

**7TH WORKSHOP OF THE EURO AREA BUSINESS CYCLE NETWORK (EABCN)**  
**Estimation and Empirical Validation of Structural Models for Business Cycle Analysis**  
Zürich, 29-30 August 2006

**REPORT**

The seventh EABCN workshop focused on the estimation and the empirical validation of structural models for business cycle analysis, and for open economies in particular. The workshop was held in Zürich on 29th and 30th of August, hosted by the Swiss National Bank, and was organized by **Fabio Canova** (Università Bocconi, Universitat Pompeu Fabra, London Business School and CEPR), **Andreas Fischer** (Swiss National Bank and CEPR) and **Domenico Giannone** (Université Libre de Bruxelles). The workshop's program was divided into three sessions, respectively 'Forecasting and Identification', 'Estimation' and 'Open Economies': ten papers were presented, each commented by two discussants.

Session 1: Forecasting and Identification

**Jean Philippe Laforte** (Board of Governors of the Federal Reserve System) opened the first session presenting the paper 'A Comparison of Forecast Performance Between Federal Reserve Staff Forecasts, Simple Reduced-Form Models, and a DSGE model', co-authored with Rochelle Edge and Micheal Kiley, both of the Board of Governors of the Federal Reserve System. In this paper, the authors analyze the forecasting performance of a richly-specified DSGE, with the broader goal of assessing its importance in the forecasting toolbox of a central bank. The DSGE model used in this paper is more disaggregated than the canonical Christiano-Eichenbaum-Evans/Smets-Wouters model; it has two production sectors – a slow-growing "consumption" goods producing sector and a fast-growing "capital" goods producing sector – and three expenditure aggregates, respectively on consumer non-durable goods and services, consumer durable goods and non-residential capital. The authors perform a comparison of the forecasting performances of their richly specified DSGE versus the Greenbook, a random walk, a four-variables VAR and a four-variables Bayesian VAR with Minnesota priors, using real-time data and focusing on the period 1996-2000 and 2000-2003 (Greenbooks are not available for this subsample). The main results presented by Laforte are the following: the DSGE model performs as well as the reduced-form forecast at predicting the future GDP growth rate, and much better than the Greenbook, whose poor performance over that period is well documented. On the other hand, the performance of the DSGE model relative to consumption is not as good relative to the other models. The author therefore concluded that the current version of their DSGE model provides forecasts that compete in terms of accuracy with popular alternative models and this fact, together with the model's ability to tell a story on the forecasts, provided support for including estimated DSGE models in the suite of models available to the central banks.

**Raffaella Giacomini** (University of California, Los Angeles) acted as first discussant for the Edge-Kiley-Laforte paper. First, she pointed out that the results of the paper indicate that in fact no forecasting method is best across variables, forecast horizons and time periods (arguably the BVAR seems the most robust) and that the DSGE performs very poorly at long horizons. She also argued that the big reduction in forecast mean absolute error for all methods from 1996-2000 to 2000-2003 could be evidence of structural instability or could also be caused by a reduction in the variance of the shocks and suggested this issue should be investigated more formally. In light of these observations, she stressed the importance of investigating the reasons for the improved fit of "new-generation" DSGE models, for example by verifying whether the restrictions such model would imply on a VAR are important (à la Del Negro, Schorfheide, Smets and Wouters). Finally she hinted to the fact that the comparison between an 11-equation (linearized) DSGE and a 4-equation VAR could be unfair and therefore suggested to compare it to a VAR with the same 11 variables to understand the value of the implied economic restrictions for forecasting.

The second discussant for the Edge-Kiley-Laforte paper was **Domenico Giannone** (Université Libre de Bruxelles). He appreciated the fact that the paper was the first forecast horserace based on truly real-time data, but questioned the authors' conclusion that the DSGE provides forecasts that compete in terms of accuracy with popular alternative models. First, the DSGE and VAR forecasts are in fact better than GB forecast only for GDP growth. Moreover, using a RBC toy model, Giannone showed that, while a random walk is a good benchmark model, the more appropriate (and model-consistent) choice for GDP growth would have been a constant growth model. Then he pointed out that 1996Q4-2000Q4 was a short period of extraordinarily strong and unexpected

expansion during which not only the toy model, but also the constant growth naïve model outperforms the professional forecasts (e.g. Survey of Professional Forecasters and Greenbook) at all horizons but the current quarter. Therefore he suggested that the reasonable forecasting performances of the DSGE model is an artifact due to the specification of the benchmark (naïve) model on the one hand and on the specificity of the sample considered on the other. Fixing these two issues a different picture emerges – i.e, there is some predictability of output growth only in the current quarter – and therefore the discussant suggested that, in order to make DSGE models credible in forecasting, they have to be combined with judgemental/conjunctural analysis. During a short panel discussion, it was also suggested to focus more on the forecasting of the interest rate to understand if the results could be driven by the reduction in volatility.

**Fabrice Collard** (Université de Toulouse, CNRS and IDEI) presented the paper ‘Short-run Restrictions: an Identification Device’, co-authored with Patrick Fève (Université de Toulouse and Banque de France) and Julien Matheron (Banque de France). The paper analyzes the principles underlying Minimum Distance Estimation (MDE) of DSGE models, which consists in estimating the structural parameters of a DSGE so as to minimize a weighted distance between the IRFs obtained from a Structural VAR and the theoretical IRFs obtained from a DSGE. In particular the paper focused on SVAR with short-run restrictions, which seem to perform better than long-run restrictions (Christiano, Eichenbaum and Vigfusson, 2005) and are able to pin down precisely all the shocks. The DSGE and the VAR should share the same recursive structure and this imposes some information restrictions on the observation of shocks. The goal of this paper is 1) to understand whether these implied information restrictions are innocuous with respect to estimation, as suggested by Christiano, Eichenbaum and Vigfusson (2005), 2) to understand under which conditions parameters are invariant to the short-run identification scheme used to identify shocks and 3) show how short-run restrictions can be used to check identification. The authors propose a variety of simple statistical tools designed to assess the role of timing restrictions on aggregate dynamics and compare the estimates coming from two versions of a fully fledged DSGE model that differ in the choice of the timing assumptions and a basic RBC model. They conclude that the degree to which restricting the information set affects the estimation depends on the strength of the internal propagation mechanism of the model and that with strong propagation the structural parameters estimated with the MDE approach are very sensitive to the timing of decisions, therefore questioning the ‘depth’ of such estimation technique.

The first discussant for this paper was **Gert Peersman** (Ghent University). He first pointed out that, unlike e.g. Rotemberg and Woodford (1998) and Christiano, Eichenbaum and Evans (2005) who use short-run restrictions to identify monetary policy shocks, this paper attempts evaluating the MDE approach with short-run restrictions on the SVAR by identifying a technology shock. The impact of the technology shock on labour is already very controversial in literature and the way short-run restrictions are implemented to identify technology shocks in the VAR using real data is problematic. Peersman therefore suggested investigating whether the same conclusions were also found when identifying a monetary policy shock with short-run restrictions, instead of a technology shock. He welcomed the fact that the paper contributed in questioning the use of short-run zero restrictions to identify deep parameters of DSGE model. He then pointed out that the use of short-run zero restrictions to identify the shocks in the VAR is already very controversial and that also long-run zero restrictions have been questioned from an empirical point of view. Qualitative (sign) restrictions, as an alternative, are much more general and easier to implement. He hinted that one could go even more general if some of qualitative restrictions are uncertain or want to be tested, e.g. use sign restrictions on the ratio of the impulse responses.

**Luca Sala** (Bocconi University) also discussed the Collard-Fève-Matheron paper. Sala first reported the definition the authors give for deep parameters: “...parameters robust to short-run identification scheme used to identify shocks” and pointed out that they analyze the “depth” of the MDE approach by verifying whether the IRFs and the estimates of the model with and without timing restrictions coincide. However, Sala stressed, imposing different timing restrictions in fact means selecting different models and therefore it is not surprising that, estimating two different (however similar) models, one obtains different parameter estimates, under any econometric method. Moreover, if a set of short-run restrictions is a model, the definition of deep parameters given in the paper can be rephrased as: “...parameters robust to the choice of the model”. And then the authors’ conclusion is that the estimation method is good when the two models are very similar, which is a peculiar result. The discussant then proposed an alternative experiment to understand if the information structure imposed in the VAR innocuous: if, e.g., in the model all variables respond simultaneously but the VAR imposes a timing restriction, then quantifying the specification errors could be informative. Sala appreciated the tension underlying the paper between the robustness and identification, but concluded by saying that he did not believe the MDE based on short-run restrictions was questionable simply because the estimates depend on the model.

Collard then responded to the comments by stressing that the focus of the paper was to investigate why, when changing timing restrictions in the monetary models à la Christiano, Eichenbaum and Vigfusson, the implications remain the same, rather than saying whether the estimation method is bad or good. He then also responded pointing out that the focus of the paper was not to study a particular shock, be it technology or monetary, rather it focused on the properties of the model when subject to restrictions.

## Session 2: Estimation

The second session of the workshop was opened by **Marco Del Negro** (Federal Reserve Bank of Atlanta), presenting his paper 'Prior Choice and DSGE Model Comparisons', co-authored with Frank Schorfheide (University of Pennsylvania). The paper aims at building a procedure to form priors for the parameters that govern the law of motion of the unobservable exogenous shocks (auxiliary parameters) that can overcome the two main shortcomings of the choice of priors that is standard in the literature. First, since it is difficult to form beliefs about the auxiliary parameters, the latter are often assumed to be independent and the priors are chosen to match the moments of the endogenous variables. However, the independence assumption can lead to a prior distribution that assigns non-negligible probability mass to regions of the parameters space where the model is quite unreasonable. Second, in Bayesian model comparisons, having specified a prior distribution for a benchmark model, researchers often use the same prior for alternative model specifications in order to assess the relative importance of various model features. But identical parameterizations of the exogenous shock processes can generate very different dynamics across model specifications, and thus can unduly penalize some specifications, as highlighted by the author using a simple example. To overcome the two problems the authors propose using a dummy prior observation prior based on a quasi-likelihood function from a VAR approximation of the DSGE. Del Negro finally presented the results of the application of this procedure to a New Keynesian DSGE. In particular, the authors find that models without nominal wage rigidities can still explain persistence in inflation and that the evidence for indexation in the Phillips Curve becomes tenuous once priors are constructed with their method.

**Frank Smets** (European Central Bank and CEPR), the first discussant for the Del Negro-Schorfheide paper, praised the paper for having raised awareness of potential pitfalls in prior choices and for offering a solution. He pointed out however that in the proposed methodology several non-trivial choices need to be made, like the choice of the lag length for the approximating VAR or the tightness of the prior. Moreover, Smets stressed that the methodology does not solve the problem of dependence amongst the structural parameters, which may be equally important when testing different models. The discussant suggested solving the problem of dependence amongst the structural parameters by using a training sample to calculate the prior posterior distribution for each of the models (as Sims, 2004 suggested for comparing non-nested models). This method has two main advantages. First, it does not involve choices such as the lag length of the VAR, it only requires to pick a pre-sample. Second, it allows adjusting the distribution of all the parameters, not only the one of the auxiliary parameters. Finally, Smets pointed out that compared to using a training sample one advantage of the Del Negro-Schorfheide methodology is that it allows to focus on particular moments and this may be useful if one actually has prior information, not from a pre-sample, but from other data sources, other countries, etc. The second discussant was **Simon Potter** (Federal Reserve Bank of New York). He started by appreciating the fact that the authors show very clearly that most standard approaches to constructing priors in DSGE models can be very dangerous and propose a method based on dummy observations to avoid some of these dangers. Potter also presented some simulations from a simple AR model that clarified and highlighted the problem of priors choice in the presence of dependence among parameters. He then stressed that, since using same priors across different models can have unintended effects on Marginal Likelihoods and Bayes Factors, priors should be chosen so that prior predictive distributions of location and scale are close. However he disagreed with the suggestion of the Del Negro-Schorfheide paper that one should also take into account the autocorrelation functions. Indeed, since most analysis of DSGE models focuses on linear approximation with Gaussian errors, the only relevant information in data for Bayesian is location, scale and autocorrelation function. Therefore, standardizing the prior predictive distributions for location, scale and for the autocorrelation function, you are not allowing the data to discriminate among different models.

The author responded to the comments by stressing that he believes that using a training sample to compare DSGE models is often not good either because you have too few observations (you do not get a lot out of it) or too many observations (too much concentration).

**Oreste Tristani** (European Central Bank) presented the paper 'Euro Area Inflation Persistence in an Estimated Nonlinear Model', co-authored with Gianni Amisano (Università di Brescia). While the existing literature focuses

either on statistical measures of persistence or linear Phillips curve type analyses, this paper studies inflation persistence within the framework of a nonlinear model, which can generate variation in inflation persistence through the existence of nonlinearities in the model as opposed to exogenously specified breaks in the inflation rate. Further motivations for using a nonlinear model are 1) that nonlinear models can account for richer conditional dynamics than a linear one and that different patterns of persistence could be consistent with the same model, 2) that large deviations from the steady state happen and if the linear model is an approximation, these deviations from the steady state may be large and induce biased estimates and 3) that nonlinear models provide sharper estimates. After having sketched the main model features (two versions of it depending on whether the inflation target is stationary or a random walk), Tristani outlined the solution method and described the estimation technique used in the paper. The authors use a conditional particle filter, which, compared to the particle filter, has the advantage that it is less sensitive to outliers and can work also in absence of measurement error. The authors also investigate the presence of breaks. The results of the paper highlight that, although the second order estimates tend to be more precise, nonlinear solutions do not produce striking changes in mean parameter estimates. In the model without breaks, nonlinear terms are sizable: impulse responses are easily regime dependent. Moreover, inflation "persistence" (in response to a change in the target) has declined over the sample considered.

**Sumru Altug** (Koç University and CEPR) acted as first discussant to this paper. She expressed overall appreciation of the paper and stressed that it raised a number of methodological issues of great interest. First of all, unlike many recent applications of DSGE modeling, the paper does not employ a linearized solution to the original model, allowing instead second-order moments to influence the first moments of the generated series. Second, the model postulated in this paper is small: this has the advantage that the effects of the different features that drive economy-wide dynamics are well understood. Moreover, this paper contributes to the existing literature by extending the use of full information methods to a DSGE model of inflation persistence, while many recent applications of RBC/DSGE modeling have followed a limited information approach, which has the drawback that model identification may fail. Finally, the model used in this paper differs from many recent DSGE models in that it does not possess a full set of "real" frictions such as adjustment costs. Altug stressed that the latter frictions are very ad hoc and motivated by the need to make the model fit the data rather than to explain the behavior of the agents. She proposed instead introducing irreversibility in investment. Irreversibility provides a theoretically more appealing way of generating the smooth response of investment to shocks since it implies an endogenous, time-varying adjustment cost or risk premium and provides a role for uncertainty, risk and learning.

The second discussant of the paper was **Michael Dueker** (Federal Reserve Bank of St Louis). The discussant started out by noticing that in fact the authors do not introduce nonlinearities, they just do not remove features that are already present in the model. He then drew the attention to the fact that the model presents a path-dependency problem, tackled by the particle filter through a collapsing procedure for integrating out the past state variables as we proceed with the filtering: this induces an approximation in the likelihood function. Dueker suggested that the paper should discuss more the trade-off between the approximation error from due to linearizing the model and the approximation error deriving from integrating out past values of the state variables. Pointing out to the inefficiency of the random walk MH sampler, the discussant advocated the use of a single 'tailored' proposal density (with a fixed mean) to be used as an independence proposal generator for all draws. He expressed perplexity about the fact that the marginal likelihood of two versions of the model considered in the paper differ so much, given that the AR coefficient for the inflation target in the first model is so high, and suggested that the two versions of the model considered in the paper could have been written, respectively, as a fixed endpoint model and moving endpoint model.

Tristani responded to the comments by pointing out that in fact the size of the model was constrained rather than a choice and that indeed they were also puzzled with the outcomes of the comparisons of the two models.

**Juan Francisco Rubio-Ramirez** (Duke University and Federal Reserve Bank of Atlanta) presented his paper 'Estimating Macroeconomic Models: a Likelihood Approach', co-authored with Jesus Fernandez-Villaverde (Duke University, NBER and CEPR). The goal of the paper is performing likelihood-based inference in nonlinear and/or non-normal DSGE models and they do so using a particle filter. The author stressed that both nonlinearities and non-normalities are important. First of all, linearization eliminates asymmetries, threshold effects, precautionary behavior, big shocks, etc..., not allowing for the possibility to study such features of the model. Moreover it induces an approximation error that has been shown to have considerable effects. For what regards non-normality, there is a lot of evidence of time-varying volatility in time series and the issue has renewed its importance with the recent discussion about Great Moderation. After having discussed in great detail the functioning of the particle filter, Rubio-Ramirez presented an application to a neoclassical business cycle

model with investment-specific technological change and stochastic volatility. The main results of the application are the following. First, the stochastic volatility features of the model are important in the explanation of the behavior of observed US data. Second, the decline in aggregate volatility has been a gradual process since the late 1950s, interrupted only by the turbulence of the 1970s. Third, the reduction in the preference shock is a plausible explanation for increase and subsequent fall in the volatility of growth in real US output per capita. The first discussion of this paper was made by **Gianni Amisano** (Università di Brescia). After a brief sketch of the paper's motivations and aims, the discussant drew the attention to some of the features of the particle filter that present particular problems. First, the filter is based on a blind proposal and this can induce a low numerical accuracy. Second, particle filter is highly sensitive to outliers. Finally, it does not work in absence of measurement error. The authors, as Amisano highlighted, develop a very clever modification of particle filter that works also in models with rank deficiencies in measurement errors covariance matrix. He nevertheless suggested using alternative filters, such as the conditional particle filter of the auxiliary variables particle filter, which tend to be much more accurate. Regarding the empirical exercise, the discussant recommended using also forecasting performance measures in order to compare the different model specifications. He also suggested using filtered estimates of the state variables to assess the goodness of fit of the model, rather than the smoothed estimates, as is done by the authors. Finally Amisano recommended that the authors take into account parameter uncertainty by using a Bayesian approach instead of conditioning of the maximum likelihood parameter estimates.

**Raf Wouters** (National Bank of Belgium) acted as second discussant. The discussant first defined the result that the business cycle is explained by investment-specific technology and preference shocks quite surprising, since both shocks fail to generate a positive correlation between consumption and investment in response to investment-specific technology and preference shocks. Therefore Wouters hinted to misspecification of the model in this dimension. He then pointed out that, in the paper, the decline in the volatility of output is exclusively related to the decline in the volatility of the preference shock, in contrast with other estimates for the US. The authors claim that this difference can be explained by the use of information on the relative investment price and the interaction between the nonlinearity and non-normality in the estimation process. Thus, the discussant investigated the importance of this interaction in identify shocks and estimating parameters by estimating a linear-normal model on simulated data from a nonlinear (second-order approximated) non-normal model. The results of this experiment was that, although likelihood might have been relatively low for the linear-normal model, the parameter estimates and the estimated shock series were typically not affected that much. Therefore the discussant concluded that estimating standard DSGE models with this method does not make much of a difference.

Rubio-Ramirez responded to the comments by pointing out that they while doing smoothing they use ML estimates, because smoothing is very time-consuming and doing it on a distribution would become extremely cumbersome. He then commented that indeed the smoothed estimates of the shocks obtained by Wouters were strikingly similar to the actual shocks, but he hinted that filtering, instead of smoothing would probably give very different results, in particular the model would probably respond by overshooting and undershooting.

The session on estimation was resumed on the morning of the 29<sup>th</sup> with the paper 'The Phillips Curve under State-Dependent Pricing' by Hasan Bakhshi (Lehman Brothers), Hashmat Khan (Carleton University) and **Barbara Rudolf** (Swiss National Bank). In this paper, the authors derive a closed-form solution for short term inflation within the framework of a DSGE model with state-dependent pricing. The presenter stressed state-dependent pricing has the advantage of endogenizing the timing of the price adjustment, i.e. firms adjust the time pattern of their price adjustment in response to change in macroeconomic conditions. She then gave a detailed insight on how they derive the state-dependent Phillips Curve. The latter, which nests the New Keynesian Phillips curve as a special case, relates inflation to lagged inflation, expected future inflation, current and expected future marginal costs, and current and past variations in the distribution of price vintages. The presenter discussed the properties of the state-dependent Phillips curve. Based on steady-state comparisons, she showed how the coefficients respond to changes in the model calibration of adjustment costs under both low (3%) and high inflation (6%) environments. Finally Rudolf presented results regarding the performance of the hybrid New Keynesian Phillips curve in an economy with state-dependent price-setting: the hybrid New Keynesian Phillips curve fares well as long as there is no or little state-dependent price-setting, but that it generates too much persistence in the macroeconomic variables, once the state-dependent variations are sizeable. The presenter concluded by illustrating the problems the authors are facing in performing Bayesian estimation of DSGE models with state-dependent pricing: having an infinite number of lagged inflation terms, they have to truncate them, but the truncation seems to have sizeable effects on the estimation.

The first discussant of this paper was **Michele Lenza** (European Central Bank). After having summarized the results of this paper, the discussant pointed out that there might be something missing in the state-dependent Phillips Curve. Showing the results of an estimation of a New Keynesian Phillips Curve on US data from 1970 to 2006, Lenza illustrated that the relative importance of the backward and forward looking terms of inflation was very different across the period with high inflation (1970-1984) and low inflation (1985-2006), with the coefficient of the backward looking term being much smaller (and the forward looking term being much larger) in presence of low inflation. The Phillips Curve derived by Bakhshi, Khan and Rudolf instead does not seem to capture this feature of the data, since the coefficients they obtain by estimating the New Keynesian Phillips Curve on data in high and low inflation environments simulated from their state dependent Phillips Curve remain unvaried across the two subsamples. Lenza also pointed out that the framework in the paper does not feature real rigidities that are shown to be relevant in empirical studies in order to reproduce key features of US inflation without relying on excessive inflation inertia. By consequence, in the calibrated state dependent Phillips curve inflation is more sensitive to marginal costs than it is found in empirical studies. Therefore he suggests adding elasticity of goods demand increasing in price and firm specific inputs.

**Paolo Surico** (Bank of England) acted as second discussant. He praised the fact that the state-dependent price-setting framework of the paper allowed to endogenize inflation inertia through the role of trend inflation, but also drew the attention to another possible (less explored) endogenous source of inflation inertia, namely indeterminacy, since the weak interest rate response to monetary policy can create large and persistent deviations of inflation from its target. Surico then stressed that models should ideally be able to produce a positive relationship between trend inflation and the backward-looking term in the Phillips Curve and that moreover this relation cannot be structural in the sense of Lucas. He then showed a graph, provided to him by the authors but that surprisingly was not in the paper, which showed that the authors managed to reproduce that feature when they consider certain types of distributions of adjustment costs and that moreover the frequency of price adjustment is not policy invariant. The discussant concluded by noticing that both state-dependent pricing and trend inflation enlarge the indeterminacy region and therefore suggested that the authors discuss in their paper what are the conditions for a unique RE equilibrium and derive the analytical expression for the Taylor principle as a function of both adjustment probabilities and trend inflation.

Further comments revolved on the use of likelihood-based methods for the estimation. It was also suggested that another source of inflation inertia could be heterogeneity, among sectors, of price durations.

The last paper presented in the estimation session was 'Nominal Rigidities, Distribution Costs and the Dynamics of the Real Exchange Rate: a Bayesian Approach' by Riccardo Cristadoro (Banca d'Italia), Andrea Gerali (Banca d'Italia), **Stefano Neri** (Banca d'Italia) and M. Pisani (Banca d'Italia). Neri started by pointing out that the stylized facts on the real exchange rate - i.e. that it is negatively correlated with relative consumption and that its fluctuations are extremely volatile and persistent and do not significantly affect the other macroeconomic variables - have proved quite difficult to explain. Many authors have extended open economy models with features such as sticky prices, sticky wages, non-traded goods and distribution services in order to replicate the stylized facts. The goal of this paper is to empirically investigate these extensions by estimating different versions of a two-country new open economy model using Bayesian techniques on euro-area data and US macroeconomic variables. The main features of the models are: international price discrimination (due to the presence of distribution costs and the local currency pricing assumption), distribution costs for traded goods (intensive in local non-traded goods), sticky prices and wages, pricing to market, home bias in consumption preferences, incomplete financial markets at the international level and systematic monetary policy. Moreover they introduce a shock to the uncovered interest parity. The models differ in the degree of exchange rate pass-through into import prices and for the presence or not of the UIP shock. The main results are the following. First, the model with distribution costs is able to replicate the main stylized facts of the real exchange rate and outperforms in terms of fit (marginal density) the local currency pricing and producer currency pricing models. Second, the presence of the UIP shock is important to mimic the real interest rate, as confirmed by the forecast error variance decomposition and the fact that the models that do not incorporate it fit the data worst.

The first discussion of this paper was made by **Gunter Coenen** (European Central Bank). The discussant drew the attention to the dilemma of current-generation open-economy models – namely that in these models the contribution of foreign shocks to domestic fluctuations is negligible and international co-movement is essentially absent, in sharp contrast with available reduced-form evidence – and pointed out that this model was not immune from this problem either. He highlighted that this inability to capture these features may be due to misspecification, which leads to invalid cross-equation restrictions on the reduced-form representation of the model resulting in implausible parameter estimates and need for inclusion of ad-hoc shocks. The inclusion of ad-hoc shocks may however have the unintended consequence of shutting down the channels of international

transmission. Therefore Coenen suggested the inclusion of a common shock, capturing the common factor in national business cycles. Moreover he pointed out that there seem to be quite serious identification problems on some parameters. Finally the discussant suggested that the model evaluation could focus, not only on a small set of stylized exchange-rate facts, but also on other aspects of potential interest, as e.g. the typical hump-shaped response pattern of the real exchange rate or the volatility of import volumes and the need for adding import adjustment costs. Such evaluation could be based on autocorrelation/autocovariance functions, rather than selected moments, and then be compared to those of an unconstrained VAR model.

**Robert Kollman** (Université de Paris XII and CEPR) acted as second discussant for this paper. The discussant described the paper as a “combination model” that brings together many elements from a vast literature, such as the different mechanisms that insulate real activity from fluctuations in the real exchange rate (exchange rate disconnect), and then tries to disentangle their effects. He then made some comments and suggestions. First, Kollman pointed out that the euro area is not US main trading partner and that therefore, focusing exclusively on the euro area-US relation, the model might underestimate the importance of the exchange rate channel. Then he recommended to using more variables in the estimation: to be able to discriminate between local currency pricing and producer currency pricing, for example, one has to look at data on import price. Similarly, looking at trade data is crucial for estimating for trade elasticity. Moreover, the discussant pointed out that the model is able to determine persistence in real exchange rate fluctuations, because the UIP shock is very persistent, but micro evidence shows that such shocks are much less persistent. Finally Kollman suggested that the authors specify more accurately the firms sector: a Leontieff technology is highly implausible, while with more sectoral disaggregation they could increase price elasticity of trade flows.

Several other comments revolved around the importance of international co-movement and the possibility of adding a common shock. Neri concluded by pointing out that the reason for which the use as observables many price variables and few quantities is that most of such data, e.g. the trade variables, exists only in nominal terms and are not that good.

### Session 3: Open Economies

**Pau Rabanal** (La Caixa) opened the third and last session of the workshop, presenting his paper ‘Euro-Dollar Real Exchange Rate Dynamics in a Two-Country Model: What is Important and What is Not’, co-authored with Vicente Tuesta (Banco Central de Reserva de Peru). In this paper, they use a Bayesian approach to estimate a two-country NOEM model using data for the United States and the US, and perform model comparisons to assess the importance of departing from the law of one price and the complete market assumptions. Rabanal outlined the main features of the model that is used in the paper as a baseline – i.e. tradable goods, habit formation, home bias, Calvo-type restriction in price setting with backward looking indexation, law of one price and complete markets. Then, he pointed out that they compare this baseline model with three alternatives: a version of the baseline model where there are sticky imports prices with local currency pricing, one with incomplete markets and one with both of these extensions. Unlike other authors, they leave out the UIP shock and focus more carefully on the role of traditional shocks, such as demand, technology, monetary and preference shocks) in explaining real exchange rate fluctuations. The presenter then offered a detailed overview of the results obtained in the paper. First, the preferred model was the one with incomplete markets and producer currency pricing, since it provided a good fit to the data, estimated parameter values that were in line with the literature, and was able to capture the negative correlation between relative consumption and the real exchange rate. However, he stressed that the failure of the LCP assumption is likely due to the fact that they did not use imports prices in the estimation. Finally, Rabanal pointed out that their results indicated that both demand and technology shock have a major role in explaining the behavior of the real exchange rate, while monetary shocks did not.

**Max Gillman** (Cardiff University) acted as first discussant for this paper. The discussion focused on three main points. First, Gillman drew the attention to the fact that the model does not include capital and does not allow factor price equalization across countries: this determines more volatility in the aggregate prices and hence in the real exchange rate. He pointed out that assuming sticky prices was a substitute for identifying underlying factor market immobilities and recommended instead to build capital into the model and explicitly model the restrictions to factor mobility. The second comment regarded the monetary shock, which is said to be unimportant by the authors, in contrast to the mainstream literature. This paper assumes international monetary shocks (e.g accelerations or decelerations in worldwide inflation or sudden financial or technology shocks), but such shocks are infrequent and thus should be considered irrelevant in the estimation. Finally Gillman argued that in this paper there are many frictions, but any likely central friction is skated around. Furthermore growth is

considered exogenous - while it obviously is not - and persistence of shocks is not the same as explaining long run changes in variables because of taxation.

The second discussant to the Rabanal-Tuesta paper was **Andreas Fischer** (Swiss National Bank). After a brief introduction on the paper's motivation and main results, the discussant started his comments by arguing that the paper put a lot of emphasizes on model comparison and not enough on model validation. He then questioned whether the negative correlation among the real exchange rate and relative consumption, crucial in the paper, was robust, and suggested that its properties should have been investigated and built into the model. Regarding the estimation, Fischer was not convinced by the evidence from the incomplete markets models. There are two parameters that are crucial for the incomplete markets extension to the model: the first one, at least in the model with LCP, is estimated being close to 1, value at which the model reverts back to a complete markets model, while the second estimate lacks robustness. Finally, the discussant pointed out that forecast produced by the model with incomplete markets and PCP – the preferred model in the paper – should be compared with the forecasts coming from the closed economy model, rather than with a random walk with drift. In closed economy model the real exchange rate has been removed, but the unit root global shock is still there and we can assume the real exchange rate operates through it. This comparison is strikingly in favor of the closed economy.

**Gregory de Walque** (National Bank of Belgium) presented the paper 'An Estimated Two-Country DGSE Model for the Euro-Area and the US Economy', co-authored with Frank Smets (European Central Bank and CEPR) and Raf Wouters (National Bank of Belgium). The paper extends the Smets and Wouters closed economy models for the euro area and US to an integrated two-country model and estimates it with Bayesian methods. The empirical exercise focuses on the estimation of the elasticity of substitution between domestic and foreign goods, the restrictions implied by the UIP condition for the exchange rate dynamics and the overall model dynamics, and on the assessment of the role of various types of shocks in explaining the exchange rate volatility as well as trade balance variations. After having outlined the model's main features, de Walque presented the main results for three versions of the model: namely, model with high substitution elasticity, a model with low substitution elasticity, and a model without UIRP assumption, in which the exchange rate is assumed to be an exogenous AR(1) process. The reason for considering two versions of the model differing only for the degree of substitution elasticity is that there exists a critical value of this parameter ( $\sim 1.5$ ) for which the exchange rate is extremely volatile and the model has a very low marginal likelihood (below this threshold, the impact of the real exchange rate on the current accounts reverses and the terms of trade wealth effects dominate the switching expenditure effect), and therefore the choice of the model depends on the initialization. Some of the main findings were the following. First, the spillover effects of a monetary policy shock remain small and depend crucially on elasticity of substitution. Second, the restrictions that are imposed by the UIRP condition on the reaction of the models to the various shocks are not supported by the data.

**Bruce Preston** (Columbia University and Federal Reserve Bank of New York) focused his discussion on four main issues. First, he briefly drew the attention to the fact that the model was estimated with many series in differences and instead suggested having a benchmark model that takes the trends and resulting theoretical restrictions seriously. The discussant then focused on the fact that the model, like all NOEM models, is unable to explain the comovement in consumption, output, employment and investment of the two countries and cannot replicate the significant influence of foreign disturbances on home business cycles. The discussant then stressed that comovement is a general problem not only for open economy models, but for all DSGE models and called for greater efforts in this direction. Preston also pointed out to some identification issues with the parametrization of the persistence in terms of endogenous structural components and/or exogenous disturbance components. Preston concluded presenting a small example which illustrated the relevance of such identification issues for policy evaluation. He estimated the mode of a small open economy model à la Gali-Monacelli, using two different priors, one agnostic about endogenous and exogenous sources of persistence, the second one assuming exogenous sources of persistence. The estimation resulted in two modes having the same value of the posterior, but completely different parameter estimates; thus determining completely different policy coefficients.

The second discussion was carried out by **Martin Ellison** (University of Warwick and CEPR). The discussant started by acknowledging the huge effort made by the authors to estimate such an elaborate model and appreciated the addition of an oil shock, as a possible explanation for global comovement. However, the results of the estimation, Ellison argued, are disappointing: the international spill-over is very low, the oil shock is not relevant and the real exchange rate mostly driven by its own UIP shock. The discussant's first comment concentrates on the model's specification. First, he recommends taking some distance from the representative agent model and modeling incomplete markets within one countries and complete markets cross countries (Kocherlakota and Pistaferri, 2006). He also pointed out the possibility of having determinacy issues, caused by

the presence of the final goods prices (which are affected by import prices) in the monetary policy rule. Ellison also questioned the modeling of the oil shock as an AR(1) process, which can be problematic given the clear evidence of nonlinearity and the fact that the causes of high oil prices have plausibly changed, thus determining very different effects. Finally the discussant highlighted the problems the authors have in estimating the elasticity of substitution between foreign and domestic goods and hinted that this could be due to the fact that in the log-linearization, that term drops out completely: he hence suggested considering a second-order approximation in order to tackle this issue.

The paper 'Evaluating an Estimated New Keynesian Small Open Economy Model' by Malin Adolfson (Sveriges Riksbank), Stefan Laseen (Sveriges Riksbank), **Jesper Lindé** (Sveriges Riksbank and CEPR) and Matthias Villani (Sveriges Riksbank) concluded the workshop. This paper estimates a new Keynesian small open economy model using Bayesian estimation techniques on Swedish data. The model differs from standard NOEM models in that the UIP condition is modified to allow for a negative correlation between the risk premium and the expected change in the nominal exchange rate. The main findings of the paper are the following. First, there is evidence for break in policy rule supported by the data, independently of the specification of the UIP condition. Second, the modified UIP condition is strongly preferred to standard UIP specification in terms of Bayesian posterior odds. Moreover, the specification of UIP condition important for the model's forecasting performance. In particular, the model with modified UIP condition improves the interest rate, real exchange rate and CPI inflation forecasts substantially at longer horizons, but worsens the root mean square error for output and hours worked. The forecasting performance of both DSGE specifications is generally better than classical VARs and Bayesian VARs with Litterman priors. More importantly, the model with modified UIP condition induces hump-shaped impulse response functions and intrinsic persistence in the real exchange rate. However, applying Del Negro and Shorfheide (IER, 2004) and Del Negro et al. (2004) DSGE-VAR( $\lambda$ ) and DSGE-VECM( $\lambda$ ) to examine to what extent the cross restrictions implied by the two specifications are supported by the data, the authors find that both variants of the DSGE are plagued by misspecification. The presenter concluded by pointing out that, while standard models have poor forecasting performance for the nominal interest rate, the model with modified UIP condition determines a clear improvement in this dimension and that therefore, when using the DSGE model in policy analysis, they currently use the specification with the modified UIP condition.

The paper's first discussant was **Paul Söderlind** (Swiss National Bank, University of St. Gallen and CEPR). First, he gave an overview of the paper, highlighting the ambitiousness of the model the authors use, the careful Bayesian estimation, and the interesting evaluation of the model. Söderlind however question their approach to modifying the UIP curve. First of all, he questioned the validity of the empirical evidence the authors present on the failure of the UIP. In particular, the discussant analyzed thoroughly the Swedish dataset used by the authors, highlighted the presence of several outliers and extreme values, and then stressed how the presence of such outliers rendered fitting the data with a linear model for the risk premium difficult and possibly useless. The risk premium is in fact modelled as a linear function of the current and expected depreciation in this paper and it is somehow similar to affine yield curve models. The discussant then argued that sticking reduced forms in DSGE model was probably not the best way to go and suggest really trying to 'microfound' the risk-premium. For example, he suggested investigating if a Campbell&Cochrane habit formation could do the job or the use of 3rd order approximation.

**Fabio Milani** (University of California, Irvine) acted as second discussant. He started by giving a brief overview of the paper's aims and results. He then praised the very serious model validation made by the authors, who look at relative fit (marginal likelihoods), absolute fit (DSGE as prior for VAR), forecasting performance and impulse responses matching. His second comment regarded the use of nominal rigidities to imply imperfect pass-through. This approach, Milani argued, can be criticized but on a theoretical and on an empirical level, since it cannot fit the positive correlation between exchange rates and the terms of trade and it generates unrealistic stickiness in the price of imports. Therefore he suggested using other theoretically more consistent explanations, such as price discrimination, trade costs and distribution sector intensive in local inputs. The discussant then drew the attention to the fact that the authors had used very tight priors for certain parameters and this had affected model comparison. Another point the discussant made was that the benchmark model is a VAR with 15 variables, not a more standard small monetary VAR, and that this is taken to be the "truth". He concluded raising some minor issues regarding the fact that the indexation coefficient should not be the same under different policy regimes (Lucas critique).