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# Essays on Financial Crises, Big Recessions and Slow Recoveries

by

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## DECLARATIONS

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I declare that the contents of this thesis are based on my own research in accordance with the regulations of Warwick University. The work in this thesis is original, unless where indicated by references. This thesis has not been submitted for examination at any other university.

Juan Carlos Castro-Fernández

September 2017

## ABSTRACT

In this thesis I presented two essays motivated by the observation that financial crises tend to be accompanied by deeper recessions and slower recoveries, partly due to debt burden (e.g. Reinhart & Rogoff, 2009; Hong and Tornell, 2005; Jordà, et al., 2013).

In the first essay I evaluate this claim against the contrasting view that magnitude and persistence of recessions is rather the consequence of bigger and more persistent shocks (Stock & Watson, 2012). To do so, I compute recovery and recession paths through the estimation of impulse responses by local projections methods (Jordà, 2005). I found that the occurrence of financial crises is associated with more severe recessions only if the recession itself is big enough. But this effect disappears when the output loss caused by the recession is below the historical average. More importantly, neither the magnitude of the loss, nor the occurrence of financial crises, nor debt accumulation are associated with sluggish output growth during recoveries.

It has also being suggested that expectations prior to the crisis help to determine the magnitude and length of recessions following financial crises (Chauvet and Guo, 2003; Cerra and Saxena, 2008). This and the role of pre-crisis dynamics is not properly reflected in standard DSGE models. In the second essay I account for the effect of pre-crisis dynamics and evaluate whether financial crises are different. To do so, I introduce optimism (in the form of unrealised news about capital quality) in an otherwise standard DSGE model with financial frictions. Under this framework, optimism generates investment-debt / boom-bust cycles accompanied by long recessions. I found that within this framework cycles associated with financial and technology news shocks are different regarding the responses of asset prices and banks' net worth. Real variables respond similarly to unjustified financial or technological optimism.

*Keywords:* Financial crises, deep recessions, slow recoveries, local projections, boom – bust cycles, financial constraints, debt overhang, news shocks



# 1 BIG RECESSIONS AND SLOW RECOVERIES

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## 1.1 INTRODUCTION

Recent episodes of financial crisis in developed countries, such as the subprime crisis in the United States that led to the great recession in 2007-2009, have emphasised the widely supported idea that economic downturns that are accompanied by financial crisis tend to be bigger and longer than other economic crises (e.g. Reinhart & Rogoff, 2009). To that extent, a bulk of empirical literature has dealt with the measurement of the real effects of financial crisis. A recurrent suggestion from this literature is that debt burden plays an important role in determining the duration and magnitude of the recessions (e.g. Hong and Tornell, 2005 and Jordà, et al., 2013 and 2015).

Conversely, other studies have found that financial crises have small or no effect on the severity of the recessions, as well as on the speed of recovery (e.g. Romer and Romer, 2015). It has been suggested as an alternative explanation that the crisis severity and speed of recovery are correlated with the size and persistence of the underlying shocks and that the effect of the financial nature of the crisis is negligible (Romer and Romer, 2015; Stock and Watson, 2012). Therefore, this last branch of literature suggests that slow recoveries are somewhat associated with deep recessions.

This mixed evidence set a dilemma between the two approaches and bring about the question whether recessions and recoveries are significantly different when accompanied by a financial crises or if this has something to do with the magnitude of the recession itself. To shed some light on this debate an empirical examination of the two positions is performed in this paper using the macro-financial data base gathered by Jordà et al. (2017).

In other words, the purpose of this paper is twofold. On one hand, I evaluate whether financial crises, and excessive debt play a role determining the severity of the recession and speed of recovery. And on the other hand, an evaluation of the effect on output dynamics of the magnitude of the shock itself is performed. This is done

using local projection methods to estimate recession and recovery paths as in Jordà, et al. (2013).

The business cycle dynamics literature is related to this chapter, particularly the literature on whether business cycles accompanied by financial crises are different and on the sources of business cycles fluctuations. With respect to the shocks driving macroeconomic fluctuations, the literature has focused mainly on three: technology, monetary and fiscal shocks. Estimations of medium-scale DSGE models have highlighted the importance of identifying the contributions to output volatility by fluctuation sources (Smets and Wouters, 2003 and 2007). Then a problem that economists have had to tackle is how to identify such shocks (For a review see Ramey, 2016). This is of great importance if you try to compare episodes with different characteristics (for instance financial crisis with normal recessions).

Regarding, the effect of financial crises, most of the studies have found evidence supporting the idea that financial crises are accompanied by deeper and longer recessions. And most of them have used data for both developed and developing countries (v.g. Reinhart & Rogoff, 2009) or developing countries data exclusively (Berkmen, et al., 2012; Hong & Tornell, 2005). The identification strategy for the financial crisis episodes has been predominantly discursive (v.g. Reinhart & Rogoff, 2009; Claessens, et al., 2009; Bordo, et al., 2001; Jordà, et al., 2013, 2015 and 2017). This implies that most of the studies relied on dummy variables as indicators of the financial turmoil, and as Romer and Romer (2015) have highlighted, have used the peak to trough decline on output as a measure of the deepness of the recession.

In this respect, Romer and Romer (2015) and Stock and Watson (2012) differ from most of the literature in both the identification strategy and on the focus on developed countries. The former uses a modified discursive strategy, focusing on the cost of financial intermediation and assigning different values to the variable depending on the severity of the financial disruption. Then they use Jordà's (2005) local projection methods to estimate the effects of financial turmoil on the severity of the recession. They have also remarked on some problems with previous financial crisis effect literature including estimation bias and reverse causation. On the other hand, Stock and Watson (2012) use a dynamic factor model to identify the different shocks and quantify their contribution to output volatility for different recession episodes in the USA. As mention before, both studies found evidence that the

severity of the recession is related to the magnitude and persistence of the underlying shocks.

By estimating recession paths using the Jordà method, Jordà et al. (2013 and 2015) and Romer and Romer (2015) reduce the downwards bias of the crisis in countries with very strong trend growth. Notwithstanding the reverse causation problem remains in the sense that crisis might be the result and the cause of recessions.

I use a very similar approach here. Unlike Jordà et al. (2013 and 2015), I control for the magnitude of the shock by grouping the data according to the deviation of the growth rate with respect to the country-specific historical mean. This allows me to evaluate the size claim by Romer and Romer (2005) and Stock and Watson (2012). Reverse causation remains a problem for the estimation of recession paths, and therefore the magnitude of the financial crises effect on the output loss. But this problem is reduced when estimating the effects of the financial crisis and the magnitude of the shock on the speed of recovery. This is one of the contributions of the chapter with respect to previous literature.

In this respect, I found evidence suggesting that neither financial nature of the crisis nor the severity of the recession is associated with slower recoveries. This is, the output growth rate following either a big or a financial recession is not significantly sluggish compared with small or non-financial recessions. On the other hand, when grouped by size, financial crises are not accompanied by deeper than usual recessions if they are small.

Financial recessions are statistically distinguishable from normal downturns only if the output loss is above the historical mean. Additionally, some support is given to Jordà, et al. (2013) finding that debt accumulation during the expansion helps to determine the magnitude of the recession. This evidence is more significant for big non-financial recessions.

Furthermore, the claim that the magnitude and persistence of the underlying shock are determinants for both the severity of the recession and the speed of recovery, implies that standard DSGE models should be enough to explain these two features of the data. I analysed this using simulated data from a basic RBC model and found that the model is able to reproduce big and small recessions and that the recoveries

are not associated with the size of the shock. In fact, recovery period growth after big recessions seems to be slightly faster than after episodes with small output losses.

Overall, the evidence found in this paper suggest that neither the financial nature of the crisis nor the magnitude of the shocks producing the downturn are associated with sluggish recoveries. It is also found that debt run-ups play a statistically significant role in determining the magnitude of the recession but it has no significant effect on output growth during recovery.

Other factors should be playing a role determining both the magnitude of the recession and the speed of recovery. Gali, et al. (2012) identify policy tightness (zero lower bound), risk premium and investment specific technology shocks as the main drivers of slow recoveries in the US. It is needed to dig further into the determinants of slow recoveries but that is beyond the scope of this paper and is left for future research.

The rest of the chapter is organised as follows: in the next section, the data and identification of the turning points are described. The methodology for the estimation of recession and recovery paths and the initial data analysis are presented in section 3. Section 4 contains the initial regression analysis regarding the magnitude and financial crises effects. Section 5 presents the analysis of the effect of debt accumulation on both recession and recovery paths. Section 6, explains the robustness of the regression results to the inclusion of economic controls. In section 7, an estimation of recession paths is presented to evaluate whether a basic RBC model is able to generate what we observe in the data. Finally, section 8 concludes.

## 1.2 DATA AND TURNING POINTS IDENTIFICATION

In this paper, I used the panel data information gathered by Jordà et al. (2017). This panel has information for 17 developed economies from 1870 to 2013 on annual frequency. It includes variables for the real economy, credit, government and financial crisis dates among others. For the purpose of this paper, I am using the series real per capita GDP, consumption per capita, investment to GDP ratio, total

loans, population, price index, current account and a systemic financial crises identifier. A description of this data is provided in the Appendix to the chapter.

On the other hand, to be able to determine whether recession and recovery paths differ across episodes according to the characterizations by size and financial nature, business cycle turning points need to be identified. To do so, I use the Harding and Pagan (2002) algorithm for annual frequency, which is equivalent to the use of Bry and Boschan (1971) algorithm. In practice, this is similar to identifying the last positive growth period in a sequence as a peak, with the advantage that the algorithm guarantees that peaks and troughs alternate.

I identify turning points for a single variable (real GDP) and perform the analysis in terms of how output behaves during recessions and recoveries. Given the frequency of the data and the purpose of the paper, there are no great gains from using a multivariable turning points identification strategy.

Accordingly, 375 peaks and troughs are identified. Following Jordà et al. (2013) I excluded from the data episodes that are influenced by wars. To do so, peaks happening 2 years after a war or 5 years before were excluded (and its corresponding trough too). I also excluded recessions for which there are not enough data points to get a full window for a recession path. As a consequence, peaks and troughs happening on or after 2009 are excluded. Then the sample is reduced to 278 usable peaks.

Additionally, the analysis presented here requires recessions to be classified as being accompanied or not by a financial crisis. This is done using the systemic financial crisis variable. This variable was built using the results from previous literature on financial crises including Bordo et al. (2001) and Reinhart and Rogoff (2009), among others (Jordà, et al., 2017). A recession is labelled as financial if a crisis episode is reported 2 years before or after the peak. This is done avoiding the association of a crisis episode to more than one recession by favouring the episode that is preceded

by a financial crisis. As can be seen in Table 1.1, this results in 71 out of 278 usable peak observations classified as financial.<sup>1</sup>

*Table 1.1 Number of usable peaks by phases of financial development and type of episode*

Phases of Financial Development	Non-Financial	Financial	Total
Pre WWI	112	29	141
Inter-Wars	20	19	39
Bretton Woods	25	0	25
Post Bretton Woods	50	23	73
Total	207	71	278

To consider varying economic conditions (average growth and volatility) and differences in credit access across time, data is partitioned according to the four phases of financial development as proposed in Jordà et al (2013)<sup>2</sup>. These phases are: the pre-World War I period (1870-1914), the interwar period (1918-1939), the Bretton Woods period (1945-1971) and the post Breton Woods period (1972-2013).<sup>3</sup> It is interesting to notice that no recessions are classified as financial during the Bretton Woods period.

A second classification needed for the analysis is the one regarding the size of the recession measured as the logarithmic percentage difference between the peak and the next trough, i.e. the accrued loss during the contractionary phase of the cycle. Using this variable, a recession is classified as big if the output loss exceeds its mean for a particular country during a particular phase of financial development<sup>4</sup>.

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<sup>1</sup> Episodes classified as financial by Jordà et al. (2013) are also classified as that following this methodology.

<sup>2</sup> This also allows for comparability of the results found in this paper with theirs.

<sup>3</sup> The use of an alternative partition of the data using the WWII as threshold does not change the qualitative results.

<sup>4</sup> The qualitative results hold, when we define big as output losses that are 1 standard deviation above the mean.

*Table 1.2 Number of usable peaks by type, magnitude of the episode and phases of financial development*

	Small			Big		
	Non-Financial	Financial	Total	Non-Financial	Financial	Total
<b>Pre 1st WW</b>	78	14	92	34	15	49
<b>Inter-Wars</b>	11	13	24	9	6	15
<b>Bretton Woods</b>	13	0	13	12	0	12
<b>Post Bretton Woods</b>	35	8	43	15	15	30
<b>Total</b>	<b>137</b>	<b>35</b>	<b>172</b>	<b>70</b>	<b>36</b>	<b>106</b>

As can be seen in Table 1.2., about half the financial crises are classified as big. In total there are 105 recession episodes where the output loss exceeded the respective historical mean. It can also be observed that most of the recessions classified as non-financial are also small (138 episodes). In the next section I analyse further the data according to the classifications used in the paper. Also I explain how local projections are used in this paper to estimate the average recession paths for each of these groups of recessions.

In Table 1.2., we can also see the number of usable episodes by phases of financial development, the severity of the recession and financial nature of the episode. Interestingly, during the inter-wars period most of the financial recessions produced below average output losses. Moreover, a higher number of non-financial rather than financial recessions were classified as big.

The financial recessions categorised as big include the great depression in the United States, the 1929 episodes in France Italy and Japan and the 1930 recessions in Norway and Sweden. Meanwhile, the big non-financial recessions include among others the 1923 Danish recession, the 1925 and 1929 British recessions, and the 1929 Swiss and Dutch episodes. The 1929 non-financial recession can be linked to the great depression in the USA, but they were the by-product of trade no financial effects of the latter

In the next section, I analyse further the data according to the classifications used in the paper. I also explain the usage of local projections in this paper to estimate the average recession paths for each of these groups of recessions.

### 1.3 BIG RECESSIONS AND FINANCIAL CRISIS

As stated in the introduction, the purpose of this paper is to evaluate the claims that financial crises are accompanied by deeper and longer recessions on the one hand (Reinhart & Rogoff, 2009). And on the other, that this effect is negligible and slow recoveries are rather associated with a magnitude effect of the recession itself (Stock & Watson, 2012). That is, the magnitude of the recession is, if anything, weakly associated with financial crises and the speed of recovery depends on the magnitude and persistence of the underlying shocks.

The first step to assess those statements is to analyse the raw data on recession episodes according to the classifications presented in the previous section. In particular, to examine the mean and variance of recession magnitudes corresponding to financial or non-financial episodes. In terms of severity, Table 1.3 shows that both the output loss mean and standard deviation are bigger for episodes accompanied by financial crises. This is true for almost all phases of financial development with the exception of the inter-wars period when the opposite is true.

*Table 1.3 Average accrued output loss (peak-to-through output reduction) by financial development phase, size and financial nature of the crisis*

	Non-Financial	Financial	Small			Big		
			Non-Financial	Financial	Total	Non-Financial	Financial	Total
Pre 1st WW	-3.4151 (3.5518)	-4.1269 (3.9521)	-1.9281 (1.5124)	-1.2645 (1.5152)	-1.8271 (1.5234)	-6.8265 (4.4586)	-6.7985 (3.6424)	-6.8179 (4.1876)
Inter-Wars	-9.2770 (11.7197)	-6.5479 (8.0778)	-3.4129 (4.6298)	-3.2632 (3.3222)	-3.3318 (3.8838)	-16.4442 (13.9407)	-13.6648 (10.9353)	-15.3324 (12.4799)
Bretton Woods	-1.2843 (1.0997)	.	-0.7335 (.6438)	.	-0.7335 (.6438)	-1.8810 (1.1999)	.	-1.8810 (1.1999)
Post Bretton Woods	-2.2169 (2.1378)	-4.2949 (2.9376)	-1.2684 (1.0689)	-1.7114 (.8477)	-1.3508 (1.0369)	-4.4302 (2.3924)	-5.7713 (2.6643)	-5.0776 (2.5735)
Total	-3.4347 (4.9929)	-4.8369 (5.2056)	-1.7654 (1.8956)	-2.1090 (2.4003)	-1.8353 (2.0057)	-6.7018 (7.1402)	-7.5647 (5.8234)	-6.9894 (6.714)

Notes: Standard deviations in parenthesis

This suggests that financial crises are, on average, accompanied by more severe recessions. Notwithstanding, there is a caveat: the dispersion of the severity of the recession is also greater for financial crises, implying that financial crises can also be accompanied by smaller, less painful recessions.



In fact, differences between financial and non-financial episodes are reduced when the sample is divided by size. Thus, it seems that the conclusion of financial recessions being more painful than normal recessions does not necessarily hold. This seems to be in accordance with the view that the crisis severity and speed of recovery are correlated with the size and persistence of the underlying shocks (Romer & Romer, 2015; Stock & Watson, 2012).

*Table 1.4 Average growth after trough by size and financial nature of the crisis*

Horizon	Non-Financial	Financial	Small			Big		
			Non-Financial	Financial	Total	Non-Financial	Financial	Total
1 year	3.6137 (2.7655)	3.5186 (2.5587)	3.2925 (2.6704)	2.9789 (1.9871)	3.2348 (2.5558)	4.2711 (2.86)	4.1932 (3.0418)	4.2501 (2.8928)
2 years	5.4235 (4.2133)	5.4026 (4.0389)	4.7929 (3.7262)	5.2060 (3.2612)	4.8690 (3.6391)	6.7136 (4.8465)	5.6484 (4.9059)	6.4264 (4.8579)
3 years	7.5944 (6.0151)	6.6443 (6.8792)	6.5763 (5.2774)	5.9981 (7.2795)	6.4696 (5.679)	9.4057 (6.8098)	7.2167 (6.5571)	8.7217 (6.7793)

Notes: Standard deviation in parenthesis

Regarding the speed of recovery, Table 1.4 shows the average accrued growth one, two and three years after the trough. This data suggest that there are no significant differences between growth rates during the recovery of financial and non-financial recessions. Interestingly, it also shows that big recessions' average recovery speed is faster than that of smaller recessions. I confirm these results with the regression analysis that is presented in the following sections of the paper.

The visual examination of the moments of the magnitude of the recession and speeds of recovery by size and financial nature is not enough to draw sound conclusions. But it suggests that it is necessary to group data by size to get a clear picture of the role played by the financial nature of the episodes, so that this is not confused with a scale effect as suggested by some authors (v.g. Stock & Watson, 2012 and Romer & Romer, 2015).

To unveil the correlation between big recessions, financial crises and slow recoveries in the next two sections of the paper an empirical evaluation of size and financial crisis effects is performed. To do so, the recession and recovery paths are estimated using local projection methods (Jordà, 2005). With a twofold purpose of making the results comparable to the ones found by Jordà, et al. (2013) and to evaluate the claim that debt burden plays a role in determining the magnitude and duration of a crisis,

I interact credit excess with the classification variables and include the same controls used by the aforementioned authors.

According to this methodology, recession and recovery paths are defined as the cumulative impulse responses of output growth to a particular shock as in Jordà et al (2013, 2015). For the purpose of this chapter, it is enough to classify the shocks in terms of financial, non-financial, big and small categories. Also, the recoveries are defined as the responses from the trough to the same dummy variables. In practice, we need to estimate the following regression for every horizon point ( $h=1-5$ ):

$$\Delta_h y_{i,t+h} = \alpha + \alpha_i + \beta_1 shock_{i,t} + \beta_2 X_{i,t} + u_{i,t}$$

Here  $\Delta_h y_{i,t+h}$  stands for the log difference of output between periods  $t$  and  $t+h$ ,  $\alpha$  is the common constant,  $\alpha_i$  are individual country  $i$  fixed effects. The variable  $shock_{i,t}$  is a dummy taking the value of one when the shock hits. In the context of this work, the dummy variables indicate either a peak or a trough and whether the recession associated with them is classified as financial, non-financial, big or small. Finally,  $X_{i,t}$  is a vector of covariates and  $u_{i,t}$  is the vector of robust errors associated with the estimation.

The estimation is done using panel data fixed effects and errors are clustered at the country level. In this way, errors are allowed to be auto-correlated. This is necessary to get valid inference from LP estimators (Jordà, 2005) and it is the equivalent to HAC errors in a time series framework.

The parameters of interest are the common trend ( $\alpha$ ) and the marginal cumulative effect of the shock ( $\beta_1$ ). The sum of the two gives us the average recession and recovery paths depending on whether we are using peak or trough dummies. In the next section, an assessment of whether recession and recovery paths differ significantly among classifications is presented. To do so, I use the financial database for 17 developed countries gathered by Jordà, et al. (2017). In a latter section, we use this same methodology and simulated data to find out whether macroeconomic theory is able to reproduce the patterns found in the data and to get some insight on the claim that the magnitude of the shock is correlated with the speed of recovery.

## 1.4 AN EVALUATION OF FINANCIAL CRISES AND MAGNITUDE EFFECTS.

It has been claimed that financial crises have a differential effect on economic growth in the short and the medium run producing deeper recession and slower recoveries (e.g. Reinhart and Rogoff, 2009 and Claessens, et al., 2009). If this is true in general, then they should have different recession and recovery paths regardless of the group size. To evaluate this, following the strategy described in the last section, I estimate these paths using local projections (Jordà, 2005). Initially, the following two equations with only dummy shocks are estimated:

$$(1) \quad \Delta_h y_{i,t+h} = \alpha + \alpha_i + \beta_B B_{i,t} + \beta_S S_{i,t} + u_{i,t}$$

$$(2) \quad \Delta_h y_{i,t+h} = \alpha + \alpha_i + \beta_F F_{i,t} + \beta_N N_{i,t} + u_{i,t}$$

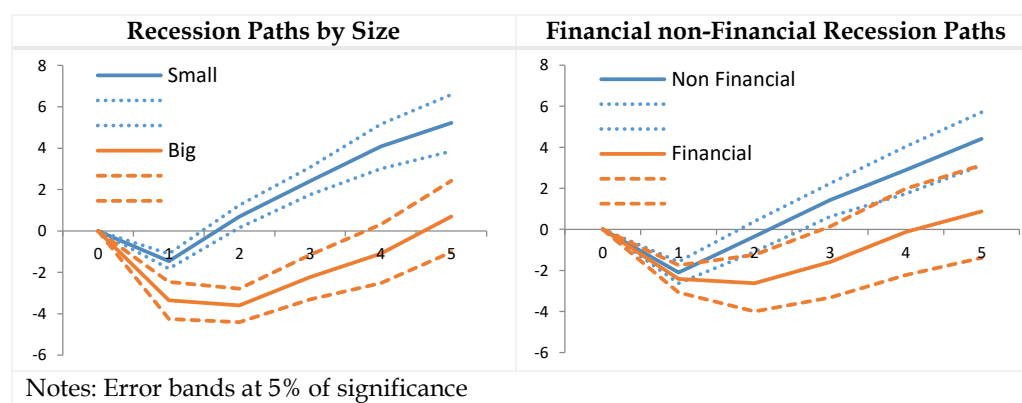
Here B stands for big, S for Small, F for Financial and N for non-financial. The time horizon  $h$  refers to the number of periods ahead of either the peak or the trough. As indicated before, when dummy variables take the value of one at peaks the estimated cumulative impulse responses correspond to the recession paths. Conversely, when unitary values are taken at troughs, the estimation results can be interpreted as recovery paths. These paths are computed as the sum of  $\alpha + \beta_j$  where  $j$  stands for B, S, F or N; and  $\alpha$  can be interpreted as the average growth trend net of countries fixed effects.

The estimation is done using panel data fixed effects and errors are clustered at the country level. In this way, errors are allowed to be auto-correlated. Recession paths estimated using equation 2 (right panel of Figure 1) are qualitatively equivalent to the results reported in Table 5 in Jordà, et al. (2013, p. 13). Quantitative differences with respect to those results might arise since the data available has been reviewed and augmented in terms of coverage.

From these regressions we can conclude that average financial recessions seem to be deeper and one year longer than non-financial ones. While on average non-financial

recession losses are fully recovered after one year, it takes two years to recover from a financial recession (this is until year 4).<sup>5</sup>

Figure 1.1 Recession paths without controls



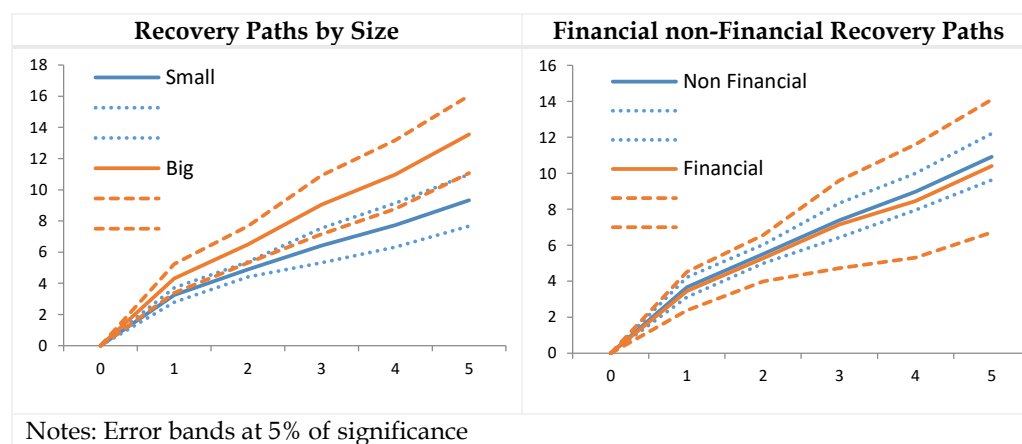
As can be noticed in Figure 1.1 Recession paths without controls, these same results are extendable to big recessions when comparing them with small ones. This might be due to a much higher proportion of financial recessions being categorized as big. I will show later that when grouped by size financial crises matter only if the recession is severe enough. That is, there are no significant differences between normal and financial episodes when output losses are small. In other words, for a recession to be more severe it is not enough to be accompanied by a financial crisis.

On the other hand, estimations of recovery paths are reported in Figure 1.2. In this case, the sum  $\alpha + \beta_j$  in equations 1 and 2 corresponds to the cumulative growth rate  $h$  years after the trough. The results from these estimations suggest that financial recessions do not seem to exhibit a significantly different recovery path from a non-financial recession (right panel, Figure 1.2).<sup>6</sup>

<sup>5</sup> This is no longer true when allowing a financial crisis episodes to be associated with more than one recession when we do not include controls. In this case the financial recession is not significantly different from the non-financial for the whole sample.

<sup>6</sup> This result is consistent when allowing for a financial crisis episode to be associated with more than one recession.

Figure 1.2 Recovery paths without controls



Regarding the severity of the recession, growth rates during recoveries from big recessions seem to be higher than from small recessions on average. This implies that the time to recover from an average big or a financial recession is longer due to a scale effect. This means that it takes longer to recover from a bigger loss at a given growth rate. It also implies that other factors should be playing a role in determining the speed of recovery.

Some previous findings for the last three recessions in the US, suggest that the zero lower bound and wage rigidities played a role determining the speed of recovery (Gali, et al., 2012). A similar role has been attributed to fiscal consolidation. The most frequent culprit in the literature is debt overhang (e.g. Hong & Tornell, 2005). The latter will be evaluated in a following section.

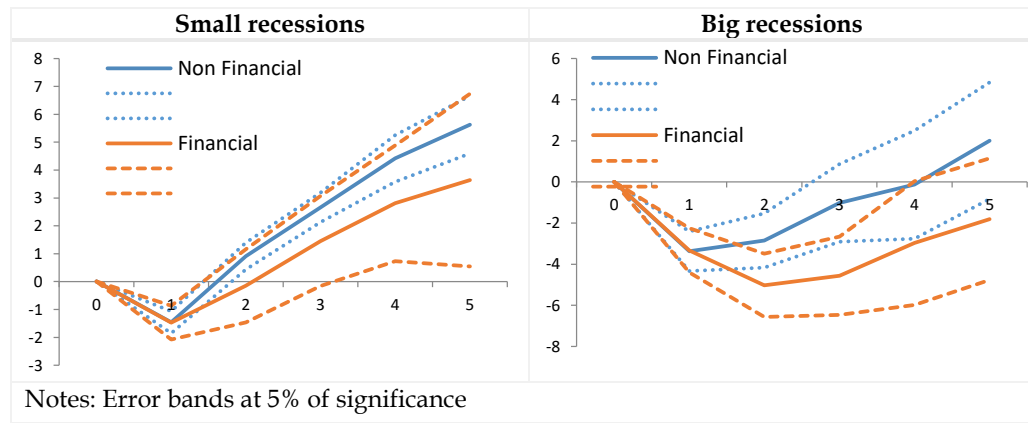
*Financial nature is only important if the recession is big*

Up to now, the evidence presented shows remarkable similarities between the results obtained using financial and size dummies. By interacting these two categories, we can get further insight about the average recession and recovery paths. To do so, a regression of cumulative growth as a function of the interaction of the dummy variables is run. Specifically, the following equation is estimated:

$$(3) \quad \Delta_h y_{i,t+h} = \alpha + \alpha_i + \beta_{bf} B_{i,t} * F_{i,t} + \beta_{bn} B_{i,t} * N_{i,t} + \beta_{sf} S_{i,t} * F_{i,t} \\ + \beta_{sn} S_{i,t} * N_{i,t} + U_{i,t}$$

Here N, F, B, S are defined as before and  $\beta_{jk}$  is the response of the cumulative growth to the interaction of the treatment variables identifying recessions episodes by size ( $j=\{b,s\}$ ) and financial non-financial nature ( $k=\{f,n\}$ ). This is equivalent to estimating equation 2 grouping by size.

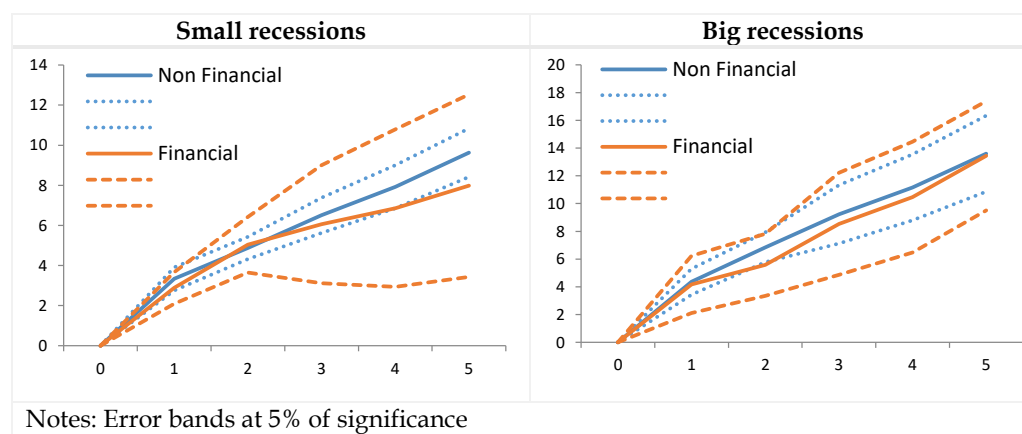
Figure 1.3 Recession paths grouped by size including controls



The results of this regression are plotted in Figure 1.3. It is observed that small recessions are not significantly different among them irrespective of whether they are classified as financial or not. Some of Jordà et. al (2013) results still hold conditional on output losses being higher than the historical mean during a particular financial development phase (right panel Figure 1.3). Taking this condition into account, financial crises are accompanied by recessions 1 year longer on average. This implies that the cumulative output loss is around 2 percentage points bigger on average. As a consequence the economy is significantly below its initial output level 4 years after a peak associated with a financial crisis.

On the other hand, the average economy is fully recovered from a non-financial big recession 4 years after the trough. These numbers are considerably higher than the single year it takes for an average economy to recover from a small recession (whether financial or not). These results are consistent when using an alternative financial recession identification that allows for financial crises episodes to be linked with more than one recession.

Figure 1.4 Recovery paths grouped by size including controls



Regarding recovery paths (Figure 1.4), as before, we can get the cumulative impulse responses to the treatment variables by changing the reference point to the trough in equation 3. In this case the results suggest that the recovery paths are not significantly different whether recessions are accompanied by a financial crisis or not. This means that, in terms of output growth rates during the recovery, there are no differences between financial and non-financial episodes.

This confirms the results reported when using equation 2. We can conclude also that there are no significant differences among recoveries from big and small recessions. This also confirms that on average big recession take longer to recover because the output loss is bigger and not because of a slower growth rate.

### *The usual suspects*

From the analysis up to this point we observe that deep recessions can be accompanied by financial crises, but this is not an unequivocal relationship. There are deep recessions that are not related with financial crises and there are financial crises accompanied by small recessions. Then the determinants of the size of the recession, and therefore the time of recovery, are not necessarily associated to the nature of the crisis. The usual culprits in the literature are debt overhang (v.g. Dell’Ariccia et al, 2008; Hong and Tornell, 2005; Kannan, 2012; Jorda et al, 2013), asset bubbles (v.g. Jorda et. al, 2015), different magnitude of the shocks (Stock and Watson

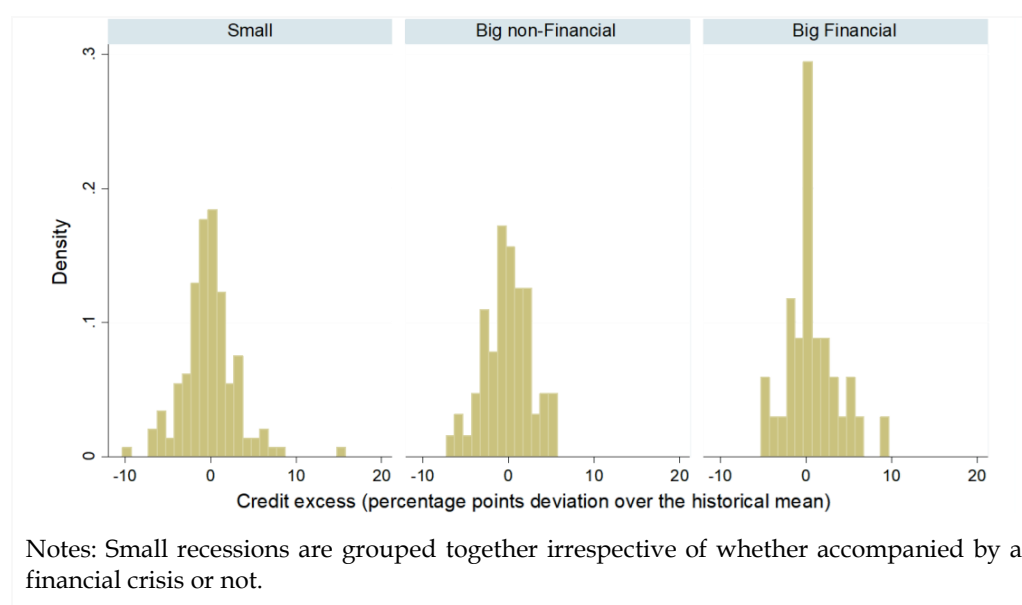
2012), Monetary and fiscal policy tightness (v.g. Hall, 2016; Gali et al., 2012) among other causes that might be also associated with slow recoveries.

Notice that the results showed that the size of the recessions does not seem to determine the speed of recovery. But finding the determinants of the size of the recession might be important for the duration of the recovery. To do so we add to the analysis the most usual explanation in the literature in the next section. This is: debt accumulation. Exploring other alternatives is out of the scope of this paper and is left for future research.

## 1.5 DEBT RUN-UP AND OUTPUT LOSS

Jordà et al. (2013) evaluated the effect on the recession paths of credit excess – defined as the deviation in percentage points of the average credit to GDP ratio growth during the expansion from its historical average during a particular phase. They concluded that credit excess has a significant negative impact on the recession paths whether accompanied by a financial crisis or not. This is, recessions are deeper and longer if there was excessive credit growth during the expansion.

*Figure 1.5 Density of credit excess by size and financial nature of the crisis*





As can be seen in Figure 1.5, a high percentage of big financial crisis are preceded by “excessive” debt to GDP ratio growth. Additionally, looking at the distributions of credit excess for the three classification, there seems not to be a clear difference between them. This suggests that if excessive debt plays a role independently from the magnitude of the recession or the occurrence of financial crises, then the effect should be similar across types of episodes.

To evaluate the importance of debt run ups, we should compute the different recession paths accounting for credit excess. Given the availability of data on credit excess, the usable sample of business cycles peaks is reduced to 245, of which 65 are associated with financial crisis, 89 exhibit excess credit and 98 recessions are considered big.

Since the number of big financial and small financial recessions preceded by abnormal debt to GDP ratio growth are just 22 and 12 respectively, the assessment of the effect of a debt run-up on the severity of a recession is done using credit excess variable (E) as previously defined instead of using a treatment dummy. To do so, the following regression is estimated:

$$(4) \quad \Delta_h y_{i,t+h} = \alpha + \alpha_i + \beta_{bf} B_{i,t} * F_{i,t} + \beta_{bn} B_{i,t} * N_{i,t} + \beta_s S_{i,t} \\ + \beta_{bfd} B_{i,t} * F_{i,t} * E_{i,t} + \beta_{bnd} B_{i,t} * N_{i,t} * E_{i,t} + \beta_{sd} S_{i,t} * E_{i,t} + U_{i,t}$$

We already showed that financial recessions are only different from non-financial conditional on being deep. As a consequence, in equation 4 the interaction between the dummies small and financial is excluded. This means that we are having results for small recessions, big non-financial and big financial episodes. This should not make a big difference in terms of the interpretation of the results since they are focused on the contribution of debt overhang to deep recessions and speed of recovery.

As can be noted by the results reported in Table 1.5, the significant effects on the recession paths vary widely among types of episodes. All episodes seem to be deeper when accompanied by excessive debt. While the most significant effects are for big non-financial recessions. For the latter, one percentage point of credit excess implies an additional cumulative output loss of 2.111% with respect to the peak after 5 years on average. This is much bigger than the average effect on small recessions (0.41%).

Table 1.5 Regression results: Interactions with credit excess from peak

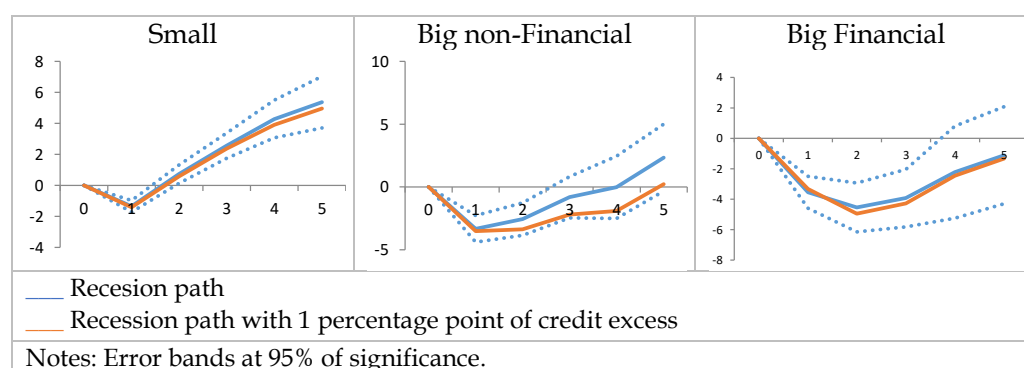
VARIABLES	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Small x Credit Excess</b>	-0.0647** (0.0251)	-0.148* (0.0748)	-0.197* (0.112)	-0.376** (0.132)	-0.410** (0.146)
<b>Big x Credit Excess</b>	-0.183 (0.189)	-0.835*** (0.186)	-1.386*** (0.376)	-1.898*** (0.615)	-2.111*** (0.587)
<b>Financial x Credit Excess</b>	0.231 (0.136)	-0.411** (0.147)	-0.340 (0.295)	-0.248 (0.339)	-0.213 (0.410)

Notes: Robust standard errors in parentheses

Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

On the other hand, it seems that most of the effect of debt run ups recessions is concentrated in the magnitude of the output loss and that it only affects the paths of big non-financial episodes (Figure 1.6). This is confirmed by the results of the regression from the trough reported in Table 1.6, according to which there are no significant effects of debt run-ups on growth rates during the recoveries at 5% of significance for every type of episode.

Figure 1.6 Typical recession paths and debt run-up effect.



The rationale for this could be associated with two effects of debt run-ups. Firstly, if this is due to a high public debt, governments will be forced to pursue fiscal consolidation programmes causing an initial deeper output loss. Secondly, financial frictions literature suggest that negative shocks associated with financial crises, restrict credit and slow the pace of investment delaying recovery (e.g. Bernanke and Gertler, 1989; Gertler et al., 2010). Notwithstanding, this channels seem to be affecting

only the magnitude of the recession itself but no hurting the growth potential of the economy on the medium run.

*Table 1.6 Regression results: Interactions with credit excess from trough*

VARIABLES	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Small x Credit Excess</b>	-0.0824 (0.0766)	-0.0620 (0.125)	-0.275* (0.134)	-0.291* (0.161)	-0.259 (0.229)
<b>Big x Credit Excess</b>	0.157 (0.139)	-0.0290 (0.273)	0.0677 (0.367)	-0.248 (0.527)	0.157 (0.566)
<b>Financial x Credit Excess</b>	0.00968 (0.200)	0.538 (0.583)	0.666 (0.696)	0.861 (0.848)	1.048 (0.713)

Notes: Robust standard errors in parentheses

Significance levels: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

To sum up, credit excess has a significant effect on the severity of the recession but not on the speed of recovery. This effect is less important for small recessions and for recoveries from big financial recessions. Given their mixed significance, it is needed to check whether debt accumulation effects disappear once controls are introduced in section 6.

## 1.6 ROBUSTNESS CHECK: INCLUDING ECONOMIC COVARIATES

The results reported in the previous section suggest that recessions that are big are significantly different from small recession but only with respect to the size of the shock. This is, the magnitude of the loss is not associated with a slower recovery. This is also true for financial recessions.

Regarding the effect of debt on recessions and recovery paths, findings from previous literature (Jordà, et al., 2013) are somewhat confirmed with some caveats. Big non-financial recessions are the most significantly affected by excessive debt accumulation. Excess debt growth has a magnifying effect on output loss, but growth during the recovery seem to be not significantly affected. As with size and financial

crisis effect, debt overhang seem to play no role determining the speed of recovery, defined as the growth rate during the recovery.

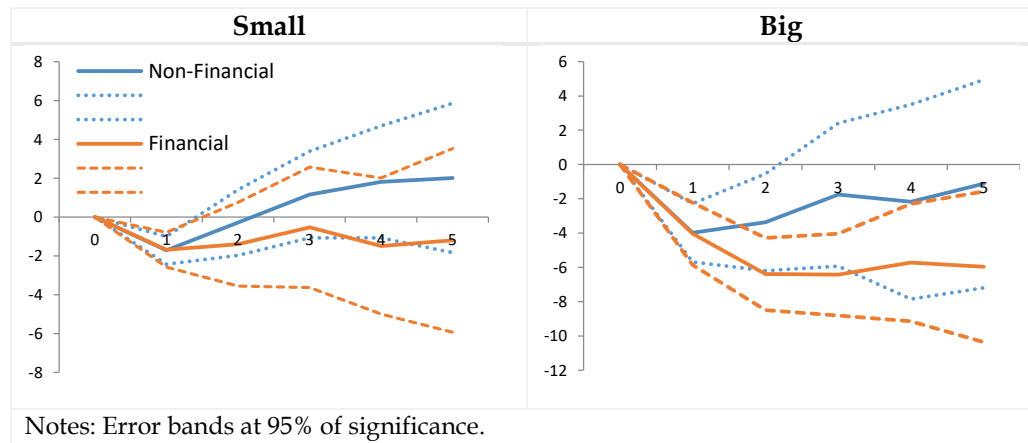
Notwithstanding, these results are not entirely believable, since omitted variable bias could be present. This is, the dynamics of output growth is determined by more factors apart from the nature of the crisis or whether the recovery is caused by a big or a small shock. To remove this possible bias, regression 3 is modified by introducing economic controls as follows:

$$(5) \quad \Delta_h y_{i,t+h} = \alpha + \alpha_i + \sum_j \beta_j T_{j,i,t} + \sum_{k=0}^K \Gamma_k X_{i,t-k} + U_{i,t}$$

Where  $(\alpha + \beta_j)$  is a point of the average recession or recovery path associated with treatment  $T_{j,i}$ . Notice that here treatment  $j$  refers to the interaction of financial dummies with size dummies, such that we are having 4 groups as in equation 3. Finally,  $X_{i,t-k}$  is a matrix of economic controls.

For comparability with the results reported by Jordà et al. (2013) in what follows I am reporting the results of this regression when including the same controls used by them. These controls are: the growth rates of real GDP per capita and real total loans per capita, the CPI inflation rate, the short-term and long-term interest rates, the investment to GDP and the current account to GDP ratios. Controls are included contemporaneously and lagged one period.

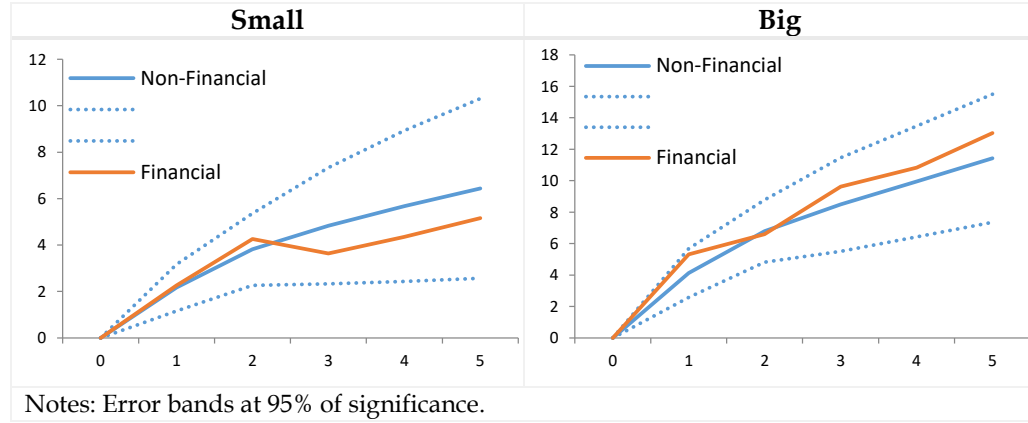
Figure 1.7 Recession paths estimation including controls



The results reported in Figure 1.7 are consistent with the ones found with regression 3. Small recession are statistically the same whether financial or not. Big recessions are deeper than small ones and when they are accompanied by a financial crises they experienced a second year of negative growth and therefore the output loss associated with them is bigger.

When the analysis is made for recovery paths (Figure 1.8.), we can conclude that average growth rates during recovery are not affected significantly by the nature of the crisis and that big recessions are recovering at a higher growth rate than small recessions. This is also a robust result from previous sections.

Figure 1.8 Recovery paths estimation including controls



In section 5 we found that debt run-ups have a significant impact on the magnitude of the recession especially for big non-financial recessions. Again, to confirm those results, we run a regression with controls  $X_{i,t-k}$  as in equation 6 including treatment dummies for small, big non-financial and big financial episodes. Interactions between these three dummy variables and the excess credit variable are also included.

$$(6) \quad \Delta_h y_{i,t+h} = \alpha + \alpha_i + \sum_j \beta_j T_{j,i,t} + \sum_j \delta_j T_{j,i,t} * E_{i,t} + \sum_{k=0}^K \Gamma_k X_{i,t-k} + U_{i,t}$$

In this specification the  $\delta_j$  parameters are giving us the impact of 1 additional percentage point credit excess on the recession and recovery paths for the average episode of type  $j$ . As can be seen in Table 1.7, these coefficients are only significant at

the 5% for small recessions in year 1 and for big non-financial recessions from the second year onwards.<sup>7</sup>

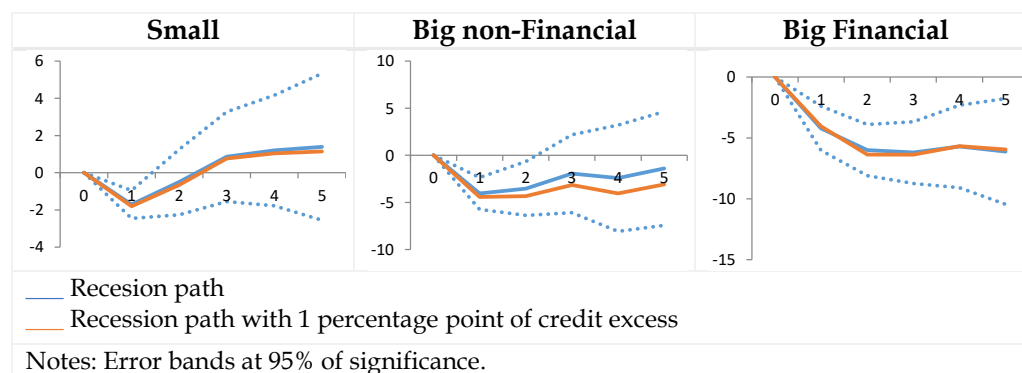
Table 1.7 Regression results: Interactions with credit excess from peak

VARIABLES	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Small*Credit Excess</b>	-0.0961** (0.0381)	-0.163* (0.0814)	-0.105 (0.120)	-0.155 (0.132)	-0.246 (0.184)
<b>Big*Credit Excess</b>	-0.372* (0.199)	-0.805** (0.287)	-1.203** (0.501)	-1.622** (0.676)	-1.691** (0.645)
<b>Financial*Credit Excess</b>	0.153 (0.145)	-0.374* (0.184)	-0.178 (0.288)	0.0321 (0.317)	0.166 (0.382)

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Figure 1.9 Regression results: Interactions with credit excess from peak



Furthermore, it can be seen in Figure 1.9 that on average credit excess negatively affects growth for big non-financial recessions, such that the contribution keeps growing until it reaches about 1.7 additional percentage points of output loss after 5 years. It is also noticeable that once controls are introduced the significance of the effect of credit excess on small and big financial recessions diminishes.

<sup>7</sup> One possible explanation for the effect on big financial recessions to be less important could have to do with the dummy variable associated with them already picking up some of its effect.

When the regression is run taking the trough as a reference point, I found that credit excess has a significant impact at 5% only for recovery paths from a big financial recession on years 2 and 5. It can be seen in Table 1.8 that from the second year of recovery, the accrued growth is significantly pushed upwards. This results goes against the argument that debt overhang help to explain slow recoveries.

*Table 1.8 Regression results: Interactions with credit excess from peak*

VARIABLES	Year 1	Year 2	Year 3	Year 4	Year 5
Small*Credit Excess	-0.0138 (0.105)	0.150 (0.166)	0.0466 (0.174)	-0.0942 (0.199)	-0.123 (0.259)
Big*Credit Excess	0.379 (0.242)	0.439 (0.346)	0.663 (0.472)	0.451 (0.598)	0.744 (0.631)
Financial*Credit Excess	0.158 (0.204)	1.010** (0.380)	1.164 (0.680)	1.339* (0.760)	1.450*** (0.471)

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Therefore, we can conclude that excessive debt accumulation during the expansion preceding a recession. Help to explain the magnitude of the output loss, especially for big non-financial recessions. On the other hand, I did not find statistical evidence supporting the claim that debt overhang is associated with slower recoveries. Therefore, the analysis made in this paper only supports a positive effect of the magnitude of recessions on the speed of recovery. This finding is analysed in the next section when comparing it with what a standard business cycle model implies.

## 1.7 SIZE EFFECT REVISITED

The analysis presented in this paper showed that the financial nature of the recession and the debt over hang seem not to be associated with growth rates variability during recoveries. In fact, the size of the recession is the only factor playing a statistically significant role. Contrary to what some authors suggest (v.g. Romer & Romer, 2015), big recessions are not associated with sluggish recoveries, but with faster growth

rates during the recovery phase. This implies that the size of the shock is not positively correlated with persistence of the recession.

In a similar way to Romer and Romer (2015), Stock and Watson (2012) concluded that the 2007-2009 recession in the US was the product of bigger and more persistent shocks. Both of these studies suggest a positive relationship between size and persistence of the recessions. Moreover, they conclude that the mechanisms of the crisis plays no or a limited role determining the magnitude and persistence of a recession.

Assuming that those authors are right and the size of the recession is associated with a higher persistence, then a simple DSGE model should be enough to recreate small and big recessions. More importantly, It should be enough to generate big recessions that are at the same time more persistent.

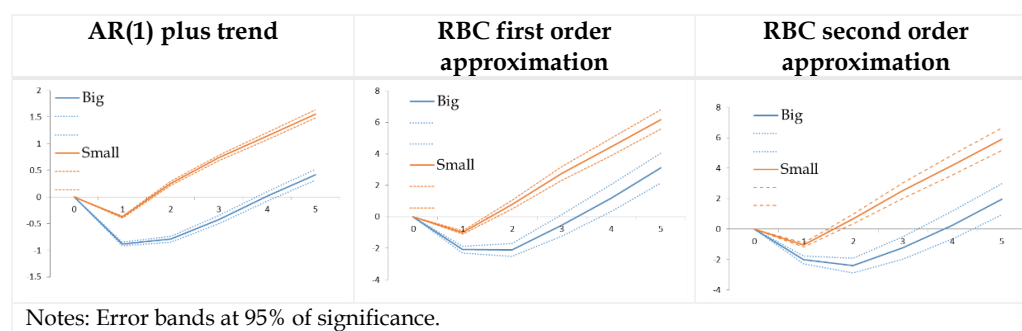
I test in this section whether theory supports the findings in this paper or the suggested positive association between persistence and size of the recession supported by the aforementioned literature. To do so, I use simulated series from a typical RBC model (King & Rebelo, 1999) and then I estimate the typical recession and recovery paths conditional on the size of the recession.

To make comparable the results from this Monte Carlo experiment with the results obtained from the data presented previously, I use the same calibration as in King and Rebelo (1999) and add a trend to the stationary data obtained from the simulation. Then, I add 4 consecutive data points to form an annual observation. Finally, as before I identify turning points using the Bry and Boschan (1971) algorithm and estimate the impulse responses by local projections methods (Jordà, 2005). Additionally, the error bands are computed as the by-result of estimations for 10,000 rounds of simulations.

The results reported in Figure 1.10 look overwhelmingly similar to those obtained from the estimation of equation 1 using empirical data. A typical big recession has two consecutive years of negative growth, 1 more than an average small recession. Additionally, the characteristic growth path during the recovery from a big recession is not significantly different from the recovery path from a small episode.



Figure 1.10 Typical recessions from simulated data



The previous result might have nothing to do with the fitness of the RBC model. As seen in Figure 1.10, when replicating the exercise for a typical AR(1) process plus trend we obtained very similar results to the ones obtained with a linear approximation of the RBC model. A bigger shock produces a deeper initial fall in output. What the non-linearities of the model are adding is the amplification of the shock to the second year.

This means that even in theoretical models the size and persistence of the shocks are not enough to explain the business cycle dynamics. Amplification and transmission mechanisms are important to determine the effect of the shock in a DSGE model. In the case of a standard RBC model, the amplification mechanisms (general equilibrium dynamics and non-linearities) help to determine the duration of the recession (the number of periods with negative growth).

Therefore, some economic mechanisms should be explaining both deep recession and slow recoveries (apart from the description of the data as an AR processes). Popular mechanisms are financial frictions and policy shocks. The former may produce credit crunches during the recovery affecting investment dynamics, while the latter may affect output growth if government are restricted in the use of policy instruments, for instance by a fiscal consolidation programme or a zero lower bound (Gali, et al., 2012). Evaluating these explanation is out of the scope of the purpose of this essay. It is lead for future research to evaluate empirically what factors –apart from the ones evaluated in the previous sections of the paper– might explain slower recoveries and whether theoretical models account for them.

## 1.8 CONCLUSIONS

In this paper, I test the views that big recessions and slow recoveries are the consequence of the financial nature of the crises or the by-product of bigger and more persistent shocks. To do so, I estimate by local projections the recession and recovery paths conditional on size and financial nature of the crisis using annual data for 17 countries (Jordà, et al., 2017).

The evidence presented here allows to conclude that financial recessions are more painful than normal recessions conditional on them being big enough. Furthermore, it can also be concluded that the severity of the recession is, if something, associated with faster growth during recoveries. Besides, recoveries from financial crises are not significantly slower in general.

On the other hand, the claim that deep recessions and slow recoveries are the by-product of bigger and more persistent shocks (Romer and Romer, 2015; Stock and Watson, 2012) is an incomplete answer. Using simulated data from a simple RBC model, I concluded that non-linearities play a role determining the magnitude and duration of a recession. Therefore, other factors such as rigidities and frictions may be responsible for the recession magnitude and the sluggishness of the recovery.

The role of debt run-ups was also evaluated. The evidence confirms partly Jordà et al. (2013) finding that debt accumulation play a role determining the magnitude of the recession. Notwithstanding, the statistical evidence does not support that debt over-hang plays a role determining growth during recoveries. Further research is needed to unveil additional factors explaining both big recessions and slow recoveries.

## 1.9 APPENDIX: DATA DESCRIPTION

I use the Macro Financial data base gathered by Oscar Jordà, Moritz Schularick, and Alan M. Taylor (2017) (JST from now on). For comparability with Jordà et al (2013), I use the same variables they used in their full model. This is, the real per capita GDP, consumption per capita, investment to GDP ratio, total loans, population, price index, current account and the systemic financial crises identifier. The data is available for the following 17 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States of America.

### Systemic financial crisis variable.

To begin with, the financial crises dummy was build using previous literature results. In particular, Reinhart and Rogoff (2009) and Bordo et al. (2001) were used for most of the episodes and countries. These two references are the main contributors to the financial crisis dummy and therefore the definitions they use for systemic financial crises are worth to mention. For Bordo et al. (2001) a financial crisis is an episode of “financial-market volatility marked by significant problems of illiquidity and insolvency among financial-market participants and/or by official intervention to contain such consequences” (Bordo et al. 2001, pp 55).

Notwithstanding the definition of systemic financial crisis used by the authors is the one reported in Laeven and Valencia (2008). That is, a financial crises are “events during which a country’s banking sector experiences bank runs, sharp increases in default rates accompanied by large losses of capital that result in public intervention, bankruptcy, or the forced merger of major financial institutions” (Jordà et al., 2010, pp. 5). According to this, the financial crisis variable takes a value of one if in a given year for a given country an event with the characteristics mentioned before happened.

### Real per capita GDP

The real per capita GDP is an index using 2005 as base year. This is a spliced series that relies on Barro and Ursua (2010) data base for the 1970-2004 period. From 2005 onwards the series is completed using growth rates from the World Bank.

### Real Consumption per capita

This is an index with 2006 as base year. As with the real per capita GDP, the main source for this information is the series collected by Barro and Ursua (2010) for the period 1901-2009. From 2010 onwards the series is completed using the World Bank Data on household final consumption expenditure per capita (constant 2005 US\$, Chain linked).

### Investment to GDP ratio

This is also a spliced series. Depending on the country the sources change. Although multiple sources are used, JST (2017) have tried to improve the robustness of the series by replacing multisource data on Nominal Gross Capital Formation with data from the IMF – International Financial Statistics for the post-WWII period. The investment ratio is then constructed by dividing the nominal gross capital formation by the nominal GDP. The latter is also a multisource data series that relies on the IMF – International Financial Statistics for the post-WWII period.

### Total Loans

This variable refers to the total loans to non-financial private sector expressed in nominal terms in local currency. It is used to build the total loans to GDP ratio using the nominal GDP, as described before. This ratio is used to build the variable credit excess, which is defined as the deviation in percentage points from the historical average of the total loans to GDP ratio by phases of financial development as defined in Jordà et al. (2013).

The sources for the total loans are diverse among countries and depending on the case are completed using data from the IMF – IFS. For more information check the documentation of the JST (2017) database.

### Population

The population is a series taken from the Angus Madison Database (2008), Historical statistics of the world economy, for the period 1870 – 2009. It is completed with data on population growth from the IMF for the period 2009 – 2013. When the data was not available for a specific country in the main database it was completed with information from alternative sources. A special case is Finland, where the whole series (1870 – 2013) was taken from Statistics Finland (2016).

### Price index

It is a collection of consumer price indexes with base year 1990. For most of the countries the series is based on A. Taylor (2002) A Century of Purchasing-Power Parity, Review of Economics and Statistics, vol. 84(1), p139-150. The series is completed with data on average consumer inflation from the IMF – World Economic Outlook.

### Current account

Finally, the current account is a nominal, local currency series. It is used to compute the current account to GDP ratio, using the nominal GDP series as described before. The series is constructed from multiple sources. For more details check Jordà et al. (2017).

## 2 OPTIMISTIC EXPECTATIONS AND FINANCIAL CRISES

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### 2.1 INTRODUCTION:

The US subprime crisis was followed by a long and deep recession, much deeper and longer than any previous post-war US recession. At the same time, European Union countries suffered a combination of banking and government debt crises that caused large drops in employment and GDP.<sup>8</sup> These episodes proved false the idea that big financial and economic crises are exclusive to developing and emerging economies in which capital and financial markets are less efficient. It also underscored the fact that economic downturns that are accompanied by financial crises seem to be bigger and more persistent than other economic crises, and they are usually accompanied by persistent falls in asset prices and an explosive trend in government debt. (e.g. Reinhart and Rogoff, 2009; Cerra and Saxena, 2008)

Additionally, it seems that pre-crisis debt growth plays a role not only in feeding the risk of financial crisis, but also as a determinant of the magnitude of the recession (e.g. Hong and Tornell, 2005; Jorda et al., 2013). Dell’Ariccia et al (2008) and Kannan (2012) found evidence in this direction using firm level data, while Berkmen et al (2012) found that developing countries with a highly leveraged financial system, a rapid growth in credit and a preference for short term debt tend to experience stronger impacts of financial crises on growth. In the same spirit, there is evidence suggesting that when asset bubbles are fuelled by credit booms, the recessions that follow tend to be longer and deeper (Jorda et al., 2015).

On the other hand, empirical evidence suggests that output expectations prior to the crisis play an important role in determining the dynamics of the economy and explaining the financial crisis (Chauvet and Guo, 2003, and Cerra and Saxena, 2008).

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<sup>8</sup> Real GDP growth rates in 2009 for the Euro Area and the USA were -3.77% and -2.78%, according to the IMF data. Unemployment rates were above 8% in the USA during the period 2009-2012. Euro zone unemployment rallied from 7.58% in 2008 to 12.2% in 2013.

These findings are all consistent with the idea that the pre-crisis dynamics are important in determining the severity and persistence of recessions.

In this paper, I use unrealised news to model optimism in an otherwise standard DSGE model. This allows the pre-crisis dynamics to be related to the downturn dynamics. At the same time, comparisons of the effect of news about different shocks are done to evaluate the idea that financial crises are associated with deeper recessions and slower recoveries (Reinhart & Rogoff, 2009) due to some differential characteristics of these episodes.

The financial frictions literature has taught us that these frictions are an important amplification and propagation mechanism (e.g. Bernanke and Gertler, 1989). Within this framework, crisis experiments have been modelled as negative shocks on technology (e.g. Kiyotaki and Moore, 1997), net worth (e.g. Bernanke et al, 1999), and deleveraging shocks (e.g. Eggertsson and Krugman, 2012) among others. This literature has brought a better understanding of the link between macroeconomic and financial variables. Notwithstanding, important features of the economy and of the mechanisms behind the crisis might be missing. This is because negative exogenous and/or idiosyncratic shocks are usually blamed for the occurrence of economic downturns. In this way, pre-crisis economic dynamics have been neglected in standard economic DSGE models.

Conversely, the approach used in this paper accounts for the importance of the correlation between optimistic expectations, debt run-ups and the occurrence of deep and persistent downturns. I show here a model where the pre-crisis behaviour and the bust that follows are generated by optimistic expectations about future investment returns. To do so, I introduce news to an otherwise standard DSGE framework with financial frictions as presented by Gertler and Kiyotaki (2010). Financial optimism is modelled as unconfirmed news about capital returns, that if unjustified (ex-post) leads to a deleveraging process, an asset price bust and a financial crisis. An advantage of this framework is the fact that shocks to capital returns affect financial intermediaries more directly than typical TFP shocks. This allows me to distinguish between a “financial” and a traditional technology shock.

The modelled behaviour is similar to Keynes’ (1936) “animal spirits”, Pigou’s (1927) waves of optimism and Minsky’s (1977) financial instability hypothesis. . If people

believe that an investment project is going to be profitable (and that the risk is acceptable), then they are willing to invest in that project. Entrepreneurs take on debt and a boom of debt and investment takes place. This also leads to a rise in asset prices.

A crisis occurs when the expectations about future high returns on investment (capital value) turn out to be false. In this case, returns on investment are not enough to service the debt. At the same time, asset prices go down, reflecting the actual productivity of capital and consequently, fire sales of assets need to take place to pay the debt. This leads to an investment drop and a decline in output and net worth. This is a debt – deflation process à la Fisher (1933). Debt burden jointly with financial frictions implies that investment is delayed further, making recessions more persistent.

In this way, agents can affect the returns of their own investments and their balance sheets by accumulating capital and debt beyond what is optimal, due to optimism. This idea has been incorporated to some extent in models that use expectations as endogenous drivers of stock price collapses (e.g. Branch and Evans, 2011; Williams, 2012).

More generally this chapter is related to literature claiming that expectations can drive the business cycle. This includes the adaptive learning, the sunspots cycles literature and the news driven cycles literature. In the former, agents have bounded rationality and behave like econometricians trying to forecast the future. They could or could not know the exact structure of the economy and they are gradually learning about the economic environment. Mitra et al (2013), Eusepi and Preston (2011), Williams (2003), Milani (2007, 2011) and Cellarier (2006, 2008) among others have used adaptive learning to explain the role of expectations as drivers of the business cycles and have concluded that under this framework endogenous economic fluctuations can arise. In the same spirit Branch and Evans (2011) showed that least squared learning is capable to generate endogenous booms and bust in asset prices as a response to changes in the fundamentals. Also Williams (2012) using a similar framework showed that changes in beliefs can generate asset prices cycles but in his model portfolio choice matter and a flight to quality happens as a result of correction on expectations.



The literature on sunspot cycles arising from financial frictions, or rational bubbles, is also related to this work. In this literature, multiple equilibria exist. Sunspot shocks lead the economy from a good state to a bad state and a crisis occurs. A bubble occurs when the market price of an asset and the value of its fundamentals differ. The bubbly state exists as a consequence of financial frictions (for a full review of this literature see Benhabib and Farmer, 1999; Hamilton, 2016; and Martin and Ventura, 2018). In the rational bubble literature, there is a positive wealth effect of the bubble (e.g. Martin and Ventura, 2012) instability arise because the bubble can burst. Recently, Kunieda and Shibata (2016) propose a combination of two policies to prevent self-fulfilling financial crisis while taking advantage of the positive wealth effect of the bubble.

Within the rational expectations framework it has been shown that signals about future changes in some variables such as technological progress can cause cyclical movements due to people's tendency to speculate about future economic environment (Beaudry and Portier, 2004, 2006, 2007 and 2013). According to the news view busts are rare events that only occur if optimistic news about the future of the economy turn out to be wrong (Beaudry and Portier 2013). Information shocks can generate cyclical movements only in a multi-sector framework (Beaudry and Portier, 2004 and 2007) and investment – liquidation cycles and asset prices booms and bust arise because of taking false information as true. Once the fault in information is unveiled adjustment take place.

Dispersed information can be modeled under this framework as in Lorenzoni (2009) where market niches are introduced through the figure of islands. Agents consuming and producing in each island cannot estimate accurately the economy fundamentals due, among other factors, to the presence of multiple island specific shocks and the inability to observe the aggregated shocks on the economy. More recently, using this framework Gunn and Johri (2013) analyzed the effects of news about technology progress on banking and Gomes and Medicino (2012) introduce news as drivers of housing prices bubbles and busts.

The model presented here is strongly related with Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). The main difference with respect with these two has to do with what they have called the crisis experiment. The former is a typical financial frictions model where a crisis occurs in response to a negative shock to capital quality.

The latter define a crisis experiment as a negative news shock where the adjustment process is smoothen by modifying the probability assigned to the bad event happening. In the model presented in this chapter a crisis occurs when good news about capital quality are not realized and the adjustment process needs to take place immediately.

Secondly, While Gertler and Karadi (2011) studied the effects of waves of pessimism, I studied the possibility that pre-crisis dynamics as well as the downturn accompanied by the crisis could occur because of optimistic expectations. A difference with previous literature about expectations driven financial crises is that I compare the responses to technological and financial news, concluding that only financial news can produce a financial crisis (as defined in this chapter).

The rest of the chapter is organized as follows: In section 2 I presented a simplified model as in Gertler and Kiyotaki (2010) which includes a private banking sector where financial frictions arise endogenously, as a consequence of the incentive to deviate resources for their own use. Unlike Gunn and Johri's (2013) work, news about capital value, rather than the efficiency of the banking sector, drive the business cycles. It is also closely related to Gertler and Karali (2010) but unlike them, I do not restrict the way the economy adjusts to unrealised news.

In section 3 the calibration of the model is presented and a crisis experiment is defined. The results of this experiment are analysed in section 4. I found that optimistic news about future returns on capital lead to an excessive accumulation of debt and capital and, subsequently, to a boom in output. Once agents realise they were wrong, they need to liquidate capital to pay back the debt, but now the price of capital is much lower and they need to fire sale assets. This is a distinguishing feature of the model compared with Gunn and Johri's (2013).

In section 5, I compare cycles driven by financial and technology optimism. I found that the latter are not accompanied by asset price booms nor by an improvement in banks net worth during the expansion. This also implies bigger adjustments in these variables once people learn the truth about capital returns. I also found that financial crises are accompanied by stronger debt cycles. Some robustness checks are presented in section 6. Finally, some conclusions are presented in the last section.

## 2.2 OPTIMISM AND FINANCIAL CRISIS

To represent an economy where animal spirits play an important role – not only causing a financial crisis, but also amplifying and magnifying shocks – I introduce news, or anticipated shocks, on investment returns (or assets value). Agents cannot tell whether the information is accurate, and their behaviour following the news generates booms in asset prices and build-ups of debt. When the news turn out to be wrong, they are followed by asset prices busts, deleveraging processes and long lasting recessions.

I modify the simplest version of the financial intermediation model by Gertler and Kiyotaki (2010). This is the case of a frictionless interbank market such that the only financial friction is related to the inability of the depositors to enforce the repayment of their “loans” to the banks. A banker has incentives to divert funds raised through deposits to personal uses. If she does that, then the bank defaults on its debt and it shuts down. The model is described in the following sub section.

### 2.2.1 The model

The economy is populated by a continuum of households whose members can either be bankers or workers. Banks raise deposits from households and make loans to the goods producers. There are two types of producers: capital goods producers that operate under perfect competition, and goods producers of size 1. The behaviour of these economic units is described next.

#### 2.2.1.1 Goods producers:

Firms operate under perfect competition in a national market and face a Cobb-Douglas technology as follows:

$$(1) \quad Y_t = A_t F(K_t, L_t) = A_t K_t^\alpha L_t^{1-\alpha}$$

They receive funding for their investment projects from the banks in the form of state dependent securities that pay returns  $Z_t$ . Firms buy capital goods ( $K$ ) from capital goods producers at the price  $Q$  and hire labour ( $L$ ) from families at an hourly wage  $W$ .

Optimization conditions are standard. Therefore, wages and returns per unit of capital are respectively given by:

$$(2) \quad W_t = (1 - \alpha)A_t \left( \frac{L_t}{K_t} \right)^{-\alpha} = (1 - \alpha)A_t \left( \frac{Y_t}{L_t} \right)$$

$$(3) \quad Z_t = \alpha A_t \left( \frac{L_t}{K_t} \right)^{1-\alpha} = \alpha \left( \frac{Y_t}{K_t} \right)$$

Capital accumulation equation is given by:

$$(4) \quad K_{t+1} = \Psi_{t+1}[I_t + (1 - \delta)K_t]$$

A shock to the capital quality ( $\Psi_{t+1}$ ) is interpreted here as a capital productivity shock or, more precisely, as a capital value shock. This would have indirect effects on the marginal productivities through a channel similar to a scale effect.

### 2.2.1.2 Capital goods producers:

Meanwhile, capital goods producers sell capital goods at the price  $Q$  to goods producers and they face convex adjustment costs of investment so that their maximization problem is:

$$\max_{I_t} E_t \sum_{i=0}^{\infty} \beta^i \frac{\lambda_{t+i}}{\lambda_t} \left\{ Q_{t+i} I_{t+i} - \left[ 1 + f \left( \frac{I_{t+i}}{I_{t+i-1}} \right) \right] I_{t+i} \right\}$$

The adjustment cost function has the following properties:  $f(1) = f'(1) = 0$  and  $f''(\cdot) > 0$ ; and  $\lambda$  is the households' Lagrange multiplier associated to its budget

constraint. The optimality condition for them is given by equation 5 and it implies that in steady state the price of capital goods needs to be 1.

$$(5) \quad Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{I_{t+1}}{I_t}\right)^2 f'\left(\frac{I_{t+1}}{I_t}\right)$$

### 2.2.1.3 Households:

The representative household is composed by a continuum of members of size 1. It is formed by  $f$  bankers and  $(1-f)$  workers. There is perfect consumption insurance within the household which implies that the consumption is the same irrespective of being a banker or a worker. The utility function follows (Christiano, et al., 2008):

$$\max_{\{C_t\}, \{L_t\}} E_t \sum_{i=0}^{\infty} \beta^i \left[ \ln(C_{t+i} - \zeta C_{t+i-1}) - \chi \frac{L_{t+i}^{1+\varepsilon}}{1+\varepsilon} \right]$$

Households choose their demand for consumption goods and their supply of hours worked subject to a budget constraint that includes transfers to and from financial and non-financial firms. Bankers transfer non-negative dividends to the families given their flow of funds constraint, and workers supply labour and transfer wage income to the families. The only asset households can hold are bank deposits. They receive the riskless gross interest rate  $R$  in exchange for their deposits. Therefore, the representative household budget constraint is given by:

$$(6) \quad D_{t+1} + C_t = W_t L_t + \Pi_t + R_t D_t$$

Here  $D$  is the quantity of bank deposits holdings and  $\Pi$  are the net transfers from firms and banks. Deposits might be interpreted as one period maturity bonds. Given this, households optimization conditions are given by:

$$(7) \quad W_t \lambda_t = \chi L_t^\varepsilon$$

$$(8) \quad E_t \beta \frac{\lambda_{t+1}}{\lambda_t} R_{t+1} = 1$$

$$(9) \quad \lambda_t = \frac{1}{(C_t - \zeta C_{t-1})} - \beta \zeta \frac{1}{(C_{t+1} - \zeta C_t)}$$

Notice that  $\lambda$  here represents the derivative of the Lagrangian with respect to current consumption. If the habit formation parameter ( $\zeta$ ) is set to zero we go back to the case without habit formation.

#### 2.2.1.4 Banks:

Financial intermediaries are modelled as in Gertler and Kiyotaki (2010). Following them, a proportion  $(1 - \sigma)$  of banks randomly exits the market every period. This prevents bankers from overcoming financial constraints by retaining earning. Exiting banks need to transfer any retained earnings to households and become workers. For simplicity, the number of banks is constant, therefore each period randomly  $(1 - \sigma)f$  workers become bankers.

Banks raise deposits ( $D_t$ ) from households at the beginning of each period, they agree to pay an interest rate  $R_{t+1}$ . Later they learn the level of investment and make loans to goods producers in the form of state contingent securities. These securities pay a dividend of  $Z_{t+1}$  and gross returns given by:

$$(10) \quad R_{kt+1} = \Psi_{t+1} \frac{Z_{t+1} + (1 - \delta)Q_{t+1}}{Q_t}$$

A representative bank maximises the discounted sum of future net worth subject to the flow of funds constraint as follows:

$$\text{Max } V_t = E_t \sum_{i=1}^{\infty} (1 - \sigma) \sigma^{i-1} \beta^i \left( \frac{\lambda_{t+i}}{\lambda_t} \right) N_{t+i}$$

s.t.

$$(11) \quad Q_t S_t = N + D_t$$

Where the net worth of an individual bank ( $N$ ) is defined as:

$$N_t = [Z_t + (1 - \delta)Q_t] \Psi_t S_{t-1} - R_t D_{t-1}$$

*Financial friction:*

Bankers have incentives to transfer funds to their families. Divertible funds for an individual bank will be equal to  $\theta Q_t S_t$ . Diversion of funds will result in default and bankruptcy will occur. In this event, creditors would be able to reclaim the remaining  $(1 - \theta)Q_t S_t$  funds.

To prevent banks from transferring funds to their families the following incentive constraint needs to hold always:

$$V_t(S_t, D_t) \geq \theta Q_t S_t$$

Where  $V_t(s_t, d_t)$  is the maximized value of the value function.

Banks choose  $S_t$  and  $D_t$  at the beginning of period  $t$ , before aggregate uncertainty is realized (because they choose to divert funds between periods). Therefore, their maximization problem can be summarized by the following Bellman equation:

$$V_{t-1}(S_{t-1}, D_{t-1}) = E_{t-1} A_{t-1,t} \left\{ (1 - \sigma) N_t + \sigma \max_{d_t, s_t} V_t(S_t, D_t) \right\}$$

To solve this problem we need to guess the linear form for the value function, where  $Y_{st}$  and  $Y_t$  are time varying parameters, representing the banks' marginal valuation of securities and deposits (debt).

$$V_t(s_t, d_t) = Y_{st} S_t - Y_t D_t$$

The maximization of the value function subject to the incentive constraint implies a restriction on the amount of credit a bank can supply, in other words, it limits their ability to buy securities such that:

$$(12) \quad Q_t S_t = \phi_t N_t$$

Where  $\phi_t$  is the leverage ratio and it is defined by:

$$\phi_t = \frac{Y_t}{\theta - \mu_t}$$

With

$$\mu_t \equiv \frac{Y_{st}}{Q_t} - Y_t > 0$$

$\mu_t$  represents the marginal excess valuation of securities over deposits, such that when it rises, the securities valuation gets higher.

Conditions on  $Y_t$  and  $\mu_t$  for the value function to be linear<sup>9</sup> complete the optimization conditions of the banks as follows:

$$(13) \quad Y_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1}$$

$$(14) \quad \mu_t = E_t \Lambda_{t,t+1} \Omega_{t+1} (R_{kt+1} - R_{t+1})$$

With:

$$\Omega_{t+1} = 1 - \sigma + \sigma(Y_{t+1} + \phi_{t+1}\mu_{t+1})$$

Where  $\Omega_{t+1}$  is the stochastic marginal value of net worth.

Notice that when financial frictions are absent, the banks' optimization conditions are reduced to the equality of the expected returns on securities and the current deposits interest rate. Therefore, when  $\theta = 0$  the model is equivalent to a RBC model with investment adjustment cost and a capital production sector.

#### 2.2.1.5 *Equilibrium:*

In the aggregate, banks' net worth is the sum of existing surviving and entering banks' net worth. The latter receive transfers from the families equal to a proportion  $\xi$  of the total value of aggregated banks' assets. Which imply the following aggregate net worth equation for any particular period.

$$(15) \quad N_t = [Z_t + (1 - \delta)Q_t](\sigma + \xi)\Psi_t S_{t-1} - \sigma R_t D_{t-1}$$

Where S and D stand for aggregated securities holdings and aggregate deposits, respectively.

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<sup>9</sup> This conditions are implied by the Value function iterations.



Equilibrium in goods market, retail credit market (deposits market), and securities market (loans to firms) imply the following:

$$(16) \quad Y_t = C_t + \left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right] I_t$$

$$(17) \quad D_t = Q_t S_t - N_t$$

$$(18) \quad S_t = I_t + (1 - \delta)K_t$$

This equilibrium conditions plus all the numbered equations complete the system of equations used to find the steady state.

### 2.2.1.6 Optimism:

Optimism is introduced through news shocks as in Christiano et al. (2008). The stochastic process for  $\Psi_t$  then is given by:

$$(19) \quad \Psi_t = \rho \Psi_{t-1} + \varepsilon_t + \xi_{t-p}$$

Where  $\varepsilon_t$  and  $\xi_{t-p}$  are i.i.d. non-correlated shocks and  $\xi_{t-p}$  is the news shock. In period  $t-p$ , people received news about capital quality in period  $t$ , but they cannot tell whether it is true or false. When news turns out to be false, a boom followed by a “financial” crisis occurs. Notice that here the news shock is not modelled as a signal extraction problem. If it were modelled in that way, the qualitative responses of the model to the news shock wouldn’t be different.

## 2.3 CALIBRATION AND CRISIS EXPERIMENT

To perform some simulations and analyse the effects of optimism, as defined in the previous section, numerical values are assigned to all the parameters of the model. The discount factor is set to 0.99, a very standard parameterisation that implies a deposit annualised interest rate of around 4.1% in steady state. Following Gertler and Kiyotaki (2010) I set a high value for the Frish labour elasticity to compensate for the

lack of labour market frictions<sup>10</sup>. Given this parameter, the weight of labour in utility ( $\chi$ ) is calibrated to match labour supply in steady state equal to 0.2381. Assuming that workers are endowed with one unit of time, this implies that a representative worker works 40 hours a week.

Following Gertler and Kiyotaki (2010) the survival rate of banks is set to 0.972 implying an average bank's life of 10 years, and  $\theta$  and  $\xi$  are set to match steady state target values for the leverage ratio ( $\phi$ ) of 4 and the interest rate spread ( $R_k - R$ ) of 19 basis points. The later is equivalent to assuming an 1% annual spread and it is consistent with the average historical spread between US commercial papers and US T-bill rates, and between US mortgage and long term US government bonds rates.<sup>11</sup> With respect to capital producers, I assumed a quadratic investment adjustment cost function. This formulation looks simplistic, but other functional forms that fulfil the requirements reported in the last section do not produce qualitatively different results.

Finally, the calibration strategy also looks for generating macroeconomic co-movement. This is consistent with evidence (Görtz et al., 2016) supporting positive co-movement between output, consumption, and hours, and reductions in credit spreads in response to TFP news. These findings suggest that in a model of financial frictions it is important to have co-movement to news shocks plus positive initial effects on consumption.

Although, Barsky and Sims (2011) found contrasting evidence using a VAR estimation strategy for an RBC model. It has been found that their results are due in part to the use of an outdated database that suffers from a noisy series of utilization adjusted TFP (Kurmann and Sims 2017). Also, the differences between them and other studies could be due to subsample instability, since their results depend on the forecast horizons (Beaudry et al, 2012).

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<sup>10</sup> The results are robust to a more standard calibration of this parameter.

<sup>11</sup> This is easily verifiable by computing the arithmetic average of the spread using the data available through FRED.

In this chapter, a financial crisis is defined as an episode where an expansion is characterised by debt run-ups and growth in output, consumption and investment; while a recession is defined as a loss in output, employment and a considerable reduction in investment accompanied by a fall in asset prices. This goes in line with empirical evidence that shows that the recession of 2008 was characterized by a deleveraging process increased financial frictions, high unemployment, depressed GDP, low investment and household consumption (Hall, 2012). Then if a recession like this, can be caused by financial news, they should generate macroeconomic co-movement.

An alternative to get co-movement that is widely accepted in the news literature is to modify the preferences such that the wealth effect is low. This is complimented with investment adjustment cost and variable capital utilization as in Jaimovich and Rebelo (2009).<sup>12</sup> I did not use this alternative since within this framework you need to use a very restrictive parameterisation to get co-movement in response to both, news on the capital quality and the technology shocks<sup>13</sup>. In particular, the Jaimovich and Rebelo (2009) setting turns out to be problematic when getting co-movement in response to capital quality news shocks, since it requires setting the elasticity of labour supply to infinity with logarithmic utility or setting the risk parameter to at least 1.2 (non log utility function) and a very high elasticity of labour and investment adjustment cost parameters.

Instead of departing from the Gertler and Kiyotaki (2010) setting, I prefer to set investment adjustment cost and habit formation parameters high enough to produce co-movement between employment, investment and consumption as in (Christiano, et al., 2008). Then, the habit formation parameter is set to 0.9 and the marginal adjustment cost is set to 30 times the percentage increase in investment. All the parameters' values are presented in *Table 2.1*.

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<sup>12</sup> For a comprehensive review of the alternative ways to deal with the co-movement puzzle view Wang (2012).

<sup>13</sup> See the appendix for a parameterization that generates co-movement in an RBC model.

Table 2.1. Calibration: Baseline model

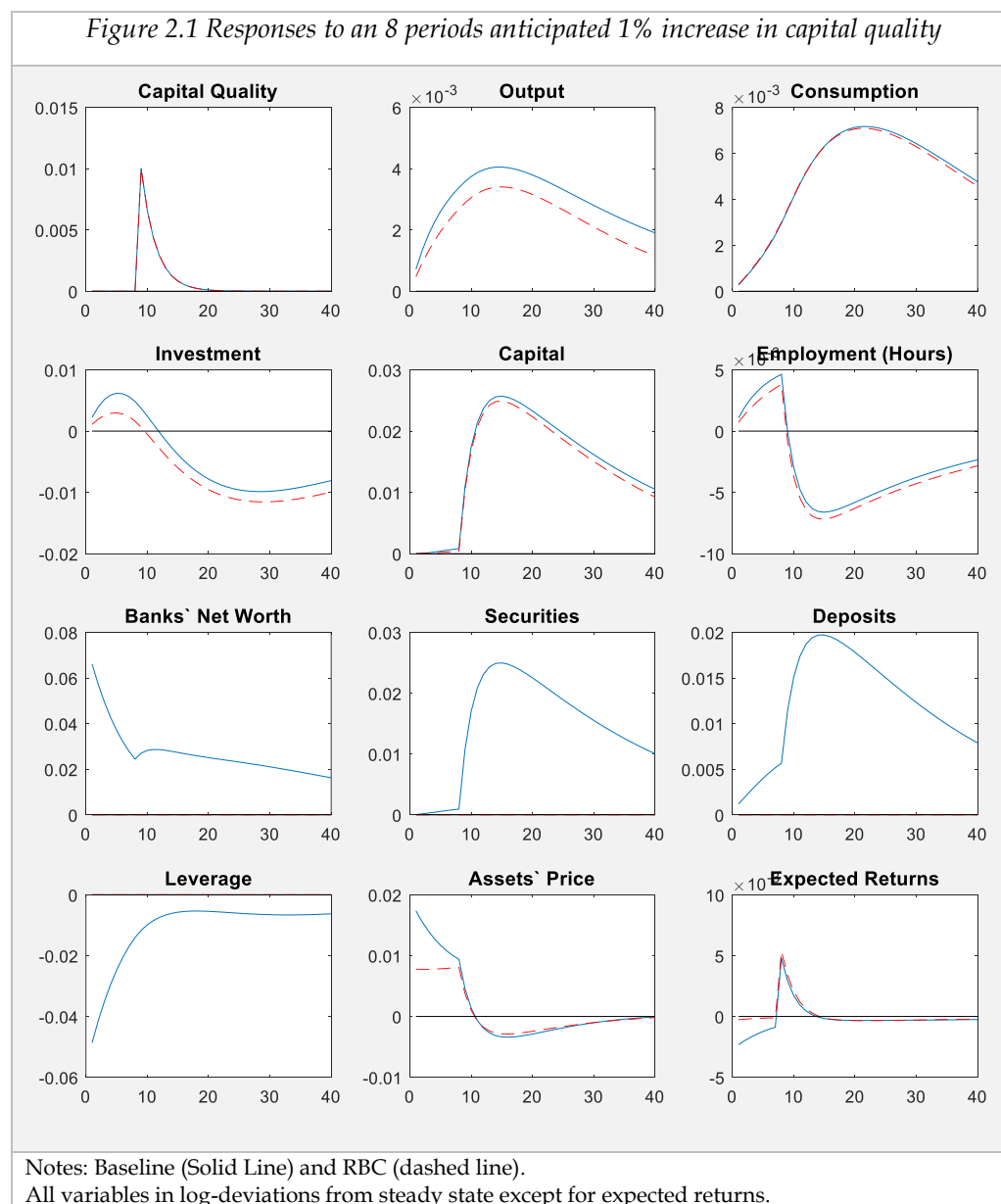
<b>Households</b>		
$L$	0.2381	Labour supply in steady state
$\beta$	0.9900	Discount rate
$\zeta$	0.9000	Habit parameter
$\chi$	4.5565	Relative utility weight of labour
$\varepsilon$	0.1000	Inverse Frisch elasticity of labour supply
<b>Financial intermediaries</b>		
$R_k - R$	0.0019	Steady state spread
$\Phi$	4.0000	Leverage ratio in steady state
$\theta$	0.3409	Fraction of divertible assets
$\xi$	0.0027	Transfer to entering bankers
$\sigma$	0.972	Survival rate of the bankers
<b>Adjustment costs</b>		
$f'(1)$	30	Marginal adjustment cost
<b>Intermediate good firms</b>		
$\alpha$	0.330	Effective capital share
$\delta$	0.025	Depreciation rate
<b>Stochastic Process</b>		
$\rho$	0.660	Autoregressive capital quality parameter

In the next section I present the responses of the model to news about an increase in the value of capital eight periods ahead. The anticipation of the shock leads agents to try to accumulate capital before the shock is realised. The most interesting dynamics are observed when the shock  $\xi_{t-p}$  is not realised. This is a crisis experiment, in the sense that all the decisions made based on the anticipation of the shock need to be corrected. The accumulation of capital and debt turn out to be excessive, once agents learn that the news was wrong. It would become clear that this dynamics creates a debt-investment cycle accompanied by asset liquidation and a recession.

## 2.4 RESULTS:

The analysis of two different settings is reported in the following pages. In both scenarios agents in the economy received news in period one about an increase of 1% in the value of capital eight periods later (i.e. in period nine). This can be interpreted as an increase in either the capital productivity or in the effective units of capital. In the first scenario the shock is realised in period 9, so that decisions made in

anticipation turn out to be optimal ex-post. Conversely, in the second setting the shock is not realised and these decisions become sub-optimal ex-post.



To begin with, the effects of the news shock in the first scenario are represented by the impulse response functions reported in Figure 2.1. Dashed lines account for the responses to the news shock in the model without financial frictions, and solid lines represent the full model responses ("baseline" in what follows).

As can be seen in the graph, financial frictions did not play a major role in the qualitative responses of all the real variables, the asset prices and the expected

returns. Quantitatively, the model with financial frictions implies stronger increases in output, investment, employment and asset prices in anticipation of the realizations of the shock. In the absence of financial frictions, banks' optimization implies that net worth needs to remain at zero such that returns on securities are transferred to depositors when interests are paid. This implies that banks use all their deposits to buy securities.

In the baseline model, following the good news about the future, banks demand for securities, capital stock and households' deposits increase gradually. The positive forecast about future returns leads to an increase in the price of securities, which drives banks' net worth upwards. At the same time, thanks to the increase in investment and employment, a boom in production is generated. Consumption also increases, thanks to the strong habit formation.

Unlike an unanticipated shock, people start investing before the shock is realized, reaching the desired level of capital before-hand. This is an increase in savings decisions in response to the perspective of having higher future returns. Also, the effect of the shock on several variables, including capital stock, securities, and employment is rather gradual. This could imply lower financial cost for the banks (compared with a counterfactual onetime purchase), since they spread their demand for securities across a longer period of time.

On the verge of the realization of the shock, expected returns increase strongly and investment slows down. Once the increase in capital quality is realized, investment keeps slowing down and the value of capital (or the effective units of capital) increases. This is equivalent to saying that the capital became more productive and, as a consequence, "effective" units of capital keep increasing even when investment is below its steady state level. In terms of the model, the capital is multiplied by the quality shock increasing in size. Then, less investment is required to keep the capital growing. After some time, capital starts to adjust back to its steady state level.

Regarding employment, motivated by the higher desire to save – invest in anticipation of the shock, households decide to increase their labour supply to accumulate more capital. As a result of higher returns, the initial increase in consumption is followed by a bigger and long-lasting increase. The higher future consumption implies a downwards shift in the labour supply. This implies that

employment falls below the steady state after the shock is realized. This is at least partly a consequence of habit formation as point out by Wang (2012).

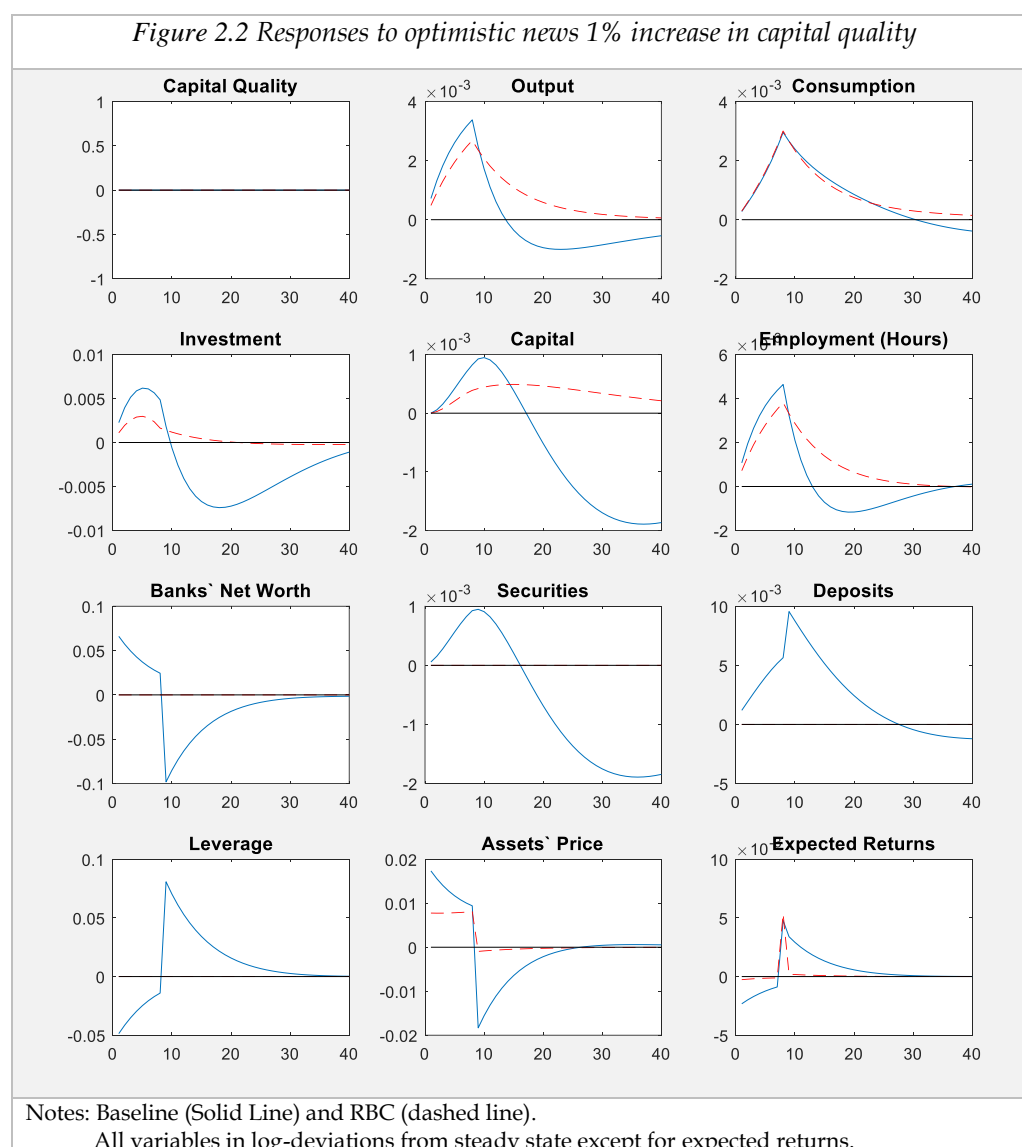
Concerning production, it increases initially due to capital and labour growth. After the shock is realized a small additional increase in output occurs as capital productivity increases with the shock. Since employment is reduced, output growth also reduces until it returns to its steady state level.

As investment increases, the demand for securities and capital goods goes up and, therefore, the price of capital goods increases as well. It starts to decline before the shock is realized, but once it is realized, after the sudden fall in investment, the price falls further, going below its steady state level. Afterwards, the capital goods price adjusts back, slowly converging towards the steady state level. This fluctuation of asset prices is not strong enough to produce a strong deterioration in the aggregate banks' net worth.

Since households want to save more in anticipation of the news about capital returns, deposits (banks' debt) increase gradually and leverage starts to increase consequently. Once the shock is realized the debt increases further, then it is gradually paid back. This is equivalent to saying that people are not liquidating assets or creditors are not demanding anticipated payments, due to the higher returns on investment. Alternatively, if we consider debt as one period contracts that can be rolled over, then this can be interpreted as the creditors being willing to continue financing banks.

#### **2.4.1 A crisis produced by optimism**

Regarding the case when news turns out to be false (Figure 2.2), once people learned their mistake they make big adjustments in their investment decisions. This is reflected in a strong reduction in investment. This adjustment happens in a sudden and people start to withdraw their deposits. Because the productivity boost did not happen, capital do not gain value but instead starts to decrease until the liquidation is enough to pay back the debt.



This over-liquidation of assets is the result of financial constraints combined with debt burden. Since banks need to pay back the creditors, but the returns on capital are lower than expected, they need to liquidate capital. However, now the asset prices have plummeted and then the liquidation occurs at fire sale prices implying that more capital needs to be liquidated. Once banks have paid back all their excessive debt, they can accumulate capital again and it slowly comes back to the steady state level.

The rationale for fire sales is twofold: firstly, the bust in asset prices and secondly, the deleveraging process that results from the inability to get additional funds due to the



financial constraints. There is a double causation between the liquidation and asset's prices. The latter falls due to the reduction in investment and capital that happens once the shock is not realised, and the former gets bigger as the prices plummet.

As a consequence of the assets liquidation and prices bust, banks' net worth falls dramatically, up to almost 10% below the steady state. This adds to the vicious circle of low investment, low asset prices, low banks capacity to buy securities and to fund firms, and fire sales.

Given the sudden reduction in employment and the strong fall in capital, the product falls too, generating a long-lasting recession. This recession is matched with reductions in consumption growth and investment, along with a deleveraging process and a deterioration of banks' balance sheets.

To sum up, the news shock in the baseline model can generate the debt accumulation, asset prices boom, and output boom prior to a crisis, as well as the bust in asset prices, the deleveraging process and the long-lasting recession that characterize financial crises (Reinhart & Rogoff, 2009).

#### **2.4.2 The role of financial frictions**

The dotted lines in Figure 2.2 represent the responses of the model without financial frictions to unrealised news about an 1% increase in capital quality. It can be noted that the volatility in asset prices is negligible compared to the baseline scenario. The ability to get funding, plus the mild fall in asset prices rule out the fire sales witnessed when financial frictions are present.

As a consequence, once agents learn that the news was wrong, investment, consumption, employment and output return gradually to the steady state and a recession is avoided.<sup>14</sup> Regarding capital stock, in absence of financial frictions liquidation is not necessary and capital slowly adjusts back to its steady state level.

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<sup>14</sup> Notice that the impulse responses should be interpreted as deviations from a balanced growth path, and therefore a recession only happens when these functions go below zero.

In summary, in this framework unjustified optimism is not able to generate a recession in absence of financial constraints. This supports the claim that financial frictions are an important transmission mechanism for news shocks (e.g. Görtz et al., 2016).

## 2.5 FINANCIAL CRISES AND “NORMAL” RECESSIONS

The capital quality shock used in this paper is a way to introduce exogenous changes to the value of capital (Gertler and Kiyotaki, 2010). Changes in the value of capital affect directly asset prices and banks' net worth. This choice was motivated by the idea of resembling a financial crisis, where asset prices fall noticeably with investment.

On the other hand, other models have been able to recreate the fall in banks' net worth typical of a financial crisis using different shocks that are not as easily linked to investment – debt cycles. For instance, Gunn and Johri (2013) modelled financial crises as the result of unrealised news about financial frictions themselves (banks' ability to reclaim debt). This implies that a financial crisis might happen because people were over confident about the health of the banking system. But this lets aside an explanation of the deterioration of the financial institutions health.

The capital quality shock has the advantage that it can be interpreted as a shock to the returns on investment as well as a financial shock. Then the interpretation of a financial crisis occurring because people (including bankers) got over confident about investment returns and this caused a bubble in asset prices, is more easily justified within this paper's framework. Also, it is more compelling than assuming that the banking system was bad beforehand for an undetermined reason.

Besides, if the capital quality shock can be interpreted as a financial crisis, as in Gertler and Kiyotaki (2010). Then, it is worthwhile to check whether the responses to news about it are different to some extent to TFP news driven cycles. This would help to answer the question whether theory can distinguish between a financial and a non-financial recession in a model with financial frictions. Empirically, it is possible to assess the role of particular shocks to economic volatility and to classify episodes as

driven mainly by financial factors or not (v.g. Romer & Romer, 2015 and Stock & Watson, 2012)

To check whether the same qualitative results hold when the model is hit by unrealized news about a standard technology shock, I assume the following stochastic process for the technology shock.

$$(22) \quad A_t = \rho_A A_{t-1} + v_t + \eta_{t-p}$$

Where  $v_t$  and  $\eta_{t-p}$  are i.i.d. non-correlated shocks and  $\eta_{t-p}$  represents news about technology progress received  $p$  periods ahead. The timing is as follows: in period 1 people receive news about higher TFP to be realised eight periods later. In period nine they realise the news was wrong. This setting makes the result comparable to our crisis experiment. I am assuming a value of 0.99 for the autoregressive parameter ( $\rho_A$ ).

Impulse responses to 1% unrealised news shocks about capital quality (dotted line) and technology shocks (solid line) are reported in Figure 2.3. Output and consumption responses are both qualitatively and quantitatively similar, regardless of the nature of the shock. Something similar happens with the response of employment.

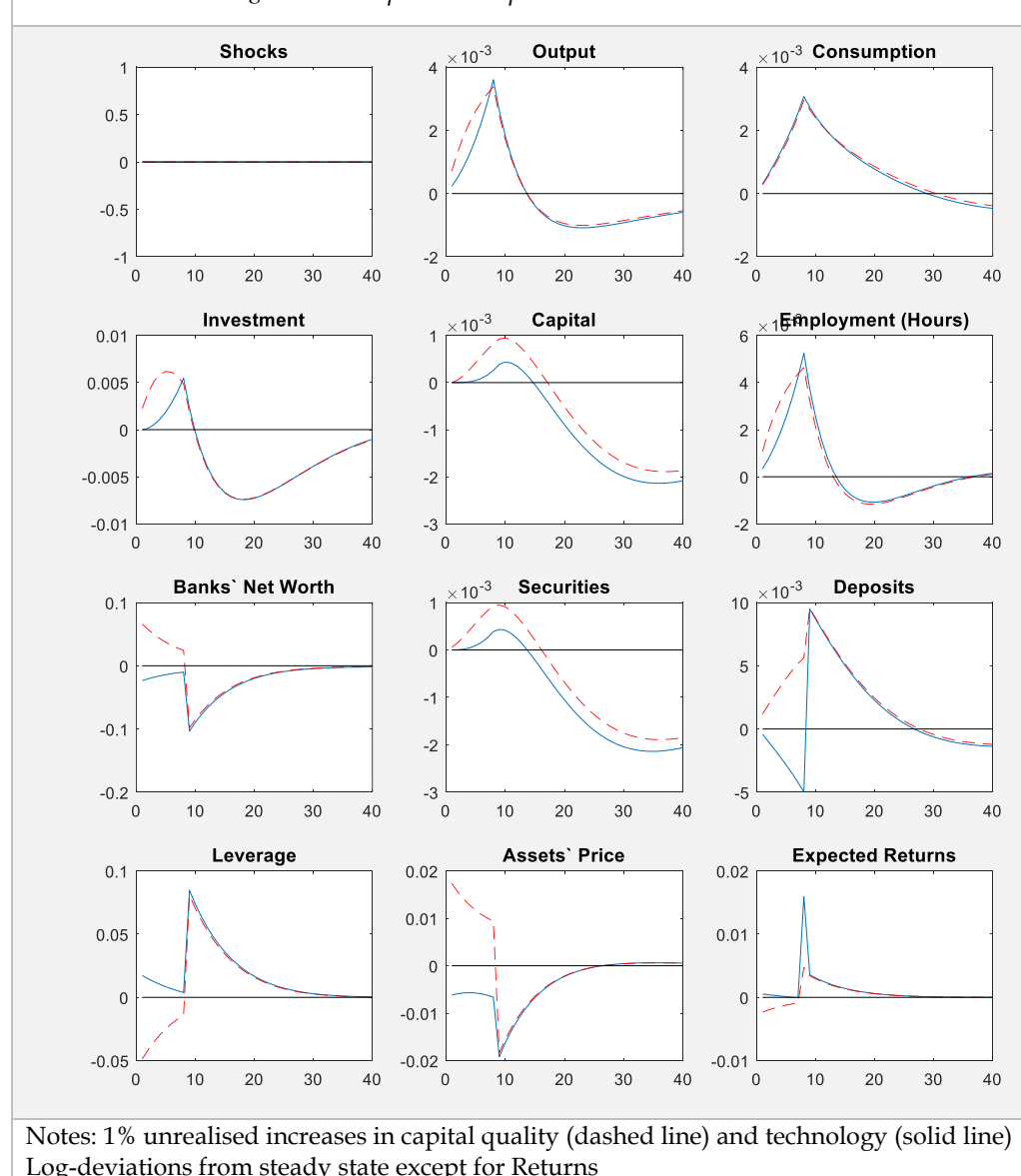
Investment and capital stock exhibit different responses to both shocks. The former grows more during the anticipation period in response to news about capital quality. Nevertheless, investment dynamics does not seem to be significantly different once agents learn they were wrong. This implies a similar adjustment in the capital stock, and therefore a similar magnitude of the liquidation needed to pay back the debt (considering the liquidation as the difference from the peak value to the lowest value). The same dynamics could be extrapolated to the volume of securities.

Nonetheless, contrary to what one could expect, banks' net worth dynamic responses to news about the two shocks are rather different. In particular, during the expansion it increases with respect to its steady state in response to news about capital quality, while it goes below the steady state in response to technology news.

These dissimilar responses have to do with the dynamics of asset prices in anticipation of the two shocks. News about capital quality leads to an asset price boom, since expected returns on capital are expected to increase upon realization of

the shock. In practice, agents are expecting that one unit of capital in periods one to eight is going to become 1.01 effective units of capital in period nine. Because of the assumption of perfect competition in the securities market, the price dynamics reflect changes in the discounted expected returns and therefore go up with news about higher future capital quality.

Figure 2.3 Responses to optimistic news in baseline model



Since the demand for investment goods grows less, and more gradually, in response to technology news, asset prices do not respond in the same way as they do to news about capital quality. To understand this better, is necessary to look at the responses of expected returns when the news turns out to be true (Appendix 2). After the shock

is realised, expected returns fall below the steady state in response to technology news, while they converge gradually to the steady state after capital quality news is realised. This implies that, while the TFP shock increases aggregated productivity, this does not necessarily translates into better returns per unit of capital.

Consequently, asset prices go below its steady state level in response to technology shocks, and they fall further once agents realise their expectations were wrong. This last adjustment also happens in response to unrealised news about capital quality, but it is quantitatively stronger. This implies a worse deterioration of banks' net worth in response to news about returns on investment than in response to technology news.

It can be concluded that the main difference between technology news and capital quality news driven business cycles, in this model, has to do with the inability of the former to generate a boom-bust cycle in asset prices and milder debt cycle and deterioration in banks' balance sheets. It is noteworthy, that unjustified optimism about both technology and capital quality generates very similar dynamics in output, consumption, investment and employment. This is supported by empirical evidence that suggests that recessions associated with financial crises are not particularly different (Stock & Watson, 2012). In the next section, I present some robustness checks on the main results to discard that some particular assumptions are generating the results.

## **2.6 ROBUSTNESS CHECKS: CO-MOVEMENT AND FRISCH ELASTICITY**

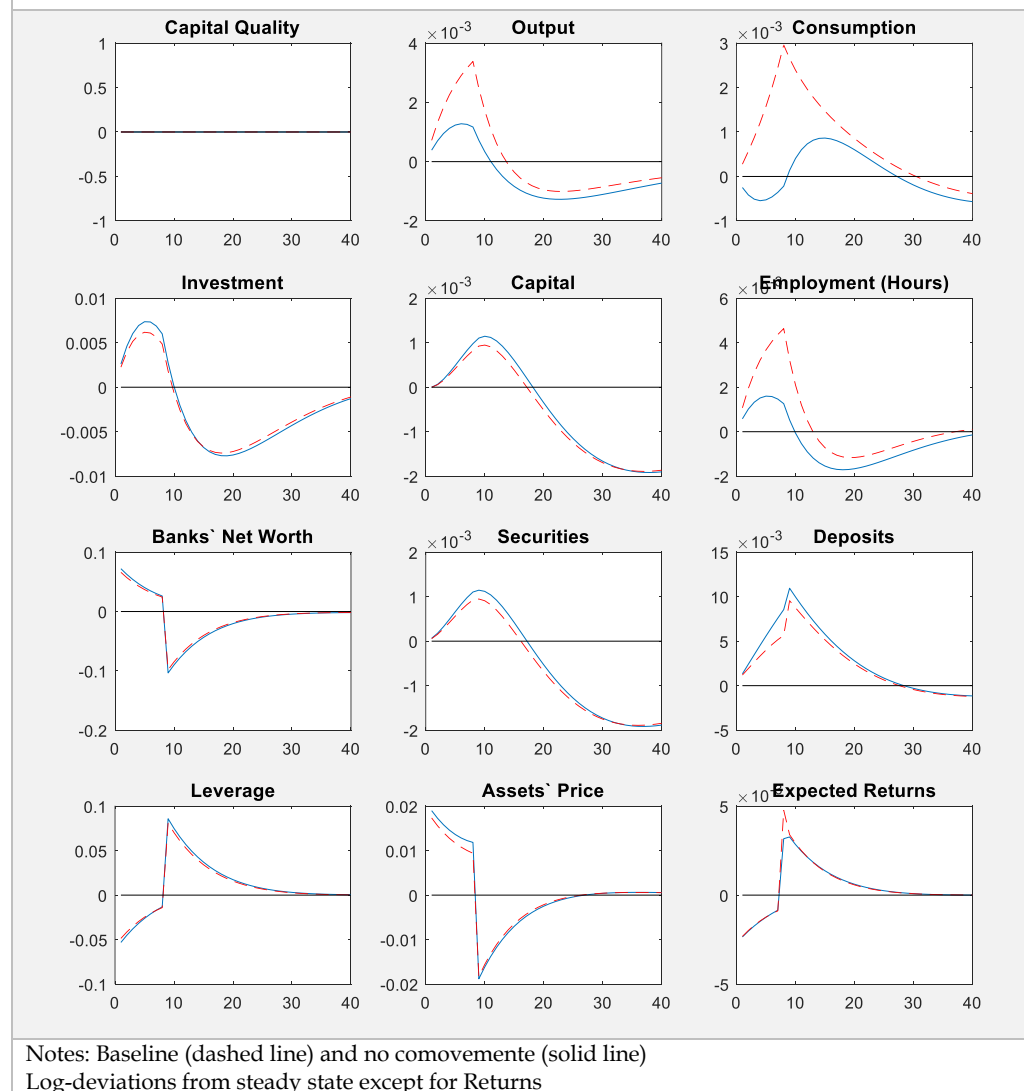
### **2.6.1 Co-movement**

It was mentioned before that co-movement of consumption, investment and employment was a desirable trait of the model given the inclusion of financial frictions and some evidence from the literature (Görtz et al., 2016). This was achieved by setting strong enough habit formation and investment adjustment costs (Christiano et al., 2008). We also observed that this was responsible in part for the fall in employment when the news about capital quality was realised. It is necessary to check that the main results are not affected by this. That is, wrongly optimistic expectations about future capital returns can generate a boom followed by a recession

accompanied by a bust in asset prices, a deleveraging process, capital liquidation and a deterioration of banks net worth.

Since the key parameter for this strategy to achieve macroeconomic co-movement is the one related to habit formation (Wang, 2012), setting it to zero should remove its effects. If the results are robust to co-movement, only the qualitative dynamics of consumption should be affected. Responses to an unrealised news shock under this parameterisation, along with the baseline results, are reported in Figure 4. It can be noticed from the graphs that, with the exception of consumption, the qualitative results remain the same when the habit formation parameter ( $\zeta$ ) is set to zero.

Figure 2.4 Responses to optimistic news 1% increase in capital quality



After the positive news about the quality of capital is received, output, employment and investment increase with respect to their steady state level. Also, a boom in asset prices is produced and debt is accumulated. Once agents realise they were wrong, a strong adjustment in investment is required. At the same time, asset prices plummet and fire sales of capital goods are needed to pay back the debt. In this sense a deleveraging process starts and capital is depleted, reducing output and employment.

In summary, when the model is parameterised so that positive co-movement of consumption with respect to employment and investment is not guaranteed, the main result still holds. This is, an optimistic shock about returns on investment can generate a boom-bust cycle in asset prices that is accompanied by an output boom followed by a recession, a deterioration of banks' net worth and a deleveraging process.

### **2.6.2 Frisch elasticity of labour supply**

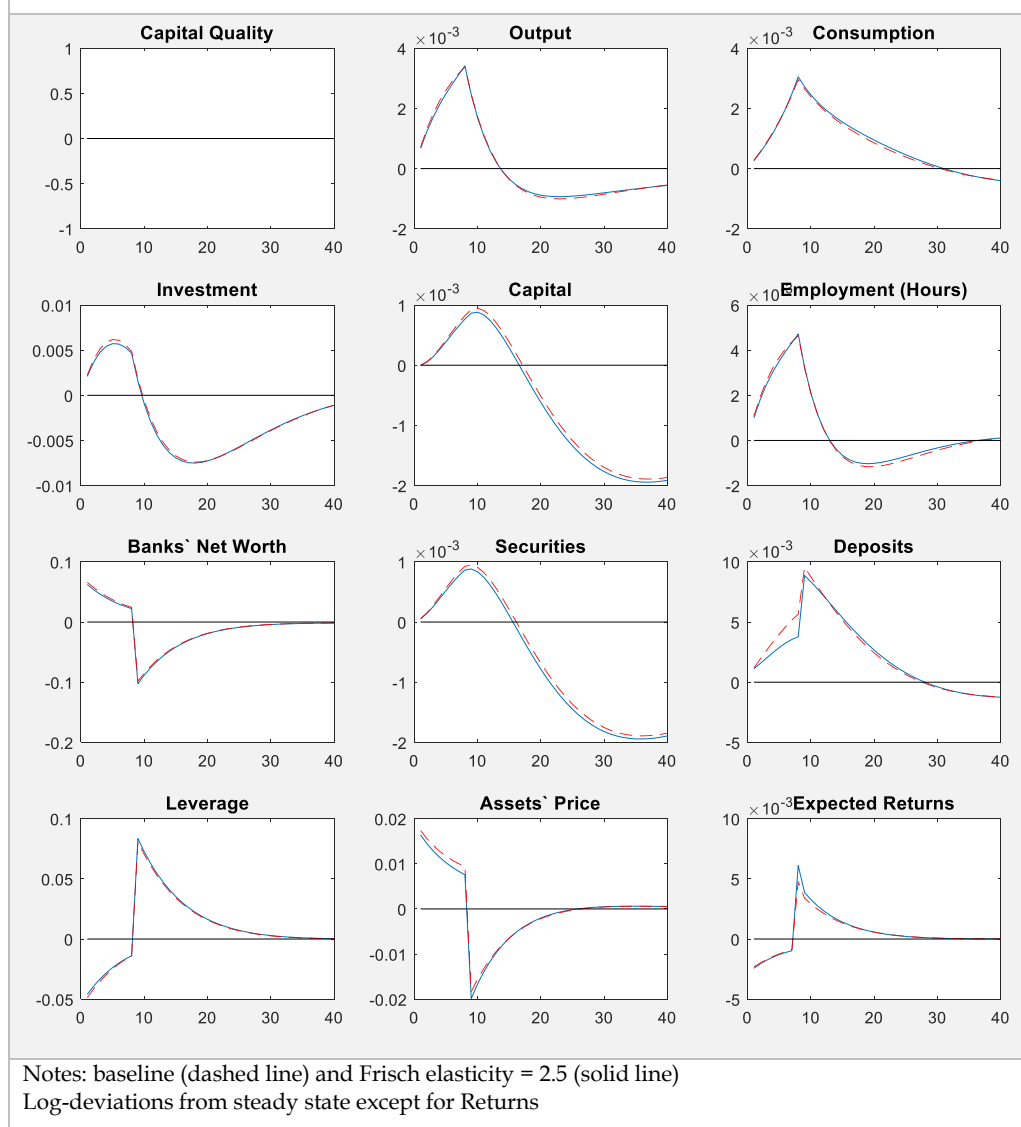
As mentioned earlier, I followed Gertler and Kiyotaki (2010) regarding the parameterization of most of the model. Therefore, I have set a Frisch elasticity of labour supply of 10 to compensate for the lack of frictions in the labour market. This value is much higher than the standard calibrations found in the literature and the macro estimates of this parameter (Peterman, 2016).

Given that other strategies to get co-movement are very sensitive to that parameter, it is necessary to test that the results are not driven by this particular parameterization. To do so, I replicate the result setting the Frisch elasticity of substitution to a more acceptable parameter of 2.5. As can be seen in Figure 5, there are no significant changes in the quantitative nor qualitative responses of the system to news about capital quality. This is also true for the responses to technological news.<sup>15</sup>

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<sup>15</sup> See Appendix 2

Figure 2.5 Responses to optimistic news 1% increase in capital quality



## 2.7 CONCLUSIONS:

In this paper, I presented a model where optimistic behaviour about future returns on investment may generate not only the dynamics characterising an economy during a financial crisis, but also the pre-crisis process leading to the run-up in debt and the asset prices boom.



This excessive debt accumulation, in combination with the banks' credit constraints generates to liquidate assets. This implies a reduction in capital that is bigger than its increase during the boom, due to plummeting asset prices and the need to repay the debt with lower than expected returns on capital. In the context of the model, the banks hold the burden of the crisis and their net worth suffers widely due to the fall in the value of assets. However, these costs are not transferred to households since the probability of bankruptcy is not a function of the bank's performance.

These results, are consistent when co-movement of consumption is not imposed, this is, when habit formation is ruled out of the model. I show that with or without habit formation the same qualitative results hold, with the sole exception of consumption dynamics. More importantly, the model can still produce an expansion followed by a recession that is accompanied by a boom-bust cycle in asset prices and a debt run-up followed by a liquidation and deleveraging process.

Comparisons of the responses to unrealised technology and capital quality news under the baseline specification lead to conclude that banks net worth deterioration is notably higher in response to the former. This is due to the fact that technology news does not generate a boom in asset prices, and the reduction in them that occurs when the shock is not realised is smaller than the bust produced by unjustified optimism about capital quality. This is the only significant difference between the responses to the two shocks, which suggests that in a very standard DSGE model with financial frictions, the effects of news about financial and non-financial shocks produce similar responses in real variables.

The model highlights the importance of expectations about future returns as a factor helping to explain deep and long lasting recession. Further research is needed to explain the relationship between the size of the recession and the speed of recovery that seems to characterize some crises. Future research could explore the time series properties of non-technology shocks like the one used here in order to fully underscore the role of these shocks if any.

## 2.8 APPENDICES

### 2.8.1 Appendix 1: the Jaimovich-Rebelo (2009) Approach.

Jaimovich and Rebelo (2009) found parameters that generate positive co-movement with positive responses of consumption and employment to TFP and investment specific news shocks. Given their baseline parameterization for a simple RBC model, they reported threshold values for key parameters in Table 1 of their paper. Any other shock is not analysed in this framework and as a consequence, introducing any other shock requires the determination of the threshold values that guarantee co-movement. To do so, I add the capital quality shock to their framework such that the capital accumulation equation is now given by:

$$(A1) \quad K_{t+1} = \Psi_{t+1} \left( K_t(1 - \delta(u_t)) + I_t \left[ 1 - F \left( \frac{I_t}{I_{t-1}} \right) \right] \right)$$

Additionally I ignore the investment specific technology shock. This implies that the first order conditions are now given by:

$$(A2) \quad \lambda_t = (C_t - \chi L_t^\tau X_t)^{-\sigma} + \mu_t \gamma C_t^{\gamma-1} X_t^{1-\gamma}$$

$$(A3) \quad \lambda_t F_L(u_t K_t, L_t) = \tau \chi L_t^{\tau-1} X_t (C_t - \chi L_t^\tau X_t)^{-\sigma}$$

$$(A4) \quad \chi L_t^\tau (C_t - \chi L_t^\tau X_t)^{-\sigma} + \mu_t = \beta(1 - \gamma) E_t \left\{ \mu_{t+1} \left( \frac{C_{t+1}}{X_t} \right)^\gamma \right\}$$

$$(A5) \quad \lambda_t = E_t \left\{ \eta_t \Psi_{t+1}(\Xi_t) + \beta \eta_{t+1} \Psi_{t+2} \left( \frac{I_{t+1}}{I_t} \right)^2 F' \left( \frac{I_{t+1}}{I_t} \right) \right\}$$

With

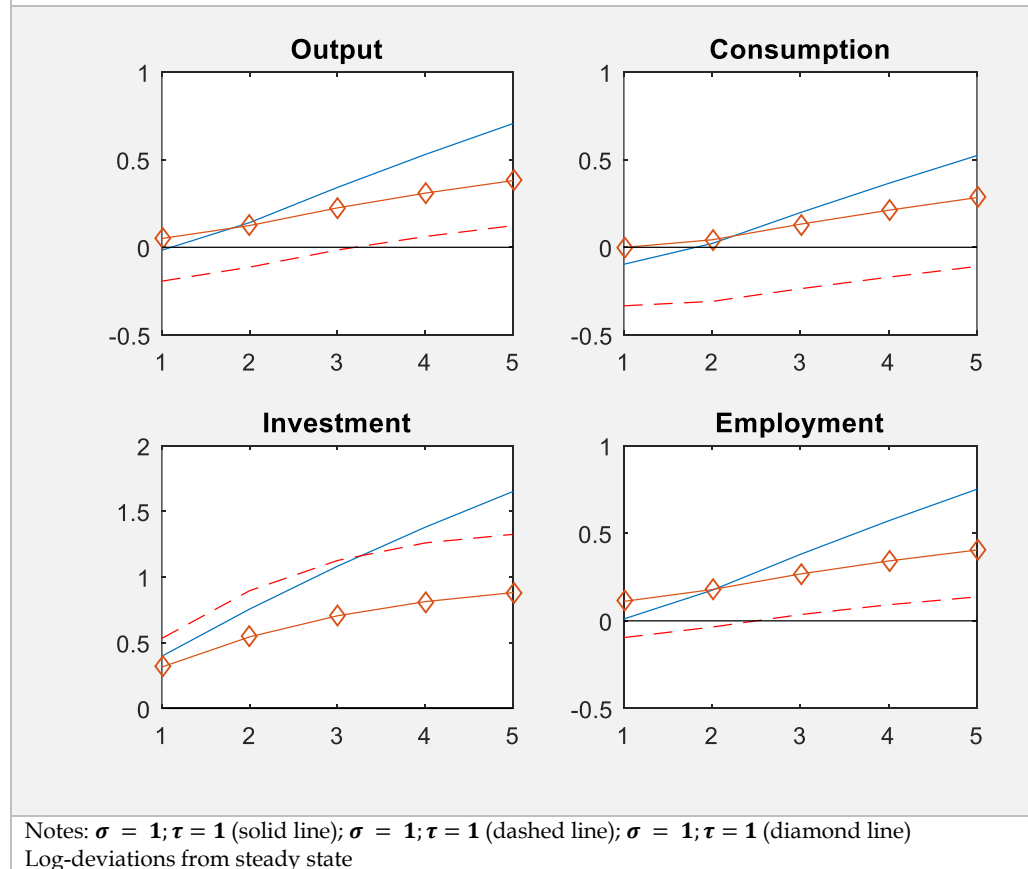
$$\Xi_t = 1 - F \left( \frac{I_t}{I_{t-1}} \right) - \frac{I_t}{I_{t-1}} F' \left( \frac{I_t}{I_{t-1}} \right)$$

$$(A6) \quad \lambda_t F_u(u_t K_t, L_t) = E_t[\eta_t \Psi_{t+1} \delta'(u_t)]$$

$$(A7) \quad \eta_t = \beta E_t[(\Psi_{t+1})^{-1} \{ \lambda_{t+1} F_K(u_{t+1} K_{t+1}, L_{t+1}) + \eta_{t+1} \Psi_{t+2} \delta(u_t) \}]$$

Setting  $\sigma = 1$  the same thresholds reported by Jaimovich and Rebelo in Table 1 produce co-movement in response to technology news. Notwithstanding, the response of investment output and employment to the capital quality news shock requires a high adjustment cost ( $F''(1)$ ), but consumption is un-responsive to all the parameters except the elasticity of labour supply. When this last is set to infinity ( $\tau = 1$ ) and the rest of the parameters are set as in the Jaimovich and Rebelo (2009) baseline, consumption and output respond initially negatively to the news about future increases in capital quality. Therefore, still setting this parameter to this extreme value is not enough to get consumption co-movement.

Figure 2.6 Responses to 1% realised in period 3 capital quality news shock

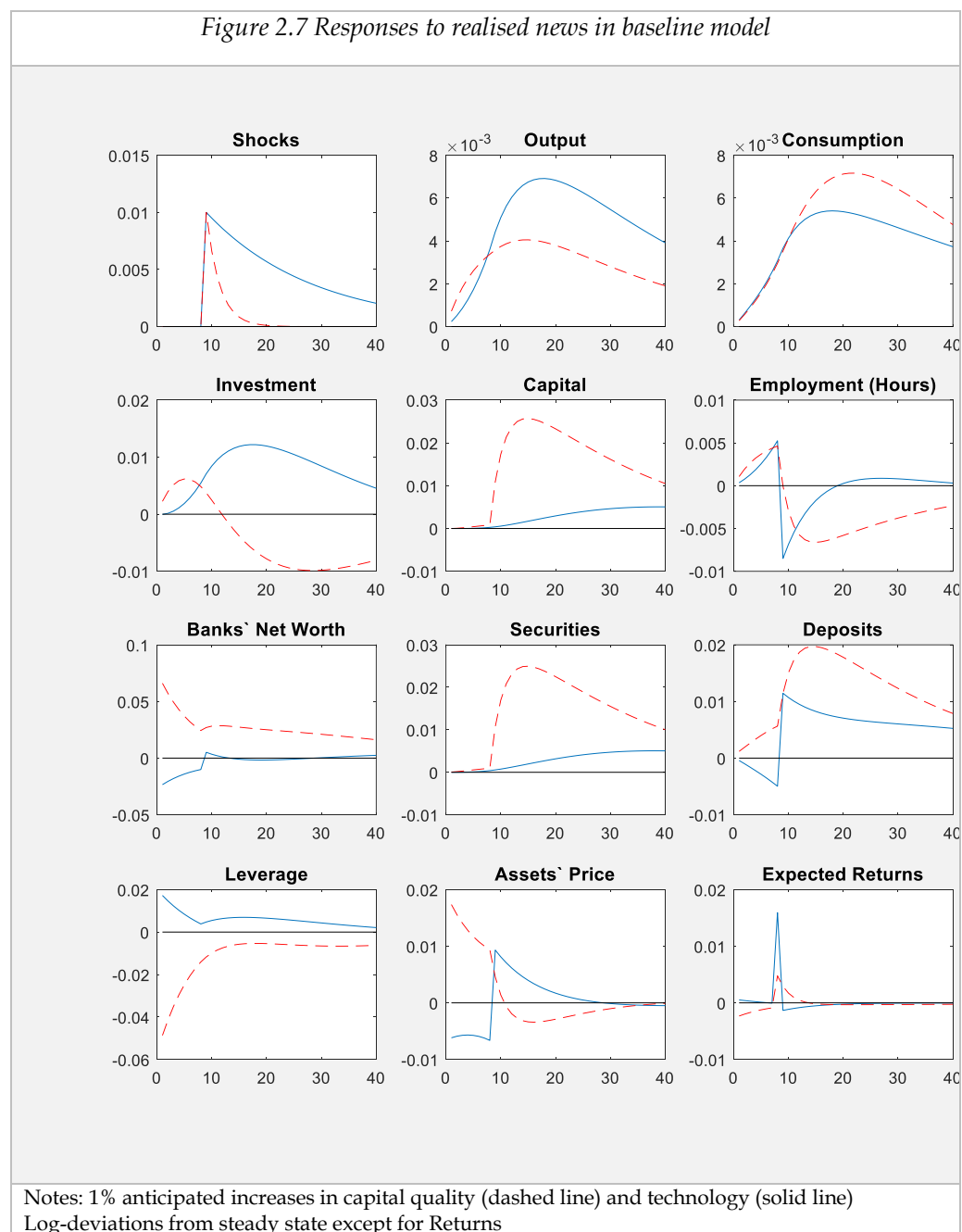


Co-movement can be achieved by setting  $\sigma > 1$ . In particular, with a value of 1.2 and a minimum of 6.6 for the labour supply elasticity ( $1/(\tau - 1)$ ) we can get co-movement. The graph below shows impulse responses to two periods anticipated capital quality shocks that are realised in period 3 under different parameterizations.

These results are conditional on the anticipation horizon. If news is received more than two quarters before the realisation of the shock, the parameterisation for getting co-movement needs to be more restrictive. Given this, plus the fact that under this strategy there are already several frictions affecting the behaviour of the system, such as investment adjustment cost and variable capital utilization, and the restriction on the wealth effect to guarantee co-movement, I opted for a simpler strategy to get co-movement since it would be less restrictive.

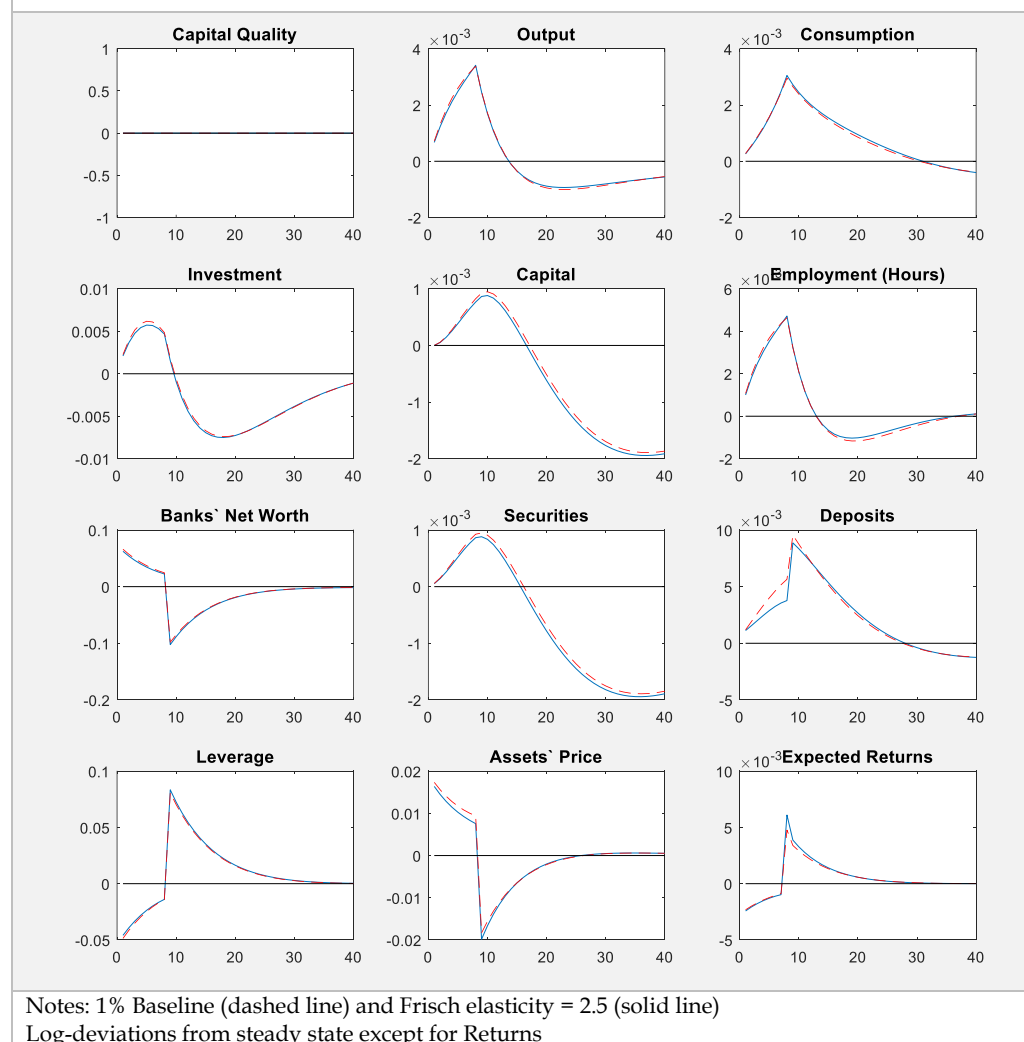
## 2.8.2 Appendix 2: Responses to realised technology and capital quality news shocks.

Figure 2.7 Responses to realised news in baseline model



### 2.8.3 Appendix 3: Responses to unrealised technological news with high and low Frisch Elasticity.

Figure 2.8 Responses to 1% un-realised technology news shocks



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