národní
úložiště
šedé
literatury

Survey of Research on Financial Sector Modeling within DSGE Models

Brázdik, František; Hlaváček, Michal; Maršál, Aleš
2011

Dostupný z `http://www.nusl.cz/ntk/nusl-123963`

RESEARCH AND POLICY NOTES 3

František Brázdik, Michal Hlaváček, Aleš Maršál:
Survey of Research on Financial Sector Modeling within DSGE Models:
What Central Banks Can Learn from It

2011

CNB CZECH
NATIONAL BANK

RESEARCH AND POLICY NOTES

**Survey of Research on Financial Sector Modeling
within DSGE Models: What Central Banks Can Learn from It**

František Brázdik
Michal Hlaváček
Aleš Maršál

3/2011

CNB RESEARCH AND POLICY NOTES

Survey of Research on Financial Sector Modeling within DSGE Models: What Central Banks Can Learn from It

František Brázdik, Michal Hlaváček, Aleš Maršál[*]

Abstract

This survey gives insight into the ongoing research in financial frictions modeling. The recent financial turmoil has fueled interest in operationalizing financial frictions concepts and introducing them into tools for policy makers. The rapid growth of the literature on these issues is the motivation for our review of the presented approaches. The empirical facts that motivate the inclusion of financial frictions are surveyed. This survey provides a description of the basic approaches for introducing financial frictions into dynamic stochastic general equilibrium models. The significance and empirical identification of the financial accelerator effect is then discussed. The role of financial frictions models in CNB monetary and macroprudential policy is also described. It is concluded that given the heterogeneity of the approaches to financial frictions it is beneficial for the conduct of monetary policy to focus on the development of satellite approaches. The role of financial frictions in DSGE models for macroprudential policy is also discussed, as these models can be used to generate stress-testing scenarios. It can be concluded that DSGE models with financial frictions could complement current stress-testing practice, but are not able to replace stress tests.

Nontechnical Summary

The recent financial turmoil initiated an extensive debate on the prospects of current economic modeling strategies, on the future macroeconomic agenda and on the causes of the crisis. Until recently, the workhorse general equilibrium models used for analysis and forecasting abstracted from modeling credit markets or frictions originating from the financial sector. However, the theoretical and empirical literature on credit market imperfections is rapidly expanding and could offer arguments for introducing financial frictions into DSGE models.

The "financial accelerator" is the most common feature of the introduction of financial frictions into models. This mechanism implies that endogenous forces in credit markets amplify and propagate shocks to the real economy. Depending on the micro-foundations of the acceleration mechanism, two main approaches can be distinguished in the literature.

Financial frictions can be introduced by capturing firms' balance sheet effects on investment by relying on a one-period stochastic optimal debt contract with costly state verification. The key aspect is that such a setting allows endogenous determination of the "external finance premium" defined as the difference between the cost of external sources of funding and the opportunity cost of funds internal to the firm. Due to the agency problem in lending, the external finance premium depends inversely on borrowers' net worth and amplifies the responses to financial shocks.

Also, by introducing collateralized loans, the financial accelerator effect can be introduced into models with durable assets. Endogenous collateral constraints link the credit capacity of borrowers to the value of their asset holdings. In good times, increased asset values allow financially constrained agents to expand their borrowing and increase consumption and investment, thus further stimulating real activity. On the contrary, unfavorable disturbances decrease the value of the collateral and induce an additional cut in expenditures, thus amplifying adverse economic shocks.

Recent literature also attempts to define a role for the banking sector, where financial intermediaries have an active role in determining market prices or the supply of financial assets. These financial intermediaries can operate in a framework of either perfect competition or monopolistic competition. This allows modeling of interest rate setting behavior and thus the heterogeneity in the adjustment of bank rates to changing conditions in money market interest rates.

The use of financial frictions DSGE models in practical monetary policy is limited by the absence of a standardized financial frictions approach, as the numerous approaches that do exist differ significantly in their results. Due to uncertainty in the choice of approach, the CNB's policy is to develop several alternative satellite models which supplement the core prediction model. The use of DSGE models with financial frictions in macroprudential policy is even less straightforward than in the case of monetary policy. DSGE models can be used to create stress testing scenarios, as they can improve the fit of the satellite models for stress testing. An advantage could arise from extending the prediction horizon of stress tests, as this could improve modeling of the gradual build-up of risks during a "boom and bust" financial cycle. Therefore, DSGE models could bring new insights to the time dimension of systemic risk and improve modeling of the procyclicality of the financial sector. However, the extended DSGE models are not designed to replace stress testing, especially in its cross-sectional dimension.

1.   Introduction

In this work, the recent literature focusing on financial frictions in the framework of general equilibrium macroeconomic models is reviewed. Dynamic stochastic general equilibrium (DSGE) models have recently become a very popular tool for describing economies not only in academia, but also in many central banks, where they are now a major part of the decision-making process. The popularity of DSGE models stems from the presence and rigorous treatment of microeconomic foundations describing the behavior of economic agents. The presence of microeconomic foundations allows for more detailed and structured analysis of the origins and evolution of observed business cycles than econometric models (VAR and VECM) can provide.

Despite the vast theory developed and used in practice, the standard DSGE models do not include the interaction of financial markets with the rest of the economy. Most macroeconomic theories and applications assume smooth and perfect functioning of financial markets. These simplifying assumptions allow for abstraction from the constraints present in markets and make market arrangements less complex. Due to this abstraction from constraints and arrangements, the implications of market imperfections for business cycles are included in standard models only implicitly or insufficiently, or are even ignored. Interest in the investigation of interactions between financial markets and the rest of the economy grows significantly at times of recession (e.g. the Asian financial crisis in 1997 and the sub-prime crisis in 2008), when rigidities and constraints are apparent in the functioning of financial markets.

However, the origins of the interest in investigating the influence of financial markets on business cycles can be found in the work of Gertler (1988) and Bernanke and Gertler (1989), long before the Asian financial crisis erupted. The introduction of financial rigidities led to the creation of models that distinguish the sources of capital for funding the investment projects of economic agents. Further development led to the construction of models with constraints on the amount of credit available for investment (Iacoviello (2005)). However, a common characteristic of the aforementioned papers is the absence of financial intermediaries, e.g. banks or capital funds. Due to this drawback the theoretical development of the models also focused on the explicit specification of the role of banks.

The recent interest in the investigation of financial rigidities has been fueled by the sub-prime crisis and its wide and significant impact on the financial sector and the economy. Therefore, a significant increase can be observed in the number of papers focusing on theories of investment behavior, the optimal structure of financing, and asymmetric information (e.g. Brzoza-Brzezina and Makarski (2009) and Iacoviello and Neri (2010)).

The recent interest in financial frictions has also sparked interest in surveying the actual literature (e.g. Research Task Force Working Group on the Transmission Channels between the Financial and Real Sectors of the Basel Committee on Banking Supervision (2011) and Brzoza-Brzezina et al. (2011)). However, these surveys are either not focused on DSGE modeling or are quite brief and contain no description of practical uses. Therefore, in this survey the framework used in the Czech National Bank (CNB) for macroprudential analysis is described.

The following section presents the motivation for models of financial frictions stemming from business cycle properties. In the third section, modeling of the external finance premium is reviewed. In the fourth section, models with credit constraints are presented. In the fifth section, the specification of the role of financial intermediaries in financial markets is described. In the

sixth section, the potential use of models with financial frictions in practical monetary and macroprudential policy making is discussed.

2.   Motivation

The most apparent property of economic output observable in the data is its long-term growth. However, this growth is not always straightforward. Generally, fluctuations around the trajectory with a positive trend can be observed. These fluctuations can be characterized by their amplitude, persistence, and asymmetry.

Although a decrease has been identified, the amplitude of the observed fluctuations is still considered significant, as in Bernanke and Gertler (1995) and Kocherlakota (2000). Also, the fluctuations are observed to be asymmetric: a decrease in the growth rate below its long-term average is usually followed by a significant period of slower growth. The research done by Falk (1986) and Acemoglu and Scott (1997) documents more substantial and rapid periods of economic slowdown than periods of boom.

The development of models capable of reproducing the characteristics of these fluctuations is leading to a better understanding of business cycles. It is also leading to advances in knowledge of the impacts of monetary policy decisions. However, standard DSGE models are still not able to reproduce the characteristics of economic fluctuations without the use of extensive and persistent shocks. Empirical studies focused on the identification of shocks conclude that extensive and persistent shocks cannot easily be found and explained (e.g. Cochrane (1994) and Summers (1986)). Therefore, the reproduction of business cycle properties by models is still motivating the search for a mechanism able to transform shocks in a specific sector of the economy into extensive, persistent, and asymmetric fluctuations in the aggregate output of the economy.

Notwithstanding the advances in reproducing business cycle properties, the identification of shocks that are driving cycles has come into the focus of the recent literature (e.g. Benk et al. (2005), Christiano et al. (2006) and Jermann and Quadrini (2009)). In these papers, the identification of shocks is based on a combination of econometric methods and DSGE models. The conventional approach to analyzing the extent and persistence of fluctuations is to create VAR models first. Using VAR models it is possible to identify the amplitude and shape of the impulse response functions for structural shocks. Moreover, the impulse responses of VAR are compared to the responses of DSGE models. This comparison allows us to evaluate the mechanisms of DSGE models, which originate from microeconomic foundations, in light of the extent and persistence of the impulse response. Empirical papers such as Reichlin (2004) criticize the standard DSGE framework for problems with modeling the characteristics of business cycles, e.g. its inability to explain the observed degree of macroeconomic volatility or why financial markets may, in some cases, aggravate the consequences and persistence of shocks originating in the real economy. These problems motivate the introduction of frictions originating in financial markets into DSGE models. Recently, this motivation has been increased by the effects of the sub-prime crisis and subsequent economic slowdown.

The standard models assume that representative economic agents operating in perfect financial markets have immediate access to an unlimited amount of funding. In the recent literature focusing on the modeling of financial markets, the mechanism for the transformation of shocks into extensive and persistent responses is the presence of rigidities and constraints that limit perfect accessibility to an unlimited amount of funding. The mechanisms that can amplify shocks

from the economy can be allocated to the following classes: cash-flow constraints, collateral constraints, external funds limits, and financial regulations.

Cash-flow constraints emerge when firms are not able to raise enough capital from their internal funds and have to use external funds, which are usually more costly. Costs related to raising external capital lead to an increase in the cost of investment decision-making in relation to expected profits.

Collateral constraints play a significant role when firms with high leverage ratios face a deterioration in the conditions for raising additional external funds.

Constraints on the supply of external funding are present when the possibility of financial intermediaries screening the results of investment projects leads to the emergence of an external finance premium and thus allows only a limited amount of external capital to be obtained.

A prerequisite for the introduction of financial rigidity is therefore the invalidation of the Modigliani-Miller theorem on the independence of a firm's value from its funding structure. Modigliani and Miller (1958) formulated their theorem under the assumptions of efficient markets (elimination of arbitrage opportunities), the absence of distortions from tax system changes, zero bankruptcy costs, and perfect information. Modigliani and Miller (1958) have shown that under these assumptions, for the total value of a firm it does not matter whether the funds of the firm are increased by shares or loans.

If the Modigliani-Miller theorem is at least approximately in line with reality, it is possible to omit the role of financial markets in obtaining funds because financial characteristics will become unimportant in the decision-making process of firms and financial agents. The omission of financial characteristics leads to simpler models. However, the omission of the role of financial markets has come under scrutiny since the first tests of this theorem. As a result, an increasing number of studies incorporate financial factors into the models. Generally, the aim of these studies is to identify the mechanism for the transformation of observed shocks into fluctuations with properties corresponding to the observed properties of business cycles.

Mechanisms capable of transforming sudden and short-lived failures of financial markets into sharp and prolonged fluctuations in the real economy are generally labeled financial accelerator mechanisms. Bernanke et al. (1999) attributed the presence of a financial accelerator mechanism to the existence of an external finance premium (the credit channel, limiting the supply of external resources) or collateralization of debt (the collateral constraint channel). In the following sections, each of these channels will be described separately, even though their incorporation into the model has the same goal - the creation of a financial accelerator mechanism.

3. Credit Channel

This section is focused on financial accelerator models, which originate from the presence of an external finance premium. This premium is a key concept of financial accelerator models, whose history begins with the studies of Bernanke and Gertler (1989) and Bernanke (1993). The same applies to studies that entail further improvements to the basic models, such as Bernanke and Gertler (1995) and Fukunaga (2002). This section focuses on models where external capital is used for productive purposes. A focus on the use of debt because of its tax advantages for firm value optimization, as in Jermann and Quadrini (2009), is beyond the scope of this review.

In a frictionless world, a firm or entrepreneur is able to raise capital from external sources in exchange for a share in its future stream of profits. However, in the real world agents face certain restrictions when searching for external sources of capital. These restrictions occur due the limited supply of credit (credit rationing) or unattractiveness of the lending conditions. The limitations on, and conditions of, lending originate from information asymmetry between the borrower and the lender. The cost of external financial resources is therefore a premium (external financing premium) which a debtor must pay to creditors, generally in the form of higher interest on rented external finance. The costs of external sources can vary considerably and depend on many characteristics, such as company risk, net worth, and the return on the proposed investment project.

The external finance premium is defined as the difference between the cost to the borrower of raising capital in the financial markets (external funding) and the opportunity cost of the borrower's use of internal resources. The data (see De Graeve (2008) or Banerjee (2002)) show that external funding (equity borrowed from creditors) is almost always more expensive than using internal resources (capital raised from own profits). This is due to the increase in the costs of lenders, who have to evaluate the prospects of success of the investment projects and monitor the borrower's conduct. For a better fit of the data, models should try to account for the observed positive premium on external funds. The existence of a premium is declared in the assumptions of these models.

Due to the costs of processes associated with obtaining external funding, the external finance premium is almost always positive, but it can be different for different borrowers. The external finance premium which a debtor must pay is dependent on his financial situation. A debtor is financially assessed in terms of his net worth and the actual amount of liquidity and the expected income stream of his investment projects. The size of the external finance premium decreases with increasing net worth or liquidity and a proven record of realization of successful investment projects. A debtor with a better financial position and history is therefore rewarded by a lower cost of external sources of capital.

A fundamental property of the external finance premium is its counter-cyclical nature (see, for example, Besley et al. (2008)) because the firm's income and worth increase in periods of economic growth and this improves its financial position (pro-cyclicality of profits and asset prices). A shock occurring in the financial markets (a change in the availability of external resources), will propagate to the rest of the economy. In the event of an adverse shock, the external finance premium will increase and this increases the cost of obtaining external funding and worsens the financial position of the debtor. The further deterioration in financial position leads to a further increase in the premium and a further reduction in demand for funding. The decrease in the utilization of resources leads to a reduction in investment projects and thus reduces economic output and the future stream of profits from projects. The less profitable projects lead to an increase in dependence on external funding and a decrease in net worth, leading to an increase in the premium. This shows how a small shock can, via the financial accelerator mechanism, significantly affect the whole economy for a long time.

One of the sources of imperfect functioning of financial markets is the information asymmetry that arises between the borrower and lender. Lenders providing funding for investment projects face information asymmetry because they have less, or more imprecise, information about the status of investment projects than debtors. Therefore, a significant share of the costs of external financing of investment projects can be attributed to this asymmetry.

Due to the presence of asymmetric information, financial contracts often include the possibility of costly monitoring of the status of the investment project (costly state verification) by the creditor, because the control delivered by only monitoring the financial market is considerably simplified. Monitoring of project results, as assumed by Diamond (1965), is linked with a significant cost of obtaining information, which increases the project implementation costs. Akerlof (1970) illustrates the way in which the presence of information asymmetry between the parties to a contract may result in restriction of the functioning of the market or, in extreme cases, in the establishment of barriers to the existence of a market. Akerlof (1970) shows that such barriers to the functioning of markets arise in particular when contracts with full guarantees are used. Akerlof (1970) also discusses measures that can eliminate or suppress information asymmetry to improve the functioning of markets.

The types of contracts designed for the presence of asymmetric information and with the possibility of monitoring have been studied by Townsend (1979). The theoretical micro-foundations of these contracts assume the existence of producers of capital who generate capital through investment projects to which lenders lend their funds for a pre-agreed profit. Producers of capital constantly face the possibility of bankruptcy of their investment project. However, producers can observe the results of their projects free of charge. Creditors have to pay for monitoring when trying to find the actual yield of the project in which their funding is used. The lender faces the dilemma of when to opt for monitoring of project results, as it is not cost-effective to monitor every project.

Moreover, monitoring costs are reflected in the premium paid by debtors. Despite these costs, lenders use monitoring because without it the producers of capital would report lower than actual income. Moral hazard occurs because it is optimal to pay the lowest possible financing cost, as Freixas and Rochet (2008) show. Townsend (1979) specifies a contract type able to handle this information asymmetry and describes the properties of this contract. The optimal contract is defined by a function describing the returns on the contract when bankruptcy or success occurs. Also, the optimal contract defines the reported income threshold. The optimal contract is specified as follows: after the reporting of a project return higher than or equal to the threshold, the lender does not require auditing of the project result; if the reported profit from the project is lower than the monitoring threshold, the lender always requires an audit of the project result.

The monitoring threshold is a decreasing function of the amount of the borrower's capital, because wealthier borrower can pay an agreed yield despite greater losses in the event of an adverse project result. The monitoring threshold is an increasing function of the risk-free return, which serves as an alternative to investing in the project. The difference between the monitoring threshold and the risk-free yield serves as an impulse for the emergence of financial agents who mediate the investment contract.

3.1   Model by Bernanke and Gertler (1989)

Bernanke and Gertler (1989) introduced entrepreneurs (producers of capital) and lenders into a model of overlapping generations. A household in this model can be imagined as a mixture of entrepreneurs and lenders. Entrepreneurs use financial contracts in the form described by Townsend (1979) to transform their assets and borrowed funds through investment projects into capital goods. The capital goods are used by firms to produce consumer goods. In model by Bernanke and Gertler (1989), only entrepreneurs can see the results of their individual projects. Lenders have to pay monitoring costs to verify the results of investment projects. Using the

framework of an overlapping generations model in which agents live only a limited time avoids discussion of the reputation and history of capital investment.

The role of households is to take decisions on the quantities of goods consumed and saved. Saved goods are provided at a risk-free rate to a financial agent (a lender or consortium of lenders) and used by entrepreneurs (financial agents) to implement investment projects. Figure 1 is a simplified sketch of the flow of goods and capital in model by Bernanke and Gertler (1989).

Figure 1: Sketch of Agency Costs Model by Bernanke and Gertler (1989)
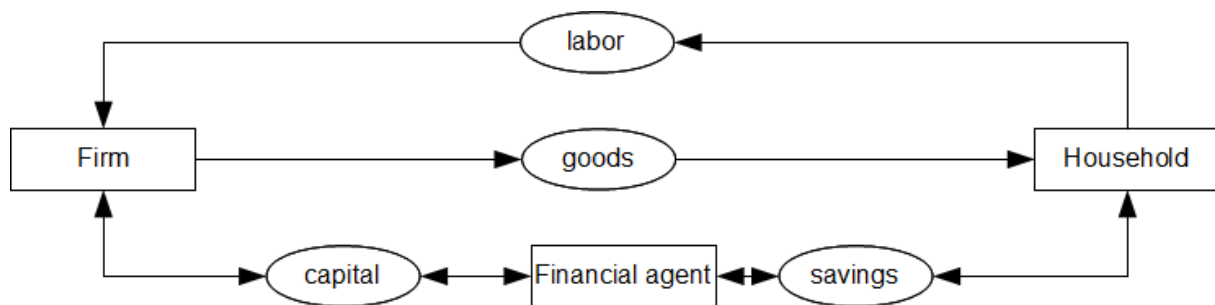
Bernanke and Gertler (1989) consider financial agents who undertake business projects that produce capital demanded by firms producing goods. Financial agents try to meet the demand for capital by implementing investment projects and provide households with contracts with the possibility of auditing project results.

Monitoring costs combined with uncertainty about the outcome of the project leads to a positive premium on external resources, which restricts loans to the producer of capital. The existence of the premium and its pro-cyclical nature are fundamentals of the financial accelerator mechanism, which propagates supply shocks to all parts of the economy.

To analyze the dynamics of model by Bernanke and Gertler (1989), a positive shock to the productivity of firms is assessed. Expected growth in the price of capital leads to expectations of increased profits of financial agents. Therefore, they increase their demand for goods used to produce capital and offer an increase in profits from investment projects. The higher profits of entrepreneurs increase their wealth, resulting in a downward shift of the threshold for monitoring. As a consequence of the positive shock to productivity and the increase in net worth it is cheaper to acquire households' savings for the implementation of investment projects. This stimulates further growth of investment and capital production, which promotes future economic growth. Bernanke and Gertler (1989) called this type of amplification a shock accelerator effect on investment income. Subsequent studies recognize this mechanism as a financial accelerator.

3.2   Model by Bernanke et al. (1999)

After the development of overlapping generations models, one of the first attempts to introduce types of frictions, as presented by Townsend (1979), into the standard infinite horizon framework was the seminal paper by Carlstrom and Fuerst (1997). They embed the contracting problem into the standard real business cycle model. Therefore, later on, Bernanke et al. (1999)

present an advanced model with a financial accelerator mechanism. Bernanke et al. (1999) place producers of capital who face an external finance premium in a New-Keynesian DSGE model which is characterized by the presence of price rigidities. In this model, financial intermediaries (producers of capital) face random termination (a mechanism capturing the ongoing births and deaths of firms). This assumption of termination, as in older models, allows one to abstract from investment reputation. Also, bankruptcy of financial intermediaries prevents them from accumulating enough internal funds to achieve independence from external sources of funds.

In this dynamic stochastic general equilibrium model, the economy is populated by households (lenders), firms, and retailers. Households supply labor, consumer goods, and provide savings as shown in Figure 2. In addition, the model includes a government which conducts both fiscal and monetary policy. Government expenditures are financed by lump-sum taxes and money creation. The model is closed by a description of monetary policy, whose only role is targeting inflation. The model of Bernanke et al. (1999) allows us to analyze the response of the economy to a technology shock, a monetary policy shock, and a shock to government expenditures.

In this dynamic stochastic general equilibrium model, economy is populated by households (lenders), firms and retailers. Households supply labor, consume goods and provide savings as shown in Figure 2. In addition model includes a government, which conducts both fiscal and monetary policy. Government expenditures are financed by lump-sum taxes and money creation. The model is closed by the description monetary policy and its only role is targeting inflation. Model by Bernanke et al. (1999) allows to analyze the response of the economy on technology, monetary policy shock and the shock to government expenditures.

The production sector is made up of heterogeneous firms set in a perfect competition environment which use capital and labor to produce consumption goods. The net worth of companies originates from investing their capital and labor. This net worth of firms is considered when obtaining the necessary capital to produce consumption goods via a financial intermediary. The financial contracts used minimize the expected costs of financial intermediation. Bernanke et al. (1999) assume that only one-period contracts between borrowers and lenders are feasible. A similar assumption is made by Carlstrom and Fuerst (1997), as allowing for longer-term contracts does not affect the basic results. The form of the financial contract and the assumption of production with constant returns to scale generate a linear relationship between demand for capital and entrepreneurial net worth.

Unlike households, firms disappear and arise constantly. This prevents firms from accumulating enough resources to become independent of external sources of capital. Firms raise capital using the above-described type of optimal financial contract based on net worth. The role of retailers is to do nothing other than buy consumption goods from firms and differentiate them costlessly. Households then purchase constant elasticity of substitution (CES) aggregates of these retail goods. With retailers offering their differentiated products in an environment of monopolistic competition, price rigidity is introduced into this model. Profits from retail activity are rebated lump-sum to households.

Using this advanced model, Bernanke et al. (1999) show that the financial contract provides a monotonically increasing linear relationship between the capital-to-wealth ratio (leverage ratio, debt to assets, or debt to net worth) and the premium on external funds.

As the net worth of producers is pro-cyclical, a counter-cyclical external finance premium also appears in this model. The counter-cyclical external finance premium imposes limits on the pro-

Figure 2: Sketch of BGG (1999) Model
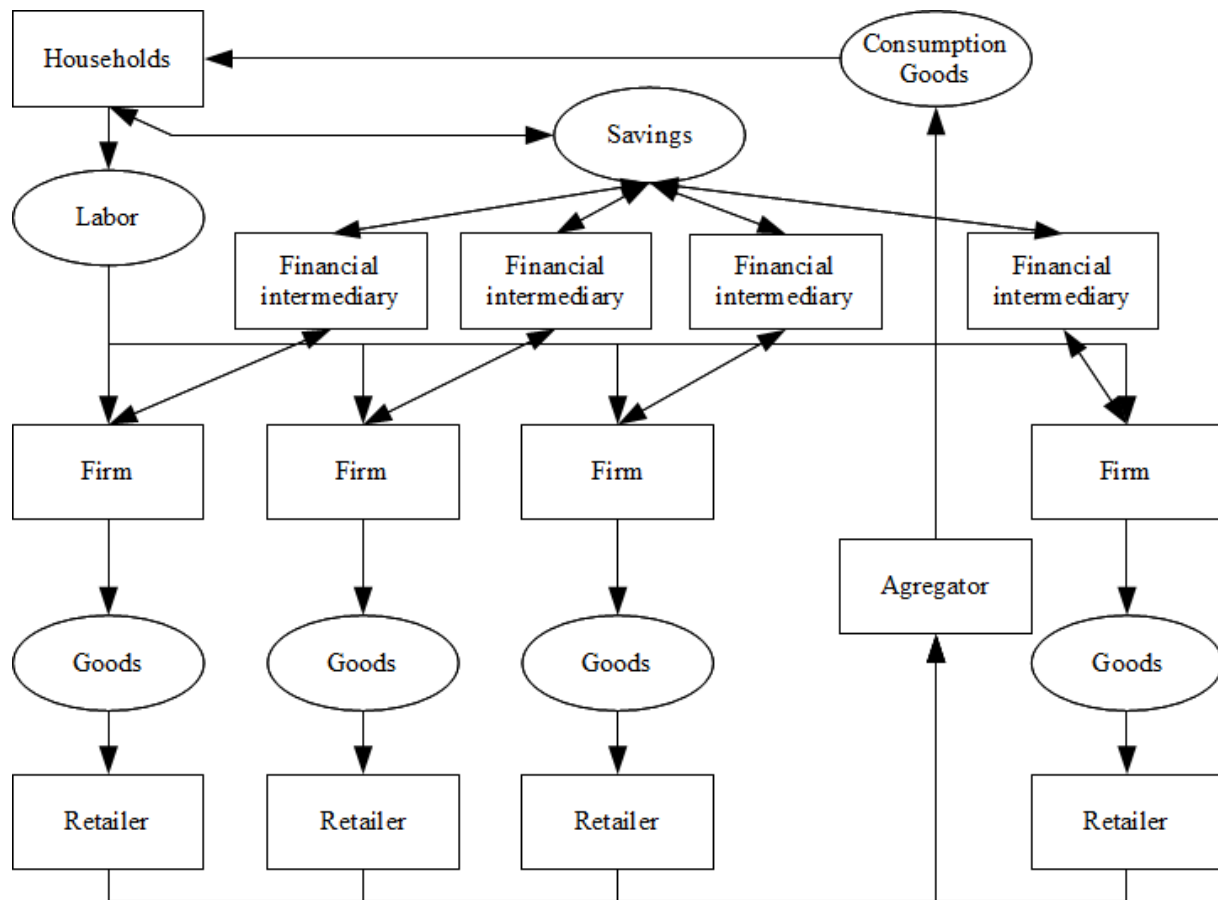
vision of funding for investment projects. The emergence of positive shocks reduces demand for external funding because an increase in profits from investment projects increases the net worth of producers of capital. However, the counter-cyclical property of the external finance premium can be questioned. As Gomes et al. (2003) show, the empirical success of the costly external finance model lies in part in the fact that, for a fixed amount of internal funds, more investment requires more borrowing. This raises the monitoring costs and, consequently, the cost of external funds. It is this positive relation between investment and borrowing costs that generates an increase in marginal adjustment costs and slows down capital accumulation in the early stages of an expansion, thus making it possible to obtain hump-shaped responses to underlying shocks. However, while this rise in marginal costs helps to generate large volatility in stock returns, it is necessarily associated with a pro-cyclical rise in the default premium, a feature that is at odds with the data. Thus, the very mechanism behind the realistic movements in key aggregates is also responsible for the model's shortcoming along the asset-pricing dimension.

Bernanke et al. (1999) expand their analysis of business cycles by comparing models with and without a financial accelerator mechanism. The authors note that the presence of a financial accelerator may explain the extent and persistence of fluctuations, which are a response to monetary policy and demand and supply shocks.

As the impulse responses show, the financial accelerator mechanism itself does not deliver the desired properties of the responses. Therefore, Bernanke et al. (1999) comment on the drawbacks of their model. First, they mention the immediate response to the monetary policy shock in the model. In the real world this response is usually delayed. Bernanke et al. (1999) show that by adding a delay in the investment process it is possible to correct this deficiency. Second, to increase the amount of firm heterogeneity the authors introduce firms with easy and less easy access to credit. As they still view their model as restricted, they propose several extensions, e.g. the introduction of a nontrivial role for banks, nominal debt contracts, and the use of an open economy model. Some of these extensions are discussed in the following section.

3.3 Further Extensions of Models

An early extension of the framework by Bernanke et al. (1999) is presented by Christiano et al. (2003) in their analysis of the Great Depression. Christiano et al. (2003) state that to capture the key forces of economic cycles, features such as perceptions of risk, disturbances to labor demand and capacity utilization, and wage frictions should be introduced into the model. Also, the model should incorporate a banking system which is rich enough that one can consider the interactions between real economic activity and various monetary aggregates such as currency, bank reserves, and demand deposits.

Using the extended model, Christiano et al. (2003) replicate the important features of the data observed during the Great Depression. In this period, they also identified an increase in households' preferences for holding money and a shift away from the formation of savings. According to the authors, the reduction of savings led to the emergence of a restriction on the amount of external funds available for capital creation and to growth in the external financing premium. The authors conclude that the financial accelerator mechanism strengthened the liquidity preference shock and affected the rest of the economy.

The model of Aoki et al. (2004) extends the model of Bernanke et al. (1999) to include investment in housing. In Aoki et al. (2004), producers of capital are replaced by homeowners, who undertake investment projects that result in the provision of residential services to households, as Figure 3 shows.

Homeowners face an external finance premium when searching for capital for their purchases of real estate. The motivation for this paper is based on the strong pro-cyclical nature of residential investment and house prices because residential investment costs depend on the structure of household wealth. Also, the demand for houses depends on the return on housing services provision and the expected marginal cost of financing. The model of Aoki et al. (2004) containing the financial accelerator mechanism is able to replicate the characteristics of the data (housing investment, housing prices, and consumption) and highlights the importance of the presence of an external finance premium to account for these properties.

The implications of including an external finance premium in the DSGE framework in order to match the data characteristics are generally based on the comparison of different models. Meier and Müller (2006) compare the model with a financial accelerator and the model with increasing capital adjustment costs. They focus on the monetary policy transmission mechanism, and so they primarily examine the responses to a monetary policy shock. They argue that both models are able to replicate the characteristics of the observed data on investment. As a result, the authors do not consider the external financing mechanism to be more important

Figure 3: Flow of Funds and Services in Model by Aoki et al. (2004)
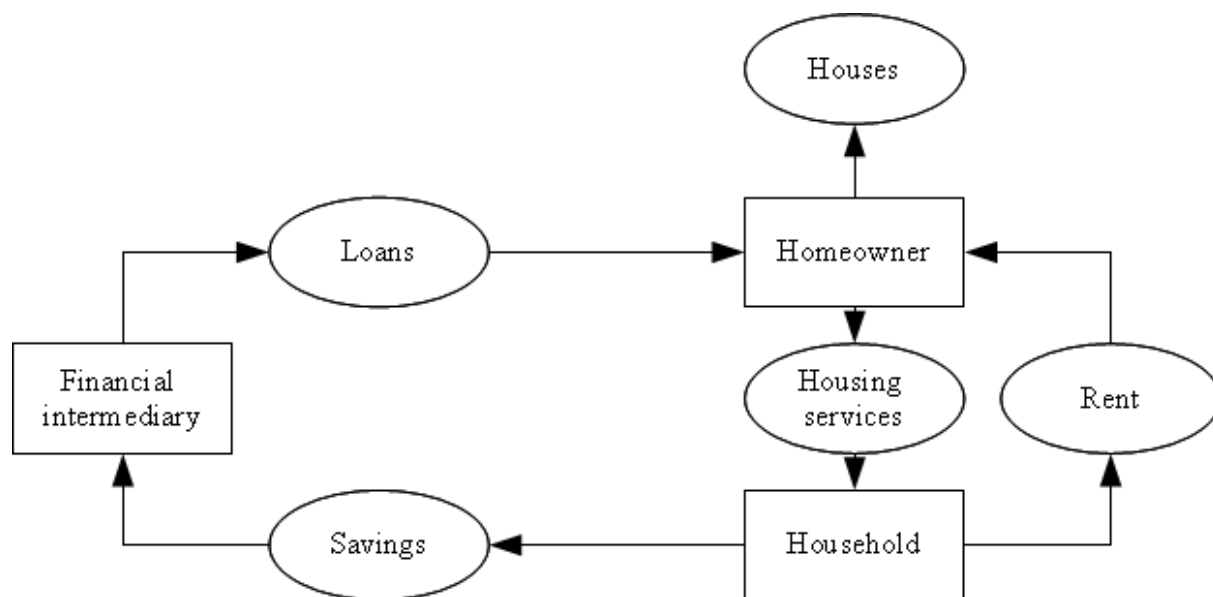
than the mechanism of costly investment for description of the properties of the transmission mechanism.

As most financial contracts are specified in nominal terms, Christiano et al. (2010) developed a financial accelerator model that allows producers to raise capital through nominal contracts.[1] By comparing the model with and without the financial accelerator mechanism they identified only very small differences resulting from the inclusion of the external financing premium. The responses to demand shocks in their model with the financial accelerator do not show significant differences to the model without the financial accelerator. The authors also identified only minor differences in the extent of fluctuations in real output and investment. Due to the use of nominal contracts, the authors attribute only minor importance to the financial accelerator mechanism in explaining the observed fluctuations in economic cycles as compared to the aforementioned studies.

Similarly as Christiano et al. (2010), Christensen and Dib (2008) extend the model of Bernanke et al. (1999) by two important features. First, the debt contracts in the extended model are written in terms of the nominal interest rate, which better reflects the nature of debt contracts in the United States and other developed economies. This adds the possibility of debt-deflation effects as mentioned in the literature on the Great Depression, e.g. Christiano et al. (2003). Second, Christensen and Dib (2008) employ a monetary policy characterized by a modified Taylor-type rule under which the monetary authority adjusts short-term nominal interest rates in response to inflation, output, and money-growth changes. This is important because the response of monetary policy is an important element determining the quantitative importance of the financial accelerator. As Bernanke et al. (1999) note, the greater the extent to which monetary policy is able to stabilize output, the smaller is the role of the financial accelerator in amplifying and propagating business cycles in output or investment (see also Fukunaga (2002) for an example).

---

[1] Christiano et al. (2007a) is an earlier version of Christiano et al. (2010)

Using the extended model, Christensen and Dib (2008) conclude that the inclusion of the financial accelerator mechanism leads to a better fit of the observed data properties (in terms of output and investment volatilities and the likelihood-ratio test). The authors estimate the parameters of the model with an external finance premium and show that this model of the U.S. economy has a better fit than the estimated model without an accelerator. Christensen and Dib (2008) note that the inclusion of the external financing premium allows the propagation of investment shocks to the rest of the economy. They also note a gain in the amplification of fluctuations caused by structural shocks. Moreover, Christensen and Dib (2008) focus on changes in the impulse responses to demand shocks, which show that introducing the financial accelerator greatly amplifies and propagates the effects of demand shocks on investment, while dampening those of supply shocks. Increased demand of households for consumption renders as a reduction in savings and increases the premium on external financing of capital formation. This increase in premium leads to restriction of the availability of capital required for the production of consumer goods for households. This restriction limits the response of producers to absorb the increased demand. However, in the presence of the financial accelerator mechanism the volatility of output and other real variables is marginal. This is partly due to the aggressive response of the monetary authority to output variations produced by the estimated policy rule when the financial accelerator is included. However, as the variance decomposition shows, the presence of the accelerator extends the horizon over which monetary policy shocks play a role in output fluctuations.

Generally, it can be concluded from the above summary of studies focusing on the external finance premium that its presence mostly improves the fit of the characteristics of the economic data. The significance of this financial rigidity in capturing the characteristics of business cycles is tested by placement in different models of general equilibrium. The comparison shows that the effect of the external financing premium is strongly dependent on the assumptions made about the type of financial contract, monetary policy, and the source of shocks. However, it can be concluded that models with a financial accelerator mechanism may better capture the degree and persistence of fluctuations observed in the data.

External finance premium models are not able to generate the asymmetric character of the observed fluctuations. These models also neglect the direct effect of expectations of future economic development at the current premium level because the premium is derived only from the current value of the net worth of capital producers. Due to this fact, models with a financial accelerator mechanism have only a limited ability to capture the increase in bankruptcy rates seen during economic bad times. This ensues from the micro-foundations of the models, as they assume a constant length of investment projects and a constant probability of project bankruptcy.

4.   Collateral Constraint

Models with an external financing premium do not contain limits on the availability of the external funds needed by the producer of capital. The only limiting factor is the price, which is increasing in the amount of external funding needed from the lender. An alternative approach to modeling the financial accelerator mechanism is to incorporate a limit on the amount of funds available. The limit applies to the layout of the debtor's balance sheet. The limitation arising from the balance sheet is motivated by the creditworthiness of the borrower. The availability and amount of the debtor's assets facilitates the provision of loans by means of the debtor's assets (collateral) used to secure the loans.

In models using a collateral constraint to impose limits on the availability of funding, in the event of bankruptcy of an investment project that is being implemented by a capital producer creditors may recover the debt only if the loans are fully secured. Loans are collateralized by the debtor's durable assets such as land, property, and long-term capital. These assets are transferred to the lender in the event of bankruptcy of the debtor's investment project. The nominal value of these durable assets determines the amount of the loan the borrower can get. In external finance premium models, the amount of the loan is constrained by the interest rate, which depends on the net worth of the debtor.

As mentioned in the previous section, external finance premium models are not able to capture the observed asymmetry of the fluctuations of business cycles. Collateralized debt is an appropriate limitation of the availability of funds which may help to replicate the observed asymmetry. The emergence of asymmetry in fluctuations is motivated by the following comparison of the firm's decisions in cases with and without access to external resources. A general assumption of this comparison is that the allocation of financial capital (deposits at the bank) and production facilities (machinery) is optimal. In the case of sub-optimal allocation, the financial capital will be used to purchase production facilities to optimize the allocation. Assume that the firm is not able to obtain external resources. Suppose that it unexpectedly receives a temporary upward shock to income. Due to the assumption of optimal allocation of production factors, the firm either consumes this additional revenue or increases its financial capital.

When the firm is hit by an adverse shock or by a reduction in its income, the response depends on the size of the shock. A small negative shock can be absorbed either by reducing the amount of financial capital or by reducing the consumption of resources, or by a combination of the two. In the case of a large negative shock, it may happen that the financial capital is depleted. The firm then has to adjust the scope of its activities by reducing the number of production facilities.

However, under the assumption of the possibility of obtaining external resources, after the firm has depleted its own resources it will prefer to search for external resources and the return to the original optimal allocation of resources will be gradual and long lasting. Because the firm is able to absorb small positive and negative shocks, while large negative shocks have real effects on the extent of its production, the limit on the availability of funding acts as an asymmetric propagator of shocks.

The models of debt securitization are based on original work by Hart and Moore (1994). They describe a model of a financial contract for raising external capital funds under the assumptions that the debtor cannot guarantee success and may not be able to fulfill the terms of the project. The possibility of repudiation of the contract or bankruptcy of the project leads to the existence of an upper limit on debt - a credit limit. The size of this limit depends on the value of the assets which the debtor can use to secure his loan.

4.1   Model by Kiyotaki and Moore (1997)

In their seminal work, Kiyotaki and Moore (1997) constructed a theoretical model in which firms use contracts with fully secured debt to obtain capital resources. This model shows how small-scale and temporary shocks to the productivity of firms can lead to significant fluctuations that spread throughout the economy. The assets of firms are not only used for the production of consumer goods, but also as collateral for raising capital. The source of the financial accelerator effect and propagation of technology shocks to the rest of the economy is the interaction of asset prices for debt securitization and credit limits.

In model by Kiyotaki and Moore (1997), households - farmers and gatherers - are characterized by different degrees of patience for consumption. Impatient farmers have a lower subjective discount factor that in equilibrium generates an incentive to borrow. Hence, the ex-ante heterogeneity induces credit flows between the impatient farmers and the patient gatherers. Also, firms differ by the presence of credit limits arising from the presence of debt collateralization. Firms own capital (land) that can be used either for production of goods or as collateral when searching for external funds. The rest of the model is a fairly standard model of real business cycles. Kiyotaki and Moore (1997) demonstrate that even small and short-term shocks to productivity or income distribution can cause prolonged changes in production, consumption, and prices of capital.

Figure 4: Shock Acceleration in Model by Kiyotaki and Moore (1997)
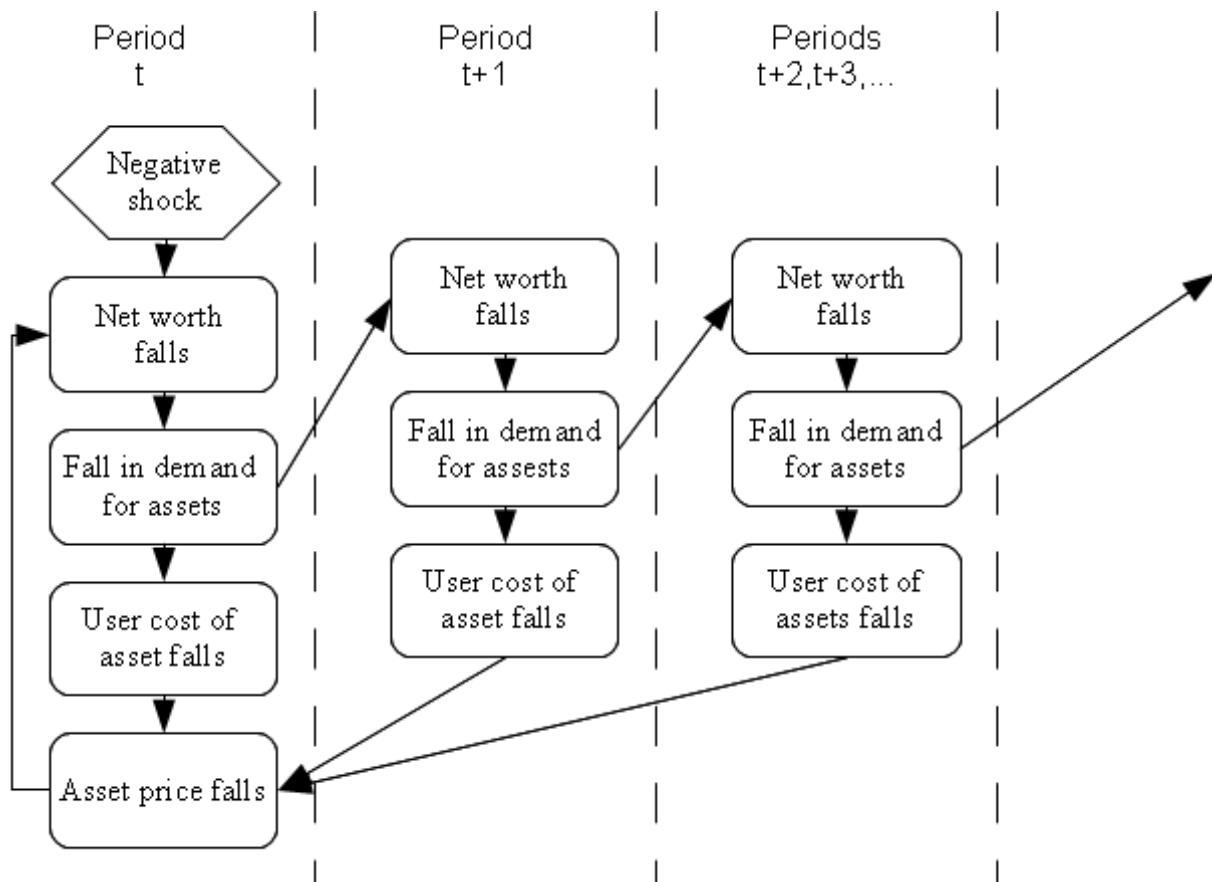
Figure 4 shows the effect of shocks as presented by Kiyotaki and Moore (1997) . A key mechanism in the amplification and propagation of shocks in the model with debt collateralization is changes in the value of collateral and their reflection in credit limits. A negative shock to the price of land used to secure debt leads to a decrease in the net worth of firms. Producers that become constrained by the credit limit are forced to reduce their demand for investment, including investment in land. The decline in demand for investment leads to a decrease in expected future output and income, thereby reducing expected demand in subsequent periods. The expected decline in demand for land by credit-constrained firms and the clearing of markets (to maintain equilibrium in the markets) forces credit-unconstrained firms to demand more land. This leads to a decrease in the opportunity cost of holding land, which gives rise to a fall in the price of land in the period of the shock. Due to the expected and actual decline in the land price, the

shock hurts the credit-constrained firms a second time and forces them to make deeper cuts in their investment in land.

Kocherlakota (2000) presents the motivation for including an asymmetric financial accelerator mechanism. He assumes that the land is owned by firms and serves as an alternative production factor to other means of production (machinery, manufacturing facilities). However, the land can be used as collateral for obtaining external resources. In the case of a large negative shock to demand, firms are forced to reduce the size of their manufacturing facilities. This leads to a reduction in the price of land because land and manufacturing facilities are alternative assets. This reduction in the size of operations leads to a reduction in the limit on the amount of external resources that a firm can obtain by use of collateralized loans. This model mechanism leads to further spread and amplification of the response to a negative shock to demand for the company's products.

Kiyotaki and Moore (1997) argue that the securitization of debt plays a significant role in amplifying the fluctuations of economic cycles. However, Kocherlakota (2000), using his theoretical models with secured debt, demonstrates that the mechanism of securing debt alone is not capable of delivering a strong financial accelerator effect (credit constraints do not generate enough amplification and asymmetry). He shows that the strength of the financial accelerator mechanism increases with an increasing share in the production function of factors whose alternative function is debt securitization.

Cordoba and Ripoll (2004) assess the assumptions made by Kiyotaki and Moore (1997) to demonstrate the significant role of contracts with debt collateralization in providing debt contracts as being too specific. Furthermore, Cordoba and Ripoll (2004) conclude that the financial accelerator effects in Kiyotaki and Moore (1997) are mainly due to constant returns to scale in the production of investment projects (linearity of the production function) and to the willingness of lenders to support a project of any size (risk neutrality of lenders). Under these assumptions, the amplification of fluctuations in real economic cycles can be generated by a small degree of smoothing and high utilization of assets to secure debt in the production function. Therefore, Cordoba and Ripoll (2004) opt to use more realistic assumptions (decreasing returns to scale, risk-averse players). Under these more realistic assumptions they demonstrate the insignificance of the financial accelerator effect for the amplification of responses. As their simulations indicate, large amplification can be obtained merely with the "right" combination of a low elasticity of intertemporal substitution, a large, but not too-close-to-one capital share, and a sizeable, but not too-close-to-one share of constrained agents. They conclude that unless one has this right combination of parameters, collateral constraints can generate amplification when compared with perfect-market models, but this amplification is small.

The original models of the external finance premium and the models with collateralized debt contracts rely on contracts in real terms rather than in nominal terms. Like Christiano et al. (2010), Iacoviello (2005) is motivated by the criticism of real contracts. Iacoviello (2005) constructed a model with nominal contracts and demand for real estate. In this model, the holding of real estate provides the benefit of housing to households and can be used to secure debt. The new model by Iacoviello (2005) is able to show an asymmetric response to shocks. In the case of a period of positive shocks (e.g. to productivity or net worth) and under the assumption of nominal contracts, the credit limit does not constrain the size of the loan. The author notes that his model is able to capture the observed positive correlation of aggregate demand and real estate prices. This supports the importance of the collateralized debt mechanism for the presence of a financial accelerator effect.

Iacoviello and Neri (2010) constructed a model to reflect the characteristics of fluctuations in household consumption. In this model, motivated by the recent developments in the U.S. economy, households use their homes to secure debt. As Figure 5 illustrates, the model features two sectors of production. The housing sector utilizes capital, land, and labor to provide housing services to households. Consumption goods and business capital are produced in the non-housing sector by utilization of labor and capital.

Figure 5: Model With Collateral Constraints Iacoviello and Neri (2010)
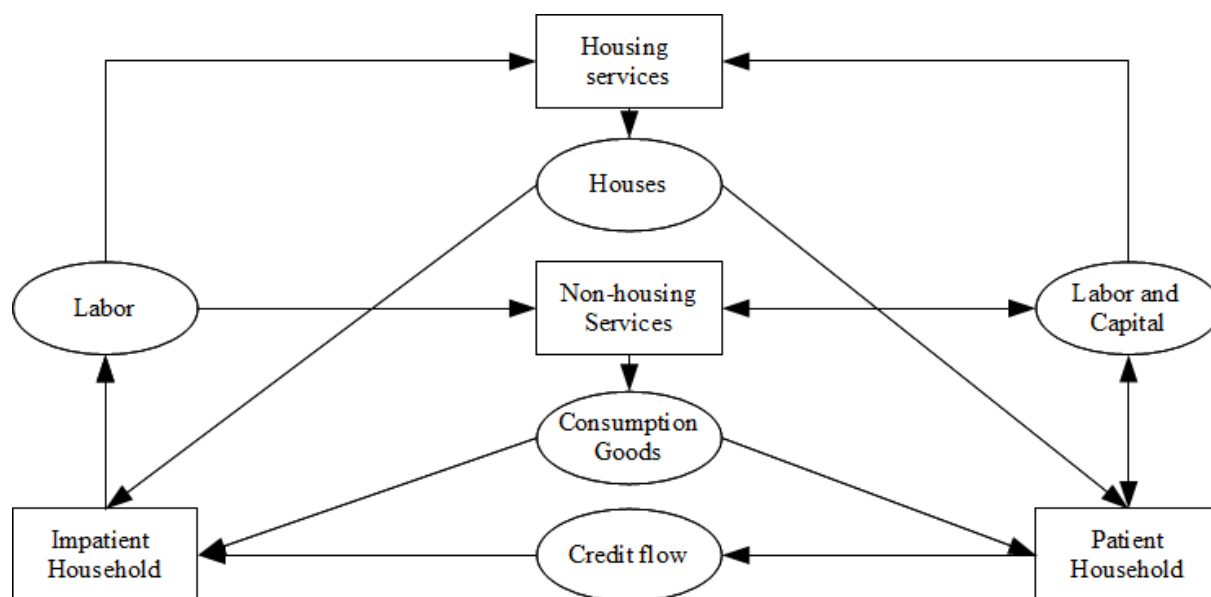
As an extension to Kiyotaki and Moore (1997), Iacoviello and Neri (2010) consider two types of households: patient (lender, farmer) households and impatient (borrower, gatherer) households. Patient households work, consume, accumulate housing, supply capital to firms, and supply funds to impatient households. Impatient households work, consume, and accumulate housing; they only accumulate the net worth required to finance the down payment on their home. Due to an inability to fully enforce repayments of debt, impatient agents have to use the housing stock as collateral. Also, the housing stock is considered as a separate argument of households' utility function, in addition to consumption and leisure.

This model is able to explain the trends in real housing prices and investment over the last four decades. The results support the importance of the mechanism of collateralized debt. Iacoviello and Neri (2010) use their model to show that the presence of collateral constraints amplifies the financial accelerator effect and propagates shocks from the housing market to the rest of the model economy. Negative price shocks in the housing market, via the collateral constraint, reduce the amount of household loans used to facilitate household consumption.

The relationship between house prices and household consumption allows the model to capture the extent of fluctuations in the growth of household consumption as observed in the data. An assessment of the variance decomposition shows that housing demand can explain 25%, housing supply 25%, and monetary factors approximately 15% of the volatility of housing investment and housing prices.

The finding of earlier studies that the impact of credit constraints is muted (e.g. Kocherlakota (2000) or Cordoba and Ripoll (2004)) motivates Liu et al. (2010) to re-examine the comovement of housing and investment. They consider the finding of earlier studies to be disappointing and indeed puzzling in light of the recent turmoil in the housing market and the concurrent deep recession. Persistent comovements between housing prices, land prices, and business investment can be found in the U.S. data.

Liu et al. (2010) use a model to demonstrate that the credit transmission mechanism introduced by Kiyotaki and Moore (1997) is empirically relevant. In this model, the household consumes a homogeneous good, housing services (land), and leisure, and supplies labor and loanable funds in competitive markets. The entrepreneur consumes and produces the homogeneous good. Production of the good requires labor, capital, and land as inputs. To finance consumption, production, and investment, the entrepreneur borrows loanable funds subject to a credit constraint. In particular, the borrowing capacity is constrained by a fraction of the present value of land and the accumulated capital stock. Thus, land and capital serve as both inputs for production and collateral for borrowing.

Liu et al. (2010) conclude that the previous literature finds muted impacts of credit constraints because it focuses on total factor productivity (TFP) shocks. A TFP shock does not have a large impact on asset prices because it moves future dividends and the risk-free interest rate in the same direction. Previous studies fail to obtain positive comovements between housing prices and business investment because they assume that a subset of households, instead of entrepreneurs (productive agents), are credit-constrained (Iacoviello and Neri (2010)). Allowing entrepreneurs to be credit-constrained is an essential feature of the model of Liu et al. (2010) for generating persistent comovements between the housing price and business investment. As the housing demand shock raises the land price, it also raises the entrepreneur's net worth and borrowing capacity, which provides an incentive for and enhances the ability of the entrepreneur to increase business investment. Through the dynamic interactions between the land price and investment made possible by credit constraints, a shock to housing demand is amplified and propagated to generate important macroeconomic fluctuations.

Also, as in the section on the credit channel, the models of collateralized debt can be extended to an open economy framework. The introduction of an external finance premium into the small open economy model can be used to describe the spread of financial distress among open economies. To analyze the impact of the current economic crisis, Brzoza-Brzezina and Makarski (2009) constructed an open economy model with a financial accelerator mechanism. The financial accelerator mechanism in their model of the Polish economy helps generate significant real and nominal effects. By use of the model the authors identified the financial shocks that hit Poland in the period between the end of 2008 and the beginning of 2009. Brzoza-Brzezina and Makarski (2009) argue that domestic financial shocks can explain about 1 percentage point of the decline in Polish real economic output. This analysis reveals the importance of foreign shocks, which explain up to 2.6 percentage points of the decline in output in the period from the third quarter of 2008 to the second quarter of 2009.

As in the case of the external finance premium, the quantitative significance of introducing a financial accelerator by means of collateralized debt is not straightforward. The amplification of the responses and the increase in their persistence are heavily dependent on the parametrization and assumptions of the models used. In collateralized debt models, the use of nominal contracts attenuates the effects of the financial accelerator mechanism in the case of supply shocks. As

in the external finance premium models, reinforcement of the accelerator mechanism can be achieved by increasing the share of collateral in the production function.

The extent of the financial accelerator mechanism's effects also depends on the origin of the shock that drives the fluctuations. It is possible to observe significant amplification of the responses to financial shocks, as these shocks affect the prices of the goods used to secure loans (such as real estate and durable goods). By contrast, usually only a weak financial accelerator effect can be observed for non-financial shocks, which can only slightly affect the amount of the credit limit and demand for collateral.

However, the collateralized debt models also do not include a description of the banking sector. There is no explicit role for the banking sector in these models. Creditors and debtors negotiate their financial contracts in the capital market without intermediaries. Therefore, in the next section, models that feature an explicit role for banks are presented.

5. Banking Sector

In the previous sections, two mainstream methods introducing financial rigidities into DSGE models were presented: the financial accelerator mechanism in the framework of Bernanke et al. (1999)) and models with collateralized debt based on the work of Kiyotaki and Moore (1997) and Iacoviello (2005).

The presented models of financial frictions were constructed without an explicit role for banks and thus the focus was primarily on the demand side of credit. The role of banks and other financial institutions was not specified, as financial contracts are arranged directly in the financial market under the known form of a contract for the acquisition of external funding. The main objective of the literature discussed in the previous sections is to capture the extent and persistence of fluctuations in aggregate output, whereas the literature introducing a banking sector into DSGE models has been motivated mainly by the aim of explaining specific features of the financial crisis. The papers presented in the previous section are often concerned with difficulties in explaining certain data features. The research on models with a banking sector examines questions related to the role of banks in the financial market. The goal is to explain banks' behavior.

The seminal models introducing a banking sector into the DSGE framework have focused on highlighting the necessity for monetary policy to account for differences between the interbank interest rate and other short rates, e.g. the government bond rate. The following research extends the framework by adding various financial frictions and agents in order to study the role of bank capital in business cycle fluctuations. The financial crisis has emphasized the importance of systematic risk and sudden changes in that risk. Thus, the studies below search for the foundations for the existence of risky portfolios. The liquidity crisis after the Lehman collapse triggered the development of models studying the function of the bank capital requirement in the process of loan creation. Last but not least, monetary policy actions have motivated studies of the Fed's unconventional policy instruments during the financial crisis.

The pioneering model introducing banks into the DSGE model is by Goodfriend and McCallum (2007). The model builds on the methodology of Bernanke et al. (1999). Goodfriend and McCallum (2007) develop a banking sector in order to describe the interaction and differences between various types of interest rates to determine how much the central bank is misled by

relying on a standard model without a banking sector. The credit and balance sheet channels are placed in the banking sector. The banking sector is set up similarly as a firm's optimization problem. Loan creation in the competitive banking firm sector is introduced by the production function and cash-in-advance assumption

Loan production depends on collateral and loan-monitoring costs. The authors use a standard Cobb-Douglas production function with two inputs: collateral and labor. Both government bonds and capital can be used as collateral. However, capital is inferior to bonds as collateral because the related monitoring costs of the true value of capital are higher than those for government bonds. Labor input is used to monitor loans supplied by homogeneous households. The importance of the cash-in-advance assumption lies in its attribute of relating consumption to deposits and introducing the medium-of-exchange property of money. To pay for consumption spending, the household has to hold given amount of deposits at the time of purchase. Therefore, the cash-in-advance assumption creates demand for deposits in the model.

The model by Goodfriend and McCallum (2007) includes various types of interest rates. The model uses as a reference rate the stochastic discount factor in the same form as can be found in the basic New Keynesian DSGE model (one period risk-free security). Government bonds serve as collateral. Due to this additional function, risk-free securities have to be more expensive (i.e. deliver a lower yield in equilibrium than the reference rate). The authors assume that capital has lower quality as collateral, hence it has to provide a higher yield in equilibrium to its holder than government bonds.

The no-arbitrage condition between the loan market and the asset market determines the interbank rate. The interbank rate, which is also the policy rate, is identical to the reference rate. The loan rate must account for the cost of loan monitoring and collateral costs, therefore it has to be higher than the interbank rate in order to avoid an arbitrage opportunity. On the perfectly competitive banking market deposits must pay the interbank rate. However, because banks are forced to hold reserves that do not bear interest, the deposit interest rate must be lower than the interbank rate. This competitive banking market setup creates two opposite external finance premium effects. The first is called the "banking attenuator" effect, which dampens the effect of monetary policy shocks. The second effect amplifies monetary policy actions, similarly as in Bernanke et al. (1999).

The spread between the reference rate and the loan rate is procyclical. This means that the banking sector attenuates a monetary policy shock because the external finance premium grows in booms and drops in recessions. The intuition for this lies in the formulation of the banking sector production function and in the cash-in-advance constraint faced by the household when purchasing consumption goods. This constraint forces the household to hold cash for goods purchases in advance and constitutes a need to hold deposits before buying consumption goods. An expansionary monetary shock drives consumption growth in the model economy. The higher consumption generates a proportional increase in the demand for bank deposits. Growing loans require more banking services to monitor the collateral value. Consequently, the concave character of the Cobb-Douglas production function implies that the monitoring costs grow faster than the amount of loans. The higher costs of lending given by the increased spread between the loan rate and the reference rate discourage demand for loans and further dampen consumption growth.

On the other hand, the "banking accelerator" effect arises from the fact that the monetary policy shock raises the opportunity cost of investment, therefore the marginal product of capital and

the price of capital have to increase. The higher price of capital increases the collateral value and hence implicitly decreases the monitoring costs. The increased demand for deposits is compensated by a lower marginal cost of loan production. Goodfriend and McCallum (2007) argue that for reasonable parameter values the "attenuator" effect is stronger and the external finance premium is procyclical.

The next important contribution to the literature comes from Cúrdia and Woodford (2009). They concentrate on similar questions as Goodfriend and McCallum (2007). The important novelty is given by the specific model framework. Cúrdia and Woodford (2009) develop a stylized model with a banking sector where the basic New-Keynesian model is its special case. They differ in their modeling approach by assuming heterogeneous households able to change their type. This implies that the credit spread is a function of the markup in the intermediary sector and the costs of the loan (monitoring and origination), both possibly exogenous or endogenous.

The modified model delivers an economy with financial intermediation realized between households rather than households and firms. Half of households are lenders and the other half borrowers. Borrowers have a higher marginal utility of consumption than lenders. As savers discount the future less than borrowers, the optimality conditions of the model contain two discount factors. Consequently, the model produces two different interest rates. The lower interest rate paid on deposits is equivalent to the policy rate. Adding the credit spread to the deposit rate (lower rate) one gets the rate charged by intermediaries for borrowing. The spread between the interest rate available to savers and the interest rate that borrowers pay for the loan is time varying, and in their paper Cúrdia and Woodford (2009) consider the spread to be determined by exogenous as well as endogenous factors. The endogeneity of the credit spread comes from the markup in the intermediary sector. This markup varies in response to the total volume of lending. Furthermore, the cost of loans has the character of intermediation technology as in Goodfriend and McCallum (2007), where labor input is needed to monitor collateral value and the other input is collateral itself.

In order to keep the model tractable, Cúrdia and Woodford (2009) come up with an elegant solution and introduce insurance against both the aggregate risk and the idiosyncratic risk associated with a change of household type. Without insurance, the distribution of the marginal utility of income would be too dispersed because of the histories of each individual type of household and the model would not have a stable solution. The fact that the change of household type is random, together with the insurance, enables the authors to perform aggregation and derive a stationary equilibrium. The heterogeneous agent approach allows the authors to abstract from the assumption that households need to hold deposits before purchasing goods.

The paper's main implication for monetary policy is that including the credit channel in the standard New-Keynesian (NK) model does not fundamentally alter optimal monetary policy. The response to a financial shock should be the same as that to the linear combination of shocks standard in New-Keynesian models. An interesting exception is the fiscal shock. In the basic NK model, Ricardian equivalence holds, while in the model with credit frictions changes in the path of government debt have significant effects on inflation, output, and interest rates. These effects arise from the assumption that government borrowing is not subject to credit frictions. Thus, even if government borrowing crowds out private borrowing one to one, the absence of credit frictions (production of public debt is cheaper) leads to higher output and a lower loan rate. In other words, investors lending to the government do not require collateral and do not pay for monitoring. Consequently, the growing volume of lending does not increase the time-varying spread between the deposit rate and the lending rate.

Cúrdia and Woodford (2009) also suggest an answer to recent suggestions for closer monitoring of changes in the volume of lending. In the presented model, the credit spread matters for monetary policy. The volume of bank credit is only one of the determinants of the credit spread. Hence, policy makers should focus their attention on the credit spread rather than the volume of lending. Nevertheless, Cúrdia and Woodford (2009) show that a monetary policy rule stabilizing aggregate credit does not have desirable properties.

The influence of work by Cúrdia and Woodford (2009) lies in the fact that they build on the broadly known baseline NK model and carefully discuss all its assumptions and its derivation. This allows the authors to convincingly assess the implications of the credit market and its imperfections in a standard NK framework. The introduction of financial intermediation through heterogeneous households comes with a cost in the form of omitting the direct effect of financial intermediation on production. In the real world, however, financial intermediation is triggered by a time delay in the production process when firms need to borrow in order to buy input. Frictions in financial intermediation have a direct impact on the consumption-leisure trade-off in the Cúrdia and Woodford (2009) model framework. The model does not capture the intermediation where saving households lend to investing firms. Obstacles in this process have a direct effect on production. Omitting this effect may give rise to false policy implications of the model. The credit spread is the main ingredient of the model's credit market. The spread is nevertheless exogenously put into the model. It is not derived from agents' behavior and is therefore subject to the Lucas critique. The next drawback of the way the spread is modeled is that it abstracts from the threat of default. Yet default is one of the main factors determining the spread between interest rates. From this point of view, the model adds very little to the Goodfriend and McCallum (2007) model.

Chronologically at about the same time as Cúrdia and Woodford (2009), Christiano et al. (2007b) ask if banking, and the financial sector in general, are quantitatively important for the business cycle and what the possible implications are for monetary policy. The character of the motivating question is therefore in line with the research encompassing models relying on agency problems and balance sheet frictions. Christiano et al. (2007b) extend the model of Bernanke et al. (1999) by introducing a financial sector. The banking sector is integrated into the model using the methodology of Chari et al. (1995) and estimated by Bayesian methods. The modeling approach to banking is in the spirit of Goodfriend and McCallum (2007) in the way liquidity is supplied. Instead of a loan production function, however, they use a deposit production function. Christiano et al. (2007b) argue that the Bernanke et al. (1999) type of financial frictions improves the data fit, but the banking sector plays a small role. The function of monetary policy in accommodating financial shocks is limited in their model.

To reflect issues associated with credit risk (pressure on a bank's capital positions and liquidity), further research using a banking sector in DSGE models integrates endogenous banking capital into the bank's balance sheet. Gerali et al. (2009) introduce a banking sector into the DSGE model to study the role of banking intermediation, and in particular the implication of tightening credit conditions and their transmission to the real economy. They merge the model of Christiano et al. (2007b) and Iacoviello (2005) and extend it to include an imperfectly competitive banking sector in both the deposit market and the loan market. This setup has important consequences for monetary policy because the central bank policy rate is not transmitted fully and instantaneously into households' and firms' decisions. The monopolistic power of banks over the loan and deposit rate changes the pass-through of the policy rate. Gerali et al. (2010) extend the model estimated by Bayesian method and provide a more thorough discussion of the policy implications.

Explanation of the stylized facts of the global financial crisis motivates Christiano et al. (2010) to further extend their earlier model (Christiano et al. (2007b)) in a way that can explain the main elements of the crisis. They find that liquidity constraints and changing risk perceptions are the main determinants of economic fluctuations. Financial frictions in the credit supply turning market risk into systemic risk contribute importantly to the model's empirical fit. The ability of the central bank to supply liquidity when the supply of credit in the banking sector is low has significant smoothing effects on the business cycle.

Another sub-class of models featuring a banking sector concentrates on analysis of the Fed's unconventional balance sheet operations in reaction to the consequences of the financial crisis. Gertler and Karadi (2011) use a model with an agency problem between intermediaries and their depositors to produce endogenous constraints on intermediary leverage ratios, as a drop in banks' capital has an impact on borrowing and lending. A specific feature of the model is that the central bank acts as an intermediary. The monetary authority can borrow funds from savers and then lend them to investors. The distinction from private banks lies in the fact that the central bank does not face constraints on its leverage ratio. The central bank borrows against collateral in the form of government bonds. By buying its own debt the central bank avoids agency problems. Gertler and Karadi (2011) show that especially when the policy rate hits its zero lower bound the net benefits of unconventional monetary policy are significant. This model is extended in Gertler and Kiyotaki (2010) by the introduction of an interbank market. The paper models the situation where banks are not willing to lend to one another. Banks face an idiosyncratic liquidity shock which creates a deficit or surplus of funds across financial institutions. Together with agency problems, the disruption to the inter-bank market affects real activity. These models are used to illustrate the fact that various credit market interventions may mitigate the negative effects of financial frictions at times of crisis.

The most recent contributions to the literature dealing with the banking sector in DSGE models go back to the roots of the financial crisis and search for the underlying rationality in building risky portfolios. The contribution of Gertler et al. (2011) focuses on explaining the motivations of banks to take excessive risks. Their aim in their very recent working paper is not just to match the banks' vulnerability to risk, but also to explain why banks tend to build risky balance sheets. The modeling framework builds on Gertler and Karadi (2011) and Gertler and Kiyotaki (2010). The endogenous choice of a risky balance sheet is incorporated by a trade-off between short-term debt and equity. The authors conclude that appropriately designed macroprudential policy can mitigate moral hazard costs. Incentives for risk taking reduce the benefits of credit policies stabilizing the financial markets.

The model by Dib (2010) stands out by offering a synthesis of much of what can be found in the studies discussed previously. Dib (2010) unifies many of the ingredients of previous research and adds an analysis of a bank's capital requirement condition and its effects on business cycle fluctuations. The economy is populated by workers and bankers maximizing their utility functions. The difference compared to the heterogeneous households in Cúrdia and Woodford (2009) is that the share of workers and bankers is fixed and they do not change their types. In addition, the utility function is derived from different variables in each group. Bankers are assumed to be owners of both saving and lending banks. The role of bankers is to create a link between changes in bank capital and changes in the real economy. This link allows the efficient market hypothesis to be rejected in the short run and highlights the default risk of the lending bank.

Dib (2010) assumes that two types of banks, saving and lending, operate in the heterogeneous intermediary sector. Saving banks collect deposits from workers. They maximize their profit in a monopolistic market by setting the nominal interest rate and the composition of their portfolio (solving a problem analogous to the one of firms). A certain share is invested in government bonds and the rest is used to lend on the interbank market. The lending bank may make use of injections of liquidity from the central bank, facilitating modeling of a quantitative monetary easing. The lending bank is also allowed to swap part of its loans for bonds in order to simulate a qualitative easing by the Fed. Moreover, banks can endogenously default (default is a control variable in the model) on fractions of their interbank borrowing and bank capital returns.

Model by Dib (2010) model meets the expectation relating to models featuring financial frictions and amplifies the propagation of supply-side shocks. As in Goodfriend and McCallum (2007), however, demand shocks in the model with an active banking sector have dampening effects on the propagation and transmission of shocks to real variables. Financial shocks affect real variables much less in the model with a banking sector than in models with an external finance premium and collateralized debt.

6. DSGE and Macro-prudential Analysis in the Czech National Bank

Though the financial crisis has led to an increase in interest in DSGE models featuring financial frictions and an endogenous financial sector, the models described in previous sections usually comprise purely academic research and their policy-making applications are relatively limited. This section summarizes some arguments discussed in connection with the practical use of such models both in monetary policy and in macroprudential policy.

6.1 Use of Financial Friction for Monetary Policy Purposes

As summarized in the previous sections, and as discussed within the central banking community, the potential gains arising from including financial frictions in central banks' prediction models can be large.[2] The extension of the models used by central banks to include financial frictions helps improve the fit of these models and our understanding of the historical development of economic indicators. Also, it can lead to improvements in the calibration of the relevant coefficients and elasticities. Extended models also strengthen prediction capability and thus improve the conduct of monetary policy. Capabilities are further improved by an understanding and quantification of the transmission mechanisms of monetary policy to the real economy. Extended models also support the development of supplementary types of analysis, as they can help identify fields of interest for central banks' analytical efforts.

Though many central banks have experimented with DSGE models with financial frictions (e.g. the central banks of Canada (Dib (2010) and Christensen et al. (2009)), the Czech Republic ([Brůha et al. (2011)), Italy (Angelini et al. (2011) and Gerali et al. (2010)), New Zealand (Hoskin et al. (2009)), Poland (Brzoza-Brzezina et al. (2011)), Sweden (model RAMSES; Christiano et al. (2007b)), the United Kingdom (Saporta (2009)), and the European Central Bank (NAWM model; Christiano et al. (2010) and Paries et al. (2010)) there is no unified approach that represents the "state of the art", in contrast to the use of "traditional" DSGE models, where the models are to some extent standardized (see Tovar (2009)). As 412-2011 discuss, this is due to the following reasons:

---

[2] Extensive discussions have been going on within the Macroprudential Research Network (MaRs) founded by the European Central Bank: http://www.ecb.int/home/html/researcher_mars.en.html

- The review of approaches to financial frictions in previous sections shows that there are numerous approaches and variations thereof. These approaches differ in the nature of the financial frictions and also in their transmission to the real economy. Even relatively small technical changes to the assumptions on financial frictions can give rise to diverse quantitative results.

- The models have to be focused on specific individual types of frictions to keep them operational. It is virtually impossible to model several types of financial frictions at once, as this would make such models very complex. Parameter estimation and calibration would be difficult, and it would also be challenging to interpret the results.

- Interaction between different types of financial frictions could lead to very complex implications - interacting frictions could amplify or suppress each other.

- Acceptance or rejection of the significance of financial frictions is complicated by the fact that episodes of financial sector turmoil are quite rare. This makes calibration and estimation of such models questionable. Also, the relevant data series are not available in sufficient length or quality (for example, for a discussion of the quality of housing prices for the Czech Republic see Hlaváček and Komárek (2009)) and so various proxies have to be used.

Given the above-mentioned uncertainties relating to the selection of the relevant type of financial frictions for the prediction model, the CNB's policy is to keep its benchmark G3 model unchanged (for a description of the model properties see Andrle et al. (2009)). CNB policy is to develop a set of several parallel satellite models using different types of financial frictions or less standard transmission mechanisms. There are several streams of model development going on in the CNB research program. Some of the project results have already been applied, as mentioned by Brůha et al. (2011):

- The stream of research developed mainly in the project of Polanský et al. (2009) aspires to incorporate the financial accelerator mechanism into a small open economy and takes into account stylized facts about the Czech financial sector. The models developed in this stream consider an alternative assumption of original "state contingent contracts" (Bernanke et al. (1999)) as well as an extension to "state non-contingent contracts" developed by Kumhof and Beneš (2011). The use of state non-contingent contracts significantly affects the dynamics of the model, as stated by Brůha et al. (2011).

  An alternative model in this stream of research uses similar assumptions to those presented by Christiano et al. (2007b). They demonstrate the incorporation of financial frictions into a small open economy and extend the standard DSGE model to include modeling of the labor market.

  A common feature of this stream is the use of the IRIS Toolbox, which is able to combine the linear and non-linear parts of the model. Also, the parameters of the models are set specifically for the Czech economy by use of Bayesian techniques.

- The stream of research developed in the project of Zděnek et al. (2010) aims to include housing markets in DSGE models. The models developed in this stream build mainly on the collateral constraints assumption as presented by Iacoviello and Neri (2010) and Christensen et al. (2009). These models are aimed at extending the CNB's G3 model. A major extension of the model is the inclusion of rental housing, used mainly by impatient households.

- There is also a stream of research that sets out to build DSGE models with a banking sector, as in Franta et al. (2009) and Derviz and Seidler (2010). This stream aims to develop a framework for examining the effects of macroprudential policies on the Czech financial and real sectors. These studies should facilitate discussion of the interactions of monetary, macroprudential, and microprudential policies.

6.2   Use of Models With Financial Frictions for Macroprudential Policy Purposes

While the use of DSGE models with financial frictions for monetary policy is relatively straightforward (matching the properties of macroeconomic fluctuations and understanding the full scope of monetary policy transmission channels), their use for macroprudential policy is much more demanding. Their complexity means that there are almost no practical applications of such models. Also, these applications are focused mainly on stylized evaluation of the effects of macroprudential instruments on macroeconomic performance (notable exceptions being Angelini et al. (2011), Gelain (2011) or Paries et al. (2010)).

This results from the setup, as the objectives of macroprudential policy are broader than those of traditional monetary policy and thus are still not fully settled (for a discussion of macroprudential policy issues see Frait and Komárková (2011)). Furthermore, restrictions on the use of DSGE models originate from the fact that macroprudential analysis often orients itself toward assessment of the vulnerability of a financial system to exceptional but plausible events, which are often related to non-equilibrium, divergent states of the financial system. These states cannot easily be modeled by standard equilibrium models, which are dependent on an appropriate definition of the steady state.

However, DSGE models are often used in practice for creating scenarios for the most commonly used tool of macroprudential analysis: stress testing (for a review of the use of stress testing in central banks see, for example, Čihák (2006)). This is especially true for central banks that use DSGE models for standard monetary policy analysis, such as the Czech National Bank.[3]

The use of DSGE models in the creation of stress-testing scenarios has advantages due to the following features of this process. The stress-testing scenarios always include a "baseline scenario", which is supposed to be the most likely scenario of future macroeconomic development. From the point of view of consistency of external communication in different central bank publications it is crucial to present the baseline scenario in line with the official central bank forecast. Also, compared to the various types of central bank prediction models (e.g., the previously used multi-equation Quarterly Projection Model (QPM) used in the CNB, which was also used for generating stress scenarios), DSGE prediction models introduce far more degrees of freedom in the creation of stress scenarios. DSGE models usually include many sources of volatility (shocks), allowing alternative trajectories to be modeled. Finally, DSGE models usually rely on calibrated parameters, which can be altered to the match the requirements of the stress scenario. This option can only be used in very specific cases.

This shows that stress scenarios based on DSGE models are much more flexible. However, the main advantage of using a DSGE model when creating stress-test scenarios is that it delivers model-consistent future paths of the relevant macroeconomic variables.

---

[3] For a description of the CNB's DSGE model used for supporting monetary policy decisions, see Andrle et al. (2009). For a description of the three generations of the stress-testing models used in the CNB see Čihák and Heřmánek (2005), Čihák et al. (2007) and Geršl and Seidler (2010).

The current banking sector stress-testing framework is illustrated in Figure 6 The DSGE model generates the scenarios (part I of the diagram) used in the initial assessment of market risks (interest rate and foreign exchange risks; see part II of the diagram). These are directly reflected in banking sector balance sheets (part IV of the diagram), which form the main "body" of the stress testing. The macroeconomic variables from the stress scenarios then enter numerous satellite models. These satellite models include credit risk models for both the household and corporate sectors (part III.1; for estimation of these models see Jakubík (2007)), credit growth models (part III.2), housing price models, which are reflected in the loss given default (LGD) for housing loans (part III.3; see Hlaváček and Komárek (2009)), and banking sector income models (part III.4, see Geršl and Seidler (2010)). The outcomes of the satellite models again enter the banking sector balance sheets and generate additional stress on banks.

The aforementioned individual satellite models often use different methodologies. The methodologies used range from simple ad-hoc approaches to banking sector income and LGD models to more sophisticated Merton-type models for credit risk estimation. In this framework it is also important for the individual satellite models to be interrelated, which causes other problems. [4] In addition to the impacts of different types of risks on banking sector balance sheets, the current stress-testing framework includes models of interbank contagion, which try to capture the role of interconnectedness within the banking sector (part V of Figure 6; see Čihák et al. (2007)) and also some feedback effects influencing the real economy (part VI of the diagram; see Geršl and Jakubík (2010)). In contrast to the stress-testing framework, which is quite detailed, especially in its banking sector balance sheet segment, the feedback effects to the real economy are quite stylized (they are based on feedback effects via the influence on bank lending and the development of investment activity) and are not included in every stress-testing exercise.[5]

The above discussion of the current use of DSGE scenarios in stress testing might also produce some guidelines on how extended versions of DSGE models featuring elements of the financial sector could help in creating more realistic stress-testing scenarios. Clearly the inclusion of the financial frictions described in sections 3 and 4 (i.e., in models without banking sector capital) would lead to a wider set of model/scenario-generated variables, which, in turn, could lead to better estimation of the satellite models (the selection of explanatory variables included in the satellite models is constrained by their existence in the model used in the generation of the stress scenarios). Moreover, in the second step the DSGE model extended to include financial frictions could widen the initial macroeconomic scenarios (part I of Figure 6) to encompass variables that are now being generated by the current satellite models (e.g. defaults, credit growth or housing price growth). Thus, such an "extended" macroeconomic scenario could under some circumstances integrate some of the current satellite models. This could have some positive features, as this approach could help to solve the above-mentioned problems with interrelation of the individual satellite models. Moreover, such an extended macroeconomic scenario could include some of the feedback effects between the real economy and financial variables that are not included in the current framework (e.g. the link between investment and loans to the private sector and others) and are not modeled in the current setup.

---

[4] This is depicted in Figure 6 by dotted arrows, e.g. the projected probability of default from the credit risk model influences the share of non-performing loans which enters the banking sector income model with a lag. One could also think about mutual interrelations between housing price growth and mortgage loan development and other mutual links.

[5] Though the results of the stress-testing exercise are published for the aggregate banking sector, this part includes the balance sheets of all individual banks.

Figure 6: Use of DSGE Models in Building Up Macroeconomic Scenarios for Stress Testing
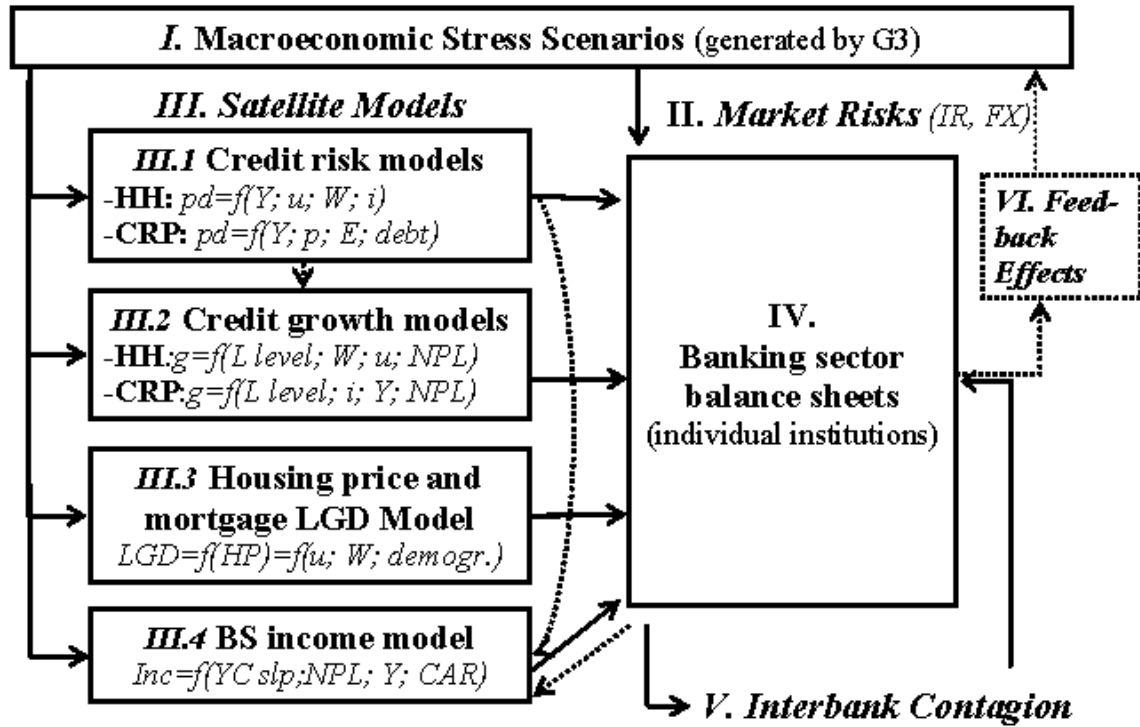
The "second generation" of DSGE models featuring a financial sector that already includes an explicit banking sector (section 5) could lead to a third step of integration of DSGE models into the stress-testing setup. In this case it could eventually replace the remaining satellite models (e.g. the banking sector income model III.4) and to some extent even the "core" of the stress testing, namely, the banking sector balance sheets (part IV of the diagram). This "cannibalization" of the stress testing would have the clear advantage of model-consistent modeling of feedback effects (part VI of Figure 6).

DSGE-based models could also help the current setup by prolonging its prediction horizon.[6] In fact, the current setup covers only one phase of the time dimension of systemic risk.[7] Within "boom and bust" cycles, stress testing covers only the "cleaning" or "resolution" phase, when the risk has already materialized. However, its ability to model the gradual build-up of risks in the "leaning phase" is substantially limited by this short horizon.

---

[6] The stress test currently uses a 2-year horizon, but it is being prepared for extension to the 3-year horizon.

[7] Systemic or macro-prudential risk is supposed to have two dimensions (see Frait and Komárková (2011)). One is the time dimension, which reflects the build-up of systemic risk over time and relates to endogenous boom and bust cycles and procyclicality in the behavior of financial institutions. Macroprudential policies should be different in the leaning and cleaning phases - firstly the prevention of systemic risk, and then, if prevention fails, mitigation of the impacts when risks materialize. The second, cross-sectional, dimension of systemic risk reflects the interrelationships between individual financial institutions at a given point in time via both their mutual and chained exposures (either direct exposures or similarity in investment). The time and cross-sectional dimensions to a large extent evolve jointly and so cannot be strictly separated.

As mentioned in previous sections, within these endogenous boom and bust cycles, DSGE models with a financial sector are able to fit the procyclicality of the financial system. This originates from their ability to capture the endogenous relation between the real economy and the financial sector and to better model the feedback effects.

However, the DSGE type of models will never replace stress testing, especially in its cross-sectional dimension. They are not able to include detailed information on the distribution of individual banks' characteristics, which is crucial in the assessment of the sustainability of the banking sector. Also, such models are not able to assess interbank contagion. DSGE models based on representative agents will not be able to cover the detailed structure of banking sector balance sheets as used in ad-hoc stress-testing exercises (e.g. the risk in a specific part of the corporate sector, such as the property development sector). Thus, traditional stress testing, though methodologically quite simple, will always have an advantage in terms of flexibility. Therefore, it is clear that DSGE models with a financial sector will complement rather than replace current stress-testing practice. It has to be mentioned that DSGE models with a financial sector have to be tailor-made for each country. In the case of the Czech Republic, this customization should reflect the surplus of liquidity in the banking sector. Also, it has take into account developments in the financial sector, especially fast growth of housing loans and foreign ownership of domestic banks. It also has to differentiate between types of loans, and at least between household and corporate sector loans. Contrary to other countries, it does not have to include foreign currency loans.

7. Conclusions

In this survey, mechanisms for including financial intermediaries and financial rigidities into general equilibrium models are described. The inclusion of these mechanisms is motivated by the observed property that even a small financial shock can cause a significant and long-term response. General equilibrium models can help identify the origin of shocks and are useful for the analysis of shock transmission between sectors of the economy. Also, these models are useful for various monetary policy experiments and predictions of shock impacts. Standardized versions of these models, however, expect the financial markets to function smoothly and provide external sources of capital without price distortions and without limits.

Financial frictions can be included by introducing an external financing premium due to the risk of a debtor defaulting on a financial contract for the provision of external resources. The premium originates from costly monitoring of the debtor.

Financial frictions can also be included by imposing restrictions on the amount of external sources that the debtor may obtain. This restriction is based on the need to collateralize the loan to cover inability to fulfill obligations under a financial contract.

Both of these approaches for including financial frictions lead to the emergence of a financial accelerator mechanism, whose presence leads to the amplification of shocks. This amplification can explain the observed volatility of aggregate economic output. However, these approaches do not specify a role for financial intermediaries. This survey also contains a description of approaches to specifying this role in financial markets. However, it is often found that the inclusion of financial intermediaries mutes the extent of the financial accelerator. Despite the rapid expansion of the use of general equilibrium models, these models are not yet able to capture all relevant features of the data - the degree and persistence of fluctuations. However,

an analysis by Tovar (2009) highlights the role of these models in the decisions of central banks. Describing the observed data properties is a challenge for these models and their users, who will face more complex models whose properties and responses are difficult to manage, analyze, and communicate.

The use of the financial frictions DSGE model in practical monetary policy is currently limited by the absence of a unified approach representing the "state of the art". The absence of a standardized approach originates from the large number of approaches to the implementation of financial frictions. Moreover, to deliver operational models with operational financial frictions, it is difficult to model several types of frictions at the same time. The estimation/calibration of such models is complicated by the low frequency of episodes of financial stress. Because of these uncertainties, the policy of the CNB is to develop several alternative satellite models which complement the core prediction model. This development currently covers several types of models with a financial accelerator extended to include non-state-contingent contracts. It also covers models with collateral constraints linked to housing prices, which are extended to include substitution between rented and owner-occupied housing. Moreover, streams of development are focusing on models with an explicit role for banks and their capital.

The use of DSGE models with financial frictions in macroprudential policy is even less straight-forward than their use in monetary policy. This is due to the broader setup and objectives of macroprudential policy, which are not settled yet. DSGE models with financial frictions can be used to create scenarios for existing macroprudential analysis tools and stress testing. The introduction of DSGE models with financial frictions may help to improve estimation of the satellite stress-testing models and eventually absorb some of the satellite models. DSGE models featuring an explicit role for the banking sector can help improve modeling of feedback effects between the real economy and financial variables. DSGE models can be helpful for extending the forecast horizon in the current forecasting framework. Within "boom and bust" cycles this could improve modeling of the gradual build-up of risks during the "leaning phase" of the financial cycle.

Finally, DSGE models with financial frictions should deliver new insights into the time dimension of systemic risk and cast more light on financial sector procyclicality. However, the current state of DSGE modeling does not provide enough evidence that this type of model will be able to replace stress testing, especially in its cross-sectional dimension.

References

ACEMOGLU, D. AND SCOTT, A. (1997): "Asymmetric Business Cycles: Theory and Time-series Evidence." *Journal of Monetary Economics,* 40(3):501–533.

AKERLOF, G. A. (1970): "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *The Quarterly Journal of Economics,* 84(3):488–500.

ANDRLE, M., HLEDIK, T., KAMENIK, O., AND VLČEK, J. (2009): "Implementing the New Structural Model of the Czech National Bank." Working Papers 2009/2, Czech National Bank, Research Department

ANGELINI, P., NERI, S., AND PANETTA, F. (2011): "Monetary and Macroprudential Policies." Temi di discussione (Economic Working Papers) 801, Bank of Italy, Economic Research Department

AOKI, K., PROUDMAN, J., AND VLIEGHE, G. (2004): "House Prices, Consumption, and Monetary policy: A Financial Accelerator Approach." *Journal of Financial Intermediation,* 13(4):414–435.

BANERJEE, A. V. (2002): *Contracting Constraints, Credit Markets and Economic Development.* In Dewatripoint, M., Hansen, L., and Turnovsky, S., editors, *Advances in Economics and Econometrics: Theory and Applications,* volume 3 of, chapter 1, pages 1–46. Cambridge University Press.

BENK, S., GILLMAN, M., AND KEJAK, M. (2005): "Credit Shocks in the Financial Deregulatory Era: Not the Usual Suspects." *Review of Economic Dynamics,* 8(3):668–687.

BERNANKE, B. AND GERTLER, M. (1989): "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review,* 79(1):14–31.

BERNANKE, B. S. (1993): "Credit in the Macroeconomy." *Quarterly Review,* (Spr):50–70.

BERNANKE, B. S. AND GERTLER, M. (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *The Journal of Economic Perspectives,* 9(4):27–48.

BERNANKE, B. S., GERTLER, M., AND GILCHRIST, S. (1999): *The Financial Accelerator in a Quantitative Business Cycle Framework.* In Taylor, J. B. and Woodford, M., editors, *Handbook of Macroeconomics,* volume 1 of *Handbook of Macroeconomics,* chapter 21, pages 1341–1393. Elsevier.

BESLEY, T. J., MEADS, N., AND SURICO, P. (2008): "Household External Finance and Consumption." CEPR Discussion Papers 6934, CEPR Discussion Papers

BRŮHA, J., HLÉDIK, T., POLANSKÝ, J., RYŠÁNEK, J., TONNER, J., AND VLČEK, J. (2011): "Role finančních frikcí v MP rozhodování (The Role of Financial Frictions in Monetary Policy Decision Making)." Internal CNB document.

BRZOZA-BRZEZINA, M. AND MAKARSKI, K. (2009): "Credit Crunch in a Small Open Economy." MPRA Paper 18595, University Library of Munich, Germany

BRZOZA-BRZEZINA, M., KOLASA, M., AND MAKARSKI, K. (2011): "The Anatomy of Standard DSGE Models with Financial Frictions." National Bank of Poland Working Papers 80, National Bank of Poland, Economic Institute

CARLSTROM, C. T. AND FUERST, T. S. (1997): "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis." *American Economic Review,* 87(5):893–910.

CHARI, V. V., CHRISTIANO, L. J., AND EICHENBAUM, M. (1995): "Inside Money, Outside Money and Short Term Interest Rates." NBER Working Papers 5269, National Bureau of Economic Research, Inc

CHRISTENSEN, I. AND DIB, A. (2008): "The Financial Accelerator in an Estimated New Keynesian Model." *Review of Economic Dynamics,* 11(1):155–178.

CHRISTENSEN, I., CORRIGAN, P., MENDICINO, C., AND NISHIYAMA, S.-I. (2009): "Consumption, Housing Collateral, and the Canadian Business Cycle." Working Papers 09-26, Bank of Canada

CHRISTIANO, L., MOTTO, R., AND ROSTAGNO, M. (2010): "Financial Factors in Economic Fluctuations." Working Paper Series 1192, European Central Bank

CHRISTIANO, L. J., MOTTO, R., AND ROSTAGNO, M. (2003): "The Great Depression and the Friedman-Schwartz Hypothesis." *Journal of Money, Credit, and Banking,* 35(6): 1119–1197.

CHRISTIANO, L. J., EICHENBAUM, M., AND VIGFUSSON, R. (2006): "Assessing Structural VARs." International Finance Discussion Papers 866, Board of Governors of the Federal Reserve System (U.S.)

CHRISTIANO, L. J., MOTTO, R., AND ROSTAGNO, M. (2007): "Financial Factors In Business." In *The Implications of Changes in Banking and Financing for the Monetary Policy Transmission Mechanism,* in European Central Bank Conference. ECB.

CHRISTIANO, L. J., TRABANDT, M., AND WALENTIN, K. (2007): "Introducing Financial Frictions and Unemployment into a Small Open Economy Model." Working Paper Series 214, Sveriges Riksbank (Central Bank of Sweden)

ČIHÁK, M. (2006): "How Do Central Banks Write on Financial Stability?" IMF Working Papers 06/163, International Monetary Fund

ČIHÁK, M. AND HEŘMÁNEK, J. (2005): "Stress Testing the Czech Banking System: Where Are We? Where Are We Going?" Research and Policy Notes 2005/02, Czech National Bank, Research Department

ČIHÁK, M., HEŘMÁNEK, J., AND HLAVÁČEK, M. (2007): "New Approaches to Stress Testing the Czech Banking Sector (in English)." *Czech Journal of Economics and Finance (Finance a úver),* 57(1-2):41–59.

COCHRANE, J. H. (1994): "Shocks." *Carnegie-Rochester Conference Series on Public Policy,* 41:295–364.

CORDOBA, J.-C. AND RIPOLL, M. (2004): "Credit Cycles Redux." *International Economic Review,* 45(4):1011–1046.

CÚRDIA, V. AND WOODFORD, M. (2009): "Credit Frictions and Optimal Monetary Policy." BIS Working Papers 278, Bank for International Settlements

DE GRAEVE, F. (2008): "The External Finance Premium and the Macroeconomy: US Post-WWII Evidence." *Journal of Economic Dynamics and Control,* 32(11):3415–3440.

DERVIZ, A. AND SEIDLER, J. (2010): "Macroprudential Policies in Small Open Economies: Specifics, Effectiveness, Limits." CNB research project B3/11, Czech National Bank

DIAMOND, P. A. (1965): "National Debt in a Neoclassical Growth Model." *The American Economic Review,* 55(5):1126–1150.

DIB, A. (2010): "Banks, Credit Market Frictions, and Business Cycles." Working Papers 10-24, Bank of Canada

FALK, B. (1986): "Further Evidence on the Asymmetric Behavior of Economic Time Series over the Business Cycle." *The Journal of Political Economy,* 94(5):1096–1109.

FRAIT, J. AND KOMÁRKOVÁ, Z. (2011): *Financial Stability, Systemic Risk and Macroprudential Policy.* In *CNB Financial Stability Report 2010/2011*Occasional Publications - Chapters in Edited Volumes, *chapter 0,* pages 96–111. Czech National Bank, Research Department.

FRANTA, M., BENEŠ, J., AND HLAVÁČEK, M. (2009): "Developing the Czech National Bank's Integrated Monetary and Macro-Prudential Policy Framework." CNB research project B1/11, Czech National Bank

FREIXAS, X. AND ROCHET, J.-C. (2008): *Microeconomics of Banking.* The MIT Press, 2nd edition.

FUKUNAGA, I. (2002): "Financial Accelerator Effects and Japan's Business Cycle." Working Paper 6, Bank of Japan

GELAIN, P. (2011): "Macro-Prudential Policies in a DSGE Model With Financial Frictions.", in 7th Dynare Conference, Atlanta, USA.

GERALI, A., NERI, S., SESSA, L., AND SIGNORETTI, F. M. (2009): "Credit and Banking in a DSGE Model." In Laxton, D. and Leon, L., editors, *Macro-Linkages, Oil Prices and Deflation Workshop.* IMF, IMF.

GERALI, A., NERI, S., SESSA, L., AND SIGNORETTI, F. M. (2010): "Credit and Banking in a DSGE model of the Euro Area." Temi di discussione (Economic Working Papers) 740, Bank of Italy, Economic Research Department

GERŠL, A. AND JAKUBÍK, P. (2010): *Procyclicality of the Financial System and Simulation of the Feedback Effect.* In *CNB Financial Stability Report 2009/2010*Occasional Publications - Chapters in Edited Volumes, *chapter 0,* pages 110–119. Czech National Bank, Research Department.

GERŠL, A. AND SEIDLER, J. (2010): *Stress Test Verification as Part of an Advanced Stress-Testing Framework.* In *CNB Financial Stability Report 2009/2010*Occasional Publications - Chapters in Edited Volumes, *chapter 0,* pages 92–101. Czech National Bank, Research Department.

GERTLER, M. (1988): "Financial Structure and Aggregate Economic Activity: An Overview." *Journal of Money, Credit and Banking,* 20(3):559–88.

GERTLER, M. AND KARADI, P. (2011): "A Model Of Unconventional Monetary Policy." *Journal of Monetary Economics,* 58(1):17–34.

GERTLER, M. AND KIYOTAKI, N. (2010): *Financial Intermediation and Credit Policy in Business Cycle Analysis.* In Friedman, B. M. and Woodford, M., editors, *Handbook of Monetary Economics,* volume 3 of *Handbook of Monetary Economics,* chapter 11, pages 547–599. Elsevier.

GERTLER, M., KIYOTAKI, N., AND QUERALTO, A. (2011): "Financial Crises, Bank Risk Exposure and Government Financial Policy." Technical report 740, N.Y.U. and Princeton

GOMES, J. F., YARON, A., AND ZHANG, L. (2003): "Asset Prices and Business Cycles with Costly External Finance." *Review of Economic Dynamics,* 6(4):767–788.

GOODFRIEND, M. AND MCCALLUM, B. T. (2007): "Banking and Interest Rates in Monetary Policy Analysis: A Quantitative Exploration." *Journal of Monetary Economics,* 54(5): 1480–1507.

HART, O. AND MOORE, J. (1994): "A Theory of Debt Based on the Inalienability of Human Capital." *The Quarterly Journal of Economics,* 109(4):841–879.

HLAVÁČEK, M. AND KOMÁREK, L. (2009): "Housing Price Bubbles and their Determinants in the Czech Republic and its Regions." Working Papers 2009/12, Czech National Bank, Research Department

HOSKIN, K., NIELD, I., AND RICHARDSON, J. (2009): "The Reserve Bank's New Liquidity Policy for Banks." *Reserve Bank of New Zealand Bulletin,* 72:5–18.

IACOVIELLO, M. (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review,* 95(3):739–764.

IACOVIELLO, M. AND NERI, S. (2010): "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics,* 2(2):125–64.

JAKUBÍK, P. (2007): "Credit Risk and Stress Testing of the Banking Sector in the Czech Republic." *Czech Journal of Economics and Finance (Finance a úver),* 57(1–2):60–78.

JERMANN, U. AND QUADRINI, V. (2009): "Macroeconomic Effects of Financial Shocks." NBER Working Papers 15338, National Bureau of Economic Research, Inc

KIYOTAKI, N. AND MOORE, J. (1997): "Credit Cycles." *Journal of Political Economy,* 105 (2):211–48.

KOCHERLAKOTA, N. R. (2000): "Creating Business Cycles Through Credit Constraints." *Quarterly Review,* (Sum):2–10.

KUMHOF, M. AND BENEŠ, J. (2011): "Risky Bank Lending and Optimal Capital Adequacy Regulation." IMF Working Papers 11/130, International Monetary Fund

LIU, Z., WANG, P., AND ZHA, T. (2010): "Do Credit Constraints Amplify Macroeconomic Fluctuations?" Working Paper 2010-01, Federal Reserve Bank of Atlanta

MEIER, A. AND MÜLLER, G. J. (2006): "Fleshing Out the Monetary Transmission Mechanism - Output Composition and the Role of Financial Frictions." *Journal of Money, Credit and Banking,* 38(8):2099–2134.

MODIGLIANI, F. AND MILLER, M. H. (1958): "The Cost of Capital, Corporation Finance and the Theory of Investment." *The American Economic Review,* 48(3):261–297.

PARIES, M. D., SORENSEN, C. K., AND PALENZUELA, D. R. (2010): "acroeconomic Propagation Under Different Regulatory Regimes: Evidence from an Estimated DSGE Model for the Euro Area." Working Paper Series 1251, European Central Bank

POLANSKÝ, J., TONNER, J., VAŠÍČEK, O., AND RYŠÁNEK, J. (2009): "Developing a Small Open DSGE Model with a Financial Sector." CNB research project B2/10, Czech National Bank

REICHLIN, P. (2004): *Credit, Intermediation, and the Macroeconomy: Models and Perspectives,* chapter Credit markets, Intermediation and the Macroeconomy. Oxford University Press, USA.

RESEARCH TASK FORCE WORKING GROUP ON THE TRANSMISSION CHANNELS BETWEEN THE FINANCIAL AND REAL SECTORS OF THE BASEL COMMITTEE ON BANKING SUPERVISION (2011): "The Transmission Channels Between the Financial and Real sectors: A Critical Survey of the Literature." Working Paper 18, Bank for International Settlements

SAPORTA, V. (2009): "The Role of Macroprudential Policy." Discussion Paper, Bank of England

SUMMERS, L. H. (1986): "Some Skeptical Observations on Real Business Cycle Theory." *Quarterly Review,* (Fall):23–27.

TOVAR, C. E. (2009): "DSGE Models and Central Banks." *Economics – The Open-Access, Open-Assessment E-Journal,* 3(16):1–31.

TOWNSEND, R. (1979): "Optimal Contracts and Competitive Markets with Costly State Verification." Staff Report 45, Federal Reserve Bank of Minneapolis

ZDĚNEK, M., MOLNÁR, P., HLOUŠEK, M., AND TONNER, J. (2010): "DSGE Model with Housing Market." CNB research project B5/11, Czech National Bank

13/2011	Michal Franta Roman Horváth Marek Rusnák	*Evaluating changes in the monetary transmission mechanism in the Czech Republic*
12/2011	Jakub Ryšánek Jaromír Tonner Osvald Vašíček	*Monetary policy implications of financial frictions in the Czech Republic*
11/2011	Zlatuše Komárková Adam Geršl Luboš Komárek	*Models for stress testing Czech banks´ liquidity risk*
10/2011	Michal Franta Jozef Baruník Roman Horváth Kateřina Šmídková	*Are Bayesian fan charts useful for central banks?* *Uncertainty, forecasting, and financial stability stress tests*
9/2011	Kamil Galuščák Lubomír Lízal	*The impact of capital measurement error correction on firm-level production function estimation*
8/2011	Jan Babecký Tomáš Havránek Jakub Matějů Marek Rusnák Kateřina Šmídková Bořek Vašíček	*Early warning indicators of economic crises:* *Evidence from a panel of 40 developed countries*
7/2011	Tomáš Havránek Zuzana Iršová	*Determinants of horizontal spillovers from FDI: Evidence from a large meta-analysis*
6/2011	Roman Horváth Jakub Matějů	*How are inflation targets set?*
5/2011	Bořek Vašíček	*Is monetary policy in the new EU member states asymmetric?*
4/2011	Alexis Derviz	*Financial frictions, bubbles, and macroprudential policies*
3/2011	Jaromír Baxa Roman Horváth Bořek Vašíček	*Time-varying monetary-policy rules and financial stress:* *Does financial instability matter for monetary policy?*
2/2011	Marek Rusnák Tomáš Havránek Roman Horváth	*How to solve the price puzzle? A meta-analysis*
1/2011	Jan Babecký Aleš Bulíř Kateřina Šmídková	*Sustainable real exchange rates in the new EU member states:* *What did the Great Recession change?*
15/2010	Ke Pang Pierre L. Siklos	*Financial frictions and credit spreads*
14/2010	Filip Novotný Marie Raková	*Assessment of consensus forecasts accuracy: The Czech National Bank perspective*
13/2010	Jan Filáček Branislav Saxa	*Central bank forecasts as a coordination device*
12/2010	Kateřina Arnoštová David Havrlant Luboš Růžička Peter Tóth	*Short-term forecasting of Czech quarterly GDP using monthly indicators*
11/2010	Roman Horváth Kateřina Šmídková	*Central banks´ voting records and future policy*

	Jan Zápal	
10/2010	Alena Bičáková Zuzana Prelcová Renata Pašaličová	*Who borrows and who may not repay?*
9/2010	Luboš Komárek Jan Babecký Zlatuše Komárková	*Financial integration at times of financial instability*
8/2010	Kamil Dybczak Peter Tóth David Voňka	*Effects of price shocks to consumer demand. Estimating the QUAIDS demand system on Czech Household Budget Survey data*
7/2010	Jan Babecký Philip Du Caju Theodora Kosma Martina Lawless Julián Messina Tairi Rõõm	*The margins of labour cost adjustment: Survey evidence from European Firms*
6/2010	Tomáš Havránek Roman Horváth Jakub Matějů	*Do financial variables help predict macroeconomic environment? The case of the Czech Republic*
5/2010	Roman Horváth Luboš Komárek Filip Rozsypal	*Does money help predict inflation? An empirical assessment for Central Europe*
4/2010	Oxana Babecká Kucharčuková Jan Babecký Martin Raiser	*A Gravity approach to modelling international trade in South-Eastern Europe and the Commonwealth of Independent States: The role of geography, policy and institutions*
3/2010	Tomáš Havránek Zuzana Iršová	*Which foreigners are worth wooing? A Meta-analysis of vertical spillovers from FDI*
2/2010	Jaromír Baxa Roman Horváth Bořek Vašíček	*How does monetary policy change? Evidence on inflation targeting countries*
1/2010	Adam Geršl Petr Jakubík	*Relationship lending in the Czech Republic*
15/2009	David N. DeJong Roman Liesenfeld Guilherme V. Moura Jean-Francois Richard Hariharan Dharmarajan	*Efficient likelihood evaluation of state-space representations*
14/2009	Charles W. Calomiris	*Banking crises and the rules of the game*
13/2009	Jakub Seidler Petr Jakubík	*The Merton approach to estimating loss given default: Application to the Czech Republic*
12/2009	Michal Hlaváček Luboš Komárek	*Housing price bubbles and their determinants in the Czech Republic and its regions*
11/2009	Kamil Dybczak Kamil Galuščák	*Changes in the Czech wage structure: Does immigration matter?*
10/2009	Jiří Böhm Petr Král Branislav Saxa	*Percepion is always right: The CNB´s monetary policy in the media*
9/2009	Alexis Derviz	*Funding costs and loan pricing by multinational bank affiliates*

	Marie Raková	
8/2009	Roman Horváth Anca Maria Podpiera	*Heterogeneity in bank pricing policies: The Czech evidence*
7/2009	David Kocourek Filip Pertold	*The impact of early retirement incentives on labour market participation: Evidence from a parametric change in the Czech Republic*
6/2009	Nauro F. Campos Roman Horváth	*Reform redux: Measurement, determinants and reversals*
5/2009	Kamil Galuščák Mary Keeney Daphne Nicolitsas Frank Smets Pawel Strzelecki Matija Vodopivec	*The determination of wages of newly hired employees: Survey evidence on internal versus external factors*
4/2009	Jan Babecký Philip Du Caju Theodora Kosma Martina Lawless Julián Messina Tairi Rõõm	*Downward nominal and real wage rigidity: Survey evidence from European firms*
3/2009	Jiri Podpiera Laurent Weill	*Measuring excessive risk-taking in banking*
2/2009	Michal Andrle Tibor Hlédik Ondra Kameník Jan Vlček	*Implementing the new structural model of the Czech National Bank*
1/2009	Kamil Dybczak Jan Babecký	*The impact of population ageing on the Czech economy*
14/2008	Gabriel Fagan Vitor Gaspar	*Macroeconomic adjustment to monetary union*
13/2008	Giuseppe Bertola Anna Lo Prete	*Openness, financial markets, and policies: Cross-country and dynamic patterns*
12/2008	Jan Babecký Kamil Dybczak Kamil Galuščák	*Survey on wage and price formation of Czech firms*
11/2008	Dana Hájková	*The measurement of capital services in the Czech Republic*
10/2008	Michal Franta	*Time aggregation bias in discrete time models of aggregate duration data*
9/2008	Petr Jakubík Christian Schmieder	*Stress testing credit risk: Is the Czech Republic different from Germany?*
8/2008	Sofia Bauducco Aleš Bulíř Martin Čihák	*Monetary policy rules with financial instability*
7/2008	Jan Brůha Jiří Podpiera	*The origins of global imbalances*
6/2008	Jiří Podpiera Marie Raková	*The price effects of an emerging retail market*
5/2008	Kamil Dybczak David Voňka	*The effect of oil price shocks on the Czech economy*

	Nico van der Windt	
4/2008	Magdalena M. Borys Roman Horváth	*The effects of monetary policy in the Czech Republic:* *An empirical study*
3/2008	Martin Cincibuch Tomáš Holub Jaromír Hurník	*Central bank losses and economic convergence*
2/2008	Jiří Podpiera	*Policy rate decisions and unbiased parameter estimation in* *conventionally estimated monetary policy rules*
1/2008	Balázs Égert Doubravko Mihaljek	*Determinants of house prices in Central and Eastern Europe*
17/2007	Pedro Portugal	*U.S. unemployment duration: Has long become longer or short* *become shorter?*
16/2007	Yuliya Rychalovská	*Welfare-based optimal monetary policy in a two-sector small open* *economy*
15/2007	Juraj Antal František Brázdik	*The effects of anticipated future change in the monetary policy* *regime*
14/2007	Aleš Bulíř Kateřina Šmídková Viktor Kotlán David Navrátil	*Inflation targeting and communication: Should the public read* *inflation reports or tea leaves?*
13/2007	Martin Cinncibuch Martina Horníková	*Measuring the financial markets' perception of EMU enlargement:* *The role of ambiguity aversion*
12/2007	Oxana Babetskaia- Kukharchuk	*Transmission of exchange rate shocks into domestic inflation: The* *case of the Czech Republic*
11/2007	Jan Filáček	*Why and how to assess inflation target fulfilment*
10/2007	Michal Franta Branislav Saxa Kateřina Šmídková	*Inflation persistence in new EU member states: Is it different than* *in the Euro area members?*
9/2007	Kamil Galuščák Jan Pavel	*Unemployment and inactivity traps in the Czech Republic:* *Incentive effects of policies*
8/2007	Adam Geršl Ieva Rubene Tina Zumer	*Foreign direct investment and productivity spillovers:* *Updated evidence from Central and Eastern Europe*
7/2007	Ian Babetskii Luboš Komárek Zlatuše Komárková	*Financial integration of stock markets among new EU member* *states and the euro area*
6/2007	Anca Pruteanu-Podpiera Laurent Weill Franziska Schobert	*Market power and efficiency in the Czech banking sector*
5/2007	Jiří Podpiera Laurent Weill	*Bad luck or bad management? Emerging banking market* *experience*
4/2007	Roman Horváth	*The time-varying policy neutral rate in real time: A predictor for* *future inflation?*
3/2007	Jan Brůha Jiří Podpiera Stanislav Polák	*The convergence of a transition economy:* *The case of the Czech Republic*
2/2007	Ian Babetskii Nauro F. Campos	*Does reform work?* *An econometric examination of the reform-growth puzzle*

1/2007	Ian Babetskii Fabrizio Coricelli Roman Horváth	*Measuring and explaining inflation persistence:* *Disaggregate evidence on the Czech Republic*
13/2006	Frederic S. Mishkin Klaus Schmidt- Hebbel	*Does inflation targeting make a difference?*
12/2006	Richard Disney Sarah Bridges John Gathergood	*Housing wealth and household indebtedness: Is there a household* *'financial accelerator'?*
11/2006	Michel Juillard Ondřej Kameník Michael Kumhof Douglas Laxton	*Measures of potential output from an estimated* *DSGE model of the United States*
10/2006	Jiří Podpiera Marie Raková	*Degree of competition and export-production relative prices* *when the exchange rate changes: Evidence from a panel of Czech* *exporting companies*
9/2006	Alexis Derviz Jiří Podpiera	*Cross-border lending contagion in multinational banks*
8/2006	Aleš Bulíř Jaromír Hurník	*The Maastricht inflation criterion: "Saints" and "Sinners"*
7/2006	Alena Bičáková Jiří Slačálek Michal Slavík	*Fiscal implications of personal tax adjustments in the Czech* *Republic*
6/2006	Martin Fukač Adrian Pagan	*Issues in adopting DSGE models for use in the policy process*
5/2006	Martin Fukač	*New Keynesian model dynamics under heterogeneous expectations* *and adaptive learning*
4/2006	Kamil Dybczak Vladislav Flek Dana Hájková Jaromír Hurník	*Supply-side performance and structure in the Czech Republic* *(1995–2005)*
3/2006	Aleš Krejdl	*Fiscal sustainability – definition, indicators and assessment of* *Czech public finance sustainability*
2/2006	Kamil Dybczak	*Generational accounts in the Czech Republic*
1/2006	Ian Babetskii	*Aggregate wage flexibility in selected new EU member states*
14/2005	Stephen G. Cecchetti	*The brave new world of central banking: The policy challenges* *posed by asset price booms and busts*
13/2005	Robert F. Engle Jose Gonzalo Rangel	*The spline GARCH model for unconditional volatility and its* *global macroeconomic causes*
12/2005	Jaromír Beneš Tibor Hlédik Michael Kumhof David Vávra	*An economy in transition and DSGE: What the Czech national* *bank's new projection model needs*
11/2005	Marek Hlaváček Michael Koňák Josef Čada	*The application of structured feedforward neural networks to the* *modelling of daily series of currency in circulation*
10/2005	Ondřej Kameník	*Solving SDGE models: A new algorithm for the sylvester equation*
9/2005	Roman Šustek	*Plant-level nonconvexities and the monetary transmission*

		mechanism
8/2005	Roman Horváth	*Exchange rate variability, pressures and optimum currency area criteria: Implications for the central and eastern european countries*
7/2005	Balázs Égert Luboš Komárek	*Foreign exchange interventions and interest rate policy in the Czech Republic: Hand in glove?*
6/2005	Anca Podpiera Jiří Podpiera	*Deteriorating cost efficiency in commercial banks signals an increasing risk of failure*
5/2005	Luboš Komárek Martin Melecký	*The behavioural equilibrium exchange rate of the Czech koruna*
4/2005	Kateřina Arnoštová Jaromír Hurník	*The monetary transmission mechanism in the Czech Republic (evidence from VAR analysis)*
3/2005	Vladimír Benáček Jiří Podpiera Ladislav Prokop	*Determining factors of Czech foreign trade: A cross-section time series perspective*
2/2005	Kamil Galuščák Daniel Münich	*Structural and cyclical unemployment: What can we derive from the matching function?*
1/2005	Ivan Babouček Martin Jančar	*Effects of macroeconomic shocks to the quality of the aggregate loan portfolio*
10/2004	Aleš Bulíř Kateřina Šmídková	*Exchange rates in the new EU accession countries: What have we learned from the forerunners*
9/2004	Martin Cincibuch Jiří Podpiera	*Beyond Balassa-Samuelson: Real appreciation in tradables in transition countries*
8/2004	Jaromír Beneš David Vávra	*Eigenvalue decomposition of time series with application to the Czech business cycle*
7/2004	Vladislav Flek, ed.	*Anatomy of the Czech labour market: From over-employment to under-employment in ten years?*
6/2004	Narcisa Kadlčáková Joerg Keplinger	*Credit risk and bank lending in the Czech Republic*
5/2004	Petr Král	*Identification and measurement of relationships concerning inflow of FDI: The case of the Czech Republic*
4/2004	Jiří Podpiera	*Consumers, consumer prices and the Czech business cycle identification*
3/2004	Anca Pruteanu	*The role of banks in the Czech monetary policy transmission mechanism*
2/2004	Ian Babetskii	*EU enlargement and endogeneity of some OCA criteria: Evidence from the CEECs*
1/2004	Alexis Derviz Jiří Podpiera	*Predicting bank CAMELS and S&P ratings: The case of the Czech Republic*

CNB RESEARCH AND POLICY NOTES

3/2011	František Brázdik Michal Hlaváček Aleš Maršál	*Survey of research on financial sector modeling within DSGE models: What central banks can learn from it*
2/2011	Adam Geršl Jakub Seidler	*Credit growth and capital buffers: Empirical evidence from Central and Eastern European countries*

1/2011	Jiří Böhm Jan Filáček Ivana Kubicová Romana Zamazalová	*Price-level targeting – A real alternative to inflation targeting?*
1/2008	Nicos Christodoulakis	*Ten years of EMU: Convergence, divergence and new policy prioritie*
2/2007	Carl E. Walsh	*Inflation targeting and the role of real objectives*
1/2007	Vojtěch Benda Luboš Růžička	*Short-term forecasting methods based on the LEI approach: The case of the Czech Republic*
2/2006	Garry J. Schinasi	*Private finance and public policy*
1/2006	Ondřej Schneider	*The EU budget dispute – A blessing in disguise?*
5/2005	Jan Stráský	*Optimal forward-looking policy rules in the quarterly projection model of the Czech National Bank*
4/2005	Vít Bárta	*Fulfilment of the Maastricht inflation criterion by the Czech Republic: Potential costs and policy options*
3/2005	Helena Sůvová Eva Kozelková David Zeman Jaroslava Bauerová	*Eligibility of external credit assessment institutions*
2/2005	Martin Čihák Jaroslav Heřmánek	*Stress testing the Czech banking system: Where are we? Where are we going?*
1/2005	David Navrátil Viktor Kotlán	*The CNB's policy decisions – Are they priced in by the markets?*
4/2004	Aleš Bulíř	*External and fiscal sustainability of the Czech economy: A quick look through the IMF's night-vision goggles*
3/2004	Martin Čihák	*Designing stress tests for the Czech banking system*
2/2004	Martin Čihák	*Stress testing: A review of key concepts*
1/2004	Tomáš Holub	*Foreign exchange interventions under inflation targeting: The Czech experience*

CNB ECONOMIC RESEARCH BULLETIN

November 2011	*Macro-financial linkages: Theory and applications*
April 2011	*Monetary policy analysis in a central bank*
November 2010	*Wage adjustment in Europe*
May 2010	*Ten years of economic research in the CNB*
November 2009	*Financial and global stability issues*
May 2009	*Evaluation of the fulfilment of the CNB's inflation targets 1998–2007*
December 2008	*Inflation targeting and DSGE models*
April 2008	*Ten years of inflation targeting*
December 2007	*Fiscal policy and its sustainability*
August 2007	*Financial stability in a transforming economy*
November 2006	*ERM II and euro adoption*
August 2006	*Research priorities and central banks*