by-period utility functions, impatience parameters, state-dependent endowments and state-dependent financial intermediation efficiency, aggregate transfers, transition probabilities, and the bankruptcy cost in case of default,

$$\mathcal{E} = \Big(u, \left(\beta_i, y_i, h_i(\sigma_0^-)\right)_{i=b,s}, \theta, \Upsilon, \Pi, m\Big).$$

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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DEFINITION 1 *A financial markets equilibrium for an economy $\mathcal{E}$, initial housing stocks $(h_i(\sigma_0^-))_{i=b,s}$ and initial shock z_0 is a collection*

$$\Big((\bar{h}_b(\sigma_t), \bar{d}_b(\sigma_t), \bar{c}_b(\sigma_t)), (\bar{h}_s(\sigma_t), \bar{d}_s(\sigma_t), \bar{c}_s(\sigma_t)), (\bar{D}(\sigma_t), \bar{S}(\sigma_t)),$$

$$\bar{q}(\sigma_t), \bar{R}_D(\sigma_t), \bar{R}(\sigma_t), \bar{\Upsilon}(\sigma_t) \Big)_{\sigma_t \in \Sigma}$$

satisfying the following conditions:

(1) Markets clear for all $\sigma_t \in \Sigma$:

$$\begin{aligned} n_b \bar{h}_b(\sigma_t) + n_s \bar{h}_s(\sigma_t) &= 1 \\ \bar{D}(\sigma_t) + n_b \bar{d}_b(\sigma_t) &= 0 \\ \bar{S}(\sigma_t) - n_s \bar{s}_s(\sigma_t) &= 0 \end{aligned}$$

(2) For borrowers,

$$(\bar{h}_b(\sigma_t), \bar{d}_b(\sigma_i), \bar{c}_b(\sigma_t)) \in \arg \max_{c_b \geq 0, h_b \geq 0, d_b \leq 0} U_b(c_b, h_b)$$

such that for all $\sigma_t \in \Sigma$

$$c_b(\sigma_t) + \bar{q}(\sigma_t) h_b(\sigma_t) + d_b(\sigma_t) \leq y(\sigma_t) + d_b(\sigma_t^-) \bar{R}_D(\sigma_t^-) + \bar{q}(\sigma_t) h_b(\sigma_t^-) + \bar{\Upsilon}(\sigma_t)$$
$$\bar{R}_D(\sigma_t) d_b(\sigma_t) + m \cdot E[\bar{q}(\sigma_t z) | \sigma_t] h_b(\sigma_t) \geq 0$$

(3) For savers,

$$(\bar{h}_s(\sigma_t), \bar{s}_s(\sigma_i), \bar{c}_s(\sigma_t)) \in \arg \max_{c_s \geq 0, h_s \geq 0, s_s \geq 0} U_s(c_s, h_s)$$

such that for all $\sigma_t \in \Sigma$

$$c_s(\sigma_t) + \bar{q}(\sigma_t) h_s(\sigma_t) + s_s(\sigma_t) \leq y(\sigma_t) + s_s(\sigma_t^-) \bar{R}(\sigma_t^-) + \bar{q}(\sigma_t) h_s(\sigma_t^-) + \bar{\Upsilon}(\sigma_t)$$

(4) For financial intermediaries

$$(\bar{D}(\sigma_t), \bar{S}(\sigma_i)) \in \arg \max_{D \geq 0, S \geq 0} \bar{R}_D(\sigma_t) D(\sigma_t) - \bar{R}(\sigma_t) S(\sigma_t)$$

such that for all $\sigma_t \in \Sigma$

$$D(\sigma_t) \leq \theta(\sigma_t) S(\sigma_t)$$

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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(5) Free entry for financial intermediaries

$$\bar{R}_D(\sigma_t)\bar{D}(\sigma_t) - \bar{R}(\sigma_t)\bar{S}(\sigma_t) = 0$$

(6) Per-capita transfers are given by

$$\bar{\Upsilon}(\sigma_t) = (1 - \theta(\sigma_t))\bar{S}(\sigma_t)$$

2.2.3 Wealth Recursive Equilibria

For the quantitative exercise, we define a wealth recursive formulation in the spirit of Kubler and Schmedders (2003). Since we have only two agents, the relative wealth of one agent, defined by a single value on the unit interval, uniquely define the complement of the other agent relative wealth; the borrowers' beginning-of-period wealth-share is :[17]

$$\omega_b(\sigma_t) = \frac{q(\sigma_t)h_b(\sigma_t^-) + R_D(\sigma_t^-)d(\sigma_t^-)}{q(\sigma_t)} \tag{2.9}$$

Note that the collateral constraints, the constraints on asset holdings, and the utility functions satisfying Inada-conditions, together with assumption 1, imply that the wealth share lies in the unit interval, $\omega_b \in [0, 1]$; by definition, $\omega_s = 1 - \omega_b$. The equilibrium policy function is then a function of the discrete exogenous state variable z and the financial wealth distribution is $\Omega = (\omega_b, 1 - \omega_b)$.

As we solve for an equilibrium numerically, we follow Kubler and Schmedders (2003) and compute ϵ-equilibria.[18] For the approximation of the equilibrium policy functions we adopt the time-iteration algorithm with linear interpolation proposed by Grill and Brumm (2010). That is, we approximate the equilibrium policy on a fine grid for the borrowers' wealth share. For points outside the grid we use linear piecewise interpolation. See appendix 2.6.2 for a detailed description of the algorithm.

[17]Here, we used the market clearing conditions for the housing, debt, and savings markets and the fact that financial intermediaries make zero-profits in equilibrium, so that $h_b(\sigma_t^-) + h_s(\sigma_t^-) = 1$ and $R_D(\sigma_t^-)d_b(\sigma_t^-) + R(\sigma_t^-)s_s(\sigma_t^-) = 0$.

[18]For a definition and interpretation of ϵ-equilibria, we refer to the original text.

2.3 Quantitative Analysis

This section studies the quantitative effects of the Great Recession on house prices and households' welfare. The Great Recession is modeled as contemporaneous negative shocks to both aggregate income and financial intermediation (mortgage rate spread). In this way, our simulation is driven by the empirical facts that motivated our research question. The next subsection outlines our calibration strategy. We then have a short section on the long-run stationary wealth distribution and we present our quantitative results on welfare effects.

2.3.1 Calibration

In the benchmark calibration, we assume an elasticity of substitution between houses and consumption equal to 1, so that $\rho = 0$. Risk aversion is set equal to $\gamma = 2$. These are standard values used in the literature. In general, it is not straightforward to calibrate these parameters as macro and micro evidence span a relatively large sets of parameter estimates. As in Glover *et al.* (2011), the risk aversion γ is the crucial parameter for the elasticity of house prices with respect to aggregate shocks. The elasticity of substitution between consumption and savings plays an important role for the elasticity of welfare gains/losses to changes in the wealth distribution. Therefore, in section 2.4, we provide a sensitivity analysis for different values of the risk aversion parameter and allow for some substitutability between housing and non-durable consumption as recently found by Bajari *et al.* (2010). Notice that one period in the model corresponds to one quarter in the data.

Insert Table 2.2 here

The parameter ϕ is the expenditure share of non-durable consumption. We pick the value to match the average housing wealth over GDP in the data during the period 1998-2007. For aggregate housing wealth, we used the sum of the value of owner occupied real estate of private households plus the residential housing wealth of non-financial non-corporate private business. The savers' discount factor β_s is set so that the average interest rate on savings in the model matches the average return on savings, equal to 1.5% during 1998 - 2007 (at annualized level). The borrowers' discount factor β_b and m are jointly calibrated to match the average wealth share of the borrowers and the leverage ratio of the borrowers. Since there is not necessarily a one-to-one mapping between the parameters and their targets, we follow an iterative procedure to find values for β_s, β_b, m and ϕ. That is, we first guess values for the parameters and then compare the computed moments to their counterparts in the data. If they do not match, we change the values and repeat until they do. The procedure leads to a quite satisfactorily match between model and data moments.[19]

The relative population size of borrowers is set to 42%, corresponding to the fraction of borrowers in the SCF when using the weighted average share of households with a negative net asset position as defined in appendix 2.6.1. This estimate is in line with the calibration in Iacoviello (2008).

The stochastic processes for the exogenous state variables y_t and θ_t are assumed to be independent. This is in line with the correlation in the data.[20] We assume that both aggregate income and the intermediation spread shock take two values each, that is $y_t = \{y_L, y_H\}$ and $\theta_t = \{\theta_L, \theta_H\}$. For the intermediation shock, we assume that the transition probabilities

[19]The variable definitions used to calculate the data moments are as close as possible to the definition of the model counterparts. For a detailed description of how we compute the relative wealth share and the leverage ratio in the data, see appendix 2.6.1.

[20]We also conducted a VAR analysis for GDP growth and spreads for different lag-lengths and orderings and found no evidence for significant spillover terms and no contemporaneous correlations between GDP and mortgage spreads. Only in one specification (VAR of order two), the null of a Granger-causality of output growth on spreads is rejected, though the coefficients for individual lags of output were not significantly different from zero.

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are given by:

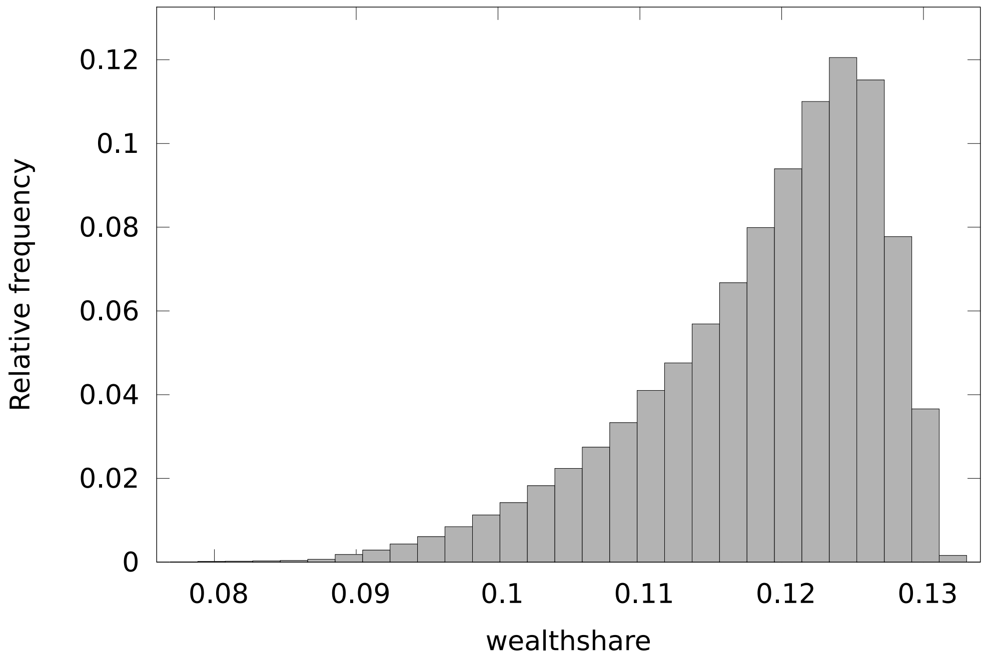
$$\pi_{ij} = (1-\rho)\pi_j + \delta_{ij}\rho \qquad for\ i,j = H,L$$

where $\delta_{ij} = 1$ if $i = j$ and 0 otherwise; $\pi_j > 0$ is the unconditional probability of being in state j, and by definition we have $\sum_j \pi_j = 1$. The parameter ρ governs the persistence of the shock.[21] The unconditional probability of a high intermediation efficiency, $P(\theta = \theta_H)$, is set to 0.565, the fraction of quarters in which the U.S. experienced low spreads between 1998:I and 2009:II. We set $\theta_L = 0.99207$, $\theta_H = 0.9985$, and $\rho_\theta = 0.868$ so that we match the mean, standard deviation and the autocorrelation of the spreads in the data (for the data counterparts see table; for a description of the data see appendix 2.6.1).

For the income shock, we choose y_H and y_L to match the mean, normalized to $E(y) = 1$, and an average peak-to-trough drop in GDP of 5% during a recession. The conditional probability of the low realization of y being in a recession today π^y_{LL} is chosen to match an average duration of a recession equal to five quarters. This is in line with the NBER recession dates between 1980:I and 2009:II. The transition probability of the high income realization conditional on high income today, $\pi^y_{HH} = 1 - (1 - \pi^y_{LL})\frac{1-\pi^y_H}{\pi^y_H}$, is obtained by setting the unconditional probability of a recession equal to 15% ($\pi_H = 0.85$). This is in line with NBER recession dates between 1980:I and 2009:II.

To summarize, the exogenous state space is then given by $\Sigma = \{(y_H, \theta_H)$, (y_L, θ_H), (y_H, θ_L), $(y_L, \theta_L)\}$ and - given the assumption that income and intermediation processes are uncorrelated - the transition matrix for the exogenous process is just the Kronecker product of the individual transition probability matrices for the income shock and the intermediation shock. Table 2.2 summarizes the calibrated parameter values and the targets.

Figure 2.3: Wealth distribution



2.3.2 Stationary wealth distribution

Figure 2.3 shows the long-run stationary wealth distribution simulated over one million time periods.[22] Recall that the wealth distribution across agents is entirely summarized by the borrowers' fraction of wealth ω_b. On average, the borrowers hold 11.7% of the total wealth of the economy (which is equal to the value of housing q). The distribution of the borrowers' wealth share is concentrated around the mean and has a spike to the right at around 12.6%, which correspond to states of the world when there is a long period of credit and income expansion. In these states, the borrowers' collateral constraint is binding and the interest rate on borrowing is relatively low; demand for housing is high and expected house prices

[21] See Backus *et al.* (1989) and Mendoza (1991)

[22] Because of the simple persistence rule used to discretize the exogenous processes, the high number of simulation periods makes sure that the exogenous processes have the same stochastic properties as their data counterparts.

are therefore high. This marginally relaxes the constraint, so that aggregate debt and savings are high. Because house prices are rising and borrowers are accumulating housing, their wealth share increases. Conversely, negative realizations of aggregate shocks make the borrowers' wealth share drop. We will explain these mechanisms in detail in the following section(s).

2.3.3 Welfare effects in the Great Recession

We now turn to our main quantitative exercise, the estimation of welfare effects of the Great Recession. For this purpose we construct an event window around the Great Recession. We define the Great Recession as a state of the world with low income and high spreads that is preceded by a state of the world where income is high and spreads are low (i.e. intermediation is high). We then go along the equilibrium path of the simulated economy and select all sequences that match these criteria. In figure 2.4, we plot the average of selected realizations over all sequences including ten quarters preceding the crisis and ten quarters after the crisis. We compare the Great Recession to two counter-factual scenarios. First, we ask what would happen if spreads were low before and stayed low *during* the recession (this corresponds to the long dashed line in 2.4 which we label as *low-spreads* series). This experiment helps us to compare the welfare effects of a negative income shock when leverage is high or low before the shock realizes. Second, we look at a recession that occurs when spreads where already high before and during the crisis (short dashed line in figure 2.4 which we label as *high-spreads*). By comparing this scenario, with the Great Recession, we calculate the welfare effects of de-leveraging in the crisis.

Panel (a) and (b) show the evolution of income and mortgage spreads. In all scenarios, income first increases previous to the recession and then drops by 5 percent in period 0 when the recession hits. In the Great Recession, mortgage spread first decreases towards its lowest value in period -1 and then jump to 3.5 percent in period 0. In the *low-spreads* counterfactual

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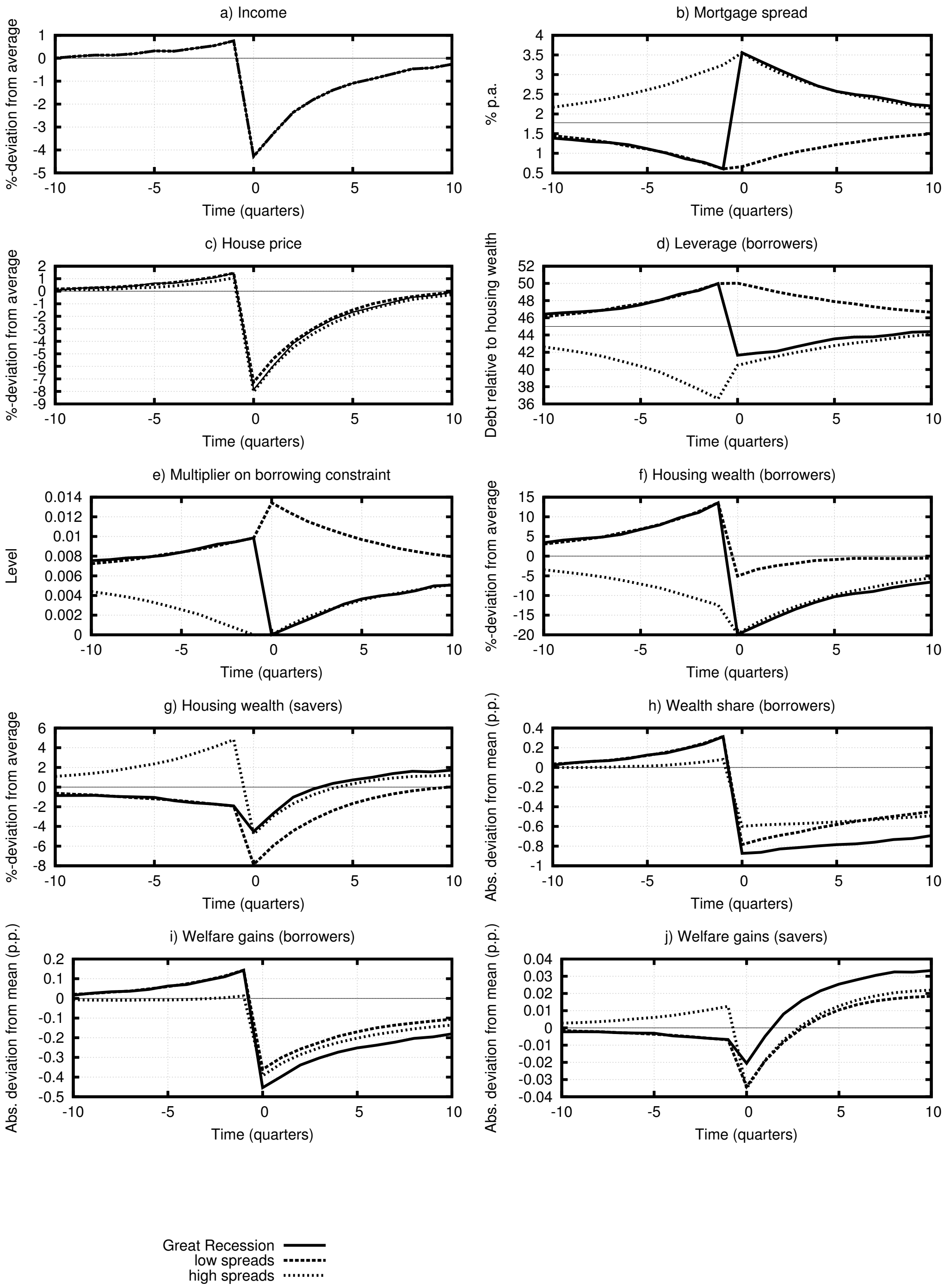
Figure 2.4: Great Recession (solid line) versus different intermediation regimes



Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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scenario spreads decline and stay in their lowest realization in periods -1 and 0 and then return towards their long-run mean, around 1.75 percent per annum. Similarly in the *high-spreads* counterfactual scenario, spreads increase slowly previous to the recession, peaking at 3.5 percent p.a. in period 0 and then return slowly towards their long-run mean. From panel (c) it is evident that house-prices are clearly driven by aggregate income and not by mortgage spreads. Mortgage spreads, however, have an important impact on the borrowers' leverage ratio, defined as end-of-period leverage or $L_t^{EoP} = -\frac{d_t}{q_t h_{bt}}$; when spreads are low, borrowers leverage up by increasing their debt holdings faster than their housing wealth. This means they move towards the constraint. In our simulation, in the pre-crisis, leverage peaks at around 50 percent. When spreads increase in period 0, it becomes too costly for borrowers to roll-over their mortgages and deleverage sharply so that the constraint gets slack. This is reflected by the multiplier associated with the collateral constraint that drops to zero. The time-path of leverage looks quiet different under the other two counterfactual scenarios. In the *low-spreads* case, borrowers stay leveraged also in period 0 and then de-leverage slowly following the path of spreads. In the *high-spreads* case, aggregate leverage is already low previous to the negative income shock and borrowers are pushed towards the collateral constraint in period 0 when house prices fall. This is because borrowers search to smooth the recession by borrowing up to the limit (which is tighter because the house price drops in the recession). This is also reflected by the increase in the multiplier on the collateral constraint shown in panel (e). Therefore, shocks to financial intermediation affects the borrowers' leverage ratio through the relative price of debt (the mortgage spread). Panels (f) and (g) show the paths for housing wealth for borrowers and savers, respectively. This figures illustrate the following. If mortgage spreads would have stayed low during the recession (*low-spreads* case), borrowers would have lost less in terms of housing wealth than in the benchmark scenario, whereas savers would have lost more housing wealth. The movements in leverage and housing wealth are reflected by the evolution of borrowers' wealth share, shown in panel (h). In this panel the solid line shows drop much more than the the long-dashed line. Importantly the wealth share recovers much slower after the Great Recession compared to the case when mortgage spreads would have stayed low during the crisis. This means that borrowers negative wealth shock is quite persistent in the Great Recession. Finally, panels (i) and (j) show the corresponding welfare gains for the two type of households (in consumption equivalents relative to long-run expected utility, for a formal definition see next paragraph). Borrowers lose the most in the Great Recession while savers lose the least when compared to the other counterfactual scenarios. Note that only after two or three quarters, savers' expected life-time utility becomes positive and stays persistently above zero. This indicates substantial redistributive forces that is connected to the discussion about the borrowers' relative wealth share.

These findings are quantitatively formalized in table 2.3. The table compares the model predictions with the data (we observe the on-impact change in house price, the change in housing wealth for borrowers and savers in the period 2007-2009) and - in addition - shows the average change in borrowers' wealth share and the welfare gains/losses in the recession for the two types of households, denoted by λ_b and λ_s, respectively. We define welfare gains in two ways. First, we define welfare gains of the recession as the compensation that is needed to make agents indifferent between the expected life-time utility in period -1 (i.e. the quarter that precedes the recession) and expected life-time utility in period 0 (i.e. the quarter when the recession hits). Negative numbers therefore reflect welfare losses of the recession. We refer to these numbers as '*on-impact welfare gains*'. Second, we report welfare gains of the expected life time-utility that agents have 7 periods[23] after the recession relative to the average expected life-time utility, that is $\sum_{\sigma=1}^{4} \pi_\sigma V_i(\omega(\sigma), \sigma)$ for $i = b, s$.[24] Also in this case we report the wel-

[23]The recent recession lastet 7 quarters according to NBER recession dates.

[24]The probability π_σ is the unconditional (or stationary) probability that state $\sigma \in \Sigma$

DOI: 10.2870/11929

fare gains in percent of total consumption compensation that is needed to make agents indifferent between the two alternatives. We refer to this second type as *'welfare gains after 7 periods'*.

Insert Table 2.3 here

Based on figure 2.4 and table 2.3 we can summarize the following two key findings:

1. High leverage makes the borrowers' wealth share more sensitive to house price changes.

2. A negative intermediation shock, when coupled with a negative income shock, results in higher (smaller) welfare losses for borrowers (savers).

Result 1 says that the higher the leverage ratio in the economy when entering a recession, the more the wealth gets distributed away from borrowers to savers. In other words, a given house price drop due to an aggregate income shock leads to more bigger wealth losses for borrowers to savers when there is more leverage prior to the shock. If the economy is experiencing high intermediation efficiency previous to a recession, the leverage ratio of borrowers will be high. The borrowers' wealth share will then be very sensitive to price changes.
Result 2 deals with the second question raised in the introduction: whether a larger redistribution of wealth translates into more inequality in terms of welfare. We find that this crucially depends on whether the collateral constraint binds. That is, whether borrowers wish to stay up against the constraint, or move away from it. This result implies that the wealth loss from a recession only translates into a larger (smaller) welfare loss for borrowers (savers) when there is a simultaneous deterioration in the efficiency of financial intermediation. In particular, when spreads would

occurs.

have stayed low during the recession, shown in row three, the borrowers' welfare gain would have been 17 percent higher compared to the Great Recession. Savers would have lost three times more compared to the Great Recession. The intuition for both results is summarized in the following two paragraphs.

Intuition for Key Result 1 Let us now show the intuition behind these results graphically. To see the effects on the wealth distribution, we can rewrite the borrowers' wealth share in terms of the leverage ratio:

$$w_{b,t} = h_{b,t-1}(1 - L^{BoP}(q_t)) \tag{2.10}$$

where $L^{BoP}(q_t) = -\frac{R_{D,t-1}d_{b,t-1}}{q_t h_{b,t-1}}$ denotes the beginning of period leverage carried over from last period, evaluated at the house price of the current period.[25] Taking the total derivatives of the wealth share around $q_t = q_{t-1}$, one can see that the growth rate of the borrowers' wealth share is proportional to the growth rate of house prices and the proportionality factor is a function of leverage:

$$\frac{dw_{b,t}}{w_{b,t}} = \frac{L(q)}{1 - L(q)}\frac{dq}{q}.$$

If financial intermediation efficiency is low and spreads are high, leverage is likely to be small and a given drop in house prices translates into a smaller drop in wealth. In other words, when borrowers' leverage is high, any aggregate price drop makes borrowers - on impact - relatively poorer in terms of wealth.

Of course, the price today is an equilibrium outcome; that is, the pricing function depends on the state of the economy. We have no closed form

[25]Note that by assumption 1, $L^{BoP}(q_t)$ is strictly smaller than one. This can be seen by the following. When leverage is high, most likely the collateral constraint is binding. Using the collateral constraint from last period and substituting it into the definition of beginning-of-period leverage, one obtains $m\frac{E_{t-1}(q_t)}{q_t}$. By assumption 1 and verified ex-post along the equilibrium path, this object is smaller than one.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

solution for this pricing function but we can plot the equilibrium house prices as a function of the wealth share using the simulated economy. This function is - for any realization of the exogenous shock $z \in \mathcal{Z}$ - decreasing in w_b, or

$$q = Q(w_b, z) \qquad \frac{\partial Q}{\partial w_b} < 0. \tag{2.11}$$

Given the promised value of previous-period debt, $R_{D,t-1}d_{b,t-1}$, and given the housing stock carried over from last period, $h_{b,t-1}$, the equilibrium wealth share in period t is implicitly defined by the solution to (2.10) and (2.11), or

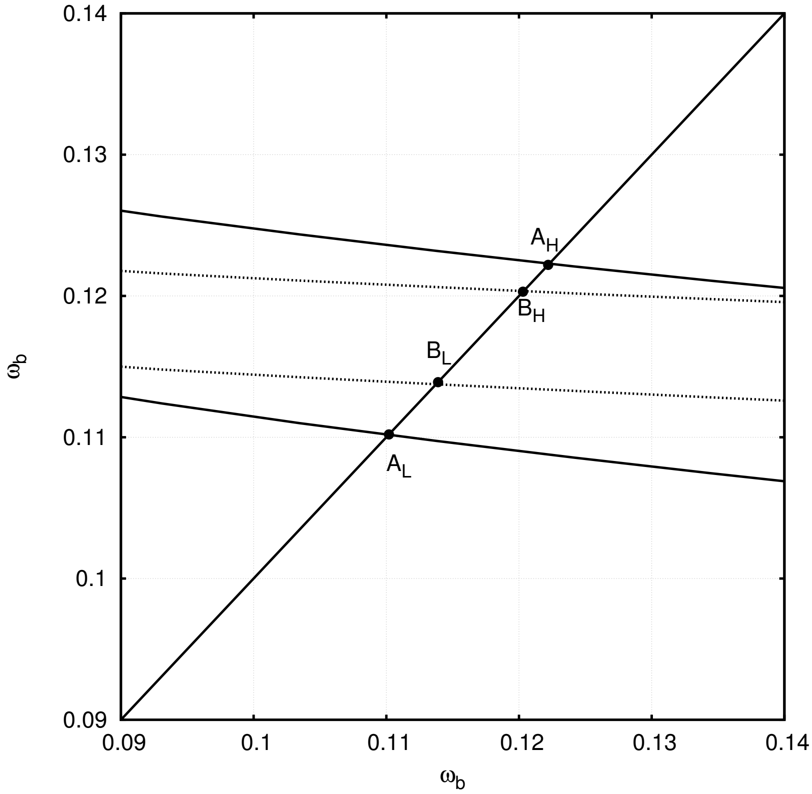
$$w_{b,t} = h_{b,t-1}\left(1 + \frac{R_{D,t-1}d_{b,t-1}}{Q(w_{b,t}, z_t)h_{b,t-1}}\right) \tag{2.12}$$

Figure 2.5 plots the left-hand side and right hand side of equation (2.12) as a function of the borrowers' wealth share w_b for different income realizations and for given assumptions on the level of debt and housing level. The solid line plots the right-hand side of equation 2.5 under the assumption that value of debt and housing stock in $t-1$ are relatively high (i.e. intermediation efficiency was high), while the dashed line assumes that debt and housing stock carried over from the previous period are low (i.e. financial efficiency was low).[26] When the previous period debt is high (solid line), the wealth share is more sensitive to exogenous shocks to income (drop from point A_H to A_L) compared to the case when debt carried over from last period is relatively low (drop from B_H to B_L). This illustrates the relationship between leverage and wealth dynamics during a recession: the effect comes from a different elasticity of wealth with respect to changes in prices which, in turn, depend on the aggregate state of financial intermediation.

Intuition for Key Result 2. Result (2) relates to combined income and negative intermediation shock. When house prices fall and there is a con-

[26]We set the respective values for housing stock and debt equal to the average value in period -1 of the event window above for the respective intermediation regime.

Figure 2.5: Response of equilibrium wealth share to a negative income shock, for previously high (solid lines) versus low intermediation (dashed lines)



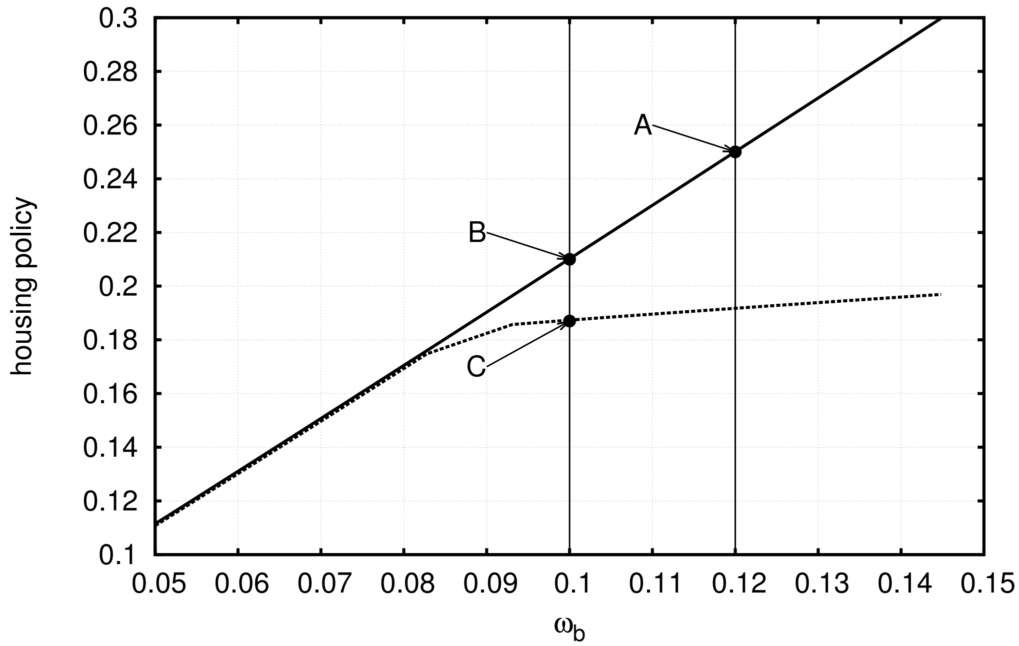
Notes: The figure plots the left-hand side (45 degree line) and the right hand side of equation (2.12) as a function of the borrowers' wealth share w_b and for different intermediation regimes. The solid lines show the right-hand side under the assumption that $h_{b,t-1}$ and $R_{D,t-1}d_{b,t-1}$ are relatively high (in absolute value) because of high financial intermediation. Given the assumption on debt and housing, point A_H materializes if income stays high whereas A_L is the wealth share when income drops to y_L. The dashed line shows the right-hand side under the assumption that $h_{b,t-1}$ and $R_{D,t-1}d_{b,t-1}$ are relatively low, that is for low intermediation. In this scenario, B_H is the wealth share that materializes when income stays high, whereas the wealth share drops to B_L when income falls to y_L

temporaneous negative intermediation shock, borrowers face a higher interest rate on debt, which prevents them from rolling over the debt and

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

moving away from the collateral constraint. This forces the borrowers to substantially decrease their stock of housing.

Figure 2.6: Equilibrium housing policy depends non-linear on wealth when financial intermediation efficiency changes from high to low



Notes: Solid line: housing policy as a function of the borrowers' wealth share, conditional on high financial intermediation efficiency. Dashed line: housing policy as a function of wealth, conditional on low financial efficiency. The vertical line intersecting at A is the borrowers' wealth share in a state with high income and high financial intermediation and the vertical line intersecting at B is borrowers' wealth share in the period when the Great Recession hits the economy.

Figure 2.6 plots the borrowers' housing stock policy function for high and low intermediation efficiency (respectively solid and dashed line). Following the Great Recession, the relative wealth of the borrower drops. As financial intermediation also drops during the recession from high to low efficiency, the housing stock drops from A to C. This is a substantially larger drop than would have occurred had the efficiency of intermediation stayed high. In this case, for the same drop in wealth, the decrease of the housing stock would have been less sharp (from A to B). In other words, the elasticity of demand for housing with respect to income shocks depends on the efficiency of the financial intermediation sector.

Summary of the welfare effects. First, both agents lose in response to an aggregate negative income shock, and borrowers always lose more than savers because they are financially constrained and unable to cushion themselves from negative shocks. Second, while borrowers experience a welfare loss in the case of a negative financial intermediation shock, savers are virtually unaffected. Third, in the simulated recession, we observe that the borrowers' welfare loss is larger than the algebraic sum of the welfare losses in response to negative income and intermediation shocks in isolation. The opposite is true for the savers. This comes from a non-linearity in the reaction of consumption that comes when borrowers are forced to deleverage and move away from the collateral constraint. In such a scenario savers can even gain from the joint income and intermediation shock (relative to an income shock alone) because they become relatively wealthier.

This set of results leads to the conclusion that, following the Great Recession, while both types of agents experienced a welfare loss, savers could cushion themselves from the negative impact of the negative aggregate shocks by substituting their savings for depreciated houses. This conclusion, while qualitatively comparable with the recent findings of Hur (2012), highlights a different mechanism. In this model, savers are able to cushion themselves from the negative effects of the Great Recession because of the asymmetric effects of financial intermediation shocks and the high level of leverage prior to the shock.

An important remark relating to the magnitudes of the obtained welfare estimates concerns the error analysis of our numerical algorithm. That is, if the mistakes agents make using our algorithm are larger (in consumption equivalents) than the calculated welfare gains/losses, these numbers would have no quantitative validity. We find that the maximum relative

Euler Error of our approximation is 3e-5 (or -4.5 in log(10)-scale). This implies that an agent, using our approximation of the equilibrium policy functions, would lose 30 Dollars for each million spent. For details see appendix 2.6.6. We therefore conclude that our quantitative findings are valid and quantitatively meaningful.

2.3.4 Always binding collateral constraint

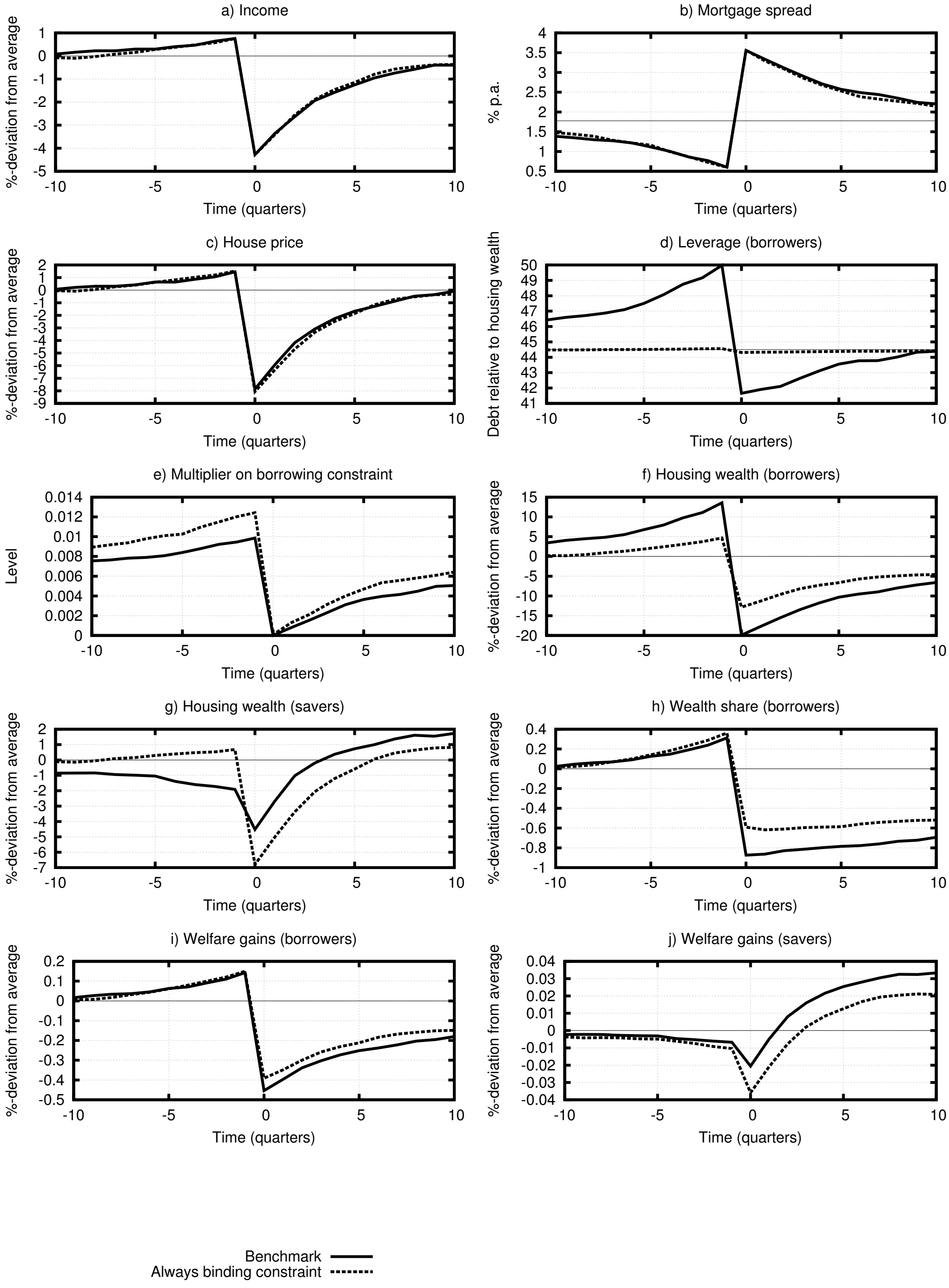
We solve the model employing a global solution method rather than the more widely used log-linearization method. This is necessary in order to take into account the fact that the collateral constraint is not always binding, but comes at the cost of a more complex numerical implementation. In this section we show how large is the cost of assuming always binding constraints in this framework.

To this end, we solve an alternative specification of the model by forcing the borrowers to have an always-binding constraint. In this case, the leverage ratio of the economy is always equal to $m\frac{E_{t-1}q_t}{q_t}$, which therefore needs to be re-calibrated for this specification in order to match the leverage ratio we find in data. The results are summarized in table 2.4. Compared to the benchmark model, we find that in a version of the model with always-binding collateral constraints: (i) the quantitative effects on house prices are larger relative to the benchmark model for a negative financial intermediation shock; ii) in the Great Recession, the welfare losses for borrowers (savers) are smaller (higher) in absolute terms. To summarize, the borrowers' welfare loss is lower by 0.07 percentage points (in absolute terms), while the savers' lose 0.04 percentage points more when compared to the benchmark model. Most importantly, the non-linearity of previous-period leverage completely vanishes, as the borrowers' wealth losses and the agents' welfare gains are just the algebraic sum of the effects when the economy is hit with each shock separately.

Insert Table 2.4 here

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Figure 2.7: Great Recession in benchmark model (solid line) versus always binding constraint (dashed line)



Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

The reason for these differences is that models with always binding constraint have the peculiarity of a constant elasticity of demand for debt with respect to changes in interest rate. In other words, following a spread shock, the borrowers' change in next period's debt has to be strictly proportional to the present discounted value of the drop in next period's housing wealth. When debt is costly, borrowers are prevented from moving away from the constraint. Aggregate debt moves less with respect to the benchmark case and this, in equilibrium, reduces the savers' ability to switch from savings to housing. This is the reason why house prices drop more in response to a negative intermediation shock. The elasticity of borrowers' wealth share to any given drop in house prices is always constant and given by $\frac{m^{AB}}{1-m^{AB}}$, where the superscript stands for 'always binding'. Note that, in order to match the average leverage ratio in the data, $m^{AB} = 0.45$, which is lower than $m = 0.5$ in the benchmark calibration. The elasticity of the borrowers' wealth share is therefore constant, and is strictly less than one. This result suggests that the assumption of always-binding collateral constraints is not innocuous when making a welfare analysis.

2.4 Sensitivity Analysis

In this section we compare the quantitative implications of changing the elasticity of substitution between housing and non-durable consumption, and the coefficient of risk aversion. Note that, for all changes in these parameters, we re-calibrate the rest of the parameters that in order to match the targeted data moments. This allows us to compare the relative performance of each parameterization with the benchmark case.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

2.4.1 Elasticity of substitution between housing and non-durable consumption

Here we conduct a sensitivity analysis for one of the two parameters that we fixed in the benchmark calibration to unity: the elasticity of substitution between housing and non-durable consumption. Table 2.5 summarizes the quantitative findings for a higher level of substitutability between housing and non-durable consumption, setting $\rho = 1.25$.[27]

Insert Table 2.5 here

Table 2.5 shows that, with increasing substitutability between housing and non-durable consumption, house prices (and therefore wealth) react more strongly to an intermediation shock when compared to the benchmark case. This, like in the case with the always-binding constraint, results in a decreased elasticity of demand for debt with respect to changes in the interest rate for borrowing. In addition, the Great Recession leads to smaller (bigger) welfare losses for borrowers' (savers') in this calibration. Borrowers are hurt less because they substitute housing for non-durable consumption, which is less painful when these goods are substitutes. This is also the reason why there is less redistribution in terms of welfare from borrowers to savers. Though, in absolute terms, savers lose more. Nevertheless, the key findings relating to the role of leverage in wealth dynamics and the role of the intermediation shock in a recession are unchanged.

2.4.2 Risk aversion

In this section we show quantitative analyses of Great Recession episodes for different values of the risk aversion parameter taken from the related

[27]This parameter value is taken from Piazzesi *et al.* (2007), who consider a representative agent framework with housing; As mentioned earlier in the paper, an elasticity of substitution larger than one between housing and non-durable consumption has also recently been found by Bajari *et al.* (2010).

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

literature. In particular, while the business cycle literature usually features a log-separable utility function with elasticity of substitution and risk aversion equal to unity, the macro-finance literature and recent contributions on the distributive effects of the Great Recession focus on a broader set of parameter values for risk aversion.[28] Table 2.6 summarizes the effects of the simulated Great Recession for the benchmark and other model specifications for different values of the risk aversion parameter.

Insert Table 2.6 here

As in Glover *et al.* (2011), the higher is the coefficient of risk aversion, the higher is the negative impact of a recession on equilibrium aggregate house prices. The the observed drop in the house price during the Great Recession is consistent for a risk aversion parameter between 2 and 3. The welfare analysis also confirms that bigger wealth shocks (due to the drop in house prices) translate into larger negative welfare effects for borrowers. This effect is again amplified by financial intermediation shocks, which make it more difficult to smooth negative income shocks. In contrast, savers are more able to cushion themselves from the negative effects of the Great Recession. The intuition is the same as in the benchmark model. Following the reduction in aggregate debt, savers are able to reallocate their portfolios from savings towards housing (when it is relatively cheap). Consequently, the higher is the coefficient of risk aversion, the smaller are the overall welfare losses for savers.

[28]Glover *et al.* (2011) set the risk aversion equal to 3 in the benchmark case, and then conduct a sensitivity analysis. They find that the magnitude of equilibrium price responses increase non-monotonically as risk aversion increases. Piazzesi *et al.* (2007), in a capital asset pricing model with housing, find that a model featuring a higher level of risk aversion better performs in matching the moments of housing returns.

2.5 Conclusions

Using a dynamic general equilibrium model calibrated to the US economy, we evaluate the quantitative effects of (i) aggregate income shocks and (ii) shocks to financial intermediation on house prices and on the welfare of two types of agents: leveraged agents (borrowers) and non-leveraged agents (savers).

The quantification of welfare costs associated with the US Great Recession along this cross-section complements recent contributions Glover *et al.* (2011) and Hur (2012) and adds a new mechanism stemming from shocks within the capital market. Our set-up is well suited for the evaluation of the welfare consequences of credit supply shocks in a recession, and complements other recent studies by exploring the effects of financial intermediation shocks in a model with endogenous collateral constraints.

We find that, following a shock modeled on the Great Recession, all the agents in the economy experience a welfare loss, and borrowers always lose more than savers. This finding comes from the fact that savers, being unconstrained, change their portfolio allocations and smooth the negative shock by buying the deflated asset (housing). We find that a financial intermediation shock that occurs in a recession forces borrowers to de-leverage, and amplifies the re-distribution from savers to borrowers, which translate in higher welfare losses for the latter.

Finally, we find that, in a model where borrowers are always borrowing constrained, the non-linearity in the amplification mechanism coming from the financial intermediation shock vanishes, and the effects on wealth and welfare are smaller.

We provide a number of sensitivity checks. While the redistributive effects (both in terms of wealth and welfare) between borrowers and savers are decreasing in the substitutability between housing and non-durable consumption, the drop in house prices is bigger when risk aversion is stronger, leading to a proportional increase in redistribution.

Although the paper focuses on the distributive effects of the Great Recession on borrowers and savers, we do not explicitly consider the possibility that borrowers can default on their debt obligations. While this could potentially benefit borrowers at the expense of their creditors, empirical evidence suggests that this feature of the U.S. Great Recession was restricted to a subset of borrowers, the sub-primers, who are not explicitly modeled here. Adding this third form of heterogeneity to the analysis is, in our opinion, an interesting avenue for future research.

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2.6 Appendix

2.6.1 Data

The following series used in Figure 1 and Figure 2 are from Federal Reserve Economic Data: the federal funds rate, the one year mortgage interest rate (released by the Primary Mortgage Market Survey by Freddie Mac), the mortgage (defined as home mortgages from the balance sheet of U.S. households and nonprofit organizations) and real estate (defined as the market value of real estate from the balance sheet of U.S. households and nonprofit organizations). All series are at quarterly frequency. The series for house prices is the National Composite Home Price Index for the United States (the release is by S&P/Case-Shiller Home Price Indices). The spread has been calculated as the difference between the one year mortgage interest rate and the federal funds rate each quarter.
In the calibration section, we calculate housing wealth as percentage of US nominal GDP (yearly) by using historical data of the flows of funds tables from the Board of Governors. US nominal GDP is from the Bureau of Economic Analysis. Our definition of housing wealth includes the market value of real estate belonging to households, non-profit and non-financial non-corporate business.
The micro-data used for the calibration of the relative wealth distribution of borrowers and the leverage ratio are provided by the 1998 to 2009 waves of Survey of Consumer Finances (SCF). Unfortunately, the SCF does not provide information on the precise date at which households were interviewed. Consequently, we assume that the observed portfolios in 2009 reflect the distribution of household net worth at the end of 2007. Averaging for all the waves between 1998 and 2009 helps in targeting data moments that are not strongly influenced by the years preceding the Great Recession. Surveyed households have been partitioned into *borrowers* and *savers* depending on their net asset position. The net asset position is defined as the sum of savings bonds, directly held bonds, the cash value

of life insurance, certificates of deposits, quasi-liquid retirement accounts and all other types of transaction accounts (we consider these aggregated values to be deposits in the model) minus the debt secured by primary residence (mortgages, home equity loans, etc.) and the debt secured by other residential property, credit card debt and other forms of debt (we refer to these aggregated values as debt in the model). If the net asset position is positive, we consider the household to be a saver in our model economy, otherwise we consider her to be a borrower. The reason to use a broad definition of aggregate deposits and debt in the data counterpart is that it is difficult to target borrowers and savers by strictly restricting attention to particular classes of debt. We moreover define net wealth per capita as the sum of the net asset position and the value of the primary residence and other residential properties, for both leveraged and net savers. Finally, we aggregate the net wealth of both groups (borrowers and savers) and we calculate the relative net wealth of borrowers as the ratio between their net wealth over the total net wealth in the economy. The leverage ratio of the borrowers is instead obtained as the weighted average mean (using SCF sample weights) of the net asset position over the value of primary and secondary residences. The reference values that are matched by the model are obtained by cutting the 5% tails of the distribution of net worth in each wave of the SCF This is done to cut the extreme observations that may bias the average values of net worth in the US economy. We want, in fact, to avoid the possibility of including in the range of borrower households that maintain large positions in the stock or housing markets and hold little savings.

2.6.2 Numerical Details

The algorithm employed is an adoption of the time-iteration procedure with linear interpolation used in Grill and Brumm (2010). As we have only two agents, a fine grid for wealth is enough to deliver satisfactorily small Euler errors. For this reason, we do not adapt the grid around the

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

points where the collateral constraint is binding, as proposed by Grill and Brumm (2010).

2.6.3 Equilibrium conditions

We want to describe the equilibrium in our economy in terms of policy functions that map the current state into current policies. Furthermore, we want to focus on recursive mappings - that is, time-invariant functions that satisfy the period-by-period first-order equilibrium conditions. In what follows, we characterize these equilibrium conditions in every detail. For each agent $i = b, s$, denote by $\nu_i(w, z)$ the Lagrange multiplier with respect to her budget constraint and by $\phi_i(w, z)$ the Kuhn- Tucker multiplier attached to her collateral constraint. In addition, we treat saving and debt as two separate assets: saving is an asset in which the agent can only take long positions, $s_i \geq 0$; debt is an asset with return R_D in which agents can only take short positions, $d_i \leq 0$. Denote the Kuhn-Tucker multipliers attached to these inequalities as χ_i and μ_i, respectively. Then, for each tuple consisting of wealth and exogenous state today $\sigma = (w, z)$, the (time-invariant) policy and pricing functions have to satisfy the following system of equations (we will show below how to solve for these time-invariant functions):

- Agent's first order conditions

$$
\begin{aligned}
u_1(c_i(\sigma), h_i(\sigma)) - \nu_i(\sigma) = 0 \\
u_2(c_i(\sigma), h_i(\sigma)) - q(\sigma)\nu_i(\sigma) = 0 \\
-\nu_i(\sigma) + \beta^i E[\nu_i(\sigma^+)|\sigma]R(\sigma) + \chi_i(\sigma) = 0, \qquad & i = s, b \\
-\nu_i(\sigma) + \beta^i E[\nu_i(\sigma^+)|\sigma]R_D + \phi_i(\sigma)R_D(w, z) - \mu_i(\sigma) = 0 \\
-\nu_i(\sigma)q(\sigma) + u_2(c_i(\sigma), h_i(\sigma)) + \\
+\beta^i E[\nu_i(\sigma^+)q(\sigma^+)]|\sigma] + \phi_i(\sigma)mE[q(\sigma^+)|\sigma] = 0
\end{aligned}
$$

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

- Agent's budget constraints

$$n_b y(s) + n_b \Upsilon(\sigma) + w \cdot q(\sigma) - d_b(\sigma) - s_b(\sigma) - q(\sigma)h_b(\sigma) - c_b(\sigma) = 0$$
$$n_s y(s) + n_s \Upsilon(\sigma) + (1-w) \cdot q(\sigma) - d_s(\sigma) - s_s(\sigma) - q(\sigma)h_s(\sigma) - c_s(\sigma) = 0$$

NB: Here we have already used the definition for the borrower's wealth share and rewritten the budget constraints in these terms (see the law of motion for wealth below as a reminder of how we defined the wealth share).

- Zero profits in the financial sector

$$\theta(s) \cdot R_D(\sigma) - R(\sigma) = 0$$

- Market clearing in housing and financial sector

$$h_s(\sigma) + h_b(\sigma) - 1 = 0$$
$$d_b(\sigma) + d_s(\sigma) + \theta(s) \cdot (s_b(\sigma) + s_s(\sigma)) = 0$$

- Transfers

$$\Upsilon(\sigma) - (1 - \theta(s))(s_b(\sigma) + s_s(\sigma)) = 0$$

- Complementary slackness conditions

$$\begin{aligned} \mu_i(\sigma) \geq 0, d_i(\sigma) \geq 0, &\quad \mu_i(\sigma) \perp d_i(\sigma) \\ \chi_i(\sigma) \geq 0, s_i(\sigma) \geq 0, &\quad \chi(\sigma) \perp s_i(\sigma), \qquad i = s, b \\ \phi_i(\sigma) \geq 0, CC_i(\sigma) \geq 0, &\quad \phi_i(\sigma) \perp CC_i(\sigma) \end{aligned}$$

where $CC_i(\cdot)$ is the collateral constraint of agent i, that is,

$$CC_i(\sigma) \equiv R_D(\sigma) d_i(\sigma) + mE[q(\sigma^+)|\sigma] h_i(\sigma) \geq 0$$

- Implicit "Law of motion" for borrower's wealth share

$$w^+(\sigma, z^+) \equiv \frac{R_D(\sigma)d_b(\sigma) + R(\sigma)s_b(\sigma) + q(w^+(\sigma, z^+), z^+)h_b(\sigma)}{q(w^+(\sigma, z^+), z^+)}.$$

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

2.6.4 Algorithm

The structure of the above period-by-period equilibrium conditions can be summarized as follows: Given a guess for the policy and pricing functions in the next period - denoted by f^{prime} - we can compute the expectations in the agents' first order conditions. The functions that map current states to current policies - denoted by f - are then obtained by solving the static system of non-linear given in the previous subsection. More formally, the structure of the problem can be summarized as follows. For all tuples $\sigma = (w, z)$, we have

$$\psi(f^{prime})(\sigma, f(\sigma), \mu(\sigma)) = 0, \qquad \zeta(\sigma, f(\sigma)) \geq 0 \perp \mu(\sigma) \geq 0.$$

The system of equations $\psi[f^{prime}](\cdot)$ contains first order conditions of agents and the financial sector and market clearing conditions. The function $\zeta(\cdot)$ contains the sign restrictions and collateral constraints. $\mu(\cdot)$ denotes the respective Kuhn-Tucker multipliers. A recursive policy function f then solves $\psi[f](\sigma, f(\sigma)\mu(\sigma)) = 0$ such that the complementary slackness conditions are satisfied. The time iteration algorithm defined below finds the approximate recursive policy function iteratively.

In each iteration, taking as given a guess for f^{prime}, we obtain f by solving the above system of equations and then updating our guess by interpolating the obtained policy function on the implicitly defined next period wealth. The following box summarizes our algorithm in a form of Pseudo-code:

1. Select a grid $\mathcal{W}$, an initial guess f^{init} and an error tolerance ϵ. Set $f^{prime} = f^{init}$.

2. Make one time-iteration step:

   (a) For all $\sigma = (w, z)$, where $w \in \mathcal{W}$, find the function $f(\sigma)$ that solves

   $$\psi(f^{prime})(\sigma, f(\sigma), \mu(\sigma)) = 0, \qquad \zeta(\sigma, f(\sigma)) \geq 0 \perp \mu(\sigma) \geq 0.$$

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

(b) Use the solution f and the guess f^{prime} to update wealth tomorrow and interpolate f on the obtained values for wealth tomorrow.

3. If $||f - f^{prime}|| < \epsilon$, go to step 4. Else set $f^{prime} = f$ and repeat step 2.

4. Set numerical solution $\tilde{f}$ equal to the solution of the infinite horizon problem, $\tilde{f} = f$.

2.6.5 Kuhn-Tucker equations (Garcia-Zangwill trick)

At each grid point - given the guesses of the policy functions for the next period - we have to solve a system of nonlinear equations, containing both inequalities and equalities. The period-by-period equilibrium conditions are basically standard Kuhn-Tucker (K-T) conditions. In order to employ standard non-linear equation solvers like fsolve in Matlab or Ziena's Knitro, it is computationally more stable to eliminate the inequalities and recast the problem as a system consisting of equations only. In this section we describe how to do this. In general, we can write the Kuhn-Tucker conditions of any convex NLP problem as:

$$\begin{gathered}\Delta f(x)' + \sum_{j=1}^{r} \lambda_j \Delta g_j(x)' + \sum_{j=1}^{s} \mu_j \Delta h_j(x)' = 0 \\ \lambda_j \geq 0, g_j(x) \geq 0, \qquad j = 1, \ldots, r \\ \lambda_j g_j(x) = 0, \qquad j = 1, \ldots, r \\ h_j(x) = 0, \qquad j = 1, \ldots, s\end{gathered} \tag{2.13}$$

plus a constraint qualification restriction (CQ). The system in (2.13) are mixtures of equalities and inequalities. Since inequalities tend to be cumbersome and can potentially prevent numerical software from solving the NLP via path-following, we will rewrite the K-T conditions so that they are a system consisting solely of equations Zangwill and Garcia (1981).

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

The reformulation is as follows. Let k be a positive integer, and given $\alpha \in \mathbb{R}^1$, define:

$$\alpha^+ = [\max\{0, \alpha\}]^k$$
$$\alpha^- = [\max\{0, -\alpha\}]^k.$$

Hence, we always have $\alpha^+ \geq 0$, $\alpha^- \geq 0$, and $\alpha^+\alpha^- = 0$. Note also that both variables, $\alpha^+$and α^-, are $(k-1)$-continuously differentiable. Using this transformation, we can recast the K-T conditions and create the Kuhn-Tucker *equations* Zangwill and Garcia (1981):

$$\Delta f(x)' + \sum_{j=1}^{r} \alpha_j^+ \Delta g_j(x)' + \sum_{j=1}^{s} \mu_j \Delta h_j(x)' = 0 \tag{2.14}$$
$$\alpha_j^- - g_j(x) = 0, \qquad j = 1, \ldots, r$$
$$h_j(x) = 0, \qquad j = 1, \ldots, s$$

where $\alpha = (\alpha_1, \ldots, \alpha_r) \in R^r$ and (α^+, α^-) are defined as above. Note that the (K-T) equations defined here are precisely equivalent to the K-T conditions in (2.13). In particular, if (x^*, α^*, μ^*) satisfies the K-T equations, then (x^*, λ^*, μ^*) satisfies the the K-T conditions with $\lambda_j^* \equiv (\alpha_j^*)^+$, $j = 1, \ldots, r$. Conversely, if (x^*, λ^*, μ^*) satisfies the K-T conditions in (2.13), then (x^*, α^*, μ^*) satisfies the K-T equations in (2.14) with

$$\alpha_j^* \equiv \begin{cases} (\lambda_j^*)^{1/k} & \text{if } g_j(x^*) = 0 \\ -(g(x^*)_j)^{1/k} & \text{if } g_j(x^*) > 0 \end{cases} \qquad j = 1, \ldots, r.$$

2.6.6 Numerical Accuracy

In order to measure the accuracy of our approximation procedure, we calculate two statistics: first, we compute the relative Euler errors along the equilibrium path for very long time series. Second, for each exogenous shock, we randomly draw 3000 points from the wealth grid and compute

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

the relative Euler Errors. To summarize the findings: for all simulated models, the maximum relative Euler Error is 3e-5 (or -4.5 in log(10)-scale). This implies that an agent, using our approximation of the equilibrium policy functions, would lose 30 Dollars for each million spent. It is important to compare this number to the welfare gains we obtain in the benchmark model. The borrowers' welfare loss on impact of an financial intermediation shock is 0.07 percentage points, that is, in log(10) scale, equal to -3.15. This number is one order of magnitude bigger, so even when netting these numbers by the mistakes that agents make, we conclude that our quantitative findings are still valid.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

2.7 Tables

Table 2.2: Calibration

Parameter	Value	Model	Data Target	Source
		Preferences		
γ	2			Benchmark value from literature
ρ	0			Benchmark value from literature
ϕ	0.97	196%	196%	Average housing value over GDP (annualized) 1998 - 2009
β_s	0.996	1.5%	1.5%	Average return on savings (annualized)
β_b	0.988	11.7%	11.3%	Borrowers' financial wealth share (SCFaverage 1998-2009)
m	0.5	45%	44.4%	Borrowers' leverage ratio (SCF average between 1998-2009)
		Relative population size		
n_b	0.42	42%	42%	Share of borrowers (SCF average 1998-2009)
		Intermediation shock		
π^{θ}_{H}	0.565		56.5%	Probability of low spreads during 1998-2009:II
ρ_{θ}	0.868	0.868	0.868	Autocorrelation of spreads during 1998-2009:II
θ_L	0.9985	1.8 %	1.75 %	Average spread during 1998-2009:II (annualized)
θ_H	0.99207	1.27 %	1.27 %	Standard deviation of spread during 1998-2009:II (annualized)
		Income shock		
π^{y}_{H}	0.85	15%	15%	Probability of recession 1980- 2009:II (NBER dates)
π^{y}_{LL}	0.8	5 quarters	5 quarters	Average duration of recession (NBER dates) 1980- 2009:II
y_L	0.9572	5%	5%	Average Peak to trough drop in GDP 1980- 2009:II
y_H	1.0076			Normalization $E(y) = 1$

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 2.3: Welfare effects of a recession (5 percent drop in income) for different spread regimes

	Δq	$\Delta(qh_b)$	$\Delta(qh_s)$	$\Delta\omega_b$	λ_b	λ_s
Data	-11	-16	-9	?	?	?
On impact, relative to pre-recession peak						
Great Recession	-9.18	-29.47	-2.65	-1.19	-0.60	-0.01
Low spreads	-8.59	-16.42	-6.07	-1.10	-0.50	-0.03
High spreads	-9.00	-8.34	-9.15	-0.68	-0.41	-0.05
After 7 periods, relative to long-run mean						
Great Recession	-1.29	-9.54	1.00	-0.78	-0.24	0.03
Low spreads	-1.01	-0.56	-1.13	-0.55	-0.15	0.01
High spreads	-1.37	-8.79	0.69	-0.54	-0.18	0.02

Notes: Column two shows the percentage change of the house price between date -1 and date 0, the period of the recession. Column three and four tabulate the percentage change in housing wealth between date -1 and 0 for borrowers and savers, respectively. Column four tabulates the absolute change of the borrowers' wealth share between date -1 and date 0 (in percentage points). Columns six and seven show the welfare gains of the recession in total consumption equivalents (relative to expected utility in period -1) for borrowers and savers, respectively. The Great recession is defined as a contemporaneous drop in income and financial intermediation (i.e. high spread) in period 0. The counterfactuals in row three (four) assume that financial intermediation is high (low) in both periods -1 and 0.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 2.4: Always binding collateral constraint

	Δq	$\Delta(qh_b)$	$\Delta(qh_s)$	$\Delta\omega_b$	λ_b	λ_s
Data	-11	-16	-9	?	?	?
On impact, relative to pre-recession peak						
Great Recession	-9.44	-16.72	-7.43	-0.95	-0.54	-0.03
Low spreads	-8.65	-14.83	-6.94	-0.86	-0.46	-0.04
High spreads	-8.58	-15.17	-6.86	-0.88	-0.47	-0.04
After 7 periods, relative to long-run mean						
Great Recession	-1.16	-5.73	0.06	-0.56	-0.18	0.02
Low spreads	-1.21	-2.91	-0.75	-0.23	-0.09	-0.00
High spreads	-1.05	-7.83	0.76	-0.83	-0.25	0.03

Notes: Column two is the change in house prices between period -1 (the period just before the shock occurs) and period 7 (following the start of the recession). Column three shows borrowers' start-of-period leverage ratio, defined as $L_{b,t}^{BoP}$ in the period of the shock $t = 0$; note that this leverage ratio is a function of the price today only (variables with subscript $t-1$ are given numbers). Column four shows the corresponding change in borrowers' financial wealth share between period -1 and period 7. Column five reports the borrowers' end-of-period leverage ratio, defined as L_t^{EoP} after the Great Recession - in period $t = 7$. Columns six and seven show the welfare gains/losses of borrowers and savers, respectively. All numbers are in percent.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 2.5: Welfare effects in model with higher elasticity of substitution between housing and non-durable consumption

	Δq	$\Delta(qh_b)$	$\Delta(qh_s)$	$\Delta\omega_b$	λ_b	λ_s
Data	-11	-16	-9	?	?	?
On impact, relative to pre-recession peak						
Great Recession	-9.10	-38.87	-0.34	-1.19	-0.57	-0.02
Low spreads	-8.54	-17.83	-5.78	-1.12	-0.49	-0.03
High spreads	-9.09	-6.71	-9.51	-0.47	-0.35	-0.06
After 7 periods, relative to long-run mean						
Great Recession	-0.96	-12.92	1.88	-0.82	-0.23	0.03
Low spreads	-1.05	0.92	-1.52	-0.64	-0.16	0.02
High spreads	-1.52	-11.74	0.90	-0.34	-0.13	0.00

Table 2.6: Welfare effects of the Great Recession, different risk aversion parameters

	Δq	$\Delta(qh_b)$	$\Delta(qh_s)$	$\Delta\omega_b$	λ_b	λ_s
Data	-11	-16	-9	?	?	?
On impact, relative to pre-recession peak						
$\gamma = 1$	-5.25	-22.52	-0.04	-0.60	-0.47	-0.04
$\gamma = 2$ (benchmark)	-9.18	-29.47	-2.65	-1.19	-0.60	-0.01
$\gamma = 3$	-12.80	-35.83	-4.84	-1.84	-0.73	0.02
$\gamma = 5$	-19.21	-37.31	-14.21	-2.33	-1.09	0.04
After 7 periods, relative to long-run mean						
$\gamma = 1$	-0.91	-6.95	0.72	-0.37	-0.15	0.01
$\gamma = 2$ (benchmark)	-1.29	-9.54	1.00	-0.78	-0.24	0.03
$\gamma = 3$	-1.38	-11.79	1.62	-1.21	-0.32	0.05
$\gamma = 5$	-1.40	-12.91	1.44	-1.52	-0.51	0.07

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Chapter 3

CEO compensation, credit crisis and financial regulation: a cross-country analysis

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

3.1 Introduction

The 2007-2009 Great Recession highlighted that capital market failures may represent an important driver of economic downturns. There seems to be a widespread agreement among researchers and practitioners that, at the onset of the crisis, financial institutions took too much risk as a result of the failure of risk management and financial regulation (see for instance Diamond and Rajan (2009)). In particular, executive managers monetary incentives have been identified as important examples of failures of governance in the banking industry. In the recent past, executive compensation tied to firm performance such as bonuses related to firm value, stock options, or equity-plans have become standard tools of managerial remuneration by shareholders in all sectors, and especially in banking (Giannetti and Metzger (2013)[1]).

The theoretical literature has highlighted different mechanisms that shed light on the relation between the pay-for-performance sensitivity of managerial compensation risk taking that goes beyond what shareholders' objectives. The model of Benmelech *et al.* (2010) builds on the assumption that managers are able to hide the true state of the profitability of the firm and maximize their own revenue from equity portfolio holdings; they show that while executives' stock-based compensation may increase the alignment of managers' and shareholders' objectives, it may also induce the managers to misreport the true state of the firm and concentrate on short run, rather than long run, objectives. They also show that a combination of stock and bonuses may be the optimal compensation mix.[2] Other theoretical contributions build on the effect of leverage on risk-shifting in the context of double agency conflict: first, between shareholders and

[1] They find that the increase in equity-based compensation and the consequent increase in the total compensation is related to greater competition for talents that creates retention motives and accentuates agency problems in the allocation of effort

[2] In light of these findings, in the empirical analysis we will consider separately the effects of cash bonuses and equity-based compensations.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

debt-holders and second, between managers and shareholders. Cerasi and Daltung (2007) show that the effect of bonuses tied to firm value may have an ambiguous effect on risk-taking incentives for managers: on one side, the higher the bonus, the higher the monitoring effort by managers and the lower the risk taking; on the other side, a higher bonus substitutes the direct monitoring of shareholders and therefore leads to greater risk taking. This last mechanism may be exacerbated in the case of highly leveraged firms such as banks.

Taken together, the predictions from the theoretical literature are far from leading to a unique prediction. This calls for an empirical investigation, especially in the banking sector following the financial crisis. On these grounds, Fahlenbrach and Stulz (2011) have empirically explored the relation between CEO incentives and bank performance in the 2007-2008 financial crisis using a cross-section of US banks. They find that banks where CEO incentives were better aligned with shareholders' interests did not perform better than other banks. They analyze the effects of different components of remuneration packages such as stock options or cash bonuses and conclude that none of them can explain the negative realizations of US bank returns during the downturn.

In the same spirit, in the first part of this paper, we empirically explore the relation between CEO incentives and bank performance in the 2007-08 financial crisis in a sample of banks that operate in different countries. To our knowledge this is the first paper that addresses this research question from a cross-country perspective. A lack of evidence is certainly due to the difficulties in the collection of data about CEO compensation schemes. To overcome this problem, we match three sources of data: Capital IQ - People Intelligence, Bankscope and Datastream[3].

In the empirical analysis we separately consider the incentive effects given by direct share ownership and stock options; the reason is that these two equity-based compensation schemes may give rise to different incentives

[3]See section 3.2 for a detailed description of the data collection process.

to take risk. On one side, stock options provide convex payoffs where managers are insured on the downside; this may lead to excessive risk-taking in leveraged firms (Jensen and Meckling (1976)). Despite a large number of studies, the sign of the relation between stock options and risk-taking is still debated in the empirical literature, (see Gormley *et al.* (2013)). On the other side, insider ownership should instead provide the most direct alignment between managers' and shareholders' objectives (Murphy (1990)).

We find that the sensitivity of CEO equity portfolios to share prices (option delta) in 2006 has strong predictive power over bank performance in the financial crisis; a higher delta is related to a lower stock return and a higher risk return. We use two measures of bank performance: 1) buy and hold returns over the period 2007:III-2008:IV (the stock return); 2) the standard deviation of the stock returns over the same time window (the risk return). The reason for using these two measures is that Guay (1999) finds that firms equity risk is positively related to the convexity of the monetary incentives provided to CEOs; in particular Coles *et al.* (2006) find that the stock return volatility of risky investments is positively affected by the deltas and vegas calculated on managers' options.[4]

In the second part of the paper, thanks to the cross-country dimension of our sample, we explore the interaction between CEO incentives and national bank regulations.[5] In particular, we concentrate our analysis on four indicators of national regulation that may directly affect the intensity of monitoring by bank stakeholders on managers: an index of the power of the national supervisor, an index of the intensity of monitoring by the private sector, the presence of explicit deposit insurance[6], and the presence

[4]See 3.7 for a definition of option delta and vega and how they have been calculated.

[5]The data source is the Survey III posted on the World Bank website in the summer of 2007,which provides information on banking policies in 2006 for 142 countries; see Barth *et al.* (2008) for a review.

[6]Following Demirguc-Kunt *et al.* (2005) we consider explicit deposit insurance differing from implicit deposit insurance by the reliance on a formal definition in national banking

of restrictions on bank activities.

The assumption is that, in different regulation systems: a) the risk shifting propensity of managers due to monetary incentives may be lower because a stricter monitoring by the supervisor and/or by the private sector may indirectly induce stricter monitoring by shareholders on managers; b) shareholder - manager incentives are better aligned towards moral-hazard behavior in countries with explicit deposit insurance, see Keeley (1990)); c) the possibility of investing in risky and opaque assets for banks is restricted, possibly reducing shirking opportunities of managers.

Our results suggest that stricter monitoring slightly lowers the positive impact of options delta on stock return volatility; moreover, insider ownership by managers reduces the volatility of stock returns. The interpretation is that insider ownership works in the direction of lowering the risk taking of managers when the intensity of outside monitoring is higher (John and John (1993)). Furthermore we show that both stock options and direct ownership may induce a higher propensity to risk-shift, and are related to worse performance, in countries with explicit deposit insurance. In this subset of countries, we find that both option delta and insider ownership lead to lower returns and higher stock volatility in the financial crisis. Finally in countries where restrictions on bank activities are stronger, we find that insider ownership leads to relatively better returns in the financial crisis. This last result, under the assumption that restrictions on assets are related to increased transparency about bank investments, suggests that a better alignment of CEOs and shareholders incentives leads to lower risk taking when monitoring on managers' is easier to pursue.

Our line of research complements Laeven and Levine (2009) who empirically analyzed the interaction between corporate governance and regula-

laws; explicit deposit insurance varies among countries by the application to different types of financial institutions and by the amount of coverage. In this paper we consider the law that applies to commercial banks; we furthermore assume that the insurance is funded with a fair premium paid by the commercial bank. Although restrictive, this assumption seems to fit the application of this law by the majority of countries.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

tion and its effect on bank risk taking. They find that more concentrated ownership induces higher risk taking and that this relation varies with national regulations. In particular, concentrated ownership boosts risk taking in countries with greater restrictions on bank activities and with explicit deposit insurance. Unlike Fahlenbrach and Stulz (2011), we find a negative relation between option compensation and performance in the financial crisis. This may be related to the fact that their analysis is concentrated only on US banks and that the cross-sectional variability is not big enough in the Great Recession, when both the financial markets and the overall economy crashed deeply. Our paper contributes to the recent literature on the role of banks' corporate governance on performance during the recent financial crisis. Ellul and Yeramilli (2013) studied the impact of heterogeneity in risk management functions at the bank level in the US on tail risk. Moreover, in a cross-country analysis, Beltratti and Stulz (2012) show that shareholders have effectively aligned bank managers to their interests at the expense of depositors in the recent financial crisis.

One major concern in this kind of analysis is related to endogeneity: manager compensation may in fact be designed by shareholders in anticipation of a predictable risk; in such a case, reverse causality represents one of the major challenges faced by the econometrician. We are interested in documenting the relation between CEO monetary incentives, bank regulations and crisis performance. We argue that in our empirical setup, endogeneity concerns due to reverse causality are mitigated by two concurrent reasons: 1) we regress crisis performance variables on lagged pre-crisis variables; 2) the financial crisis can be hardly classified as an anticipated shock. Both market operators and managers were arguably unaware in 2006 of the coming crisis in mid-2007. We, in fact, show that banks' stock returns in 2006 were positive and extremely high; in addition, the quarterly average of insider ownership by CEOs in our sample did change between 2006 and 2007, but the difference is not statistically significant[7]. This last piece

[7]The quarterly average of insider holding has been 1.7% and 1.5% respectively at the

of evidence confirms the conjecture that bank managers were not aware of the coming financial crisis even in the early quarters of 2007.

The rest of the paper is organized as follows: section 3.2 describes the dataset; section 3.3 provides some descriptive statistics on the sample of banks and CEO compensation; section 3.4 documents the relation between bank performance in the financial crisis and realized CEO compensation; section 3.5 studies the interaction between CEO incentives and national regulation; and section 3.6 concludes.

3.2 Data sources

We build a new database by matching four different sources of data. The final goal of the paper is to obtain a panel where each observation represents a Bank-CEO-Year-Country quadruple. In particular, we want to combine information at bank level (such as balance sheet) with information on compensation at CEO level, for different points in time and for different countries. One issue with building such a dataset is the difficulty in matching different sources absent direct linkages between databases. In order to link accounting and performance data with CEO compensation data, we merge observations from two different sources: Bankscope[8] and Capital IQ - People Intelligence[9]. From Capital IQ we initially select all commercial banks, saving institutions (SIC codes: 6020, 6021, 6029, 6036) and bank holding companies (BHCs which SIC code is 6719) for which the compensation of CEOs is observed for at least one year over the period

end of 2006 and of 2007.

[8]A directory and financial reporting service on 30,000 banks worldwide provided by Bureau van Dijk. It provides standardized reports, ratings, and ownership data as well as financial analysis functions.

[9]A database provided by Standard and Poor on the profiles of public and private firms worldwide including financials, officers and directors, ownership, advisory relationships, transactions, securities, key developments, estimates, key documents, credit ratings and filings.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

2005-2009; from BHCs we exclude those banks whose primary specialization is brokerage and financial services (SIC codes 6162, 6199, 6200 and 6211). We then match this group of selected banks with the top ten largest publicly listed banks as defined by their total assets. We select the top ten banks for each year from 2005 to 2009. This selection process allows us to include in the sample banks that eventually disappeared during the crisis because of mergers and acquisitions or default. We end up with 126 banks from 28 countries. The final list of banks is in table 3.1. Not surprisingly, the majority of observed banks are from countries where the disclosure of manager compensation is mandatory (the USA and Canada, for example). Sample size is a common problem in this kind of study (Fahlenbrach and Stulz (2011) and Beltratti and Stulz (2012)). We prefer to keep the total number of observations relatively low rather than incur the risk of over-representation of some countries. As argued by Laeven and Levine (2009), the benefit of focusing on the largest banks is mainly related to an enhanced comparability between banks from different countries. The largest corporations tend, in fact, to comply with international accounting standards. This concern is even stronger in our case because in some countries, the disclosure of manager compensation in the annual reports is recommended by the authority but not compulsory. The third source of data is represented by Datastream, from which we obtain information about stock returns and equity prices at daily and weekly frequency. Finally, we add information about countries' financial regulations using some measures from the third Survey by the World Bank discussed in Barth *et al.* (2008). A more detailed list of variables used in the following sections is available in Appendix 3.7.1.

3.3 Descriptive statistics

In this section, we provide descriptive statistics for both the sample of banks and CEO compensations. In particular, in the following section, we

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

examine accounting statistics at the end of 2006 and performance statistics in the period from the end of October 2007 to the end of December 2008 for the selected banks; later we examine summary statistics of CEO compensations and equity ownership at the end of 2006. Notice that all variables have been converted into US dollars at the end of the year.

3.3.1 Banks

Table 3.4 shows the descriptive statistics for the selected sample of banks. Notice that the total number of observations changes across variables because they are taken from different data sources. The total number of banks in the sample is quite limited; this results from two main reasons: 1) these are the banks for which we observe the CEO compensation in 2006; 2) the matching of different data sources inevitably leads the loss of some observations. We end up with a sample of large banks: the value of total assets is much bigger than in related papers, which concentrate on a sample of US banks. The Tier 1 capital ratio is not observed for all banks. The difference between the minimum and the maximum amount Tier 1 is explained by the differences in bank regulations across countries[10]. Given this heterogeneity we will insert this variable as a control in our analysis - though it is not observed in more than 10% of the observations in our sample. The positive book to market ratio signals that banks were potentially growing in 2006 and that the huge drop in stock returns from 2007:III was an unexpected event. Panel B highlights the summary statistics for our performance indicators, which will be used in the regression analysis. The average buy and hold return in the period 2007:III-2008:IV is about -47%; this highlights how deep the financial crisis has been for the banking sector worldwide.

Insert Table 3.4 here

[10]For example, in Europe it is 8%, while in the US it is 6%

3.3.2 CEO compensations

Table 3.5 provides descriptive statistics about the compensation packages and the value of equity portfolios for the CEOs employed in 2006 in the sample of selected banks described above. Panel A summarizes the various components of total compensation. While cash bonuses linked to bank performance are commonly included in managers' compensation contracts all around the world, equity bonuses are less common (in 2006 the median bank did not award an equity bonus in the form of shares, restricted shares or options). Moreover, cash bonuses account for 43% of total compensation on average and are larger than total salary for half of our sample of banks. Panel B highlights that, on average, CEO insider ownership is about 1.4%, while the median value of their total equity portfolio (which includes the value of options and restricted shares) is about 7 million dollars. We also find that about 35% of banks used stock options in their compensation packages. The value of these components suggests us that it is important to consider the impact on CEO incentives given by these variables.

Insert Table 3.5 here

3.4 Credit crisis and CEO compensations

In this section we document the relation between bank performance in the period 2007:III - 2008:IV and the various components of CEO compensations measured in the fiscal year 2006 using the following specification of OLS regression model:

$$Performance_{i,07-08} = \alpha + \beta CEOcompensation_{i,2006} + \gamma Controls_{i,2006} + \epsilon_i \tag{3.1}$$

In the analysis below we will consider two indicators of performance as dependent variables: the buy and hold return of each bank stock price and

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

the standard deviation of equity returns. We decided to exclude the first two quarters of 2009[11] in the measures of performance because bank returns in this last part of the recession may have been strongly affected by national recovery policies. On the right hand side of equation 3.1, as CEO compensation variables, we will separately consider measures of short term incentives (cash bonus over total salary) and measures of longer term incentives (equity portfolio positions) to capture the different roles given by different components of CEO compensation. Among the equity positions, we will distinguish between the incentives given by insider ownership and stock options. As we will show, these two components may, under certain conditions, work in opposite directions. The reason is that stock options give convex payoffs to the manager that is insured on the downside. On the other hand, insider ownership should perfectly align the incentives of managers and shareholders because the former group fully bear the costs of a negative realization of stock prices. Moreover, as standard in the corporate finance literature, we will separately consider the effects of option deltas and option vegas. Finally, we will exclude from the analysis the equity bonuses awarded in 2006; the reason is that these awards implicitly enter in the portfolio of stock options or of unrestricted shares accumulated and held by each CEO at the end of 2006.

3.4.1 Stock performance

In this section we consider as dependent variables the buy and hold returns in the period 2007:III - 2008:IV. Table 3.6 summarizes the results.

Insert Table 3.6 here

In columns (1) to (3) we separately consider the relation between stock performance and each component of CEO compensation. In column (4) we consider all of the CEO compensation components and we add as controls: the market return of stock price between 2005 and 2006, the book

[11] The NBER dates of the Great Recession are 2007:III-2009:II

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

to market ratio and leverage ratio evaluated at book value (all these variables are measured at the end of 2006, see Appendix3.7.1 for variable definitions). In column (5) we add the Tier 1 Regulatory Capital ratio, which is a measure of capital adequacy and liquidity; although we lose some observations by including this variable, it is an important control because it has been found that better capitalized banks performed better during the financial crisis (Beltratti and Stulz (2012)). The analysis highlights a strong predictive power for the delta of options: an increase in 1% points in delta option is related to a decrease of about 0.2% in stock return. This result points to the risk-taking incentive effect of stock options: banks that remunerated CEOs with more stock options in 2006 performed worse in the financial crisis. The results also suggest that better performing banks in 2006 performed worse in 2007-2008 (book to market ratio) and that better capitalized (higher Tier 1) performed better.

3.4.2 Risk return

In this section we replicate the analysis of the previous section taking as dependent variable the variability of stock returns. Throughout the current paper we will use two measures of performance. The reason is that the convexity of monetary returns may affect not only the return of investments but also the riskiness (Guay (1999) and Coles *et al.* (2006)). Results are in Table 3.7. We show that stock option incentives did not only impact on the return of equity but also on its volatility. Moreover, in contrast to the results of the previous section, in columns (2) and (4), we show a statistically significant negative effect from insider ownership. Higher insider holding is associated with a lower volatility of stock returns. Those results confirm that different equity remuneration policies may give different incentives and result in opposite outcomes. In particular, given that direct ownership does not insure the CEO in the case of big losses, it has provided the incentive not to invest in high return - high risky assets.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Insert Table 3.7 here

3.5 The effect of financial regulation

We interprete the results of previous sections as the evidence that weak monitoring, combined with pay-for-performance compensation for managers, lead to higher risk-taking by managers. In this second part of the empirical analysis we will validate this interpretation by working on the interaction between regulation and CEO monetary incentives. The reason for conducting this analysis is twofold. First, different regulation allows us to test wether supervision efficiency by shareholders and remuneration policies in 2006 jointly explains the cross-sectional differences in performance. Secondly, this analysis complements previous work on the effects of corporate governance and regulation on risk-taking and sheds new light on the mechanisms that may induce CEOs to take excessive risks in the eyes of regulators. Accordingly, in the current section, we provide evidence on the relation between performance and monetary incentives in different regulatory environments. We exploit some of the information provided by the World Bank III Survey on the regulatory regimes of different countries in 2006. In particular, in the sub-section below we will consider the effects of the intensity of monitoring and, in the final subsection, we will analyze the effects of deposit insurance and restrictions on bank activities.

3.5.1 The effect of monitoring

We consider two measures of intensity of monitoring: monitoring by the national supervisor and by the private sector. In the current analysis, we want to study the effects of CEO monetary incentives in an environment where the intensity of monitoring is relatively higher. We assume that these two measures of intensity of monitoring directly affects the effi-

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

ciency of supervision by bank shareholders on managers. We want to see if greater monitoring may reduce the risk-shifting incentive given by CEO remuneration. To this end, we restrict our regression analysis to banks in countries where those indexes are above the median. Results are in Table 3.8.

Insert Table 3.8 here

Columns (1) and (2) show the effects of CEO monetary incentives on stock return and risk for the group of banks in countries with stricter monitoring by the financial supervisor, while columns (3) and (4) show the effects for banks in countries with higher monitoring by the private sector. Results in columns (1) and (3) suggests that the relation between option delta in 2006 and buy and hold returns in 2007-2008 is still positive with stronger monitoring. However this effect is lower in magnitude in the case of stronger monitoring by the private sector. At the same time, both in columns (2) and (4) it is showed that the impact of option delta on risk return is lower in magnitude with stronger monitoring. Similarly we find that the effect of insider ownership on volatility of stock returns is lower in magnitude and statistically significant with respect to the whole sample. We conclude that we do find evidence that the risk taking incentive given by pay-for-performance is lower with stronger outside monitoring.

3.5.2 Deposit insurance and restriction on bank activities

As in the previous section, here we proceed with a regression analysis by conditioning on countries where there was explicit deposit insurance in 2006 and on countries where restrictions on bank activities were stronger (in countries where the index is above the median). Results are in Table 3.9. The presence of deposit insurance provides an ideal environment for studying the effects of monetary incentives when there is explicit room for

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

moral hazard behavior. Keeley (1990) argues that the reason is that banks can borrow from depositors at a very low risk free rate and invest the proceeds in risky assets. By opposite, we assume that restrictions on bank activities may increase transparency and lower the cost of monitoring by shareholders and lower the risk taking. Results are in Table 3.9; the analysis with deposit insurance and asset restrictions are shown in columns (1)-(2) and (3)-(4) respectively.

Insert Table 3.9 here

Results suggest that, in presence of deposit insurance, shareholder and manager objectives are effectively aligned towards high risk shifting to borrowers; in fact, we find that both delta options and direct ownership lead to lower returns and higher stock volatility during the financial crisis. By contrast, in countries where restrictions on bank activities are stronger, there is a positive relation between insider ownership and bank performance. This last result suggests that a better alignment of CEOs and shareholders incentives are more powerful in determining bank performance monitoring on bank investments is easier and, by opposite, shirking by managers is more difficult to pursue.

3.6 Conclusions

This paper contributes to the recent literature about the determinants of bank performance in different countries during the recent financial crisis. We find that monetary incentives given to managers in 2006 affected performance: while delta option lead to worse performance (both in stock return and risk return), direct insider ownership was related to less volatility in the stock returns. By exploiting cross-country heterogeneity in banking regulation, we find that higher pay for performance sensitivity in CEO remuneration is a powerful determinant of bad performance in countries with explicit deposit insurance; the opposite is true in countries where

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

there is stricter monitoring on bank activities by outside stakeholders. This paper represents a first step towards the study of the joint relation between bank risk taking, CEO monetary incentives, and financial regulation from empirical point of view. A deeper understanding of these interactions may have policy implications in the current debate about new regulations for banks and for managerial compensations.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

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Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

3.7 Appendix

3.7.1 Definition of key variables and Data source

Compensation - Capital IQ

- Total salary: amount paid as salary for the year 2006
- Cash bonus: amount paid as bonus for the year 2006
- Equity bonus: it is the sum of bonus not paid in cash in the year 2006; it comprises restricted stock awards, stock grant awards, option awards
- Total annual compensation: Total salary + Cash Bonus + Equity Bonus + other annual compensation in not specified categories
- Insider ownership: it is the ratio between insider ownership (source: Capital IQ) and total number of shares of the company (source: Datastream)
- Total value of options: it is the value of options calculated using the Black and Scholes formula; the exercise price and the expiration year is provided by Capital IQ; the share price at the end of year is downloaded from Datastream; the risk-free interest rate is the 10-year maturity interest rate on US bonds (source: Federal Reserve). The total number of options is given by the sum of exercisable options, unexercisable options, unearned and unexercised options, unexercised options.
- Value of total portfolio: It is the market value of insider equity (number of shares multiplied by the equity price at the end of the year), the total value of options and the total value of restricted shares (evaluated at the end of the year)

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

- Delta of options: sensitivity of CEO option portfolio value to share price. It is the weighted sum of the deltas of each option award in different years; the weights are determined by the number of each option award divided by total number of option in 2006.

- Vega of options: sensitivity of CEO option portfolio value to stock return volatility. It is the weighted sum of the deltas of each option award in different years; the weights are determined by the number of each option award divided by total number of option in 2006.

Accounting - Bankscope

- Total Assets: Total earning assets plus Cash and due from banks plus Foreclosed real estate plus Fixed assets plus Goodwill plus Other intangibles plus Current tax assets plus deferred tax plus Discontinued operations plus Other assets in 2006

- Total Liabilities: Total interest-bearing liabilities plus Fair value portion of debt plus Credit impairment reserves plus Reserves for pension and other plus Tax liabilities plus Other deferred liabilities plus Discontinued operations plus Insurance plus Other non-interest-bearing liabilities in 2006

- Total Equity: Common equity plus Non-controlling interest plus Securities revaluation reserves plus Foreign Exchange Revaluation Reserves plus Other revaluation reserves in 2006

- Leverage (book value): Total equity over total assets in 2006

- Net income: pre-tax profit in 2006

- Book to Market ratio: Market value of equity (total number of shares multiplied by end of year price of share - source Datastream) over Total equity

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

- Tier1 Capital ratio: This is regulatory measure of capital adequacy. That is shareholder funds plus perpetual non cumulative preference shares as a percentage of risk weighted assets and off balance sheet risks measured under the Basel rules.

- Tangible asset ratio: This is like a pure leverage ratio but it removes goodwill or any other intangible asset from both equity and the asset side of the balance sheet as in difficulty a banks's intangible may be worthless.

Stock data - Datastream

- Buy and hold return 2007-2008: buy and hold return on banks' stock over the period 2007:III-2008:IV

- Risk return 2007-2008: standard deviation of weekly returns over the period 2007:III-2008:IV

Regulation data - World Bank

- Private monitoring: an index of monitoring on the part of the private sector; we will consider a dummy equal to 1 if the value is above the median in our sample.

- Official: an index of the power of banking supervisor authority; we will consider a dummy equal to 1 if the value is above the median in our sample.

- Deposit insurance: dummy variable equal to 1 if the country has an explicit deposit insurance

- Restrict: an index of restrictions by national regulator on banks' activities; ; we will consider a dummy equal to 1 if the value is above the median in our sample.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

3.8 Tables

Table 3.1: List of Banks

Name of the bank	Country
Australia and New Zealand Banking Group Limited	AUSTRALIA
National Australia Bank Limited	AUSTRALIA
Bendigo and Adelaide Bank Limited	AUSTRALIA
Bank of Queensland Ltd.	AUSTRALIA
Westpac Banking Corporation	AUSTRALIA
Commonwealth Bank of Australia	AUSTRALIA
Erste Group Bank AG	AUSTRIA
Pubali Bank Ltd.	BANGLADESH
Dexia SA	BELGIUM
The Toronto-Dominion Bank	CANADA
Laurentian Bank of Canada	CANADA
Royal Bank of Canada	CANADA
The Bank of Nova Scotia	CANADA
Home Capital Group Inc.	CANADA
Canadian Imperial Bank of Commerce	CANADA
National Bank of Canada	CANADA
Bank of Montreal	CANADA
Canadian Western Bank	CANADA
China Merchants Bank Co., Ltd.	CHINA
Industrial and Commercial Bank of China Limited	CHINA
China Construction Bank Corporation	CHINA
Bank of China Limited	CHINA
Komercni Banka AS	CZECH REPUBLIC
Danske Bank A/S	DENMARK
Credit Agricole S.A.	FRANCE
BNP Paribas SA	FRANCE
Natixis	FRANCE
Societe Generale Group	FRANCE
Commerzbank AG	GERMANY
Aareal Bank AG	GERMANY
Deutsche Postbank AG	GERMANY
Deutsche Bank AG	GERMANY
Dah Sing Financial Holdings Limited	HONG KONG
Hang Seng Bank Limited	HONG KONG
The Bank of East Asia, Limited	HONG KONG
Wing Hang Bank Limited	HONG KONG
BOC Hong Kong Holdings Ltd.	HONG KONG
Chong Hing Bank Limited	HONG KONG
Dah Sing Banking Group Limited	HONG KONG

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 3.2: List of Banks 2, continued

Name of the bank	Country
Bank of Baroda	INDIA
ICICI Bank Ltd.	INDIA
Housing Development Finance Corporation Limited	INDIA
Oriental Bank of Commerce	INDIA
HDFC Bank Ltd.	INDIA
Allied Irish Banks, p.l.c.	IRELAND
The Governor and Company of the Bank of Ireland	IRELAND
Israel Discount Bank Limited	ISRAEL
Bank Leumi Le-Israel BM	ISRAEL
First International Bank of Israel Ltd.	ISRAEL
Mizrahi Tefahot Bank, Ltd.	ISRAEL
Union Bank of Israel Ltd.	ISRAEL
Bank Hapoalim B.M.	ISRAEL
Unione di Banche Italiane Scpa	ITALY
Banca Popolare di Sondrio	ITALY
UniCredit S.p.A.	ITALY
Banco Popolare Societa Cooperativa Scarl	ITALY
Banca Carige S.p.A.	ITALY
Banca popolare dell'Emilia Romagna	ITALY
Arab Bank plc	JORDAN
Capital Bank of Jordan	JORDAN
Bank of Jordan	JORDAN
Cairo Amman Bank	JORDAN
Malayan Banking Berhad	MALAYSIA
FNB Namibia Holdings Limited	NAMIBIA
Van Lanschot NV	NETHERLANDS
SpareBank 1 SR-Bank	NORWAY
Sandnes Sparebank	NORWAY
SpareBank 1 SMN	NORWAY
NIB Bank Limited	PAKISTAN
Faysal Bank Limited	PAKISTAN
Habib Metropolitan Bank Limited	PAKISTAN
United Bank Ltd.	PAKISTAN
Bank Al Habib Limited	PAKISTAN
Bank Alfalah Limited	PAKISTAN
Allied Bank Limited	PAKISTAN
MCB Bank Ltd.	PAKISTAN
Askari Bank Limited	PAKISTAN

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
European University Institute DOI: 10.2870/11929

Table 3.3: List of Banks 3, continued

Name of the bank	Country
Bank Polska Kasa Opieki	POLAND
Bank Millennium Spolka Akcyjna	POLAND
BRE Bank SA	POLAND
Bank Zachodni WBK SA	POLAND
Bank Handlowy W Warszawie SA	POLAND
Absa Group Limited	SOUTH AFRICA
Standard Bank Group Limited	SOUTH AFRICA
Capitec Bank Holdings Ltd.	SOUTH AFRICA
FirstRand Limited	SOUTH AFRICA
Sasfin Holdings Limited	SOUTH AFRICA
Cadiz Holdings Ltd.	SOUTH AFRICA
Nedbank Group Limited	SOUTH AFRICA
Banco Popular Espanol S.A.	SPAIN
Banco Santander, S.A.	SPAIN
Banco Bilbao Vizcaya Argentaria, S.A.	SPAIN
Nordea Bank AB (publ)	SWEDEN
Swedbank AB	SWEDEN
Skandinaviska Enskilda Banken AB (publ)	SWEDEN
Svenska Handelsbanken AB	SWEDEN
HSBC Holdings plc	UNITED KINGDOM
Standard Chartered PLC	UNITED KINGDOM
Paragon Group of Companies plc	UNITED KINGDOM
The Royal Bank of Scotland Group plc	UNITED KINGDOM
Arbuthnot Banking Group PLC	UNITED KINGDOM
Barclays PLC	UNITED KINGDOM
Lloyds Banking Group plc	UNITED KINGDOM
U.S. Bancorp	UNITED STATES OF AMERICA
Fifth Third Bancorp	UNITED STATES OF AMERICA
SunTrust Banks, Inc.	UNITED STATES OF AMERICA
Regions Financial Corporation	UNITED STATES OF AMERICA
BBandT Corporation	UNITED STATES OF AMERICA
Citigroup, Inc.	UNITED STATES OF AMERICA
JPMorgan Chase and Co.	UNITED STATES OF AMERICA
Bank of America Corporation	UNITED STATES OF AMERICA
The PNC Financial Services Group, Inc.	UNITED STATES OF AMERICA
Wells Fargo and Company	UNITED STATES OF AMERICA
SLM Corporation	UNITED STATES OF AMERICA
The Bank of New York Mellon Corporation	UNITED STATES OF AMERICA

Table 3.4: Summary Statistics for the sample of banks

	Mean	St. Dev.	Median	Number	Min.	Max.
Panel A:*Accounting data*						
Total Assets	288935.2	544937	61590.9	126	204.0783	3480005
Total Liabilities	272384.1	515539	56701.26	126	112.2349	3246247
Total Equity	15019.78	29238.37	4117.332	126	62.12338	210170.2
Leverage (book value)	.0775749	.0508819	.0654814	126	.0209757	.4508393
Net income over total asset	.0133372	.0119696	.0104837	126	.0027138	.0919265
Book to Market ratio	1.471307	4.168797	.6321529	120	.0478978	32.13791
Tier1 Capital ratio	9.682818	3.208868	8.66	110	5.5	23.8
Tangible asset ratio	6.478413	4.654734	5.45	126	1.37	42.56
Panel B:*Perfomance indicators*						
Buy and hold return 2007-2008	-.4722741	.2772084	-.4775868	121	-.9594446	.6239023
Risk return 2007-2008	.0664083	.0198854	.0639792	121	.0329217	.1567338

The table provides summary statistics for the sample of banks selected according to criteria described in Section 2. The list of banks and the definition of the variables are in the Appendix. All variables in Panel A are measured in million of US dollars at the end of Fiscal Year 2006. Original variables used to obtain performance indicators in Panel B has been downloaded from Datastream in US dollars.

Table 3.5: Summary Statistics for CEO compensations

	Mean	Median
Panel A:*Compensation 2006*		
Total salary	6014365	725616.2
Cash bonus	1305616	331126.3
Equity bonus	1264812	0
Total annual compensation	8737911	1290499
Bonus over total compensation	.4314459	.4925723
Cash bonus over total salary	.7637955	1
Panel B:*Equity portfolio 2006*		
Insider ownership	.0138157	.0001
Total value of options	7324591	0
Value of total portfolio	2.19e+07	725392
Delta of options	.0641493	0
Vega of options	.0035714	0

The table provides summary statistics for the sample of the compensation and the portfolio of equity of CEOs appointed in the selected banks in 2006. The definition of the variables are in the Appendix. All variables in Panel A and Panel B are measured in US dollars at the end of Fiscal Year 2006.

Table 3.6: Estimation results: Buy and hold returns 2007:III-2008:IV (BHR_0708)

Dependent variable:			BHR_0708		
	(1)	(2)	(3)	(4)	(5)
cash_salary_2006	-0.0120			0.00209	0.0122
	(0.0106)			(0.0107)	(0.00929)
insider_2006		0.357		0.0695	-0.268
		(0.382)		(0.273)	(0.317)
option_delta_2006			-0.149***	-0.200**	-0.184**
			(0.0381)	(0.0940)	(0.0722)
option_vega_2006			0.231	-0.279	1.329
			(1.406)	(1.702)	(0.966)
market_return_2006				-0.301***	-0.292***
				(0.1000)	(0.0945)
book_to_market_2006				0.0119	0.0128
				(0.0157)	(0.0161)
leverage_market_2006				0.102	-0.00474
				(0.233)	(0.185)
Tier_1_Capital_Ratio_2006					0.0283***
					(0.00573)
Constant	-0.455***	-0.478***	-0.463***	-0.413***	-0.689***
	(0.0313)	(0.0261)	(0.0262)	(0.0536)	(0.0663)
N	121	120	121	118	102

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All covariates are measured in US dollars at the end of Fiscal Year 2006.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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Table 3.7: Estimation results: Risk return 2007:III-2008:IV (RR_0708)

Dependent variable:	RR_0708				
	(1)	(2)	(3)	(4)	(5)
cash_salary_2006	0.00101			-0.000420	-0.000358
	(0.000698)			(0.000737)	(0.000737)
insider_2006		-0.0546***		-0.0356***	-0.0168
		(0.0106)		(0.0135)	(0.0154)
option_delta_2006			0.0134***	0.0159**	0.0147**
			(0.00463)	(0.00652)	(0.00584)
option_vega_2006			0.0972	0.138	-0.0193
			(0.172)	(0.194)	(0.0700)
market_return_2006				0.0200***	0.0237***
				(0.00661)	(0.00482)
book_to_market_2006				-0.000459	-0.000367
				(0.000646)	(0.000627)
leverage_market_2006				-0.00117	0.000784
				(0.0146)	(0.0114)
Tier_1_Capital_Ratio2006					-0.000975*
					(0.000498)
Constant	0.0649***	0.0672***	0.0652***	0.0614***	0.0678***
	(0.00207)	(0.00187)	(0.00177)	(0.00323)	(0.00552)
N	121	120	121	118	102

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All covariates are measured in US dollars at the end of Fiscal Year 2006.

Table 3.8: Estimation results: External Monitoring

	National supervisor		Private sector	
	(1)	(2)	(3)	(4)
	BHR_0708	RR_0708	BHR_0708	RR_0708
cash_salary_2006	0.0167	-0.000132	0.0108	-0.000235
	(0.0120)	(0.000783)	(0.0101)	(0.000779)
insider_2006	0.269	-0.0431*	-0.338	-0.0266*
	(0.196)	(0.0248)	(0.290)	(0.0140)
option_delta_2006	-0.257***	0.0122**	-0.167**	0.0142**
	(0.0893)	(0.00563)	(0.0707)	(0.00575)
option_vega_2006	0.914	-0.0508	1.087	-0.0288
	(1.104)	(0.0645)	(1.024)	(0.0697)
market_return_2006	-0.194*	0.0135***	-0.349***	0.0199***
	(0.0976)	(0.00462)	(0.106)	(0.00437)
book_to_market_2006	0.0355***	-0.00107***	0.0157	-0.000191
	(0.00231)	(0.000111)	(0.0169)	(0.000682)
leverage_market_2006	0.182	-0.00600	-0.0614	-0.0000738
	(0.234)	(0.0142)	(0.177)	(0.0106)
Tier_1_Capital_Ratio_2006	0.0235***	-0.000459	0.0301***	-0.000688
	(0.00632)	(0.000460)	(0.00607)	(0.000478)
Constant	-0.674***	0.0686***	-0.671***	0.0665***
	(0.0817)	(0.00567)	(0.0774)	(0.00585)
N	62	62	77	77

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All covariates are measured in US dollars at the end of Fiscal Year 2006.

Oliviero, Tommaso (2014), Financial intermediation and the great recession : microeconomic and macroeconomic issues
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Table 3.9: Estimation results: Deposit Insurance and Restrictions on bank activities

	Deposit insurance		Restriction on activities	
	(1)	(2)	(3)	(4)
	BHR_0708	RR_0708	BHR_0708	RR_0708
cash_salary2006	0.0165*	-0.000559	0.0114	-0.000211
	(0.00972)	(0.000857)	(0.0102)	(0.000776)
insider_2006	-1.146***	0.0549*	0.432**	-0.0295
	(0.325)	(0.0301)	(0.187)	(0.0219)
option_delta_2006	-0.214**	0.0254***	-0.237*	0.0143***
	(0.0913)	(0.00644)	(0.138)	(0.00432)
option_vega_2006	0.675	0.0685	1.207	-0.00648
	(2.027)	(0.178)	(0.989)	(0.0693)
market_return_2006	-0.244	0.0368**	-0.111	0.0179***
	(0.198)	(0.0146)	(0.0920)	(0.00464)
book_to_market_2006	-0.00916*	0.000170	0.0280***	-0.00121***
	(0.00500)	(0.000374)	(0.00878)	(0.000292)
leverage_market_2006	0.102	-0.0280*	0.206	-0.00642
	(0.227)	(0.0147)	(0.368)	(0.0139)
Tier_1_Capital_Ratio_2006	0.0543***	-0.00388**	0.0211**	-0.000129
	(0.0170)	(0.00148)	(0.00808)	(0.000426)
Constant	-0.964***	0.0924***	-0.667***	0.0609***
	(0.176)	(0.0157)	(0.0746)	(0.00488)
N	63	63	64	64

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All covariates are measured in US dollars at the end of Fiscal Year 2006.