A detailed overview of available models

A List of Models Available in the Macroeconomic Model Data Base (version 3.4.1)

1. CALIBRATED MODELS

1.1	NK_ADE25cpi	Auray et al. (2025): Central Banks targets CPI inflation
	NK_ADE25ppi	Auray et al. (2025): Central Banks targets PPI inflation
1.2	NK_AFL15 *	Angeloni et al. (2015)
1.3	NK_BGEU10	Blanchard and Galí (2010) Calibrated for the European labor market
	NK_BGUS10	Blanchard and Galí (2010) Calibrated for the U.S. labor market
1.4	NK_BGG99	Bernanke et al. (1999)
1.5	NK_CDK24	Chan et al. (2024)
1.6	NK_CFP10	Carlstrom et al. (2010)
1.7	NK_CGG99	Clarida et al. (1999)
1.8	NK_CGG02	Clarida et al. (2002)
1.9	NK_CK08	Christoffel and Kuester (2008)
1.10	NK_CKL09	Christoffel et al. (2009)
1.11	NK_CW09	Curdia and Woodford (2009)
1.12	NK_DEFK17	Del Negro et al. (2017)
1.13	NK_DT12	De Fiore and Tristani (2013)
1.14	NK_ET14	Ellison and Tischbirek (2014)
1.15	NK_FLMF18	Filardo et al. (2018)
1.16	NK_FNL23	Ferrari and Nispi Landi (2023)
1.17	NK_GHP16	Gnocci et al. (2016)
1.18	NK_GK11	Gertler and Karadi (2011)
	NK_GK09lin	linear model based on the working paper of Gertler and Karadi (2011)
1.19	NK_GK13	Gertler and Karadi (2013)
1.20	NK_GLSV07	Galí et al. (2007)
1.21	NK_GM05	Galí and Monacelli (2005)
1.22	NK_GM07	Goodfriend and McCallum (2007)
1.23	NK_GM16	Galí and Monacelli (2016)
1.24	NK_GMAS25cpi	Monacelli (2025): Central Bank targets CPI inflation
	NK_GMAS25ppi	Monacelli (2025): Central Bank targets PPI inflation
1.25	NK_GN25	Gnocato (2025)
1.26	NK_GS14	Gambacorta and Signoretti (2014)
1.27	NK_GSSZ17	Gilchrist et al. (2017)
1.28	NK_IR04	Ireland (2004)
1.29	NK_JO15ht	Jang and Okano (2015) - high trading
	NK_JO15lt	Jang and Okano (2015) - low trading
1.30	NK_KM16	Krause and Moyen (2016)
1.31	NK_KRS12	Kannan et al. (2012)
1.32	NK_KW16	Kirchner and van Wijnbergen (2016)
1.33	NK_LWW03	Levin et al. (2003)
1.34	NK_MCN99cr	McCallum and Nelson (1999), (Calvo-Rotemberg model)
1.35	NK_MI14	Michaillat (2014)
1.36	NK_MM10	Meh and Moran (2010)
1.37	NK_MPT10	Monacelli et al. (2010)
1.38	NK_NS14	Nakamura and Steinsson (2014)
1.39	NK_PP17	Paoli and Paustian (2017)
1.40	NK_PSV16	Pancrazi et al. (2016)
1.41	NK_RA16	Rannenberg (2016)

* Solving this model requires the MATLAB Optimization Toolbox.

1. CALIBRATED MODELS (CONTINUED)

1.42	NK_RW06	Ravenna and Walsh (2006)
1.43	NK_RW97	Rotemberg and Woodford (1997)
1.44	NK_ST13	Stracca (2013)
1.45	RBC_DTT11	De Fiore et al. (2011)

2. ESTIMATED US MODELS

2.1	US_ACELm	Altig et al. (2005), (monetary policy shock)
	US_ACELswm	no cost channel as in Taylor and Wieland (2011) (mon. pol. shock)
	US_ACELswt	no cost channel as in Taylor and Wieland (2011) (tech. shocks)
	US_ACELt	Altig et al. (2005), (technology shocks)
2.2	US_AJ16	Ajello (2016)
2.3	US_BR13	Blanchard and Riggi (2013)
2.4	US_BB18	Balke and Brown (2018)
2.5	US_BKM12	Bils et al. (2012)
2.6	US_CCF12	Chen et al. (2012)
2.7	US_CCTW10	Smets and Wouters (2007) model with rule-of-thumb consumers, estimated by Cogan et al. (2010)
2.8	US_CD08	Christensen and Dib (2008)
2.9	US_CET15	Christiano et al. (2015)
2.10	US_CFOP14	Carlstrom et al. (2014)
2.11	US_CFP17exo	Carlstrom et al. (2017) - exogenous level of long-term debt
	US_CFP17endo	Carlstrom et al. (2017) - endogenous level of long-term debt
2.12	US_CMR10	Christiano et al. (2010a)
	US_CMR10fa	Christiano et al. (2010a) - small version with financial accelerator
2.13	US_CMR14 **	Christiano et al. (2014)
	US_CMR14noFA **	Christiano et al. (2014)-Version without financial frictions
2.14	US_CPS10	Cogley et al. (2010)
2.15	US_DG08	De Graeve (2008)
2.16	US_DNGS15	Del Negro et al. (2015)
	US_DNGS15_SW	Del Negro et al. (2015) w/o financial frictions
	US_DNGS15_SWpi	Del Negro et al. (2015) w/o financial frictions and time-varying inflation target
	US_DNGS15_SWSP	Del Negro et al. (2015) reestimation of Smets and Wouters (2007) with longer time-series
2.17	US_FGKR15	Fernández-Villaverde et al. (2015)
2.18	US_FM95	Fuhrer and Moore (1995a)
2.19	US_FMS13	Fève et al. (2013)
2.20	US_FRB03	Federal Reserve Board model linearized as in Levin et al. (2003)
2.21	US_FRB08	linearized by Brayton and Laubach (2008)
	US_FRB08mx	linearized by Brayton and Laubach (2008), (mixed expectations)
2.22	US_FRB22_mceall	Brayton and Reifschneider (2022): all expectations are model consistent
	US_FRB22_mcapwp	Brayton and Reifschneider (2022): financial market, wage and price expectations are model consistent, other expectations are based on a small VAR
	US_FRB22_mcap	Brayton and Reifschneider (2022): financial market expectations are model consistent, other expectations are based on a small VAR
	US_FRB22_var	Brayton and Reifschneider (2022): all expectations are based on VAR predictions

** Solving these models requires the Statistics Toolbox for MATLAB or the statistics and io package for Octave, respectively.

2. ESTIMATED US MODELS (CONTINUED)

2.23	US_FU19	Fratto and Uhlig
2.24	US_FV10	Fernández-Villaverde (2010)
2.25	US_FV15	Fernández-Villaverde et al. (2015)
2.26	US_GG24	Gagliardone and Gertler (2024)
2.27	US_HL16	Hollander and Liu (2016)
2.28	US_IAC05	Iacoviello (2005)
2.29	US_IN10	Iacoviello and Neri (2010)
2.30	US_IR11	Ireland (2011)
2.31	US_IR15	Ireland (2015)
2.32	US_JPT11	Justiniano et al. (2011)
2.33	US_KK14	Kliem and Kriwoluzky (2014)
2.34	US_KS15	Kriwoluzky and Stoltenberg (2014)
2.35	US_LTW17	Leeper et al. (2017)
	US_LTW17gz	Leeper et al. (2017) - different fiscal rule
	US_LTW17nu	Leeper et al. (2017) - no government consumption in the utility function
	US_LTW17rot	Leeper et al. (2017) - with rule of thumb consumers
2.36	US_LWY13	Leeper et al. (2013)
2.37	US_MI07	Milani (2007)
2.38	US_MR07	Mankiw and Reis (2007)
2.39	US_OR03	Orphanides (2003b)
2.40	US_OW98	Orphanides and Wieland (1998) equivalent to MSR model in Levin et al. (2003)
2.41	US_PM08	IMF projection model US, Carabenciov et al. (2008a)
	US_PM08fl	IMF projection model US (financial linkages),Carabenciov et al. (2008a)
2.42	US_PV15	Poutineau and Vermandel (2015b)
2.43	US_RA07	Rabanal (2007)
2.44	US_RE09	Reis (2009)
2.45	US_RS99	Rudebusch and Svensson (1999)
2.46	US_VGIP15	Vasconez et al. (2015)
2.47	US_SW07	Smets and Wouters (2007)
2.48	US_VI16bgg	Villa (2016) - with Bernanke et al. (1999) financial accelerator
	US_VI16gk	Villa (2016) - with Gertler and Karadi (2013) financial friction
2.49	US_VMDno	Verona, Martins and Drumond (Verona et al. (2013)) - Normal times
	US_VMDop	Verona, Martins and Drumond (Verona et al. (2013)) - Optimistic times
2.50	US_YR13	Rychalovska (2016)

3. ESTIMATED EURO AREA MODELS

3.1	EA_ALSV06	Andrés et al. (2006)
3.2	EA_AWM05	ECB's area-wide model linearized as in Dieppe et al. (2005)
3.3	EA_BE15	Benchimol (2015)
3.4	EA_BF17	Benchimol and Fourçans (2017)
3.5	EA_CKL09	Christoffel et al. (2009)
3.6	EA_CW05ta	Coenen and Wieland (2005), (Taylor-staggered contracts)
	EA_CW05fm	Coenen and Wieland (2005), (Fuhrer-Moore-staggered contracts)
3.7	EA_DKR11	Darracq Paries et al. (2011)
3.8	EA_GE10	Gelain (2010)

** Solving these models requires the Statistics Toolbox for MATLAB or the statistics and io package for Octave, respectively.

3. ESTIMATED EURO AREA MODELS (CONTINUED)		
3.9	EA_GNSS10	Gerali et al. (2010)
3.10	EA_PV15	Poutineau and Vermandel (2015a)
3.11	EA_PV16	Priftis and Vogel (2016)
3.12	EA_PV17	Priftis and Vogel (2017)
3.13	EA_QR14 **	Quint and Rabanal (2014)
3.14	EA_QUEST3	QUEST III Euro Area Model of the DG-ECFIN EU, Ratto et al. (2009)
3.15	EA_SR07	Sveriges Riksbank euro area model of Adolfson et al. (2007)
3.16	EA_SW03	Smets and Wouters (2003)
3.17	EA_SWW14	Smets et al. (2014)
3.18	EA_VI16bgg	Villa (2016) - with Bernanke et al. (1999) financial accelerator
	EA_VI16gk	Villa (2016) - with Gertler and Karadi (2013) financial friction
4. ESTIMATED/CALIBRATED MULTI-COUNTRY MODELS		
4.1	DEREA_GEAR16	Gadatsch et al. (2016) model of Germany, EMU, and RoW
4.2	ESREA_FIMOD12	Stähler and Thomas (2012) model of Spain and EMU
4.3	G2_SIGMA08	The Federal Reserve's SIGMA model from Erceg et al. (2008) calibrated to the U.S. economy and a symmetric twin.
4.4	G3_CW03	Coenen and Wieland (2002) model of USA, Euro Area and Japan
4.5	G7_TAY93	Taylor (1993) model of G7 economies
4.6	GPM6_IMF13	IMF global projection model with 6 regions Carabenciov et al. (2013)
4.7	EACZ_GEM03	Laxton and Pesenti (2003) model calibrated to Euro Area and Czech republic
4.8	EAES_RA09	Rabanal (2009)
4.9	EAUS_NAWM08	Coenen et al. (2008), New Area Wide model of Euro Area and USA
4.10	EAUS_NAWMctww	Cogan et al. (2013)
5. ESTIMATED MODELS OF OTHER COUNTRIES		
5.1	BRA_SAMBA08	Gouvea et al. (2008), model of the Brazilian economy
5.2	CA_BMZ12	Bailliu et al. (2012)
5.3	CA_LS07	Lubik and Schorfheide (2007), small-scale open-economy model of the Canadian economy
5.4	CA_TOTEM10	Murchison and Rennison (2006)
5.5	CL_MS07	Medina and Soto (2007), model of the Chilean economy
5.6	FI_AINO16	Kilponen et al. (2016), the AINO II model
5.7	HK_FPP11	Funke et al. (2011), open-economy model of the Hong Kong economy
5.8	HK_FP13	Funke and Paetz (2013), open-economy model of the Hong Kong economy
5.9	UK_SM11	Millard (2011), open-economy model of the United Kingdom with energy

Most models assume that expectations of future realizations of model variables such as for example future exchange rates, prices, interest rates, wages and income are formed in a model-consistent, rational manner. A few models assume backward-looking expectations formation, in particular the models from Rudebusch and Svensson (1999) and Orphanides (2003b). Most, but not all models are linear, or linear approximations of nonlinear models. In this case the variables appear as percentage deviations from their steady state values. There are many differences in model structure, in terms of size, in terms of countries covered, or the extent of microeconomic foundations considered.

1 Calibrated Models

1.1 NK_ADE25cpi: Auray et al. (2025)

Auray et al. (2025) develop a two-country New Keynesian DSGE model of trade wars and monetary policy. The model is applied to the U.S.–China trade war episode of 2018–2019 to evaluate empirical relevance and counterfactual monetary policy scenarios. It explicitly incorporates nominal rigidities, imperfect competition, endogenous trade policy, and international spillovers, to study how monetary rules shape the outcome of trade wars. The model assumes that export prices are set in the producer's own currency, so that tariffs imposed by trading partners directly affect import prices and the terms of trade. It also includes markup distortions, sticky prices through Rotemberg adjustment costs, and discretionary tariff setting by each country. Some parameters are calibrated to match U.S. and Chinese macroeconomic features, while others are estimated with Bayesian methods using quarterly data.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption of home and foreign goods and disutility of labor, subject to an intertemporal budget constraint. Preferences are logarithmic over consumption and exhibit a Frisch elasticity of labor supply. Households choose consumption of home and imported goods, hours worked, and holdings of one-period nominal bonds, taking wages, prices, tariffs, and firm profits as given. Lump-sum transfers include redistributed tariff revenues and firm profits. Home bias in consumption is calibrated to match observed U.S.–China bilateral trade shares. The nominal budget constraint includes tariff-adjusted import prices. Government transfers are exogenous but funded by tariff revenues and follow an i.i.d. one-time shock.
- Aggregate Supply: The final goods, which are produced under perfect competition, are used for consumption by households. The final goods producer maximizes profits subject to a CES aggregator of intermediate goods, which introduces monopolistic competition in the market for intermediate goods and implies a constant elasticity of substitution between different intermediate goods. A continuum of intermediate firms produce differentiated goods using a production function with Cobb–Douglas technology and stochastic productivity. Firms choose prices to maximize the present value of expected profits, subject to downward-sloping demand and Rotemberg price adjustment costs, which create nominal rigidities. Even in the absence of nominal rigidities, monopoly distortions persist due to imperfect competition, leading to an inefficiently low level of output relative to the efficient benchmark. Tariffs further distort production and prices by shifting relative demand between home and foreign goods.
- Shocks: A total factor productivity shock in each country, a discretionary tariff shock in each country, and two monetary policy shocks: one in the home country and one in the foreign country. Productivity shocks follow highly persistent AR(1) processes, while tariff shocks are modeled as i.i.d. deviations from the steady-state tariff rates. Monetary policy shocks are also AR(1), capturing persistent deviations from the monetary policy rules in each country. All shocks are normally distributed with calibrated standard deviations of 0.01. /Estimation: The model is calibrated and estimated for the U.S. and China using Bayesian techniques on quarterly data. Key structural parameters are calibrated based on empirical evidence and trade data, while monetary policy parameters, price adjustment costs, and other shock processes are estimated. The estimation uses macroeconomic and trade-related observables and delivers posterior distributions consistent with recent findings in the literature.
- Replication: We replicated the impulse response functions to monetary policy and tariff shocks under Smets Wouters (2007) monetary policy rule. The variables include Inflation, Output, Output Gap, Interest, Consumption, and other, reproducing the key findings on the welfare implications of CPI versus PPI targeting.

1.2 NK_AFL15: Angeloni et al. (2015)

Angeloni et al. (2015) propose a DSGE model where banks are subject to runs, modelled as a discipline device in the spirit of Diamond and Rajan (2000, 2001). Banks invest in risky projects and fund operations via bank equity and run-prone deposits, such that their funding structure endogenously determines bank fragility. In the model, expansionary monetary policy (either following a monetary policy shock or responding to other exogenous shocks) increases bank leverage and risk. An accelerating balance sheet channel is offset by banks' risk taking such that business cycle fluctuations are dampened relative to a model without a financial sector.

- Aggregate Demand: The representative household derives utility from consumption and disutility from labor. It saves and invests in bank demand deposits and bank capital. Households also own the production sector and receive lump-sum nominal profits. The resulting optimality conditions are a standard intra-temporal labor-consumption trade-off and an Euler equation for savings in the form of bank deposits. In the latter, the return on demand deposits is subject to a time-varying risk premium due to the possibility of runs.
- Aggregate Supply: The firm side is characterized by monopolistic competition and nominal rigidities in the form of Rotemberg (1982) quadratic price adjustment costs. This gives rise to a standard Rotemberg (1982)

forward-looking New Keynesian Phillips curve. Capital investment is undertaken by capital producers facing capital adjustment costs.

- Financial Sector: Firms finance investment fully via bank lending. A fraction of household members are bank capitalists, such that households own financial intermediaries. Bank managers choose banks' funding structure on behalf of depositors and bank capitalists subject to a moral hazard problem resulting from their superior project knowledge. Bank managers are incentivized by the contractual payoff structure and the threat that depositors might run the bank, which entails costly project liquidation. The latter happens if the idiosyncratic bank project returns are too low for all depositors to be reimbursed, a risk that increases with endogenously chosen bank leverage.
- Shocks: A productivity shock, a monetary policy shock and a government shock.
- Calibration/Estimation: The model is calibrated at quarterly frequency. Parameter values for the household and firm sector are standard in line with existing literature. Bank parameter values are calibrated to match US data. All exogenous shocks follow an AR(1) process with persistence parameters and standard deviations as implied by the empirical analysis in Section 3 or other empirical results.

1.3 NK_BGEU10 and NK_BGUS10: Blanchard and Galí (2010)

Blanchard and Galí (2010) derive a small-scale New Keynesian Model with labor market frictions to analyze optimal monetary policy under different labor market conditions. They consider two different calibrations of the model. One specification for the European labor market which is assumed to be sclerotic, and another one for the U.S. labor market considered as more fluid.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure, subject to an intertemporal budget constraint. Households supply one homogeneous type of labor, and face an exogenous separation rate.
- Aggregate Supply: In this economy, there are two types of firms. Competitive firms produce intermediate goods using labor services. Retail firms have monopolistic power and re-package intermediate output.
- Rigidities: Nominal rigidities are modeled by standard Calvo (1983) pricing. Real wage is a non-linear function of productivity, introducing real wage rigidities.
- Shocks: An adverse technology shock, and the common monetary policy shock.
- Calibrations: For the fluid US labor market, shorthand named NK_BGUS10 above, unemployment rate is equal to 5 percent, and the job finding rate is set to a monthly rate of 0.3, consistent with US evidence. For the sclerotic European labor market, labeled NK_BGEU10 above, Unemployment rate is equal to 10 percent, and the job finding rate is set to a monthly rate of 0.1.

1.4 NK_BGG99: Bernanke et al. (1999)

Bernanke et al. (1999) introduce credit market imperfections into an otherwise standard New Keynesian model with capital and show that these financial frictions contribute to propagate and amplify the response of key macroeconomic variables to nominal and real shocks. An agency problem arises due to asymmetries of information in borrower-lender relationships. The economy is inhabited by three types of agents, risk-averse households, risk-neutral entrepreneurs and retail firms.

- Aggregate Demand: Households gain utility from consumption, leisure and real money balances. Household optimization results in a standard dynamic IS equation. Entrepreneurs use capital and labor to produce wholesale goods that are sold to the retail sector. Each period, entrepreneurs have to accumulate capital that becomes available for production in the subsequent period. Entrepreneurs have to borrow from households via a financial intermediary to finance capital purchases. Since the financial intermediary has to pay some auditing costs to observe the idiosyncratic return to capital, an agency problem arises. The optimal contract leads to an aggregate relationship of the spread between the external finance costs and the risk-free rate and entrepreneurs' financial conditions represented by the leverage ratio.
- Aggregate Supply: Retail firms act under monopolistic competition. They buy wholesale goods produced by entrepreneurs in a competitive market and differentiate them at zero cost. Price stickiness is introduced via the Calvo framework. Bernanke et al. (1999) assume that reoptimizing firms have to set prices prior to the realization of shocks in that period, so that previous period's expectations of the output gap and future inflation enter the New Keynesian Phillips curve.
- Shocks: The model exhibits a technology shock, a demand shock and the common monetary policy shock. Since we have no information about the variances of the shock terms, we set all shock variances equal to zero.
- Calibration/Estimation: The model is calibrated at quarterly frequency.

1.5 NK_CDK24: Chan et al. (2024)

The model

1.6 NK_CFP10: Carlstrom et al. (2010)

Carlstrom et al. (2010) build a small-scale calibrated New Keynesian DSGE model with agency costs, which are modelled as constraint on the firm's hiring of labour as in the holdup problem of Kiyotaki and Moore (1997).

- Aggregate demand: Households maximize their lifetime utility, where the per-period utility function is separable in consumption and two types of labour. They can buy standard one-period bonds and firm shares, with the latter paying of dividends.
- Aggregate Supply: Entrepreneurs have linear consumption preferences and operate the intermediate good firms. These firms combine both types of labour into the intermediate good using a Cobb-Douglas production function. Due to a hold-up problem, entrepreneurs face a collateral constraint on their hiring of one labour input, in that the wage bill cannot exceed a Cobb-Douglas combination of net worth and profits. This introduces a credit friction. Monopolistically competitive final goods firms purchase intermediate goods from entrepreneurs and create final goods using a linear production function. Final goods pricing is subject to Rotemberg quadratic adjustment costs. The final goods are aggregated to an output bundle according to a CES function.
- Shocks: A productivity shock, a mark-up shock, a net worth shock and a monetary policy shock.
- Calibration/Estimation: The model is calibrated using standard values in the literature, in particular following Woodford (2003). Credit-related parameters are calibrated using the average spread between BB+ and 10-year Treasury bonds from 1996 to present.
- Replication: We simulated the impulse response functions to a monetary policy shock and a technology shock under a simple Taylor rule, Figure 1 and Figure 2 in the paper.

1.7 NK_CGG99: Clarida et al. (1999), hybrid model

The model is similar to NK_RW97 but it features a hybrid Phillips curve with endogenous persistence in inflation. Also, government spending is not treated explicitly. The model and its implications for monetary policy are discussed in detail in Clarida et al. (1999) from page 1691 onwards.

- Aggregate Demand: Hybrid New Keynesian IS curve.
- Aggregate Supply: Hybrid New Keynesian Phillips curve.
- Shocks: A cost-push shock, a demand shock and the common monetary policy shock.
- Calibration/Estimation: We use the same parametrization as in in NK_RW97, however expected inflation enters the Phillips curve with a weight of 0.52 and lagged inflation with a weight of 0.48. In the IS curve the expected output gap has a weight of 0.56 and the lagged output gap has a weight of 0.44.

1.8 NK_CGG02: Clarida et al. (2002), two-country model

Clarida et al. (2002) derive a small-scale, two-country, sticky-price model to analyse optimal monetary policy. The two countries are symmetric in size, preferences and technology.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure, subject to an intertemporal budget constraint. They own the firms, are a monopolistically competitive supplier of labor to the intermediate firms and additionally hold their financial wealth in the form of one-period, state-contingent bonds, which can be traded both domestically and internationally.
- Aggregate Supply: Domestic production takes place in two stages. First there is a continuum of intermediate goods firms, each producing a differentiated material input under monopolistic competition using a production function that is linear in labor input and includes an exogenous technology parameter. They set nominal prices on a staggered basis à la Calvo and receive a subsidy in percent of their wage bill to achieve an undistorted steady state. Final goods producers then combine these inputs into output, which they sell to households under perfect competition. Wages are perfectly flexible. Thus, all workers will charge the same wage and work the same amount of hours. Clarida et al. (2002) introduce an exogenous time-varying elasticity of labor demand to vary the wage-mark-up over time. The system of equations is collapsed into an IS equation and a Phillips curve, which determine the output gap and inflation, conditional on the path of the nominal interest rate both for the domestic and the foreign economy.

- Foreign sector: Producer currency pricing is assumed so that the Law of one price holds for the final consumption good and the CPI based real exchange rate is unity. Together with the assumption of complete markets this ensures that the consumption levels are equal in both countries at any point in time.
- Shocks: A cost push shock and the common monetary policy shock.
- Calibration/Estimation: We take the parametrization of the small open economy model in Galí and Monacelli (2005) to calibrate the model. Galí and Monacelli (2005) calibrate the stochastic properties of the exogenous driving forces by fitting AR(1) processes to log labor productivity in Canada, which is their proxy for the domestic country, and log U.S. GDP, which they use as proxy for world output. The sample period comprises 1963:1–2002:4.

1.9 NK_CK08: Christoffel and Kuester (2008)

Christoffel and Kuester (2008) incorporate search and matching frictions à la Mortensen and Pissarides (1994) into an otherwise standard New Keynesian business cycle model.

- Aggregate Demand: There is a large number of identical families in the economy. Each family consists of unemployed and employed members with time-additive expected utility preferences and an external habit. The representative family pools the labor income of its working members, unemployment benefits of the unemployed members and financial income. The family maximizes its welfare function by choosing consumption and nominal bond holdings subject to its budget constraint.
- Aggregate Supply: There are three sectors of production in the economy. Firms in the first sector produce a homogeneous intermediate good where labor is the only production input. The production process is subject to matching frictions. Nominal wages in the labor sector are Calvo staggered. The wholesale sector demands labor as the only production input in a perfectly competitive market to produce differentiated goods using a constant-return-to-scale production technology. Subject to price-setting impediments à la Calvo, the intermediate good is sold under monopolistic competition to a final retail sector. Retailers bundle differentiated goods into a homogeneous consumption/investment basket. These goods are then sold to consumers and government.
- Shocks: Three shocks: a serially correlated shock to the risk premium that drives a wedge between the return on bonds held by the families and the interest rate set by the central bank, an AR(1) labor sector-wide technology shock process, and a government spending shock.
- Calibration/Estimation: The model is calibrated to US data from 1964:Q1 to 2006:Q3. The underlying data set used covers data on output, hours worked, total wages, wages per employee, real hourly wages, vacancies, the civilian unemployment rate, the inflation rate and the interest rate.

1.10 NK_CKL09: Christoffel et al. (2009)

Christoffel et al. (2009) explore the role of labor markets for monetary policy in the Euro Area in a closed-economy, single-country New Keynesian model with Mortensen and Pissarides (1994) type of matching frictions. To allow for a direct channel from wages to inflation, the model builds on the right-to-manage framework of Trigari (2006). Moreover, Christoffel et al. (2009) incorporate staggered wage-setting à la Calvo and account for job-related fixed costs as in Christoffel and Kuester (2008). The aim of the paper is to investigate to which extent a more flexible labor market would alter the business cycle behavior and the transmission of monetary policy, employing a genuine Euro Area calibration (NK_CKL09). Second, by estimating the model with Bayesian techniques (EA_CKL09, see section 3.5) they analyze to which extent labor market shocks are important determinants of business cycle fluctuations. The results support current central bank practice to put considerable effort into monitoring Euro Area wage dynamics and treat some of the other market information as less important for monetary policy.

- Aggregate Demand: The demand as well as the supply structure follow closely the one described in Christoffel and Kuester (2008). The economy consists of a large number of identical families that comprise unemployed and employed members with time-additive expected utility preferences that exhibit an external habit. The representative family pools the labor income of its working members, unemployment benefits of the unemployed members and financial income from assets that family members hold via a mutual fund. Each household also owns representative shares of all firms in the economy. It maximizes the sum of unweighted expected utilities of its individual members, by taking consumption, saving, vacancy posting, and labor supply decisions on their behalf.
- Aggregate Supply: The economy consists of three production sectors. The labor packers use exactly one worker as input to produce a homogeneous intermediate good labeled labor good. The process of labor bargaining is governed by wage rigidities. The wholesale sector buys the labor good from the labor packers in a perfectly

competitive market and produces differentiated goods using a constant-return-to-scale production technology. These goods are sold under monopolistic competition to a final retail sector at a price that is subject to impediments à la Calvo and to a partial indexation rule. Retailers bundle the differentiated goods into a homogeneous consumption/investment basket and sell it to the consumers and to the government.

- Shocks: Three labor market shocks: a shock to the costs of posting a vacancy, a shock to the rate of separation, and a shock to the bargaining power of workers; a government spending shock; a wholesale sector cost-push shock.
- Calibration/Estimation: For the calibration exercise (NK_CKL09) a quarterly Euro Area data set from 1984:Q1 to 2006:Q3 is used. The model is also estimated with Bayesian techniques (EA_CKL09) employing output, year-on-year inflation, the nominal interest rate, wages per employee, unemployment and proxies for total hours worked and vacancies as observable variables.

1.11 NK_CW09: Curdia and Woodford (2009)

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 implemented version in the 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 of the response of the economy 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, which 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 uses labor to produce differentiated goods. Price stickiness is introduced via the Calvo framework. The financial intermediary produces loans. He faces intermediation costs, which determine the interest rate spread between the borrowing rate and the savings rate. In addition to 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 and another one on consumption expenditure of borrowers. In addition, the model also includes shocks on government purchases of the composite good, labor supply, the wage markup, distortionary tax, technology, government debt, monetary policy. Finally, the model has financial disturbances to the real resource cost of loan origination and monitoring as well as to the costs of fraudulent borrowing.
- Calibration: Many of the model parameters follow those of standard New Keynesian models such as those in Woodford (2003). The new parameters needed for the present model are those relating to heterogeneity or to the specification of the credit frictions.

1.12 NK_DEFK17: Del Negro et al. (2017)

Del Negro et al. (2017) introduce a liquidity friction into an otherwise standard DSGE model. This friction comes in two forms. First, a borrowing constraint for entrepreneurs so that they can only borrow up to a fraction of the value of their current investment. Second, a resaleability constraint that limits the amount of "illiquid" assets that can be sold. With this setup, the importance of a shock to the liquidity of private paper on the economy is examined. Can it generate a shock similar to the one in 2008 and can the government, through an increase in liquidity, effectively intervene in the economy? They find that the financial shock and the liquidity policy can have quantitatively large effects.

- Aggregate Demand: Households consist of a continuum of members each drawn to be either a worker supplying labor or an entrepreneur with an opportunity to invest. At the end of each period they share their consumption purchases and assets. Entrepreneurs want to sell as much equity and government bonds as possible to finance new capital, which yields a higher return. Hence, a negative liquidity shock affects entrepreneurs, who are not able to sell their equity anymore, thus reducing investment.
- Aggregate Supply: Intermediate good producers combine labor and capital services to produce their goods while paying a fixed cost of production. Prices are set in a staggered way, following Calvo (1983). The goods market is characterized by monopolistic competition. Labor unions set the wage for each type of labor on a staggered

basis. Competitive final good producers combine intermediate goods to sell a homogeneous final good. Finally, perfectly competitive capital producers produce investment goods that are sold to the entrepreneurs.

- Shocks: The liquidity shock comes through a change in the parameter of the resaleability constraint.
- Estimation: The model is calibrated at quarterly frequency with U.S. data from 1953:Q1 to 2008:Q3.

1.13 NK_DT12: De Fiore and Tristani (2013)

De Fiore and Tristani (2013) extend an otherwise standard New Keynesian model by introducing financial market imperfections: (wholesale) Firms need to pay wages prior to production, thus external financing is required. Asymmetric information and costly state verification between borrowers and lenders generate financial frictions in nominal terms. These frictions contribute to the propagation of the response of macroeconomic key variables to real and nominal shocks. The economy is populated by households owning retail sector firms, and entrepreneurs owning wholesale sector firms.

- Aggregate Demand: Households gain utility from consumption and leisure. Optimization leads to a standard forward-looking IS-Curve, augmented by a feed-back term on expected future spread increases. Additionally, a term including the current nominal rate is added, since this increases the financial mark-up and thus entrepreneurs' consumption.
- Aggregate Supply: The wholesale sector produces a homogeneous good under perfect competition, but subject to asymmetric information and monitoring costs. The retail sector uses the wholesale good to sell differentiated goods under monopolistic competition and Calvo Pricing.
- Shocks: The model exhibits a technology shock, the common monetary policy shock, a shock to the endowment of wholesale firms.
- Calibration: The model is calibrated at quarterly frequency, following the calibration of Woodford (2003).

1.14 NK_ET14: Ellison and Tischbirek (2014)

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 react 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-style 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 of 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 Galí (2008) and Smets and Wouters (2003, 2007).

1.15 NK_FLMF18: Filardo et al. (2018)

Filardo et al. (2018) analyse the implications of monetary policy reacting to commodity prices in the presence of the risk of misdiagnosing the drivers of commodity price developments. They use a global economic model that builds on Nakov and Pescatori (2010), and in which the global economy is split into commodity importers and exporters and commodity prices are determined endogenously by global supply and demand. The economic performance of monetary authorities depends on their ability to identify whether commodity prices are driven by global supply or demand shocks.

- Aggregate Demand: The representative household in the commodity-importing countries maximizes lifetime utility over consumption and labor subject to a standard budget constraint. The representative household in the commodity-exporting countries owns the exporting firm wholly and its utility function depends only on the consumption of final goods subject to the constraint that consumption expenditures equal dividends from commodity production. Cross-border financial autarky is assumed.
- Aggregate Supply: The commodity supply stems from two types of commodity-exporting countries: a competitive and a monopolistic one. The latter one sets prices above marginal costs, the competitive ones take prices as given. The commodity is produced using final goods sold by commodity-importing countries. There are no nominal rigidities in the commodity-exporting countries. Final goods are produced in the commodity-importing country using labor and commodities as inputs. Final-good producers act under monopolistic competition and set prices according to Calvo (1983). Monetary policy is conducted only from the perspective of the commodity-importing country.
- Shocks: The model features aggregate demand and supply shocks..
- Calibration: The model is calibrated at a quarterly frequency and mostly in line with the literature. The commodity share in the consumption basket matches the share of primary commodity inputs in the US CPI (10%). The share of commodities in the production function is set to 10%, following Arseneau and Leduc (2013). The competitive commodity production sector has a size of 10% relative to GDP.

1.16 NK_FNL23: Ferrari and Nispi Landi (2023)

Ferrari and Nispi Landi (2023) develop a medium-scale closed economy environmental DSGE model and calibrate it for the Euro Area. The model features a polluting sector and examines to what extend Green Quantitative Easing is a useful policy tool to reach a net zero target in emissions.

- Aggregate Demand: Households maximize their lifetime utility, where the choice variables are consumption, hours worked, as well as green, brown and public bonds. Households feature a greenium, i.e. they derive utility from investing in "green" (non-polluting) firms, and disutility from investing in "brown" (polluting) firms.
- Aggregate Supply: The representative final-goods firm uses a CES bundle to produce the final good with input from an intermediate firm. There are intermediate firms in monopolistic competition that produce bundles of green and brown production. They set their prices subject to the demand of the final good firm and pay quadratic adjustment costs. They use input from Green and Brown firms, which they acquire for a type-specific price. Green and Brown firms issue bonds to households and the central bank and buy capital from a capital producer. Polluting firms have to pay a tax for every unit of emissions they produce. For each unit of brown output, there are carbon units released in the atmosphere and complied in the atmospheric stock of carbon. A fraction of emissions is abated.
- Shocks: The model contains a total factor productivity shock and an expansionary monetary policy shock.
- Calibration/Estimation: The model is calibrated to the Euro Area, following the New Area- Wide Model (NAWM-II).
- Replication: We replicated the impulse response functions to a positive TFP and an expansionary Monetary Policy shock. The variables include output, consumption, and inflation.

1.17 NK_GHP16: Gnocci et al. (2016)

Gnocci et al. (2016) introduce housework in an otherwise standard business cycle model. Introducing substitutability between home-produced and market goods, they generate com-plementarity between market consumption and hours worked and analyse how it affects the size of the fiscal multiplier.

- Aggregate demand: Households maximize their lifetime utility, subject to an intertemporal budget constraint, where the utility function is increasing in both consumption and leisure and concave. They can consume home produced goods and market goods. Leisure is the residual time after subtracting hours worked at home and on the market from the time endowment.
- Aggregate supply: There are infinitely many monopolistically competitive firms that buy market capital and hours worked to produce varieties of the market good. Prices are set following Calvo (1983).
- Shocks: This paper presents responses to a government spending shock.
- Calibration: The model is calibrated at quarterly frequency in order to match especially the sample averages of the ratio of investment to the capital stock, the capital-output ratios, the hours worked at home and on the market, and the share of government expenditure in GDP. The time series used refer to the time period 1950:Q1 to 2007:Q2, excluding the financial crisis.

1.18 NK_GK11: Gertler and Karadi (2011)

Gertler and Karadi (2011) build a quantitative monetary DSGE model with financial intermediaries that face endogenously determined balance sheet constraints. The authors use the model to analyse unconventional monetary policy measures.

- Aggregate Demand: The representative household's utility is separable in consumption and leisure and allows for habit formation in consumption. Households postpone their consumption by holding deposits with the financial intermediaries. The amount of deposits is determined in such a way as to guarantee that the bankers' incentive constraint is satisfied. Expected-lifetime utility is maximized by choosing consumption and labor supplied to intermediate firms.
- Aggregate Supply: The financial intermediaries issue contingent claims to firms, financed by deposits. An agency problem between the intermediaries and the depositors generates an endogenous leverage constraint with respect to the leverage ratio of the financial intermediaries. Competitive firms produce intermediate goods using labor services and capital, the latter of which is produced by a capital producer. Retail firms have monopolistic power and re-package intermediate output. Nominal frictions are introduced in the form of Calvo sticky prices. Non-reoptimizing firms index their prices to the previous period's inflation rate.
- Shocks: Capital quality shock, which affects the effective quantity of the capital stock.
- Calibration/Estimation: The financial sector parameters are chosen to satisfy a steady state interest rate spread of 100 basis points, a steady state leverage ratio of four, and an average lifetime horizon of bankers of a decade. The calibration of the conventional parameters mostly follows Christiano, Eichenbaum and Evans (2005).

1.19 NK_GK13: Gertler and Karadi (2013)

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 (which are subject to adjustment costs) and financed issuing state-contingent securities to banks. Monopolistic retail firms, subject to Calvo-style 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 or, while facing a zero-lower-bound constraint, 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.

1.20 NK_GLSV07: Galí et al. (2007)

Galí et al. (2007) extend the standard New Keynesian model to allow for the presence of rule-of-thumb consumers for which consumption equals labor income. This enables them to generate an increase in consumption in response to a rise in government spending, in a way consistent with much of the recent evidence. Rule-of-thumb consumers

partly insulate aggregate demand from the negative wealth effects generated by the higher levels of (current and future) taxes needed to finance the fiscal expansion, while making it more sensitive to current disposable income. The article considers two labor market structures. Here, the version of the model with imperfect labor markets is replicated and implemented in the MMB.

- Aggregate demand: Households gain utility from consumption and leisure subject to appropriate budget constraints. A fraction $(1 - \lambda)$ of households have access to capital markets where they can trade a full set of contingent securities, and buy and sell physical capital (Ricardian households). The remaining fraction λ of households do not own any assets nor have any liabilities, and just consume their current labor income (rule-of-thumb households). Additionally, two alternative labor market structures are considered in the paper. The first one assumes a competitive labor market, with each household choosing the quantity of hours supplied given the market wage. Under the second labor market structure wages are set in a centralized manner by an economy-wide union. In that case hours are assumed to be determined by firms (instead of being chosen optimally by households), given the wage set by the union.
- Aggregate supply: Intermediate firms act under monopolistic competition and set nominal prices in a staggered fashion à la Calvo (1983). Their products are used as inputs by firms which produce final goods. Perfectly competitive final-good firms produce with a constant returns technology.
- Shocks: This paper presents responses to a government spending shock.
- Calibration: The model is calibrated at quarterly frequency.

1.21 NK_GM05: Galí and Monacelli (2005)

Galí and Monacelli (2005) develop a model of a small open economy which is part of a world economy comprised of a continuum of small open economies sharing identical preferences, technology and market structure but facing imperfectly correlated productivity shocks. With this framework, the authors analyze the macroeconomic implications of three different rule-based policy regimes for a small open economy, pointing out the trade-offs the authorities face between the stabilization of the nominal exchange rate, domestic inflation and the output gap.

- Aggregate Demand: The representative household in a small open economy seeks to optimize its utility separable between consumption and leisure subject to its budget constraint. Consumption is a composite of domestic and foreign goods, weighted by the degree of home bias in preferences, which represents the index of country openness. The dynamic IS equation is similar to that found for a closed economy but with the degree of openness influencing the sensitivity of the output gap to interest rate changes. Furthermore, the natural interest rate depends on the expected growth of world output.
- Aggregate Supply: Differentiated goods are produced from a typical firm using a linear technology with labor as input. Firms face price stickiness à la Calvo as in the case of a closed economy. Importantly, marginal costs are increasing in the terms of trade and in world output. The degree of country openness affects the slope of the New Keynesian Phillips curve of the small open economy, thus affecting the response of inflation to variations in the output gap.
- The Foreign Sector: Purchasing Power Parity and the law of one price hold. There is prefect exchange rate pass-through. Under the assumption of complete international financial markets, an international risk sharing in the form of the uncovered interest rate parity is obtained.
- Shocks: A domestic productivity shock and a world demand shock.
- Calibration/Estimation: The model is calibrated mostly to fit some characteristics of the Canadian economy. In order to calibrate the stochastic properties of the exogenous driving forces, AR(1) processes are fitted, using quarterly, HP-filtered data over the sample period 1963:Q1–2002:Q4.

1.22 NK_GM07: Goodfriend and McCallum (2007)

Goodfriend and McCallum (2007) develop a small New Keynesian model with a banking sector and several interest rates to analyze the role of the banking sector for the evaluation of monetary policy. There are two versions of the model: one in which monetary policy is represented by a money supply rule, and one in which it is represented by a rule for the short-term nominal interest rate. Here, we focus on the latter. The model in the original article contains a mistake, which is detailed in the replication package. We implement the corrected version of the model in the MMB.

- Aggregate Demand: A representative household-firm maximizes expected utility derived from consumption and labor. The utility function is additive separable. Its budget constraint features capital accumulation, real balances and government bonds. Furthermore it receives the income derived from wages and (in its function as a monopolistically competitive firm) from selling its good on the market. Furthermore, consumption is constrained via a transaction constraint by the amount of deposits in the bank.

- Aggregate Supply: Goods are produces with a standard Cobb-Douglas production function, featuring labor and capital. In the linearized system, the capital stock is held constant. The model features a standard New Keynesian Phillips Curve.
- Banking System and Interest Rates: The balance sheet of the bank features loans and money holdings on the asset side and deposits on the liability side. The bank produces loans with a Cobb-Douglas production function featuring labor for monitoring loans as well as collateral. Collateral is a function of the amount of capital and bonds in the economy. The model features interest rates on a hypothetical riskless bond without collateral value, the rate on bonds, on capital (both determined by the respective collateral values of bonds and capital), on loans, and the interbank rate, which serves as a policy instrument in the interest rate rule.
- Shocks: The model features an interest rate shock, a TFP shock, a shock to the collateral value of capital, and a shock to the monitoring efficiency of banks.
- Calibration/Estimation: The model is calibrated to match features of US data. The non-banking parameters are standard. The parameters in the banking system are set such as to match interest rate spreads, the reserve ratio and the velocity of money in the US.

1.23 NK_GM16: Galí and Monacelli (2016)

Galí and Monacelli (2016) study the gains from increased wage flexibility using a small open economy model with staggered price and wage setting and comparing the cases of an independent monetary policy versus a currency union. The model builds on the framework developed in Galí and Monacelli (2005), extended by introducing sticky nominal wages (in addition to sticky prices) and additional shocks (labor tax shock, domestic demand, exports, and world interest rate). Two results stand out: (i) the effectiveness of labor cost reductions as a means to stimulate employment is much smaller in a currency union, and (ii) an increase in wage flexibility often reduces welfare, more likely so in an economy that is part of a currency union or with an exchange rate-focused monetary policy.

- Aggregate Demand: The representative household (that has a continuum of members) in a small open economy seeks to optimize its utility separable between consumption and leisure subject to its budget constraint. Consumption is a composite of domestic and foreign goods, weighted by the degree of home bias in preferences, which represents the index of country openness. Each household member is specialized in a differentiated occupation and supplies labor. Workers specialized in each occupation (or a union representing them) set the corresponding nominal wage, subject to an isoelastic demand function for their services. Each period only a fraction of labor types, drawn randomly from the corresponding population, have their nominal wage reset.
- Aggregate Supply: Differentiated goods are produced from a typical firm using a technology and constant elasticity of substitution (CES) function of the quantities of the different types of labor services employed. Firms face price stickiness à la Calvo (1983). Employment is subject to a proportional payroll tax, common to all labor types.
- The Foreign Sector: As in Galí and Monacelli (2005), the size of the home economy is presumed to be negligible relative to that of the world economy, which allows taking world aggregates as exogenous. Furthermore, it is assumed that the law of one price holds and that financial markets (both domestic and international) are complete.
- Monetary Regime: Equilibrium behavior of the small open economy under two monetary policy regimes is considered. Under the first, which they refer to as inflation targeting, the central bank focuses on stabilizing domestic inflation. Under the second monetary regime, the home economy is assumed to be part of a world currency union, where domestic nominal interest rate will move one-for-one with the world interest rate, independent of domestic economic conditions.
- Shocks: Domestic productivity and demand shock, two types of global shocks (export shock and world interest rate shock) and the labor tax shock.
- Calibration: The model is calibrated mostly to fit some characteristics of the Euro Area and its peripheral countries.

1.24 NK_GMAS25cpi: Monacelli (2025)

Monacelli (2025) develops a model of a small open economy that is part of a world economy comprised of a continuum of small open economies sharing identical preferences, technology, and market structure but facing imperfectly correlated productivity shocks. With this framework, the authors analyze the macroeconomic implications of three different rule-based policy regimes for a small open economy, pointing out the trade-offs the authorities face between the stabilization of the nominal exchange rate, domestic inflation, and the output gap.

- Aggregate Demand: The representative household in a small open economy seeks to optimize its utility separable between consumption and leisure subject to its budget constraint. Consumption is a composite of domestic and foreign goods, weighted by the degree of home bias in preferences, which represents the index of country openness. The dynamic IS equation is similar to that found for a closed economy, but with the degree of openness influencing the sensitivity of the output gap to interest rate changes. Furthermore, the natural interest rate depends on the expected growth of world output.
- Aggregate Supply: Differentiated goods are produced from a typical firm using a linear technology with labor as input. Firms face price stickiness à la Calvo as in the case of a closed economy. Importantly, marginal costs are increasing in terms of trade and in world output. The degree of country openness affects the slope of the New Keynesian Phillips curve of the small open economy, thus affecting the response of inflation to variations in the output gap.
- The Foreign Sector: Purchasing Power Parity and the law of one price holds. There is a perfect exchange rate pass-through. Under the assumption of complete international financial markets, an international risk sharing in the form of the uncovered interest rate parity is obtained.
- Shocks: A domestic productivity shock and a world demand shock.
- Calibration/Estimation: The model is calibrated mostly to fit some characteristics of the Canadian economy. In order to calibrate the stochastic properties of the exogenous driving forces, AR(1) processes are fitted, using quarterly, HP-filtered data over the sample period 1963:Q1–2002:Q4.
- Tariffs: In addition to Galí and Monacelli (2005), this model also includes import tariffs; the tariff revenue is not considered, it more fares as an exogenous price shock. The target inflation for the monetary policy rule used is the CPI, such that imports also have a weight in the central bank's policy decision.
- Replication: As the model is still in working paper status, we derived a similar model to Monacelli (2025) with some elements of Bianchi & Coulibaly(2025). As only the tariff sector is affected, the model is observationally equivalent to Galí and Monacelli (2005) when no tariffs are present!
- For NK_GMAS25_PPI the setup is exactly the same as in NK_GMAS25, with the difference that here the central bank targets PPI inflation, so only domestic prices. This leads to different policy decisions and trajectories compared to NK_GMAS25. Again, in the absence of tariffs, the model is observationally equivalent to Galí and Monacelli (2005).

1.25 NK_GN25: Gnocato (2025)

NK_GN25 is a tractable HANK model developed by Gnocato (2025) focusing on the effects of energy price shocks on unemployment and labor-market dynamics.

- Agents and Structure: The model distinguishes between workers and firm owners, with explicit labor-market flows driven by search and matching frictions. Unemployment and job-finding rates are endogenously determined. Workers have Stone–Geary preferences with a subsistence level of energy consumption, where the relative share of energy in total consumption differs between employed and unemployed workers.
- Production and Energy: Oil/energy is required as an input in production. Production technologies combine labor and energy using a Leontief specification.
- Monetary Policy: The central bank follows a Taylor rule, responding to both inflation and measures of labor-market slack. The policy rule can be modified to explore welfare implications under alternative regimes.
- Shocks: The model is subject to exogenous energy-price shocks, productivity shocks, and standard monetary disturbances. Household heterogeneity implies differential exposure to shocks.
- Calibration: Parameters are set to match euro area data in the early 2020s, focusing on the joint dynamics of energy prices, unemployment, and output.
- Replication: Model replication includes computing IRFs to energy shocks under complete inflation targeting.

1.26 NK_GS14: Gambacorta and Signoretti (2014)

Gambacorta and Signoretti (2014) simplify the model by Gerali et al. (2010), which introduc-es a monopolistically competitive banking sector into a DSGE model with financial frictions á la Iacoviello (2005). This simplified version focuses on two frictions: a borrowing constraint, depending on the collateral's value, and a bank leverage constraint.

- Aggregate demand: Additionally to banks, there are two types of agents in the model: patient households and impatient entrepreneurs. Subject to a budget constraint, the households maximize their lifetime utility, choosing the levels of consumption, labor supply and bank deposits. Entrepreneurs are net borrowers and maximize their lifetime utility, choosing levels of consumption, labor demand and bank loans, subject to budget and borrowing constraints.
- Aggregate supply: Entrepreneurs produce a wholesale good using household's labor and own physical capital. Retailers buy the intermediate goods, brand them and sell the differentiated goods at a price including a mark-up over the purchasing cost. Sticky prices á la Rotemberg (1982) imply a New Keynesian Phillips curve.
- Banking sector: Each bank consists of two units: a wholesale and a retail branch. The wholesale unit collects deposits from households and issues loans, paying the interest rate set by the central bank and earning a wholesale loan rate. There exists a target leverage ratio and for deviating the bank has to pay a cost. The retail unit acts under monopolistic competition. It buys wholesale loans, differentiates them and resells them, applying a constant mark-up.
- Shocks: There is a technology shock and a cost-push shock.
- Calibration: The calibration is based on Gerali et al. (2010).

1.27 NK_GSSZ17: Gilchrist et al. (2017)

Gilchrist et al. (2017) present a small-scale DSGE models with financial frictions to explain inflation dynamics during the financial crisis. In response to contractionary financial or demand shocks, financial frictions create incentives for firms to raise prices, therefore mitigating the deflationary effects of shocks.

- Aggregate demand: Households maximize their lifetime utility, where the per-period utility function is separable in consumption and labour. Household utility from consumption is subject to good-specific external habits á la Ravn, Schmitt-Grohé and Uribe (2006).
- Aggregate supply: Intermediate goods production is done by a continuum of monopolistically competitive firms using a production function with decreasing returns to scale and fixed operating costs. Firms maximize the present value of discounted dividends and must commit to pricing and production decisions prior to realizations of their idiosyncratic shock. Depending on the shock realization, firms must raise external funds in order to pay workers. Firms can obtain external funds by issuing new equity subject to dilution costs reflecting agency problems in the financial markets. Firms also face Rotemberg (1982) quadratic adjustment costs when changing nominal prices.
- Shocks: Technology shock, demand shock, financial shock and a monetary policy shock.
- Calibration: The model is calibrated for the US using standard values for the core block and following previous literature for the deep habits, the elasticities of substitution and financial market frictions.
- Replication: We simulated the impulse response functions to a demand shock in the economy with financial frictions and nominal rigidities, Figure 5 (red line) in the paper.

1.28 NK_IR04: Ireland (2004)

Ireland (2004) develops a small New Keynesian model with real money balances entering both the forward-looking IS curve and the Phillips curve. The model is used to study the role of money in the U.S. business cycle.

- Aggregate Demand: A representative household maximizes expected utility, nonseparable between consumption and real money balances while separable in leisure, subject to a budget constraint. The optimizing behavior of this household leads to a forward-looking IS curve with real money balances entering the specification. This is due to the non-separability of real balances to consumption in the utility function, as real balances affect the marginal rate of intertemporal substitution.
- Aggregate Supply: A representative firm produces final goods according to a constant-returns-to-scale technology, using labor and intermediate goods as inputs. On the other hand, intermediate goods are produced under a linear technology using labor as input. The representative intermediate goods-producing firm has monopolistic power in the market, therefore acting as a price-setter. However, price setting is subject to Rotemberg quadratic adjustment costs. The optimizing behavior of this firm leads to a forward-looking Phillips curve with real money balances entering the specification.
- Shocks: An overall preference shock, a real money balances preference shock, a productivity shock and a monetary policy shock.
- Calibration/Estimation: Estimated via maximum likelihood using U.S. quarterly data over the period 1980:Q1–2001:Q3.

1.29 NK_JO15ht, NK_JO15lt: Jang and Okano (2015)

Jang and Okano (2015) examine the effects of foreign productivity shocks on monetary policy in a symmetric two-country New Keynesian model, following Galí and Monacelli (2005). In response to asymmetric productivity shocks, firms in one country achieve a more efficient level of production and the terms of trade are directly affected by changes in both economies' output levels. International trade creates a transmission channel for inflation dynamics to which domestic monetary authority should react. Authors conclude that duration of output and inflation responses to changes in the level of foreign productivity is strongly affected by trade openness and that a monetary authority should be cautious about changes in foreign productivity level. Moreover, open economies should coordinate their policy responses to asymmetric shocks.

- Aggregate Demand: The representative household in both economies seeks to optimize its utility that is separable in consumption and leisure, subject to its budget constraint. Consumption is a composite of domestic and foreign goods, weighted by the degree of home bias in preferences, which represents the index of country openness. The dynamic IS equation is similar to that found for a closed economy but with the degree of openness influencing its coefficients.
- Aggregate Supply: Differentiated goods are produced from a typical firm using a linear technology with labor as input. Firms face price stickiness à la Calvo as in the case of a closed economy. The degree of country openness affects the slope of the New Keynesian Phillips curves in both economies. Additionally, firms borrow from households at the gross nominal interest rate in order to pay wages. Nominal wage, therefore, corresponds to the discounted value of the nominal payoff in period t+1 generated by the portfolio held by households (Ravenna and Walsh (2006)).
- Shocks: Foreign productivity shock, but domestic productivity shock, as well as foreign and domestic monetary policy shocks, could be considered.
- Calibration: The model calibration is based on open-economy DSGE literature, with the parameter values as in Smets and Wouters (2002), Faia and Monacelli (2008), and Rabanal and Tuesta (2010).

1.30 NK_KM16: Krause and Moyen (2016)

The aim of the authors is to study the effects of an inflation target increase on real public debt. For this purpose, they employ a standard New Keynesian model augmented with long term debt with stochastic maturity.

- Aggregate Demand: As in Rotemberg and Woodford (1997), households maximize lifetime utility from consumption leisure and money holdings subject to an intertemporal budget constraint while they own the firms. They have access to one-period bonds payed at the policy interest rate rule and to long term bonds with stochastic maturity.
- Aggregate Supply: Final good producing firms operate under perfect competition, combining the intermediate goods in final good. Intermediate firms are monopolistic competitors with a linear production function on labour, facing price rigidity à la Calvo.
- Financial Authority: The government follows a tax rule that reacts to deviations of real debt from its steady state level. Revenues come from a labour tax and newly issued debt while expenditures consist of exogenous government spending, interest payments on bonds and principal payments of the redeemed bonds.
- Monetary Authority: The Central Bank follows a Taylor interest rate rule with high persistence, that responds to output gap as well as to deviations of the inflation target from its steady state.
- Shocks: The model incorporates various shocks such as a monetary policy shock, an inflation target shock, a government spending shock and finally a debt shock. A debt shock is assumed to increase debt by 65% from the current debt- to GDP ratio. All variables responses are expressed as percentage deviations from the steady state values apart from inflation and interest rates which are reported in annualized absolute deviations.
- Calibration: The model is parametrized at quarterly frequency. Basic parameters values follow Smets and Wouters (2007). The stochastic maturity of bonds is set to 0.0472 so as to match the average maturity of US debt accounting to 5.3 years..

1.31 NK_KRS12: Kannan et al. (2012)

The NK_KRS12 model is a DSGE model with housing in the spirit of Iacoviello (2005) and Iacoviello and Neri (2010) to study the role of monetary policy in mitigating the effects of house price booms. They find that a monetary policy rule with credit aggregates can help counter accelerator mechanisms that push up credit growth and house prices. They also study the effect of macroprudential polices on welfare.

- Aggregate Demand: There are two types of households, the borrowers ("impatient") and the savers ("patient"). They both derive utility from consumption, holdings of housing and leisure. The impatient households discount the future more heavily. This specification induces the impatient households to face borrowing constraints, which is consistent with standard lending criteria used in the mortgage market where the borrowing is limited to a fraction of the housing value. For both types of households, the holdings of housing are subject to housing adjustment costs.
- Aggregate Supply: There are two type of producers: Final good producers operating under perfect competition and intermediate good producers that supply their goods imperfectly. Price is set à la Calvo-type of restrictions.
- Financial Sector: Borrowers and savers can meet only through financial intermediaries, which charge a spread that depends on the net worth of borrowers. The determination of the spread follows the financial accelerator idea of Bernanke et al. (1999).
- Shocks: A housing demand shock, a financial shock and a technology shock.
- Calibration/Estimation: A mixture of calibrated and estimated parameters for the US economy. Parameters governing real and nominal rigidities are taken from Iacoviello and Neri (2010).

1.32 NK_KW16: Kirchner and van Wijnbergen (2016)

Kirchner and van Wijnbergen extend the model by Gertler and Karadi (2011) such that banks are allowed to hold government bonds in addition to capital assets. In this model, the authors analyze the effects of a government spending shock. The main point of the paper is that when banks are balance sheet constrainted, debt-financed fiscal expansions trigger a crowding out of loans to private firms on the banks' balance sheet and reduce the government spending multiplier. Additionally the effects of equity injections into the banking system by the government are evaluated.

- Aggregate Demand: as in NK_GK11
- Aggregate Supply: as in NK_GK11
- Financial Sector: similar to NK_GK11, but in addition to loans to private firms, banks hold government bonds on their balance sheet. Thus fiscal policy becomes relevant and enters the model.
- Shocks: The model features a government spending shock, a capital quality shock, a monetary policy shock, and a TFP shock.
- Calibration/Estimation: The calibration of most parameters in the paper follows NK_GK11. The divertibility parameter for government bonds is the same as for capital assets. The debt-to-GDP ratio is set to 60% of annualized GDP.

1.33 NK_LWW03: Levin et al. (2003)

This model is used for comparison in the robustness analysis of monetary policy rules by Levin et al. (2003). Its structure is similar to the NK_RW97 model presented above, but without explicit treatment of government spending.

- Aggregate Demand: Standard New Keynesian IS curve.
- Aggregate Supply: Standard New Keynesian Phillips curve.
- Shocks: A cost-push shock, a shock to the real interest rate and the common monetary policy shock.
- Calibration/Estimation: In calibrating the model, the parameter values of Woodford (2003) adjusted for annualized variables as in Levin et al. (2003) are used.

1.34 NK_MCN99cr: McCallum and Nelson (1999)

The model in McCallum and Nelson (1999) is used to monitor the performance of operational monetary policy rules. Two distinct variants of the model are used, mainly differing in the choice of the aggregate supply setup. In the first setup, aggregate supply is based on a standard Calvo-Rotemberg (NK_MCN99cr) specification of the Phillips curve where inflation is linked to expected inflation and the output gap. In the second setup of the model, the authors introduce the so-called P-bar price adjustment (NK_MCN99pb) where price changes occur in order to gradually eliminate deviations of actual from market clearing values of output.

- Aggregate Demand: Standard New Keynesian IS and LM curve.
- Aggregate Supply: Two setups: (i) Standard New Keynesian Phillips curve (NK_MCN99cr), (ii) P-bar price adjustment (NK_MCN99pb).
- Shocks: A shock to the IS curve which follows an AR(1) process, a shock to the LM curve, an investment shock, a shock on capacity output and the common monetary policy shock.
- Calibration/Estimation: The model equations are estimated individually by ordinary least squares and instrumental variable estimation for U.S. data. The sample period comprises 1955–1996.

1.35 NK_MI14: Michaillat (2014)

Michaillat (2014) embeds a search-and-matching model into a New Keynesian model to analyse the effects of an increase in public employment at different stages of the business cycle. In this model, the public-employment multiplier is positive and countercyclical.

- Aggregate Demand: A representative large household maximizes expected lifetime utility by choosing an optimal consumption stream subject to a budget constraint. Workers in a household pool their income before choosing their consumption of the final good and how much to save via one-period bonds. The government does not consume in the form of purchasing goods from the private sector but compensates public employees.
- Aggregate Supply: Final-Good firms produce the final good using intermediate goods and sell it on a perfectly competitive market. The intermediate good is produced by a monopolist using labor as the sole input. The monopolist faces a price-adjustment cost following Rotemberg (1982) and needs to pay a hiring cost.
- Labour Market: The labor market has a search-and-matching structure in which the number of matches is given by a Cobb-Douglas function of vacancies and unemployment. The probability of finding a job and the rate of filling vacancies both for the private and the public sector depend on the labor market tightness. The fraction of destroyed worker-job matches is constant and exogenous and the real wage is a function of technology.
- Shocks: In the model there is a technology shock that directly affects real wages.
- Calibration: The model is calibrated to a weekly frequency to US data. The calibration in the replication file remains weekly, but the model that is implemented in the MMB is calibrated to a quarterly frequency.

1.36 NK_MM10: Meh and Moran (2010)

The NK_MM10 model is a medium-scale DSGE model with a banking sector where bank capital plays a crucial role in mitigating the moral hazard problem between bankers and their creditors. The model is developed to see whether or how significant the capital position of bank influences the business cycle through a bank capital channel. There are three groups of agents in the model: households, entrepreneurs, and banks.

- Aggregate Demand: Households consume, allocate savings between currency and bank deposits, provide the differentiated labor services, choose a capital utilization rate, and buy capital goods. Entrepreneurs and bankers are risk neutral and they consume their accumulated wealth when exiting the economy. New agents with zero assets replace exiting ones. Monetary authority sets the short-term interest rate according to the Taylor rule.
- Aggregate Supply: Monopolistically competitive firms manufacture intermediate goods subject to nominal rigidities. Competitive firms produce final goods aggregating intermediate goods. Entrepreneurs produce capital goods with a technology that uses final goods as inputs and faces idiosyncratic uncertainty.
- Financial Contract: The optimal financial contract among three parties (an entrepreneur, a bank, an investor (household)) borrowed from Holmstrom and Tirole (1997) represents the financial sector in the model economy. There are two moral hazard problems presented in this framework due to the imperfect and costly monitoring technology of a bank. The certain levels of banks' net worth as well as entrepreneurial net worth are needed in order to incentivize banks and investors.
- Shocks: A technology shock, a monetary policy shock, a shock to bank capital
- Calibration/Estimation: Many of model parameters are calibrated following the previous DSGE literature such as Christiano et al. (2005). Parameters related to financial contract are calibrated such that the model's steady state meets several counterpart empirical moments.

1.37 NK_MPT10: Monacelli et al. (2010)

Monacelli et al. (2010) employ a model with search and matching frictions in the labor markets to analyze the effects of government spending on the unemployment rate in the US. While the main analysis in the model is conducted in an RBC model, the replicated and implemented model in the MMB is the version of the model with sticky prices that is discussed in section 7 of Monacelli et al. (2010). While in most versions of the model, which the authors discuss, the unemployment multiplier is small, they show that large effects of government spending on unemployment can be obtained, when complementarities between consumption and leisure in the utility function is coupled with price stickiness.

- Aggregate Demand: The representative household is modelled as a large family with a continuum of members. They pool income and consumption and maximize a common utility function. There are complementarities between consumption and leisure in the utility function. Households consume, work, and invest in bonds and capital assets, where investment in capital is subject to adjustment costs. They search for vacant jobs and engage in wage bargaining with hiring firms.

- Aggregate Supply: Firms produce output goods with a Cobb-Douglas production function featuring capital and labor. The model version implemented here, additionally features monopolistically competitive retailers, which are subject to nominal rigidities à la Calvo. Firms engage in wage bargaining as well.
- Labor market: Matches in the labor markets are produced with a Cobb-Douglas function of unemployed workers and vacancies. The probabilities of finding a job and of filling a vacancy are endogenous. The separation rate is exogenous. Wages are the result of Nash bargaining between households and firms. The respective reservation wages for households and firms are functions of the disutility of labor, the marginal product of labor and the respective search costs for households and firms.
- Shocks: The model features a government spending shocks and an interest rate shock.
- Calibration/Estimation: In the replication file, the model is calibrated to monthly frequency. In file that is implemented in the MMB, the calibration is quarterly. The model is calibrated to US data. The parameters specific to the labor market are chosen such that is matches the average job finding probability and the average tightness in the data, and to satisfy the Hosios condition.

1.38 NK_NS14 : Nakamura and Steinsson (2014)

Nakamura and Steinsson (2014) analyze the effects of government spending in a monetary and fiscal union like the United States. They estimate so-called Open Economy Multiplier (OEM), the effect an increase in government spending of one region has on relative output and employment in another region of the union. Their model explores three different types of New Keynesian DSGE open economy models consisting of two regions within one country to estimate the OEM. The authors find that the model with firm-specific capital replicates the empirical estimates the best. This model is implemented in the MMB.

- Aggregate Demand: Households maximize Greenwood, Hercowitz and Huffman (1988) (GHH) type utility in both region subject to their budget constraints. The GHH utility function emphasizes the complementarity of consumption and labor supply. Both regions have integrated goods market and each household consumes both home and foreign goods. The solutions to the HHs' problem in each region, the Euler equations, represent the aggregate demand. They show that the change in consumption is a function of the expected inflation, interest rate and the change in labor supply. Furthermore, consumption in the two regions are linked by relative labor supply and the real exchange rate capturing relative purchasing power.
- Aggregate Supply: Firms in each region produce their own goods using labor and capital. Each firm maximizes its profit subject to the demand constraint from home and foreign consumption and government spending in their own region. Regarding the price setting, firms keep their price unchanged with the probability of α according to Calvo (1983). For the capital stock, each firm has its own capital and decides how much to invest in each period. Firms face convex capital adjustment costs, leading to smooth capital formation. Consequently, the aggregate supply, represented by the Phillips curve, is standard.. The current inflation rate depends on discounted future inflation and firm marginal cost.
- Policies: Since this model assumes two regions within a monetary union, there exists one central bank whose policy affects both regions simultaneously. However, fiscal spending is carried out on the regional level, tax is levied on the federal level. Taxes are assumed to be non-distortionary.
- Shocks: There is a government spending shock in each region and a monetary policy shock.
- Calibration/Estimation: The parameters are calibrated to match the U.S. economy.

1.39 NK_PP17: Paoli and Paustian (2017)

Paoli and Paustian (2017) study optimal monetary and macroprudential policies in a small-scale calibrated New Keynesian DSGE model with a moral hazard problem between banks and depositors in the spirit of Gertler and Karadi (2011). The possibility of banks diverting funds from depositors implies that banks are constrained in the amount they can lend to firms. This financial friction motivates the use of macroprudential instruments.

- Aggregate demand: Households maximize their lifetime utility, where the per-period utility function is separable in consumption and two types of labour. They can hold deposits at financial intermediaries.
- Aggregate Supply: Intermediate firms combine both types of labour into the intermediate good using a Cobb-Douglas production function. The entrepreneurs operating the intermediate firms must pay the wage bill associated with one of the inputs before production. Monopolistically competitive final goods firms purchase intermediate goods from entrepreneurs and create final goods using a linear production function. Final goods pricing is subject to Rotemberg quadratic adjustment costs. The final goods are aggregated to an output bundle according to a CES function.

- Financial intermediaries: Banks lend to intermediate goods producers and collect deposit. They also receive a direct subsidy from the macroprudential authority. Bankers maximize terminal net wealth and have the possibility to divert a certain fraction of assets. This yields an endogenous leverage constraint such that the incentive compatibility constraint is satisfied. Together with the borrowing-in-advance constraint, this introduces a credit friction.
- Shocks: A productivity shock, a mark-up shock, a net worth shock, a moral hazard shock and a monetary policy shock.
- Calibration/Estimation: The parameters are calibrated to match the U.S. economy at quarterly frequency.

1.40 NK_PSV16: Pancrazi et al. (2016)

Pancrazi et al. (2016) consider the so-called financial accelerator mechanism used in many articles since Bernanke et al. (1999) and show that the procedure of approximating the price of old capital by the net-of-depreciation price of new capital has profound implications when the capital depreciation rate is positive. When accounting for the appropriate price of capital, the effects of the financial accelerator are even stronger than originally assessed. Since the setup is the same as in Bernanke et al. (1999) where entrepreneurs borrow in credit markets to finance their investment in capital, the strength of the financial accelerator turns out to depend crucially on the dynamics of the price of capital. This conclusion has important first-order effects on the solution of a model that assumes a positive depreciation rate of capital together with investment adjustment costs.

- Aggregate demand: Households gain utility from consumption, leisure and real money balances. They work, consume, pay taxes, hold money, and invest their savings, in form of deposits, in a financial intermediary that pays the riskless rate of return. These deposits are transferred to entrepreneurs in the form of loanable funds. Entrepreneurs use capital and labor to produce wholesale goods that are sold to the retail sector. Each period, entrepreneurs have to accumulate capital that becomes available for production in the subsequent period. Entrepreneurs have to borrow from households via a financial intermediary to finance capital purchases. Since the financial intermediary has to pay some auditing costs to observe the idiosyncratic return to capital, an agency problem arises. The optimal contract leads to an aggregate relationship of the spread between the external finance costs and the risk-free rate and entrepreneurs' financial conditions represented by the leverage ratio.
- Aggregate supply: Retail firms act under monopolistic competition. They buy wholesale goods produced by entrepreneurs in a competitive market and differentiate them at zero cost. Price stickiness is introduced via the Calvo (1983) framework. Bernanke et al. (1999) assume that reoptimizing firms have to set prices prior to the realization of shocks in that period, so that previous period's expectations of the output gap and future inflation enter the New Keynesian Phillips curve.
- Shocks: This paper presents responses to a technology shock, as well as to a monetary policy shock.
- Calibration/Estimation: The model is calibrated at quarterly frequency.

1.41 NK_RA16: Rannenberg (2016)

Rannenberg (2016) develops a model, which combines the financial frictions developed by Bernanke et al. (1999) and by Gertler and Karadi (2011), and analyses the effects of contractionary shocks, to capture features of the Great Recession. The role of both financial frictions are illustrated by comparing model variants, in which one, none or both frictions are turned off. The model matches the relative volatility of the external finance premium and the procyclicality of bank leverage observed in US data. Here, the full model is replicated and implemented.

- Aggregate Demand: Representative households consume, work, and invest in riskless one-period bonds. Utility is separable in consumption and leisure. The utility function features habit formation.
- Aggregate Supply: Perfectly competitive capital good producers invest in new capital, subject to convex investment adjustment costs. Retailers produce output with a Cobb-Douglas production function featuring capital and leisure. They finance a fraction of their factor costs by working capital loans from banks. They act under monopolistic competition and set their prices subject to Calvo frictions. The model used in the simulation additionally features variable capital utilization.
- Financial Sector: Banks extend riskless loans to retailers and risky loans to entrepreneurs. When bankers exit the sector, they consume a fraction of their net worth. The initial net worth that new bankers receive is a constant. In all other features they are identical to banks in Gertler and Karadi (2011). While banks are risk averse, entrepreneurs are risk-neutral. They accumulate capital, take loans from banks and can default. In all other features they are modelled as in Bernanke et al. (1999). The optimal contract is between the bank and the entrepreneur.

- Shocks: The implemented model features a TFP shock, a government spending shock, and an interest rate shock.
- Calibration/Estimation: The model is calibrated to US data over the period from 1990Q1 to 2013Q4. Rannenberg highlights some of the targets for the calibration in the data. Among them the risk free rate, the spread of the loan rate over the risk-free rate, the leverage ratio of the non-financial sector, the quarterly bankruptcy rate of entrepreneurs, and the bank capital ratio.

1.42 NK_RW06: Ravenna and Walsh (2006)

Ravenna and Walsh (2006) build a New Keynesian model with a cost channel of monetary transmission and study optimal monetary policy.

- Aggregate Demand: The model economy consists of households, firms, the government, and financial intermediaries interacting in asset, goods, and labor markets. Households maximize their expected present discounted value of utility defined over a composite consumption good, a taste shock and leisure. The composite good consists of differentiated products produced by final goods producers. Households enter each period with cash holdings, receive their wage income and use it to make deposits at the financial intermediary. The remaining cash balances are available for the purchase of consumption goods. At the end of a period, households receive profit income from the financial intermediary and firms, and the principal and interest on their deposits at the intermediary.
- Aggregate Supply: The goods market is characterized by monopolistic competition, and the adjustment of prices follows the Calvo setting. Firms must borrow money from the financial intermediary at the gross nominal interest rate to pay for part of their wage bill.
- Shocks: A composite demand shock.
- Calibration/Estimation: The model is calibrated to the US economy.

1.43 NK_RW97: Rotemberg and Woodford (1997)

The model and the estimation strategy is discussed in detail in Rotemberg and Woodford (1997). The equations of this model can be derived from the behavior of optimizing agents. The expectational IS equation and the policy rule together can be viewed as determining aggregate demand, while the New-Keynesian Phillips curve equation determines aggregate supply. The Phillips curve equation can be obtained as a log-linear approximation to the first-order condition of optimizing firms with either Calvo-style staggered price contracts (Yun, 1996) or convex costs of price adjustment (Rotemberg, 1982). The IS equation can be obtained as a log-linear approximation of the representative household's first-order equation in a model in which consumption, leisure, and real money balances are each additively separable in the utility function, and total consumption demand (private and government consumption) is equal to aggregate output.

- Aggregate Demand: Standard New Keynesian IS curve.
- Aggregate Supply: Standard New Keynesian Phillips curve.
- Shocks: A cost-push shock following an AR(1) process, the common monetary policy shock, a government spending shock representing the common fiscal policy shock.
- Calibration/Estimation: Rotemberg and Woodford (1997) match the empirical impulse response functions to a monetary policy shock in a VAR (detrended real GDP, inflation, funds rate) and the empirical variances with the variances and the theoretical impulse responses from the model to all three shocks. Quarterly U.S. data for the period 1980:Q1–1995:Q2 is used. The estimated parameters are taken from Woodford (2003) table 6.1. However, we do not have information on the calibration of the shock processes. Hence, we employ the estimation results from Adam and Billi (2006) for the NK_RW97 shock specifications.

1.44 NK_ST13: Stracca (2013)

Stracca develops a New Keynesian model with money endogenous and exogenous money. While exogenous money is base money supplied by the central bank, endogenous money is equivalent to bank deposits that affect macroeconomic dynamics due to a deposit in advance constraint for households. In the model, the presence of inside money attenuates the effects of technology and monetary policy shocks.

- Aggregate Demand: A representative households chooses consumption, labor supply, bond holdings and deposit holdings. The utility function is additive separable in consumption, labor and deposit holdings, where quadratic adjustment costs for deposit holding are introduced into the utility function. Next to its budget constraint, it faces a deposit-in-advance constraint that generates a motive for deposit supply.

- Aggregate Supply: Intermediate good producers produce output with a Cobb-Douglas function featuring labor and capital. They finance the wage bill and investments with loans from banks. They are monopolistically competitive and set prices. Price setting and capital accumulation are subject to quadratic adjustment costs. Final good producers repackage the intermediate goods and sell them as final goods.
- Financial Sector: The bank finances itself with deposits, bonds and central bank credit. It extends loans and holds base money. The two components of the cost of financial intermediation are proportional to the amount of loans and the amount of deposits, respectively.
- Shocks: The model features a policy rate shock, a TFP shock, a shock to the demand for inside money and a shock to the supply of inside money.
- Calibration/Estimation: The model is calibrated to US data.

1.45 RBC_DTT11: De Fiore et al. (2011)

De Fiore et al. (2011) introduce financial frictions into an otherwise standard RBC model without price stickiness. Specifically, they assume that total funds, which are required for production, are nominal and predetermined. Monetary policy can therefore affect the real value of funds. Furthermore, the amount of internal funds is limited, such that entrepreneurs always have to borrow external funds via financial contracts with banks. A state verification problem arises due to asymmetric information since idiosyncratic productivity shocks are firms' private information. Banks have to pay monitoring costs to reach perfect information.

- Aggregate Demand: Households gain utility from consumption, leisure and real money balances. Households can hold deposits at financial intermediaries, government bonds and money. They are subject to lump-sum transfers. Government consumption is assumed to be a share of production net of the monitoring costs.
- Aggregate Supply: Firms act under perfect competition. Entrepreneurs use labor with a linear technology and aggregate productivity is stochastic. Additionally, each firm faces an idiosyncratic shock whose realization is private information.
- Financial Sector: Each period, entrepreneurs have to accumulate funds that become available for financing production in the subsequent period. They have to borrow from households via financial intermediary as internal funds are limited. Since the financial intermediary has to pay monitoring costs to observe the idiosyncratic shock, a state verification problem arises.
- Shocks: The model exhibits a technology shock, three different financial shocks (exogenous reduction in the level of internal funds, shock to the standard deviation of idiosyncratic technology shocks, increase in the monitoring cost parameter) and the common monetary policy shock.
- Calibration/Estimation: The model is calibrated at quarterly frequency. The volatility of idiosyncratic productivity shocks and the steady-state death probability of entrepreneurs are chosen, so as to generate an annual steady-state credit spread of approximately 2 percent and a quarterly bankruptcy rate of approximately 1 percent following Carlstrom and Fuerst (1997). The monitoring cost parameter is set at 0.15 according to Levin, Natalucci and Zakrajsek (2004). The calibration of the conventional parameters mostly follows Christiano et al. (2005).

2 Estimated U.S. Models

2.1 US_ACEL: CEE/ACEL by Altig et al. (2005)

The purpose of the authors is to build a model with optimizing agents that can account for the observed inertia in inflation and persistence in output (Christiano et al., 2005). In the version by Altig et al. (2005) firm-specific capital is introduced to get a Calvo parameter consistent with the microeconomic evidence of price re-optimizations on average once every 1.5 quarters. The Modelbase contains four different specifications of the CEE/ACEL model, labeled by m = monetary policy shock, t = technology shock and sw = SW assumptions, i.e. no cost channel and no timing constraints as in Taylor and Wieland (2009).

- Aggregate Demand: The representative household's utility is separable in consumption and leisure and allows for habit formation in consumption. Expected-lifetime utility is maximized, choosing optimal consumption and investment, as well as the amount of capital services supplied to the intermediate firms (homogenous capital model) and portfolio decisions. Investment adjustment costs are introduced. Furthermore, the household determines the wage rate for its monopolistically supplied differentiated labor services whenever it receives a Calvo signal. In those periods, in which it does not receive a signal, the wage is increased by the lagged inflation rate augmented by the steady state growth rate of a combination of the neutral technology shock and the shock to

capital embodied technology. Labor services are sold to a competitive firm that aggregates the differentiated services and supplies the resulting aggregated labor to the intermediate goods firms.
In the firm-specific capital model, the capital stock is owned by the firms.

- Aggregate Supply: The final consumption good is produced under perfect competition using differentiated intermediate goods as inputs. Each intermediate good is produced by a monopolist employing capital (which is firm-specific in one variant of the model) and labor services. The production function is augmented by a technology shock. Capital is pre-determined. Hence, if capital is firm-specific, marginal costs depend positively on the firm's output level. Furthermore, it is assumed that the monopolistic firms have to pay the wage bill in advance which requires borrowing from a financial intermediary. Nominal frictions are introduced in the form of Calvo sticky prices. Non-reoptimizing firms index their prices to previous periods inflation.
- Shocks: The common monetary policy shock, a neutral technology shock and an investment specific technology shock.
- Calibration/Estimation: The model has been estimated by matching the empirical impulse response functions to a monetary policy shock in a ten variable VAR with the theoretical impulse responses from the model to a monetary policy shock. Quarterly U.S. data from 1959:Q2–2001:Q4 is used.
- Replication: Using the US_ACELm model we replicated the impulse response functions for annualized quarterly inflation, output, annualized quarterly money growth and the annualized quarterly interest rate to a one standard deviation monetary policy shock.

2.2 US_AJ16: Ajello (2016)

Ajello (2016) develops a medium-scale model with financial frictions to analyze the role of US firm financing, in particular the financing gap, for business cycles and vice versa. In the model, shocks to financial intermediation play a major role for GDP and investment.

- Aggregate Demand: The representative household is composed of a continuum of members. Household consume, hold bonds and accumulate net worth. The utility function is separable in consumption and leisure and features habit formation. Each period, all members receive an idiosyncratic shock that determines the productivity of their investments, and thus their investment behavior. In equilibrium, the members of the household can be divided into three subgroups: sellers who take up credit from banks and invest in new capital, keepers, who install new capital, but do not borrow funds, and buyers, who supply labor to firms, forego investment into own productive capital and buy equity claims on other members' capital stock instead. The leverage of households is limited by a collateral constraint. Additionally, their financial claims are illiquid. Labor markets feature monopolistic supply and sticky nominal wages with wage indexation.
- Aggregate Supply: Intermediate good producers have a Cobb-Douglas Production function that features capital and labor. They are monopolistically competitive and set price subject to a Calvo friction with price indexation. Final good producers repackage intermediate goods and sell them as final goods. Investment good producers face convex investment adjustment costs.
- Financial Sector: Banks buy claims from sellers and sell them to buyers. Financial intermediation is subject to resource costs that create a spread between the ask and bid price of financial claims.
- Shocks: The model features seven shocks: a TFP shock, a government spending shock, an interest rate shock, a shock on the spread, a discount factor shock, a price markup shock, and a wage markup shock.
- Calibration/Estimation: The log-linear model is estimated for the U.S. by means of Bayesian techniques for the period $1989Q1-2008Q2$ using eight variables: GDP, consumption, investment, labor, wage rate, the nominal interest rate, inflation, the spread between BAA corporate bonds and ten-year Treasury notes, and the financing gap share. Measurement errors are introduced into the observation equations for the spread and the financing gap share.

2.3 US_BR13: Blanchard and Riggi (2013)

In Blanchard and Riggi (2013), the authors study the evolving impact of oil price shocks on the U.S. economy within a small-scale NK DSGE model. The model is designed to explain changes in the macroeconomic transmission of oil shocks across different historical periods, particularly pre- and post-1984.

- Aggregate Demand: Households optimize intertemporal utility, featuring external habit formation. Labor is supplied to firms under real wage rigidities. Oil is present both in the consumption basket and as an input to production. Consumption–leisure trade-offs are influenced by wage and price frictions.

- Aggregate Supply: The production side includes nominal price rigidity (Calvo pricing) and combines labor and oil as inputs in a Cobb–Douglas production function. Markup shocks and structural changes in wage rigidity are key elements, allowing the model to replicate the changing responses to oil shocks observed in the data.
- Monetary Policy: The central bank follows a standard Taylor-type rule, adjusting the policy rate in response to inflation and output-gap dynamics. Policy coefficients and the degree of price and wage rigidity vary across historical subsamples to reflect changing policy environments.
- Shocks: The model is subject to a set of structural shocks, including exogenous oil price shocks, markup shocks, and monetary policy disturbances.
- Calibration/Estimation: Parameters are estimated and calibrated to quarterly U.S. data from 1960 to 2007, allowing for empirical evaluation of the evolving macroeconomic effects of oil price shocks.
- Replication: The replication reproduces the model's results for oil price shocks parameterized using post-1984 estimated values. The replication code also contains alternative calibration and estimation values for the pre-1984 period.
- Model replications focus on matching the IRFs of key macroeconomic aggregates to oil price shocks by comparing the pre- and post-1984 periods, highlighting structural shifts.

2.4 US_BB18: Balke and Brown (2018)

In Balke and Brown (2018), the authors consider the role of oil in a medium-sized DSGE framework that models the domestic U.S. economy as well as the rest of the world (ROW). Oil is supplied to and demanded from the U.S., and the U.S. domestic economy possesses an oil-producing sector.

- Aggregate Demand: Households maximize lifetime utility including consumption habit formation. Households allocate labor to production of final goods, intermediate goods, and oil production. Reallocating labor supply induces adjustment costs. Households use oil to produce capital services and are subject to investment adjustment costs. The model exhibits real wage frictions similar to those in Blanchard and Gali (2007).
- Aggregate Supply: The final good is produced under perfect competition via a CES production function that uses the intermediate good and transportation as inputs. The intermediate good results from the intermediate good producer's profit maximization using labor and capital services as input. This optimization features nominal rigidities in the form of Rotemberg price adjustment costs. Transportation is equally modeled using a CES-type linear combination depending on labor and capital services, which need oil. The capital good supplier equivalently maximizes profits and uses oil as a direct input. The domestic economy has a stand-alone oil production sector using labor and capital as inputs.
- Foreign sector: The rest of the world is modeled in a reduced form. It supplies and demands oil and has some economic activity.
- Shocks: The model features 13 shocks including domestic and ROW oil supply shocks.
- Calibration/Estimation: Parameters and steady states in this paper are either calibrated or estimated using Bayesian inference taking advantage of quarterly data from 1991Q1–2015Q4.
- Replication: In replicating this model, we simulate a world oil supply and a world oil demand shock as well as a shock to U.S. oil productivity in line with the impulse responses presented in the paper.

2.5 US_BKM12: Bils et al. (2012)

Bils et al. (2012) construct a two-sector model based on the model by Smets and Wouters (2007) and re-estimate it on bimonthly data from 1990-2009. This is for comparing the behavior of actual and reset price ination to that for series simulated from the models, as the authors construct an empirical measure of reset price inflation on a bimonthly basis using US CPI micro data. They find that the models generate too much persistence and stability both in reset price inflation and in the way reset price inflation converted into actual inflation.

- Aggregate Demand: The same as in US_SW07, except that the consumption good demanded by the households is now a composite of the goods of the two sectors.
- Aggregate Supply: The same as in US_SW07, except that in US_BKM12 there are two sectors that produce goods. Firms in the one sector faces sticky prices and aggregate their goods according to a Kimball aggregator, firms in the other sector can set their prices flexibly and their goods are aggregated according to a CES aggregator.
- Shocks: The same as in US_SW07, except that the price markup shock in US_SW07 is now replaced by a sector specific productivity shock to the sector with flexible price setting.

- Estimation: In the paper, the SW model is reestimated with Bayesian methods using seven bimonthly US observables over the period 1990:1 to 2009:10. Also, different from US_SW07, the personal consumption deflator is used for price inflation instead of the GDP deflator. To be consistent with the MMB system, some parameters are adjusted to correspond to quarterly frequency.

2.6 US_CCF12: Chen et al. (2012)

Chen et al. (2012) simulate the Fed's second Large-Scale Asset Purchase program (LSAP II) in a medium-scale DSGE model with bond market segmentation (short- and long-term) estimated on US data. They find modest effects on GDP growth and inflation, but a lasting impact on the level of GDP. The effects would be even smaller absent a credible commitment to hold interest rates at its lower bound for an extended period of time.

- Aggregate Demand: Households are divided in unrestricted households that can trade in both, short- and long-term bonds, but face transaction costs for long-term bonds, and restricted households that can only trade in long-term bonds, but do not face transaction costs. Both types of households form habits in consumption and derive disutility from labor they supply to firms.
- Aggregate Supply: Competitive labor agencies combine differentiated labor inputs from households into a homogeneous labor composite. Competitive capital producers transform the consumption good into capital which they rent to intermediate goods producers. Monopolistic competitive intermediate goods producers hire labor and rent capital to produce intermediate goods. These are packaged into a homogeneous consumption good by competitive final goods producers.
- Government: The central bank sets the interest rate according to a conventional Taylor rule. The government supplies bonds. LSAP programs are interpreted as shocks to the composition of outstanding government liabilities compared with the historical behavior of these series.
- Shocks: Preference and labor supply shocks for restricted and unrestricted households, price markup shock, technology shock, investment-specific technology (adjustment cost) shock, monetary policy shock, government spending shock, long-term bond supply shock, fiscal tax shock, and a risk premium shock.
- Estimation: The authors use Bayesian methods for estimation. The data is quarterly for the US from the period from 1987:3 to 2009:3 obtained from FRED and includes seven series: real GDP per capita, hours worked, real wages, core personal consumption expenditures deflator, nominal effective Federal Funds rate, the 10-year Treasury constant maturity yield, and the ratio between long-term and short-term US Treasury debt.

2.7 US_CCTW10: Cogan et al. (2010)

Cogan et al. (2010) examine the effect of fiscal policy stimulus using the Smets-Wouters model of the US economy (US_SW07). They extend Smets and Wouters (2007) by introducing to the model rule-of-thumb consumers who spend all their disposable income. As the Ricardian equivalence property does not hold due to the presence of rule-of-thumb consumers, a fiscal policy rule is also included for determining a particular path for taxes.

- Aggregate Demand: There are two types of consumers. One is rule-of-thumb consumers and the other is forward-looking consumers identical to a representative household in Smets and Wouters (2007). The rest of model is the same as in US_SW07.
- Aggregate Supply: As in US_SW07.
- Shocks: As in US_SW07.
- Calibration/Estimation: The model is reestimated via Bayesian inference method with the same data set on US macroeconomic aggregates as in Smets and Wouters (2007).

2.8 US_CD08: Christensen and Dib (2008)

Christensen and Dib (2008) develop and estimate a DSGE model characterized by price stickiness, capital adjustment costs and financial frictions with the aim of evaluating the importance of the financial accelerator in the amplification and propagation of the effects of the transitory shocks to the U.S. economy. US_CD08 is a closed economy model like in Ireland (2003) enriched with financial frictions as in Bernanke et al. (1999). The model is estimated in two versions, with and without the financial accelerator mechanism.

- Aggregate Demand: The representative household derives utility from consumption, real money balances and leisure. Consumption and real balances are subject to a preference shock and a money demand shock, respectively. The household keeps deposits at the financial intermediary, supplies labor to the entrepreneurs and earns dividends from retailer firms.

- Aggregate Supply: The production sector is comprised of entrepreneurs, capital producers and retailers. The set up introducing the financial frictions is similar to Bernanke et al. (1999), apart from the fact that the debt contracts in Christensen and Dib (2008) are written in terms of the nominal interest rate. This specification allows for debt inflation effects, as unanticipated changes in inflation will affect the real cost of debt payment and the entrepreneurial net worth. Entrepreneurs borrow from financial intermediaries to buy capital from capital producers and produce intermediate goods. Due to asymmetric information between the entrepreneurs and financial intermediaries, the demand for capital is dependent on the entrepreneurs' financial conditions. Capital producers combine efficient investment goods and existing capital to produce new capital, subject to capital adjustment costs, which slow down the response of investment to different shocks. On the other side, retailers buy wholesale goods from entrepreneurs, differentiate them at no cost and sell them in a monopolistic competitive market, subject to price stickiness as in Calvo (1983) and Yun (1996).
- Shocks: A preference shock, a money demand shock, a technology shock, an investment shock and a monetary policy shock.
- Calibration/Estimation: The model is estimated using a maximum-likelihood procedure with Kalman filter on quarterly U.S. data for the period 1979:Q3–2004:Q3.

2.9 US_CET15: Christiano et al. (2015)

Christiano et al. (2015) develop a medium-scale New Keynesian model that entails a detailed labor market and financial friction. They estimate the model, and use it to account for US dynamics in and after the Great Recession.

- Aggregate Demand: Households consume, supply labor and hold capital assets, riskless bonds, and money. Their utility function is separable in consumption and money. Consumption is composed of goods from home production and market production. The utility function features habit formation in both consumption types. Next to the labor income and capital income, households derive income from firms' profits, and potentially unemployment benefits. Furthermore, they have to pay lump sum taxes. Households can either be employed, unemployed or out of the work force. Their labor market state is determined in a search and matching framework similar to Mortensen and Pissarides (1994). Wages are determined in an Alternative Offer Bargaining, developed by Christiano, Eichenbaum and Trabandt (2016).
- Aggregate Supply: The production sector is comprised of final good producers, and retailers and wholesalers. Wholesalers employ labor as determined in the search and matching process and sell their product (intermediate goods) in perfect competition to retailers. Retailers produce their goods via a Cobb-Douglas production function employing capital and intermediate goods. The production function features fixed costs. Retailers are monopolistically competitive and face price stickiness as in the Calvo framework. Nonoptimizing retailers index their prices to inflation. Final good producers act in perfect competition. They buy retailers goods and bundle them to a homogenous final good. Capital accumulation (by the households) is subject to investment adjustment costs.
- Shocks: The model features an interest rate shock, a TFP shock, an investment-specific shock and a government spending shock.
- Estimation: The model is estimated on US data from 1951:1-2008:4 using Bayesian methods such that the IRFs of the monetary policy shock and the two technology shocks match their counterparts derived form a VAR that is estimated on the same dataset.

2.10 US_CFOP14: Carlstrom et al. (2014)

Carlstrom et al. (2014) assess the importance of contract indexation in business cycle dynamics. The paper develops a mechanism for modeling financial frictions which builds on Bernanke et al. (1999) by allowing for contract indexation, and assumes a Costly State Verification framework as introduced by Townsend (1979). This mechanism is then imbedded into the medium-scale new-Keynesian model developed by Justiniano et al. (2011) and estimated by Bayesian techniques using US data on real, nominal and financial variables.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure and includes habit formation, subject to an intertemporal budget constraint. Households own firms and lenders, offer specialized labor in monopolistic competition, subject to Calvo (1983) wage-stickiness with partial indexation to inflation and to employment agencies. They save in government bonds and deposits taken by lenders, and receive dividend payments and lump-sum transfers. Additionally, it is assumed that they have access to state-contingent securities which they trade among each other. Government spending is exogenous.

- Aggregate Supply: Perfectly competitive final good producers purchase intermediate goods from monopolistically-competitive producers and combine them through CES technology into a homogenous final good which can be used for consumption or investment. Intermediate good producers, which are subject to Calvo (1983) price-stickiness with partial indexation to inflation, rent effective capital and purchase homogenous labor units to produce by means of a Cobb-Douglas production function with fixed production costs. Homogenous labor units are produced by perfectly competitive employment agencies which purchase specialized labor from the households. Perfectly competitive capital agencies manage the capital stock by renting out capital services to intermediate producers, while setting the utilization rate, and expanding the capital stock through investment. To invest, capital agencies linearly transform final goods into investment goods and transform investment goods into new capital, subject to adjustment costs. Risk neutral entrepreneurs, who purchase capital from capital agencies at the end of each period and sell it at the beginning of the next, are the sole accumulators of capital. They finance their capital purchase projects, which are subject to idiosyncratic risk, through their net worth and external financing from the lenders. The loan contract between the entrepreneurs and lender allows for the repayment rate to be state-dependent; at the optimum it is indexed to the return on holding capital.
- Shocks: An intertemporal preference shock affects households, intermediate firms' neutral technology factor and capital agencies' investment-specific productivity factor are unit root processes, wages and intermediate goods' prices are subject to mark-up shocks, capital agencies' marginal efficiency of investment is subject to an exogenous disturbance, entrepreneurs are subject to net worth and idiosyncratic risk shocks, and both government spending and the monetary policy rate are subject to shocks.
- Calibration/Estimation: The model is estimated using U.S. data by means of Bayesian techniques for the period 1972:1-2008:4 with ten macroeconomic variables: employment, inflation, the nominal interest rate, return to capital, the risk premium, real GDP, consumption, investment, real wage and relative price of investment.

2.11 US_CFP17exo, US_CFP17endo: Carlstrom et al. (2017)

Carlstrom et al. (2017) build a quantitative DSGE model which features long-term bond purchases by the central bank, in order to analyze the effect of financial market segmentation and of term-premium targeting on the effectiveness of monetary policy. The model features private financial intermediaries within segmented financial markets in which the net worth of financial institutions limits the degree of arbitrage across the term structure. This is caused by a hold-up problem between households and banks. Through portfolio adjustment costs, central bank purchases of long-term bonds have a significant effect on long yields and thereby effect capital investment and the real economy.

- 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. The household has two options of intertemporal savings (short-term deposits and accumulation of physical capital). Also short-term government bonds can be held by households but are perfectly substitutable by deposits.
- Aggregate Supply: Perfectly competitive capital producers transform investment goods into new capital, facing investment adjustment costs. Monopolistic intermediate goods producers process labor and capital within a Cobb-Douglas production and set their price subject to nominal rigidities (Calvo (1983)). The generated output is sold to final goods producing firms which repackage intermediate output and finally provide a consumption good.
- Financial Sector: Banks engage in fund channeling and maturity transformation, i.e. they buy short- and long-term government bonds which are financed by accumulated net worth and deposits. There is no direct interaction between banks and firms in this model, effects of changes on the intermediaries' balance sheet are thus always channeled to firms via household investment. The bank‘s objective is to maximize the stream of dividends to the households. The financial intermediary's net worth, however, and thereby also the size of its portfolio is subject to adjustment costs, which dampens the possibility to react to shocks. In addition, banks face a financial constraint: Their ability to attract deposits is limited by its net worth. A so called hold-up problem is used to implement this leverage constraint into the economy. Before shocks are realized, at the beginning of period t + 1, the bank may decide to default and not to repay its depositors. As a result, the fraction of financial intermediaries' assets which can still be utilized by depositors is limited. Hence, there is a compatibility constraint to ensure repayment of the depositing household. Generally, bank intermediation is required because new household investment must be financed via new debt issuance.
- Shocks: There are eight shocks in the model: productivity shock, credit shock, investment shock, monetary policy shock, natural rate shock, wage markup shock, price markup shock, QE shock.
- Calibration/Estimation: Several parameters are calibrated to match long-run features of US data. Evidence on interest rate spreads and leverage is used to pin down the steady-state loan-to-deposit spread and the leverage

ratio in the model. Parameters are calibrated as to match a term premium of 100 annual basis points and a steady-state leverage ratio of 6. This is the same calibration as in Gertler and Karadi (2013). Government bonds are calibrated to a duration of 40 quarters. The steady state balance sheet of financial intermediaries is calibrated to consist of 40

The difference between the two model versions is rooted in the behaviour of the level of long-term debt on the balance sheet of the financial intermediaries. In US_CFP17exo, central bank bond purchases and changes to the mix of short-term and long-term debt by the fiscal authority are modeled by exogenous movements in long-term debt. Consequently, the long-term yield will be endognous. Contrary, in US_CFP17endo, the central bank pegs the term premium and hence the level of long-term debt will be endogenous.

2.12 US_CMR10, US_CMR10fa: Christiano et al. (2010a)

, The US_GMR10 model combines a standard DSGE model like Smets and Wouters (2003) and Smets and Wouters (2007) with a detailed financial sector based on agency problem borrowing from Bernanke et al. (1999) to investigate the role of financial factors in business cycles. Several mechanism are imbedded into the baseline model due to several apparatus for financial frictions: the financial accelerator channel, the Fisher deflation channel and the bank funding channel. The economy consists of households, intermediate-good producing firms, final-goods producing firms, capital producers, entrepreneurs, bank and government. The US_GMR10fa model considers the financial accelerator channel shutting down the bank funding channel, namely ignoring the bank's supply of liquidity and household's demand for money.

- Aggregate Demand: Households obtain utility from having consumption and liquidity services and disutility from supplying labor services and adjusting real currency holdings. Household provide labor supply labor under monopolistic competition and make a portfolio decision over high powered money, bank deposits, short-term marketable securities and other financial securities.
- Aggregate Supply: Monopolistically competitive intermediate-good producing firms maximize profit using labor and capital (rented from entrepreneurs) subject to a Calvo price setting. They have to pay for working capital in advance of production. Perfectly competitive final-good producing firms aggregate a variety of intermediate goods. The final goods are then converted into consumption, investment and government goods. Capital producers combine investment goods with used capital purchased from entrepreneurs to produce new capital facing the convex investment cost function. Entrepreneurs own the stock of physical capital, buy new capital using their own wealth as well as bank loans, provide capital services while choosing the capital utilization rate. Government spending is modeled as a certain fraction of final good and are financed by lump-sum taxes levied to households.
- Financial System: Since a shock on entrepreneurial investments is idiosyncratic and privately-observable, it incurs the monitoring cost to banks.
- Shocks: The model include 16 shocks: a banking technology shock, a bank reserve demand shock, a term premium shock, a investment specific shock, a money demand shock, a government consumption shock, a persistent productivity shock, a transitory productivity shock, a financial wealth shock, a risk shock, a consumption preference shock, a shock on marginal efficiency of investment, an oil price shock, a price mark-up shock and an inflation target shock. All shocks are assumed to follow AR(1) process but an inflation target shock and a monetary policy shock which are treated as an i.i.d process.
- Calibration/Estimation: The model is estimated by standard Bayesian methods using quarterly data from 1985Q1 to 2008Q2 for the Euro Area (EA) and for the United States (US). In the baseline estimation 16 variables are used with consideration of a measurement error: GDP, Consumption, Investment, GDP deflator, real wages, hours worked, the relative price of investment, the relative price of oil, the short-term interest rate, the stock market, a measure of the external finance premium, real credit, two definitions of real money growth, bank reserves and the term spread.

2.13 US_CMR14, US_CMR14noFA:Christiano et al. (2014)

Christiano et al. (2014) augment a standard DSGE model such as Smets and Wouters (2003) or Smets and Wouters (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 US 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. These produce by employing labor and renting capital while subject to Calvo-style rigidities. Homogenous labor units are produced by perfectly competitive labor contractors which aggregate differentiated household labor services purchased from monopolistic unions that set wages subject to Calvo-style frictions. Households build raw capital subject to capital-adjustment costs and sell it to entrepreneurs, which they own.
- Financial Sector: Risk-neutral entrepreneurs finance their purchases of capital through their net worth and loans from competitive mutual funds. The loan contract between entrepreneurs and mutual funds is as in Bernanke et al. (1999). However, the authors introduce a shock to the variance of idiosyncratic productivity that influences individual entrepreneur's return on capital. It is referred to as a risk shock. With an agency problem between entrepreneurs and mutual funds, a positive risk shock increases the required return on borrowing, that is, the external finance premium.
- Shocks: The model includes shocks to the following 12 variables: price markup, price of investment goods, government consumption, technology growth persistence, technology (transitory), risk, consumption preference, marginal efficiency of investment, term structure, equity, monetary policy, and the inflation target.
- The model is estimated by Bayesian techniques using 12 quarterly observables covering the period 1985:Q1 to 2010:Q2. The data set includes 8 macroeconomic and 4 financial variables.
- US_CMR14noFA is the version of US_CMR14 where the financial accelerator channel has been muted. The parametrization is however that of the baseline model.

2.14 US_CPS10: Cogley et al. (2010)

Cogley et al. (2010) estimate a New Keynesian model based on Rotemberg and Woodford (1997) and Boivin and Giannoni (2006). The model is applied to provide a structural explanation of the feature that the inflation gap became less persistent after the Volcker disinflation. The key difference to a number of other mainstream models is that it allows for the inflation target to change over time. The main finding of the paper is that the most important factor explaining the change in the inflation gap persistence is the decline in the variance of the inflation target shock. Yet, changes in the non-policy parameters also contributed to the decline in the inflation gap persistence significantly.

- Aggregate Demand: The representative household maximizes lifetime utility subject to an intertemporal budget constraint. Utility from consumption and disutility from labor is separable. Preferences for consumption are subject to habit persistence. The representative household offers a continuum of different types of laborto the firms. Furthermore, the household owns the firms, obtains their profits and receives also income from labor.
- Aggregate Supply: There exists a continuum of monopolistically competitive firms. Price stickiness is embedded into the model via the Calvo (1983) framework. Each good is produced using linear technology and the sole production factor is labor. Technology follows a unit root process and its growth rate is modeled by an exogenous AR(1)-process.
- Shocks: An intertemporal preference shock, a price markup shock, a technology shock and an inflation target shock.
- Calibration/Estimation: The model is estimated using Bayesian methods on quarterly U.S. data for two subsamples: 1960:Q1-1979:Q3 and 1982:Q4-2006:Q4.

2.15 US_DG08: De Graeve (2008)

De Graeve (2008) uses a medium-scale New Keynesian model like in Smets and Wouters (2007) enriched with financial frictions as in Bernanke et al. (1999) to estimate and explore the role of the external finance premium in propagating shocks for the U.S. economy. Conditional on certain shocks, he finds that a framework with financial frictions and investment adjustment costs may give rise to a financial "decelerator".

- Aggregate Demand: As in Smets and Wouters (2007), households maximize their lifetime utility function, non-separable in consumption and leisure, subject to an intertemporal budget constraint. Preferences for consumption are subject to habit persistence. They own firms, hold financial wealth in the form of one-period, state-contingent bonds and supply labor monopolistically. Wage stickiness is introduced via the Calvo framework.

- Aggregate Supply: Apart from the intermediate and final goods firms as in Smets and Wouters (2007), a financial intermediary, capital goods producers and entrepreneurs are introduced in the model to match the structure as in Bernanke et al. (1999) and Christiano, Motto and Rostagno (2003). Intermediate goods firms face price rigidity à la Calvo while capital good producers face convex investment adjustment costs. On the other side, the presence of entrepreneurs and the financial intermediary brings financial frictions into play. Entrepreneurs borrow from financial intermediaries to buy capital (from capital producers), decide on capital utilization, rent capital services to intermediate goods firms and sell non-depreciated capital back to capital producers. However, after the purchase of the capital stock, entrepreneurs are hit by an idiosyncratic shock, observable only by them. This leads to the costly state verification framework à la Bernanke et al. (1999), giving raise to extra costs, above the risk-free rate. The optimal contract between entrepreneurs and the financial intermediary leads to an aggregate relationship of the spread between the external finance costs and the risk-free rate and entrepreneurs' financial conditions represented by the leverage ratio.
- Shocks: A preference shock, a labor supply shock, a total factor productivity shock, an investment technology shock, a government spending shock, an inflation target shock, a monetary policy shock, a wage and price mark-up shock.
- Calibration/Estimation: The model is estimated using Bayesian methods on quarterly U.S. data for the period 1954:Q1–2004:Q4.

2.16 US_DNGS15 : Del Negro et al. (2015)

Del Negro et al. (2015) build a medium-scale New Keynesian model that can predict a sharp contraction in economic activity along with a protracted but relatively modest decline in inflation, following the Great Recession. They build upon a standard DSGE model (like in Smets and Wouters (2007)) enriched with financial frictions and a time-varying target inflation rate.

- Aggregate Demand: As in Smets and Wouters (2007), households maximize a nonseparable utility function with two arguments (goods and labor effort) over an infinite life horizon, subject to an intertemporal budget constraint. Preferences for consumption are subject to habit persistence. Households supply labor monopolistically and wage stickiness is introduced via the Calvo framework.
- Aggregate Supply: Monopolistically competitive firms produce intermediate goods, which a competitive firm aggregates into a single final good that is used for both consumption and investment. The intermediate goods firms decide on labor and capital inputs, and set prices according to the Calvo model.
- Financial Sector: Building on the work of Bernanke et al. (1999), Christiano et al. (2014), and De Graeve (2008), a financial intermediary, capital producers and entrepreneurs are introduced in the model in addition to the intermediate and final goods firms as in Smets and Wouters (2007). Financial frictions come into play by the presence of entrepreneurs and the financial intermediary. Banks collect deposits from households and lend to entrepreneurs who use these funds as well as their own wealth to acquire physical capital, which is then rented to intermediate goods producers. Entrepreneurs are subject to idiosyncratic disturbances that affect their ability to manage capital which leads to the costly state verification framework as in Bernanke et al. (1999) and gives rise to a spread, above the risk-free rate. This spread is thus a function of the entrepreneurs' leverage and riskiness.
- Shocks: The model features a preference shock, a financial friction shock, a total factor productivity shock, an investment specific technology shock, a government spending shock, an inflation target shock, a monetary policy shock, a wage and price mark-up shock.
- Calibration/Estimation: The model is estimated using Bayesian methods on quarterly U.S. data for the period 1964:Q1 - 2008:Q3.

We furthermore include three variants of the model proposed and estimated by DNGS: A version without financial frictions and time-varying inflation target (DNGS15_SW), a version without financial frictions (DNGS15_SWpi) and the Smets-Wouters 2007 model estimated using the same variables as the original authors using 2012Q3 data.

2.17 US_FGKR15 : Fernández-Villaverde et al. (2015)

The purpose of the authors is to quantify the effects of fiscal volatility shocks on the dynamics of key macroeconomic variables. They rely on a medium-scale New Keynesian DSGE model in the spirit of Christiano et al. (2005), which they augment with fiscal policy. Particularly, the fiscal authority has four instruments at its disposal: government expenditure and taxes on capital income, labor income as well as consumption. Fiscal rules are standard, i.e. the fiscal authority reacts to changes in output and debt-to-GDP ratio. However, the standard deviations of fiscal variables are not constant, but follow exogenous stochastic processes. As a result, this specification allows for a clear distinction between fiscal

shocks and fiscal volatility shocks. Since the latter are shocks to the second moment, the model has to be solved using (at least) a third-order perturbation approach.

- Aggregate Demand: The representative household's utility is separable in consumption, government expenditure and leisure and allows for (external) habit formation in consumption. The household can invest in capital and hold government bonds. Investment in capital is subject to adjustment costs. Wages are sticky (Rotemberg (1982) adjustment costs). The household pays consumption taxes, labor income taxes, capital income taxes as well as lump-sum taxes.
- Aggregate Supply: The final consumption good is produced under perfect competition using differentiated intermediate goods as inputs. Intermediate goods producers operate in monopolistically competitive environment and employ capital and labor services as factors of production. Prices are sticky (Rotemberg (1982) adjustment costs).
- Shocks: A preference shock, (a labor-augmenting) productivity shock, a monetary policy shock and (four) fiscal shocks
- Calibration/Estimation: Some of the model parameters are estimated using simulated method of moments (SMM) to match US quarterly data moments, the others are set to conventional values prior to estimation.

2.18 US_FM95: Fuhrer and Moore (1995a)

The model is described in Fuhrer and Moore (1995a) and Fuhrer and Moore (1995b). We employ the parametrization used in Levin et al. (2003). Fuhrer and Moore introduce a new wage contracting model where agents care about relative real wages in order to match the strong inflation persistence observed in U.S. data.

- Aggregate Demand: The US_FM95 model represents aggregate spending by a single reduced-form equation corresponding to an IS curve. The current output gap depends on its lagged values over the past two quarters and the lagged value of the long-term real interest rate, which is defined as a weighted average of ex-ante short-term real interest rates with a duration of 40 quarters.
- Aggregate Supply: The aggregate price level is a constant mark-up (normalized to one) over the aggregate wage rate. The aggregate wage dynamics are determined by overlapping wage contracts. In particular, the aggregate wage is defined to be the weighted average of current and three lagged values of the contract wage rate. The real contract wage, that is the contract wage deflated by the aggregate wage, is determined as a weighted average of expected real contract wages, adjusted for the expected average output gap over the life of the contract. This specification yields a hybrid Phillips curve that depends additionally on current and past demand and expectations about future demand.
- Shocks: An ad hoc supply shock and the common monetary policy shock.
- Calibration/Estimation: Full-information maximum likelihood estimation on U.S. data from 1966–1994.
- Replication: We replicated the impulse response functions for annualized quarterly inflation and the output gap to a 100 basis point innovation to the federal funds rate in Figure 2 of Levin et al. (2003).

2.19 US_FMS13 : Fève et al. (2013)

Fève et al. (2013) use specifications from Justiniano et al. (2011) which is an extension of the standard Smets and Wouters (2007) model. In addition to the standard features of the model, such as habit formation, investment adjustment costs, nominal rigidities, etc., they also allow for endogenous public spending and Edgeworth complementarity/substitutability. These two novelties of the model enable to take the countercyclicality of fiscal policy into account and to better match the observed correlation between the growth rates of government spending and private consumption.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure, subject to an intertemporal budget constraint and allowing Edgeworth complementarity and substitutability. The model allows for capital accumulation, habit formation in leisure decisions, and multiple shocks. Households own firms, rent capital services to firms and decide how much capital to accumulate given certain capital adjustment costs. They additionally hold their financial wealth in the form of one-period, state-contingent bonds. The endogenous fiscal policy component is countercyclical and the stochastic component is assumed to follow a first-order auto-regressive process.
- Aggregate Supply: As in US_SW07.
- Shocks: A monetary policy shock, fiscal shock, mark-up shocks, intertemporal preference shock, investment shock and a technology shock.

- Calibration/Estimation: The model parameters are estimated by using Bayesian techniques on the following US quarterly data between 1960q1 and 2007q4: consumption growth, investment growth, real government expenditures growth, growth rate of real hourly compensation, the log of hours worked, the inflation rate and nominal interest rate.

2.20 US_FRB03: FRB-US model

2.21 US_FRB08: FRB-US model

The FRB model is a large-scale model of the U.S. economy with a relatively detailed representation of the supply side of the economy. The version US_FRB03 was linearized by Levin et al. (2003).

- Aggregate Demand: Real spending is divided into five components: private consumption, fixed investment, inventory investment, net exports and government purchases. The broad components are disaggregated further i.e. spending on fixed investment is separated into equipment, nonresidential structures and residential construction. Government spending is divided into six sub-components, each of which follows a simple reduced-form equation that includes a counter-cyclical term. The specification of most non-trade private spending equations follows the generalized adjustment cost model due to Tinsley (1993).
- Aggregate Supply: Potential output is modeled as a function of the labor force, crude energy use, and a composite capital stock, using a three-factor Cobb-Douglas production technology. The equilibrium output price is a mark-up over a weighted average of the productivity-adjusted wage rate and the domestic energy price. The specification of the wage and price dynamics follows the generalized adjustment cost framework used in the aggregate demand block. Wage inflation depends on lagged wage inflation over the previous three quarters, as well as expected future growth in prices and productivity, and a weighted average of expected future unemployment rates. Price inflation depends on its own lagged values over the past two quarters, as well as expected future changes in equilibrium prices and expected future unemployment rates. In addition, both wages and prices error-correct to their respective equilibrium levels. A vertical long-run Phillips curve is imposed in estimation. The model contains a detailed accounting of various categories of income, taxes, and stocks, an explicit treatment of labor markets, and endogenous determination of potential output. Long-run equilibrium in the model is of the stock-flow type; the income tax rate and real exchange rate risk premium adjust over time to bring government and foreign debt-to-GDP ratios back to specified (constant) levels.
- Foreign sector: The full model includes detailed treatments of foreign variables. Twelve sectors (countries or regions) are modeled, which encompass the entire global economy. In the model used in the Modelbase the full set of equations describing the foreign countries is replaced by two reduced form equations for foreign output and prices, to reduce computational cost.
- Shocks: The model exhibits a large range of shocks to which we add the common monetary policy shock and a fiscal shock that equally affects all three components of federal government spending such that a unit fiscal policy shock affects output by 1 percent.
- Replication: We replicated the impulse response functions for annualized quarterly inflation and the output gap to a 100 basis point innovation to the federal funds rate in Figure 2 of Levin et al. (2003).

2.22 US_FRB22: FRB-US model

Brayton and Reifschneider (2022) build the linear version (LINVER) of the FRB/US model. Brayton, Laubach and Reifschneider (2014) is a large-scale model of the U.S. economy. For some model parts agents in this model form model-consistent expectations, while for other parts expectations are based on the average historical dynamics of the predictions of estimated limited-information VAR models. Consequently, we include 4 model variants.

- Aggregate Demand: There are liquidity-constrained and unconstrained households. Liquidity-constrained households spend all their income each quarter. In contrast, unconstrained households consume and invest based on their assessment of their lifetime resources. Future labor and transfer income is discounted at a rate substantially higher than the discount rate on future income from non-human wealth. Unconstrained households face adjustment costs that cause them to adjust their spending gradually in response to changes in expected income and property wealth. As in the national income and product accounts, total spending by households consists of consumption of nondurable goods and non-housing services, purchases of durable consumer goods, and consumption of housing services; movements in these three components of total spending are modeled separately.
- Aggregate Supply: The key production sector is the nonfarm business sector plus imported energy. The production function in this sector is Cobb-Douglas with potential output depending on the sustainable full-employment level of labor input, actual capital services, trend energy services, and the trend component of multi-factor productivity. The key inflation measures modeled in FRB/US are for core PCE prices and ECI hourly compensation,

following the New Keynesian Phillips curve specification in the presence of nonzero trend inflation developed in Cogley and Sbordone (2008). In addition to slack and expectations of future inflation, other important determinants of total consumer price inflation include movements in the relative prices of food, energy, and non-energy imports. The government sector includes disaggregated components of spending and a wide range of tax rates and credits.

- Foreign sector: The model includes imports and exports of goods and services that depend on real activity in the rest of the world and the terms of trade. The trade-weighted dollar exchange rate is modeled assuming uncovered interest parity.
- Shocks: The model exhibits a large range of shocks including a fiscal shock that equally affects all three components of federal government spending such that a unit fiscal policy shock affects output by 1 percent.
- Calibration/Estimation: The model is partly calibrated and includes an involved estimation routine.

2.23 US_FU19: Fratto and Uhlig

Fratto and Uhlig investigate on the missing deflation puzzle by estimating versions of the Smets and Wouters (2007) on different samples of US data that include or exclude the years after the Financial Crisis. They find that markup shocks account for the almost all of the variation in inflation before and after the crisis. In the MMB, we parametrize the model according to the estimates on 1984-2015 data.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is nonseparable in consumption and leisure, subject to an intertemporal budget constraint. Smets and Wouters (2007) include external habit formation to make the consumption response in the model more persistent. Households own firms, rent capital services to firms and decide how much capital to accumulate given certain capital adjustment costs. They additionally hold their financial wealth in the form of one-period, state-contingent bonds. Exogenous spending follows a first-order autoregressive process with an iid-normal error term and is also affected by the productivity shock.
- Aggregate Supply: The final goods, which are produced under perfect competition, are used for consumption and investment by the households and by the government. The final goods producer maximizes profits subject to a Kimball (1995) aggregator of intermediate goods, which introduces monopolistic competition in the market for intermediate goods and features a non constant elasticity of substitution between different intermediate goods, which depends on their relative price. A continuum of intermediate firms produce differentiated goods using a production function with Cobb-Douglas technology and fixed costs and sell these goods to the final-good sector. They decide on labor and capital inputs, and set prices according to the Calvo model. Labor is differentiated by a union using the Kimball aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Labor packers buy the labor from the unions and resell it to the intermediate goods producer in a perfectly competitive environment. Sticky wages $\tilde{A}f$ la Calvo are additionally assumed. The Calvo model in both wage and price setting is augmented by the assumption that prices that can not be freely set, are partially indexed to past inflation rates.
- Shocks: A total factor productivity shock, a risk premium shock, an investment-specific technology shock, a wage and a price mark-up shock and two policy shocks: the common fiscal policy shock entering the government spending equation and the common monetary policy shock.
- Estimation: The model is estimated for the U.S. with Bayesian techniques for the period 1984Q1-2015Q4 using seven key macroeconomic variables: real GDP, consumption, investment, the GDP deflator, real wages, employment and the nominal short-term interest rate. The replication package additionally contains the baseline version of the model estimated on a shorter sample (1984Q1-2007Q4).

2.24 US_FV10: Fernández-Villaverde (2010)

Fernández-Villaverde (2010) employs a canonical medium-scale closed economy DSGE-Model similar to Smets and Wouters (2007), estimated on U.S. data. The model features a deterministic growth rate driven by labor-augmenting technological progress, so that the data do not need to be detrended before estimation. The code is written in non-linearized form.

- Aggregate demand: Households maximize their lifetime utility, where the utility function is separable in consumption, leisure and real money balances, subject to an intertemporal budget constraint. Consumption utility is subject to habit formation. Households own firms, rent capital services to firms and decide on investment given certain investment adjustment costs.

- Aggregate Supply: The final goods, which are produced under perfect competition, are used for consumption and investment by the households. The final goods producer aggregates intermediate goods using a constant elasticity of substitution (CES) production function. A continuum of monopolistically competitive intermediate firms produce differentiated goods using a production function with Cobb-Douglas technology and fixed costs and sell these goods to the final-good sector. They decide on labor and capital inputs, and set prices according to the Calvo model. Labor is differentiated by a union using the CES aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Labor packers buy the labor from the unions and resell it to the intermediate goods producer in a perfectly competitive environment. Sticky wages á la Calvo are additionally assumed. The Calvo model in both wage and price setting is augmented by the assumption that prices that cannot be freely set, are partially indexed to past inflation rates.
- Shocks: A total factor productivity shock, an investment-specific technology shock, an intertemporal preference shock, an intratemporal preference shock and a monetary policy shock.
- Calibration/Estimation: The model is estimated for the U.S. with Bayesian techniques for the period 1959:1−2007:1 using five key macroeconomic variables: relative price of investment, real output per capita growth, real wages per capita, CPI inflation and the federal funds rate.
- Replication: We simulated the impulse response functions to a positive one standard deviation monetary policy shock and technology shock. While FV (2010) does not show any impulse responses, our simulated IRFs are very similar to the impulse responses provided in the technical appendix to FV (2015).

2.25 US_FV15: Fernández-Villaverde et al. (2015)

Fernández-Villaverde et al. (2015) employs a canonical medium-scale closed economy DSGE-Model similar to Smets and Wouters (2007), estimated on U.S. data, but augmented with time-varying volatility in the shocks. The model features a deterministic growth rate driven by labor-augmenting technological progress, so that the data do not need to be detrended before estimation. The code is written in non-linearized form.

- Aggregate demand: Households maximize their lifetime utility, where the utility function is separable in consumption, leisure and real money balances, subject to an intertemporal budget constraint. Consumption utility is subject to habit formation. Households own firms, rent capital services to firms and decide on investment given certain investment adjustment costs.
- Aggregate Supply: The final goods, which are produced under perfect competition, are used for consumption and investment by the households. The final goods producer aggregates intermediate goods using a constant elasticity of substitution (CES) production function. A continuum of monopolistically competitive intermediate firms produce differentiated goods using a production function with Cobb-Douglas technology and fixed costs and sell these goods to the final-good sector. They decide on labor and capital inputs, and set prices according to the Calvo model. Labor is differentiated by a union using the CES aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Labor packers buy the labor from the unions and resell it to the intermediate goods producer in a perfectly competitive environment. Sticky wages à la Calvo are additionally assumed. The Calvo model in both wage and price setting is augmented by the assumption that prices that cannot be freely set, are partially indexed to past inflation rates.
- Shocks: A total factor productivity shock, an investment-specific technology shock, an intertemporal preference shock, an intratemporal preference shock and a monetary policy shock. The standard deviations of the structural innovations are subject to stochastic volatility shocks. The model also includes shocks to the two parameters in the monetary policy rule.
- Calibration/Estimation: The model is estimated for the U.S. with Bayesian techniques for the period 1959:1−2007:1 using five key macroeconomic variables: relative price of investment, real output per capita growth, real wages per capita, CPI inflation and the federal funds rate.
- Replication: We replicated the impulse response functions to a positive one standard deviation monetary policy shock and technology shock, as shown in Figure 6.1 and 6.2 of the technical appendix.

2.26 US_GG24: Gagliardone and Gertler (2024)

Gagliardone and Gertler (2024) develop a New Keynesian model designed to study the interplay between oil price shocks, labor market frictions, and monetary policy in the U.S. economy, with particular focus on the 2021–2022 inflation surge.

- Aggregate Demand: Households consume goods and supply labor. Oil is included both in the consumption bundle and as an input in production. The model incorporates real wage rigidities, while price stickiness is introduced through Calvo pricing. Habit formation in consumption is included to generate persistence in demand.

- Aggregate Supply: Production uses a CES aggregator of labor and oil, reflecting strong complementarity between the two inputs.
- Labor Market: Labor market frictions are modeled through wage rigidity and job-matching mechanisms, which allow endogenous unemployment responses to oil shocks.
- Shocks: The model incorporates a range of shocks, with emphasis on exogenous oil price changes and cost-push disturbances. Both estimated and calibrated configurations are supported.
- Calibration: The model is tailored to replicate impulse responses observed during large energy-price swings, including the recent inflation surge episodes.
- Replication: The replication reproduces IRFs for an oil price shock.

2.27 US_HL16: Hollander and Liu (2016)

Hollander and Liu (2016) analyse the role of the equity price channel in business cycle fluctuations. They incorporate the financial accelerator channel and the bank equity channel into a medium-scale New-Keynesian DSGE model. Through these two channels, the equity price channel amplifies shocks to the real economy. The model reproduces the procyclicality of the equity price found in the data.

- Aggregate Demand: There are two types of representative households, saver and borrower households. Both maximize their expected lifetime utility that depends on consumption, labour, deposits and equity investments, subject to budget constraints. Households' consumption preferences exhibit habit formation. In addition to the budget constraint, borrower households also face a borrowing constraint. Households supply labour and wages are flexible in the model.
- Aggregate Supply: Entrepreneurs produce the wholesale good using capital and labour as inputs. They face direct costs of adjusting their capital stock. Retailers buy the intermediate goods at the wholesale price, differentiate them at no cost, and sell the final good with a mark-up. Prices are subject to nominal rigidities à la Calvo (1983).
- Banking sector: The banking sector in the model builds on Gerali et al. (2010). Each bank consists of two monopolistically competitive retail branches (a loan and a deposit branch) and one perfectly competitive wholesale branch that manages the consolidated balance sheet of the respective bank.
- Shocks: There are nine shocks in the model: a technology, a monetary policy, a deposit, a loan markup (firms), a loan markup (households), households' LTV, an equity price, and a price markup shock.
- Estimation: The model is estimated with Bayesian techniques using US data from 1982Q1 to 2015Q1 on nine variables: output, inflation, equity price, household loans, entrepreneur loans, deposits, the Fed funds rate, the mortgage rate, and the Baa corporate rate.

2.28 US_IAC05: Iacoviello (2005)

Iacoviello (2005) develops a New Keynesian model with nominal and financial frictions, where debt contracts are written in nominal terms and some agents face collateral constraints tied to housing values. This gives rise to an accelerator effect for demand shocks and a decelerator effect for supply shocks. The model can match the response of the aggregate demand to housing price shocks and the hump-shaped dynamics of output to inflation surprises, observed from U.S. data.

- Aggregate Demand: There are two types of households, the "patient" and the "impatient" ones. They both derive utility from consumption, holdings of housing, real money balances and leisure. However they discount the future differently, with the impatient household discounting the future more heavily. This specification induces the impatient household to face borrowing constraints, consistent with standard lending criteria used in the mortgage market where the borrowing is limited to a fraction of the housing value. For both types of households, the holding of housing is subject to housing adjustment costs.
- Aggregate Supply: Entrepreneurs produce a homogeneous intermediate good using a Cobb-Douglas technology with labor from both types of households, capital and real estate as inputs. Housing and variable capital are subject to adjustment costs. Following Kiyotaki and Moore (1997), a limit on the obligation of the entrepreneurs is assumed. Entrepreneurs discount the future more heavily than the patient households. Both assumptions assure that the borrowing constraint is binding for entrepreneurs. In addition there are retailers who buy the intermediate goods from the entrepreneur, differentiate them at no cost and sell them at a price that can be re-optimized every period only with a certain probability. The optimization problem of the retailers yields a forward-looking Phillips curve.

- Shocks: A housing preference shock, an inflation shock, a technology shock and a monetary policy shock.
- Calibration/Estimation: A mixture of calibrated and estimated parameters. Estimation of parameters is done by minimizing a measure of the distance between the VAR impulse responses and model responses, using quarterly U.S. data for the period 1974:Q1–2003:Q2.

2.29 US_IN10: Iacoviello and Neri (2010)

The US_IN10 model is based on various dynamic equilibrium models with neoclassical core and real and nominal rigidities (e.g. Smets and Wouters (2007) model). The main goal of this model is to explain the development of the price and the quantity side of the housing market and to examine the spillovers from the housing market to the rest of the economy. The model features a multi-sector structure with housing and non-housing goods, financial frictions in the household sector (introduced through a collateral constraint imposed on a fraction of households), and rich set of shocks which take the model to the data.

- Aggregate demand: There are two types of households according to their discount factors: patient (lenders) and impatient (borrowers). A representative household within each group obtain utility from consumption and housing and disutility from supplying labor in an additively-separable way. Habit formation and balanced growth in consumption are considered. Imperfect labor mobility is introduced across sectors. Patient households accumulate housing and capital, make loans to impatient households, rent capital and land to firms, and choose the capital utilization rate. Impatient households work, consume, accumulate housing and borrow against the value of their housing. Impatient households accumulate housing and borrow the maximum possible amount against its collateral value in equilibrium.
- Aggregate Supply: Wholesale firms consists of two production units. Housing sector produces new houses (using capital, labour, land and intermediate goods). Non-housing sector produces consumption goods, investment goods and intermediate goods (using capital and labour). It is allowed for price rigidities in the consumption sector and for wage rigidities in both the consumption and housing sectors, but there are no price rigidities in the housing market.
- Shocks: An intertemporal preference shock, a labor supply shock, a housing preference shock, a cost-push shock, a monetary policy shock, a shock on the central bank's inflation target, sectoral productivity shocks (housing, consumption and non-residential sector)
- Calibration/Estimation: The model is estimated with Bayesian methods using ten US observables over the period 1965:Q1 to 2006:QIV.

2.30 US_IR11: Ireland (2011)

Ireland (2011) estimates a New Keynesian model for the US economy in order to compare the Great Recession of 2007-09 with its two immediate predecessors, the milder recessions of 1990-91 and 2001.

- Aggregate Demand: The utility function of the representative household is additively separable in consumption, real money balances and hours worked, and features habit formation in consumption. The household enters each period with money and bonds. At the beginning of each period, it receives a lump-sum nominal transfer from the central bank. Moreover, the household decides about the purchase of new bonds, the supply of labor and the consumption of finished goods. At the end of each period, the household receives nominal dividend payments resulting from the ownership of intermediate-goods-producing firms.
- Aggregate Supply: During each period, the representative intermediate-goods-producing firm hires labor to manufacture intermediate goods according to a constant-return-to-scale technology. The representative intermediate-goods-producing firm has monopolistic power, acting as a price-setter. However, price setting is subject to Rotemberg quadratic adjustment costs. The intermediate goods are then used by the finished-goods-producing firms to manufacture final goods under perfect competition.
- Shocks: An AR(1) preference shock, a cost-push shock in form of a shock to the price mark up, a technology shock that follows a random walk with drift and a monetary policy shock.
- Calibration/Estimation: The model is estimated via maximum likelihood using U.S. quarterly data on output growth, the inflation rate and the short-term nominal interest rate over the period 1930:Q1–2009:Q4.

2.31 US_IR15: Ireland (2015)

Ireland (2015) considers a model of the term structure of interest rates, where bond yields are driven by observable and unobservable macroeconomic factors. Restrictions on the model parameters help identify the effects of monetary policy and other structural disturbances on output, inflation, and interest rates and decompose movements in long-term rates into terms attributable to changing expected future short rates versus risk premia. The model is estimated on US data and highlights a broad range of channels through which monetary policy, risk premia and the economy interact.

- Model: Bond yields in this pricing model get driven by five state variables: two unobservable (a risk variable which governs all variation in bond risk premia and the central bank's inflation target) and three observable (short-term nominal interest rate, the inflation rate, and the output gap). The inflation and output gaps are allowed to depend on their own lagged values and lagged values of the model's other variables, as they would in a more conventional macroeconomic vector autoregression. The structural shocks are identified by restrictions on the parameters implied by a) no-arbitrage considerations, b) the assumption that the risk premium is solely driven by the unobservable risk variable, and c) the assumption of a Taylor-rule type interest rate policy. The estimates of the correlation and volatility parameters, together with an analysis of the impulse responses and forecast error variance decompositions implied by those estimates, are used to assess the extent to which movements in bond risk premia are driven by monetary policy and macroeconomic shocks or whether they reflect, instead, disturbances that appear purely financial in origin.
- Shocks: There are 5 structural shocks in the model: on the short-term nominal interest rate, on inflation, output gap, the inflation target and the risk premium. Furthermore there are measurement errors for the one, two and four-year bond yields.
- Calibration/Estimation: The model is estimated with US quarterly data from 1959:1 to 2007:4 for the short-term nominal interest rate, the inflation rate, the output gap, and yields on discount bonds with one through five years to maturity.

2.32 US_JPT11: Justiniano et al. (2011)

Justiniano et al. (2011) include two investment shocks into an otherwise standard new-Keynesian dynamic stochastic general equilibrium model and estimate it through Bayesian techniques using U.S. data. The first new shock, an investment-specific technology shock, affects the transformation of consumption into investment goods and is identified with the relative price of investment. The second shock affects the production of installed capital from investment goods or, more broadly, the transformation of savings into the future capital input.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure and includes habit formation, subject to an intertemporal budget constraint. Households own firms and the capital stock, monopolistically offer specialized labor to employment agencies, set the utilization rate when renting effective capital to intermediate producers, save in government bonds, and receive dividend payments and lump-sum transfers. Additionally, it is assumed that they have access to state-contingent securities traded between each other.
- Aggregate Supply: Perfectly competitive final good producers purchase intermediate goods from monopolistically-competitive producers and combine them through CES technology into a homogeneous final good which can be used for consumption or investment. Intermediate good producers, which are subject to Calvo (1983) price-stickiness with partial indexation to inflation, rent effective capital and purchase homogeneous labor units to produce by means of a Cobb-Douglas production function with a fixed production cost. The homogeneous labor units are produced by perfectly competitive employment agencies which purchase specialized labor from the households. Perfectly competitive investment good producers linearly transform final goods into investment goods, while capital good producers transform investment goods into new capital subject to adjustment costs.
- Shocks: An intertemporal preference shock affects households, intermediate firms' neutral technology factor and investment good producers' investment-specific productivity factor are unit root processes. Wages and intermediate goods' prices are subject to mark-up shocks. Capital producers' marginal efficiency of investment is subject to an exogenous disturbance, and both government spending and the monetary policy rate are subject to shocks.
- Calibration/Estimation: The model is estimated for the U.S. with Bayesian techniques for the period 1954:3 until 2009:1 using eight macroeconomic variables: employment, inflation, the nominal interest rate, real GDP, consumption, investment, real wage and relative price of investment. For the growth rates of investment-specific technology and the composite trend the authors divide the sample into two subsamples: 1954–1982 and 1983–2008.

2.33 US_KK14: Kliem and Kriwoluzky (2014)

Kliem and Kriwoluzky (2014) set up a New Keynesian model that entails a fiscal sector with several instruments, estimate it on US data and analyze the empirical plausibility and welfare properties of feedback rules for labor and capital income tax rates.

- Aggregate Demand: Households consume, supply labor and invest in capital and riskless bonds. Their utility function is separable in consumption and leisure and features habit formation as well as an exogenous consumption demand shifter. Next to the labor income and capital income (which are both taxed), it derives income from firm's dividends (which are also taxed) and fiscal transfers. They set their wages in monopolistic competition as in Erceg, Henderson and Levin (2000). Those households, which cannot update their wages in a given period index it to the steady state inflation rate.
- Aggregate Supply: The production sector is comprised of final good producers, and intermediate good producers. Intermediate good producers produce their goods via a Cobb-Douglas production function employing labor and capital. The production function features variable capital utilization and fixed costs. They are monopolistically competitive and face price stickiness as in the Calvo framework. Final good producers act in perfect competition. They buy intermediate goods and bundle them to a final good. Capital accumulation (by the households) is subject to investment adjustment costs.
- Monetary and Fiscal authorities: Monetary policy is conducted using an interest rate rule that exhibits interest rate smoothing and a response to inflation and the output gap. The government raises taxes on labor and capital income which are modelled as feedback rules reacting to the levels of government debt and output. Government consumption and transfers evolve according to exogenous AR(1) processes.
- Shocks: A preference shock, a technology shock, an investment-specific efficiency shock, a price markup shock, a wage markup shock, a monetary policy shock, a transfer shock, a government spending shock, a shock to the resource constraint and shocks to the labor and capital income tax rates.
- Estimation: The model is estimated on US data for the period of 1983:1 -2008:3 using Bayesian methods. As 12 observables are used in the estimation, additional to the 11 structural shocks, the authors add measurement error to the observation equation for tax revenues.

2.34 US_KS15: Kriwoluzky and Stoltenberg (2014)

Kriwoluzky and Stoltenberg (2014) incorporate an explicit transaction role for money in a standard cashless new Keynesian model (Woodford (2003)) and compare the role of money in the pre-Volcker period (before 1979) with the period from 1982 on. They estimate that before 1979, money played an important role in facilitating transactions while after 1982, the importance of money declined sharply. They argue that this shift can possibly explain the switch in US interest rate policy from a passive to an active setting.

- Aggregate Demand: In the model there is a continuum of infinitely lived households that maximize expected lifetime utility subject to a budget constraint that incorporates transaction costs for purchasing consumption goods. The instantaneous utility function is increasing in consumption and decreasing in labour that the households supply to firms.
- Aggregate Supply: Using the labour supply from households as the sole input, monopolistically competitive firms produce differentiated goods that are aggregated to the final consumption good. Price setting by the firms follows Calvo (1983), leading to nominal rigidities in the model.
- Shocks: There is a technology, a government spending, a wage mark-up, a taste, a monetary policy shock and a shock to transaction costs.
- Estimation: The model is estimated using Bayesian techniques on US data using real output, real consumption, annual inflation, the federal funds rate, real money balances, and real wages as observable variables. The quarterly data ranges from 1964Q1 to 2008Q2 and is split into two parts: from 1964Q1 to 1978Q4 and from 1983Q1 to 2008Q2, excluding the disinflation years.

2.35 US_LTW17, US_LTW17gz, US_LTW17nu, US_LTW17rot: Leeper et al. (2017)

Leeper et al. (2017) implement a new Keynesian model, based on Smets and Wouters (2007, 2003), yet add distorting tax rates on capital and labor income and consumption. The additional features of the model are that utility also depends on government consumption and saver households have also access to a portfolio of long-term government zero-bonds with maturity decaying at a constant rate (not only to short-term bonds). The model is used to assess the fiscal multiplier in the US.

- Aggregate Demand: The model economy is populated by a continuum of infinitely lived households of which a fraction is non-saver. Non-saver households do not have access to any savings technology, thus they consume their entire disposable income every period. The firms and the capital stock are owned entirely by saver households. The utility function is separable in consumption and leisure and assumes external habits that depend on aggregate consumption in the last period. In addition, household consumption also depends on government consumption in an additive manner.
- Aggregate Supply: Production is carried out in two stages, by a perfectly competitive final goods producer and a continuum of monopolistically competitive intermediate goods producers using capital and labour as input factors. Households provide uniquely differentiated labor in monopolistic competition. Saver households set wages optimally while non-savers follow a rule-of thumb to set their wage rates to be the average wage rates chosen by savers. Wages and prices are allowed to adjust only gradually by assuming Calvo pricing with partial adjustment of the contracts to past inflation.
- Monetary and Fiscal authorities: Monetary authorities follow a Taylor-type rule with lagged policy rates. Fiscal authorities levy distortionary taxes on income from capital, labor and consumption taxes and sell the nominal bond portfolio to finance its interest payments, government consumption and lump-sum transfers to households. Fiscal rules include a response of fiscal instruments to the market value of the debt-to-GDP ratio and an autoregressive term to allow for serial correlation. The model was restricted such that only public consumption and transfers potentially respond to debt. Tax distortions enter only the steady state.
- Shocks: Government consumption shock, transfer shock, total factor productivity shock, preference shock, investment adjustment costs shock, monetary policy shock, wage markup shock, price markup shock.
- Estimation: The baseline model, implemented into the MMB, is estimated for the U.S. by means of Bayesian techniques for the period 1955:1-2007:4 using eight key macroeconomic variables: log differences of aggregate consumption, investment, real wages, real government consumption, the real market-value of government debt, and the GDP deflator; log hours worked; the federal funds rate. Data are neither detrended nor demeaned. Drawing on the information from the prior predictive analysis, the authors eliminated rule-of-thumb agents. They also did not include tax revenues or tax rates in the observables because quarterly measures of marginal tax rates are problematic.
- Replication: The original NK-model was separated from the Matlab based code provided by the authors and translated into Dynare. The baseline scenario (solid line) among the impulse response functions in Figure 5 was replicated and compared also with the implemented version of the model. The IRFs in the model base appear to match those from the original Matlab code if one eliminates the autoregressive coefficient in the error term of the monetary policy rule in the original code. In addition to the baseline setting two counterfactual models were added, three from Figure 5 (1. lower habit formation coefficient with no government spending in utility (US_LTW17nu); 2. Inclusion of rule of thumb consumers (US_LTW17rot); 3. Instead of government consumption response to debt, there are changes in transfers (US_LTW17gz)).

2.36 US_LWY13: Leeper et al. (2013)

Leeper et al. (2013) implement a new Keynesian model, similar to those in Smets and Wouters (2007, 2003), yet add distorting tax rates on capital and labor income. The model is used to assess the effect fiscal foresight entails to a naive econometrician who estimates impulse-response functions conditioning solely on the variables observed and disregards fiscal foresight.

- Aggregate demand: The model economy is populated by a continuum of infinitely lived households of which a fraction is non-Ricardian. Non-Ricardian households do not have access to any savings technology, thus they consume their entire disposable income every period. The firms and the capital stock are owned entirely by Ricardian households. The utility function is separable in consumption and leisure and assumes external habits that depend on aggregate consumption in the last period. Households provide uniquely differentiated labor in monopolistic competition. Ricardian households have also access to state-contingent claims to eliminate the income differentials due to differentiated labor.
- Aggregate supply: Production is carried out in two stages, by a perfectly competitive final good producer and a continuum of monopolistically competitive intermediate goods producers using capital and labour as input asfactors. Wages and prices are allowed to adjust only gradually by assuming Calvo pricing with partial adjustment of the contracts to past inflation.
- Government: Monetary authorities follow a Taylor-type rule. Fiscal authorities levy distortionary taxes on income from capital and labor and pay lump-sum transfers to households.
- Shocks: Total factor productivity shock, preference shock, investment adjustment costs shock, monetary policy shock, wage markup shock, price markup shock, government spending shock, capital tax rate shock, labour tax rate shock and government transfers shock .

- Calibration/Estimation: The model is estimated for the U.S. by means of Bayesian techniques for the period 1984:1−2007:4 using ten key macroeconomic variables: consumption, investment, labor, wage rate, the nominal interest rate, inflation, capital tax revenues, labor tax revenues, the sum of real government consumption and investment, and government transfers. Government data include all federal, state, and local levels.
- Replication: Unfortunately there were no impulse response functions to be replicated. Therefore, the original NK-model was separated from the code and translated to Dynare. The impulse response functions of output and the interest rate were replicated and compared also with the implemented version of the model. The IRFs in the model base seemed to match those from the original Matlab code which were calculated manually.

2.37 US_MI07: Milani (2007)

Milani (2007) presents an estimated model with learning and provides evidence that learning can improve the fit of popular monetary DSGE models and endogenously generate realistic levels of persistence. The rational expectations version of the model is based on the those applied by Boivin and Giannoni (2006), Giannoni and Woodford (2003), and also described in Woodford (2003). The model incorporates some of the structural sources of persistence, such as habit formation in consumption and inflation indexation. The main finding of the paper is that the empirical results show that when learning replaces rational expectations, the estimated degrees of habits and indexation drop near zero. This finding suggests that persistence arises in the model economy mainly from expectations and learning.

- Aggregate Demand: The representative household maximizes lifetime utility subject to an intertemporal budget constraint. Utility from consumption and disutility from labor is separable. Preferences for consumption are subject to habit persistence. The representative household offers a continuum of different types of labor to the firms.
- Aggregate Supply: There exists a continuum of monopolistically competitive firms. Price stickiness is embedded into the model via the Calvo (1983) framework. Each good is produced using a decreasing return to scale technology and capital is assumed to be fixed, leaving labor as the only variable factor of production. The natural real rate of interest is modeled as an exogenous AR(1)-process.
- Shocks: Natural real interest rate shock, cost-push shock, monetary policy shock
- Estimation: The model is estimated using likelihood-based Bayesian methods to fit the series for output gap, inflation, and the nominal interest rate as used in a number of papers, surveyed in An and Schorfheide (2007). Yet, the paper provides an example of estimation of a simple DSGE model with non-fully rational expectations and learning. The data are quarterly for the period 1960:I to 2004:II.

2.38 US_MR07: Mankiw and Reis (2007)

Mankiw and Reis (2007) develop a general equilibrium model where rigidities come from the fact that agents are inattentive and do not update information regularly when setting prices, wages and deciding on consumption. US_MR07 is a model with information stickiness. Estimation of the model using U.S. data confirms the presence of such rigidities, especially for consumers and workers.

- Aggregate Demand: Infinitely lived households are of two types: consumers and workers. Their utility function is additively separable in consumption and leisure. They are able to save and borrow by trading bonds between themselves. Workers choose how much to work and what wage to charge for the particular variety of labor over which they hold a monopoly. Both consumers and workers take decisions but only a fraction of them, randomly drawn from their respective population, obtain new information and can re-optimize their actions. If they obtain new information, they revise their plans for future consumption and labor supply, respectively. Both, the aggregate demand (IS equation) and the equation of wages, depend on the sum of past expectations of current economic conditions, reflecting the fact that households have different sets of information. The stickier the information is (low share of informed households), the smaller the impact of shocks on spending and wages, since fewer consumers and workers are aware of them. The natural (long-run) equilibrium corresponds to a situation where all agents are perfectly informed.
- Aggregate Supply: Firms produce output using labor and sell their differentiated goods in a monopolistic competitive market. Firms are constrained in information gathering in the same fashion as households. Each period, a fraction of firms, randomly drawn from the population, obtains new information and recalculates the optimal price. The optimizing process of the firms leads to a Phillips curve equation where the price level is determined as a sum of past expectations of current economic conditions (prices, output, marginal costs, technology shocks). The summation captures the fact that firms have different sets of information. Shocks to the variables in the Phillips curve equation will have gradual effects as some firms remain unaware of these shocks and only react to them once they update their information set.

- Shocks: A mark-up good shock, a mark-up labor shock, a government shock, a technology shock and a monetary policy shock.
- Calibration/Estimation: Estimated with maximum likelihood and Bayesian methods, using quarterly U.S. data for the period 1954:Q3–2006:Q1.

2.39 US_OR03:Orphanides (2003b)

Orphanides (2003b) conducts a counterfactual analysis based on the historical experience of the United States economy to give an example of the difficulties in identifying robust policy strategies. The counterfactual analysis gives an insight how inflation and the output gap would have evolved from the 1960s to the 1990s if the Federal Reserve had actually followed two distinct activist monetary policy rules taking into account the difference between realistic and non-realistic assumptions on the availability of information on the output gap.

- Aggregate demand: The demand side of the structural model of the economy is represented by an IS equation which relates the output gap to its own lags, lags of inflation and the federal funds rate.
- Aggregate supply: The supply side is represented by an accelerationist form of the Philips curve with an adaptive representation of inflation expectations.
- Shocks: A cost-push shock, a demand shock and the common monetary policy shock.
- Calibration/estimation: The Aggregate Demand and Aggregate Supply equation are estimated in a setup that can be interpreted as a mildly restricted structural vector autoregression (VAR) of up to four lags estimated using quarterly data from 1960 to 1993.

2.40 US_OW98: FRB Monetary Studies, Orphanides and Wieland (1998)

This is a small open economy model described in Orphanides and Wieland (1998) and used to investigate the consequences of the zero bound on nominal interest rates.

- Aggregate Demand: The US_OW98 model disaggregates real spending into five components: private consumption, fixed investment, inventory investment, net exports, and government purchases. The aggregate demand components exhibit partial adjustment to their respective equilibrium levels, measured as shares of potential GDP. Partial adjustments reflect habit persistence. Equilibrium consumption and fixed investment are functions of permanent income (discounted at 10 percent) and depend on the long-term real rate. The long-term nominal interest rate is an average of expected future nominal short-term rates. The long-term real rate is determined by the Fisher equation. Inventory investment depends on three lags of output. Government spending is an AR(1) process.
- Aggregate Supply: The structure is similar to the US_FM95 model. In US_FM95 and US_OW98, the aggregate price level is a constant mark-up over the aggregate wage rate.
- Foreign Sector: Net exports depend on domestic output, world output, the real exchange rate and lagged net exports. The exchange rate is determined by an UIP condition.
- Shocks: Five demand shocks including the common fiscal policy shock in the government spending equation, an ad hoc cost push shock to the nominal wage contracts and the common monetary policy shock.
- Calibration/Estimation: The model is estimated for the period 1980–1996 using U.S. data. The demand block is estimated via IV-estimation equation-by-equation. For the supply side simulation-based indirect inference methods are used.
- Replication: We replicated the impulse response functions for annualized quarterly inflation and the output gap to a 100 basis point innovation to the federal funds rate in Figure 2 of Levin et al. (2003).

2.41 US_PM08 and US_PM08fl: Carabenciov et al. (2008a)

Carabenciov et al. (2008a) design and estimate two versions of a small projection model for the U.S. economy: one with financial real linkages, US_PM08fl and one without, US_PM08. These models are part of the IMF research agenda in developing a Small Quarterly Global Projection Model (GMP) which consists of many small country models integrated into a single global market. Both versions of the model consist of few behavioral equations, focusing on the joint determination of output, unemployment, inflation and the federal funds rate.

- Aggregate Demand: The behavioral IS curve relates the output gap to its past and expected future value, to the past value of the short interest rate gap and to a disturbance term. This specification allows for inertia and persistent effects of the shocks. In the model with financial linkages, US_PM08fl, the output gap is a function

of a financial variable as well, constructed using information from FED's quarterly Senior Loan Officer Opinion Survey on Bank Lending Practices. This variable enters in the form of a shock and it is supposed to reflect the bank lending conditions (tightening or loosening). Thus, if lending conditions are tighter than anticipated, the effect will be a lower output gap and a weaker economy.

- Aggregate Supply: In the Phillips curve equation, inflation is linked to its past and expected future values, to the lagged output gap and a disturbance term. This representation reflects the way agents set their prices: a share of them uses indexation to past inflation and others are forward looking. These expectations are based on model-consistent estimates of future inflation.
- Shocks: A shock to the level and the growth rate of potential output, a shock to the level and the growth rate of the equilibrium rate of unemployment, a shock to the equilibrium real interest rate. In the model with financial linkages, US_PM08fl, a financial shock is introduced in addition and cross correlations of the error terms between certain shocks are allowed.
- Estimation: Both models are estimated with Bayesian techniques, using U.S. quarterly data over the period 1994:Q1–2008:Q1.

2.42 US_PV15: Poutineau and Vermandel (2015b)

Poutineau and Vermandel (2015b) evaluate the role of financial intermediaries, such as banks, on the extensive margin of activity. They build a DSGE model that combines the endogenous determination of the number of firms operating on the goods market with financial frictions through a financial accelerator mechanism, given the fact that the creation of a new activity partly requires loans to finance spending during the setting period. Three main results have been obtained. First, financial frictions play a key role in determining the number of new firms. Second, in contrast with real macroeconomic shocks (where investment in existing production lines and the creation of new firms move in the opposite direction), financial shocks have a cumulative effect on the two margins of activity, amplifying macroeconomic fluctuations. Third, the critical role of financial factors is mainly observed in the period corresponding to the creation of new firms.

- Aggregate Demand: There is a continuum of identical households who consume, save and work in intermediate firms. To single out the determination and the dynamics of nominal wages, it is assumed that households delegate the task of negotiating their salary to labor unions. Formally, households provide differentiated types of labor, sold by labor unions to perfectly competitive labor packers who assemble them in a CES aggregator and sell the homogenous labor to intermediate firms.
- Aggregate Supply: The firm sector is populated by two groups of agents: intermediate firms and final goods firms. Intermediate firms produce differentiated goods, choose labor and capital inputs, and set prices according to the Rotemberg (1982) model. Final goods producers act as a consumption bundler by combining national intermediate goods to produce the homogenous final good. The total number of final firms/goods is normalized to 1, while the total number of intermediate firms/goods is endogenously determined in the model to define the extensive margin of activity. Each period, hence, a continuum of new firms decides to enter the market.
- Financial Sector: The economy is additionally populated by entrepreneurs, where the representative entrepreneur is a key agent for introducing financial frictions. This agent finances both the intensive margin (by renting capital to existinàg firms) and the extensive margin (by financing the wage bill for the creation of new firms). Entrepreneurs face a trade-off between intensive and extensive margins financing. Financial intermediaries provide funds to entrepreneurs. The representative financial intermediary collects deposits from households and lends them. From the balance sheet of the financial intermediary, the loan supply is equal to the deposits. Additionally, there is the imperfect pass-through of the policy rate on financial intermediary lending rate. It is assumed that financial intermediaries set their interest rates on a staggered basis with some degree of nominal rigidity à la Rotemberg (1982).
- Authorities: The government finances public spending by charging a tax on households. The total amount of public spending is assumed to evolve according to an AR(1) exogenous shock process. The central bank sets the interest rate in accordance with the fluctuations of price and activity imbalances.
- Shocks: There are 10 structural shocks in the model: productivity, spending, premium, investment, price cost-push, wage cost-push, rate cost-push, entry shock, collateral, and monetary policy shock.
- Estimation: The model is estimated with Bayesian methods on US quarterly data over the sample time period 1993Q1 to 2012Q3.

2.43 US_RA07: Rabanal (2007)

Rabanal (2007) incorporates a cost channel of monetary transmission into an otherwise standard medium-scale New Keynesian DSGE model by assuming that a fraction of firms need to borrow money to pay their wage bill prior to their sales receipts. The model is estimated on US data in order to analyze whether the cost channel empirically accounts for the so-called price puzzle.

- Aggregate Demand: Households obtain utility from consuming the final good and disutility from supplying labor, they own intermediate firms, lend capital services to firms and make investment and capital utilization decisions. Moreover, their utility function displays external habit formation. Capital is predetermined at the beginning of a period, but households can adjust its utilization rate subject to adjustment costs. Financial markets are assumed to be complete.
- Aggregate Supply: Intermediate good producers combine labor and capital services to produce their goods while taking the capital utilization rate decision of households as given. A fraction of intermediate good producers have to pay their wage bill every period before they sell their product. These firms borrow at the riskless nominal interest rate. Goods and labor markets are characterized by monopolistic competition. Prices and wages are set in a staggered way, following the formalism of Calvo (1983). Indexation to last period's average inflation rate is assumed for firms and households whenever they are not allowed to reoptimize. A continuum of final good producers operating under perfect competition uses intermediate goods for the production of final goods.
- Shocks: Four orthogonal structural shocks are introduced in the model. The government spending and technology shocks follow an AR(1) process. The monetary and the price markup shock are assumed to be iid processes.
- Calibration/Estimation: The model is estimated using Bayesian techniques on quarterly US data. The data set used comprises four key macroeconomic variables: real output, real wage, inflation rate and the nominal interest rate over the period 1959:Q1–2004:Q4.

2.44 US_RE09: Reis (2009)

Reis (2009) presents a dynamic stochastic general-equilibrium model with a single friction in all markets: sticky information. In this economy, agents are inattentive because of costs of acquiring, absorbing and processing information, so that the actions of consumers, workers and firms are slow to incorporate news. The paper includes the details of how an economy with pervasive inattentiveness functions, then solves the model and in the end estimates it. Uncertainty in the model arises because every period there is a different realization of the random variables characterizing productivity, aggregate demand, price and wage markups, and monetary policy. While the expectations of each agent are formed rationally, they do not necessarily use all available information. More concretely, it assumes that there are fixed costs of acquiring, absorbing and processing information, so that agents optimally choose to only update their information sporadically.

- Aggregate Demand: While the discussion presents consumers (shoppers and saver-planners) and workers separately, they are all members of one household. Representative household gains utility from consumption and leisure subject to its budget constraint. Shoppers consume a continuum of varieties of goods and determine demand for them, whereas saver-planners meet each other in the bond market in order to trade one-period bonds. In the labor market workers sell their labor. While inattentiveness occurs in all markets, not all agents in this economy are inattentive. In the goods market, the model assumes that the consumer is separated into two units: the saver-planner who updates information infrequently and the shopper who knows about the expenditure plan of the saver and observes the relative prices of the different goods. Additionally, separating consumers from workers allows them to potentially update their information at different frequencies. They do not necessarily need to share information, although belong to the same household. When workers update their information, they also learn about what the consumer has been doing, and vice-versa for consumers.
- Aggregate Supply: On the selling side of the market, there are monopolistic firms for each variety of the good. They operate a technology that uses labor in order to produce goods under diminishing returns to scale and common technology shock.
- Shocks: There are shocks in technology, monetary policy, aggregate demand, goods substitutability and labor substitutability.
- Calibration/Estimation: The model is estimated using full-information techniques that exploit the restrictions imposed by general equilibrium. Quarterly observations are used for two large economies: the United States from 1986:3 to 2006:1 and the Euro area from 1993:4 to 2005:4.

2.45 US_RS99: Rudebusch and Svensson (1999)

Rudebusch and Svensson (1999) set up a simple linear model of the U.S. economy which is used to examine the performance of different policy rules taking into account an inflation targeting monetary policy regime. The model equations are backward looking.

- Aggregate Demand: An IS curve relates the output gap to its own lags and the difference between the average federal funds rate and the average inflation rate over the current and three preceding quarters.
- Aggregate Supply: Phillips curve of the accelerationist form.
- Shocks: A cost-push shock, a demand shock and the common monetary policy shock.
- Calibration/Estimation: The model equations are estimated individually by ordinary least squares for U.S. data. The sample period comprises 1961:1-1996:2.

2.46 US_VGIP15: Vasconez et al. (2015)

Vasconez et al. (2015) present a small-scale DSGE model that emphasizes the role of oil in production and capital accumulation. The model is used to assess how improvements in oil efficiency and consumption dynamics affect macroeconomic volatility.

- Aggregate Demand: Households derive utility from consumption and leisure, with an explicit role for oil both in the consumption bundle and as an input in production. Nominal wage rigidity is absent, while price stickiness is implemented via Calvo pricing.
- Aggregate Supply: The final good is produced with labor, capital, and oil using a Cobb–Douglas production function. The model allows for either estimated or calibrated price stickiness and incorporates an explicit efficiency channel for oil use.
- Oil: Oil is an imported commodity whose price is determined exogenously in domestic-currency terms. The model does not incorporate additional open-economy features.
- Shocks: The system is driven by exogenous oil price shocks, as well as technology, price markup, government spending, capital price, and monetary policy shocks.
- Calibration/Estimation: Bayesian estimation is conducted using quarterly data from the 1984–2007 period.
- Replication: The replication reproduces IRFs for an oil price shock for both parameter variants, corresponding to the calibrated and estimated price-stickiness specifications.

2.47 US_SW07: Smets and Wouters (2007)

Smets and Wouters (2007) develop a medium-scale closed economy DSGE-Model and estimate it for the U.S. with Bayesian techniques. The model features a deterministic growth rate driven by labor-augmenting technological progress, so that the data do not need to be detrended before estimation.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is nonseparable in consumption and leisure, subject to an intertemporal budget constraint. Smets and Wouters (2007) include external habit formation to make the consumption response in the model more persistent. Households own firms, rent capital services to firms and decide how much capital to accumulate given certain capital adjustment costs. They additionally hold their financial wealth in the form of one-period, state-contingent bonds. Exogenous spending follows a first-order autoregressive process with an iid-normal error term and is also affected by the productivity shock.
- Aggregate Supply: The final goods, which are produced under perfect competition, are used for consumption and investment by the households and by the government. The final goods producer maximizes profits subject to a Kimball (1995) aggregator of intermediate goods, which introduces monopolistic competition in the market for intermediate goods and features a non constant elasticity of substitution between different intermediate goods, which depends on their relative price. A continuum of intermediate firms produce differentiated goods using a production function with Cobb-Douglas technology and fixed costs and sell these goods to the final-good sector. They decide on labor and capital inputs, and set prices according to the Calvo model. Labor is differentiated by a union using the Kimball aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Labor packers buy the labor from the unions and resell it to the intermediate goods producer in a perfectly competitive environment. Sticky wages à la Calvo are additionally assumed. The Calvo model in both wage and price setting is augmented by the assumption that prices that can not be freely set, are partially indexed to past inflation rates.

- Shocks: A total factor productivity shock, a risk premium shock, an investment-specific technology shock, a wage and a price mark-up shock and two policy shocks: the common fiscal policy shock entering the government spending equation and the common monetary policy shock.
- Calibration/Estimation: The model is estimated for the U.S. with Bayesian techniques for the period 1966:1–2004:4 using seven key macroeconomic variables: real GDP, consumption, investment, the GDP deflator, real wages, employment and the nominal short-term interest rate.
- Replication: We replicated the impulse response functions to a positive one standard deviation monetary policy shock in Figure 6 of Smets and Wouters (2007). The variables include output, hours, quarterly inflation and the interest rate.

2.48 US_VI16bgg and US_VI16gk: Villa (2016)

Villa (2016) assesses the empirical relevance of financial frictions in the US and in the Euro Area, where the above versions of the model refer to the US. It develops a medium-scale closed economy DSGE-model based on Smets and Wouters (2007) and two different financial sector extensions of this framework, in particular Bernanke, Gertler and Gilchrist (1996) and the Gertler and Karadi (2011) types.

- US_V16bgg model:
  - Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure, subject to an intertemporal budget constraint. In addition, the external habit formation makes the consumption response more persistent. Households own firms, rent capital services to firms and decide how much capital to accumulate given certain capital adjustment costs. They additionally hold their financial wealth in the form of one-period, state-contingent government bonds.
  - Aggregate Supply: Intermediate good firms maximize their profits by choosing factors of production and by signing a financial contract to obtain additional funds from lenders. Since lenders have to pay some auditing costs to observe the idiosyncratic return to capital, an agency problem arises. The financial contract implies external finance premium that depends on the inverse of the firm's leverage ratio. Retailers buy goods from intermediate good firms, differentiate them, and sell them in a monopolistically competitive market according to the Calvo model. The aggregate final good is assembled by perfectly competitive final good firms, and is used for consumption and investment by the households and by the government. The final goods producer maximizes profits subject to a Dixit-Stiglitz aggregator of intermediate goods, which introduces monopolistic competition in the market for intermediate goods and features a constant elasticity of substitution between individual, intermediate goods. Labor is differentiated by a union using the Dixit-Stiglitz aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Labor packers buy the labor from the unions and resell it to the intermediate goods producer in a perfectly competitive environment. Sticky wages Ãf la Calvo are additionally assumed.
- US_V16gk model:
  - Aggregate Demand: The representative household's utility is separable in consumption and leisure and allows for habit formation in consumption. Households postpone their consumption by holding deposits with the financial intermediaries. The amount of deposits is determined in such a way as to guarantee that the bankers' incentive constraint is satisfied. Expected-lifetime utility is maximized by choosing consumption and labor supplied to intermediate firms.
  - Aggregate Supply: Competitive firms produce intermediate goods using labor services and capital. They face adjustment costs for varying their utilization rate of capital. They finance the capital stock with loans from the financial intermediaries and buy it from capital producing firms to which they re-sell it at the end of the period after having used it. Capital producers face investment adjustment costs. The intermediate goods are bought by retail firms, which act under monopolistic competition and face nominal rigidities as in Calvo (1983). Non-reoptimizing retailers index their prices to the previous period's inflation rate.
  - Banking sector: Banks receive their funds in the form of deposits from households and lend to non-financial firms. 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.
- Shocks: Seven structural shocks: the technology shock, the investment-specific technology shock, the capital quality shock, the price mark-up shock, the wage mark-up shock, and two policy shocks - the common fiscal policy shock entering the government spending equation and the common monetary policy shock.

- Estimation: The model is estimated for EA and US with Bayesian techniques for the period 1983:Q1-2008:Q3 using seven key macroeconomic variables: real GDP, real investment, real private consumption, hours worked, GDP deflator inflation, real wage, and the nominal short-term interest rate.
- Replication: The impulse response functions to negative one-standard-deviation shocks were replicated, similar to those in Figures 3-6 in Villa (2016). The variables include output, investment, inflation, net worth and spread.

2.49 US_VMDno, US_VMDop: Verona et al. (2013)

The US_VMD model is an extended model of Christiano et al. (2010a) with a shadow banking system to account for the pattern of financial and economic boom-bust. Two versions of the model are calibrated based on the bond spread over the long run and during the 2000s' boom: the model for normal times (US_VMDno model) and the model for times of over-optimism (US_VMDop model).

- Aggregate Demand: As in US_CMR10
- Aggregate Supply: As in US_CMR10
- Financial System: It consists of loan market (traditional banking system) and bond market (shadow banking system). The loan market is modeled as a risky debt contract between the entrepreneurs and perfectly-competitive retail banks under monitoring cost in the form of costly state verification as Bernanke et al. (1999). Retail banks can diversify the idiosyncratic risk of many entrepreneurs and thus can generate a safe return on households' deposit. In the bond market, there are a continuum of safer entrepreneurs who are assumed not to default and investment banks who has some monopolistic power. The coupon rate of bonds issued is determined as a time-varying markup over the risk-free interest rate, which is a function of the elasticity of the demand for funds in the bond market. The elasticity of the demand in times of over-optimism is calibrated to be more elastic than one in normal times.
- Shocks: A monetary policy shock
- Calibration/Estimation: The model is calibrated for the U.S. economy. The parameters related to the bond market and entrepreneurs who rely on bond finance are calibrated to match empirical statistics to their counterpart of the model. The values of the remaining parameters are taken from other studies, especially from Christiano et al. (2010a).

2.50 US_YR13: Rychalovska (2016)

Rychalovska (2016) incorporates financial frictions combined with an imperfectly rational expectation formation mechanism into a medium-scale DSGE model based on Smets and Wouters (2007). The financial frictions are integrated in the form of the financial accelerator as originally applied in Bernanke and Gertler (1989) and Bernanke et al. (1996). The model contains a number of nominal and real rigidities such as monopolistic competition on goods and labor markets, Calvo price and wage stickiness, habit formation in consumption and capital adjustment costs. The paper explores the properties of the model assuming, on the one hand, complete rationality of expectations and, alternatively, several learning algorithms that differ in terms of the information set used by agents to produce the forecasts. The results suggest that the learning scheme based on small forecasting functions is able to amplify the effects of financial frictions relative to the model with Rational Expectations.

- Aggregate Demand: As in Smets and Wouters (2007), households maximize their lifetime utility function, non-separable in consumption and leisure, subject to an intertemporal budget constraint. Preferences for consumption are subject to habit persistence. Households own firms and supply labor monopolistically. Wage stickiness is introduced via the Calvo framework.
- Aggregate Supply: Apart from the intermediate and final goods firms as in Smets and Wouters (2007), following Bernanke et al. (1999) and Christiano et al. (2003), capital goods producers and entrepreneurs are introduced into the model. Competitive capital-goods producers, owned by households, produce new capital goods which are sold to entrepreneurs. Capital-goods producers combine investment goods, purchased from the final good producers, with the existing capital stock, rented from the entrepreneurs, to produce new capital goods. Capital-goods producers are subject to quadratic adjustment costs. In the formal representation of the entrepreneurs' problem the paper follows Christiano, Motto and Rostagno (2010b) and deviates from the original Bernanke et al. (1999) specification, assuming that entrepreneurs are not directly involved in the production of intermediate goods. In addition, banks are also introduced into the model, which interact with entrepreneurs and bring financial frictions into play. Entrepreneurs, who are risk neutral and survive until the next period with a certain probability, use their own funds (the net worth) and loans from the bank to finance capital that is rented to the production sector. Competitive banks finance the loans by accepting deposits from the households at the risk-free rate while entrepreneurs have to pay an external finance premium over the riskless rate in order to borrow funds.

- Shocks: total factor productivity shock, investment-specific shock, external financing premium shock, fiscal shock, a monetary policy shock, a wage and price mark-up shock.
- Estimation: The model is estimated using seven macroeconomic quarterly U.S. time series: real GDP, real consumption, real investment, real wage, hours worked, GDP deflator and the federal funds rate. The data are quarterly for the sample period 1954:1-2008:3.

3 Estimated Euro Area Models

3.1 EA_ALSV06: Andrés et al. (2006)

Andrés et al. (2006) develop a small-scale New Keynesian model with real money balances entering both the forward-looking IS curve and the Phillips curve. The model is used to assess the role played by money in the joint evolution of output, interest rates and inflation in the euro area economy. The authors find no effect of real balances on marginal utility of consumption and that prices, output and interest rates are mainly explained by real shocks and not money demand shocks.

- Aggregate Demand: A representative household maximizes expected utility, non-separable between consumption and real money balances while separable in hours worked, subject to a budget constraint. The utility function features habit formation in consumption. The optimizing behavior leads to a forward looking IS curve in which real balances enter. This is due to the intra-temporal non-separability of real balances and consumption in the utility function. Further, due to the habit formation in consumption, the IS curve includes a lag in output and two period leads in output, real balances, as well as the money demand and preference shocks.
- Aggregate Supply: A continuum of firms produces goods according to Cobb-Douglas production functions using labor as input. Firms sell their output in a monopolistically competitive market. Nominal prices are set on a staggered basis as in Calvo. Further, some of the adjusting firms use a backward-looking rule of thumb while the rest of the firms adjust their prices based on optimization of expected future revenues. The optimizing behavior of firms leads to a forward-looking Phillips curve. Due to the rule-of-thumb adjusting firms, the Phillips curve also has a backward-looking component. Via real marginal costs, besides the technology shock, also output and real balances enter the Phillips curve; under habits also lags and/or leads in output, real balances as well as money demand and preference shocks enter the specification.
- Shocks: An overall preference shock, a real money balances preferences (velocity) shock, a productivity (technology) shock, and a monetary policy shock.
- Estimation: Estimated via maximum likelihood using EA quarterly data over the period 1980:1-1999:4 for logs of detrended output, detrended real balances, inflation and gross nominal interest rates. Output, inflation and interest rate data come from the Area Wide Model dataset, while real balances are measured dividing M3 by the GDP deflator.

3.2 EA_AWM05: Area Wide model linearized by Dieppe et al. (2005)

The model is described in Fagan, Henry and Mestre (2005). It was one of the first models to treat the Euro area as a single economy. In the Modelbase we use the linearized version from Dieppe et al. (2005) that is also used in Kuester and Wieland (2005). The EA_AWM05 is an open economy model of the Euro area. Expectation formation is largely backward-looking. Activity is demand-determined in the short-run but supply-determined in the long-run with employment having converged to a level consistent with the exogenously given level of equilibrium unemployment. Stock-flow adjustments are accounted for, e.g., the inclusion of a wealth term in consumption.

- Aggregate Demand: Demand is disaggregated into private consumption, government consumption, investment, variation of inventories, exports, and imports. The term structure (12-year bond) is forward-looking. Private consumption is specified as a function of households' real disposable income and wealth, where the latter consists of net foreign assets, public debt and the capital stock. The change in the log of the investment/output ratio depends on the real interest rate, the real GDP/capital stock ratio and the lagged investment/output ratio. The authors stress that this investment equation represents the key channel through which interest rates affect aggregate demand. Government consumption is treated as exogenous.
- Aggregate Supply: Output follows a whole economy production function. Short-run employment dynamics are driven by output growth and real wages. The deflator for real GDP at factor costs, which according to Fagan et al. (2005) is the key price index of the model, is a function of unit labor costs, import prices, the output gap and inflation expectations. The growth rate of wages depends on consumer price inflation, productivity and the unemployment gap, defined as the deviation of the current unemployment rate from the NAIRU.

- Foreign sector: Besides extra-area flows, exports and imports also include intra-area flows. World GDP and world GDP deflator are treated as exogenous variables. The exchange rate is a forward-looking variable determined by uncovered interest rate parity.
- Shocks: Employment shock, factor cost-push shock, private consumption cost-push shock, gross investment cost-push shock, gross investment shock, exports cost-push shock, imports cost-push shock, private consumption shock, term structure shock, common fiscal policy shock and common monetary policy shock.
- Calibration/Estimation: Estimation on Euro area data equation by equation from 1970:1–1997:4, whereas the estimation period of some equations starts later, but not later than 1980:1.

3.3 EA_BE15: Benchimol (2015)

Benchimol (2015) checks whether money is an omitted variable in the production process. For this purpose he estimates a NK-model with real money balances in the production func-tion on European data. While he finds no strong evidence for the importance for money in production, the demand for money by firms plays a role for the economy.

- Aggregate Demand: A representative household maximizes expected lifetime utility by optimizes consumption, labor supply, money holdings and bond holdings. Money enters the utility function.
- Aggregate Supply: Firms are monopolistic competitors and prices are sticky (Calvo pricing). The production factors are labor, (exogenous) technology and real balances held by the firm. Labor markets are frictionless.
- Shocks: In the model there is a technology shock, a preference shock, a monetary policy shock, and two money demand shocks (one for households' and one for firms' demand for money).
- Estimation: The model is estimated on quarterly Eurozone data using the observables GDP per capita, GDP deflator, short term nominal interest rate and M3.

3.4 EA_BF17: Benchimol and Fourçans (2017)

Benchimol and Fourçans (2017) analyse the role of money and monetary policy as well as the forecasting performance of NK models with and without separability between consump-tion and money over three crisis periods in the Eurozone (ERM crisis, dot-com crisis and global financial crisis). For this purpose they estimate an NK-model on European data, and find that the nonseparable model generally provides better forecasting performance. Addi-tionally, they find that the effects of monetary policy differ across the three crises.

- Aggregate Demand: A representative household optimizes consumption, labor supply, money holdings and bond holdings. Money features the utility function. In the MMB the model with nonseparabilities between consumption and real balanced is implemented.
- Aggregate Supply: Firms are monopolistically competitive and face price rigidities (Calvo pricing). Labor is the only factor for production.
- Shocks: The model features a technology shock, a price markup shock as well as an interest rate shock and a shock to the money supply.
- Estimation: The model is estimated on quarterly Eurozone data using the observables GDP per capita, GDP deflator, short term nominal interest rate and M3.

3.5 EA_CKL09: Christoffel et al. (2009)

Christoffel et al. (2009) explore the role of labor markets for monetary policy in the Euro Area in a closed-economy, single-country New Keynesian model with Mortensen and Pissarides (1994) type of matching frictions. To allow for a direct channel from wages to inflation, the model builds on the right-to-manage framework of Trigari (2006). Moreover, Christoffel et al. (2009) incorporate staggered wage-setting à la Calvo and account for job-related fixed costs as in Christoffel and Kuester (2008). The aim of the paper is to investigate to which extent a more flexible labor market would alter the business cycle behavior and the transmission of monetary policy, employing a genuine Euro Area calibration (NK_CKL09, see section 1.10). Second, by estimating the model with Bayesian techniques (EA_CKL09) they analyze to which extent labor market shocks are important determinants of business cycle fluctuations. The results support current central bank practice to put considerable effort into monitoring Euro Area wage dynamics and treat some of the other market information as less important for monetary policy.

- Aggregate Demand: The demand as well as the supply structure follow closely the one described in Christoffel and Kuester (2008). The economy consists of a large number of identical families that comprise unemployed and employed members with time-additive expected utility preferences that exhibit an external habit. The

representative family pools the labor income of its working members, unemployment benefits of the unemployed members and financial income from assets that family members hold via a mutual fund. Each household also owns representative shares of all firms in the economy. It maximizes the sum of unweighted expected utilities of its individual members, by taking consumption, saving, vacancy posting, and labor supply decisions on their behalf.

- Aggregate Supply: The economy consists of three production sectors. The labor packers use exactly one worker as input to produce a homogeneous intermediate good labeled labor good. The process of labor bargaining is governed by wage rigidities. The wholesale sector buys the labor good from the labor packers in a perfectly competitive market and produces differentiated goods using a constant-return-to-scale production technology. These goods are sold under monopolistic competition to a final retail sector at a price that is subject to impediments à la Calvo and to a partial indexation rule. Retailers bundle the differentiated goods into a homogeneous consumption/investment basket and sell it to the consumers and to the government.
- Shocks: Three labor market shocks: a shock to the costs of posting a vacancy, a shock to the rate of separation, and a shock to the bargaining power of workers; a government spending shock; a wholesale sector cost-push shock.
- Calibration/Estimation: For the calibration exercise (NK_CKL09) a quarterly Euro Area data set from 1984:Q1 to 2006:Q3 is used. The model is also estimated with Bayesian techniques (EA_CKL09) employing output, year-on-year inflation, the nominal interest rate, wages per employee, unemployment and proxies for total hours worked and vacancies as observable variables.

3.6 EA_CW05: Coenen and Wieland (2005)

Coenen and Wieland (2005) develop a small-scale macroeconomic model for various staggered pricing schemes. We use a version with the nominal contract specification of Taylor (1980), labeled EA_CW05ta, and a version with the relative real wage contract specification of Fuhrer and Moore (1995a), labeled EA_CW05fm.

- Aggregate Demand: The aggregate demand equation is backward looking: two lags of aggregate demand (should account for habit persistence in consumption, adjustment costs and accelerator effects in investment) and one lag of the long-term interest rate (allows for a transmission lag of monetary policy). The long-term nominal interest rate is an average of expected future nominal short-term rates. The long-term real rate is determined by the Fisher equation.
- Aggregate Supply: As in US_FM95 and US_OW98.
- Shocks: A demand shock, a contract wage shock and the common monetary policy shock.
- Calibration/Estimation: The model has been estimated on data from the ECB Area Wide Model data set from 1974:1–1998:4. The contract wage specifications have been estimated by a limited information indirect inference technique while the IS equation has been estimated by means of the GMM.

3.7 EA_DKR11: Darracq Paries et al. (2011)

The model of Darracq Paries et al. (2011) incorporates the imperfect competitive banking sector of Gerali et al. (2010) in a DSGE model augmented by a financial accelerator in the spirit of Bernanke et al. (1999). The model allows to examine the macroeconomic implications of various financial frictions on the supply and demand of credit.

- Aggregate Demand: The model features patient (savers) and impatient (borrowers) households, as well as entrepreneurs. A representative household maximizes its intertemporal utility function choosing the level of consumption, the housing stock and labor supply, subject to a budget constraint. Wage-setting is subject to rigidities à la Calvo with indexation to both past and steady state inflation.

  Since impatient households can default on their loans, banks seize collateral. Thus, impatient households face a borrowing constraint, linked to the aggregate repayments and defaults. Entrepreneurs maximize their utility by choosing consumption, physical capital, loans from banks, the degree of capacity utilization and labor. Entrepreneurs also face a borrowing constraint, linked to the aggregate repayments and defaults on outstanding debt.
- Aggregate Supply: The production sector consists of four types of firms: entrepreneurs, capital good and housing stock producers, retailers and the distribution sector. Entrepreneurs hire labor from households and buy capital from capital good producers to produce intermediate residential and non-residential goods. Capital and housing stock producers buy final goods to produce capital and the housing stock subject to investment adjustment costs. Retailers buy intermediate goods from entrepreneurs and differentiate them. Pricing is subject to nominal rigidities à la Calvo. The distribution sector aggregates differentiated goods and sells them to the agents.

- Banking Sector: The perfectly competitive wholesale branch receives funding from the money market and manages the capital position of the banking group. Loan book financing branches and the retail deposit branches work under monopolistic competition. The latter collects deposits from savers and places them in the money market. The loan book financing branches provide funding to the commercial lending branches who supply loans to entrepreneurs and impatient households under perfect competition.
- Shocks: Efficient shocks are technology shocks in both residential and non-residential sectors, a non-residential investment specific productivity shock, a labor supply shock, a public expenditure shock, a consumption preference shock and a housing preference shock. Inefficient shocks are a price markup shock in the non-residential sector and shocks to the markup on bank interest rates. Riskiness shocks are shocks to the standard deviation of the idiosyncratic risk for impatient households and entrepreneurs. In addition, there is a monetary policy shock and a shock to bank capital.
- The model is estimated with Bayesian techniques for the euro area for 1986:Q1 to 2008:Q2. For the estimation, fifteen observables are used: output, consumption, nonresidential fixed investment, hours worked, real wages, CPI inflation rate, three-month short-term interest rate, residential investment, real house prices, household vloans, non-financial corporation loans, household deposits, and bank lending rates on household loans, on non-financial corporation loans, and on household deposits.

3.8 EA_GE10: Gelain (2010)

The model of Gelain (2010) incorporates financial frictions à la Bernanke et al. (1999) into a New Keynesian DSGE model which closely follows the structure of the model developed in Smets and Wouters (2003). The structural model allows for a dynamic analysis of the external finance premium. The paper shows that the estimated premium is not necessarily countercyclical as suggested by former studies on the Euro Area external finance premium. In the presence of certain shocks the premium responds procyclically.

- Aggregate Demand: A representative household maximizes its intertemporal utility function choosing the level of consumption, hours worked and the amount of bank deposits, subject to a budget constraint. The household's consumption preferences exhibit habit formation.
- Aggregate Supply: Each household is a monopolistic supplier of differentiated labor services requested by the domestic firms. After setting their wages in a Calvo staggered way, households inelastically supply the firms' demand for labor at the ongoing wage rate. An indexation rule is assumed for those households who are not allowed to re-optimize.
  The production sector consists of three types of firms: entrepreneurs, capital producers and retailers. Entrepreneurs hire labor from households and buy capital from capital producers to produce intermediate goods using a Cobb-Douglas production technology. Entrepreneurs have a finite expected lifetime horizon. The capital purchases are financed partly by the entrepreneur's net worth and partly by borrowing from a financial intermediary. The presence of asymmetric information between entrepreneurs and lenders creates a financial friction as in Bernanke et al. (1999). Entrepreneurs can reoptimize their prices only from time to time, as in Calvo (1983). Capital producers buy final goods to produce capital subject to investment adjustment costs. Retailers operate in a perfectly competitive market, they use a Dixit-Stiglitz technology using the entrepreneurs' intermediate goods as inputs.
- Shocks: The model exhibits eight shocks. Two preference shocks, a shock to investment adjustment costs, a technology shock in entrepreneurs' production function, a wage and a price mark up shock, a government spending shock and a monetary policy shock.
- The model is estimated using Bayesian techniques on quarterly Euro Area data for 1980:Q1 to 2008:Q3. The data set used is comprised of seven key macroeconomic variables aggregated for the Euro Area consisting of real GDP, real consumption, real gross investment, hours worked, the nominal short term interest rate, real wages per head and inflation rate.

3.9 EA_GNSS10: Gerali et al. (2010)

The model of Gerali et al. (2010) incorporates an imperfect competitive banking sector in a DSGE model with financial frictions à la Iacoviello (2005). The model allows to asses the role of both financial frictions and banking intermediation in shaping business-cycle dynamics.

- Aggregate Demand: There are two type of households, patient (savers) and impatient (borrowers) and entrepreneurs. A representative household maximizes its intertemporal utility function choosing the level of consumption, hours worked and housing services, subject to a budget constraint. Impatient households face in addition a borrowing constraint, linked to the expected value of their collateralizable housing stock. The

household's consumption preferences exhibit external habit formation. Households supply differentiated labor services through unions. Wage-setting is subject to adjustment costs, à la Rotemberg with indexation to both past and steady state inflation. Entrepreneurs maximize their utility by choosing consumption, physical capital, loans from banks, the degree of capacity utilization and labor. Entrepreneurs face also a borrowing constraint, linked to the value of their holdings of physical capital.

- Aggregate Supply: The production sector consists of three types of firms: entrepreneurs, capital good producers and retailers. Entrepreneurs hire labor from households and buy capital from capital good producers to produce intermediate goods. Capital producers buy final goods to produce capital subject to investment adjustment costs. Retailers buy intermediate goods from entrepreneurs and differentiate them. Pricing is subject to nominal rigidities.
- Banking Sector: Banks enjoy market power in conducting their intermediation activity. Bank loans should be met by deposits and/or bank capital. Each bank has three parts, two "retail" branches (giving out differentiated loans to impatient households and to entrepreneurs and raising differentiated deposits from patient households) and one "wholesale" unit (managing the capital position of the group).
- Shocks: The model exhibits a technology shock, price and wage markups shocks, a consumption preferences shock, a housing demand shock, an investment-specific technology shock, a monetary policy shock, shocks to the loan-to-value ratios on loans to firms and households, shocks to the markup on bank interest rates and balance sheet shocks.
- The model is estimated with Bayesian techniques, for the euro area for 1998:Q1-2009:Q1. For estimation twelve observables are used: real consumption, real investment, real house prices, real deposits, real loans to households and firms, overnight rate, interest rates on deposits, loans to firms and households, wage inflation and consumer price inflation.

3.10 EA_PV15: Poutineau and Vermandel (2015a)

Poutineau and Vermandel (2015a) evaluate quantitatively how interbank and corporate cross-border flows shape business cycles in a monetary union. They estimate a two-country DSGE model (equal-size Eurozone core and peripheral countries) that accounts for national heterogeneities and a set of real, nominal and financial frictions. Each country is populated by consumers, labor unions, intermediate and final producers, entrepreneurs, capital suppliers and a banking system. The set of real rigidities encompasses consumption habits, investment adjustment costs and loan demand habits. Regarding nominal rigidities, they account for stickiness in final goods prices, wages and loan interest rates. Obtained results support the key role of the cross-border channel as an amplifying mechanism in the diffusion of asymmetric shocks.

- Aggregate Demand: Households in both countries consume, save and work in intermediate firms, and maximize expected lifetime utility with respect to the consumption and labor effort. They spend their incomes on consumption, bond subscription and tax payments. In addition to that, there exist quadratic adjustment costs necessary to buy new bonds (Schmitt-Grohé and Uribe (2003)). Households provide differentiated labor types, sold by labor unions to perfectly competitive labor packers who assemble them in a CES aggregator and sell the homogenous labor to intermediate firms.
- Aggregate Supply: Each economy is characterized by two groups of firms: intermediate firms and final firms. Intermediate firms produce differentiated goods, choose labor and capital inputs, and set prices according to the Calvo model. Final goods producers act as a consumption bundler by combining national intermediate goods to produce the homogenous final good.
- Financial Sector: In each country the banking sector finances investment projects to home and foreign entrepreneurs by supplying one-period loans. The banking system is heterogeneous with regard to liquidity and banks engage in interbank lending at the national and international levels. Thus, cross-border loans are made of corporate loans (between banks and entrepreneurs) and interbank loans. In order to introduce an interbank market, authors suppose that the banking system combines liquid and illiquid banks, where liquid banks (characterized by direct accessibility to the ECB funding) supply loans to entrepreneurs and to illiquid banks. Additionally, the intermediation process between liquid and illiquid banks is costly (convex monitoring technology). So-called financial accelerator mechanism is borrowed from De Grauwe (2010) and applied in a different context, by assuming that entrepreneurs' forecasts regarding the aggregate profitability of a given project are optimistic (these values are then compared to the critical threshold which distinguishes profitable and non-profitable projects).
- Shocks: There are in total 8 country specific structural shocks and one shock in the common monetary policy rule. Namely, a productivity shock, demand shock, time-preference shock, net wealth shock, external finance premium shock, bank rate markup shock, wage markup shock, bank liability shock and ECB monetary policy shock.

- Calibration/Estimation: The model is estimated with Bayesian methods on Euro Area quarterly data over the sample period 1999Q1 to 2013Q3.

3.11 EA_PV16: Priftis and Vogel (2016)

Priftis and Vogel (2016) analyse the effects of quantitative easing (QE) in a model of the Eurozone with different assets. QE is captured by asset-purchases by the central bank. They use the model to simulate the path of QE as announced in early 2015 and find an expansionary effect on output, interest rates and inflation that is larger when QE is accommodated by low interest rates. The model is the QUEST III model (which is implemented in the MMB) plus QE.

- Aggregate Demand: There are two types of households: liquidity- and non-liquidity-constrained households. They possess the same utility function, non-separable in consumption and leisure with habit persistence in both consumption and leisure. Liquidity-constrained households do not optimize, they just consume their labor income. On the other side, non-liquidity-constrained households have access to domestic and foreign currency denominated assets, accumulate capital subject to investment adjustment costs and rent it to firms, earn profits from owning the firms and pay taxes. Income from foreign financial assets is subject to an external financial intermediation risk premium while real asset holdings are subject to an equity risk premium. Both types of households supply differentiated labor to a trade union which sets the wages by maximizing their joint utility (weighted by the share of each type). The wage setting processs is subject to a wage mark-up and to slow adjustments in the real consumption wage. The wage mark-up arises because of wage adjustment costs and the fact that a part of workers index the growth rate of wages to past inflation.
- Aggregate Supply: The final goods, which are produced from monopolistically competitive firms, are used for household consumption, investment, government consumption and export. These goods are produced with a Cobb-Douglas production function with capital and production workers (labor adjusted for overhead labor) as inputs. These firms face technological and regulatory constraints, restricting their price setting, employment and capacity utilization decisions. The final goods producer maximizes profits subject to these specific adjustment costs (all having convex functional forms) and demand conditions. Investment good producers combine domestic and foreign final goods using a CES aggregator to produce investment goods which are sold to non-liquidity-constrained households in a perfectly competitive market.
- The Foreign Sector: Demand behavior is considered the same for the home country and the rest of the world, therefore export demand and import demand are symmetric. Both equations are characterized by a lag structure in relative prices which captures delivery lags. Export firms buy domestic goods, transform them using a linear technology and sell them in the foreign market, charging a mark-up over the domestic prices. The same situation is faced by importer firms. Mark-up fluctuations arise because of price adjustment costs in both sectors. Mark-up equations are given as a function of past and future inflation and are also subject to random shocks.
- Assets and QE: QE is modelled as purchases of domestic long-term bonds in exchange for central bank liquidity. Next to physical capital and money, the model features long-term and short-term bonds.
- Shocks: The model contains a large battery of shocks as in the QUEST III model as well as QE shocks.
- Calibration: The model is calibrated in line with the QUEST III model, which has been estimated on EA data.

3.12 EA_PV17: Priftis and Vogel (2017)

Priftis and Vogel (2017) analyse the effects of quantitative easing (QE) in a model of the Eurozone. QE is captured by long-term bond purchases by the central bank. The authors find that QE mildly raised output growth and inflation. The model is the QUEST III model (which is implemented in the MMB) plus QE.

- Aggregate Demand: There are two types of households: liquidity- and non-liquidity-constrained households. They possess the same utility function, non-separable in consumption and leisure with habit persistence in both consumption and leisure. Liquidity-constrained households do not optimize, they just consume their labor income. On the other side, non-liquidity-constrained households have access to domestic and foreign currency denominated assets, accumulate capital subject to investment adjustment costs and rent it to firms, earn profits from owning the firms and pay taxes. Income from foreign financial assets is subject to an external financial intermediation risk premium while real asset holdings are subject to an equity risk premium. Both types of households supply differentiated labor to a trade union which sets the wages by maximizing their joint utility (weighted by the share of each type). The wage setting process is subject to a wage mark-up and to slow adjustments in the real consumption wage. The wage mark-up arises because of wage adjustment costs and the fact that a part of workers index the growth rate of wages to past inflation.
- Aggregate Supply: The final goods, which are produced from monopolistically competitive firms, are used for household consumption, investment, government consumption and export. These goods are produced with a

Cobb-Douglas production function with capital and production workers (labor adjusted for overhead labor) as inputs. These firms face technological and regulatory constraints, restricting their price setting, employment and capacity utilization decisions. The final goods producer maximizes profits subject to these specific adjustment costs (all having convex functional forms) and demand conditions. Investment good producers combine domestic and foreign final goods using a CES aggregator to produce investment goods which are sold to non-liquidity-constrained households in a perfectly competitive market.

- The Foreign Sector: Demand behavior is considered the same for the home country and the rest of the world, therefore export demand and import demand are symmetric. Both equations are characterized by a lag structure in relative prices which captures delivery lags. Export firms buy domestic goods, transform them using a linear technology and sell them in the foreign market, charging a mark-up over the domestic prices. The same situation is faced by importer firms. Mark-up fluctuations arise because of price adjustment costs in both sectors. Mark-up equations are given as a function of past and future inflation and are also subject to random shocks.
- Assets and QE: QE is modelled as purchases of domestic long-term bonds in exchange for central bank liquidity. Next to physical capital and money, the model features long-term and short-term bonds. The assets are held by the household and long-term and short-term bond holdings are subject to portfolio adjustment costs.
- Shocks: The model uses a large number of shocks for estimation. Discussed in the paper is the long-term bond purchases.
- Shocks: The model contains a large battery of shocks as in the QUEST III model as well as exogenous long-term bond purchases.
- Calibration: The model is calibrated in line with the QUEST III model, which has been estimated on EA data.

3.13 EA_QR14: Quint and Rabanal (2014)

Quint and Rabanal (2014) use a two-country, two-sector, two-agent 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 EMU; the two sectors capture non-durable and durable goods, the latter being housing goods. It builds on the model presented in Rabanal (2009) by extending it with a financial accelerator mechanism in households' balance sheets. Macroprudential policy aims to stabilize credit markets by affecting the fraction of liabilities banks can lend.

- Aggregate Demand: Households in the core and in the periphery maximize expected lifetime utility by choosing consumption of durable and non-durable goods, and leisure. The composite non-durable consumption good consists of domestic non-durable (i.e., tradable) and foreign non-durable goods. Purchases of durable goods take the form of residential investment. Households in each country can save in 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-style rigidities) use household labor to produce durable and non-durable intermediate goods that are combined by competitive final-good producers into durable and non-durable goods. Imperfect substitutability of labor 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 (i.e., 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 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.

3.14 EA_QUEST3: Ratto et al. (2009)

Ratto et al. (2009) develop and estimate an open economy DSGE model for the euro area with emphasis on monetary and fiscal rules, in order to explore their stabilization properties. The role of fiscal policy is explored in an environment

with rules for government consumption, investment and transfers and with financial frictions in the form of liquidity-constrained households.

- Aggregate Demand: There are two types of households: liquidity- and non-liquidity-constrained households. They posses the same utility function, non-separable in consumption and leisure with habit persistence in both consumption and leisure. Liquidity-constrained households do not optimize, they just consume their labor income. On the other side, non-liquidity-constrained households have access to domestic and foreign currency denominated assets, accumulate capital subject to investment adjustment costs and rent it to firms, earn profits from owning the firms and pay taxes. Income from foreign financial assets is subject to an external financial intermediation risk premium while real asset holdings are subject to an equity risk premium. Both types of households supply differentiated labor to a trade union which sets the wages by maximizing their joint utility (weighted by the share of each type). The wage setting process is subject to a wage mark-up and to slow adjustments in the real consumption wage. The wage mark-up arises because of wage adjustment costs and the fact that a part of workers index the growth rate of wages to past inflation.
- Aggregate Supply: The final goods, which are produced from monopolistically competitive firms, are used for household consumption, investment, government consumption and export. These goods are produced with a Cobb-Douglas production function with capital and production workers (labor adjusted for overhead labor) as inputs. These firms face technological and regulatory constraints, restricting their price setting, employment and capacity utilization decisions. The final goods producer maximizes profits subject to these specific adjustment costs (all having convex functional forms) and demand conditions. Investment good producers combine domestic and foreign final goods using a CES aggregator to produce investment goods which are sold to non-liquidity-constrained households in a perfectly competitive market.
- The Foreign Sector: Demand behavior is considered the same for the home country and the rest of the world, therefore export demand and import demand are symmetric. Both equations are characterized by a lag structure in relative prices which captures delivery lags. Export firms buy domestic goods, transform them using a linear technology and sell them in the foreign market, charging a mark-up over the domestic prices. The same situation is faced by importer firms. Mark-up fluctuations arise because of price adjustment costs in both sectors. Mark-up equations are given as a function of past and future inflation and are also subject to random shocks.
- Shocks: A wage mark up shock, a price mark-up shock, a monetary policy shock, a fiscal policy shock, world demand shock, a risk premium shock, a technology shock, an investment shock, a consumption shock, a trade shock, a labor demand shock, a foreign monetary policy shock.
- Calibration/Estimation: Estimated with Bayesian methods, using quarterly data for the euro area for the period 1981:1–2006:1.

3.15 EA_SR07: Euro Area Model of Sveriges Riksbank, Adolfson et al. (2007)

Adolfson et al. (2007) develop an open economy DSGE model and estimate it for the Euro area using Bayesian estimation techniques. They analyse the importance of several rigidities and shocks to match the dynamics of an open economy.

- Aggregate Demand: Households maximize lifetime utility subject to a standard budget constraint. Preferences are separable in consumption, labor and real cash holdings. Persistent preference shocks to consumption and labor supply are added to the representative utility function. Internal habit formation is imposed with respect to consumption. Aggregate consumption is specified as a CES function, being composed of domestically produced as well as imported consumption goods. Households rent capital to firms. Capital services can be increased via investment and via an increase in the capital utilization rate, where both options are involved with costs. Total investment in the domestic economy is represented by a CES aggregate consisting of domestic and imported investment goods. Households are assumed to be able to save through acquiring domestic bonds and foreign bonds in addition to holding cash and accumulating physical capital. A premium on foreign bond holdings assures the existence of a well-defined steady state. Households monopolistically supply a differentiated labor service. Wage stickiness is introduced in the form of the Calvo model augmented by partial indexation.
  Government consumption of the final domestic good is financed via taxes on capital income, labor income, consumption and payroll. Any surplus or deficit is assumed to be carried over as a lump-sum transfer to households.
- Aggregate Supply: The final good is produced via a CES aggregator using a continuum of differentiated intermediate goods as inputs. The production of intermediate goods requires homogeneous labor and capital services as inputs and is affected by a unit-root technology shock representing world productivity as well as a domestic technology shock. Fixed costs are imposed such that profits are zero in steady state. Due to working capital, (a fraction of) the wage bill has to be financed in advance of the production process. Price stickiness of intermediate goods is modeled as in the Calvo (1983) model. In addition, partial indexation to the contemporaneous

inflation target of the central bank and the previous periods inflation rate is included for those firms that do not receive a Calvo signal in a given period. This results in a hybrid new Keynesian Phillips curve.

- Foreign sector: Importing firms are assumed to buy a homogeneous good in the world market and differentiate it to sell it in the domestic market. Similarly, exporting firms buy the homogeneous final consumption good produced in the domestic economy and differentiate it to sell it abroad. Specifically, the differentiated investment and consumption import goods are aggregated in a second step via a CES function, respectively. The same applies to the export goods. Calvo pricing is also assumed for the import and export sector, allowing for incomplete exchange rate pass-through in the short run. The foreign economy is described by an identified VAR model for foreign prices, foreign output and the foreign interest rate.
- Shocks: Unit root technology shock, stationary technology shock, investment specific technology shock, asymmetric technology shock, consumption preference shock, labor supply shock, risk premium shock, domestic mark-up shock, imported consumption mark-up shock, imported investment mark-up shock, export mark-up shock, inflation target shock, the common monetary policy shock, shocks to the four different tax rates and a government spending shock which represents the common fiscal policy shock and which we have adjusted so that we achieve a shock size of one percent of GDP.
- Calibration/Estimation: The model is estimated using Bayesian estimation techniques for the Euro area using quarterly data from 1970:1–2002:4 in order to match the dynamics of 15 selected variables. According to the authors, they calibrated those parameters that should be weakly identified by the 15 variables used for estimation.

3.16 EA_SW03: Smets and Wouters (2003)

The EA_SW03 model of Smets and Wouters (2003) is a medium-scale closed economy DSGE model with various frictions and estimated for the Euro area with Bayesian techniques.

- Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption, leisure and real money balances, subject to an intertemporal budget constraint. Smets and Wouters (2003) include external habit formation to make the consumption response in the model more persistent. Households own firms, rent capital services to firms and decide how much capital to accumulate given certain capital adjustment costs. They additionally hold their financial wealth in the form of cash balances and one-period, state-contingent bonds. Exogenous spending is introduced by a first-order autoregressive process with an iid-normal error term.
- Aggregate Supply: The final goods, which are produced under perfect competition, are used for consumption and investment by the households and by the government. The final goods producer maximizes profits subject to a Dixit-Stiglitz aggregator of intermediate goods, which introduces monopolistic competition in the market for intermediate goods and features a constant elasticity of substitution between individual, intermediate goods. A continuum of intermediate firms produce differentiated goods using a production function with Cobb-Douglas technology and fixed costs and sell these goods to the final-goods sector. They decide on labor and capital inputs, and set prices according to the Calvo model. Labor is differentiated over households using the Dixit-Stiglitz aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Sticky wages à la Calvo are additionally assumed. The Calvo model in both wage and price setting is augmented by the assumption that prices that can not be freely set, are partially indexed to past inflation rates.
- Shocks: Ten orthogonal structural shocks are introduced in the model. Three preference shocks in the utility function: a general shock to preferences, a shock to labor supply and a money demand shock. Two technology shocks: an AR(1) process with an iid shock to the investment cost function and a productivity shock to the production function. Three cost push-shocks: shocks to the wage and price mark-up, which are iid around a constant and a shock to the required rate of return on equity investment. And finally two monetary policy shocks: a persistent shock to the inflation objective and a temporary common monetary policy shock. In addition, the common fiscal policy shock is added in the form of a government spending shock. Since government spending is expressed in output units, we set the coefficient which scales the shock to unity to achieve a shock size of one percent of GDP.
- Calibration/Estimation: The model is estimated using Bayesian techniques on quarterly Euro area data. The data set used is comprised of seven key macroeconomic variables consisting of real GDP, real consumption, real investment, the GDP deflator, real wages, employment and the nominal interest rate over the period 1970:1–1999:4.

3.17 EA_SWW14: Smets et al. (2014)

Smets et al. (2014) uses the Galí, Smets and Wouters (2012) model. It is estimated on euro area data using Bayesian estimation techniques.

- Galí et al. (2012) is based on Smets and Wouters (2007) and differs from the latter in the following ways:
  - labor decision on the extensive margin (whether to work or not) rather than the intensive margin (how many hours to work), unemployment is included as an observable variable
  - logarithmic consumption utility, the utility function is separable in consumption and leisure
  - the error term in the wage equation captures only the wage markup shock and not the preference shock (as in SW07)
  - Dixit-Stigliz type aggregator functions for aggregate labor demand and aggregate nominal wage (SW07 uses Kimball).
- Shocks: A total factor productivity shock, a risk premium shock, an investment-specific technology shock, a labor supply shock, a wage and a price mark-up shock and two policy shocks: the common fiscal policy shock entering the government spending equation and the common monetary policy shock.
- Estimation: The model is estimated for the euro area with Bayesian techniques for the period 1985:1-2009:4. In addition to SW07, unemployment is used as an observable variable for the estimation of parameters.

3.18 EA_VI16bgg and EA_VI16gk: Villa (2016)

Villa (2016) assesses the empirical relevance of financial frictions in the US and in the Euro Area, where the above versions of the model refer to the Euro Area. It develops a medium-scale closed economy DSGE-model based on Smets and Wouters (2007) and two different financial sector extensions of this framework, in particular Bernanke et al. (1996) and the Gertler and Karadi (2011) types.

- EA_V16bgg model:
  - Aggregate Demand: Households maximize their lifetime utility, where the utility function is separable in consumption and leisure, subject to an intertemporal budget constraint. In addition, the external habit formation makes the consumption response more persistent. Households own firms, rent capital services to firms and decide how much capital to accumulate given certain capital adjustment costs. They additionally hold their financial wealth in the form of one-period, state-contingent government bonds.
  - Aggregate Supply: Intermediate good firms maximize their profits by choosing factors of production and by signing a financial contract to obtain additional funds from lenders. Since lenders have to pay some auditing costs to observe the idiosyncratic return to capital, an agency problem arises. The financial contract implies external finance premium that depends on the inverse of the firm's leverage ratio. Retailers buy goods from intermediate good firms, differentiate them, and sell them in a monopolistically competitive market according to the Calvo model. The aggregate final good is assembled by perfectly competitive final good firms, and is used for consumption and investment by the households and by the government. The final goods producer maximizes profits subject to a Dixit-Stiglitz aggregator of intermediate goods, which introduces monopolistic competition in the market for intermediate goods and features a constant elasticity of substitution between individual, intermediate goods. Labor is differentiated by a union using the Dixit-Stiglitz aggregator, too, so that there is some monopoly power over wages, which results in an explicit wage equation. Labor packers buy the labor from the unions and resell it to the intermediate goods producer in a perfectly competitive environment. Sticky wages à la Calvo are additionally assumed.
- EA_V16gk model:
  - Aggregate Demand: The representative household's utility is separable in consumption and leisure and allows for habit formation in consumption. Households postpone their consumption by holding deposits with the financial intermediaries. The amount of deposits is determined in such a way as to guarantee that the bankers' incentive constraint is satisfied. Expected-lifetime utility is maximized by choosing consumption and labor supplied to intermediate firms.
  - Aggregate Supply: Competitive firms produce intermediate goods using labor services and capital. They face adjustment costs for varying their utilization rate of capital. They finace the capital stock with loans from the financial intermediaries and buy it from capital producing firms to which they re-sell it at the end

of the period after having used it. Capital producers face investment adjustment costs. The intermediate goods are bought by retail firms, which act under monopolistic competition and face nominal rigidities as in Calvo (1983). Non-reoptimizing retailers index their prices to the previous period's inflation rate.

  - Banking sector: Banks receive their funds in the form of deposits from households and lend to non-financial firms. 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.

- Shocks: Seven structural shocks: the technology shock, the investment-specific technology shock, the capital quality shock, the price mark-up shock, the wage mark-up shock, and two policy shocks - the common fiscal policy shock entering the government spending equation and the common monetary policy shock.
- Estimation: The model is estimated for EA and US with Bayesian techniques for the period 1983:Q1-2008:Q3 using seven key macroeconomic variables: real GDP, real investment, real private consumption, hours worked, GDP deflator inflation, real wage, and the nominal short-term interest rate.
- Replication: The impulse response functions to negative one-standard-deviation shocks were replicated, similar to those in Figures 3-6 in Villa (2016). The variables include output, investment, inflation, net worth and spread.

4 Estimated/Calibrated Multi-Country Models

4.1 DEREA_GEAR16: Gadatsch et al. (2016)

Gadatsch et al. (2016) is a 3-country New-Keynesian model for the German economy with a comprehensive fiscal block. 2 of those countries form a monetary union and have a common monetary policy.

- Aggregate Demand: A fraction of households are rule-of-thumb consumers and consume the entire income each period. Optimizing households make optimal choices regarding savings in physical capital, as well as national and international (financial) assets and purchases of consumption goods. Household may find a job in the private or in the public sector or stay unemployed.
- Aggregate Supply: Monopolistic competitors in each region produce a variety of differentiated products and sell these to the home and foreign market. Price and wage setting are both subject to Rotemberg price adjustment costs. The fiscal authority purchases consumption and investment goods produced in the private sector. Public capital stock and public employment improve private-sector productivity. Fiscal authorities finance themselves with distortionary taxes on private consumption, on labor income and on capital returns, lump-sum taxes as well as social security contributions paid by firms. They can also issue new debt.
- Foreign sector: Both regions of the currency union are modeled in detail. A VAR is set up to depict the rest of the world. There is international trade in goods and assets.
- Shocks: The model exhibits 41 structural shocks, where all shocks (besides fiscal and monetary policy shocks) follow an AR(1) process.
- Calibration/Estimation: The model is estimated using Bayesian estimation techniques using quarterly data of Germany, Euro Area countries, and eight countries for the rest of the world for the period 1999:Q1–2013:Q4.

4.2 ESREA_FIMOD12: Stähler and Thomas (2012)

Stähler and Thomas (2012) build a medium-scale model for the Spanish economy. It contains two countries which form a monetary union and features an extensive fiscal sector.

- Aggregate Demand: A fraction of households are non-Ricardians and consume the entire income each period. The remaining households maximize lifetime utility (habit formation) and can hold capital, government debt, and international bonds. Both types of households enjoy utility from government services. Households can be employed in the private or public sector, or are unemployed.
- Aggregate Supply: Intermediate goods firms maximize profits subject to Calvo price stickiness. The public capital stock influences firm productivity. Labor firms hire workers from households and sell labor services to intermediate goods firms. The labor market includes search and matching frictions. The government introduces several distortionary taxes and provides public good and capital. It can finance itself with debt and follows some rules for taxes and other variables.
- Foreign sector: Both regions are modeled in detail. Consumption and investment goods are traded with a home bias.
- Shocks: The model exhibits a consumption and technology shock, as well as shocks to monetary and fiscal policy.
- Calibration/Estimation: The model is calibrated for the Spanish economy inside the monetary union.

4.3 G2_SIGMA08: FRB-SIGMA by Erceg et al. (2008)

The SIGMA model is a medium-scale, open-economy, DSGE model calibrated for the U.S. economy. Erceg et al. (2008) in particular take account of the expenditure composition of U.S. trade and analyse the implications for the reactions of trade to shocks compared to standard model specifications.

- Aggregate Demand: There are two types of households: households that maximize a utility function separable in consumption, with external habit formation and a preference shock, leisure and real money balances, subject to an intertemporal budget constraint (forward-looking households) and the remainder that simply consume after-tax disposable income (hand-to-mouth households). Households consume, own the firms and accumulate capital, which they rent to the intermediate goods producers. Erceg et al. (2008) introduce investment adjustment costs à la Christiano et al. (2005), where it is costly for the households to change the level of gross investment. Households also choose optimal portfolios of financial assets, which include domestic money balances, government bonds, state-contingent domestic bonds and a non-state contingent foreign bond. It is assumed that households in the home country pay an intermediation cost when purchasing foreign bonds, which ensures the stationarity of net foreign assets. Households rent their labor in a monopolistic market to firms, where forward-looking households set their nominal wage in Calvo-style staggered contracts analogous to the price contracts and hand-to-mouth households simply set their wage each period equal to the average wage of the forward-looking households.
- Aggregate Supply: Intermediate-goods producers have an identical CES production function and rent capital and labor from competitive factor markets. They sell their goods to final goods producers under monopolistic competition and set prices in Calvo-style staggered contracts. Firms, who don't get a signal to optimize their price in the current period, mechanically adjust their price based on lagged aggregate inflation. Final good producers in the domestic and foreign market assemble the domestic and foreign intermediate goods into a single composite good by a CES production function of the Dixit-Stiglitz form and sell the final good to households in their country. Erceg et al. (2008) introduce quadratic import adjustment costs into the final goods aggregator, which are zero in steady state. It is costly for a firm to change its share of imports in a final good relative to their lagged aggregate shares. Thus the import share of consumption or investment goods is relatively unresponsive in the short-run to changes in the relative price of imported goods even while allowing the level of imports to jump costlessly in response to changes in overall consumption or investment demand. Government purchases are assumed to be a constant fraction of output. Government revenue consists of income from capital taxes (net of the depreciation write off), seignorage income and revenue from lump-sum taxes (net of transfers). The government issues bonds to finance the difference between government revenue and expenditure. Lump-sum taxes are adjusted both in response to deviations of the government debt/GDP ratio from a target level and to the change in that ratio.
- Foreign sector: Local currency pricing is assumed. Intermediate goods producers price their product separately in the home and foreign market leading to an incomplete exchange rate pass-through. Erceg et al. (2008) point out, that empirically imports and exports in the U.S. are heavily concentrated, with about 75 percent in capital goods and consumer durables, but the production share of capital goods and consumer durables is very low. To account for this fact in the two-country model they allow the import share in the final good aggregator for investment goods to be higher than the import share in the final good aggregator for consumption goods.
- Shocks: Since we have no information about the variances of the shock terms, we set all shock variances equal to zero. The government spending shock of the home country represents the common fiscal policy shock. The common monetary policy shock is added for the home country.
- Calibration/Estimation: The model is calibrated at a quarterly frequency. Parameters of the original monetary policy rule are estimated using U.S. data from 1983:1–2003:4.

4.4 G3_CW03: Coenen and Wieland (2002) G3 countries

In this model different kinds of nominal rigidities are considered in order to match inflation and output dynamics in the U.S., the Euro area and Japan. Staggered contracts by Taylor (1980) explain best inflation dynamics in the Euro area and Japan and staggered contracts by Fuhrer and Moore (1995a) explain best U.S. inflation dynamics. The authors evaluate the role of the exchange rate for monetary policy and find little gain from direct policy response to exchange rates.

- Aggregate Demand: The open-economy aggregate demand equation relates output to the lagged ex-ante long-term real interest rate and the trade-weighted real exchange rate and additional lags of the output gap. The demand equation is very similar to the G7_TAY93 model without any sectoral disaggregation. Lagged output terms are supposed to account for habit persistence in consumption as well as adjustment costs and accelerator effects in investment. The lagged interest rate allows for lags in the transmission of monetary policy. The

exchange rate influences net exports and thus enters the aggregate demand equation. The long term nominal interest rate is an average of expected future nominal short-term rates. The long-term real interest rate is determined by the Fisher equation.

- Aggregate Supply: For the U.S., relative real wage staggered contracts by Fuhrer and Moore (1995a) are used (see the US_FM95 model for a detailed exposition). For the Euro area and Japan the nominal wage contracts by Taylor (1980) are used. Note that Taylor contracts, with a maximum contract length exceeding two quarters, result in Phillips curves that explicitly include lagged inflation and lagged output gaps. Thus, the critique that with Taylor contracts inflation persistence is solely driven by output persistence (Fuhrer and Moore, 1995a) is mitigated.
- Foreign sector: All three countries are modeled explicitly. The Modelbase rule replaces monetary policy for the U.S.. For the Euro area and Japan the original interest rules remain. Foreign output does not affect domestic output directly, but indirectly via the exchange rate in the demand equation. The bilateral exchange rates are determined by UIP conditions.
- Shocks: Contract wage shocks, demand shocks and the common monetary policy shock which is added for the U.S..
- Calibration/Estimation: Euro area data, (fixed GDP weights at PPP rates from the ECB area-wide model database), U.S. data and Japanese data. For the U.S. and Japan OECD's output gap estimates are used. For the Euro area log-linear trends are used to derive potential output. The estimation is robust to different output gap estimations. Demand block: GMM estimation where lagged values of output, inflation, interest rates, and real exchange rates are used as instruments. Supply side: simulation-based indirect inference methods. Estimation period: U.S. 1980:1–1998:4, Euro area 1980:1–1998:4 and Japan 1980:1–1997:1.

4.5 G7_TAY93: Taylor (1993) G7 countries

Taylor (1993) describes an estimated international macroeconomic framework for policy analysis in the G7 countries: USA, Canada, France, Germany, Italy, Japan and the UK. The model consists of 98 equations and a number of identities. This model was the first to demonstrate that it is possible to construct, estimate, and simulate large-scale models for real-world policy analysis (Yellen, 2007). Taylor (1993) argues that a multicountry model is appropriate for the evaluation of policy questions like the appropriate mix of fiscal and monetary policy or the choice of an exchange rate policy.

- Aggregate Demand: The IS components are more disaggregated than in the US_OW98 model. For example, spending on fixed investment is separated into three components: equipment, nonresidential structures, and residential construction. The specification of these equations is very similar to that of the more aggregated equations in the US_OW98 model. The aggregate demand components exhibit partial adjustment to their respective equilibrium levels. In G7_TAY93, imports follow partial adjustment to an equilibrium level that depends on U.S. income and the relative price of imports, while exports display partial adjustment to an equilibrium level that depends on foreign output and the relative price of exports. Uncovered interest rate parity determines each bilateral exchange rate (up to a time-varying risk premium); e.g., the expected one-period-ahead percent change in the DM/U.S.$ exchange rate equals the current difference between U.S. and German short-term interest rates.
- Aggregate Supply: The aggregate wage rate is determined by overlapping wage contracts. In particular, the aggregate wage is defined to be the weighted average of current and three lagged values of the contract wage rate. In contrast to the US_FM95 model and the US_OW98 model, G7_TAY93 follows the specification in Taylor (1980), where the current nominal contract wage is determined as a weighted average of expected nominal contract wages, adjusted for the expected state of the economy over the life of the contract. This implies less persistence of inflation than in the US_FM95 and the US_OW98 model. The aggregate price level is not set as a constant mark-up over the aggregate wage rate as in US_FM95 and US_OW98. Prices are set as a mark-up over wage costs and imported input costs. This mark-up varies and prices adjust slowly to changes in costs. Prices follow a backward-looking error-correction specification. Current output price inflation depends positively on its own lagged value, on current wage inflation, and on lagged import price inflation, and responds negatively (with a coefficient of -0.2) to the lagged percent deviation of the actual price level from equilibrium. Import prices adjust slowly (error-correction form) to an equilibrium level equal to a constant mark-up over a weighted average of foreign prices converted to dollars. This partial adjustment of import and output prices imposes somewhat more persistence to output price inflation than would result from staggered nominal wages alone.
- Foreign sector: G7_TAY93 features estimated equations for demand components and wages and prices for the other G7 countries at about the level of aggregation of the U.S. sector. Financial capital is mobile across countries.
- Shocks: Interest rate parity shock, term structure shock, durable consumption shock, nondurable consumption shock, services consumption shock, total consumption shock, aggregate consumption shocks for Germany and

Italy, for the other countries disaggregated, nonresidential equipment investment shock, nonresidential structures investment shock, residential investment shock, inventory investment shock, fixed investment shock, inventory investment shock, real export shock, real import shock, contract wage shock, cost-push shock, import price shock, export price shock, fiscal policy shock, where we have adjusted the size of the fiscal policy shock for the U.S. - the common fiscal shock - so that a unit shock represents a 1 percent of GNP shock and a monetary policy shock where again the common Modelbase monetary policy shock enters the monetary policy rule for the U.S..

- Calibration/Estimation: The model is estimated with single equation methods on G7 data from 1971–1986.

4.6 GPM6_IMF13: Carabenciov et al. (2013)

Carabenciov et al. (2013) construct and estimate a six region model with both financial and real linkages. The study is the sixth of a series the IMF research agenda in developing a Small Quarterly Global Projection Model (GMP) which consists of small country models integrated into a single global market. The six regions represent the US, the euro area (EA), Japan, Emerging Asia, a five-country block of inflation-targeting Latin American countries and a "remaining-countries" group. The three first regions are regrouped under the label G3 and differ from the rest 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 US 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 six economies is characterized by a few behavioral equations.

- Aggregate Demand: The behavioral IS curve relates the output gap to domestic, external and financial-real linkages. The domestic effects consist of past and expected future values of the output gap and of the past value of the medium-term real interest rate. The specification allows for inertia in the system, with complex forward looking elements. The medium-term real interest rate provides the transmission channel between monetary policy action and the real economy. The external effects are driven by the effective real exchange rate gaps and the foreign demand channel. An overvaluation of the currency, i.e. a negative exchange rate gap, has a negative impact on the output gap. Foreign demand captures the spillovers from trade and allows for a direct and a global impact of the foreign output gaps separately. The financial-real linkages capture the bank lending conditions originating from the G3 economies and for each of these countries, tighter lending conditions translate into a negative output gap.
- 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. Backward-looking elements represent the direct and indirect indexation to past inflation, as well as the decision made by price setters who base their expectations on past rates of inflation. The forward-looking element captures the proportion of price setters who have model-consistent inflation expectation. The real effective exchange rate gap is the import weighted real exchange rate gaps of the trading partners, as import prices capture the pass-through from exchange rate movements to the CPI the best.
- The Policy Rule: is an Inflation-Forecast-Based rule that determines the short-term nominal rate for the G3 countries. It reacts to three quarters ahead inflation following Orphanides (2003a), the real interest rate and the domestic output gap.
- The Medium-term Real Interest Rate: is a model-specific variable that enters the Aggregate Demand equation. It 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.
- The Uncovered Interest Parity: serves to link the country models beyond the aggregate demand block. It is augmented for the emerging country models to include a trend component to capture real appreciation of their currencies.
- Unemployment rate: The model specifies a dynamic version of Okun's law for the G3 regions. It links the unemployment rate to its lagged value and the contemporaneous output gap.
- Shocks: Shocks to aggregate demand, to the bank lending conditions, to inflation, to the short run rate, to the uncovered interest parity and to the unemployment rate enter the G3 models. The model specifies more stochastic shocks than observables to prevent the model from generating systematic forecast errors over extended periods. Thus, 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 the equilibrium rate of unemployment, a shock to the equilibrium real interest rate and finally a shock to the equilibrium real exchange rate in each economy.

- Calibration/Estimation: The model is estimated with Bayesian techniques. The estimated coefficients of Carabenciov, Ermolaev, Freedman, Juillard, Kamenik, Korshunov, Laxton and Laxton (2008b) are taken as a starting point, i.e. as given, then each emerging country region is added individually to estimate the region's seven coefficient: the forward and backward looking components on inflation and the coefficient of the output gap in the Phillips Curve; the lagged and forward looking coefficients of output in the Aggregate Demand equation; and all three coefficients in the Policy Rule. The rest of the coefficients are calibrated. The resulting six country regions are put together to estimate three parameters: the coefficient on the spillover activity variable, the coefficient on the financial spillover variable for emerging economies in the output gap equations and finally, the coefficient on the real exchange rate gap terms in the Phillips Curve equation. The model uses quarterly data over the period 1999:Q1 to 2010:Q2.

4.7 EACZ_GEM03: IMF model of Euro Area and Czech Republic, Laxton and Pesenti (2003)

The model is a variant of the IMF's Global Economy Model (GEM) and consists of a small and a large open economy. The authors study the effectiveness of Taylor rules and inflation-forecast-based rules in stabilizing variability in output and inflation. They check if policy rules designed for large and relatively closed economies can be adopted by small, trade-dependent countries with less developed financial markets and strong movements in productivity and relative prices and destabilizing exposure to volatile capital flows. In contrast to Laxton and Pesenti (2003) we focus on the results for the large open economy (Euro area) rather than the small open economy (Czech Republic).

- Aggregate Demand: Infinitely lived optimizing households; government spending falls exclusively on nontradable goods, both final and intermediate. Households face a transaction cost if they take a position in the foreign bond market.
- Aggregate Supply: Monopolistic intermediate goods firms produce nontradeable goods and tradable goods. It exists a distribution sector consisting of perfectly competitive firms. They purchase tradable intermediate goods worldwide (at the producer price) and distribute them to firms producing the final good (at the consumer price). Perfectly competitive final good firms (Dixit-Stiglitz aggregator) use nontradable and tradeable goods and imports as inputs. Households are monopolistic suppliers of labor and wage contracts are subject to adjustment costs. Households own domestic firms, nonreproducable resources and the domestic capital stock. Markets for land and capital are competitive. Capital accumulation is subject to adjustment costs. Labor, capital and land are immobile internationally. Households trade a short-term nominal bond, denominated in foreign currency. All firms exhibit local currency pricing, thus exchange rate pass-through is low.
- Shocks: Risk premium shock, productivity shock, shock to the investment depreciation rate, shock to the marginal utility of consumption, government absorption shock where the one affecting the large foreign economy represents the common fiscal policy shock, shock to the marginal disutility of labor, preference shifter. We add the common monetary policy shock to the policy rule of the large economy.
- Calibration/Estimation: Calibrated to fit measures of macro-variability of the Euro area (1970:1–2000:4) and Czech Republic (1993:1–2001:4).
- Notes: Due to the symmetric setup of the model, we use the same policy rule in both countries.

4.8 EAES_RA09: Rabanal (2009)

Rabanal (2009) uses a two-country, two-sector DSGE model of a currency union with nominal rigidities to study the sources of persistent inflation differentials between the EMU and one of its member countries, Spain. Moreover, the paper aims at explaining the first moments of the data by introducing time trends for the country- and sector-specific technology shock processes that can give rise to permanent inflation differentials in the model.

- Aggregate Demand: Households in Spain and in the rest of EMU have utility functions separable in consumption and leisure and displaying external habit formation in consumption. The composite consumption good is defined as a CES aggregate consisting of domestic tradable and nontradable, and foreign tradable goods. Preferences are assumed to be the same across countries, but countries differ with respect to the composition of their consumption basket.
- Aggregate Supply: Each economy is characterized by two sectors. Monopolistic intermediate firms use labor, supplied by the households, as the only input to produce tradable and nontradable goods. They set prices to maximize profits subject to a set of demand equations. Price setting follows a modified version of the Calvo framework with two indexation mechanisms in place that account for the fact that steady state inflation might be non-zero. Across countries the same production technologies are deployed but countries differ in the degree of wage and price stickiness and in the degree of indexation.

- Foreign sector: Rabanal (2009) models two countries in the European monetary union of unequal size. They produce differentiated tradable goods that are imperfect substitutes of each other, but there is no price discrimination for the same type of good across countries.
- Shocks: Ten shocks are introduced in the model: sector- and country-specific AR(1) shock processes for the government spending and the technology shock with an Euro Area tradable shock component, and an iid monetary policy shock.
- Calibration/Estimation: The model is estimated using Bayesian estimation techniques using quarterly euro area data for the period 1996:Q1–2007:Q4.

4.9 EAUS_NAWM08: Coenen et al. (2008)

Coenen et al. (2008) use a calibrated, two-country version of the New Area-Wide Model developed at the European Central Bank to examine the Euro Area tax structure and the potential benefits and spillovers of a tax reform (reducing labor market distortions). The real effects of fiscal policies are analyzed in an environment with heterogeneous households. Countries in Coenen et al. (2008) are symmetric but of different size where the U.S. represents the rest of the world.

- Aggregate Demand: Only a share of households have access to domestic and international financial markets, accumulates capital and holds money. The other part of households do not have access to financial markets and neither holds capital. They smooth consumption solely by adjusting their money holdings. Both types of households maximize a lifetime utility function with external habit in consumption and supply differentiated labor services with monopoly power in wage setting. Wages are determined in à la Calvo (1983) fashion. Households that receive permission to re-optimize their wages choose the same wage while the other part follows an indexation scheme, with wages being a geometric average of past changes in the price of the consumption good. Households gross income is subject to a rich taxation structure. They pay taxes on consumption purchases, on wage income, on rental capital income and on dividend income. Furthermore, they pay social security contributions, a lump-sum tax and receive transfers. Purchases of consumption, financial investment in international markets and capital utilization are subject to specific proportional costs.
- Aggregate Supply: Producers are distinguished between producing tradable and non-tradable goods. The intermediate goods firm produces a single, tradable differentiated good using an increasing-returns-to-scale Cobb-Douglas technology with capital services and labor as inputs. These goods are sold both in domestic and foreign market under monopolistic competition. Price setting is subject to staggered price contracts à la Calvo (1983). Firms that receive permission to re-optimize their prices choose the same price (be it for the domestic or for the foreign market) while the other firms follow an indexation scheme, with prices being a geometric average of past changes in the aggregate price indexes. The final goods firms produce three non-tradable final goods: private consumption goods, investment goods and public consumption goods. Final non-tradable private consumption and private investment goods are modeled in an analogous manner. These final goods are assembled with CES technology, combining intermediate domestic and imported foreign goods. Varying the use of imported intermediate goods in the production process is subject to adjustment costs, therefore changes in the relative price of imported goods go unreflected in the short-run. These final goods are sold taking the price as given. On the other side, the public consumption good is a composite of only domestically produced intermediate goods.
- The Foreign Sector: The demand for imported goods is equal to the sum of the respective demands for intermediate goods for private consumption and investment. These intermediate goods are sold in the home market by the foreign intermediate-good producer. The price of the intermediate good imported from abroad is equal to the price charged by the foreign producer (local currency pricing).
- Shocks: A government spending shock, a transfer shock, a productivity shock, a monetary policy shock. (Distortionary tax rates on consumption, on dividends, on rental capital income, on labor income and payments on social security contributions are given as exogenous processes but constant).
- Calibration/Estimation: The model is calibrated to the Smets and Wouters (2003) model, with steady-state ratios based on observed data for the euro area and U.S., respectively.

4.10 EAUS_NAWM08CTWW13: Cogan et al. (2013)

Cogan et al. (2013) use a version of the EAUS_NAWM08 model of Coenen et al. (2008) to study the fiscal consolidation plan on the U.S.economy. In EAUS_NAWM08CTWW13, the US economy is calibrated following Cogan et al. (2010).

- Aggregate Demand: As in EAUS_NAWM08.
- Aggregate Supply: As in EAUS_NAWM08.

- The Foreign Sector: As in EAUS_NAWM08.
- Shocks: As in EAUS_NAWM08.
- Calibration/Estimation: Differently from the EAUS_NAWM08 model, parameters for the US are calibrated with reference to other estimated models, including the Cogan et al. (2010).

5 Estimated Models of Other Countries

5.1 BRA_SAMBA08: Gouvea et al. (2008)

Gouvea et al. (2008) build and estimate a small open economy model for the Brazilian economy. The BRA_SAMBA08 model is developed at the Central Bank of Brazil to provide support for its policy decisions. This version of the model is used as a tool to analyze the response of the Brazilian economy when subject to different shocks.

- Aggregate Demand: There are two types of households: optimizers and rule-of-thumbers. Both maximize a similar utility function separable in consumption and leisure but subject to different budget constraints. Unlike the optimizers, the rule-of-thumb households do not have access to credit, asset and capital markets. They just consume their wage income. The optimizers have access to domestic and foreign currency denominated bonds, accumulate capital subject to capital adjustment costs, earn from renting the capital and pay taxes. On the other hand, both types of households supply labor in a competitive market.
- Aggregate Supply: The production sector is comprised of producers and assemblers. Monopolistic competitive firms are the ones producing differentiated goods under a Cobb-Douglas technology with labor, capital services and imported goods as inputs. Following Galí and Gertler (1999), only a fraction of firms are allowed to adjust prices optimally ("forward-looking firms"). The remaining firms follow a rule of thumb. The homogeneous final good is assembled by a representative firm using a CES aggregator and is sold in a competitive market. The final good can be used for private consumption, government consumption, investment and exports.
- The Foreign Sector: The world is assumed to be populated by a continuum of small open economies as in Galí and Monacelli (2005), each of them producing a differentiated good in the global market. The demand for home country's exports is obtained from the aggregation of the demands from foreign countries, expressed in a world currency. The domestic importing firm takes the demand for its goods from the producers' input choices.
- Shocks: An inflation target shock, a fiscal target shock, a preference shock, a labor supply shock, an investment shock, a foreign investor's risk aversion shock, a country risk premium shock, a technology shock, a monetary policy shock, a fiscal policy shock, a world imports shock, a world inflation shock and a world interest rate shock.
- Calibration/Estimation: Estimated with Bayesian methods, using quarterly Brazilian data for the period 1999:Q2–2007:Q4.

5.2 CA_BMZ12: Bailliu et al. (2012)

Bailliu et al. (2012) investigate interactions between monetary 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. The household purchases consumption goods and a one-period government bond. The household's income consists of labor income, bond payoff and dividends on the 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 à la Calvo (1983). They buy intermediate goods from entrepreneurs and differentiate them at no cost. A Dixit-Stiglitz aggregator combines intermediate goods to form the final good.
- Financial Sector and Macroprudential Policy: The financial friction is modeled along the lines of Bernanke et al. (1999), i.e. 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- 2009:Q3. The observable time series are: output (excluding government expenditures), investment, the nominal interest rate, inflation and the external finance cost.

5.3 CA_LS07: Lubik and Schorfheide (2007)

Lubik and Schorfheide (2007) estimate four small-scale open economy DSGE models with Bayesian techniques for Canada, Australia, New Zealand and the UK. The paper studies to what extent central banks respond to exchange rate movements when setting nominal interest rates, finding that the Bank of Canada and the Bank of England do include the nominal exchange rate in their policy rule. The database contains the model for Canada.

- Aggregate Demand: The model treats the world economy as a continuum of small open economies. The representative household maximizes its utility separable between consumption and leisure subject to its budget constraint. Consumption is a composite of tradable home and foreign goods.
- Aggregate Supply: Differentiated goods are produced by monopolistic-competitive firms using a linear technology with labor being the only production input. The firms set their prices in a Calvo staggered way. The marginal costs depend positively on the terms of trade and world output.
- The Foreign Sector: Purchasing power parity and the law of one price hold. There is perfect exchange rate pass-through. The securities markets are assumed to be complete, and hence international risk sharing in the form of the uncovered interest rate parity is obtained.
- Shocks: A nominal interest rate shock, a terms of trade shock, a shock to world demand and a shock to the world inflation rate are introduced in the model.
- Calibration/Estimation: The model is estimated with Bayesian methods using quarterly Canadian data for the period 1983:Q1–2002:Q4.

5.4 CA_TOTEM10: Murchison and Rennison (2006)

CA_ToTEM10 represents the 2010 vintage of ToTEM (Terms-of-Trade Economic Model) which is an open-economy, DSGE model developed by Murchison and Rennison (2006). The Bank of Canada uses this model as a tool for policy analysis and projections for the Canadian economy.

- Aggregate Demand: Households are classified as 'lifetime income' consumers and 'current income' consumers, reflecting the fact that not all consumers can access credit markets. Lifetime income consumers smooth their consumption across time through borrowing and saving while 'current income' consumers consume their current income each period. Lifetime income consumers choose consumption, domestic and foreign bond holdings, labor supply and wages to maximize a utility function non-separable in consumption and leisure subject to a dynamic budget constraint. Both types of households supply differentiated labor services giving them power when negotiating the wages with the domestic producers. However, renegotiation of the wages is allowed only once in six months, on average, and only a constant proportion of wage contracts are renewed every period. The dynamic wage equation is a function of past and expected future wage inflation and an error-correction component.
- Aggregate Supply: The production sector is comprised of final good producers, an import sector and a commodity sector. Final goods firms produce consumption goods and services, investment goods, and export goods. The production process of these goods is analogous, differing only on the share of imported goods used in production. In this process, first a capital-labor composite is produced using CES technology, which is then combined with a commodity input to produce the domestic good. Final goods then are a combination of the domestic good and the imported good. Through these steps, the firm faces capital adjustment costs, investment adjustment costs and labor adjustment costs. Final goods firms sell their differentiated goods in a monopolistic competitive fashion having power over prices. However, not all firms can re-optimize their prices every period. A share of firms updates prices according to a geometric average of lagged core inflation and expectations of the inflation target. In ToTEM, pricing decisions are considered as strategic complements, where firms have a strong incentive to follow what other firms do. The commodity sector is represented by a domestic firm operating in a competitive market, producing commodities using capital services, labor and land under a CES technology. These raw goods are either sold to a continuum of imperfectly competitive commodity distributors or exported (for the world price of the commodity denominated in Canadian currency). The commodity distributors repackage the commodity goods and sell them to households and to the final goods producers. These distributors face

nominal rigidities à la Calvo in price setting, which limits the degree of exchange rate pass-through to consumer prices in the short-run.

- The Foreign Sector: The import sector is represented by firms who buy imported goods in the world market for a given world price (law of one price holds). These goods are sold to domestic firms, which use them as inputs in their respective production functions. Imperfect exchange rate pass-through in the short-run is present as the price of imports is temporarily fixed in the currency of the importing country and because import firms face nominal rigidities à la Calvo when setting prices. As in other sectors, imported goods inflation is a function of past and expected future imported goods inflation and an error-correction component. Export goods firms are part of the final good producers sector as discussed above. They have some degree of market power and therefore face a downward-sloped demand curve (rest of the world demand).
- Shocks: A demand shock, a risk-premium shock, an inflation target shock, a commodity price shock, a technology shock, world demand shock and a price mark-up shock.
- Calibration/Estimation: Calibrated with parametrization chosen to match univariate autocorrelations, bivariate correlations and variances estimated using Canadian data for the period 1980-2004.

5.5 CL_MS07: Medina and Soto (2007)

Medina and Soto (2007) develop a small-open economy DSGE model for the Chilean economy. The CL_MS07 is structurally similar to models developed by Christiano et al. (2005), Altig et al. (2005), and Smets and Wouters (2007). Still, a richer specification for the production sector and for fiscal policy is designed to account for special characteristics of the Chilean economy.

- Aggregate Demand: There are two types of households, Ricardian and non-Ricardian households. The Ricardian type households maximize a utility function separable in consumption, leisure and real money balances subject to their intertemporal budget constraint. They have access to three types of assets, namely money and one-period non-contingent foreign and domestic bonds. Each of these households is a monopolistic supplier of differentiated labour and only a fraction of them can re-optimize their nominal wage. Rigidity à la Calvo in wage setting follows Erceg et al. (2000). Households that cannot re-optimize their wages follow an updating rule considering a geometric weighted average of past CPI inflation and the inflation target. On the other side, the non-Ricardian households do not have access to any of the assets and own no shares in domestic firms. They simply consume the after-tax disposable income and set their wage equal to the average wage of the Ricardian households. The aggregate consumption for both types of households is a composite of a core consumption bundle (domestic and foreign goods, given by a CES aggregator) and oil consumption.
- Aggregate Supply: The economy is characterized by three types of firms: intermediate tradable-goods producers, import goods retailers and commodity good producers. Intermediate-goods producers have monopoly power and maximize profits by choosing the prices of their differentiated goods subject to the corresponding demands, and the available technology with labor, capital and oil as inputs. Capital is rented to them from a representative firm which accumulates capital and assembles new capital goods subject to investment adjustment costs. Optimal price setting of intermediate-goods producers is subject to à Calvo probability. Firms that cannot re-optimize their price follow a rule with partial indexation to past inflation and the inflation target. The pricing structure leads to a hybrid New Keynesian Phillips curve. A commodity good producer is introduced in the model to match a particular relevant sector for the Chilean economy, namely the cooper sector. This firm produces a homogeneous commodity good only for export. The production technology follows an exogenous stochastic process that does not require any input. The price of the homogeneous commodity good is determined in the foreign market.
- Foreign sector: Local currency pricing is introduced through Calvo price stickiness faced by import goods retailers, which resale foreign goods in the domestic market. This allows for incomplete exchange rate pass-through in the short-run, important for expenditure-switching effects of the exchange rate. A CES technology is used to combine a continuum of differentiated imported varieties to produce a final foreign good, which is consumed by households and used for assembling new capital goods.
- Shocks: a transitory productivity shock, a permanent productivity shock, a commodity production shock, a labor supply shock, an investment adjustment cost shock, a preference shock, a government expenditure shock, a monetary policy shock, a foreign commodity price shock, a foreign oil price shock, a foreign output shock, a foreign interest shock, a foreign inflation shock and a price of imports shock.
- Calibration/Estimation: The model is estimated using Chilean quarterly data for the period 1987:1–2005:4.

5.6 FI_AINO16: Kilponen et al. (2016)

Kilponen et al. (2016) present the AINO 2.0 model, which is the DSGE model used at the Bank of Finland for forecasting and policy analysis. It is a small open economy model of the Finnish economy within the Euro Area and the rest of the world. The framework includes standard frictions and rigidities as well as a monopolistically competitive banking sector in the spirit of Gerali et al. (2010).

- Aggregate Demand: Households maximize their lifetime utility, where the per-period utility function is separable in consumption and labour. They can invest in the domestic capital stock (via capital goods producers), in euro area bonds, rest of the world bonds and domestic bonds. Households supply labour and act as wage setters in monopolistically competitive labour markets.
- Aggregate Supply: Production of domestic intermediate goods is subject to a CES production function with time varying mark-up and Harrod-neutral technological progress under monopolistic competition. Final consumption and investment goods are produced by domestic retailers operating under perfect competition, combining both domestic and imported goods. Export goods are produced by separate exports goods producing firms with a CES production function including domestic intermediate goods and imported goods. Domestic intermediate goods and export goods producers are subject to nominal rigidities in the form of Calvo (1983) pricing.
- Banking sector: The economy is populated by entrepreneurs who rent capital to the domestic intermediate good firms at the beginning of the period and sell the undepreciated capital to capital producers (owned by households) at the end of the period. Entrepreneurs finance the difference between expenditures and net worth from banks. Banks have market power and set rates on loans, subject to adjustment costs.
- Shocks: Six types of technology shocks, 3 types of domestic mark-up shocks, 4 types of domestic demand shocks (including a standard government consumption shock), 7 foreign/external shocks and 4 financial shocks (among them the euro area interest rate shock).
- Estimation: The model is estimated using Bayesian methods on 24 observables of Finnish and foreign data, with the sample period being 1995Q2 to 2014Q4.
- Replication: We simulated the impulse response functions to a productivity shock and a euro area interest rate shock, Figure 6 and Figure 8 in the paper.
- Implementation: Monetary policy is exogenous in this framework, as it does not explicitly model the euro area economy and associated monetary policy decisions. Hence, the model is implemented without the option to choose among various monetary policy rules. However, the implementation allows to compare the fiscal policy shock in the model to other models.

5.7 HK_FPP11: Funke et al. (2011)

Funke et al. (2011) develop a small open economy DSGE model and estimate it for Hong Kong with Bayesian techniques. The model adopts the perpetual youth approach and allows for wealth effects from the stock market on consumption behavior.

- Aggregate Demand: The economy consists of an indefinite number of cohorts facing a constant probability of dying each period, which implies a constant expected effective decision horizon of consumers. Given the lifetime uncertainty, agents' consumption pattern is affected by their expected lifetime wealth (in terms of the wealth in stock market), where the stock price is modeled as the discounted sum of future dividends. In this open economy the consumers are free to allocate their consumption between domestic goods and foreign goods, and the intertemporal allocation is characterized by an otherwise conventional Euler equation that captures the impact of stock-price dynamics.
- Aggregate Supply: Domestic firms act under monopolistic competition and produce consumption goods. Nominal frictions are introduced in the form of Calvo sticky prices. Non-reoptimizing firms index their prices to previous period's domestic producer price inflation.
- The Foreign Sector: The rest of the world is modeled exogenously. Foreign output affects domestic output through international risk sharing directly, and also indirectly via the terms of trade channel.
- Shocks: A productivity shock, a foreign demand shock, a cost push shock and a stock-price gap shock.
- Calibration/Estimation: The model is estimated using Bayesian methods. Funke et al. (2011) employ quarterly data on four observables for the sample 1981:Q1–2007:Q3: the real GDP of Hong Kong, the Hang Seng index, the consumer price index of Hong Kong and US GDP. The last series is used as a proxy for foreign demand.

5.8 HK_FP13: Funke and Paetz (2013)

Funke and Paetz (2013) develop a two-agent, two-sector, open-economy DSGE model and estimate it for Hong Kong with Bayesian methods. The model introduces credit market frictions as a form of a binding collateral constraint on borrowers and adopts a fixed exchange-rate regime as monetary policy.

- Aggregate Demand: Households consists of borrowers and savers. They both obtain utility from consuming non-housing goods and housing and disutility from providing labor. There is habit formation in consumption, both non-housing goods and housing are CES indices of domestically-produced goods and foreign-produced ones. Borrowers are not able to access to the international financial markets and face the collateral constraint linking to the value of housing and the loan-to-value ratio. Savers can purchase both domestic bonds foreign bonds. A symmetric steady state and perfect international risk/sharing are assumed.
- Aggregate Supply: Each sector has a two-stage structure of production. Perfectly competitive retailers produce final goods by aggregating intermediate goods according to a CES technology, and monopolistically competitive frims produce intermediate goods subject to nominal rigidity à la Calvo.
- The Foreign Sector: The rest of the world is modeled exogenously. Foreign output affects domestic output through international risk sharing directly, and also indirectly via the terms of trade channel.
- Shocks: Sector-specific productivity shocks, housing preference shocks, a loan-to-value shock, a government expenditure shock, sectoral cost push shocks, a foreign consumption shock, a foreign housing shock and shocks on foreign price distortions.
- Calibration/Estimation: The model is estimated with Bayesian methods using quarterly data for seven macroeconomic variables ranging from 1981:Q1 to 2007:Q3.

5.9 UK_SM11: Millard (2011)

Millard (2011) takes the small-scale open economy DSGE model and estimates it for the U.K. with Bayesian techniques. The main complication is that there are non-energy and energy consumption goods, while energy is split into petrol and utilities. Including energy prices should help to explain UK macroeconomic data.

- Aggregate Demand: The representative household consumes the three final goods: Petrol, utilities, and 'non-energy' subject to external habit formation, investment adjustment costs, and variable capital utilization. Each household supplies differentiated labor to firms as monopoly suppliers. Wage setting exhibits nominal wage rigidity and partial indexation of wages to inflation. In addition, households have the option of holding either foreign or domestic bonds, but trading foreign bonds comes at a quadratic cost.
- Aggregate Supply: Each of the consumption goods is produced according to a sector-specific production function. Sticky prices in each sector imply sector-specific New Keynesian Phillips Curves. The production functions themselves involve different combinations of five inputs: Labor, capital, imported (non-energy) intermediates, oil, and natural gas. Value-added is produced by combining domestic capital and labor. Non-energy output is produced by a large number of imperfectly competitive firms by combining value added and imports with energy inputs. The energy input is a Leontief bundle of petrol and utilities. Firms producing petrol and gas are engaged in monopolistic competition. The quantity of oil and natural gas used in U.K.'s utilities and petrol production is the sum of the U.K.'s endowment of oil and net trade in oil with the rest of the world. The fiscal authority levies a duty on petrol and consumes some of the non-energy good.
- Foreign sector: World energy prices are exogenous. Oil and gas prices adjust immediately to the world prices. U.K. import prices take time to adjust to purchasing power parity.
- Shocks: The model features 12 shocks including world demand shocks for oil and gas.
- Calibration/Estimation: The model is estimated for the U.K. with Bayesian techniques for the period 1996 Q2 to 2009 Q3 using ten data series.

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