D8.6 – Expanding the Macroeconomic Model Database by New Policy-Focused Models with Explicit Financial Sector

Project acronym: MACFINROBODS

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As part of this deliverable, the following models have been added to the Macroeconomic Model Database:

- Curdia, Vasco and Michael Woodford (2009), Credit Frictions and Optimal Monetary Policy, BIS Working Paper No 278.
- Gertler, Mark and Peter Karadi (2013), QE 1 vs. 2 vs. 3...: A Framework for Analyzing Large-Scale Asset Purchases as a Monetary Policy Tool, International Journal of Central Banking, 9, 5-53.

The choice of models will be discussed in Deliverable D8.7, that will provide a systematic comparison of the empirical implications of models with explicit financial sector.

In what follows, a one-page description is given for each of the models listed above. Deliverable D8.6, per se, however, is the software code attached in the zip-package MMB_SoftwareD8.6.zip. The zip-package contains the Macroeconomic Model Database software, a user guide, and a readme-file with short instructions on how to run the software. Please note that the acknowledgement regarding funding has been added to the pre-amble of the master executable file MMB.m and to the readme-file.
MMB Model CA_BMZ12


Bailliu et al. (2012) investigate interactions between monetary policy and macroprudential policy and examine whether policy makers should respond to financial imbalances. The model is a closed economy that accounts for standard New Keynesian features and has a financial friction along the lines of Bernanke et al. (1999) and Christensen and Dib (2008). The model is estimated using Canadian data. The authors show that it is welfare improving to react to financial imbalances. The size of the benefits, however, depends on the nature of the shock.

Aggregate Demand: The representative household derives utility from consumption and disutility from labor. Accordingly, it maximizes utility subject to its resource constraint. In period $t$, the household purchases consumption goods and a one period government bonds. The household’s income consists of labor income, bond payoff and dividends on equity it owns on retailer firms.

Aggregate Supply: Entrepreneurs, capital producers and retailers operate in the production sector of the economy. Entrepreneurs borrow from lenders to purchase capital from capital producers and produce intermediate goods. Capital producers combine investment goods and existing capital to produce new capital, subject to quadratic capital adjustment costs. Retailers operate in a monopolistically competitive environment and are subject to price rigidities a la Calvo (1983). They buy intermediate goods from entrepreneurs and differentiate them at no cost. A Dixit-Stiglitz aggregator combines intermediate goods to a quantity of the final good.

Financial Sector and Macroprudential Policy: The financial friction is modeled along the lines of Bernanke et al. (1999): There is a costly state verification contract between the entrepreneurs (borrowers) and the lenders. In this model, the contract is set in nominal terms, similarly to Christensen and Dib (2008). The contract implies a negative relationship between borrower’s net worth and the funding costs (external finance premium). The macroprudential policy tool is modeled as an exogenous component of the external finance premium.

Shocks: A financial shock (affecting the external finance premium), a technology shock, a monetary policy shock, a preference shock and an investment-specific shock.

Calibration/Estimation: The model is estimated by Bayesian techniques on quarterly Canadian data for the sample 1997:Q1 to 2009:Q3. The observed time series are: output (excluding government expenditures), investment, the nominal interest rate, inflation and the external finance cost.
Carabenciov et al. (2013) construct and estimate a six region model with both financial and real linkages. The six regions represent the U.S., the Euro Area, Japan, Emerging Asia, a five-country block of inflation-targeting Latin American countries and a “remaining-countries” group. The first three countries/regions are re-grouped under the label G3 and differ from the other countries/regions in five ways: (i) they have an unemployment sector; (ii) there is a trend of appreciation of the real exchange rate for the emerging economies; (iii) there is no bank lending tightening variable for non-G3 economies; (iv) G3 economies are assumed to have achieved their inflation-targets; and (v) priors for estimations differ between the two groups. In addition, the model includes financial spillovers not only from the U.S., but from the EA and Japan as well, a global demand shock, a medium-term interest rate, and real exchange rate linkages. Each of the 6 countries/regions is characterized by several behavioral equations.

**Aggregate Demand**: The IS-curve relates the output gap to domestic, external and financial-real linkages. The domestic effects consist of past and future values of the output gap and of the past value of the gap in the medium-term real interest rate. The latter is a function of the current real policy rate, the expected average real policy rate over the coming year, the expected average real policy rate over the next three years, and the expected average real policy rate over the next five years. External effects are driven by the effective real exchange rate gap and the foreign demand channel.

**Aggregate Supply**: The Phillips curve expresses inflation as a function of its past and its future value, the lagged output gap, the change in the effective real exchange rate gap of the country and a disturbance term. The model specifies a dynamic version of Okun’s law for the G3 regions, linking the unemployment rate to its lagged value and the contemporaneous output gap.

**Financial Sector**: The financial-real linkages capture the bank-lending conditions originating from the G3 economies. For each of these countries, tighter lending conditions negatively affect the output gap. The policy rule is an inflation-forecast-based rule that determines the short-term nominal rate for the G3 countries; it reacts to inflation three quarters ahead, the real interest rate and domestic output gap.

**Shocks**: Shocks to aggregate demand, bank-lending conditions, inflation, the short-run rate, the uncovered interest parity and unemployment rate enter the G3 models. The model features a shock to the level and the growth rate of potential output, a shock to the level and the growth rate of unemployment, a shock to the real interest rate and a shock to the real exchange rate in each economy.

**Calibration/Estimation**: Parameters are set through a mixture of calibration and Bayesian estimation. The model uses quarterly data for the period 1999:Q1 to 2010:Q2.
MMB Model US_CMR14, US_CMR14noFA


Christiano et al. (2014) augment a standard DSGE model in the spirit of Smets and Wouters (2003, 2007) with a financial accelerator mechanism as in Bernanke et al. (1999). In particular, the return on capital of individual entrepreneurs is subject to idiosyncratic uncertainty. The model is fitted to U.S. data, while modeling aggregate risk as the innovation to the variance of the distribution determining the return on capital. The paper’s main finding is that fluctuations in risk are the most important shock driving the business cycle.

**Aggregate Demand:** Households maximize expected lifetime utility by choosing consumption of final goods, labor supply and investment. They obtain funds from supplying labor, purchasing long- and short-term bonds, building and selling raw capital, as well as from various lump-sum transfers. Further, each household is subject to taxes on consumption and labor income.

**Aggregate Supply:** Competitive final goods producers purchase and combine intermediate goods from monopolistic intermediate goods producers (which are subject to Calvo-type price-stickiness) that produce employing labor and capital. Homogeneous labor units are produced by perfectly competitive labor contractors, who aggregate differentiated household labor services purchased from monopolistic unions that set wages subject to Calvo-type frictions. Households build raw capital subject to capital-adjustment costs and sell it to entrepreneurs, whom they own.

**Financial Sector:** Risk-neutral entrepreneurs finance their purchases of capital through their net worth and loans from competitive mutual funds. Entrepreneurs’ purchases of capital are subject to an i.i.d. mean unity log-normal idiosyncratic shock that converts their raw capital into effective capital, which is competitively rented – subject to a capital tax – and the sold to households. The loan contract between entrepreneurs and mutual funds is as in Bernanke et al. (1999).

**Shocks:** The model includes shocks to the following variables: price markup, price of investment goods, government consumption, persistence of growth of technology, transitory component of technology, risk, consumption preference, marginal efficiency of investment, term structure, equity, monetary policy, and the inflation target.

**Calibration/Estimation:** The model is estimated by Bayesian techniques using quarterly macroeconomic and financial variables covering the period, 1985:Q1 to 2010:Q2.

**Note:** US_CMR14noFA is a version of US_CMR14 in which the financial accelerator channel has been muted. The parameterization is, however, that of the base model.
MMB Model NK_CW09

Curdia, Vasco and Michael Woodford (2009), Credit Frictions and Optimal Monetary Policy, BIS Working Paper No 278.

Curdia and Woodford (2009) extend the basic representative-household New-Keynesian model as in Woodford (2003) to allow for a spread between the interest rate available to savers and borrowers. The spread can vary for endogenous or exogenous reasons (the version implemented in MMB uses endogenous variation). The authors investigate how much of a difference the inclusion of financial frictions (relative to the frictionless baseline) makes for the model’s predictions for the response to various types of shocks under a given monetary policy rule.

**Aggregate demand:** Households maximize their lifetime utility, where the utility function is separable in consumption and leisure, subject to an intertemporal budget constraint. Households are either savers or borrowers, who differ in the utility that they can obtain from current expenditure. They own the firms and the financial intermediary. Households are monopolistically competitive suppliers of labor to the firms. Savers and borrowers hold their financial wealth in the form of one-period, riskless nominal contracts with the financial intermediary. The government also consumes a part of the composite good produced by the firms.

**Aggregate supply:** The production side consists of the firms and the financial intermediary. A continuum of firms use labor to produce differentiated goods. Price stickiness is introduced via the Calvo framework. The financial intermediary produces loans. He/she faces intermediation costs, which determine the interest rate spread between the lending and the borrowing interest rate. The costly loan origination part of the spread is due to the fact that some borrowers are fraudulent and do not plan to repay their loans. Both frictions are increasing in the amount of lending. As these intermediation costs vary, so does the spread between the lending and the borrowing interest rate.

**Shocks:** The model features one shock on consumption expenditure of savers/lenders and another one on consumption expenditure of borrowers. In addition, the model also includes shocks on: government purchases of the composite good, labor supply, wage markup, distorting tax, technology, government debt and monetary policy. Finally, the model features financial disturbances to the real resource cost of loan origination and monitoring as well as to the costs of fraudulent borrowing.

**Calibration/Estimation:** Many of the model parameters are also parameters of the basic NK model and in the case of these parameters similar numerical values as in Woodford (2003) are assumed. The new parameters that are needed for this model are those relating to heterogeneity or to the specification of the credit frictions.
**MMB Model NK_ET14**


Ellison and Tischbirek (2014) develop a small-scale New-Keynesian model with a banking sector and include unconventional monetary policy in the form of asset purchases by the central bank. The aim of the paper is to investigate whether allowing for (always active) unconventional monetary policy as an addition to conventional interest rate policy can be welfare-increasing. The authors find that asset purchases have a stabilizing and welfare-enhancing effect on the economy. The optimal monetary policy mix prescribes that conventional interest rate policy reacts to inflation only, while unconventional asset purchases should be used to stabilize output.

**Aggregate Demand:** Households maximize expected lifetime utility by choosing consumption of final goods and labor supply. They obtain funds from labor services, interest on deposits and dividend payments from firms. Each household is subject to dividend and lump-sum taxes.

**Aggregate Supply:** Monopolistically competitive firms produce consumption goods, employing household labor with a decreasing-returns-to-scale production function and subject to Calvo-type price rigidities.

**Financial Sector:** Perfectly-competitive banks take deposits from households and purchase short- and long-term government bonds. In choosing the composition of the aggregate savings device offered to the household sector, banks perceive households as heterogeneous with regard to their desired investment horizon and assets of different maturities are considered imperfect substitutes. The price of single assets is thus influenced by supply and demand effects specific to that maturity. The central bank sets the short-term interest rate and can influence yields at different maturities by purchasing government bonds. The treasury issues short-term bonds in a quantity consistent with the interest rate set by the central bank and long-term bonds following a rule linking the real quantity of long-term bonds to steady-state output.

**Shocks:** The model features seven shocks: to the interest rate, asset purchases, consumption preference, labor supply preference, technology, intra-temporal elasticity of substitution and government expenditure. All shocks are AR(1) processes.

**Calibration/Estimation:** Calibration is based on Gali (2008) and Smets and Wouters (2003, 2007).
Gertler and Karadi (2013) build a quantitative DSGE model in order to analyze central bank large-scale asset purchases (LSAP). The model features private financial intermediaries that face endogenously determined balance sheet constraints stemming from a moral hazard problem in their deposit financing, giving rise to external finance premia. Unconventional monetary policy in the form of LSAP can reduce these premia and hence stimulate real economic activity.

**Aggregate Demand**: The representative household’s utility is separable in consumption and leisure, and features habit formation in consumption. Expected-lifetime utility is maximized by choosing consumption and labor supply. Households can hold deposits at financial intermediaries, government bonds, private assets issued by firms and are subject to lump-sum transfers.

**Aggregate Supply**: Competitive intermediate goods are produced with a Cobb-Douglas technology using capital and labor. Household labor is purchased in competitive markets. Capital goods are bought from competitive capital goods producers (who are subject to adjustment costs) and financed by issuing state-contingent securities to banks. Monopolistic retail firms, subject to Calvo-type price stickiness, repackage intermediate goods.

**Financial Sector**: Banks transfer funds from households to non-financial firms and to the government, while engaging in maturity transformation. They hold long-term government bonds and securities from non-financial firms and fund themselves with short-term liabilities (beyond their net worth). A moral hazard/costly enforcement problem constrains the ability of banks to obtain funds from households, while they are able to perfectly monitor firms and enforce contracts. The central bank that can conduct monetary policy either by adjusting the short-term interest rate – while facing a zero-lower-bound constraint – or by engaging in asset purchases, either of long-term government bonds, private securities or both. Government expenditures are composed of government consumption and net interest payments from an exogenously-fixed stock of long-term debt. Revenues consist of lump-sum taxes and the earnings from central bank intermediation net transaction costs.

**Shocks**: There are six shocks in the model: a total factor productivity shock, a government consumption shock, a capital quality shock and three monetary policy shocks (interest rate as well as asset purchase shocks to either private assets or government bonds).

**Calibration/Estimation**: The financial sector parameters are calibrated to satisfy a steady-state interest rate spread for government bonds of 50 basis points, and for private assets of 100 basis points, and an ad-hoc steady-state leverage ratio for banks. The calibration of the conventional parameters is standard.
Quint and Rabanal (2014) use a two-country, two-sector DSGE model of the Euro Area with nominal and financial frictions to study the interactions of monetary and macroprudential policy. The two countries represent the core and the periphery in the Euro Area; the two sectors capture non-durable and durable goods, the latter being housing goods. The model builds on the model presented in Rabanal (2009) by extending it with the financial accelerator mechanism in households’ balance sheets. Macroprudential policy aims to stabilize credit markets by affecting the fraction of liabilities that banks can lend.

**Aggregate Demand:** Households in the core and in the periphery maximize expected lifetime utility by choosing consumption for durable and non-durable goods, as well as leisure. The composite non-durable consumption consists of domestic non-durable (that is, tradable) and foreign non-durable goods. Purchases of durable goods take the form of residential investment. Households in each country can save through deposits and bonds, and can take out one-period loans from domestic competitive financial intermediaries.

**Aggregate Supply:** Each economy is characterized by two sectors. Monopolistic firms (subject to Calvo-type rigidities) use household labor to produce durable and non-durable intermediate goods that are combined by competitive final-goods producers into durable and non-durable goods. Imperfect substitutability of labor supply is assumed between the two sectors and wages are flexible. Final durable goods are sold only to domestic households, which they use to increase the value of their housing – subject to adjustment costs.

**Financial Sector and Macroprudential Policy:** Impatient households finance part of their residential investment through loans subject to a contract, analogous to that of Bernanke et al. (1999), where default occurs when the value of their outstanding debt is higher than the value of the house they own (which is common knowledge) – depending on the realization of their idiosyncratic “housing quality shock”. This induces a spread between the lending (that is, mortgage) and deposit rates, which depends on housing market conditions. Savers’ funds are channeled across countries through international financial intermediaries which trade domestic financial intermediaries’ bonds and charge a risk premium, which depends on the net foreign asset position of the country.

**Shocks:** Thirteen shocks are present in the model: four sector-specific technology shocks (two for each country), four preference shocks (one for each type of good in each country), two housing quality variance shocks (one for each country), a risk premium shock, and two union-wide shocks (technology and monetary policy).

**Calibration/Estimation:** The model is estimated by means of Bayesian techniques using quarterly Euro Area data for the period from 1995:Q4 to 2011:Q4. The core country is an aggregate of France and Germany, and the periphery is represented by the GDP-weighted average of Greece, Ireland, Italy, Portugal and Spain.