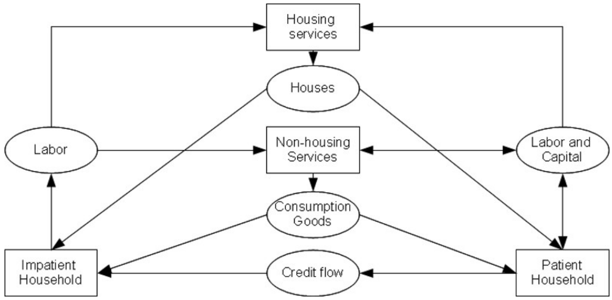
Figure 5 Model with Collateral Constraints by Iacoviello and Neri (2010)



their manufacturing facilities. This leads to a reduction in the price of land because land and manufacturing facilities are alternative assets. This reduction in operation size lowers the limit on the amount of external resources that a firm can obtain via collateralized loans. This mechanism exaggerates the spread and amplification of the response to a negative shock to demand for the company's products.

Kocherlakota (2000) uses his theoretical models with secured debt to demonstrate that the mechanism of securing debt alone is not capable of delivering a strong financial accelerator effect. 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) consider the assumptions made by Kiyotaki and Moore (1997) as being too specific and conclude that the financial accelerator occurs due to constant returns to scale in the production of investment projects and to the willingness of lenders to support a project of any size. 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. They demonstrate the insignificance of the financial accelerator effect for the amplification of responses. As their simulations indicate, large amplification can be obtained only with the 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.

Like Christiano et al. (2010), Iacoviello (2005) is motivated by the criticism of real contracts to construct a model with nominal contracts and demand for real estate. The holding of real estate provides the benefit of housing to households and secures debt. Iacoviello (2005) is able to show an asymmetric response to shocks, as after a period of positive shocks and under the assumption of nominal contracts, the credit limit does not constrain the size of the loan. This supports the importance of collateralized debt for the presence of a financial accelerator effect.

Iacoviello and Neri (2010) constructed a model to reflect the characteristics of fluctuations in household consumption with two sectors of production, as *Figure 5* illustrates. The housing sector utilizes capital, land, and labor to provide housing services. Consumption goods and business capital are produced in the non-housing sector by utilization of labor and capital.

As an extension to Kiyotaki and Moore (1997), Iacoviello and Neri (2010) consider two types of households: patient and impatient. 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 provides utility, in addition to consumption and leisure.

The results support the importance of the mechanism of collateralized debt, as it amplifies the financial accelerator effect and propagates shocks from the housing market to the rest of the 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. The finding of earlier studies that the impact of credit constraints is muted motivates Liu, Wang and Zha (2010) to re-examine the comovement of housing and investment and they show that the credit transmission mechanism introduced by Kiyotaki and Moore (1997) is empirically relevant. In the model by Liu, Wang, and Zha (2010), the household consumes a homogeneous good, housing services, 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. Land and capital serve as both inputs for production and collateral for borrowing.

Liu, Wang, and Zha (2010) conclude that the previously found muted impacts of credit constraints are due to the focus 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, are credit-constrained. Allowing entrepreneurs to be credit-constrained is an essential feature of Liu, Wang, and Zha's (2010) model 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, a shock to housing demand is amplified and propagated to generate important macroeconomic fluctuations.

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 (e.g. Brzoza-Brzezina and Makarski, 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 depends 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.

5. Banking Sector

The presented models of financial frictions were constructed without an explicit role for banks. 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 literature introducing a banking sector into DSGE models has been motivated mainly by the aim of explaining specific features of the financial crisis. 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 systemic 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, Gertler, and Gilchrist (1999). A banking sector is introduced 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. 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 a given amount of deposits at the time of purchase. Therefore, the cash-in-advance assumption creates demand for deposits in the model.

The competitive banking market setup creates two opposite external finance premium effects. The first is called the "banking attenuator" effect. 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). The important novelty to Goodfriend and McCallum 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. 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 spread between the interest rate available to savers and the interest rate that borrowers pay for the loan is time varying.

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.

The influence of the paper 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. On the other hand, omitting frictions in financial intermediation may give rise to false policy implications of the model. The modeling of the spread abstracts from the threat of default, one of the main driving forces determining the interest rate spread. Christiano, Trabandt, and Walentin (2007) ask if the banking sector, and the financial sector in general, are quantitatively important for the business cycle and what the possible implications are for monetary policy. They extend the model of Bernanke, Gertler, and Gilchrist (1999) by introducing a financial sector and estimate it 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. They argue that the BGG (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, 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, in particular the implication of tightening credit conditions and their transmission to the real economy. They merge the model of Christiano, Trabandt, and Walentin (2007) 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 to estimation by Bayesian techniques 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 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 with 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, Kiyotaki, and Queralto (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.

A synthesis of much of what can be found in the previous models is provided in the model by Dib (2010). 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.

6. DSGE and Macroprudential Analysis in the CNB

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 Frictions 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. 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.

Though many central banks have experimented with DSGE models with financial frictions 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 Brůha et al (2011) discuss, this is due to the following reasons:

- 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 and can give rise to diverse quantitative results.
- At the same time 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.
- 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. Also, the relevant data series are not available in sufficient length or quality.

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, Hledik, Kamenik, and Vlček, 2009) and develop a set of several parallel satellite models using different types of financial frictions. There are several streams of model development going on in the CNB research program, ranging from workstreams aspiring to incorporate the financial accelerator mechanism into a small open economy (with an alternative assumption of original "state contingent contracts" as well as an extension to "state non-contingent contracts" developed by Kumhof and Beneš, 2011), through workstreams aiming to include housing markets in DSGE models, to workstreams that set out to build DSGE models with a banking sector.

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. The practical applications of such models are quite rare and are focused mainly on stylized evaluation of the effects of macroprudential instruments on macroeconomic performance.

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, 2010). 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.[1]

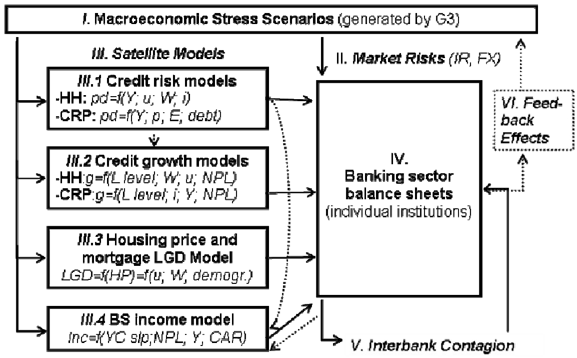
The use of DSGE models in the creation of stress-testing scenarios has advantages due to the following features of this process. The stress-testing scenarios always include a "baseline scenario," which is supposed to be the most likely scenario of future macroeconomic development and which should be in line with the official central bank forecast. Also, compared to the various types of central bank prediction models, 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 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.

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

[1] For a description of the CNB's DSGE model used for supporting monetary policy decisions, see Andrle, Hledik, Kamenik, and Vlček (2009). For a description of the three generations of the stress-testing models used in the CNB see Čihák and Heřmánek (2006), Čihák, Heřmánek, and Hlaváček (2007), and Geršl and Seidler (2010).

Figure 6 Use of DSGE Models in Building Up Macroeconomic Scenarios for Stress Testing



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 (parts III.1–III.4). 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 that range from simple ad-hoc approaches to more sophisticated Merton-type models. In this framework it is also important for the individual satellite models to be interrelated, which causes other problems.[2] 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, Heřmánek, and Hlaváček, 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 and are not included in every stress-testing exercise.

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. 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"

[2] 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 interrelations between housing price growth and mortgage loan development and other mutual links.

macroeconomic scenario could under some circumstances integrate some of the current satellite models. 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).

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.[3] Within "boom and bust" cycles,[4] 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.

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 (including ad-hoc stress-testing exercises). Also, such models are not able to assess interbank contagion. 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.

7. Conclusion

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

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

[4] 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.

can cause a significant and long-term response. General equilibrium 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. The use of DSGE models with financial frictions in macroprudential policy is even less straightforward 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.

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