The effects of capital requirements on real economy: a cointegrated VAR approach for US commercial banks

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by

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Abstract: this paper addresses the following questions: which was the contribution of banks' assets to the US' expansion in the period until the financial crisis? Did commercial banks respect capital requirements? The two questions are strictly interrelated as, according to a recent literature, business cycle is directly related to banks' capital requirements for market and credit risk. The analysis highlight that US commercial banks actually respected capital requirements but these were not relevant in the explanation of US growth; it confirms that most of the growth can instead be explained by the rise in productivity.

Nevertheless, the analysis does not consider the role of the non banking intermediation (investment banks, broker dealers, mutual funds, etc.) that steadily increased until the crisis. Its effects over real economy could be investigated in further work.

JEL classification: E44, E32, G21, G01
Key words: commercial banks, crisis, capital requirements, business cycle

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Introduction

The 2007-2009 financial crisis developed in the US financial system and then it spread in all the developed countries, hitting their banking and financial systems and severely hurting real economies. Banks – especially U.S. banks – have been blamed of the excessive increase of assets and credit that created the conditions for the subsequent turmoil. Nevertheless, banks' leverage increase should be limited by the amount of available capital and by the need to guarantee a fixed ratio between capital and assets, as stated by banking regulation. In particular, from the introduction of the first Basel Accord, the ratio of a bank's capital to its risk-weighted assets (i.e. the total capital ratio) must be no lower than 8% (weights reflect the presumed degree of risks associated to that kind of assets).

This paper tries to analyze the interrelation between real and financial variables in US, attempting to answer to the following questions: was the capital requirements' constraint really binding for the US commercial banks? Did the increase in banks' assets significantly contribute to US expansion in the real sector and in the financial markets until the crisis?

These two questions are strictly interconnected as, according to a recent literature, business cycle is directly related to banks' risk based capital requirements for market and credit risk. Any negative macroeconomic shock that increases risks and produces capital losses would require less capitalized banks to raise new capital in order to respect the capital ratios. If banks cannot easily increase their capital because of frictions in capital markets, they tend to cut assets by selling securities and reducing loans provision to respect capital requirements: this behaviour amplifies the effects of downturns in the real and financial world. The opposite happens during expansions.

The estimates in the paper show that banks actually respected capital requirements, targeting a constant leverage ratio: it is shown that assets and capital shared a lung run relationship since the introduction of capital requirements. Nevertheless, banks' variables do not seem to be relevant in explaining either US' business expansion until the crisis or the rise in financial markets; the analysis testifies instead the importance of the increase in total factor productivity as a source of growth.

The paper concentrates on banks, but further work could try to evaluate the role of the non banking intermediation (investment banks, broker dealers, mutual funds, etc.) over business cycle, i.e. if the non banking intermediation increase (that was considerable until the crisis) can help explain the U.S. expansion until the financial crisis.

The paper is organized as follows: section 1 offers a review of the literature about the interaction between real and financial variables; section 2 describes the effects of capital requirements on real economy; section 3 introduces the econometric model and the data; section 4 is devoted to understand if US commercial banks actually respected capital requirements from their introduction until the crisis; sections 5 and 6 model the capital requirements transmission channel to the real economy, making recourse to a structural cointegrated vector error correction model (VECM); in section 6 the effects of banks' variables over real ones are analyzed by the impulse response functions; the last section concludes.

1. Related literature

Since the 1929 Great Depression the economic theory has tried to explain the interaction between financial variables and real economy. The beginning of this literature can be ideally fixed in 1933 with Fischer's (1933) debt-deflation theory. At that time Fischer recognized the role of over-indebtedness (in one or more sectors of the economy) and deflation as the main reasons giving rise to great depressions ("the more the debtors pay the more they owe"); according to this theory, other factors like over production or under consumption or over capacity play a secondary role.

During the 2007-2008 financial turmoil, Minsky's financial instability hypotheses[1] has been seen as able of explaining what was happening, so that some economists refer to the financial crisis as a "Minsky moment"[2]. Like in the debt-deflation theory, in Minsky's idea, a capitalist economy becomes more and more fragile during a period of growth and low interest rates that induce over-indebtedness: in a period of growth, enterprises in profitable sectors of the economy register high returns by increasing the amounts of debt; their success and high profits expectations encourages others to take the same behaviour in the same area. The rise in the debt moves the economy or a sector of the economy from the *hedges* finance to the *speculative* finance, ending in the *Ponzi* finance. Hedge finance is characterized by most borrowers being able to pay back interests and principal of their loans; in the speculative

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[1] This section is based on the following papers and books by Minsky H. P.:

"Private Sector Asset Management and the Effectiveness of Monetary Policy: Theory and Practice", The Journal of Finance, 1969; "Central Banking and Money Market Changes", The Quarterly Journal of Economics, 1957; "Financial Crises: Systemic or Idiosyncratic", The Jerome Levy Economics Institute of Bard College Working Paper No. 51, 1991; "The Capital Development of the Economy and The Structure of Financial Institutions", The Jeromc Levy Economics Institute of Bard College Working Paper No. 72, 1992; "Uncertainty and the institutional structure of the capitalist economies" The Jerome Levy Economics Institute of Bard College, Working Paper No. 155, 1996; "John Maynard Keynes". New York: Columbia University Press, 1975; Can "It" Happen Again? Essays on Instability and Finance". Armonk, N.Y.: M. E. Sharpe, 1992; "Stabilizing an Unstable Economy". New Haven, Conn.: Yale University Press, 1986; "Reconstituting the United States' Financial Structure: Some Fundamental Issues."Working Paper No. 69. The Levy Economics Institute. January, 1992; "The Financial Instability Hypothesis." Working Paper No.74. The Levy Economics Institute.May, 1992.

[2] Whalen (2007).

finance most borrowers can just pay interests, so they have to roll over the financing; finally in the *Ponzi* case, companies must borrow to pay both interests and principal. The *Minsky moment* arises when companies cannot rollover their debt anymore and begin selling their assets; it is endogenously produced within the economy: the economic cycle is neither generated by an exogenous shock nor by a technological shock but, essentially, by the propensity of people to assume increasing risks. The subsequent process is very fast: the price of the assets falls down and credit suddenly dries up, leading investment, output and employment to decrease sharply. Lower instability can be reached with significant contra-cyclical government deficit, which aims at stabilizing profits (as private investment declines in recession) and with an accommodative and interventionist monetary policy, when instability emerges from financial markets.

The financial accelerator models emphasize instead the importance of the value of the guarantees the borrowers can offer; they show how lending and spending - and consequently the business cycle - can depend on changes in the warranties value.

Bernanke et al. (1998) develop a dynamic general equilibrium model in the context of dynamic new Keynesian economics that incorporates growth, money, monopolistic competition and nominal rigidities. They also incorporate credit-market frictions that endogenously amplify and propagate real effects of nominal shocks, even small shocks. The mechanism described involves the link between "external finance premium" (that is to say the difference between the cost of funds raised externally and the opportunity cost of funds internal to the firm) and the net worth of potential borrowers (i.e. borrowers' liquid assets plus collateral value of illiquid assets less outstanding obligations). The "external finance premium" depends inversely on borrowers' net worth as the lower borrowers' wealth to contribute to the project, the higher the agency costs (the cost of observing the borrower's realized return); in equilibrium the lenders must be compensated for higher agency costs by a larger premium. As borrowers' net worth is pro cyclical, like profits and assets prices, the external finance premium is countercyclical, enhancing the cyclicality in borrowing, investment, spending and production.

Kiyotaki and Moore (1997) develop a model of a dynamic economy in which lenders cannot force borrowers to repay their debts unless debts are secured by durable assets such as land, buildings and machinery. These assets also represent factors of production. Borrowers credit limits are affected by the prices of collateralized assets. At the same time, these prices are affected by the size of the credit limits. The dynamic interaction between

credit limits and asset prices turns out to be a transmission mechanism by which the effects of shocks persist, amplify and spill over other sectors, allowing small, temporary shocks to generate large and persistent fluctuations in output and assets prices. They assume there are two types of firms: credit constrained ones are highly levered; they borrowed heavily against the values of their assets, whose total supply is fixed (like land); while others are credit unconstrained. If a temporary shock reduces firms' net worth, credit constrained ones are forced to cut back on their investment expenditure in assets; this hurts them in the next period as they earn less, their net worth falls, they can borrow even less and their investment reduces even more, and so on for next periods. For the market to clear, the demand for the assets from the unconstrained firms must increase, that is to say their user cost has to fall. This happens as they correctly anticipate the decline in user costs in the following periods. The fall in the assets price produces a capital loss to constrained firms that reduces their net worth even more, giving rise to deeper cuts in investments.

Iacoviello (2005) model adds to Bernanke et al. two features: collateral constrains tied to real estate values for firms, like in Kiyotaki and Moore, and nominal debt, as almost all debt contracts are in nominal terms. In this context a positive demand shock let consumer and assets prices to increase, rising the borrowing capacity of the debtors, allowing them to spend and invest more. The rise in consumer prices reduces the real value of their outstanding debt obligations, positively affecting their net worth. Given that borrowers have a higher propensity to spend than lenders, the net effect on demand is positive and acts as a powerful amplification mechanism. The financial accelerator depends upon where the shock comes from: the model features an accelerator of demand shock and a decelerator of supply shock, as adverse supply shock are beneficial to borrowers' net worth if obligations are held in nominal terms.

The financial accelerator models so far described underline the importance of constraints on the demand side of credit (the guarantees offered by the borrowers); more recently, the economic literature has highlighted the role of constraints on the supply side as a source of business cycle fluctuations. Gerali et al. (2010) extend the model in Iacoviello by introducing a stylized banking sector with imperfect competition and endogenous capital accumulation. They study the role of credit supply factors in business cycle fluctuations using a dynamic stochastic general equilibrium (DSGE) model with financial frictions and with an imperfectly competitive banking sector. Banks issue collateralized loans to both households and firms, obtain funding via deposits, and accumulate capital out of retained earnings. Loan

margins depend on the banks' capital-to-assets ratio and on the degree of interest rate stickiness. Balance-sheet constraints establish a link between the business cycle, which affects bank profits and thus capital, and the supply and cost of loans. They find that the banking sector and, in particular, sticky rates attenuate the effects of monetary policy shocks, while financial intermediation increases the propagation of supply shocks; shocks originating in the banking sector explain the largest share of the contraction of economic activity in 2008, while macroeconomic shocks played a limited role; finally an unexpected destruction of bank capital may have substantial effects on the economy.

The effects coming from banks' balance sheets and capital requirements on real economy are more specifically analyzed in the new financial accelerator model developed by Adrian and Shin (2010). In this context, the business cycle is seen as directly related to banks' risk based capital requirements for market and credit risk. During expansions, banks tend to accumulate risk, but during contractions risks show up because risk itself is counter-cyclical. Adrian and Shin underline the relationship between banks' balance sheet and financial markets: changes in assets prices immediately produce changes in banks' balance sheets if these are marked to market, having an impact on the net worth of all financial firms (NW, i.e. equity for firms, represented by the difference between asset and liabilities: A-L).

They demonstrate how market and credit risk models used by banks to determine capital requirements can induce pro cyclicality in financial markets and consequently in the real economy. Leverage is defined as the ratio between total asset A and net worth NW (A/NW=A/(A-L)) and it is strongly positively related to changes in balance sheet: if firms were passive to asset prices fluctuations an increase in asset prices would immediately produce a decrease in leverage as the denominator would increase more than the numerator. Examining data for the period 1963 to 2006, they find instead strong evidence that financial firms actively manage their balance sheet: commercial banks target a fixed leverage ratio, while security dealers and brokers and investment banks show a positive relationship between assets and leverage[3]. That is to say, investment banks respond to a rise in asset prices by expanding their balance sheets and increasing liabilities more than assets rise, the opposite happens when assets value diminishes. The reason why investment banks show pro cyclical

[3] The analysed investment banks are: Bear Stearns, Lehman Brothers, Merrill Lynch, Goldman Sachs and Morgan Stanley. Today, there are not stand alone investment banks in Wall street. The former three of them were under distressed conditions or declared bankruptcy. The other two were converted into bank holding companies.

leverage is related to their risk models and capital requirements that impose a fixed ratio between the total value at risk (VaR) of their assets and equity[4].

US commercial banks instead showed a roughly constant leverage. This behaviour is explained by Adrian and Shin with the need to maintain fixed capital requirements for credit risk. As assets in these banks are traditionally represented mostly by loans, commercial banks are more subject to capital charges for credit risk than for market risk. In a period of recession losses produce a reduction in capital; as they face capital market frictions, banks tend to reduce assets to respect capital requirements, maintaining leverage fixed; assets reduction produces a pro cyclical movement both in loans and assets prices that feeds back to the economy.

In contrast with Adrian and Shin's, some analyses find that capital ratio shocks are not very important in determining loan growth. Berrospide et al. (2010) repeated Adrian and Shin's leverage analysis for US commercial banks starting in the early 1990s (instead of 1963) to reflect the significant structural changes in banking coming from the adoption of Basel I in the U.S. and the consequences of loan market deregulation (which began in the early 1980 in many advanced economies[5]). In contrast with the prevailing view, they found much less evidence of commercial banks maintaining constant leverage ratios in later sample period. They also examined the response of loan growth to a capital ratio shock and found results in contrast to the constant leverage view, which predicts changes in loan growth on the order of six to fifteen times larger; the role of other factors such as economic activity and banks' perception of borrower riskiness seemed to be more important than capital.

2. Capital requirements and their effects on the real side of the economy

Banking regulation greatly relies on banks'capital: banks are required to maintain an adequate level of internal financial resources relative to assets'size and riskiness, to afford eventual losses and to avoid banks' moral hazard; capital also contributes to limit the risks taken by banks.

The introduction of banks' capital requirements comes back to 1988, when Basel I, the international accord to bank capital regulation, was introduced. It prescribed a minimum solvency ratio equal to 8% between capital and the sum of banks' risk-weighted assets. Risk

[4] Value at Risk (VaR) is a widely used risk measure of the risk of loss on a portfolio of financial assets. For a given portfolio, probability and time horizon, VaR is defined as a threshold value such that the probability that the mark-to-market loss on the portfolio over the given time horizon exceeds this value (assuming normal markets and no trading in the portfolio) is the given probability level.

[5] See IMF World Economic Outlook April 2008 p.104

weights were fixed per each asset category according to the presumed degree of risk (the weights were 0% for sovereigns, 20% for banks, 50% for mortgage loans, 100% for all other loans such as loans to firms and households) [6].

The second of the Basel Accords on banks' capital adequacy, Basel II, was issued by the Basel Committee on Banking Supervision[7] and initially published in June 2004. Basel II was directed at improving the consistency of banks' capital regulation internationally, make regulatory capital more risk sensitive and promote enhanced risk-management practices among large, internationally active banking organizations. Like the previous Basel I accord, it states a minimum capital requirement for banks of 8% of banks' risk weighted assets, but weights are not fixed and can be determined in two different ways. In the so called standardised approach, banks may use credit risk valuations of credit rating agencies[8], while supervisors are responsible for deciding the correspondence between rating agencies' assessment categories and risk weights. Alternatively, banks can choose the internal rating methodology for calculating their capital requirements for credit risk: this approach is subject to the explicit approval of the bank's supervisor and allows banks to use their internal rating systems; it is known as internal rating-based (IRB), in two version: foundation or advanced.

Banks' capital requirements can have important real effects and can amplify the business cycle. They essentially impose banks to maintain a fixed ratio between capital and risk weighted assets; as a consequence, the amount of capital represents a limit to loans' provision. In other terms, capital – together with funding - represents for the banks a sort of raw material to offer loans and expand assets: the higher the level of capital, the bigger the impulse that banks can give to the economy and financial markets, via loan provisions and securities acquisitions.

Any negative macroeconomic shock that increases risks and produces capital losses would require less capitalized banks to raise new capital in order to respect the capital ratios. If the market for capital were frictionless, banks would not encounter any difficulty in rising new capital and maintaining the same level of assets. If instead banks cannot easily increase their capital because of frictions in capital markets, they tend to deleverage, selling securities and reducing loans provision in order to respect capital requirements: this behaviour amplifies the effects of downturns in the real and financial world. The opposite happens during

[6] Banca D'Italia Occasional paper n.44, 2009.

[7] It is available in the Bank for International Settlement web site.

[8] These rating agencies (known as External Credit Assessment Institutions) are recognised as eligible for capital purposes by national supervisors in accordance with the criteria defined in the Accord.

expansions where financial intermediaries hold surplus capital; they expand assets offering new loans and through new securities purchases. The described mechanism works under both the first and the second Basel Accord as both of them essentially prescribe a fixed level of leverage, i.e. a constant ratio between assets and capital[9].

In the following, these aspects will be analyzed in more detail, modelling the transmission channel from commercial banks' balance sheets to real economy. The analysis can be ideally divided in twos:

1. The next section concentrates on capital requirements, trying to understand if US commercial banks targeted a constant leverage from the introduction of the first Basel Accord. This would imply that commercial banks actively managed their assets in order to maintain a constant capital to assets ratio (or capital ratios), deleveraging during downturns and expanding loans and other assets in upturns;
2. Then the transmission channel from banks balance sheets to real economy is modelled, through a Vector Error Correction Model (VECM) that takes into account real variables together with financial ones.

3. The data and the empirical model

The model consists of 7 variables: product (Y), consumption (C), investments (I), assets (A) and capital (K) for commercial banks, the s&p index (SP), the fed fund rate (F). Data have been collected by the Federal Reserve Bank of St. Louis web site. They refer to:

- gross national product (Y), gross private domestic investment (I), personal consumption expenditures (C), seasonally adjusted; they have been expressed in real terms dividing by the implicit price deflator of the gross national product (in billions of dollars);
- the effective fed fund rate (F) in percentage. The federal fund rate is the interest rate at which private depository institutions (mostly banks) lend balances (federal funds) at the Federal Reserve to other depository institutions, usually overnight. The interest rate that the borrowing bank pays to the lending bank to borrow the funds is negotiated between the two banks, and the weighted average of this rate across all such transactions is the federal funds

[9] The new Basel III Accord, issued by the Basel Committee in 2010-2011 but not yet implemented, addresses the issue of pro cyclicality of capital requirements introducing two new capital buffers: a "mandatory capital conservation buffer" of 2.5%, aimed at ensuring that banks maintain a buffer of capital that can be used to absorb losses during periods of financial and economic stress, and (ii) a "discretionary counter-cyclical buffer", which would allow national regulators to require up to another 2.5% of capital during periods of high credit growth with the purpose of achieving the broader macroprudential goal of protecting the banking sector from periods of excess aggregate credit growth.

effective rate[10]; as the Federal Reserve uses open market operations to influence the supply of money in the U.S. economy to make the federal funds effective rate follow the federal funds target rate, this variable can represent both the policy rate and the conditions of the interbank market of funds;

- seasonally adjusted assets (A) of all commercial banks (in nominal terms, millions of dollars);
- capital (K, assets less liabilities) of all U.S: commercial banks (in nominal terms, million of dollars). Strictly speaking this series represents banks' net worth but I will refer to it simply as capital (K);
- the Standard & Poor's 500 US index at the end of any quarter (SP); this series has been collected by Bloomberg's. It contains the prices of 500 large-cap common stocks actively traded in the United States and is incorporated into the model to take into account the effects of the banks' variables on financial markets. To express this variable in real term, it has been divided it by the implicit price deflator of the gross national product.

All the series are quarterly observations; they have been transformed in dollars and then in natural logarithm; the fed fund rate has been divided by one hundred and summed to one before the logarithmic transformation as it was initially expressed in percentage points.

The setting for modelling the real sector will be that of the Real Business Cycle Theory[11], according to which product, consumptions and investments show the same long run growth process induced by the growth rate of the total factor productivity. Real Business Cycle Theory allows taking into account an important source of U.S. growth in the period under consideration - the technological shock - on which there is general consensus[12]. This theory accepts the complete irrelevance of monetary policy: nominal variables, such as the money supply and the price level, are assumed to have no role in explaining fluctuations in real variables, such as output and employment[13]; nevertheless more recent versions of Real Business Cycle models take into account capital market imperfections, nominal or real rigidities and, lately, the role of banks (see Section 1).

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[10] The federal funds target rate is instead determined by a meeting of the members of the Federal Open Market Committee which normally occurs eight times a year about seven weeks apart. The committee may also hold additional meetings and implement target rate changes outside of its normal schedule. The Federal Reserve uses Open market operations to influence the supply of money in the U.S. economy to make the federal funds effective rate follow the federal funds target rate.

[11] King R. et al. (1991).

12 Gordon R. J. (2008)

[13] Mankiw N. G. (1989)

This paper tries to add the banks' capital and assets transmission channel to this framework, seeking to assess the influence of these two nominal variables on the real ones. It makes recourse to a Cointegrated Vector Autoregressive Model, as this framework allows modelling both the long run and the short dynamics among variables and also because it:

- Treats all variables as endogenous. In particular, capital and assets are endogenous with respect to product: an increase in product can have the effect of increasing banks' profits and therefore capital, this in turn can give rise to more loans provision that can have effects on product growth;
- Allows describing their joint behaviour imposing restrictions based on the economic theory (in this case the RBC theory).

The analysis proceeds as follow:

- first of all the relationship between banks' assets and capital before and after 1988 is analyzed, trying to understand if banks target a constant leverage level since that year;
- the VECM model is estimated, defining the number and characteristics of the contegration vectors according to the economic theory and the results of cointegration tests;
- in order to identify the structural form of the model, long and short run restrictions are imposed according to the economic theory and to some reasonable assumptions about short and long run parameters.

Before modelling the VECM, a univariate analysis (not reported) of the time series was performed according to the methodology developed by Pelham Box G. E. e Jenkins G. M. (1979); it showed that they are all integrated of first order or I(1) [14].

4. Is commercial banks' leverage constant?

Fig.1 represents aggregate leverage (assets divided by capital) for commercial banks and shows a sharp increase until the early eighties and than the convergence around 15 and then 10 during the following years. These values are more or less consistent with capital ratios

[14] The univariate analysis took into consideration:
- the total and partial autocorrelograms: for all series the total one slowly decreases to zero starting from a value close to one, while the partial one shows that the first order autocorrelations are significantly different to zero and close to one. This behaviour is typical of the first order autoregressive series AR(1);
- the results of an Augmented Dickey and Fuller (ADF) test, that has been performed including a drift to take into account the presence of a linear trend in all series and a time trend in the fed rate series, that shows a quadratic trend, and including the number of lags that was suggested case by case by the Schwarz information criterion. In all cases it is not possible to reject the null hypothesis of a unit root.

between 0.08 and 0.125 (and leverage between 8 and 12), showing that commercial banks have substantially targeted a constant leverage ratio since 1988 (or even before, 1984).

Insert Fig. 1 here

Source: U.S. flows of funds

As seen in the previous section, assets and capital should be strictly linked by a close relationship from the introduction of Basel I in the late eighties, as capital requirements essentially imply proportionality between the twos. From an econometric point of view this relationship could imply a cointegration relation: both series are non stationary and integrated of the first order I(1), but, as they share a long run relationship, their linear combination could be stationary (i.e. I(0)). In order to verify this hypothesis a linear regression between the two variables has been made, making recourse to OLS estimators: Stock and Watson (1991) in fact demonstrated that when two variables are cointegrated, OLS method is super consistent as its rate of convergence is T^2 rather than just T like in Chebyshev's inequality.

The regression for the period from the introduction of the first Basel Accord (Basel I) 1988q1 until 2010q1 underlines the strict positive relationship between the two variables; R-squared is close to unity and the dependent variable is significantly different from zero (see (4.1) and table 1, standard errors in parenthesis).

$$A = 9.03 + 0.75\ K \qquad (4.1)$$
$$(0.22) \quad (0.01)$$
$$Adj R^2 = 0.98$$

INSERT Table n. 1 here

To better evaluate the cointegration hypothesis, an Engel and Granger test was performed; it is equivalent to an Augmented Dickey and Fuller (ADF) over regression residuals, but shows different critical values, tabled by Engle and Granger (1987)[15].

The value of test statistic is -3.2453, which is smaller then the critical value at 5% probability level (-3.17). Therefore its possible to reject the null hypotheses of unit root and accept the alternative of stationarity of the residuals of the above regression; i.e. the hypothesis of cointegration between banks' assets and capital.

In order to verify if a similar relationship was in place before 1988, a robustness check was made repeating the same estimates as above but taking into account the period 1973q1, 1987q4. The regression between assets and capital shows in this case a much less significant relationship (see (4.2) and table 2)[16]. This result seems to offer sufficient evidence against cointegration and hence against the constant leverage view in the period before the introduction of the first Basel Accord.

$$A = -2.34 + 1.18\ K \qquad (4.2)$$
$$(4.80) \quad (0.18)$$

$$Adj R^2 = 0.40$$

INSERT Table n. 2 here

In the end, data evidence seems to prove a cointegration relation between commercial banks' capital and assets starting from 1988, when capital requirements were introduced, but not before that date. This result is in favour of the hypothesis that banks respected a constant ratio between capital and risk weighted assets or, in other terms, a constant leverage ratio, since the introduction of the first Basel accord.

From an economic point of view, a cointegration relationship between assets and capital implies that capital ratio is a binding constraint for banks: they are forced to reduce assets in case of capital losses and can instead increase assets when the economic conditions are favourable and more capital is available. This behaviour, as described in the previous

[15] No drift was included in the test as the plot of the residual series does not show any linear trend; regarding the number of lags to be included in the regression, the test takes into account what suggested by the Schwarz information criterion (4 lags).

[16] Furthermore, both the partial and the total residuals auto correlograms (not reported) describe an AR(1) process and the first order autocorrelation is very close to one; this could mean that a non stationary process is still present in residuals.

section, can have important effects on the real side of the economy amplifying the economic cycle and could have been one of the main sources of US expansion until the crisis, but also on of the reasons for the subsequent turmoil, when banks abruptly deleveraged.

5. The transmission channel of banks balance sheets on the real economy: a structural vector error correction model -SVECM.

In the following, the Vector Error Correction Model is estimated for the period 1988q1- 2007q2, i.e. from the introduction of capital requirements to the very beginning of the financial crisis. The crisis period is not included in the estimates as the aim of paper is to understand if capital requirements and the increase in banks' assets have played a role in the increase in real variables registered until the crisis, creating the conditions for the subsequent financial instability; besides, considering the crisis period (2007-2010) could introduce non linearity in the model and parameters' instability.

The reduced form VECM takes the following form:

$$\Delta y_t = \Pi y_t + \Sigma_{i=1,p-1} \Gamma_i y_t + u_t \tag{5.1}$$

where $\Pi = \alpha\beta' = -\left(I_k - A_{i+1} - \ldots - A_p\right)$, α is the loading coefficients matrix and β' is the matrix containing the cointegration vectors; $\boldsymbol{y}_t$ is the vector of m=7 variables, $\Gamma_i = -\left(A_{i+1} + \ldots + A_p\right)$ refers to the short-run parameters, u_t is an independent stochastic vector of the unobservable error terms with mean zero and non-singular covariance matrix $\boldsymbol{\Sigma u}$.

The VECM is obtained from a Vector Autoregressive (VAR) model in levels, that takes the following form:

$$y_t = \Sigma_{i=1,p} A_i y_{t-i} + u_t \tag{5.2}$$

subtracting $\mathbf{y}_{t-1}$ from both sides and rearranging terms.

The order of the variables in the VAR is the following: Y, K, F, SP, A, I, C (product, consumption, investments, assets and capital for commercial banks, the s&p index, the fed fund rate). Before proceeding it is preliminarily necessary to identify the cointegration

relations among the 7 variables considered in the analysis, having in mind that one cointegration relation has already been proved between capital and assets[17]. To this end, a Johannes cointegration test has been performed among the seven variables; in this test the null hypothesis is that the rank of the cointegration matrix Π is r=0,1,2,… against the alternative hypothesis. The first row tests r=0 against r>0; the second row tests r=1 against r>1 and so on. In the end, the estimates will take into consideration four cointegration relationships as suggested by the following Johansen trace test where the hypothesis of rank 3 is rejected in favour of rank 4[18].

INSERT Table 3 HERE

Therefore matrix $\Pi = \alpha\beta'$ in (1) is rank 4, because of the 4 cointegration relations, which are I(0) and represent the long-run equilibrium relations among the variables; the whole statistical equilibrium is driven by (m – r) = (7-4) = 3 stochastic trends.

To identify the cointegration matrix β' this paper makes recourse to the theory based procedure suggested by Pesaran (1997), imposing that:

- consumption and investments depend on gross national product, as predicted by the Real business cycle theory; a linear trend variable has also been considered in the consumption equation;

- banks'assets are related to banks'capital, gross national product and a linear trend;

- the market index depends on product;

restricting to zero all the other coefficients in the matrix β'. The time lag of the VECM is 2, that ensures residual whiteness according to a Lagrange Multiplier test[19].

The choice to introduce the product in the asset equation is in line with some other papers where banks' assets or loan provisioning is modelled[20]. The long run relationship between market indices and product has been proved in other works[21], where it is shown that the long run relationship between these variables depends on the fact that greater economic

[17] The capital series (K)'s seasonality (cfr. Fig.1) has preliminarily been adjusted it by the X11 method.

[18] The cointegration test was also performed taking into account two or three variables by time; it confirmed the results described in the text.

[19] The null hypothesis of the test is serial uncorrelation of residuals; the alternative is that residuals follow a AR(1) process. The value of the statistics is LM(49) = 53.3422 and the p-value = 0.3109. If the null Hypothesis is tested against the alternative that residuals follow a AR(4), the LM(49) = 51.8228 and its p-value = 0.3643.

[20] See for example Gambacorta L. et al. (2010)

[21] McMillan D.G.(2005)

activity (i.e. higher product) leads to a rising stock market through increased future cash flows, these in turns increase future dividends. The four cointegration equations are the following:

$$I = 1.26\ Y \quad (0.016) \tag{5.3}$$

$$C = 1.017\ Y + 0.0007\ T \quad (0.05) \quad (0.0004) \tag{5.4}$$

$$A = 3.12\ Y + 1.44\ K - 0.04\ T \quad (0.21) \quad (0.11) \quad (0.003) \tag{5.5}$$

$$SP = 2.31\ Y \quad (0.12) \tag{5.6}$$

where all coefficients are correctly signed and significant (asymptotic conditional standard errors in parentheses). As variables are expressed in terms of logarithms, cointegration coefficients represent elasticises. They show that investments, consumption, banks' assets and financial markets strongly react to a change in product as their elasticity is greater than one.

Consumption shows a positive linear trend, that captures the increase in U.S. consumption until the crisis. Banks' assets show a negative trend: capital ratios, as seen before, are expressed as capital over risk weighted assets, this trend can therefore indicate the increase in riskiness of assets (the weights) in the period under consideration.

6. The structural model

Johansen[22] has shown that a vector y_t generated by a reduced form VECM, can be expressed in the following VMA (Vector Moving Average) form:

$$y_t = C(1)\Sigma_{i=1,t} u_i + C^{\circ}(L)u_t + y_0 \tag{5.7}$$

where y_0 represents the initial conditions of non-stationary variables y_t (the hypothesis of a finite past is necessary to avoid explosive moments), $C(1)$ contains the permanent components and captures the long stochastic trend, while $C^o(L) = \Sigma_{j=0,\infty} C_j L_j$ is an infinite order polynomial in the lag operator with coefficient matrices C_j that goes to zero as j tends to

[22] Johansen S. (1995).

infinity. C^o *(L)* u_t represents the transitory components and contains the instantaneous coefficients.

According to the so called AB-model of Amisano and Giannini[23], fundamental shocks are linearly related to reduced form shocks by the following equation system:

$$A_o\, u_t = B\varepsilon_t \tag{5.8}$$

Where *Ao* is the (7 x 7) contemporaneous effect matrix; *B* is the (7 x 7) structural shocks short run response matrix and ε_t are the structural shocks that have zero mean and identity covariance matrix.

In this paper, it is assumed that the contemporary correlation matrix A_0 is an identity 7*7 matrix (this is known as the *B* model setup in the Amisano and Giannini framework), according to the quite plausible assumption that none of the seven variables immediately react to an innovation in the others. Therefore equation system (5.8) becomes:

$$u_t = B\varepsilon_t \tag{5.9}$$

and the covariance matrix of u_t, $\boldsymbol{\Sigma}u$ is equal to *BB'*. This matrix is not uniquely specified as $\boldsymbol{\Sigma}_u = BB'$ represents only ½ m (m+1) = 28 independent equations because of its symmetry. Some more ½ m(m-1) = 21 restrictions are necessary for the identification.

In order to obtain these restrictions and identify the structural shocks hitting the system ε_t It is necessary to switch from the reduced form to the structural representation by replacing u_t by $B\varepsilon_t$:

$$y = C(1)B\Sigma_{i=1,t}\boldsymbol{\varepsilon}_i + C^{\circ}(L)B\boldsymbol{\varepsilon}_t + y_0 \tag{5.10}$$

The structural shocks ε_t have a non singular covariance matrix: as a consequence also *B* is non singular.

[23] Amisano G. and Giannini C. (1997)

C(1)B has rank (m–r) = (7-4) = 3 because *C(1)* has rank 3 for the presence of 4 cointegration relations that produces at most 4 columns of zeros in this matrix. The model is characterized by r=4 transitory and stationary components and by (m –r)= 3 permanent and non-stationary components.

To identify the structural form 21 restrictions have to be imposed over the matrices *C(1)B* and $C^o(L)B$.

- r(m-r)= 4(7-4)= 12 restrictions can be derived from the cointegration relationships and are added to the long run matrix C(1); they are represented by 4 zero columns in this matrix corresponding to the long run answers coming from the transitory components;
- a number of (m-r)(m-r-1)/2 = (7-4)*(7-5)/2=3 more restriction can be imposed over this matrix according to hypotheses coming from the economic theory;
- other r(r −1)/2= 6 restrictions will be imposed on the contemporary relation matrix B according to feasible assumptions.

The restrictions imposed over the long run matrix *C(1)* are the following:

- the product series does not respond to any shock coming from the other variables apart from its own shock (the technological shock); these hypotheses are consistent with the Real Business Cycle theory and its theoretical presumption that only supply shocks have permanent effects on productivity. They also reflect the idea that money is neutral in the long run, as also the fed fund rate does not influence the product (c_{13}=0). These restrictions give rise to zeros in the first row of the matrix, apart from the first element;
- the fed rate does not affect banks' capital in the long run (c_{23}=0),. This assumption, together with the hypothesis that the fed rate does not affect the product described above complete the hypothesis of neutrality of money in the long run as they imply that the effective federal fund rate affects neither of the other permanent components, i.e. the variables that "drive" the system in the long run (product and banks' capital). As a consequence, no other variable is influenced by the policy rate in the long run.

According to these restrictions the C(1) matrix will be:

$$C(1) = \begin{bmatrix} c_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{21} & c_{22} & 0 & 0 & 0 & 0 & 0 \\ c_{31} & c_{31} & c_{32} & 0 & 0 & 0 & 0 \\ c_{41} & c_{42} & c_{43} & 0 & 0 & 0 & 0 \\ c_{51} & c_{52} & c_{53} & 0 & 0 & 0 & 0 \\ c_{61} & c_{62} & c_{63} & 0 & 0 & 0 & 0 \\ c_{71} & c_{72} & c_{73} & 0 & 0 & 0 & 0 \end{bmatrix}$$

(5.11)

Regarding the *B* matrix, it has been restricted making recourse to feasible assumptions for the short run: i.e. supposing that consumption and investments do not immediately influence banks' capital and the market index (b_{25}, b_{27}, b_{46}, b_{47}=0) and that a shock to investments does not immediately influence the fed rate (b_{36}=0). Another important short run assumption is that banks' assets do not immediately influence product (b_{15}=0). This restriction relies on the idea that:

- banks require some time before providing a new loan;
- it takes some times before households and firms employ the funds received with loans and their expenditure has real effects.

Under these hypotheses, the equation system (5.9) becomes:

$$\begin{bmatrix} u_{Yt} \\ u_{Kt} \\ u_{Ft} \\ u_{SPt} \\ u_{At} \\ u_{It} \\ u_{Ct} \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & 0 & b_{16} & b_{16} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} & 0 & 0 \\ b_{31} & b_{32} & b_{32} & b_{34} & b_{35} & 0 & b_{37} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} & b_{56} & b_{57} \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & b_{66} & b_{67} \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & b_{77} \end{bmatrix} \begin{bmatrix} \varepsilon_{Yt} \\ \varepsilon_{Kt} \\ \varepsilon_{Ft} \\ \varepsilon_{SPt} \\ \varepsilon_{At} \\ \varepsilon_{It} \\ \varepsilon_{Ct} \end{bmatrix}$$

(5.12)

6.1. Structural VECM Analysis: Impulse Response Functions

Having estimated the Structural Cointegrated VAR model, it is possible to obtain the impulse response functions (IRFs) provided by the Vector moving average representation. They describe the response of each variable to a shock coming from another one *s* period before. Aim of this paper is to verify if, after a positive (or negative) shock over capital:

- banks are induced to increase (decrease) assets, expanding (reducing) loans and the purchase of securities, but keeping on targeting a fixed ratio between capital and assets;
- the increase (decrease) in assets (loans and securities) to household and firms let consumption and investments rise (diminish) and bonds' and stocks' prices increase.

The IRFs obtained cover 40 quarters afterwards the occurring of the shock.

Regarding real variables, as expected, the s&p500, investments, product and consumption, as well as, positively react to a shock in product (s1) that testify the importance of the technological innovation over growth (Fig. 2 to 5).

Impulse Response Functions to a shock to product (s1)

INSERT FIG. 2 TO 5 HERE

A positive shock (one b.p.) to banks' capital (s2) produces a permanent and significant increase in banks' assets while an increase in assets produces a (not very long lasting) increase in capital (Fig. 6 and 7).

Impulse Response Functions to a shock to banks' capital (s2)

INSERT FIG. 6 AND 7 HERE

A positive shock to banks assets (s5) does not produce a significant response in the other series (Fig.8 to 10)[24].

Impulse Response Functions to a shock to banks' assets (s5)

INSERT FIG. 8 TO 11 HERE

[24] This result is consistent with some recent studies about the effect of the new capital requirements, defined by the Basel Committe after the financial crisis, over real economy. They show that each percentage point increase in the capital ratio causes a very small decline (median 0.09 percent) in the level of steady state output, relative to the baseline. See Angelini P. et. al. (2011).

Moreover an increase in banks assets should give rise to a positive response in financial markets; but even in this case the Fig. 11 shows a response that is not significantly different from zero[25]. Even the response of product to a shock in the fed fund rate (not reported) appears not significant. This result would suggest that the stance of monetary policy was not determinant for the growth in the period under consideration, contradicting the common view that it significantly contributed to the Great Moderation.

This result would suggest that the stance of monetary policy was not determinant for the growth in the period under consideration, contradicting the common view that it significantly contributed to the U.S. expansion[26].

Fig.12-Response Function of the product (Y) to a shock to the fed fund rate (s3)

INSERT FIG. 12 HERE

In the end the results of the estimates seem to confirm that the U.S. growth in the period under consideration was essentially due to the technological innovation, as widely recognized. Commercial banks assets expansion does not seem to have played a fundamental role in the period under consideration.

Conclusions

The paper concentrates on the role of U.S. commercial banks assets over U.S. expansion until the financial crisis. Banks – especially US banks – have been blamed of the excessive increase of assets and credit that created the conditions for the subsequent turmoil. Nevertheless, banks' leverage increase should be limited by the amount of available capital and by the need to guarantee a fixed ratio between capital and assets, as stated by banking regulation. In particular, from the introduction of the first Basel Accord, the ratio of a bank's capital to its risk-weighted assets (the total capital ratio) must be no lower than 8% (weights reflect the presumed degree of risks associated to that kind of assets).

The paper tries to analyze the interrelation between real and U.S. banks balance sheet variables, attempting to answer to the following questions: was the capital requirements' constraint really binding for the US commercial banks? Did the increase in banks' assets

[25] To better evaluate the short run effect of banks'assets over product, I have also tried a different specification of the model relaxing the assumption that the short run response of product to assets is zero and substituting it with the assumption that the market index does not affect the product in the short run. Even with this different specification, the IFR does not show a significant effect of assets over product.

[26] See Brunnermeier M.K. et al.(2008)

significantly contribute to US expansion in the real sector and in the financial markets until the crisis?

In order to answer to these questions commercial banks behaviour has been analyzed through an empirical methodology, making recourse to a CVAR. It appears clear that banks'assets and capital are closely linked by a long run relationship since 1988, when the first capital accord Basel I essentially imposed a fixed leverage ratio for commercial banks; the analysis also shows that an increase in capital produces a corresponding increase in assets in the long run. This result seems to confirm that commercial banks actively manage their assets on the basis of their capital position in order to respect capital requirements, as suggested by some recent studies.

This behaviour should produce an increase in lending when surplus capital is available and enforce the downturn phases because of the abrupt deleveraging from banks. Nevertheless, according to the estimates, in the period before the crisis the observed increase in banks assets does not seem to have produced a significant impact over product; this results is in line with previous studies, conducted without modelling the capital - asset relationship (Berrospide et al., 2010).

The analysis confirms that most of the growth can instead be explained with the rise in productivity given by the technological shocks.

Nevertheless, it cannot be ignored that deep changes took place in the financial sector (especially in the U.S.) in the period under consideration, as new securitization techniques were developed and securitized assets (i.e. securities backed by loans) grew exponentially. These innovations allowed financial institutions other than banks (like investment banks, broker-dealers, mutual and hedge funds) to take part to the credit intermediation process, because they were among the main buyers of securitized assets[27].

Over time the development of the non banking intermediation also reduced the relative importance of commercial banks over the U.S. financial system. In 1988, the ratio between commercial banks' credit market assets and the total credit market assets held by the domestic financial sector decreased from 36% in 1980 to 24% in 2007; conversely credit market assets held by the other intermediaries rose from 64 to 75%[28]. Furthermore, according to the

[27] See Pozsar Z. et al. (2012).

[28] These percentage has been calculated making recourse to the Flows of funds, http://www.federalreserve.gov. Domestic financial system includes Abs issuers, GSE - backed mortgage pools, broker dealers, Bank Holding Companies, Banks in U.S.-Affiliated Areas, Foreign Banking Offices in U.S., U.S.-Chartered Commercial Banks, closed-End Funds, credit unions, Exchange-Traded Funds, Federal Government Retirement Funds, Finance Companies, funding Corporations, Government-Sponsored Enterprises, Life Insurance Companies,

Securities Industry and Financial Markets Association (SIFMA) global CDO[29] issuance rose from 78 billions of dollars in 2001 to 520 in 2006, abruptly declining to a bit more then 4 billions in 2009 (see SIFMA web site); securitisation in general registered an estimated outstanding of $10.24 trillion in the United States and $2.25 trillion in Europe as of the 2nd quarter of 2008[30].

In the end, non banking intermediation entered in the credit supply chain and participated to the increase in the financial system leverage. Further work could try to evaluate the contribution of non banking intermediation to the U.S. growth in the period before the crisis but also to the subsequent turmoil.

Monetary Authority, Mutual Funds, Money Market Mutual Funds, Casualty Insurance Companies, Private Pension Funds, REITs, Savings Institutions.

[29] CDOs (collateralized debt obligations) were probably the most complex type of securitized instruments; a kind of security backed by other types of securitized securities, by CDSs (Credit default swaps) or other CDOs (so called CDO square).

[30] "ESF Securitisation Data Report Q2:2008" (2008), European Securitisation Forum, London, Securities Industry and Financial Markets Association (SIFMA).

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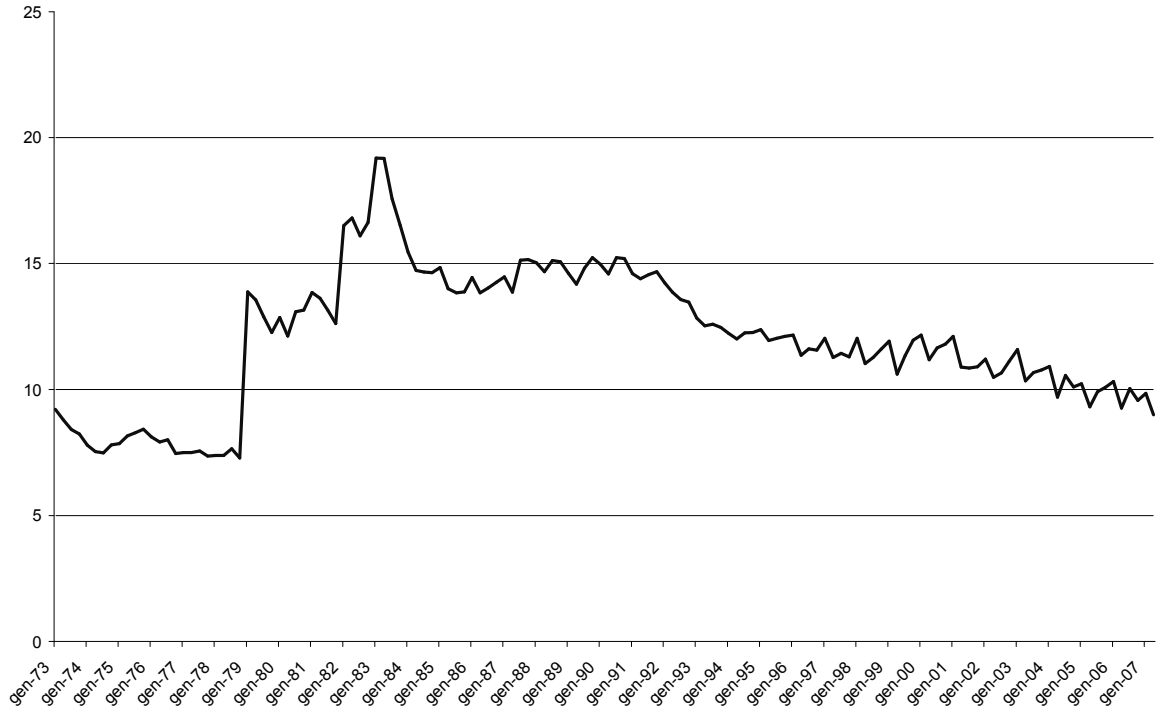
Fig. 1

Leverage in the US Commercial banks

(Assets divided by capital)



Source: U.S. Flows of funds

Table n. 1 – Regression between banks' assets and capital – 1988q1, 2010q2

Source	SS	df	MS
Model	17.5295812	1	17.5295812
Residual	.179869544	87	.002067466
Total	17.7094507	88	.201243758

Number of obs	89
F(1, 87)	8478.78
Prob > F	0.0000
R-squared	0.9898
Adj R-squared	0.9897
Root MSE	.04547

A	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
K	.7552086	.0082016	92.08	0.000	.7389069	.7715102
_cons	9.031018	.220407	40.97	0.000	8.592935	9.469101

Table n. 2 – Regression between banks' assets and capital – 1973q1, 1987q4

Source	SS	df	MS
Model	4.04782467	1	4.04782467
Residual	5.87343226	58	.101266073
Total	9.92125693	59	.168156897

Number of obs =	60
F(1, 58) =	39.97
Prob > F =	0.0000
R-squared =	0.4080
Adj R-squared =	0.3978
Root MSE =	.31822

A	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
K	1.186572	.1876788	6.32	0.000	.8108921	1.562252
_cons	-2.337639	4.797299	-0.49	0.628	-11.94048	7.265198

Table n. 3. Johansen cointegration test

H0	H1	Eigenvalues	90% critical value	Trace test
r=0	r≥0	0.5146	144.87	191.7914
r=1	r≥1	0.3828	112.65	136.8669
r=2	r≥2	0.3444	84.38	100.189
r=3	r≥3	0.3266	60.09	68.1047
r=4	r≥4	0.2298	39.75	38.0484
r=5	r≥5	0.1517	23.32	18.2094
r=6	r≥6	0.0724	10.67	5.7088

Fig. 2 - Response function of SP

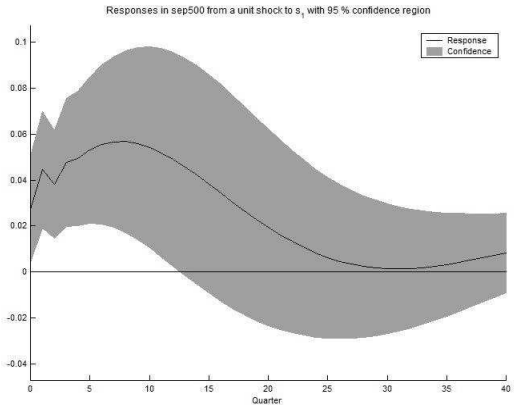


Fig. 3 - Response function of I

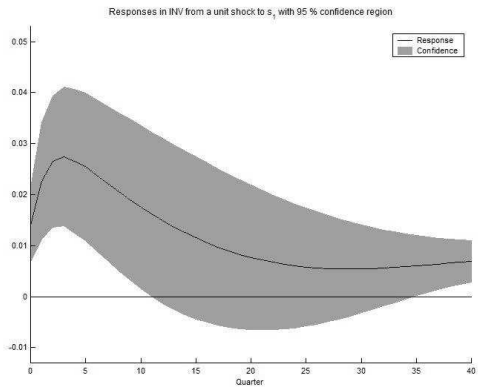


Fig. 4 Response function of Y

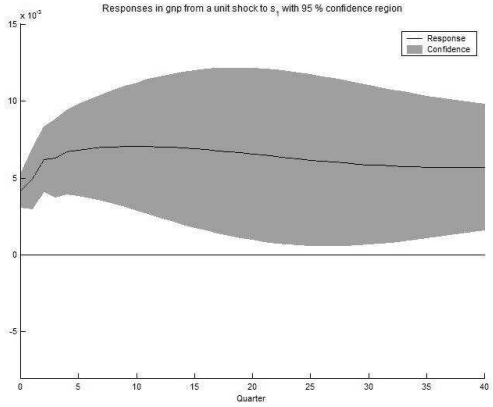


Fig. 5 Response function of C

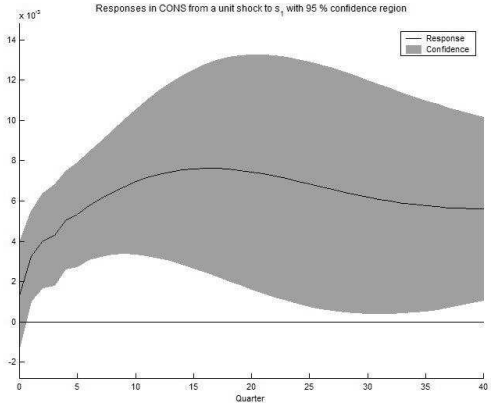


Fig. 6 Response function of A

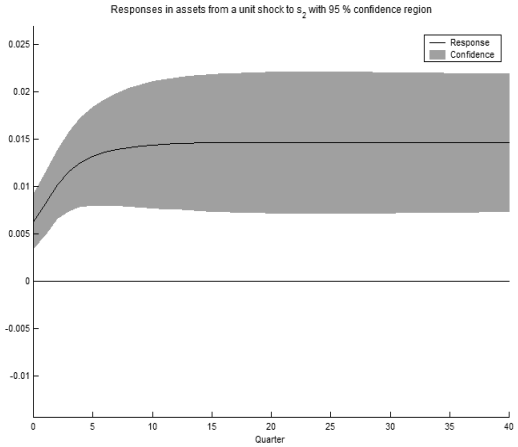


Fig. 7 Response function of K

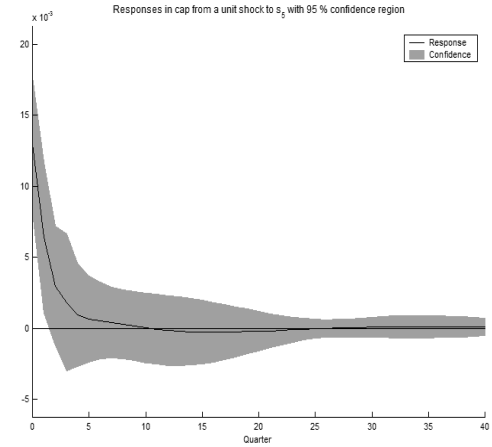


Fig. 8 Response function of C

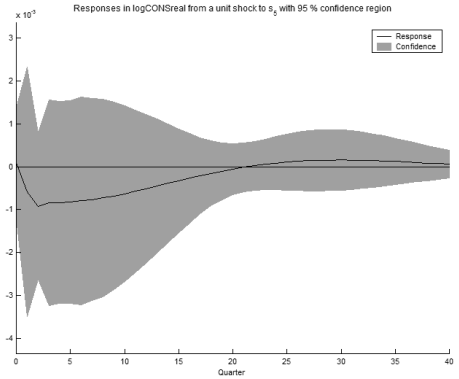


Fig.9 Response function of Y

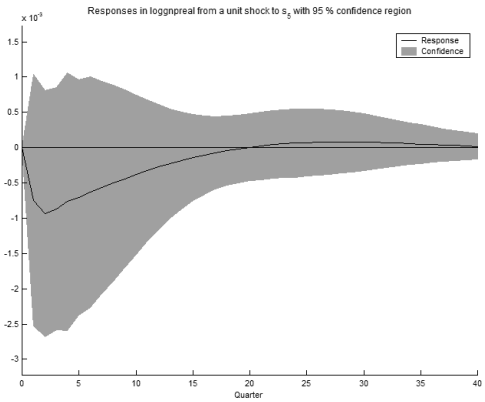


Fig.10 Response function of I

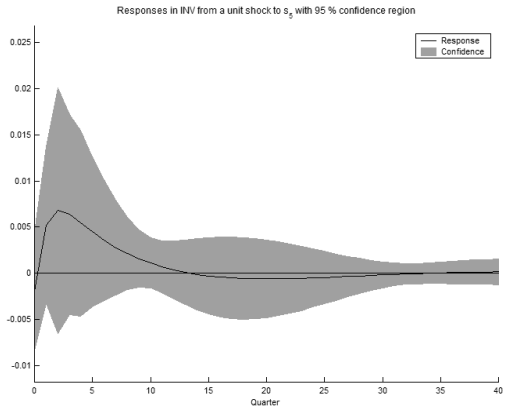


Fig.11 Response function of SP

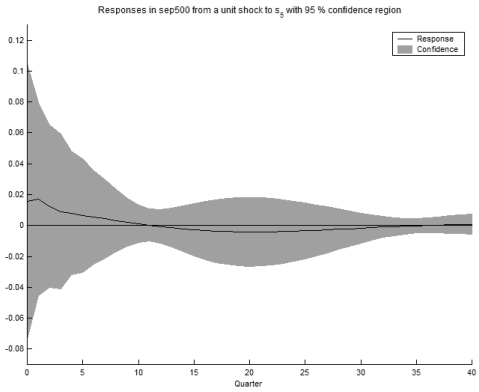


Fig.12-Response Function of the product (Y) to a shock to the fed fund rate (s3)