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Survey on Financial Market Frictions and Dynamic Stochastic General Equilibrium Models[1]

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ABSTRACT

This survey reviews the research regarding the general frameworks used for the specification of financial market frictions in dynamic stochastic general equilibrium (DSGE) models. Within the related literature, financial frictions are considered to be the prime candidates for endogenous amplification of small transitory non-financial shocks. The latest financial crisis has changed a number of macroeconomic paradigms and DSGE models were not left untouched. Pre-crisis macroeconomic models neglected the financial markets due to the fact the most economists considered them to function perfectly. As economic events pointed out the contrary, numerous research papers that tackle this problem are available in literature, therefore, this rapidly growth of literature motivates this survey.

Keywords: Dynamic Stochastic General Equilibrium Models, Financial Market Frictions, Financial Accelerator, Collateral Constraint, Survey
JEL Classifications: E21, E22, E32, E44, E59

1. INTRODUCTION

Over the past few years important progress has been made in the specification and estimation of dynamic stochastic general equilibrium (hereafter DSGE) models[2]. These models are complex by nature and call for state-of-the-art econometric techniques in order to be estimated. Also these models are powerful tools for policy makers because are able to provide a micro-founded framework for policy discussion and analysis. In theory, due to the general equilibrium characteristics, a DSGE model is able to account for inter-linkages between different sectors of the economy and can identify sources of fluctuations, answer questions about structural changes, assess the impact of policy changes, perform counterfactual scenarios and so on. Due to these facts, DSGE models caught the attention of central banks, but, so far they have yet to become a standard tool for policy decisions and analysis.

In general, the benchmark[3] DSGE model is used to assess the impact of a variety of shocks, as those arising from behavioural changes concerning households and firms' decisions, increases in government spending, in the currency risk premium, tightening of monetary policy and so on. As for the general framework, these models include a variety of agents, such as households, producers, monetary and fiscal authorities. Households consume, decide how much to invest and are monopolistic suppliers of labour. Firms are monopolistic suppliers of differentiated goods and hire labour and capital from households in order to produce their output. Both types of agents face a number of nominal rigidities like sticky wages and prices and partial indexation with inflation. The real frictions mostly refer to capital investment adjustment costs and variable capital utilization. The monetary policy is usually conducted using a standard Taylor rule which assumes that there is some degree of interest rate smoothing and the central bank targets the deviation of inflation and output from the inflation

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2 see Smets and Wouters (2002, 2007), Christiano et al. (2005), Gali and Monacelli (2005), Adolfson et al. (2007), Curdia and Woodford (2009), etc.

3 See for example Smets and Wouters (2002), Christiano et al. (2005).

objective and from the potential growth, respectively. The common assumption for the fiscal policy is that the Ricardian equivalence always holds and government consumption is modelled as first order autoregressive process. Also it is common to introduce in these models a large variety of disturbances like monetary policy shock, households' preference shocks, transitory and permanent productivity shocks, mark-up shocks for prices and wages, risk premium shock and so on.

One can notice that the benchmark DSGE model abstracts the financial markets. Therefore, the model is unable to explain some of the regularities seen in the business cycle fluctuations. Also it excludes some important areas in which a central bank may be interested, such as financial vulnerability, the feedback effect from the financial sector to the real economy, inter-linkages between domestic and international financial markets. The latest financial crisis highlighted the importance of the financial sector for the business cycle fluctuations. Pre-crisis macroeconomic models relayed only on the specification of the real economy and neglected the financial sector which was considered to be almost irrelevant in the context of low inflation rates. Moreover, the consensus among policy makers stated that price stability is enough to ensure macroeconomic stability and therefore embraced the general idea that the deterioration of financial markets is just a constant reflection of a declining economy, whereas, in reality it might be an important factor that affects the business cycle dynamics.

Even if pre-crisis operational macroeconomic models did not have a detailed specification of the financial sector, in the related literature there were attempts to tackle this problem. The most representative paper is the one written by Bernanke et al. (1999), where the financial sector, thought the financial accelerator mechanism, interacts with the business cycle. Moreover, another methods to introduce the credit frictions were available, such as the one proposed by Kiyotaki and Moore (1997), where the financial sector affects the business cycle thought the value of the collateral held the borrowers. Although these mechanisms were appealing from theoretical perspective, they only answered to a fraction of the problem, namely the demand for credit. As shown recently, at the core of the financial crisis was the incapacity of credit institutions to supply credit to the economy. Therefore, in this regard, extensive efforts were made in order to model the supply side of the credit channel.

The main objective of this paper is to review the most important ways of introducing financial credit frictions in a DSGE model. As we are focused on the flow of loans and deposits, we neglected the rest of models` frameworks. For a better understanding of these models we encourage the reader to see the original papers.

The rest of the paper is structured as follows: in the second section we present the pre-crisis approaches to introduce financial cycles in a DSGE model and in the third section we look at what has changed in this respect. Finally we conclude with a discussion where we try to reiterate the story-line and we present the some new directions for DSGE modelling.

2. DEMAND SIDE APPROACHES

As mention within the introduction, pre-crises models focused mainly on perturbations of the demand for credits. In the next two subsections we will briefly describe the frameworks of Bernanke et al., (1999), hereafter BGG (1999) and Kiyotaki and Moore (1997), hereafter KM (1997).

2.1. The BGG (1999) Framework

The model of BGG (1999) incorporates financial frictions via the financial accelerator mechanism. Consider a frictionless case where the borrower, according to the Modigliani–Miller theorem, is indifferent to the source of the borrowed funds, either internal or external. In this case entrepreneurs can raise funds from financial markets in exchange for a share of expected profits. This is a standard handbook example where financial markets function perfectly, but in real world the barrower may face some restrictions when searching for external funds. In general these restrictions arise from the asymmetry of information between the borrower and the lender, which leads to an external finance premium in form of a higher interest rate. An external finance premium can be defined as the difference between the opportunity cost of raising internal funds and the cost for the external funds. Also asymmetric information generally implies an additional cost, generally associated with monitoring costs. Therefore, an external finance premium always has a positive value.

The framework from BGG (1999) resides on a simple agency problem, which translates into an endogenous determined risk premium applied to the interest rate for credits. Because the lender does not have full and unrestricted access to borrower investment decisions and therefore the realized return, he must pay a fix auditing cost. This cost can also be interpreted as a bankruptcy cost because it augments the capital that is seized by the bank in the case of barrower default. In the model entrepreneurs are assumed to be risk-neutral and have a finite horizon which allows us to abstract the investment reputation and also to prevent the entrepreneurs to accumulate wealth up to the point of financial independency.

In this model the economy is populated by infinite-lived households, entrepreneurs and retailers. In order to be able to introduce price stickiness and the financial accelerator framework, BGG (1999) have considered that entrepreneurs are operating in a competitive environment and produce homogenous intermediate goods, which are sold to retailers in order to be differentiated. The policymakers are represented by a government that conducts both monetary and fiscal policies.

In each period entrepreneurs must (re) purchase the entire capital which will be used in the next period production activity. Also, the capital is homogeneous; therefore entrepreneurs are indifferent if the purchased capital is new or from the last period. This modelling strategy ensures that the leverage restrictions apply to the firm as a whole, not only on the marginal rate of investment. The return on the capital is sensitive to an idiosyncratic shock (besides the aggregate ones). The ex-post gross return on the capital is multiplied by the values of the idiosyncratic shock ω_j which is independent and identically distributed across time and firms with a continuously once differentiable cumulative distribution function over a non-negative support. BGG (1999) define a hazard rate based on ω and impose the restriction that the first derivate of the hazard function with respect to ω to be positive, the distribution of choice being a log-normal one.

Suppose that there is a value of ω denoted with $\bar{\omega}_j$ that truncates the distribution in two parts. If the realization of ω is smaller than the threshold value $(\omega < \bar{\omega}_j)$, the return on investment is so small that the entrepreneur can`t repay his debt, therefore enters in default. If ω is larger than the cut-off value $(\omega < \bar{\omega}_j)$, the firm repays the lender the promised amount $Z_{j,t+1}B_{j,t+1}$ and keeps the difference:

$$\Delta_{j,t+1} = \omega_j R_{k,t+1} Q_{k,t} K_{j,t+1} - Z_{j,t+1} B_{j,t+1} \tag{1}$$

Where ω_j is the realized idiosyncratic shock, $R_{k,t+1}$ in the return on capital and $Q_{k,t}K_{j,t+1}$ is the value of firm capital which in this model corresponds to the firm value as a whole.

Moreover, the thresholds value of ω can be defined as:

$$\bar{\omega}_j = Z_{j,t+1} B_{j,t+1} / R_{k,t+1} Q_{k,t} K_{j,t+1} \tag{2}$$

$\bar{\omega}_j$ is the value that assures the zero profits for entrepreneurs. From equation (2) we clearly see why a value for the idiosyncratic shock smaller than the threshold value determines the entrepreneurs to default. When this occurs, the bankrupt entrepreneur cannot buy new capital and consumes his remaining wealth, eventually fading out of the scene.

Acquisition of new capital is financed from the entrepreneurs' wealth (or net worth) and borrowed funds. The net worth is accumulated from two sources: profits from previous capital investments and from the supply of labour to the market. The net worth is of great importance for model dynamics, because the external finance premium is negatively correlated with it. Consider that at the end of period t an entrepreneur (there are an infinity of entrepreneurs) has an available net worth $N_{j,t+1}$ and in order to finance the difference between expenditures and net worth borrowers the amount of $B_{j,t+1}$:

$$B_{j,t+1} = Q_{k,t} K_{j,t+1} - N_{j,t+1} \tag{3}$$

Entrepreneurs borrow the necessary funds from financial intermediaries which are facing an opportunity costs equal to the economy risk-free interest rate R_{t+1}.

When there is aggregate uncertainty in the model, the threshold value, $\bar{\omega}_j$, will depend on the realization of the return rate on capital, $R_{k,t+1}$. Under the assumption of risk-neutral entrepreneurs, the loan contract has a simple form because they are bearing all the aggregate risk and are only interested in the rate of return of their wealth.

The values of $\bar{\omega}_j$ and $Z_{j,t+1}$ are determined by the restriction which states that a financial intermediary receive the interest rate which equals the opportunity cost of its funds. Because there are a large number of entrepreneurs, the risk is perfectly diversifiable; therefore the opportunity cost equals the risk free interest rate. A loan contract must satisfy the following restrictions (from the perspective of the financial intermediary)

$$\left[1 - F(\bar{\omega}_j)\right] Z_{j,t+1} B_{j,t+1} + (1-\mu) \int_0^{\bar{\omega}_j} \omega R_{k,t+1} Q_{k,t} K_{j,t+1} \mathrm{d}F(\omega) = R_{t+1} B_{j,t+1} \tag{4}$$

Where in the left hand side are the expected aggregate returns on loans and in the right side is the opportunity cost of lending.

After same manipulations, the above equation 4 can be written as a function of the cut-off value of the firm's idiosyncratic shock:

$$\left[1 - F(\bar{\omega}_j)\right] \bar{\omega}_j + (1-\mu) \int_0^{\bar{\omega}_j} \omega \mathrm{d}F(\omega) R_{k,t+1} Q_{k,t} K_{j,t+1} = R_{t+1}(Q_{k,t} K_{j,t+1} - N_{j,t+1}) \tag{5}$$

$F(\bar{\omega}_j)$ is the probability of default. Equation (5) is conveniently express as a function of the cut-off productivity shock. A rise of the default thresholds increases the payments to the bank in the case of non-default but in the same time raises the default probability, which eventually shrinks the aggregate expected payoffs.

An important characteristic of the financial accelerator is that it works in a pro-cyclical manner in the sense that mimics the business cycle dynamics. Consider that the economy is in the boom period where the net worth of the entrepreneurs' is increasing. This translates to a reduction of the default probability which eventually reduces the external finance premium (which is a function that depends on the monitoring costs μ, on the realization of the idiosyncratic shock ω, the value of the firm $Q_{k,t-1}K_{j,t}$ and the net worth). In an alternative scenario, where the economy enters in a bust period, the net worth of the entrepreneur diminishes, which translates into a raise in the external finance premium. The lenders opportunity costs increases and if there isn't a value of $\bar{\omega}_j$ that generate the required expected return (Equation 5), then the borrower is rationed from the market. The mechanism described above shows how a temporary adverse shock on the economy, which reduces the entrepreneurs' net worth, can generate an extended period of low lending activity, inducing a low growth of gross domestic product (GDP).

2.2. The KM (1997) Framework

In the KM (1997) framework, durable assets such as land, buildings and other production factors serve as collateral for loans. The borrower's ability to take a loan is affected by the price of collateralized assets. In the model the transmission mechanism works in this way. Consider an economy where the land (which doesn`t depreciate) is used for securing loans as well as for producing output. The total supply of land is fixed. Suppose that there are firms which are credit constrained and highly levered as a consequence of past borrowing activity. Assuming that in the period *t,* a few firms experience a temporary productivity shock that reduces their net worth. Because they cannot borrow more, the credit constraint forces them to cut the investment rate, affecting in this way the next period payoffs. Moreover, this affects the price of capital, affecting the activity of all constrained firms (the value of their collateral reduces considerable). This mechanism affects the level of investment (therefore the level of the output) for a longer period. As we can see, at the origin of this persistent drop in output was just a temporary productivity shock, which propagated thought the next periods via the financial constraints of the firms.

Their basic model of KM (1997) assumes that there are two types of farmers which are risk-neutral. They draw utility from the consumption of fruits at $t+s$. The main difference between these two types of farmers is their discount factor. Assuming that β' is the discount factor for impatient farmers and β the discount factor for patient farmers. In equilibrium impatient farmers do not postpone production, therefore $\beta'<\beta$ which ensures that they borrow to finance their activities. Also, there are further assumptions about farming. The first one states that the production is idiosyncratic, meaning that once a farmer has started the production in period *t,* only he has the necessary skills to harvest the land in $t+1$. The second one refers to the fact that each farmer can withdraw from the labour market between t and $t+1$, meaning that the output in $t+1$ will be the capital available in period t. These assumptions create the grounds for a renegotiation of the loan contract because if a farmer withdraws from the labour market the value of land without its fruits is smaller, therefore for the lenders are interested in letting the farmer to work his land by renegotiating the loan contract in order to reduce the debt burden. The financial constraint has the following form:

$$Rb_t \leq q_{t+1}k_t \tag{6}$$

Where the R is the interest, b_t is the total amount borrowed, q_{t+1} is the next period land price and k_t is the land stock. This equation states that an impatient farmer can borrow as long as the repayments doesn`t exceed the value of collateral.

The flow of funds for the impatient farmers is the following:

$$q_t\left(k_t - k_{t-1}\right) + Rb_{t-1} + x_t - ck_{t-1} = ak_{t-1} + b_t \tag{7}$$

A farmer holds k_{t-1} land at the end of period $t-1$, and has a total debt of b_{t-1}. At period *t,* he harvest ak_{t-1} tradable fruits which together with new loans b_t gives him the necessary funds to buy more land, to repay his last period debt and to buy addition goods for consumption.

The framework of KM (1997) was formerly introduced in an estimated DSGE model by Iacovellio (2005). He introduces two types of households, in line with KM (1997) framework and entrepreneurs who act in a similar way as impatient households. Therefore, in the model there are two types of agents that demand credit, namely impatient households and entrepreneurs. In the case of households the collateral is replaced with housing stock and for entrepreneurs with productive capital. The borrowing mechanism is similar for both agents, therefore we will present the problem faced by impatient households.

Impatient households discount future consumption more heavily that patient households. Their variables of choice are consumption, housing stock, labour (and money). Because their discount factor is smaller than the one from patient households, it guarantees that in the equilibrium the financial constraint holds and, therefore, they are borrowers[4]. In contrast with the framework of KM (1997), the collateral depreciates over time and there are specialized agents that produce new housing stock.

As in KM (1997) framework, Iacovellio (2005) assumes a limit on the obligation of impatient households. The lender can repossess the borrowers` assets by paying a proportional transaction costs $(1-m)\ \mathrm{E}_t(q_{t+1}h_t)$. Therefore the maximum amount that can be borrowed is $m\mathrm{E}_t(Q_{t+1}h_t/R_t)$, where m can be interpreted as loan-to-value ratio. The latter formula is the financial constraint imposed on impatient households. The interpretation is similar with the one from KM (1997).

Although this framework is quite easy to implement even when the loan-to-value ratio is variable thought time, it has a major drawback. The assumption that the borrowing constraints holds with equality every time, means that practically there is no default risk for the lender. Recently Pariès et al. (2010) and Solomon (2010) have modified the framework of Iacovellio (2005) to account for uncertainty regarding the repayment of loans. For explaining this approach, we will focus on entrepreneurs (the problem for impatient households is somewhat similar).

In the framework of Solomon (2010) each entrepreneur is risk adverse and combine labour and capital to produce final output. Also, their discount factor is smaller than the one associated with the one for patient households. As in BGG (1999), entrepreneurs fixed capital is subject to common multiplicative idiosyncratic shocks ω_t, which are independent and identical distributed across entrepreneurs with unit mean and lognormal PDF; the variance is unknown and is time-varying. Regarding the participation of entrepreneurs in the financial markets, they receive a standard loan contract from the bank, where is specified the amount of the loan and the gross interest rate to be paid if the realized value of the idiosyncratic shock is large enough.

Entrepreneurs use debt contracts which depend on aggregate shocks, but not on idiosyncratic shocks. They are part of a large family that can diversify the idiosyncratic shock, but only after the loan contracts are settled. They cannot commit to share earnings from insurance with the bank. Entrepreneurs who draw below $\bar{\omega}_t$ go bankrupt and the bank can seize a part of the capital $\bar{\omega}_t\tilde{A}_t$ with a cost proportional with the entrepreneurs' capital

4 Iacovellio (2005) has showed that a value for the discount factor associated with the impatient households near to 0.975 ensures that the financial constraint binds in steady state. The discount factor for patient households is set to match the economy's interest rate on deposits (β_{patient}=1/steady state interest rate).

$\mu\bar{\omega}_t\tilde{A}_t$. Entrepreneurs can use as collateral only a part of their capital, thus after an entrepreneur chooses to default, a bank can seize:

$$\bar{\omega}_t\tilde{A}_t = \bar{\omega}_t m_t(1-\delta_k)Q_{k,t}k_{t-1} \quad (8)$$

m_t reflects the ability to collateralize capital, δ_k is the capital depreciation rate, $Q_{k,t}$ is the price of capital and k_t is the capital stock.

In order to solve the aggregation problems, entrepreneurs are allowed to insure their production and the payments from the insurance policy are conditional on the idiosyncratic shock. The insurer can fully diversify this risk across entrepreneurs and thus, on average his profit is zero. The insurance premium cannot be seized by the bank and ex-ante, is optimal for the borrower to repay his loan, they are not allays committing to do so. Given these hypothesis, this framework generates a modified Euler equation for the new loans in such a way that the external finance premium mimics the business cycle movements. Also, another key fact of this framework is the ability to study the feedback effect from the household sector to the production sector. Moreover, in comparison with the alternative framework of KM (1997) where there is no uncertainty regarding the future value of the collateral, with this modelling approach we eliminate this potential model distortion and therefore we are able to provide a more accurate scenarios for policy makers.

3. SUPPLY SIDE APPROACHES

In the aftermath of the financial crisis researchers have begun to look for new ways to improve the current macroeconomic models. As stated in the beginning of this paper, pre-crisis macroeconomic models used by central bankers neglected the financial sector even if there were research papers that highlight the importance of the financial sector in determining the fluctuations of the business cycle[5]. In the latter section we have presented the most prominent methodologies that can be used to introduce financial frictions in a DSGE model. Although these frameworks are important turning points in the related literature, one important weakness that each one shares is that in a case when an economy is perturbed by an adverse shocks, the supply of credit remains somewhat stable whereas the demand adjust accordingly to the shock. Recently, new improvements were made to these methodologies in order to distinct two channels that affect credit dynamics, one aimed at the supply and another one to the demand for credit. Therefore, in this section we will present what we think that are two of the most used methodologies in the literature for introducing perturbations to the supply of credit. First we will discuss the model of Gertler and Karadi (2011), hereafter GK (2011) and secondly the framework proposed by Gerali et al. (2010), hereafter GNSS (2010).

3.1. The GK (2011) Framework

Gertler and Karadi (2011) develop a quantitative DSGE model with financial intermediaries that face endogenously determined balance sheet constraints. The main purpose of their model is to capture the depreciation of banks' balance sheets and the effects on real economy. In order to be able to do such a thing they introduce a simple agency problem between financial intermediaries and depositors.

Financial intermediaries finance their lending activity from deposits made by households and non-financial firms. Also, they engage in maturity transformations, by holding long-term assets and financing them with short-term liabilities. Using the original notations, where N_{jt} is the net worth of the financial intermediary, B_{jt} the level of deposits that an intermediary receives, $S_{j,t}$ the financial claims on non-financial firms, then the balance sheet can be written as:

$$Q_tS_{j,t} = N_{j,t} + B_{j,t+1} \quad (9)$$

In each period a household makes a deposit and will receive in the next period a gross interest rate from the financial intermediary, therefore $B_{j,t+1}$ can be seen as a debt for the financial intermediary and $N_{j,t}$ as his equity capital, the latter being remunerated over time. The balance sheet evolves over time as a difference between earning on assets and payments on liabilities.

Financial intermediaries are finite-lived agents and use a stochastic discount factor to evaluate future earnings. If the difference between risk adjusted return on assets and the paid interest on liabilities is positive, the banks will be inclined to expand their assets indefinitely by borrowing funds from households. To limit this ability, the authors introduce a moral hazard problem. At each period of time, a banker can choose to divert a fraction of available funds back to the household he is a member of. If depositors find out about this redirection of funds, they can force the intermediary to enter in default by recovering the remaining funds. However, the share of funds that was initially diverted to the household members of banker cannot be recovered (due to high costs), therefore is assumed to be a loss. This simple agency problem can be translated mathematically using the following restrictions:

$$V_{j,t} \geq \lambda Q_tS_{j,t} \quad (10)$$

Where $\lambda Q_tS_{j,t}$ is the fraction of diverted funds and the left hand side, $V_{j,t}$, is the loss for the banker if he diverts funds. Given the above assumptions the evolution of the net worth of a banker is:

$$N_{j,t+1} = [(R_{k,t} - R_t)\phi_t + R_{t+1}]N_{j,t} \quad (11)$$

Where $N_{j,t+1}$ is the net worth of a banker in the next period, which depends on the current period net worth on the differential between the gross interest rate on assets ($R_{k,t}$) and the gross interest rate on liabilities (R_t) on the ratio of privately intermediated assets to equity ϕ_τ (leverage ratio) and the next period interest rate on liabilities R_{t+1}. Also the leverage ratio is introduced to restrict the incentive of a banker to divert funds to a point where the losses enquired by the banker balance the gains from diverting funds. As mention earlier there is a chance that a banker exits the financial markets in the next period, leaving the spot open for another entry. The newly entered banker receives a non-returnable fund

5 I am referring to the financial cycle literature, for more information's see Borio (2004, 2007)

from its respective household in order to begin the operations – The probability of entering and exiting from the financial markets affects randomly the bankers and is modelled using an independent, identically distributed distribution.

Also in this framework a bank can be affected by a perturbation to the quality of its capital. This shock produces a decline on the net worth of a financial intermediary affecting his activities. On impact, the shock will decrease the asset value. Next, due to a weakening in the balance sheet, a financial intermediary induces a drop in asset demand reducing its price. This reduction in assets price further shrinks the bank balance sheet affecting even more its capability of supplying new loans. With this mechanism embedded into the framework, such a shock will drastically affect the GDP and due to second rounds effects the recovery of the economy takes longer. Also the authors show that unconventional monetary policy can be used to mitigate these effects, but this part is beyond the scope of this survey.

3.2. The GNSS (2010) Framework

In their paper GNSS (2010) study the role of credit-supply factors in business cycle dynamics. To this end, they specify an imperfectly competitive banking sector into a DSGE model. In their model the only saving instrument is a bank deposit and the only way to borrow is via a bank loan.

The flow of funds in the banking sector is: the impatient household makes a deposit at a retail deposit bank; these funds are then transferred to the wholesale bank. The wholesale bank uses these funds together with the bank capital to supply loans to the specialized retail banks, which at their end supply loans to the economy. Because retailers are operating in the monopolistic environment, they put a mark-up over the policy interest rate for loans and under the policy rate in the case of deposits. From this banking activity they obtain profits which are transferred to the wholesale bank, where, only a fraction of profits remains in the banking sector, the rest being transferred to patient households in form of dividends.

One of the key features of the model is the balance sheet identity:

$$B_t = D_t + K_t^b \tag{12}$$

The balance sheet constraint states that the banking sector cannot give loans more than the total amount of deposits augmented with bank capital. From the perspective of equation (12) the two sources of financing are perfectly substitutable, but the level of bank capital is pinned down by the loans to capital ratio which is exogenously given.

The banking sector is structured in two layers, wholesale and retail banks. The wholesale banks are operating in a competitive environment and are subject to capital requirements. Any deviation of the bank from the targeted assets-to-capital ratio is costly; the cost is specified as being quadratic. The targeted ratio is fixed exogenously by the macroprudential authority and is assumed to be optimal. An arbitrary change of this value (which is set around 0.1) creates perturbations of bank ability to provide loans to real sector. At aggregate level the bank capital evolves accordingly to the following rule:

$$K_t^b = \left(1-\delta\right) K_{t-1}^b + \omega j_{t-1}^b \tag{13}$$

Where δ is the depreciation rate of the bank capital due to costs related to their activity. j_{t-1}^b is the aggregate bank profits and ω is the share that remains in the banking sector after the dividends are paid to the households. The share of profits that goes to households is exogenously fixed ensuring that the capital is predetermined.

The second layer is composed of two types of retail banks one that receives deposits from the households and other two that supply loans to impatient households and entrepreneurs, respectively. All retail banks are monopolistic competitors and apply a mark-up over the interest rates that are financed. Also GNSS (2010) consider that a retail bank is subject to quadratic costs proportional to aggregate return on loans if they change the interest rate, introducing in this way interest rate stickiness. All this mechanisms ensure that the model is able to generate an imperfect passing thought of the monetary policy shocks, coming closely to empirical evidence in this matter.

The main strong point of this framework is its relative simple setup and, therefore, can be transformed to accommodate numerous features like domestic and foreign interbank market, Calvo type framework thought which the interest rates are set, a capital requirement rule, minimum requirements for the banking sector lending activity, etc.

4. CONCLUSION

In this paper we have presented different ways which are used in the literature to introduce financial market frictions into DGSE models. Pre-crisis dynamic models abstracted the financial markets affecting in this way their empirical performance, even if there were a few methodologies that could be used. The financial accelerator literature focuses on the value of external finance premium (which mimics the business cycle dynamics) to explain how a transitory shock can easily be translated into a prolonged period of slow economic growth. Also the collateral constraint approach of KM (1997) has some empirical advantages thought the fact that the financial constraint of households can influence the constraint of entrepreneurs. In this framework, there isn't an endogenously determined financial premium but instead, the borrower is rationed from the financial market if it reaches his maximum borrowing capacity determined by an exogenously given loan-to-value ratio.

As observed during the financial crises, the inability of a financial intermediary to provide loans to the economy can also affect the business cycle dynamics. This issue is generally modelled by using a principal-agent problem between depositors and lender, or by specifying targets for capital-to-assets ratio of the banks. Also in these types of models there is an endogenously determined balance sheet constrains for the banking sector, which can further affect the ability of a financial intermediary to supply loans to the economy.

The latest financial crisis has changed a few paradigms in the macroeconomics and the DSGE models weren`t left untouched. Pre-crisis macroeconomic models neglected the financial markets due to the fact the most economists considered them to function perfectly. As economic events pointed the contrary, important research groups were put together in order to find new ways to model the macroeconomic environment. An example is the research network created by the European Central Bank, called MaRs (Macro-prudential Research Network) with the objective of developing new frameworks that will provide research support for the improvement of macro-prudential supervision across European Union[6]. Another one is the research task force organized by BIS[7] which has a similar set of objectives.

Although there is a great interest in this filed, there are many problems that have not been properly solved, like the problem of non-linearities and maturity transformations which are core features for the financial system, the small number of financial instruments modelled in dynamic models, the problem of cross-border contagion and so on.

REFERENCES

Adolfson, M., Laseen, S., Linde, J., Villani, M. (2007), Bayesian estimation of an open economy DSGE model with incomplete pass-through. Journal of International Economics, 72(2), 481-511.

Basel Committee on Banking Supervision. (2012), Models and Tools for Macroprudential Analysis, BIS Working Paper, 21.

Bernanke, B., Gertler, M., Gilchrist, S. (1999), The Financial Accelerator in a Quantitative Business Cycle Framework, Handbook of Macroeconomics. North Holland: Elsevier Science. p1341-1393.

Borio, C. (2004), Market Distress and Vanishing Liquidity: Anatomy and Policy Options, BIS Working Papers, No. 158.

Borio, C. (2007), Monetary and prudential policies at a crossroads? New challenges in the new century. Moneda y Crédito, 224, 63-101.

Christiano, L., Eichenbaum, M., Evans, C. (2005), Nominal rigidities and the dynamic effect of a shock to monetary policy. Journal of Political Economy, 113(1), 1-44.

Curdia, V., Woodford, M. (2009), Credit Frictions and Optimal Monetary Policy, BIS Working Paper, 278.

Gali, J., Monacelli, T. (2005), Monetary policy and exchange rate volatility in a small open economy. Review of Economic Studies, 72, 707-734.

Gerali A., Neri, S., Sessa L., Signoretti, F.M. (2010), Credit and banking in a DSGE model of the Euro Area. Journal of Money, Credit and Banking, 42, 107-141.

Gertler, M., Karadi, P. (2011), A model of unconventional monetary policy. Journal of Monetary Economics, 58(1), 17-34.

Iacovellio, M. (2005), House prices, borrowing constraints and monetary policy in the business cycle. American Economic Review, 95(3), 739-764.

Kiyotaki, N., Moore, J. (1997), Credit cycles. The Journal of Political Economy, 105(2), 211-248.

Macro-prudential Research Network Report. (2014), Available from: https://www.ecb.europa.eu/events/pdf/conferences/140623/MaRs_report.pdf.

Pariès, M.P., Sørensen, C.K., Palenzuela, D.R. (2010) Macroeconomic Propagation under Different Regulatory Regimes. Evidence from an Estimated DSGE Model for the Euro Area, ECB Working Paper, 1251.

Smets, F., Wouters R. (2002), An Estimated Stochastic Dynamic General Equilibrium Model of the Euro Area, ECB Working Paper, 171.

Smets, F., Wouters, R. (2007), Shocks and Frictions in US Business Cycles. A Bayesian DSGE Approach, ECB Working Paper, 722.

Solomon, B.D. (2010), Firm Leverage, Household Leverage and the Business Cycle, MPRA Working Paper, 26504.

6 See the Report of the Macro-prudential Research Network.

7 Research Task Force Working Group on the Transmission Channels between the Financial and Real Sectors of the Basel Committee on Banking Supervision" and the most important findings are summarized in the BIS working paper No. 21(2012) – "Models and tools for macroprudential analysis".