Understanding the Global Demand Collapse:
Empirical Analysis and Optimal Policy Response

Guido Cazzavillan and Michael Donadelli

Università Ca' Foscari Venezia
Department of Economics

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Abstract

The goal of this project is to deeply investigate on the main causes of the global economic and financial crises and, based on a theoretical framework, to describe a suitable optimal monetary policy. According to our empirical analysis (basically based on US data) we will prove that a mix of extraordinary conditions have been crucial for the origin, develop and growth of the recent crisis. In finding what has been the main cause of such collapse we will prove that the credit crunch has played a crucial role, especially as a sort of contractionary monetary policy. We will also discuss the quantitative easing policies implemented by the Central Banks. Finally, we will seek to establish, by using an existing theoretical model and given extraordinary market conditions, in what central banks were wrong, and if so, where they made mistakes.

Address for correspondence:
Michael Donadelli
Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta S.Giobbe
30121 Venezia - Italy
e-mail: donadelli.m@unive.it

Introduction: an overview of the crisis

In this paper we present an interpretation of the economic and financial crisis that considers fundamental several issues. It is well known that in finding the real causes of the so called "sub-prime crisis", we can easily notice that there is no general and unique consensus on what were the key drivers of the global demand collapse in these last quarters. On one side researchers investigate and concentrate studies focused on the financial markets turmoil, they explain this big stop in the global demand as a consequence of the presence of fear and uncertainty in the capital markets. On the other side there is a general consensus that a major role has been played by the collapse in the world trade. Recent publications also try to understand and explain the global crisis by focusing on the real market and assessing the crucial role of the credit tightening linked to the beginning of a big amount potential foreclosure, mainly due to the increase of the interest rate. In order to incorporate all these elements, other research projects investigate on the possible merger between the above mentioned causes, thus the financial shock, the global trade collapse and the credit tightening impacts, so as to capture all the effects on the global economy as a whole. As a matter of fact the past/current economic and financial crisis has been characterized by waves of successive external shocks over the short space of three years. It started with house price and stock market declines in 2007, spikes in food and energy prices in mid-2008 further collapses in stock markets and contraction in credit markets in late 2008, and a slump in world demand in 2009. Each of the above mentioned point impacted negatively on global demand over the past three years. Before to enter in the details of our analysis, we think that an overview of the origins and causes of the economic and financial crisis is needed. Primarily a chronology of the crisis, here below represented, could be useful.

2000-2001	US Federal Reserve lowers Federal funds rate 11 times, from 6.5% (May 2000) to 1.75% (December 2001), creating an easy-credit environment that fueled the growth of US subprime mortgages

2002-2006	Fannie Mae and Freddie Mac combined purchases of incorrectly rated AAA subprime mortgage-backed securities rise from $38 billion to $90 billion per year. Lenders began to offer loans to higher-risk borrowers, including illegal immigrants. Subprime mortgages amounted to $600 billion by 2006.
Feb-07	US house prices start falling (nominal home price index decreased by 9.5% in 2007) and several subprime lenders report losses.
Jul-07	Credit spreads start to widen and home foreclosures double from one year before
Aug-07	Worldwide "credit crunch" as subprime mortgage backed securities are discovered in portfolios of banks and hedge funds around the world, from BNP Paribas (it suspends three investment funds that invested in subprime mortgage debt due to a "complete evaporation of liquidity" in the market) to Bank of China.
Aug-07	Federal Reserve injects about $100 billion and ECB injects about 100bn into the money supply for banks to borrow at a low rate.
	Other financial institutions panic and stop interbank lending.
Sep-07 to Jan-09	Fed funds rate cut 5 times (-2.25%) in order to limit damage to the economy from the housing and credit crises.
Nov-07	Reported bank losses on subprime assets = US$150bn (rising to US400bn in March 2008).
Jan-2008	January 2008 stock market downturn.
Jan-08 to Feb-08	S&P downgrade about 8000 mortgage-based securities. Bank credit growth stops. Swiss giant UBS and Fanny Mae record big unexpected losses.

Mar-08	Bear Sterns virtually insolvent. Bear Stearns is acquired for $2 a share by JPMorgan Chase in a fire sale avoiding bankruptcy. The deal is backed by the Federal Reserve, providing up to $30B to cover possible Bear Stearn losses.
Mar-08 to Apr-08	Deutsche Bank reports huge losses.
	Twice FED lowers fed funds rate (-1%); coordinates global cut.
Jun-08	US house prices falling faster in 2008 = -15%; same fall in UK
	US home foreclosures double again.
Jul-08 to Sep-08	FED guarantees debts of Fannie Mae and Freddie Mac. Treasury takes control with US$200bn bailout.
14-Sep-08	Merrill Lynch is sold to Bank of America amidst fears of a liquidity crisis and Lehman Brothers collapse.
15-Sep-08	Lehman Brothers files for bankruptcy protection. Government allows it to fail.
16-Sep-08	Moody's and Standard and Poor's downgrade ratings on AIG's credit on concerns over continuing losses to mortgage-backed securities, sending the company into fears of insolvency
17-Sep-08	The US Federal Reserve lends $85 billion to American International Group (AIG) to avoid bankruptcy.
22-Sep-08	Last two Wall Street investment banks, Morgan Stanley and Goldman Sachs, convert to become commercial banks.
25-Sep-08	Washington Mutual is seized by the Federal Deposit Insurance Corporation, and its banking assets are sold to JP Morgan Chase for $1.9 billion.
29-Sep-08	British government capitalizes Bradford & Bingley. Iceland government in 75% takeover of Glitnir bank.
2-Oct-08	Irish government guarantees bank deposits and debts for US$554bn

3-Oct-08	President George W. Bush signs the Emergency Economic Stabilization Act, creating a $700 billion Troubled Assets Relief Program (TARP) to purchase failing bank assets.
3-Oct-08	Wells Fargo bank and the fourth-largest US bank Wachovia Corp announce merger.
	Congress agrees to largest government intervention in capital markets in US history (US$700bn) debates bank ownership.
	Dutch government buys Fortis for US$23 bn.
6-Oct-08	Fed announces that it will provide $900 billion in short-term cash loans to banks.
6/10Oct-08	Worst week for the stock market in 75 years.
8-Oct-08	FED, Bank of Canada, ECB, Swiss coordinate 0.5% rate cut.
13-Oct-08	UK injects US$64 billion Royal Bank of Scotland, HBOS and Lloyds TSB.
14-Oct-08	The US taps into the $700 billion available from the Emergency Economic Stabilization Act and announces the injection of $250 billion of public money into the US banking system.
19-Oct-08	South Korean rescue package-US$130bn for banks.
Latest	Australian government guarantees all deposits at APRA-supervised banks. RBA cuts another 0.75% in November.

Table 1: Chronology of the crisis

Basically the origin of the current crisis in the financial markets can be traced back to the set of incentives that were introduced in the public policy stance to encourage and support a rapid expansion of credit with the objective of avoid a probable deeper economic recessions, especially in developed economies following the bursting of the dot.com bubble (sometimes also called I.T. bubble) and the geo-political instability due to the 9-11 terrorist attacks. To avoid a probable recession a quantitative easing policy was implemented by the US Federal Reserve. Thus, a quick moving to lower interest rates level started to produce a sort of cheap money environment where the access to credit was popularly facilitated especially to

those experiencing difficulties in the access of home ownership. A complex institutional architecture centered first around two big financial institutions, Fannie Mae and Freddie Mac, was designed to promote access to mortgage credit through implicit state guarantees, especially for individuals with low incomes, therefore with a higher default risk (the so called sub-primes). The easy access to credit market, as a consequence of low interest rates level, led to an increasing demand in the real estate market,[1] thus generating a bubble. Once interest rates rose,[2] the debt of each debtor increased and they did not pay back such debt. A huge drope in the real-estate market pushed house prices down. As a consequence the banks' asset side value drammatically decreased and financial sector began to creak.

Next sections will be used to provide an empirical general overview of the main causes of the past/current economic and financial crisis. In section 1 we will investigate on the relationship between financial/stock markets and real economic activity. On this issue a vast literature exist, we will confirm the general consensus of a strong relationship between the two market but we will also conclude that such a relationship does not hold at any time.

In section 2 we will discuss on the credit crunch, analyzing the consumer credit and money stock measures time series and their implication on the country production. Our aim will be the one to recognize a different behavior respect to the past and understand the meaning of a gap that does not find painless explanations.

In section 3 we will focus on the impact of the subprime and credit losses on the global trade which can be defined as a proxy of the global wealth. Considering the fact that in the last 20 years exports and imports between countries have been raised in volume in an exponential way,[3] we will prove the relevance of this macroeconomic component.

In section 4 we will try to investigate on the effects of uncertainty shocks on the credit market and on the real economic activity. To implement our empirical analysis a specific volatility index will be used and a standard econometric approach will be adopted.

In the last section, considering the crucial role played by the "credit availability" within this economic and financial crisis as a sort of monetary con-

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[1] Note that banks risk level was very low. Banks were confident that, in case of default, they could sell the asset (house) at higher price

[2] Note that from June, 2003 to June, 2006 Federal Reserve increased for 17 consecutive times the federal funds rate (from 1.0% to 5.25%)

[3] Referring to this statement it is sufficient to think about the formation of cooperations such as the WTO (World Trade Organization) and the NAFTA (North American Free Trade Agreement).

traction, we will try to define a suitable optimal monetary policy. In defining this policy we will extend an existing theoretical framework on optimal monetary policy under uncertainty to more than one parameters uncertainty. We will also try to extend such a model including the effect of another global player.

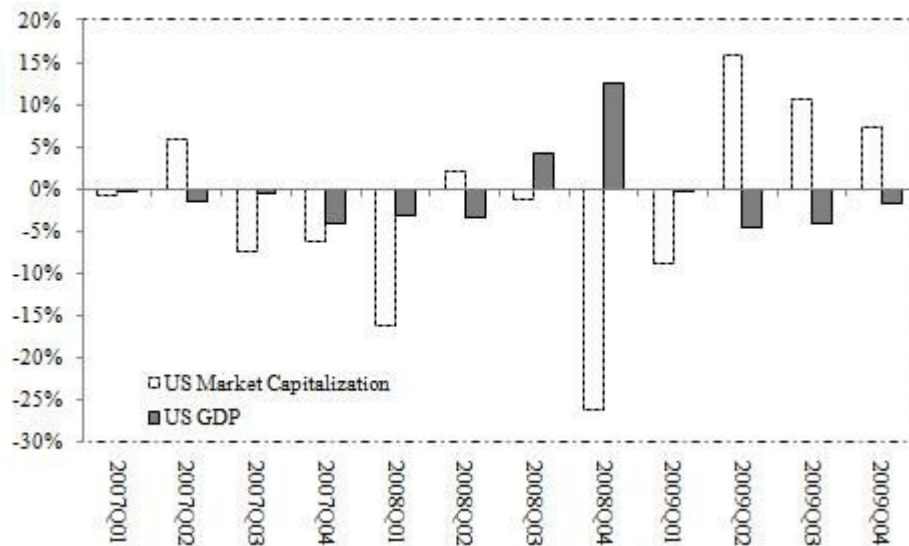# 1 Revisiting financial markets and real economic activity relationship

Figure 1: Source: Eurostat, Statistics Database (stock market capitalization is calculated by multiplying the volume of shares quoted on the stock market by their market value).

For many practitioners and researchers financial markets turmoil has played a crucial role in this crisis, especially as amplifier of the global downturn. Before to enter in the core of our paper an overview on the impact of financial markets shocks on the real economic activity is needed. It is well known that the relation between the stock market returns/performances and the real economic activity has attracted a considerable attention both in the theoretical and empirical economic as well as financial literature. The aim of this section is to revisit and investigate interrelationship between the stock

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market performance and the real economic activity. It is quite clear that the recent financial crisis and associated global demand collapse experienced by several advanced and emerging economies have increased the importance of research on the links between stock market performance and real economic activity. To give an idea of how financial market declined during the crisis and its impact on real economic activity, figure 1 shows the behaviour of the market US stock market capitalization, which represents the size and performance of stock markets, and therefore important for private investor capital in the economy, and the behaviour of the US Nominal Gross Domestic Product.

Theoretical literature on this subject shows without any doubt that stock prices are closely connected to real economic activity through a number of different channels. There has been a substantial theoretical work on the link between stock returns and economic growth. In their survey article, Morck et al. (1990) determines the five main channels, through which stock prices are connected to real economic activity, which arguably encompass most of the main theories that have been put forward in this literature. These established channels are related to the fact that firms and managers base their investment decisions on information provided by the stock market and the stock prices represent the present discounted value of all future dividends. In literature, other studies have taken shape on the links between stock prices and real economic activity. Stock market performance affects real economic activity through lowering the cost of mobilizing savings and thereby facilitating investment in the most productive technologies (Greenwood and Smith, 1997). Mauro (2003) also suggests that through the wealth channel, the stock price developments can have a major impact on consumption pattern and in turn on economic growth. Levine and Zervos (1996) conclude that the stock market supports economic growth by providing liquid capital, risk management to investors, and information on the movements of the economic fundamentals. On the other hand, several authors have provided models which display conflicting predictions about the stock market and economic growth relationship. Bhide (1993) argues that stock market volatility may reduce investment efficiency, which in turn leads to a negative impact on economic growth. Obstfeld (1994) indicates that high financial market liquidity may increase investment returns and thus decrease saving rate due to substitution effect and income effect, which is unfavorable to the economic growth. Mauro (1995) finds that in case of financial assets investment, the development of stock market will decrease the public's precautionary saving, which is also detrimental for economic growth. There exist also a line of empirical studies on the link between

stock prices/returns and output growth. An incomplete list of these studies includes: Fama (1981,1990), Wahlroos and Berglund (1986), Mullins and Wadhwani (1989), Schwert (1990), Canova and Nicolo (1995), Choi et al. (1999), Doong (2001), and Mauro (2003). Each has found that stock returns and various macroeconomic factors are, to varying degrees, correlated, using either US or other international data. Some other studies, however, provide evidence that stock market performance is not correlated with real economic activity. Stock and Watson (1990, 1998), Biswanger (2000, 2004), Mao and Mu (2007) argued that the stock price movements since early 1980's cannot be explained by fundamental factors implying that the link between stock prices and real economic activity has broke down. The causality relationship between stock returns and economic growth is also investigated in numerous empirical studies. Fama (1990), Schwert (1990), Canova and Nicolo (1995), Doong (2001), and Mauro (2003) conclude that an increase in stock market returns is an indication of an increase in industrial production growth rates.

Dep. Variab: Log(Ind. Prod.)				
Sample: 1928:11 2009:09				
Included observations: 971				
Variable	Coeff.	Std. Error	t-Stat.	P-value.
C	-0.29	0.05	-6.03	0.00
Log(Dow Jones Ind.Avg.)	0.56	0.01	79.85	0.00
R-squared	0.87			
Adjusted R-squared	0.87			

Table 2: Estimates of long-run cointegrating relationship (USA)

By using standard econometric approaches, such as the Engle-Granger cointegration procedure,[4] Granger causality test and the VAR methodology,[5] we figure out and partially confirm the causal relationship between financial markets and real economic activitiy. It is well known that a VAR model modelizes, in essence, the dynamic relationships existing between groups of variables chosen to characterize a particular economic phe-

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[4]To test for cointegration between two or more non-stationary time series I(1), it simply requires running an OLS regression, saving the residuals and then running the ADF test on the residual to determine if it is stationary I(0). The time series are said to be cointegrated if the residual is itself stationary I(0).

[5]Necessary condition for the VAR methodology implementation is the one of having stationary time series which means series integrated of order one I(0).

nomenon. As theory suggests, for stationary VARs,[6] the impulse response should die out to zero and the accumulated responses should asymptote to some (non-zero) constant. VAR methodology has been used to investigate on the dynamic relationships existing between financial markets (stock prices, market capitalization and share price indexes) and real economic activity (US industrial production).
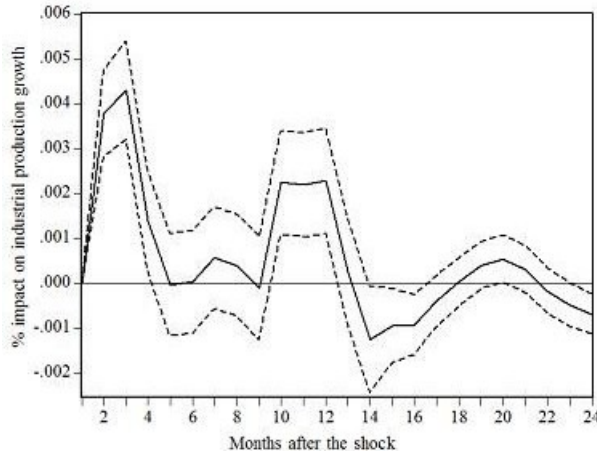

Figure 2: VAR estimation of the impact of a Dow Jones Industrial Average shock on US Industrial Production growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a Dow Jones Industrial Average shock (data sample: 1928:11M-2009:09M).

Estimates results based on the Engle-Granger cointegration test[7] and on the Granger Causality test[8] prove the presence of a long run relationship and a short-run influence of one variable on the other, between the US Dow Jones Industrial Average Stock Index and the US Industrial Production. Thus the linear combination between two series integrated of order one I(1) is stationary I(0)[9] and the null hypothesis that Dow Jones Industrial Average growth rate does not Granger cause the Industrial Production growth rate

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[6]Note that estimating a VAR in first differences would remove important information about the behavior of the variables that is contained in the common trend. So we often use the growth rate of our variables which are often stationary processes.

[7]if y_t and x_t are both I(1) and $y_t = \alpha + \beta x_t + \epsilon_t$ where $\epsilon_t = y_t - \alpha - \beta x_t \approx$ I(0), then y_t and x_t are said to be cointegrated

[8]The selection of the lag lenghts for the Granger Causality test is determined based on the Alkaike Information Criterion (AIC).

[9]Results of the ECM residuals are illustrated in appendix A.1.

is rejected (1% confidence level, see table 3).[10]

Lags: 13			
Null Hypothesis:	Obs	F-Stat.	P-value
DJIA does not Granger Cause Ind. Prod.	958	9.82	0.00
Ind. Prod. does not Granger Cause DJIA	958	1.25	0.24

Table 3: Granger Causality Test, 1928:11-2009:09 (USA)

Figure 2 displays the impulse response functions for the growth rate of the US Industrial Production Index. The results indicated that the US Industrial Production Index a stock price shock then decline starting from the fourth month and a positive effect is statistically significance up to five months. Generally speaking we may conclude that real economic activity react positively to the innovations in the stock market returns. It is also remarkable and important to notice that even if the economic and financial crisis finds its origin in the US, the literature has provided clear and robust evidence for international equity market linkages. More precisely exists a strong notion that financial markets have become increasingly globally integrated over the past decade. One important facet of financial integration is that asset prices exhibit substantial co-movements internationally, therefore there is clear evidence for positive correlation among global stock markets (see table 4).

Basically, a US stock market shock impacts on other international stock markets. In studying the relationship among equity markets Agmon (1972) shows that the behaviour of share prices in four different country (United States, United Kingdom, Germany and Japan) is consistent with the one market hypothesis. Agmon also shows that changes in the three non-US countries respond immediately to price changes in the US market index. Cheol and Sangdal (1989) demonstrate that innovations in the US stock market are rapidly trasmitted to other markets in a clearly recognizable fashion, whereas no single foreign market can significantly explain the US stock market movements. Hamao, Maulis and Ng (1992) shows that the US stock market is found to be the the most influential in terms of its impact on the performance of foreign markets. To further confirm such a global domino effect, Ehrmann and Fratzscher (2006) find that the trasmission of

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[10]On the Granger Causality test power a wide literature exists. Christiano and Ljungqvist (1988) found that the power of test on growth variables is very low, and thus there is the danger of making false inference. Hofer and Kutan (1997) denoted that the instability of results in Granger Causality test simply depends on the question whether the variables are modelled as trend or as difference stationary.

Stock Index	S&P 500	S&P 500
Period	(Jan 94 - Mar 10)	(Jan 07 - Mar 10)
S&P 500	1.00	1.00
FTSE 100	0.81	0.88
DAX	0.78	0.91
CAC 40	0.76	0.91
IBEX 35	0.71	0.83
SMI	0.71	0.85
NIKKEI 225	0.54	0.76
HANG SENG	0.66	0.74
SING INDEX	0.63	0.83
IBOVESPA	0.46	0.79

Table 4: Global Stock Indeces - Correlation Coefficients

US monetary policy shocks is very similar in strenght and nature to the general equity market linkage between the US and foreign markets on days when no monetary policy decisions take place. In appendix 7.2 we present some empirical analysis to partially prove this domino effect between US stock market and other global stock markets. Our results, based on a set of standard regression equations,[11] show that of the eight non-US stock markets the movements of stock index in Japan are the less closely related to those of the US. In terms of their relationship with the US stock market the French, the German, the Spanish, the English, the Swiss, the Brazilian and the Chinese are very similar. In addition the R^2 and the $\beta's$ are significantly high.

So far we have seen that theoretical literature provides conflicting results on the causal relationship between financial markets (stock prices, market capitalization and share price indexes) and real economic activity. Due to the fact that it does not exist a strong and unique framework about this important relationship we can not conclude that the recent global demand collapse leads exclusively to a US stock prices decline.

2   Credit Crunch: Why was it so decisive?

Following recent literature and conditional on an idea of no housing price decline, where most subprime mortgages appeared relatively riskless, we can state that the roots of the above mentioned scenario were initially created

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[11]$y_i = \alpha_i + \beta_i + \epsilon_i$

by the US house prices market decline. In assessing the role played by the credit conditions within this crisis we need first to quantify the losses arising from mortgage asset alone (in particular in the subprime sector) and second access the impact of such losses on broader credit condition in the US economy . The uncertainty, a subject that will follow us throughout this paper, has been crucial also at the beginning of this collapse. In fact at the time to compute the quantity of losses on subprime mortgages there was uncertainty in the number to publish. In July 2007 fed chairman Bernanke noted that losses of subprime mortgages could total $50-$100 billion. But by the end of 2007 most mortgages credit modelers believed that total losses will be substantially higher. For example, by December 2007, Lehman Brothers (2007) was estimating that credit losses on the currently outstanding stock of mortgages will total $250 billion in their baseline scenario of a 15% peak to trough on price drop and $320 billion in a stress scenario with a 30% drop. Similarly, as off late November Goldman Sachs (2007) was estimating mortgages losses of $243 billion in their baseline scenario and $495 billion in a stress scenario. Table 5, based on Goldman Sachs estimation, shows the global subprime mortgages exposures.[12][13] It would now be very useful to understand how an initial shock off roughly $200 billion to the leveraged intermediary sector might cause the type of turmoil faced by the global economy in these last quarters. The aftermath of this situation has been the amplification of the random components within the markets (credit markets, stock markets, trade markets). This created multiple problems over the whole financial system such as share prices falling (especially banks), higher market based interest rates due to credit default risk premium, reduced credit supply and distressed investments bank going bankrupt.

In assessing the role of global financial-credit conditions, considering the absence of reliable data on "global" financial and credit conditions, three proxies have been used. The first series is the average between large and medium firms of the percentage of banks reporting a tightening in credit on commercial and industrial loans to large and medium sized firms, minus the percentage reposting a loosening, taken from the US Federal Reserve Bank Senior Loan Officer Opinion Survey. The second proxy used is the

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[12]Note: The total for U.S. commercial banks includes $95 billion of mortgage exposures by Household Finance, the U.S. subprime subsidiary of HSBC. Moreover, calculation assumes that U.S. hedge funds account for four-fifths of all hedge fund exposures to subprime mortgages.

[13]Source: Leveraged Losses: Lessons from the Mortgage Market Meltdown David Greenlaw, Jan Hatzius, Anil K Kashyap, Hyun Song Shin (2008) - Goldman Sachs. Authors' calculations.

	Total subprime exposure	Percent of exposure
US Investment Banks	75	5%
US Commercial Banks	250	18%
US GSEs	112	8%
US Hedge Funds	233	17%
Foreign Banks	167	12%
Foreign Hedge Funds	58	4%
Insurance Companies	319	23%
Finance Companies	95	7%
Mutual and Pension Funds	57	4%
US Leveraged Sector	671	49%
Other	697	51%
Total	1368	100%

Table 5: Subprime Mortgage Exposures

total US consumer credit outstanding amount (sum of revolving and non-revolving credit) as debt that someone incurs for the purpose of purchasing a good or a service, usually including all purchases made on credit cards, lines of credits and loans. Then, in order to capture the increase in the cost of credit, the third proxy used is the spread between the three-month US Libor and the three-month Overnight Index Swap (OIS). Unfortunately, due to the absence of historical data on credit availability outside the United States, we are forced to adopt for our analysis data that represent only the US economy. This is a clear limit where global indicators would have been preferable. The first series provided by the US Federal Reserve is meant to represent changes in global credit availability. An increase in the series denotes a tightening of credit conditions, immediately, by looking at figure 3, we recognize that the series during this crisis has reached the highest level since 1990.

As seen in figure 3 and figure 4, the Fed's Senior Loan Officer Surveys for January 2010 showed a progressive tightening of standards prime mortgages, and commercial and industrial loans from 3rd quarter of 2007 to 4th quarter of 2008. Since changes in credit availability are expected to influence growth on real economic activity over the short run, an empirical analysis is
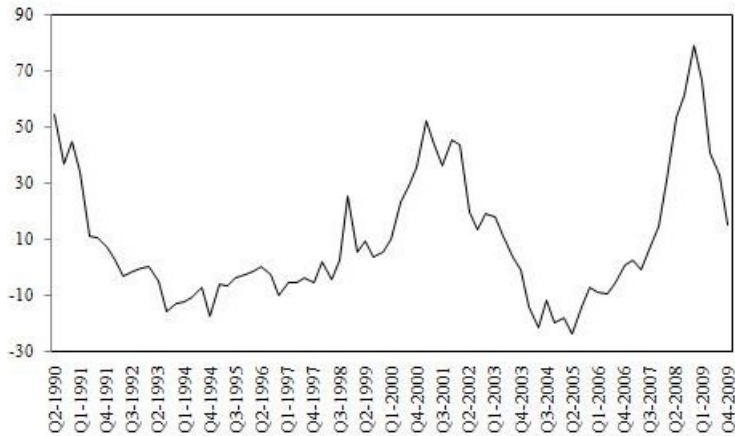
Figure 3: US Net Percentage of Domestic Respondents Tightening Standards for C&I Loans. Source: US Federal Reserve Senior Loan Officer Opinion Survey.
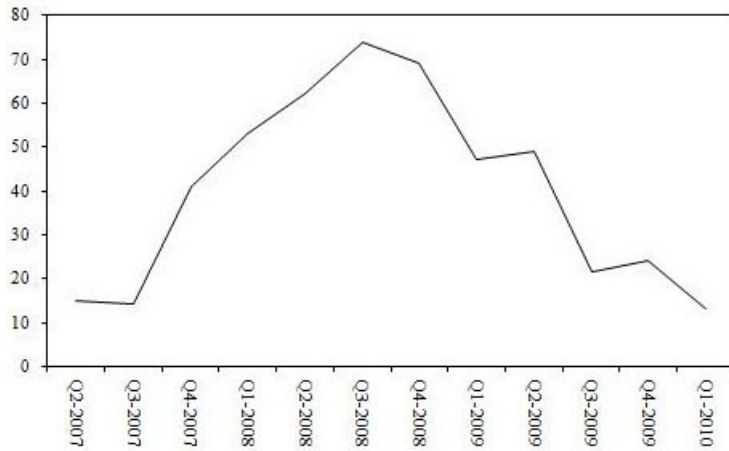

Figure 4: US Net Percentage of Domestic Respondents Tightening Standards for Mortgage Prime Loans. Source: US Federal Reserve Senior Loan Officer Opinion Survey.

needed. In what follows we will show empirical results aimed to capture the interrelationship between changes in credit availability and real economic activity. Table 6 reports the results of the Granger Causality tests between the changes in US credit conditions and the US GDP growth. We find strong

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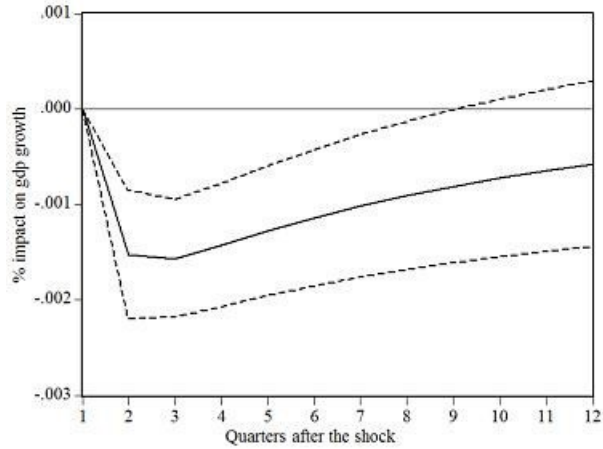
Figure 5: VAR estimation of the impact of a US credit conditions (net percentage of domestic respondents tightening standards for C&I loans) shock on US GDP growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a US credit conditions shock (data sample: 1990:2Q-2009:3Q) .

evidence that changes in US credit conditions Granger Cause real economic activity and we can reject the null hypothesis of no Granger causality also at 1% significance level. According to VAR estimation method, result of generalized impulse response function are reported in figure 5. The US GDP growth rate reacts negatively to innovation in the changes in credit conditions and such negative impact is statistically significance up to eight quarters after the shock.

Lags: 1			
Null Hypothesis:	Obs	F-Stat.	P-value
Changes in credit conditions does not Granger Cause GDP growth	77.00	26.91	0.00
GDP growth does not Granger Cause changes in credit condition	77.00	0.00	0.99

Table 6: Granger Causality Test, 1990:2Q-2009:3Q (USA)

To confirm a stressed credit conditions scenario it could be useful to look at the behavior of the other two proxies. We may easily recognize an environment characterized by big drop in the US consumer credit outstanding
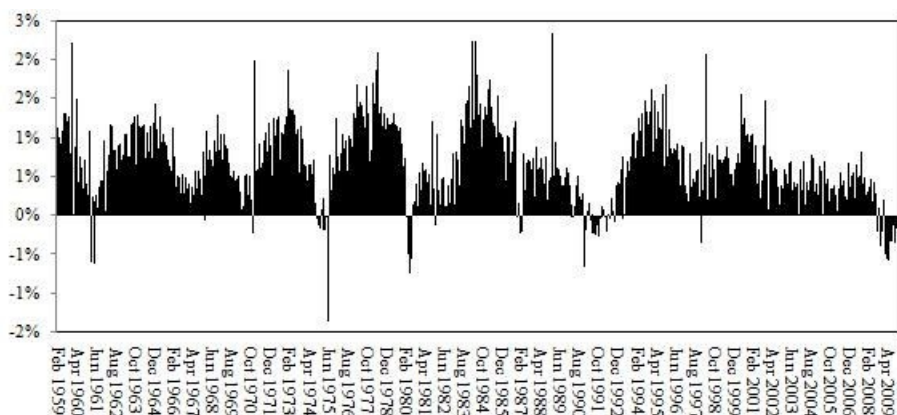
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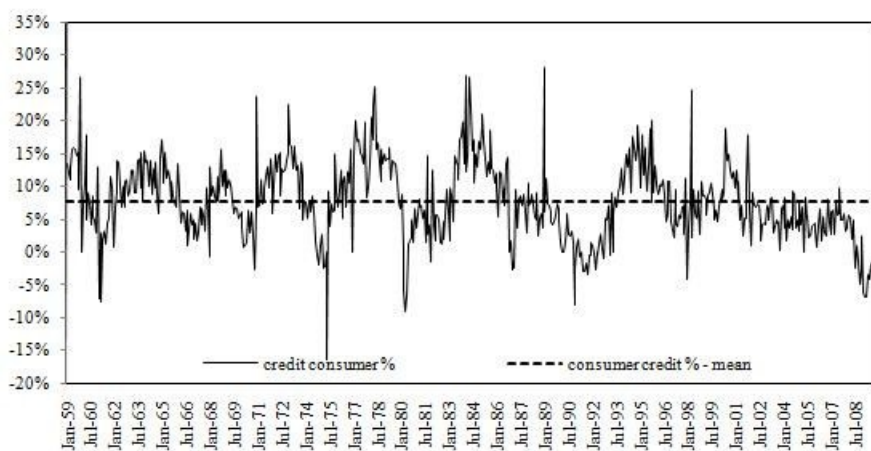Figure 6: Total US Consumer Credit. Source: US Federal Reserve.

Figure 7: Total US Consumer Credit Volatility

amount which decreased at an annual rate of 8.5% in November. Revolving credit decreased at an annual rate of 18.5%, and non-revolving credit decreased at an annual rate of 3%. An empirical research (Ivashina and Scharfstein, 2009) shows that the decline in new loans accelaretad during the banking panic. It is showed that in the fourth quarter of 2008, the dollar volume of lending was 47% lower than it was in the prior quarter and the number of issues was 33% lower than it was in the prior quarter. The drop in October, 2008 was particularly steep. The dollar volume of lending during the peak crisis period was less than one fourth of its level 18 months

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period	
entire sample (Jan:1943-Nov:2009)	0.9313
pre crisis sample (Jan:1943-Dec:2006)	0.9357
crisis sample (Jan:2007-Nov:2009)	-0.1512
Source: US Federal Reserve.	

Table 7: Consumer Credit & Industrial Production Correlation

earlier.[14] Basically the consumer power of the US, which found its key driver in the thousand lines of credit allowed to customers, collapsed forcing the US personal consumption expenditure to a 8% decrease on annul basis in the last quarter of 2008.

Figure 6 and figure 7 on consumer credit emphasize the out of the ordinary behavior of the consumer credit within this economic and financial crisis respect to the past. Consumer credit shows a dozen of consecutive monthly negative change between 2008 and 2009 (see rightside of figure 6). Thus, something happened in this economic and financial crisis that has never happened before in fifty years of consumer credit historical data. Let now play with basic statistics and let have a look on table 7. Assuming to pick up monthly data from January:2007 and November:2009 we find that the correlation between consumer credit and industrial production, which is in normal condition positive, became negative.

In this scenario people were more anxious and worried than for a very long time. There was a considerable degree of uncertainty around business, and this hit further the real economy. The uncertainty and the fear on the global markets even after the huge amount of liquidity injected by central banks held, probably due to the fact that many banks were still in trouble and they decided to keep the liquidity rather than distribute its to the retail market by allowing loans, mortgages and other forms of consumer credit, remained quite high for several months.

Figure 8 partially provides a clear proof to this extraordinary scenario. Notice that, on cumulative monthly basis, using as reference date the Lehman Brothers Chapter 11 event, the amount of credit fall by 4.33% (with a consecutive twelve months negative change) against a 8.68% increase in the money stock. This contrasts with an original condition in which to a money stock increase correspond an increase in the availability of credit. To confirm the presence of a credit crunch it is sufficient to look and the correlation

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[14]See Ivashina, Victoria and Scharfstein, David S. Bank Lending During the Financial Crisis of 2008. U.S. Monetary Policy Forum Report No. 2 (July, 2009).

period	
entire sample (Jan:1959-Nov:2009)	0.9895
pre crisis sample (Jan:1959-Dec:2006)	0.9866
crisis sample (Jan:2007-Nov:2009)	0.4603
crisis sample (Aug:2008-Nov:2009)	-0.8445
Source: US Federal Reserve.	

Table 8: Consumer Credit & M2 Money Stock Correlation

between total consumer credit and M2 (money stock measure) for different reference periods. In the last fourteen months the correlation became negative (see table 8). Roughly speaking, while money stock increased, due to quantitative easing policies, total consumer credit drammatically fell.
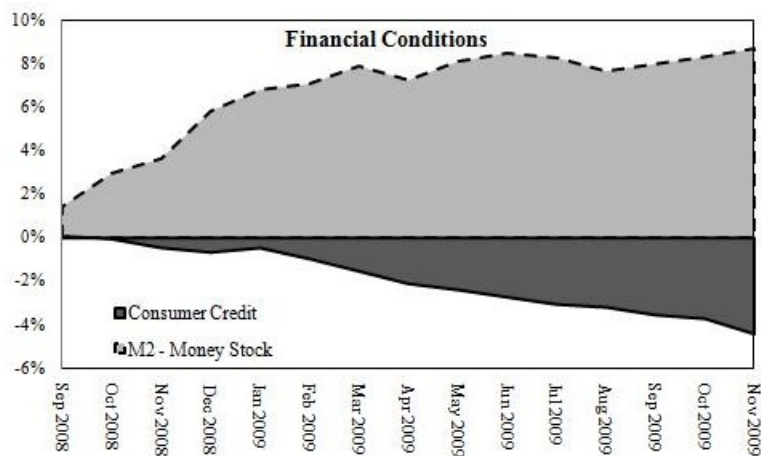
Figure 8: Consumer Credit & Money Stock during the crisis (cumulative growth rate). Source: US Federal Reserve.

Now, a question may arise: Did the liquidity use in the right way? We will try to answer in section 5. Let's continue to our data analysis. Figure 9 well represents another symptom of the credit crunch where it is showed that to an increase in M2 correspond a fall equal to 3% on one month in the Institutional Money Funds[15]. As Congressman Ron Paul claimed that

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[15]The Board of Governors of the Federal Reserve discontinued publishing data on M3 (which incorporates all data on M1 + M2 =M3) on March 23, 2006. M3 also included balances in institutional money funds, repurchase liabilities issued by depository institutions and Eurodollars held by US residents at foreign branches of US banks.

"M3 is the best description of how quickly the Fed is creating new money and credit". In other words, M3 tracks what wealthy people are doing with their bucks. In contrast to M1 and M2 that increased during the crisis the aptitude of the Fed to create new money through M3 fell. Basically a real increasing money scenario was not going on stage.
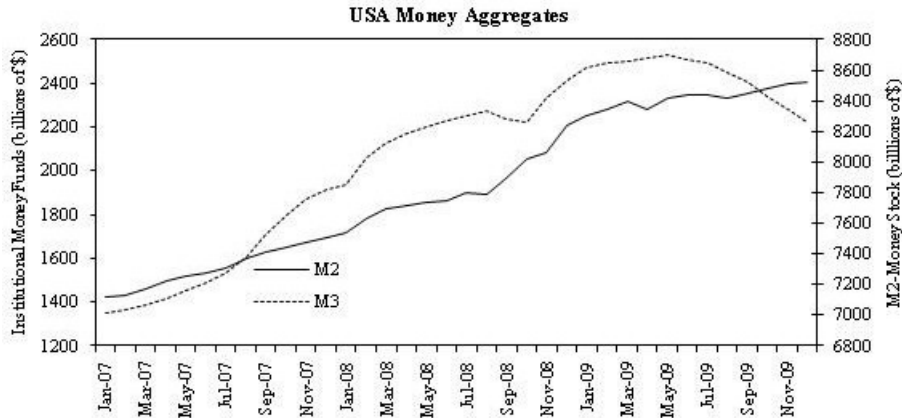

Figure 9: M2 and Institutional Money Funds (M3) during the crisis. Source: Federal Reserve Bank of St. Louis.

To further proof what we have just analyzed, this "unsuccessful" use of the quantitative easing policies can be well represented by a negative correlation between the M2 money stock and the industrial production (see table 9). To sum up figure 10 illustrates the historical path of monetary base and consumer credit of the last three years. Dashed line that represents the total consumer credit has been subjected to a fantastic performance till August, 2008 due to years of limitless credit availability (banks owned and provided liquidity through the securization process). In the aftermath of Lehman Brothers Chapter 11 (September, 2008) credit conditions began to tighten and Central Banks acted by implementing quantitative easing policies through cutting rates.

As we know the crisis became severe on August 9/10, 2007 when the money market interest rose dramatically. This can be easily represented by our third proxy, which is the spread between three month US Libor and the three month Overnight Index Swap (OIS).[16] We think that in assessing the role of credit conditions a brief analysis on this measure is required. To be

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[16]Bloomberg tickets: US0003M Index for the US Libor and USSOC CMPN Curncy for the Overnight Index Swap (OIS).
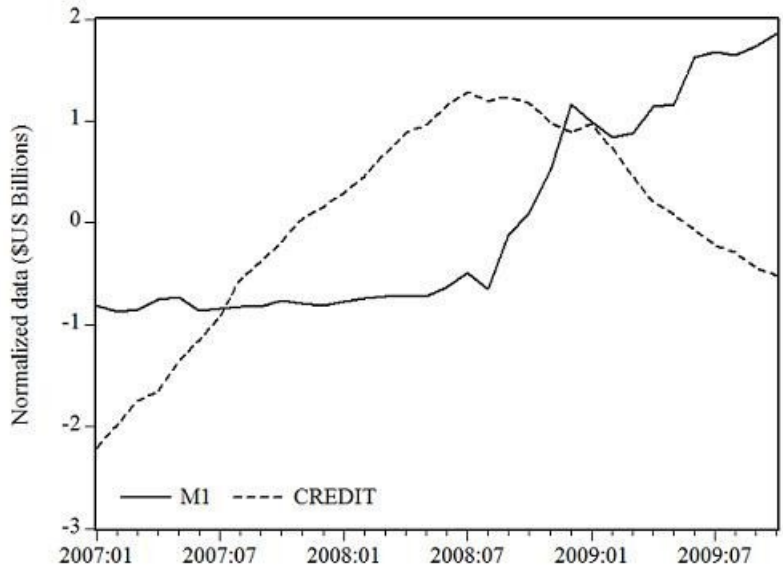
Figure 10: M1 Money Stock measure and Credit Consumer.

Period	
entire sample (Jan:1959-Nov:2009)	0.9553
pre crisis sample (Jan:1959-Dec:2006)	0.9710
crisis sample (Jan:2007-Nov:2009)	-0.9201
Source: US Federal Reserve.	

Table 9: Industrial Production & M2 Money Stock Correlation

more precise, the LIBOR-OIS spread is the difference between the LIBOR and the Overnight Index Swap rate, and is commensurate with the amount of perceived credit risk in the interbank lending market. Ordinarily, when the central banks lower their rates of interest, both the LIBOR and the OIS rates decline with it. However, when banks are unsure of the creditworthiness of other banks, they charge higher interest rates to compensate them for the greater risk. Being a measure of financial stress, the spread affects the transmission mechanism of monetary policy to the economy because trillions of dollars of loans and securities are indexed to Libor. An increase in the spread substantially will increase the cost of such loans and have a contractionary effect on the economy. Thus, a high spread leads to a limited availability of credit. Also this measure confirms the presence of a shock in the US credit market within this economic and financial crisis. If you look

at lower left of figure 11 and you extended that further to the left, you see a quite stable spread. But on August 9th and 10th of 2007 this spread jumped to unusually high levels (480 bps).
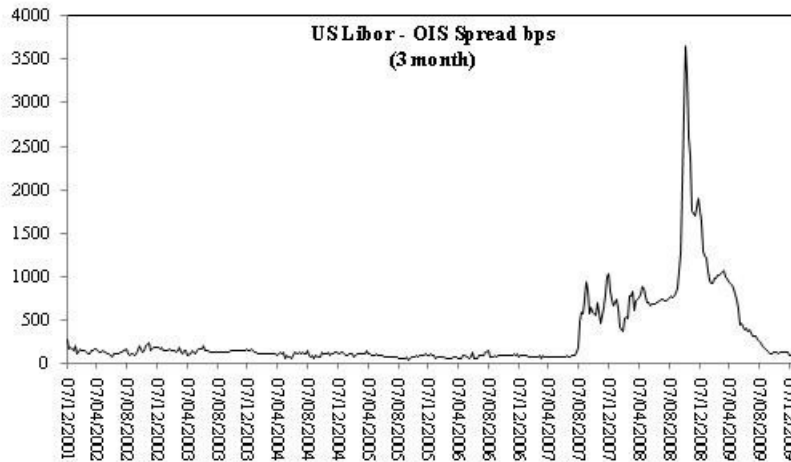

Figure 11: Three month US LIBOR three month Overnight Index Swap (OIS). Source: Bloomberg.

Figure 11 shows also how dramatically the economic and financial crisis worsened in October 2008. According to the intervention that took place (Troubled Asset Relief Program, TARP) in the US, in October 10th the spread reached an extraordinary level of 3644 bps indicating a further tightening credit market conditions. This implied a collapse in the interbank channel, which is used by banks with excess funds to lend to banks needing funds. When this interbank lending market declines because of higher interest rates, then banks are forced to hold more cash to conduct business; hence, they lend less, not only to other banks, but also to consumers. Less lending means there is less money in the economy, which lowers demands for products and services.[17]. This is what really happened in the US credit market within the recent crisis. Again figure 11 illustrates how this abnormal LIBOR-OIS spread hold for more than a year producing a stable and perpetual worsening in credit conditions. Basically the drop in the supply of credit puts upward pressure on interest rate spreads, and leads to a greater fall in lending than one might see in a typical recession. Our analysis depicts a

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[17]Note that US Personal Consumption fell by more than 8% on annual basis in the last quarters of 2008.

scenario in which tightening credit conditions after the subprime shock, not only acted as an amplifier, but even better played a fundamental role forcing consumption, production and investment. Each of the proxy utilized worked in the same direction showing extraordinary movements. Movements that have never been happened, even if we compare them to other crisis periods, which make this economic and financial crisis matchless.

3   Subprime Losses, Credit Crunch, Global Demand and World Trade

Having established the central role of mortgage-related debt in the crisis and the size of credit losses, in this section, we will try to understand how such a relatively limited and localized event (the subprime loan crisis in the United States) has to produce effects of such magnitude on the world economy. More precisely how an initial subprime estimated losses of about \$250 billion dollars ended up in a world GDP loss from 2008 to 2009 approximately equal to \$3.7 trillion dollars, so about 15 times the initial subprime loss.
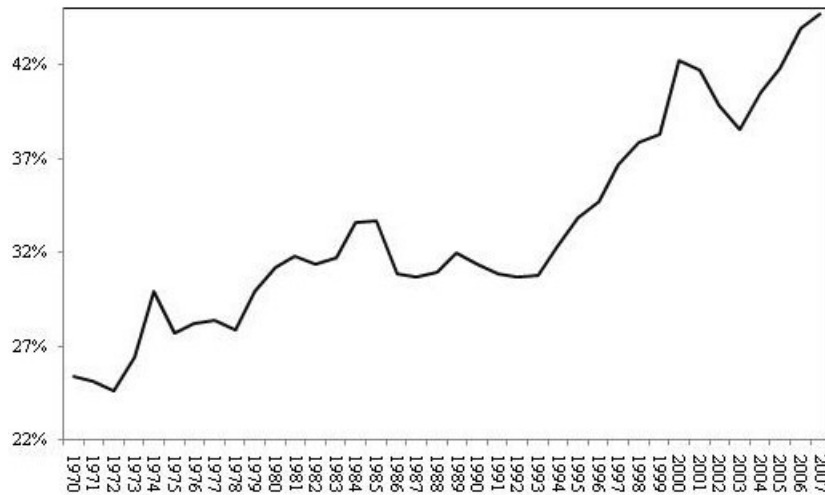

Figure 12: Trade as share of GPD. Source: OECD-OECDs Members Trade in Goods and Services as a Percentage of GDP.

The initial subprime losses through its negative impact on the credit conditions produced a sort of tightening monetary policy. It is well know from the basic macro theory that such policy produce in the short run a

decline in the output level. Moreover the scenario was quickly absorbed by extra US countries. A scenario quickly generated by the fall down in the US demand of foreign goods and services. A first stop in the global trade began, affecting not only advanced economies but also poorest countries export revenues. Conditional on a world scenario where the global trade in the last years accounted for 40% of the world demand (see figure 12), such demand-investment drop caused an immediate world trade collapse. According to the existence of a strong relationship between the credit
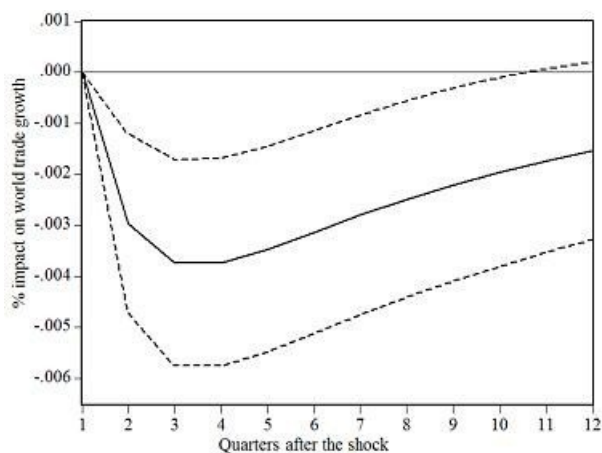

Figure 13: VAR estimation of the impact of a US credit conditions (net percentage of domestic respondents tightening standards for C&I loans) shock on World Trade growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a US credit conditions shock (data sample: 1990:2Q-2009:3Q). Source: OECD.

conditions and the real market, where to a stop in the lending market corresponds an income slowdown, thus a drop in production and consumption, we recognize a further damage to international trade. To better capture the effects of a tightening credit conditions on the real economic activity we have developed a brief analysis between US credit conditions, represented by the net percentage of domestic respondents tightening standards for C&I loans time series, and the world trade.[18] As figure 13 suggests a positive

[18] OECD database: World export (import) goods and services volumes are constructed as weighted averages of the growth rates of the volume of exports (imports) of individual countries, with the country weights based on shares of global goods and services export (import) values in 2000, expressed in US dollars. The measure of world trade is calculated as an arithmetic average of the volume of world imports and exports.

change in the net percentage of domestic respondents tightening standards for C&I loans, thus a negative scenario in the credit availability, produced a negative impact on the world trade up to several quarters after the shock and the impact is statistically significance up to the 11th quarters. Even in this additional analysis we can confirm that the credit component has been a major cause of the extension and worsening of the crisis. Not so far away the idea of being able to associate the so-called credit crunch to a restrictive monetary policy.
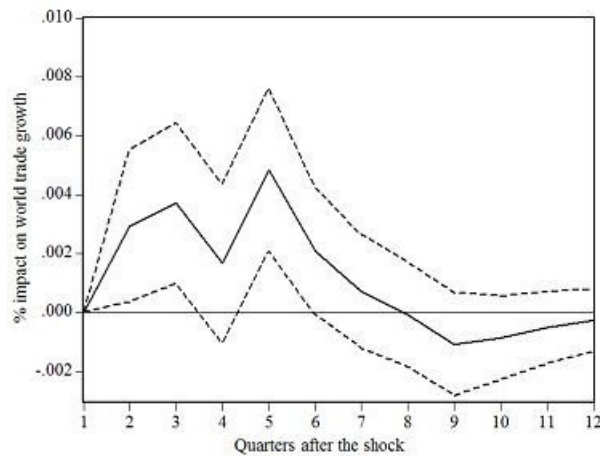

Figure 14: VAR estimation (via Montecarlo Simulations) of the impact of a Global Income shock on World Trade. Notes: Dashed lines are 1 standard-error bands around the response to a Global Income shock (data sample: 1970:3Q-2009:3Q). Source: OECD.

Figure 14 and figure 15 illustrate the impulse response functions of the world trade after an income shock. We performed two different estimations based on different samples and in both cases we can conclude that a positive shock on global income produces a statistically significance positive impact on world trade up to three quarters after the shock. On the other hand, as happened during this economic and financial crisis (partially caused of the credit crunch), in case of negative shock on the global income we will get a negative impact on the global trade. The strong relationship between income and trade is also confirmed by the Granger Causality test in table 10, the null hypothesis that global income growth does not Granger Cause the world trade growth is rejected at 1% confidence level.

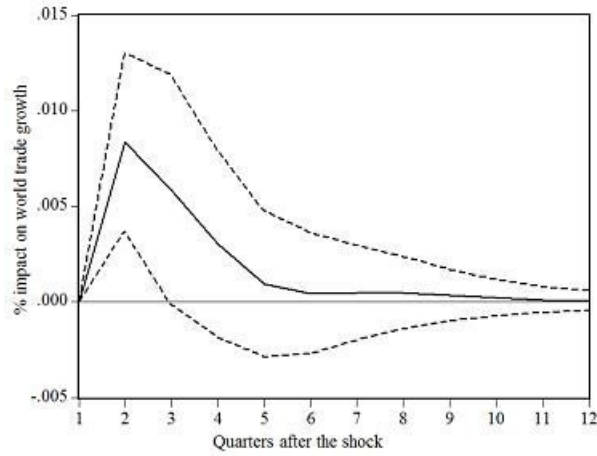What is clear from our analysis is that a sort of "chain effect" addressed

Figure 15: VAR estimation of the impact of a Global Income shock on World Trade. Notes: Dashed lines are 1 standard-error bands around the response to a Global Income shock (data sample: 1995:2Q-2009:3Q). Source: OECD.

Null Hypothesis:	Obs	F-Stat.	P-value
Granger Causality Test, 1990:2Q-2009:3Q - Lags:1			
Changes in credit conditions does not Granger Cause World Trade growth	77	12.3057	0.0008
World Trade growth does not Granger Cause changes in credit conditions	77	3.5255	0.0644
Granger Causality Test, 1996:2Q-2009:3Q - Lags:1			
Global Income growth does not Granger Cause World Trade growth	53	17.5217	0.0001
World Trade growth does not Granger Cause Global Income growth	53	2.9056	0.0945

Table 10: Granger Causality Test, Credit Conditions, Income and Trade Estimation Results

to the deterioration of the global markets condition began to take shape. It started first with the panic in financial markets, followed by the discovery of a huge amount of toxic assets. As a consequence the credit crunch born and the global demand began to freeze. Our analysis demostrates that the US tightening credit conditions have represented the starting point of this crisis but it also shows how a local phenomenon has been able to affect the world economy as a whole. To further proof this sort of "collapse chain"

it is sufficient to look at the behavior of the US savings. The US savings, in contrast to all the other US macro variables, increased during the last quarters, partially due to uncertainty and fear in the global markets.[19] Note that the US private saving rate , which on average represented the 2.6% of the US personal income during the last ten years, after the Lehman collapse to the end of 2009 jumped, tracking an average of 4.4%.[20]

Figure 16: Global Gross Domestic Product growth rate (on quarterly basis). OECD, Global Gross Domestic Product - expenditure approach .

Considering also the fact that US private consumption accounted for about 16 percent of global output it is not surprising that the economizing by US consumers has pushed the world economy into a deep recession. We also show a series of figures to capture the amplitude of the economic and financial crisis effects on the global demand and trade. From figure 16 we can easily capture the entity of the demand collapse. It shows a negative change on the Global GDP of about 8% on annual basis in the last quarter

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[19]On this point it is important to stress the fact that many people, even during the crisis, got their original wages, especially in those countries where the percentage of labor income to GDP is very high. In any case, panic, fear and uncertainty stimulated savings rather than demand, which would also be more convenient. On the other hand price of many consumer consumer goods fell.

[20]Source: Federal Reserve Bank of St. Louis. Data have been obtained as follows:

- average of monthly personal saving rates between January, 2000 and September 2008, as the pre-crisis sample;

- average of monthly personal saving rates between October, 2008 and December 2009, as the crisis sample.
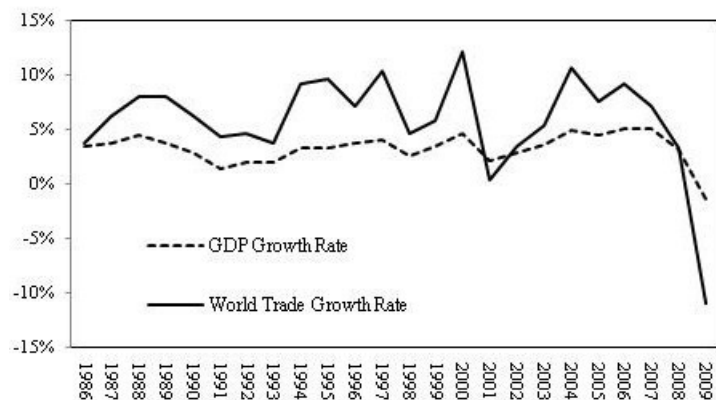
Figure 17: World Gross Domestic Product & World Trade (growth rates on annual basis). Source: International Monetary Fund, World Economic Outlook Database, October 2009.
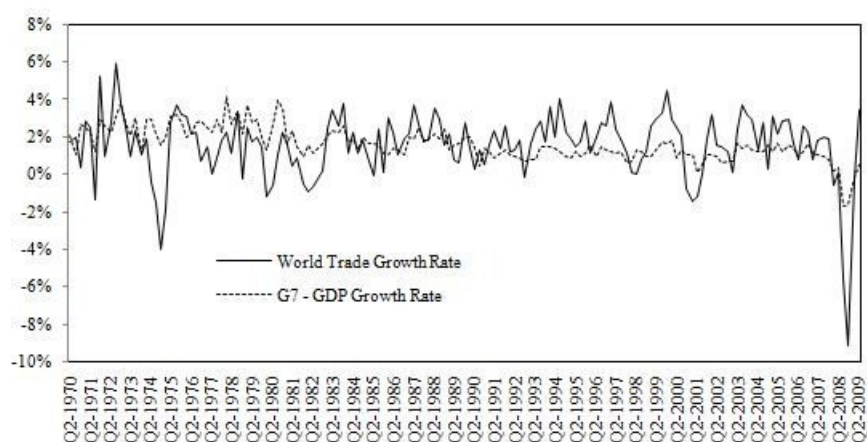

Figure 18: G7 Gross Domestic Product & World Trade (growth rates on quarterly basis). Source: OECD

of 2008. Next, from figure 17, which compares the World GDP growth rate and World Trade growth rate (on annual basis), and from figure 18, which compares the G7 GDP growth rate and the World Trade growth rate (on quarterly basis); we can conclude that global trade suffered much more than the global demand and that its impact on real economic activity can not be underestimated.

As a conclusion we can state that a mix of tightening conditions within the credit market plus the global trade collapse, as showed in this section, figure out as the most global economic and financial crisis since the great depression of the 30's.

4   Uncertainty Shocks Effects

As the empirical analysis of the previous sections pointed out, shocks in financial markets, credit market tightening conditions and world trade collapse have been crucial for the origin, growth and development of the recent economic and financial crisis. It should be quite evident that each of the above mentioned factor has showed extraordinary movements. In our opinion these effects are justified by the fact that the behavior of the world wide players within the financial markets, credit markets and real markets did not properly match the theoretical framework or a class of standard behaviors. As a matter of fact such scenario may find an explanation in the presence of panic and uncertainty in the markets. We can recognize this atmosphere, characterized by panic and uncertainty, in a series of figure here below illustrated. As observed by Nicholas Bloom in The Impact of

Figure 19: Monthly US stock market volatility (S&P 500). Source: Bloomberg.

Uncertainty Shocks, uncertainty appears to dramatically increase after ma-

jor economic and political shocks.[21] Figure 19 plots stock market volatility, used as proxy for uncertainty, which displays large bursts of uncertainty after major shocks. In fact one of the most salient effects of the credit crunch has been a huge surge in stock market volatility. The uncertainty on the financial markets and the unpredictability of the policy response of central banks and governments have all led to remarkable instability. Such an extraordinary event can be easily captured by looking at figure 19 where S&P 500 volatility - commonly known as the index of "financial fear"- has more than double since the subprime crisis first emerged in August 2007, reaching its highest level at the end of 2008 (60%). As noticed by Nicholas Bloom this big jump in uncertainty is of similar magnitude to those that followed significant economic and political shocks, such as the Cuban missile crisis, the Franklin National Financial crisis, the Black Monday, the Gulf War and the terrorist attacks of 9/11. But after these earlier shocks, volatility spiked and then quickly fell back. In fact, during past economic and political shocks, volatility dropped back to baseline levels within at most three/four months. On the contrary, the volatility level after the Lehman Brothers Chapter 11 event, have remained persistently high for nine months. It also reached the highest pick since the 1960s. Our analysis will be traced on the empirical work of Nicholas Bloom and also will be extended to the credit crunch and monetary shocks impacts on the real economic activity.
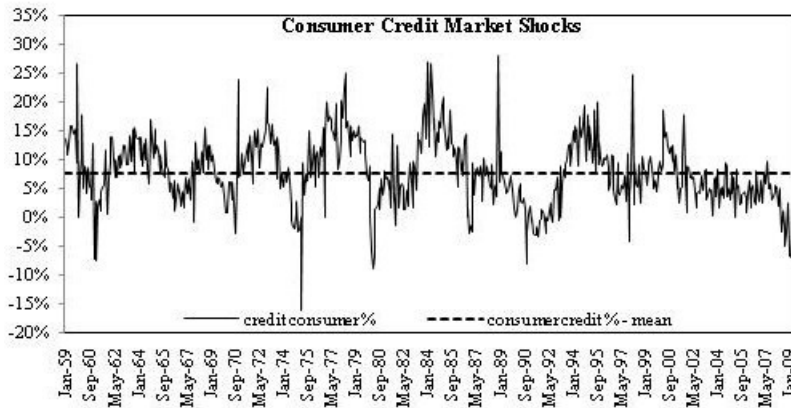

Figure 20: Consumer Credit annualized growth rate. Source: US Federal Reserve.

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[21]See Bloom, N. (2009): "The Impact of Uncertainty Shocks", *Econometrica*, Vol. 77, No. 3 (May, 2009), 623-685.
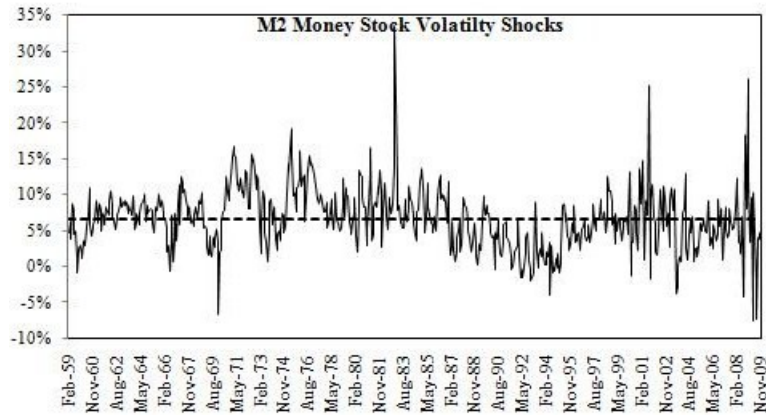
Figure 21: M2 Money Stock annualized growth rate. Source: US Federal Reserve.

Figure 22: VAR estimation of the impact of a S&P 500 Implied Volatility shock on US Industrial Production growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a S&P 500 Implied Volatility shock.

To evaluate the impact of uncertainty shocks on real economic outcomes we estimate a range of VARs based on monthly data. The variables subjected to our empirical analysis are S&P 500 implied volatility, a stock market volatility indicator, industrial production, consumer credit and M2 as

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Figure 23: VAR estimation of the impact of a S&P 500 Volatility Index (0 or 1) shock on US Industrial Production growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a S&P 500 Volatility Index shock.
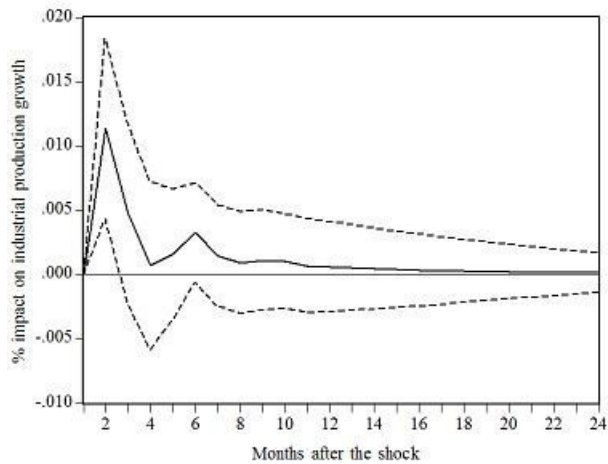
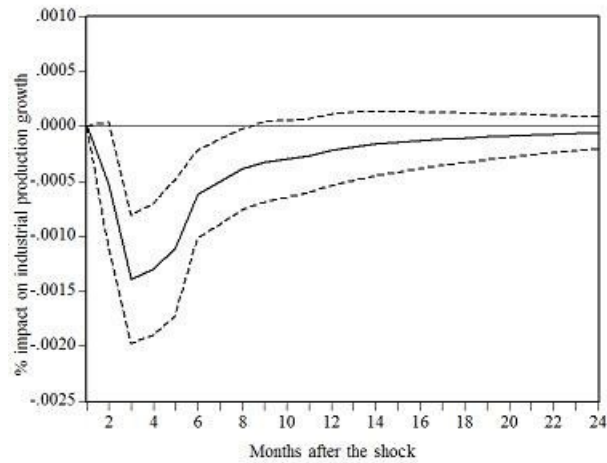

Figure 24: VAR estimation of the impact of an US Consumer Credit shock on US Industrial Production growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a Consumer Credit shock.

money stock measure. Stock market volatility indicator, consumer credit volatility index and M2 money stock volatility index are defined as a 0 or 1 binary series where we associated one to changes above the 95th percentile
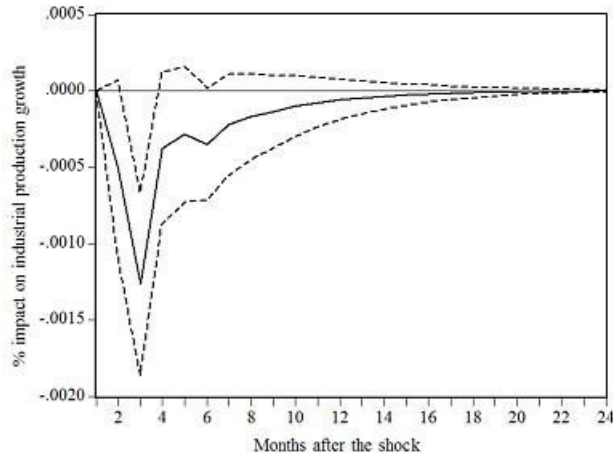
31
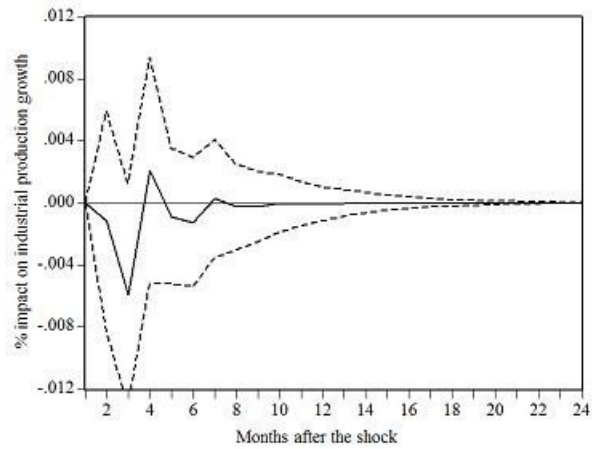
Figure 25: VAR estimation of the impact of an US Consumer Credit Index (0 or 1) shock on US Industrial Production growth rate. Notes: Dashed lines are 1 standard-error bands around the response to an US Consumer Credit Index shock.
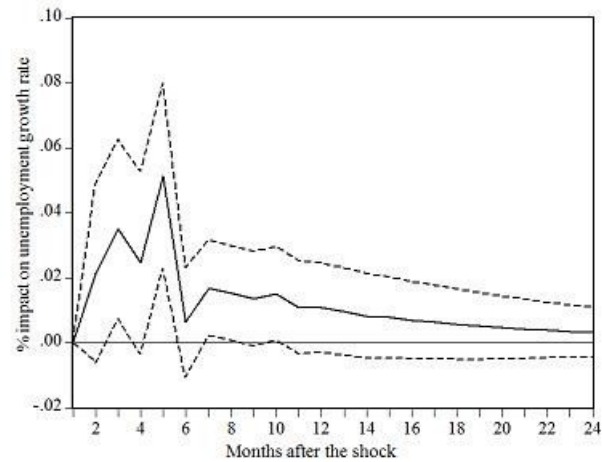
Figure 26: VAR estimation of the impact of a S&P 500 Implied Volatility shock on US Unemployment growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a S&P 500 Implied Volatility shock.

of the squared deviations from the mean distribution of the time series and zero otherwise. If we plot such special 0 or 1 series we identify that in most

Figure 27: VAR estimation of the impact of a S&P 500 Volatility Index (0 or 1) shock on US Unemployment growth rate. Notes: Dashed lines are 1 standard-error bands around the response to a S&P 500 Volatility Index shock.
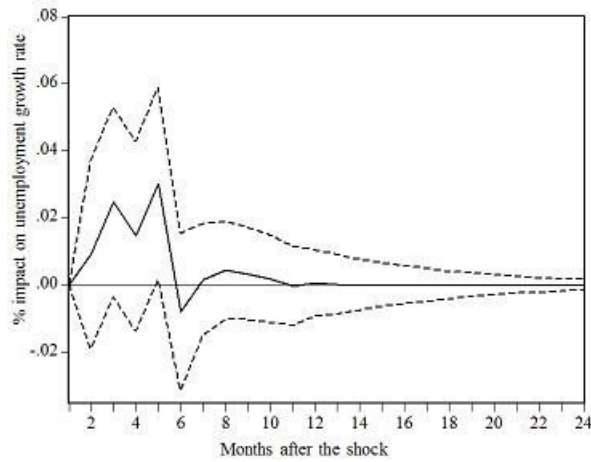
cases to each political shock corresponds a 1, which in turn refers to each pick in figure 20 and 21. Note also that the shocks in the M2 money stock market and in the consumer credit market are consistent with phases of the financial markets subject to high volatility. Not least the fact that to each volatility peak (see figure 19) corresponds a one in the other markets.

We already know, due to VAR estimations theory, that an impulse response function traces the effect of a one standard deviation shock to one of the innovations on current and future values of the endogenous variables. Vector autoregression (VAR) estimations suggest that stock market volatility shocks have a large real impact, generating a substantial drop in real economic activity and an increase in unemployment over the following six months (see figure 26). Note also that in the long run the shocks will be completely absorbed. Using the same methodology for the impact of credit crunch on real economic activity, our VAR estimation, as illustrated in figure 25, suggest that a credit market volatility shocks have a negative impact on real economic activity.[22] Estimations results confirm again how a mix of extraordinary events, such as financial markets uncertainty and credit crunch, produced a global chaos of such magnitude.

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[22] In this case dashed lines contain the zero level, this imply that the estimation is not statistically significance

5 Were the Central Banks right?

We recognized that this demand global collapse has been a consequence of several causes such as the sub-prime mortgages, the credit crunch, the trade collapse, which mixed together affected the real economic activity in a strong and permanent manner.[23] In what follows we will focus on the policies implemented by central banks to avoid a deep recession. As one of the most popular macroeconomics book for undergraduate studies can suggest us, in presence of such a drop in the demand, thus a declines in the Gross Domestic Product, the standard approach, or more precisely, the classic strategy to implement is to increase the stock of money in the market, by an open market operation where the central banks buy bonds in the bonds market. As we know the conduct of monetary policy has a direct effect on the performance of the economy because it has a major impact on money supply and interest rates. For the reason that the crisis started in the US and considering also the fact that they first implemented an expansionary monetary policy, our analysis will be mainly based on this country. US monetary policy affects all kinds of economic and financial decisions people make in this country-whether to get a loan to buy a new house or car or to start up a company, whether to expand a business by investing in a new plant or equipment, and whether to put savings in a bank, in bonds, or in the stock market, for example. Furthermore, because the U.S. is the largest economy in the world, its monetary policy also has significant economic and financial effects on other countries. It works by affecting demand across the economy-that is, people's and firms' willingness to spend on goods and services. In any case, the relationship between money supply and economic conditions is a vast subject that cannot be explained in this paper. In fact, our main purpose is not the one of explaining the effects of a quantitative easing policy, but the one of investigating on what went wrong in implementing these policies, more precisely if the monetary policies implemented within this economic and financial crisis were accurate. There is a general consensus that government actions and interventions caused, prolonged, and worsened the economic and financial crisis. As already mentioned in this paper they caused it by setting interest rates in an inadequate manner, especially comparing them with historical values. They prolonged it by misdiagnosing the problems in the bank credit markets and thereby responding incorrectly by focusing on liquidity rather than risk. They made it worse by providing

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[23]On this issue, after the Lehman Brothers Chapter 11 event, remember that US GDP displayed three consecutive quarter of negative growth's rate and that US Production Index decreased for eight consecutive months.

support for certain financial institution and their creditors but not others without a clear and understandable agenda. Even if important and fundamental from an empirical point of view a plain data analysis is not sufficient for a total understanding of the economic and financial crisis. As verified in previous sections financial markets, credit crunch and world trade collapse showed extraordinary behaviors in this recent crisis. According to those behaviors global markets' uncertainty rose dramatically. Furthermore, vagueness about the procedures or criteria for government interventions made the global market weaker and even more subject to uncertainty. Thus, we also need to understand how government actions and interventions could be implemented and if those implemented were right or not. Emphasizing the problems in the credit markets and their support in prolonging the crisis, based on a theoretical framework we will try to discuss about an appropriate monetary policy function aimed to incorporate a macro scenario characterized by credit market shocks and "systemic risk". Economic models are useful tools for helping to deal with these uncertainties partially reducing the complexity of the policy decision-making process, thus helping monetary authorities to achieve their goals. However, considering the fact that models are only an approximation of to the real economy, there will always be uncertainty about the correct structure of an economic model. As suggested by Blinder (1995) the presence of uncertainty can have important implications for policy. Uncertainty is in fact a serious consideration in the formulation of policy decisions, as summarized in the following quote by Alan Blinder while speaking on the strategy of monetary policy:

> "Unfortunately, actually to use such a strategy in practice, you have to use forecast, knowing that they may be wrong.
> You have to base you thinking on some kind of monetary theory, even though that they might be wrong.
> And you have to attach numbers to that theory, knowing that your numbers might be wrong.
> We at the Fed have all these fallible tools, and no choice but to use them"

In particular, uncertainty makes monetary authorities more conservative in the sense that they prefer to determine the appropriate policy response ignoring uncertainty, thus, "doing less". This conservative approach was first formulated, in a theoretical economic model, by William Brainard (1967).[24]

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[24]Brainard, W. (1967), "Uncertainty and the Effectiveness of Policy", *American Economic Review*, 57(2), pp. 411-425.

Brainard developed a model of policy implementation in which the policy-maker is uncertain about the impact of the policy instrument on the economy. With a single policy instrument Brainard showed that optimal policy is a function of both the first and second central moments characterizing the model parameters.[25] Basically this type of uncertainty limits movements of the policy instrument away from the level at which policymakers are most certain about its effect. Based on Brainard's intuition our model will account for different sources of uncertainty and also for another policy-maker, next we will try to understand if conservative is always the appropriate response. In our first theoretical model reinterpretation we develop a two countries model in which uncertainty does not exist and both are interested in maximizing the respectively policy functions. Suppose that the policy maker of the domestic country and the policy-maker of the foreign country are concerned respectively with the following target variables (y) and (y^*). Assume that (y) and (y^*) depend linearly on P and P^* policy instruments (obviously in this second case domestic for the first country but foreign for the second one). Four our purposes the impact of the exogenous variables may be summarized in a single variable, u for (y) and z for (y^*). Formally:

$$y = \alpha P + \beta P^* + u \tag{1}$$

$$y^* = \alpha^* P^* + \beta^* P + z \tag{2}$$

where the target variable (y) depends also on the foreign policy instrument P^* and vice versa the foreign target variable (y^*) depends also on the foreign policy instrument P. Excluding uncertainty about parameters and assuming the policy-makers choose policy on the basis of a quadratic expected utility,[26] the maximization problem become as follows:

$$min_P \quad L = E(y - \bar{y})^2 \tag{3}$$

for the domestic policy-maker, and:

$$min_{P*} \quad L = E(y^* - \bar{y^*})^2 \tag{4}$$

for the foreign policy maker.

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[25]Only the first and second moment are required because of the assumption that the policy-maker has quadratic preferences.

[26]Note that from a mathematical point of view, a quadratic form is homogeneous polynomial of degree two in a number of variables.

In both problems the policy-makers minimizes the squared deviations of output around the target level, denoted by $\bar{y}$ and $\bar{y}^*$. And substituting for (y) and (y^*) we obtain:

$$min_P \quad L = E(\alpha P + \beta P^* + u - \bar{y})^2 \tag{5}$$

$$min_{P^*} \quad L = E(\alpha^* P^* + \beta^* P + z - \bar{y}^*)^2 \tag{6}$$

thus, the associated optimal policies:

$$\frac{\partial L}{\partial P} = 0 \Rightarrow 2(\alpha P + \beta P^* + u - \bar{y})\alpha = 0$$

$$\Rightarrow P_{optimal} = \frac{\bar{y} - \beta P^* - u}{\alpha} \tag{7}$$

$$\frac{\partial L^*}{\partial P^*} = 0 \Rightarrow 2(\alpha^* P^* + \beta^* P + z - \bar{y}^*)\alpha^* = 0$$

$$\Rightarrow P^*_{optimal} = \frac{\bar{y}^* - \beta^* P - z}{\alpha^*} \tag{8}$$

where the home country chooses the best (P) given (P^*) and the foreign country chooses the best (P^*) given (P). Substituting for (P^*) and (P) we obtain the following optimal solutions/quantities for our policy-makers:[27]

$$P_{optimal} = \frac{\alpha^*(\bar{y} - u) - \beta(\bar{y}^* - z)}{\alpha\alpha^* - \beta\beta^*} \tag{9}$$

$$P^*_{optimal} = \frac{\alpha(\bar{y}^* - z) - \beta^*(\bar{y} - u)}{\alpha\alpha^* - \beta\beta^*} \tag{10}$$

In this simple two countries model we can easily recognize that, in case of negative response coefficients β and β^*, $P_{optimal}$ and $P^*_{optimal}$ should be implemented in a more aggressive way. On the other side of the coin, assuming the existence of a global and unique liquidity market, in case of positive response coefficients, policy responses could be implemented in a weaker manner.

We next represent the same model including in our structural equations (y) and (y^*) the effect of the credit crunch, both for the home and foreign countries. In our analysis the credit crunch, is intended to represent a sort of tightening monetary policy playing against the monetary expansion implemented by the central banks within the economic and financial crisis. The credit crunch effects are represented by P_2 and P_2^*. Formally:

---

[27]The solution is derived in more detail in Appendix 7.3.

$$y = \alpha_1 P_1 + \alpha_2 P_2 + \beta_1 P_1^* + \beta_2 P_2^* + u \tag{11}$$

$$y = \alpha_1^* P_1^* + \alpha_2^* P_2^* + \beta_1^* P_1 + \beta_2^* P_2 + z \tag{12}$$

where P_2 and P_2^* denote the credit crunch respectively for the domestic country and the foreign country. Maximizing the same quadratic utility function and solving for P_1 and P_1^* we obtain the following optimal policy responses:

$$P_{1\,optimal} = \frac{\bar{y} - \alpha_2 P_2 - \beta_1 P_1^* - \beta_2 P_2^* - u}{\alpha_1} \tag{13}$$

$$P_{1\,optimal}^* = \frac{\bar{y^*} - \alpha_2^* P_2^* - \beta_1^* P_1 - \beta_2^* P_2 - z}{\alpha_1^*} \tag{14}$$

If response coefficients of (y) and (y^*) to credit crunch P_2 and P_2^* are negative domestic and foreign policy makers further need to be more aggressive in implementing their quantitative easing monetary policies. Basically this scenario represents what really happened in our global liquidity market within the economic and financial crisis. Therefore (see section 3), the credit crunch acted as a tightening monetary policy, having also a negative impact on the policy-makers targets.[28] To sum up, in such a global liquidity market scenario, not only the home credit crunch impact caused tightening credit conditions, but also the one of the foreign country.

In what follows we will introduce uncertainty component in the model. As we know there are many sources of uncertainty faced by policy-makers, a number of which stem from the fact that the structure of the economy is changing over time. In this section we consider the case where at any point in time the policy-maker is uncertain about the value of the model parameters. Therefore uncertain about the effect of policy changes which has been termed multiplier uncertainty. We assume that the structural relationships of the model are known and expressed including the credit crunch components and the impact of the foreign country policies (see equations 11 and 12):

$$y = \alpha_1 P_1 + \alpha_2 P_2 + \beta_1 P_1^* + \beta_2 P_2^* + u \tag{15}$$

$$y = \alpha_1^* P_1^* + \alpha_2^* P_2^* + \beta_1^* P_1 + \beta_2^* P_2 + z \tag{16}$$

where the sources of uncertainty are represented by $[\alpha_1, \alpha_2, \beta_1, \beta_2, \alpha_1^*, \alpha_2^*, \beta_1^*, \beta_2^*, u$ and $z]$, more precisely by the response coefficients of targets (y) and (y^*) to policy actions. As listed above, policy-makers face several

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[28]Note that this is also valid for lagged values of P_2 and P_2^*.

kinds of uncertainty. Four our purposes we recognize uncertainty as the policy-maker uncertainty about the impact of the exogenous variables (u and z) and uncertainty as the policy-maker uncertainty about the response of y to any given policy action [α_1, α_2,β_1, β_2, α_1^*, α_2^*, β_1^*, β_2^*]. Therefore coefficients uncertainty is introduced by assuming that the policy-makers view the multiplier as a random variable. Thanks to the variance scaling property and the Bienoym formula we can define the total variance for our two structural equations (y) and (y^*) in the following way:[29]

$$
\begin{aligned}
\sigma_y^2 &= \sigma_{\alpha\,1}^2 P_1^2 + \sigma_{\alpha\,2}^2 P_2^2 + \sigma_{\beta\,1}^2 P_1^{*2} + \sigma_{\beta\,2}^2 P_2^{*2} \\
&\quad + \sigma_u^2 + 2\rho\sigma_{\alpha\,1}\sigma_{\alpha\,2}P_1 P_2 + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,1}P_1 P_1^* \\
&\quad + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,2}P_1 P_2^* + 2\rho\sigma_{\alpha\,2}\sigma_{\beta\,1}P_2 P_1^* \\
&\quad + 2\rho\sigma_{\alpha\,2}\sigma_{\beta\,2}P_2 P_2^* + 2\rho\sigma_{\beta\,1}\sigma_{\beta\,2}P_1^* P_2^*
\end{aligned}
$$

$$
\begin{aligned}
\sigma_y^{*2} &= \sigma_{\alpha\,1}^{*2} P_1^{*2} + \sigma_{\alpha\,2}^{*2} P_2^{*2} + \sigma_{\beta\,1}^{*2} P_1^2 + \sigma_{\beta\,2}^{*2} P_2 \\
&\quad + \sigma_z^2 + 2\rho\sigma_{\alpha\,1}^*\sigma_{\alpha\,2}^* P_1^* P_2^* + 2\rho\sigma_{\alpha\,1}^*\sigma_{\beta\,1}^* P_1^* P_1 \\
&\quad + 2\rho\sigma_{\alpha\,1}^*\sigma_{\beta\,2}^* P_1^* P_2 + 2\rho\sigma_{\alpha\,2}^*\sigma_{\beta\,1}^* P_2^* P_1 \\
&\quad + 2\rho\sigma_{\alpha\,2}^*\sigma_{\beta\,2}^* P_2^* P_2 + 2\rho\sigma_{\beta\,1}^*\sigma_{\beta\,2}^* P_1 P_2
\end{aligned}
$$

where we have also assumed that there are no correlations between the exogenous terms u and z and the respectively response coefficients. Being a weighted sum of variables, the variable with the largest weight will have a disproportionally largest weight in the variance of the total. Note that this state cannot be underestimated and may play a crucial role in the development of an optimal monetary policy.

The goal of the policy-makers is still presumed to be to minimize the squared deviations of output around the target level, denoted by $\bar{y}$. The expected loss functions are given by:

$$
min_P \quad L = E[(y - \bar{y})^2)] \tag{17}
$$

---

[29]The original form of this property states as follows: $Var(\alpha x + \beta Y) = \alpha^2 Var(x) + \beta^2 Var(y) + 2\alpha\beta cov(x; y)$ where x and y are random varibles and α and β are weights. Instead of using the covariance we have adopted the correlation by applying the relationship property between the covariance and the correlation. Formally:$\rho_{\alpha+\beta x;\ c+dy} = \frac{cov(\alpha+\beta x;\ c+dy)}{\sqrt{Var(\alpha+\beta x)\cdot Var(c+dy}} = \frac{cov(\alpha+\beta x;\ c+dy)}{\sqrt{\beta^2 Var(x)\cdot d^2 Var(y}} = \frac{\alpha\beta\cdot cov(x;\ y)}{\sqrt{\beta^2 Var(x)\cdot d^2 Var(y)}} = \frac{\alpha\beta\cdot cov(x;\ y)}{\alpha\beta\cdot\sqrt{Var(x)\cdot Var(y)}} \Rightarrow \beta d\cdot\rho_{x;\ y}\cdot\sqrt{Var(x)\cdot Var(y)} = \beta d\cdot cov(x;\ y)$.

$$min_{P*} \quad L = E[(y^* - \bar{y}^*)^2] \tag{18}$$

However this is to equivalent to minimizing the variance of $y \equiv \sigma_y^2$ around its mean value. In our previous analysis minimizing the loss function and minimizing the variance of y were equivalent because the model was characterized by certainty equivalence. This, in turn, implied that we set $E(y) = \tilde{y} = \bar{y}$. Basically we stated that the variance of y around $\tilde{y}$ was equal to the variance around $\bar{y}$. In other words, the expected value of y was equal to its target level. Adding multiplicative uncertainty the choice of optimal values of the instruments should take into account the relationship between instruments values and the variance of the goal variable.
The relevant loss functions can be rewritten as

$$min_P \quad L = E[(y - \tilde{y} + \tilde{y} - \bar{y})^2)] = E[\sigma_y^2 + (\tilde{y} - \bar{y})^2)] \tag{19}$$

$$min_{P*} \quad L = E[(y^* - \bar{y}^*)^2] = E[\sigma_y^{*2} + (\tilde{y^*} - \bar{y}^*)^2)] \tag{20}$$

where in the second expression the cross product terms from the multiplication drop out because $E(y - \tilde{y}) = 0$. Substituting for σ_y^2 and σ_y^{*2} and for the estimated value of y and y^* ($\tilde{y}$ and $\tilde{y^*}$); and by differentiating with respect to P_1 and P_1^*, and setting the derivatives equal to zero, the optimal values of P_1 and P_1^* are easily found to be:

$$P_{1\,optimal} = \frac{\tilde{\alpha}_1(\bar{y} - \tilde{\alpha}_2 P_2 - \tilde{\beta}_1 P_1^* - \tilde{\beta}_2 P_2^* - \tilde{u}) - \rho\sigma_{\alpha 1}\sigma_{\alpha 2}P_2 - \rho\sigma_{\alpha 1}\sigma_{\beta 1}P_1^* - \rho\sigma_{\alpha 1}\sigma_{\beta 2}P_2^*}{(\tilde{\alpha}_1^2 + \sigma_{\alpha 1}^2)}$$

$$P_{1\,optimal}^* = \frac{\tilde{\alpha}_1^*(\bar{y}^* - \tilde{\alpha}_1^* P_1^* - \tilde{\beta}_1^* P_1 - \tilde{\beta}_2^* P_2 - \tilde{z}) - \rho\sigma_{\alpha 1}^*\sigma_{\alpha 2}^*P_2^* - \rho\sigma_{\alpha 1}^*\sigma_{\beta 1}^*P_1 - \rho\sigma_{\alpha 1}^*\sigma_{\beta 2}^*P_2}{(\tilde{\alpha}_1^{*2} + \sigma_{\alpha 1}^{*2})}$$

where $\tilde{\alpha}_1$, $\tilde{\alpha}_2$, $\tilde{\beta}_1$, $\tilde{\beta}_2$, $\tilde{\alpha}_1^*$, $\tilde{\alpha}_2^*$, $\tilde{\beta}_1^*$ and $\tilde{\beta}_2^*$ denote the estimated values of our parameters.
The optimal policies clearly differ from the policies which would be pursued in a world of certainty or certainty equivalence. These differences can be easily recognized by comparing results in an uncertainty framework with those obtained in the certainty equivalent model. Policy-makers should make use of more information than the expected value of the exogenous variables and of the response coefficients. Even if we have assumed that the response coefficients and the exogenous variables are independently distributed, policy-makers need further information about the response coefficient variances as

well as their means. Then, if correlations exist between response coefficients, policy-makers also need to know their correlations. The economic and financial crisis has been characterized by extraordinary events which bring the global economy to a deep recession. Central banks and governments needed to produce effective strategies to get out of this recession. In order to make closer this goal a series of quantitative easing policies were implemented. But were they right? According to Brainard's intuition and in the hypothesis of correlations between response coefficients, policy-makers should be more caution in implementing their policies. From a theoretical point of view central banks would have to take into account all sources of uncertainty and therefore act accordingly to this scenario. In such unpredictable environment about the possible ex-post policies reactions a better strategy could be the one of a moderate cut reference rates policy. Roughly speaking $P_{1\,optimal}$ and $P_{1\,optimal}^*$ had to be lower. In reality this does not reflect what really happened during the crisis. In fact from September 2007 to January 2009 the Federal Reserve cut Fed funds rate 5 times (see table 10), a quite aggressive program respect to what theory suggests, also well accepted and followed by other economies. It is well know that behind this aggressive policies lay the need to preserve the mortgage market and financial institutions bankruptcy.

Date	Increase	Decrease	Level (%)
December 16, 2008	...	75 - 100	0 - 0.25
October 29, 2008	...	50	1
October 8, 2008	...	50	1.5
April 1, 2008	...	25	2
March 18, 2008	...	75	2.25
January 30, 2008	...	50	3
January 22, 2008	...	75	3.5

Table 11: Intended federal funds rate, change and level. Source: Federal Reserve

In our analysis we have tried to capture such extraordinary events providing an appropriate optimal response. We have added to the standard framework the impact of the credit crunch, referring also to the one of foreign country, and the effects of foreign country's policy. Including these components, the theoretical model suggests us that policy-makers' uncertainty increased, especially due to the credit crunch shocks. Furthermore, assigning greater weight to the credit crunch component, such component becomes fundamental in the computation of the total variance. Even if neg-

ative correlation were verified between the monetary policy response coefficient and the credit crunch impact coefficient, hence an uncertainty cutback come out, we recognize that quantitative easing policies implemented, in order to be optimal, had to be more aggressive. Emphasizing the role of the credit and assigning it a major weight, still in presence of negative correlation, the optimal solution demonstrates that quantitative easing policies were not enough to reach an immediate recovery. Suppose to assign a substantial weight to P_2 and P_2^*.[30] According to our optimal solutions for P_1 and P_1^* it is not difficult to capture how to a bigger credit crunch weights should correspond higher optimal solutions. Thus, credit crunch not only increase uncertainty but also played against the quantitative easing policies (home P_1 and foreign P_1^*). In an extraordinary scenario where to a expansionary monetary policy correspond tightening credit conditions, in fact their response coefficient are negative correlated, optimal solutions for P_1 and P_1^* suggest to be more aggressive. Basically a simple ex post analysis based on this theoretical model suggests us that on one side policy-makers should have been more cautious (due to a steady increase in the overall variance) and on the other side (given the negative correlation) they would have been more aggressive. In our opinion central banks partially underestimated the effects of such tightening credit conditions as contractionary monetary policy and furthermore did not recognize that the use o a huge amount of liquidity to save banks capital ratios produced a stop in the consumer credit market trough lower lending capacity. As a consequences a drop in the private consumption and private investment occurred. As already mentioned, Brainard argued that, in response to uncertainty about the parameter on a variable, policymakers should attenuate their policy response to movements in that variable. Even more, in case of n instruments, thus, uncertainty about n parameters, policymakers should adopted further caution in implementing their policies. Brainard's finding, however intuitive, has been shown not to be general: some forms of parameter uncertainty suggest that policymakers should discount incoming data, but others suggest that policymakers should respond more aggressively to incoming data. Our model's reorganization partially support Brainard's finding, even more showed that with n instrument, a higher uncertainty increases the size of the overall risk. On the other hand an ex-post analysis demonstrate that some parameters uncertainty, in our case, those referring to credit crunch, during the crisis obliged policymakers to be more aggressive.

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[30]Note that our main intuition is that credit crunch has been really important in the evolution of this economic and financial crisis.

6 Conclusion

Our analysis outlines and proves that variables, such as money stock, consumer credit rather than global trade, during this crisis behaved in a different way respect to standards behaviors explained by theory or past empirical analysis. On one hand this extraordinary environment could be mostly explained by the presence of uncertainty in the market. On the other hand, it is also important to stress the fact that an optimal money supply strategy has not been implemented during the crisis, generating further panic and uncertainty in the global markets. As a matter of fact a plain data analysis on money stock measures and credit condition measures show how the huge amount of liquidity injected by central banks within the economic and financial crisis have been used by investment and commercial banks to reestablish their own capital ratios rather than to distribute this liquidity in the interbank lending market through loans or mortgages, which are fundamental pre-requisites for a sustainable economic activity in terms of consumption, investment and productivity. The above mentioned reasons played against the quantitative easing policies implemented by Federal Reserve and by other central banks. In fact we have seen that central banks acted, even contrary to what suggested by the theory, in a very aggressive manner (cutting rates in a sustained way for several months). However, in our humble opinion, this liquidity did not push in the right channels avoiding an improvement in the credit market conditions. Basically liquidity stopped in the interbank sector and did not move from commercial banks to customers and firms. Therefore the currency in circulation was not sufficient to make markets safer and more confident, and also to give breath to businesses and consumers through bank loans or mortgages or other financing sources. As noticed by Paul Krugman, economists have to face up to the inconvenient reality that financial markets fall far short of perfection and that they are subject to extraordinary delusions. Financial markets have became fundamental for a global market equilibrium. They produce also fear, diffidence and uncertainty, once cracks occur economists have to do their best to incorporate the realities of finance into macroeconomics. But during the last economic and financial crisis, financial markets turmoil, even if relevant, cannot be use exclusively to justify the global demand collapse. Instead the reason of such extraordinary and prolonged slump can be found through the study of the credit market and its tightening conditions. The economic and financial crisis pointed out several weaknesses in macroeconomic monetary policies. An ex-post analysis suggests that policymakers should redesigned policy strategies, so as to implement the main lessons from the crisis, es-

pecially those concerned with financial markets shocks, exploding leverage and tightening credit conditions.

7 Appendix

7.1 Financial Markets and Real economic activity relationship

ADF Test Statistic	-2.575016	1% Critical Value*	-2.5678
		5% Critical Value	-1.9397
		10% Critical Value	-1.6158

*MacKinnon critical values for rejection of hypothesis of a unit root.

Variable	Coefficient	Std. Error	t-Statistic	P-value
ECM(-1)	-0.008683	0.003372	-2.575016	0.0102
D(ECM(-1))	0.069227	0.03218	2.151279	0.0317
D(ECM(-2))	-0.060058	0.032168	-1.867054	0.0622
D(ECM(-3))	-0.101084	0.032153	-3.143842	0.0017
D(ECM(-4))	0.035355	0.032259	1.095977	0.2734
D(ECM(-5))	0.059504	0.032274	1.843744	0.0655
D(ECM(-6))	-0.047816	0.032176	-1.486084	0.1376
D(ECM(-7))	0.056863	0.032199	1.76596	0.0777
D(ECM(-8))	0.085155	0.032247	2.640713	0.0084

Table 12: Augmented Dickey-Fuller Test Equation, DJIA Stock Index & and US Industrial Production (1929:08-2009:09)
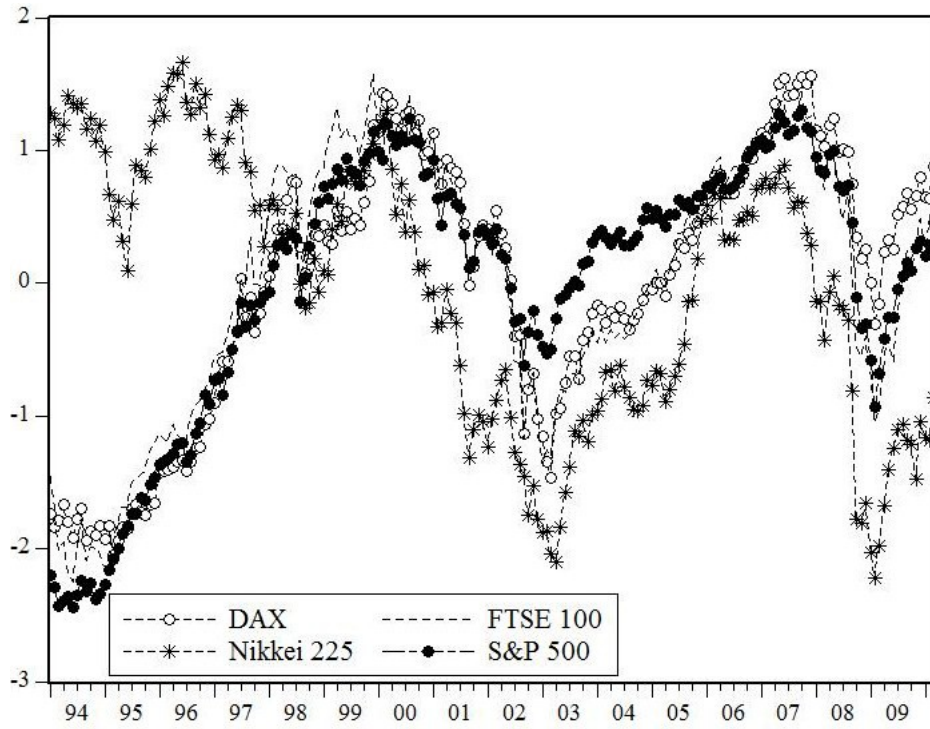
7.2 Financial Transmission

Figure 28: Global Stock Markets. Source: Reuters

	α	β	R-squared
France (CAC 40)	1.0377	1.0361	0.8962
	(0.0000)	(0.0000)	
Germany (DAX)	0.7155	1.1085	0.8702
	(0.0010)	(0.0000)	
Spain (IBEX 35)	0.2353	1.2643	0.8972
	(0.2710)	(0.0000)	
UK (FTSE 100)	4.0947	0.6357	0.8806
	(0.0000)	(0.0000)	
Suisse (SMI)	1.5913	1.0204	0.9342
	(0.0000)	(0.0000)	
Brasil (IBOVESPA)	-4.5506	2.0556	0.5536
	(0.0000)	(0.0000)	
China (HANG SENG)	5.4144	0.5906	0.4100
	(0.0000)	(0.0000)	
Japan (NIKKEI 225)	10.9074	-0.1956	0.0541
	(0.0011)	(0.0000)	

*p values are in the brackets

Table 13: Regression Parameters - Independent Variable: Log(S&P Stock Index). Sample: Jan 1994 - Mar 2010 (195 monthly observations)

7.3 Two Countries Static Model for Domestic and Foreign Optimal Monetary Policies in a certainty equivalent framework

In this appendix we generalize Brainard's (1967) solution to the optimal policy problem in a duopoly scenario for a couple of policy-maker with quadratic preferences using a two structural equations based on two instruments and one target. The model can be written in the following general form:

$$min_P \quad L = E(y - \bar{y})^2) \ for \ the \ domestic \ policy - maker \qquad (21)$$

$$min_{P*} \quad L = E(y^* - \bar{y^*})^2 \ for \ the \ foreign \ policy - maker \qquad (22)$$

subject to:

$$y = \alpha P + \beta P^* + u \qquad (23)$$

$$y^* = \alpha^* P^* + \beta^* P + z \qquad (24)$$

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which can be rewritten substituting for y and y^* as:

$$min_P \quad L = E(\alpha P + \beta P^* + u - \bar{y})^2 \tag{25}$$

$$min_{P*} \quad L = E(\alpha^* P^* + \beta^* P + z - \bar{y^*})^2 \tag{26}$$

The optimal solutions can be easily derived by setting the first partial derivatives with respect to P and P^* equal to zero:

$$\frac{\partial L}{\partial P} = 0 \Rightarrow 2(\alpha P + \beta P^* + u - \bar{y})\alpha = 0 \Rightarrow$$

$$\Rightarrow P_{optimal} = \frac{\alpha(\bar{y} - \beta P^* - u)}{\alpha^2} = \frac{\bar{y} - \beta P^* - u}{\alpha} \tag{27}$$

$$\frac{\partial L^*}{\partial P^*} = 0 \Rightarrow 2(\alpha^* P^* + \beta^* P + z - \bar{y^*})\alpha^* = 0 \Rightarrow$$

$$\Rightarrow P^*_{optimal} = \frac{\alpha^*(\bar{y^*} - \beta^* P - z)}{\alpha^{*2}} = \frac{\bar{y^*} - \beta^* P - z}{\alpha^*} \tag{28}$$

where the home country chooses the best P given P* and the foreign country chooses the best P^* given P. Substituting for (P^*) and (P) we obtain the following optimal solutions (quantities) for our two policy-makers:

$$P_{optimal} = \frac{\bar{y} - \beta(\frac{\bar{y^*} - \beta^* P - z}{\alpha^*}) - u}{\alpha} = \frac{\frac{\alpha^* \bar{y} - \beta \bar{Y^*} + \beta\beta^* P - \beta z - \alpha^* u}{\alpha^*}}{\alpha} =$$

$$= \frac{\alpha^*(\bar{Y} - u) - \beta(\bar{y^*} - z) + \beta\beta^* P}{\alpha\alpha^*} \Rightarrow P_{optimal}(\alpha\alpha^* - \beta\beta^*) = \alpha^*(\bar{Y} - u) - \beta(\bar{y^*} - z)$$

$$P_{optimal} = \frac{\alpha^*(\bar{Y} - u) - \beta(\bar{y^*} - z)}{\alpha\alpha^* - \beta\beta^*} \tag{29}$$

$$P^*_{optimal} = \frac{\bar{y^*} - \beta^*(\frac{\bar{y} - \beta P^* - u}{\alpha}) - z}{\alpha^*} = \frac{\frac{\alpha \bar{y^*} - \beta^* \bar{y} + \beta^* \beta P^* + \beta^* u - \alpha z}{\alpha}}{\alpha^*} =$$

$$= \frac{\alpha(\bar{y^*} - z) - \beta(\bar{y} - u) + \beta^* \beta P^*}{\alpha^* \alpha} \Rightarrow P^*_{optimal}(\alpha^* \alpha - \beta^* \beta) = \alpha(\bar{y^*} - z) - \beta^*(\bar{y} - u)$$

$$P_{optimal} = \frac{\alpha(\bar{y^*} - z) - \beta^*(\bar{y} - u)}{\alpha^* \alpha - \beta^* \beta} \tag{30}$$

Alternative, if we include credit crunch impact both for home country and foreign country, then the model takes the following form:

$$min_P \quad L = E(y - \bar{y})^2) \ for \ the \ domestic \ policy - maker \qquad (31)$$

$$min_{P*} \quad L = E(y^* - \bar{y^*})^2 \ for \ the \ foreign \ policy - maker \qquad (32)$$

subject to:

$$y = \alpha_1 P_1 + \alpha_2 P_2 + \beta_1 P_1^* + \beta_2 P_2^* + u \qquad (33)$$

$$y^* = \alpha_1^* P_1^* + \alpha_2^* P_2^* + \beta_1^* P_1 + \beta_2^* P_2 + z \qquad (34)$$

which can be rewritten substituting for y and y^* as:

$$min_P \quad L = E(\alpha_1 P_1 + \alpha_2 P_2 + \beta_1 P_1^* + \beta_2 P_2^* + u - \bar{y})^2) \qquad (35)$$

$$min_{P*} \quad L = E(\alpha_1^* P_1^* + \alpha_2^* P_2^* + \beta_1^* P_1 + \beta_2^* P_2 + z - \bar{y^*})^2 \qquad (36)$$

Once more optimal solutions can be easily derived by setting the first partial derivatives with respect to P_1 and P_1^* equal to zero:

$$\frac{\partial L}{\partial P_1} = 0 \Rightarrow 2(\alpha_1 P_1 + \alpha_2 P_2 + \beta_1 P_1^* + \beta_2 P_2^* + u - \bar{y})\alpha_1 = 0 \Rightarrow$$

$$\Rightarrow P_{1 \ optimal} = \frac{\alpha_1(\bar{y} - \alpha_2 P_2 - \beta_1 P_1^* - \beta_2 P_2^* - u)}{\alpha_1^2}$$

$$P_{1 \ optimal} = \frac{(\bar{y} - \alpha_2 P_2 - \beta_1 P_1^* - \beta_2 P_2^* - u)}{\alpha_1} \qquad (37)$$

$$\frac{\partial L^*}{\partial P_1^*} = 0 \Rightarrow 2(\alpha_1^* P_1^* + \alpha_2^* P_2^* + \beta_1^* P_1 + \beta_2^* P_2 + z - \bar{y^*})\alpha_1^* = 0 \Rightarrow$$

$$\Rightarrow P_{1 \ optimal}^* = \frac{\alpha_1^*(\bar{y^*} - \alpha_2^* P*_2 - \beta_1^* P_1 - \beta_2^* P_2 - z)}{\alpha_1^{*2}}$$

$$P_{1 \ optimal}^* = \frac{(\bar{y^*} - \alpha_2^* P_2^* - \beta_1^* P_1 - \beta_2^* P_2 - z)}{\alpha_1^*} \qquad (38)$$

where the home country chooses the best P_1 given P_1^* and the foreign country chooses the best P_1^* given P_1 . Substituting then for (P_1^*) and (P_1) we obtain the following optimal solutions/quantities for our two policy-makers:

$$P_{1\ optimal} = \frac{\bar{y} - \alpha_2 P_2 - \beta_1 \left(\frac{(\bar{y}^* - \alpha_2^* P_2^* - \beta_1^* P_1 - \beta_2^* P_2 - z) - \beta_2 P_2^*}{\alpha_1^*} \right)}{\alpha_1} =$$

$$= \frac{\left(\frac{\alpha_1^*(\bar{y} - \alpha_2 P_2 - \beta_2 P_2^* - u) - \beta_1(\bar{y}^* - \alpha_2^* P_2^* - \beta_2^* P_2 - z + \beta_1 \beta_1^* P_1)}{\alpha_1^*} \right)}{\alpha_1} \Rightarrow$$

$$= \frac{\alpha_1^*(\bar{y} - \alpha_2 P_2 - \beta_2 P_2^* - u) - \beta_1(\bar{y}^* - \alpha_2^* P_2^* - \beta_2^* P_2 - z + \beta_1 \beta_1^* P_1)}{\alpha_1^*} \cdot \frac{1}{\alpha_1} \Rightarrow$$

and solving for P_1:

$$P_{1\ optimal} = \frac{\alpha_1^*(\bar{y} - \alpha_2 P_2 - \beta_2 P_2^* - u) - \beta_1(\bar{y}^* - \alpha_2^* P_2^* - \beta_2^* P_2 - z)}{\alpha_1 \alpha_1^* - \beta_1 \beta_1^*} \quad (39)$$

$$P_{1\ optimal}^* = \frac{\bar{y}^* - \alpha*_2 P*_2 - \beta*_1 \left(\frac{(\bar{y} - \alpha_2 P_2 - \beta_1 P_1^* - \beta_2 P_2^* - u)}{\alpha_1} \right) - \beta_2^* P_2 - z}{\alpha_1^*} =$$

$$= \frac{\left(\frac{\alpha_1(\bar{y}^* - \alpha_2^* P_2^* - \beta_2^* P_2 - z) - \beta_1^*(\bar{y} - \alpha_2 P_2 - \beta_2 P_2^* - u) + \beta_1^* \beta_1 P_1}{\alpha_1} \right)}{\alpha_1^*} \Rightarrow$$

$$= \frac{\alpha_1(\bar{y}^* - \alpha_2^* P_2^* - \beta_2^* P_2 - z) - \beta_1^*(\bar{y} - \alpha_2 P_2 - \beta_2 P_2^* - u) + \beta_1^* \beta_1 P_1}{\alpha_1} \cdot \frac{1}{\alpha_1^*} \Rightarrow$$

and solving for P_1^*:

$$P_{1\ optimal}^* = \frac{\alpha_1(\bar{y}^* - \alpha_2^* P_2^* - \beta_2^* P_2 - z) - \beta_1^*(\bar{y} - \alpha_2 P_2 - \beta_2 P_2^* - u)}{\alpha_1^* \alpha_1 - \beta_1^* \beta_1} \quad (40)$$

7.4 Two Countries Static Model for Domestic and Foreign Optimal Monetary Policies in a parameters uncertainty framework

We still adopt our two basic structural equations with n instruments (where $n=4$):

$$y = \alpha_1 P_1 + \alpha_2 P_2 + \beta_1 P_1^* + \beta_2 P_2^* + u \quad (41)$$

$$y^* = \alpha_1^* P_1^* + \alpha_2^* P_2^* + \beta_1^* P_1 + \beta_2^* P_2 + z \quad (42)$$

assuming the response coefficients to be random variables. Therefore y and y^* are random variables with variances given by:

$$\sigma_y^2 = \sigma_{\alpha\,1}^2 P_1^2 + \sigma_{\alpha\,2}^2 P_2^2 + \sigma_{\beta\,1}^2 P_1^{*2} \sigma_{\beta\,2}^2 P_2^{*2}$$
$$+ \sigma_u^2 + 2\rho\sigma_{\alpha\,1}\sigma_{\alpha\,2}P_1 P_2 + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,1}P_1 P_1^*$$
$$+ 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,2}P_1 P_2^* + 2\rho\sigma_{\alpha\,2}\sigma_{\beta\,1}P_2 P_1^*$$
$$+ 2\rho\sigma_{\alpha\,2}\sigma_{\beta\,2}P_2 P_2^* + 2\rho\sigma_{\beta\,1}\sigma_{\beta\,2}P_1^* P_2^*$$

$$\sigma_y^{*2} = \sigma_{\alpha 1}^{*2} P_1^{*2} + \sigma_{\alpha 2}^{*2} P_2^{*2} + \sigma_{\beta 1}^{*2} P_1^2 \sigma_{\beta 2}^{*2} P_2$$
$$+ \sigma_z^2 + 2\rho\sigma_{\alpha\,1}^* \sigma_{\alpha\,2}^* P_1^* P_2^* + 2\rho\sigma_{\alpha\,1}^* \sigma_{\beta\,1}^* P_1^* P_1$$
$$+ 2\rho\sigma_{\alpha\,1}^* \sigma_{\beta\,2}^* P_1^* P_2 + 2\rho\sigma_{\alpha\,2}^* \sigma_{\beta\,1}^* P_2^* P_1$$
$$+ 2\rho\sigma_{\alpha\,2}^* \sigma_{\beta\,2}^* P_2^* P_2 + 2\rho\sigma_{\beta\,1}^* \sigma_{\beta\,2}^* P_1 P_2$$

where we also suppose that correlation between exogenous variables and their respectively response coefficients in the equation does not exist. Our uncertainty loss function can be rewritten as:

$$min_P \ L = E[(y - \tilde{y} + \tilde{y} - \bar{y})^2)] = E[\sigma_y^2 + (\tilde{y} - \bar{y})^2)] \tag{43}$$

$$min_{P^*} \ L = E[(y^* - \bar{y^*})^2] = E[\sigma_y^{*2} + (\tilde{y^*} - \bar{y^*})^2)] \tag{44}$$

Substituting then for y and y^* and their respective variances σ_y^2 and σ_y^{*2} we obtain:

$$L = E[\sigma 2_{\alpha\,1} P_1^2 + \sigma_{\alpha\,2}^2 P_2^2 + \sigma_{\beta\,1}^2 P_1^{*2} + \sigma_{\beta\,2}^2 P_2^{*2}$$
$$+ \sigma_u^2 + 2\rho\sigma_{\alpha\,1}\sigma_{\alpha\,2}P_1 P_2 + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,1}P_1 P_1^* + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,2}P_1 P_2^*$$
$$+ 2\rho\sigma_{\alpha\,2}\sigma_{\beta\,1}P_2 P_1^* + 2\rho\sigma_{\alpha\,2}\sigma_{\beta\,2}P_2 P_2^* + 2\rho\sigma_{\beta\,1}\sigma_{\beta\,2}P_1^* P_2^*$$
$$+ (\tilde{\alpha}_1 P_1 + \tilde{\alpha}_2 P_2 + \tilde{\beta}_1 P_1^* + \tilde{\beta}_2 P_2^* + \tilde{u} - \bar{y})^2]$$

$$L^* = E[\sigma_{\alpha 1}^{*2} P_1^{*2} + \sigma_{\alpha 2}^{*2} P_2^{*2} + \sigma_{\beta 1}^{*2} P_1^2 + \sigma_{\beta 2}^{*2} P_2^2$$
$$+ \sigma_z^2 + 2\rho\sigma_{\alpha\,1}^* \sigma_{\alpha\,2}^* P_1^* P_2^* + 2\rho\sigma_{\alpha\,1}^* \sigma_{\beta\,1}^* P_1^* P_1 + 2\rho\sigma_{\alpha\,1}^* \sigma_{\beta\,2}^* P_1^* P_2$$
$$+ 2\rho\sigma_{\alpha\,2}^* \sigma_{\beta\,1}^* P_2^* P_1 + 2\rho\sigma_{\alpha\,2}^* \sigma_{\beta\,2}^* P_2^* P_2 + 2\rho\sigma_{\beta\,1}^* \sigma_{\beta\,2}^* P_1 P_2$$
$$+ (\tilde{\alpha}_1^* P_1^* + \tilde{\alpha}_2^* P_2^* + \tilde{\beta}_1^* P_1 + \tilde{\beta}_2^* P_2 + \tilde{z} - \bar{y^*})^2]$$

Thus, imposing the first order conditions:

$\frac{\partial L}{\partial P_1} = 0 \Rightarrow$

$\Rightarrow 2(\tilde{\alpha}_1 P_1 + \tilde{\alpha}_2 P_2 + \tilde{\beta}_1 P_1^* + \tilde{\beta}_2 P_2^* + \tilde{u} - \bar{y})\tilde{\alpha}_1 + 2\sigma_{\alpha\,1}^2 P_1 +$

$+2\rho\sigma_{\alpha\,1}\sigma_{\alpha\,2} P_2 + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,1} P_1^* + 2\rho\sigma_{\alpha\,1}\sigma_{\beta\,2} P_2^* = 0$

$\frac{\partial L^*}{\partial P_1^*} = 0 \Rightarrow$

$\Rightarrow 2(\tilde{\alpha}_1^* P_1^* + \tilde{\alpha}_2^* P_2^* + \tilde{\beta}_1^* P_1 + \tilde{\beta}_2^* P_2 + \tilde{z} - \bar{y}^*)\tilde{\alpha}_1^* + 2\sigma_{\alpha 1}^{*2} P_1^* +$

$+2\rho\sigma_{\alpha\,1}^*\sigma_{\alpha\,2}^* P_2^* + 2\rho\sigma_{\alpha\,1}^*\sigma_{\beta\,1}^* P_1 + 2\rho\sigma_{\alpha\,1}^*\sigma_{\beta\,2}^* P_2 = 0$

we end up with the following optimal policies:

$$P_{1\,optimal} = \frac{\tilde{\alpha}_1(\bar{y} - \tilde{\alpha}_2 P_2 - \tilde{\beta}_1 P_1^* - \tilde{\beta}_2 P_2^* - \tilde{u}) - \rho\sigma_{\alpha 1}\sigma_{\alpha 2} P_2 - \rho\sigma_{\alpha 1}\sigma_{\beta 1} P_1^* - \rho\sigma_{\alpha 1}\sigma_{\beta 2} P_2^*}{(\tilde{\alpha}_1^2 + \sigma_{\alpha 1}^2)}$$

$$(45)$$

$$P_{1\,optimal}^* = \frac{\tilde{\alpha}_1^*(\bar{y}^* - \tilde{\alpha}_1^* P_1^* - \tilde{\beta}_1^* P_1 - \tilde{\beta}_2^* P_2 - \tilde{z}) - \rho\sigma_{\alpha 1}^*\sigma_{\alpha 2}^* P_2^* - \rho\sigma_{\alpha 1}^*\sigma_{\beta 1}^* P_1 - \rho\sigma_{\alpha 1}^*\sigma_{\beta 2}^* P_2}{(\tilde{\alpha}_1^{*2} + \sigma_{\alpha 1}^{*2})}$$

$$(46)$$

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