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Appropriate Macroeconomic  
Model Support for the  
Ministry of Finance and the  
National Institute of  
Economic Research:  
A Pilot Study

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National Institute of Economic Research







Appropriate Macroeconomic Model  
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Research: A Pilot Study\*

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2015, March

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# Abstract

We analyse model choices of various international institutions and find that the majority of the studied central banks have chosen so-called DSGE-models. Ministry of finances have chosen to continue using so-called Semi-Structural Models (SSM) while international organisations such as the IMF and the OECD have “a suite of models” including both DSGE and SSM. Based on these international experiences and the specific institutional set up in Sweden we list a number of criteria and rank different modelling strategies. We propose that a DSGE-model for both forecast and policy analysis including a rich modelling of fiscal policy would be appropriate for the Ministry of finance and the National Institute of Economic Research in Sweden.

[JEL classification code](#): E00.

Keywords: Macroeconomic modelling, model criteria, forecast, policy analysis, semi-structural models, DSGE, BVAR, SVAR, VAR.

# Sammanfattning

En makroekonomisk modell spelar vanligtvis en central roll i den makroekonomiska analysen både internationellt och i Sverige. Även om en makroekonomisk modell är en mycket stor förenkling av verkligheten utgör den en konsistent tolkning av den ekonomiska utvecklingen. Denna tolkning utgör ofta kittet i den ekonomiska analysen runt vilken diskussionen förs och idéer testas. En makroekonomisk modell ökar därför sannolikheten för att analysen utvecklas konsistent över tid.

Det faktum att kunskapen om ekonomins funktionssätt är begränsad samt att modeller endast inkluderar vissa aspekter av denna kunskap bidrar till att olika institutioner väljer olika modelltyper, olika modellinnehåll samt olika former för praktisk modellanvändning. Det är därför inte rättframt att identifiera gemensamma kriterier bakom olika institutioners modellbeslut. Bland de kriterier som lyfts fram av modellanvändare både utomlands och i Sverige kan följande nämnas: institutionens huvudsakliga verksamhet, behov av samarbete med andra institutioner, nationalekonomiska ställningstaganden, resurstillgång samt trender i beslutsfattares preferenser.

Trots skillnader mellan modellval och modellanvändning kan två relativt starka tendenser dock fastslås. Den första är att många centralbanker under de senaste tio åren gått över till så kallade DSGE-modeller. Det beror främst på att dessa modeller fokuserar på konjunkturrell analys och penningpolitik vilka rör centralbankers kärnverksamhet. Det finns dock undantag till denna utveckling där centralbankerna i Danmark, Nederländerna, Spanien och USA utvecklat nya DSGE-modeller men valt att behålla modeller av tidigare årgångar. Den andra tendensen är att finansdepartement och oberoende institut inte valt samma väg som centralbankerna utan använder makromodeller av tidigare årgångar i sin prognos- och analysverksamhet.

I syfte att utvärdera lämpliga modellalternativ för Finansdepartementet och Konjunkturinstitutet identifieras ett antal kriterier. Dessa rangordnas på följande sätt: möjlighet till utbyte med andra modellutvecklare, täckningsgrad (antal centrala mekanismer inklusive penning- och finanspolitik), teoretiska och empiriska fundament, möjlighet att inkludera tidsvarierande jämvikter samt flexibilitet (enkelhet/snabbhet att implementera modellförändringar).

Rapporten tar sin utgångspunkt i att både Finansdepartementet och Konjunkturinstitutet kommer att, relativt centralbanker och internationella organisationer, ha begränsade resurser till utveckling och användning av modeller. En viktig slutsats är därför att modellvalet i stor utsträckning bör ta hänsyn till i vilken utsträckning utvecklingsarbetet och användningen "kan ta rygg" på modeller och programvaror vid andra institut. Eftersom resurstillgången är avgörande (men ännu inte fastlagd) för vilken modellutveckling som är möjlig presenteras tre alternativa modellstrategier. Dessa bedöms, vid olika resurstillgång, vara mest lämpliga utifrån de uppsatta kriterierna.

Som huvudmodell bedömer Konjunkturinstitutet att en DSGE-modell som inkluderar finanspolitik och finanspolitiska kanaler bör utvecklas för

prognos- och policyanalys givet att tillräckliga resurser avsätts. Det skulle innebära ett avsteg från det internationella mönster som nämndes ovan och i rapporten framförs ett antal skäl varför Sverige skulle kunna välja en annan väg. Att anpassa och använda en DSGE-modell i en prognosmiljö är dock relativt resurskrävande. Skulle inte tillräckligt med resurser finnas tillgängliga föreslås att en DSGE-modell utvecklas för policyanalys tillsammans med enklare tidseriebaserade modeller som prognosverktyg. Rapporten analyserar också lämpliga modellval även i det fall då en DSGE-modell för policyanalys av till exempel resursskäl inte skulle anses som ett möjligt alternativ.



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# 1 Summary and conclusions

Macroeconomic models normally play a central role in macroeconomic analysis both in Sweden and internationally. Although a macroeconomic model is an enormous simplification of reality, it does constitute a consistent interpretation of economic development. This interpretation often constitutes the "binding element" in the economic analysis, and discussions take place and ideas are tested in respect of this. Therefore, a macroeconomic model increases the likelihood of the analysis developing consistently over time.

The fact that there is limited knowledge of the workings of the economy and that models only include certain aspects of this knowledge means that different institutions select different model types, different model content and different forms of practical model usage. Therefore, identifying collective criteria behind the model decisions of various institutions is not a straightforward task. The criteria highlighted by model users both in Sweden and abroad include the following: the institution's primary business, the need for cooperation with other institutions, standpoints in respect of the national economy, resource availability and trends in the preferences of decision-makers.

Despite differences between model selection and model usage, two relatively strong tendencies can be determined. The first is the fact that over the past ten years, many central banks have switched to what are known as DSGE models. This is mainly due to the fact that these models focus on cyclical analysis and monetary policy, which affects the core business of central banks. However, there are exceptions to this development; the central banks in Denmark, the Netherlands, Spain and the USA have developed new DSGE models but opted to retain models from previous years. The second tendency is for ministries of finance and independent institutes not to select the same route as the central banks, but to use macromodels from previous years in their forecasting and analysis.

A number of criteria are identified with a view to evaluating appropriate alternative models for the Ministry of Finance and the National Institute of Economic Research. These are ranked as follows: opportunity for exchange with other model developers, comprehensiveness (the number of central mechanisms, including monetary and fiscal policy), theoretical and empirical foundations, the option of including time-varying equilibria, and flexibility (simplicity/speed for implementation of model changes).

This report is based on the fact that both the Ministry of Finance and the National Institute of Economic Research will have limited resources for the development and usage of models compared with central banks and international organisations. Therefore, one important conclusion is that the model selected should largely take into account the extent to which development work and usage can be "based" on models and software at other institutes. As resource availability – which is not yet established – is crucial to which model development is possible, three alternative model strategies are presented. These are deemed to be the most appropriate on the basis of the criteria presented, depending on resource availability.

As a primary model, the National Institute of Economic Research is of the opinion that a DSGE model which includes fiscal policy and fiscal channels should be developed for forecasting and policy analysis, provided that sufficient resources are allocated.

ed.<sup>1</sup> This would involve a departure from the international pattern specified above, and the report presents a number of reasons as to why Sweden could select a different route. However, adapting and applying a DSGE model in a forecasting environment is a relatively resource-intensive task. If insufficient resources are available, it is proposed that a DSGE model should be developed for policy analysis together with simpler time series-based models as forecasting tools. This report also analyses appropriate model selections even if a DSGE model for policy analysis were not to be considered a potential alternative on account of resources available, for example.

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<sup>1</sup> "Policy analysis" means that the model is used to study how the economy reacts to different events. One of its uses includes calculating alternative scenarios for economic development in respect of an existing forecast (which is not produced by the policy model). Policy model may be estimated or calibrated, but it is not used to create forecasts.

## 2 Introduction

Both the Ministry of Finance and the National Institute of Economic Research produce forecasts which extend five (or more) years into the future. They also describe various alternative economic developments (known as scenarios) which, together with the forecasts, constitute data for economic policymakers. These tasks are broadly the same as those carried out at other similar institutions all over the world. This is also largely true of central banks, although certain differences can be identified in this regard.

Most institutions – both national and international – use a macroeconomic model for this work (several macroeconomic models are used in exceptional cases). The term "macroeconomic" here means a model which – unlike partial models – includes a minimum of macroeconomic markets and agents which interact. As described in more detail in section 3, the content, properties and theoretical foundations vary very significantly between the macromodels used by the institutions. However one thing the models referred to as "macroeconomic" in the report have in common is the fact that they describe economic relationships between supply and demand, product market and labour market, real and nominal variables, global development and exchange rate. Economic policy in the form of monetary and/or fiscal policy is also included.

There are a number of reasons as to why a macromodel is developed, maintained and used for the above purposes. The forecast performance of both partial and macroeconomic models is normally weak over periods extending more than approximately one year ahead. What can then be "offered" to economic policymakers is (in a best case scenario) a theoretically consistent description of one or more potential developments of the economy. A macroeconomic model has an advantage in that the various development paths can be based on various explicit assumptions in respect of factors such as global development, economic policy or mechanisms creating equilibrium. Moreover, a macromodel can help to provide a more in-depth understanding of the workings of the economy. Questions can be asked of the model, and the responses provided by the model can lead to new insights for the party asking the questions and/or a greater understanding of the limitations of model. Continuous use of a macroeconomic model also helps to increase the chances of consistent analysis and communication over time. The model has a disciplinary effect on the institute's interpretation of the workings of the economy, including the conceivable effects of various types of shocks. At the same time, a model can provide support when new assessments are formed.

There are three basic areas of application for a macroeconomic model at institutions such as the Ministry of Finance and the National Institute of Economic Research. It can be used to describe what has happened in the economy (historical decomposition), what will happen and why (forecasts) and what could happen (alternative scenarios).<sup>2</sup> There are various trade-offs both within and between these areas of application, and different model approaches all have their strong and weak points. For exam-

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<sup>2</sup> Moreover, there is a further usage of a more practical nature in which the model is used as a binding element for a macro forecast. This may involve gradually including assessment forecasts in the model in order to achieve a cohesive view and also to analyse the effect of the assessment forecasts on remaining endogenous model variables.

ple, the Bank of England lists the following trade-offs, which will also be present in this report (Burgess et al., 2013):

- Theoretical foundations
- Empirical adaptation
- Tractability
- Flexibility
- Comprehensiveness

The type of model selected and how the model is used differ from institution to institution. As discussed in section 3, the choice of model is dependent on a range of factors. These are not infrequently situation-specific, which means that it is difficult to make direct connections with the situations prevailing at the Ministry of Finance and the National Institute of Economic Research. However, it does emphasise the importance of identifying which factors are the most important to us, as these will help us to identify what type of model is appropriate. Section 4 analyses the factors that characterise the activities of the Ministry of Finance and the National Institute of Economic Research and which model selection criteria these imply.

As stated previously, selecting an appropriate macromodel is a difficult and multifaceted task. There are many factors to take into account. The overall assessment of the National Institute of Economic Research, as expressed in the report, therefore, is necessarily a qualitative trade-off between the relative merits of the various model approaches, given the criteria considered central to the Ministry of Finance and the National Institute of Economic Research.

## 2.1 The commission

The Ministry of Finance and the National Institute of Economic Research are currently using the macroeconomic model KIMOD for forecasting and policy analysis.<sup>3</sup> Development of KIMOD began in 2002, and since 2004 it has been used regularly for policy analysis (see Bergvall et al., 2007). KIMOD was developed as a year model and began to be used as a forecasting tool in 2007. Since 2013, the model has been based on quarters and constitutes a central element of the forecasting work and policy analysis of the National Institute of Economic Research (see the National Institute of Economic Research, 2013).

The last decade has seen significant development in the field of macroeconomic modelling, in both the world of academia and among policy institutions. The greatest change is that international policy organisations (the EU Commission, IMF and OECD) and many central banks, according to the Smets and Wouters master (2003), developed what are known as DSGE models.<sup>4</sup> Like KIMOD, these models can be used for both forecasting and policy analysis, but not all central banks have chosen to use this model type as a forecasting tool. Within international policy organisations, policy analysis is a more common area of application. In Sweden, the Riksbank was

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<sup>3</sup> See footnote 1.

<sup>4</sup> DSGE is an abbreviation for Dynamic Stochastic General Equilibrium. Section 3.1 explains the structure of these and other models.

early to develop and use its DSGE model, RAMSES, for forecasting and policy analysis. Thus there is extensive expertise and experience as regards developing and adapting a model of this type to Swedish data.

Given this background, the Ministry of Finance felt it was appropriate to investigate without bias what type of macroeconomic model could benefit the Ministry of Finance and the National Institute of Economic Research most extensively in the future. In the appropriation directions for 2014, the National Institute of Economic Research was therefore commissioned to carry out this pilot study concerning an appropriate macroeconomic model at the Ministry of Finance and the National Institute of Economic Research. The design of the commission in its entirety is specified below:

*"The authority shall implement a pilot study of appropriate model support for work on medium-term macroeconomic scenarios (1–10 years) at the National Institute of Economic Research and the Swedish Government Offices (the Ministry of Finance). Among other things, this pilot study should include an inventory of existing macroeconomic models at a number of equivalent organisations around the world, including an assessment of the advantages and disadvantages of these models. Practical aspects of the use of models in the policy environment should be noted in particular. The commission includes submitting a proposal for an appropriate macroeconomic model which can be used by both the National Institute of Economic Research and the Ministry of Finance. The commission will be implemented in consultation with the Swedish Government Offices (the Ministry of Finance). An interim report which includes preliminary conclusions must be submitted to the Government (the Ministry of Finance) by 17 October 2014. The final report on this commission must be presented to the Government (the Ministry of Finance) by 31 January 2015."*<sup>5</sup>

Besides the above description, the commission has been specified in greater detail at meetings of what is known as the Consultation Group, which comprised people from both the Ministry of Finance and the National Institute of Economic Research.<sup>6</sup> The Consultation Group has met on five occasions. The following specifications during these meetings have been of particular importance to the implementation of the commission and the formulation of the report:<sup>7</sup>

- A cyclical analysis model is of interest to both the Ministry of Finance and the National Institute of Economic Research.
- The pilot study should compare various alternatives with one another in order to facilitate a decision.
- Particular attention should be paid to how the choice of model will affect user-friendliness and the chances of recruiting staff.
- The pilot study does not necessarily need to propose *one* model for the purposes described in the commission.
- It is important to illustrate the issue of resources.
- The time restrictions of the Ministry of Finance as regards forecasting work may mean that there is no scope for a DSGE-type forecast model.

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<sup>5</sup> To view the appropriation directions of the National Institute of Economic Research in their entirety, please see <http://www.esv.se/sv/Verktyg--stod/Statsliggaren/Regleringsbrev/?RBID=15365>.

<sup>6</sup> The Consultation Group comprised Jesper Hansson, Göran Hjelm and Kristian Nilsson, as well as Thomas Bergman and Ylva Hedén from the Ministry of Finance.

<sup>7</sup> Minutes from the meetings of the Consultation Group are available from the National Institute of Economic Research upon request.

The report is formulated so that it could be used by staff at the Swedish Government Offices who are responsible for issues relating to future model development at the Ministry of Finance and the National Institute of Economic Research. These staff may include the Secretary of State responsible for the National Institute of Economic Research and the head of the economic department. Therefore, the aim is to make the report readable by people who have no expert knowledge of macroeconomic modelling. At the same time, the aim is for this report to constitute an adequate basis for decisions on both the need for model development and the direction of this.

## 2.2 Method

According to the commission cited above, the pilot study should include a description of the advantages and disadvantages of the various models used by a number of equivalent organisations throughout the world. Model development and model usage are controlled by many "soft", not infrequently, institution-specific factors which are not evident from published documents. Therefore, the commission was implemented using two primary information sources: (i) model documentation and (ii) conversations with model developers (meetings, seminars, emails and telephone calls).

The pilot study work began with a broad but general survey of the types of models used in the Nordic countries, along with a number of small open economies which have historically been at the forefront of model usage (Canada, the Netherlands, New Zealand and the United Kingdom. This provided ideas for seminars, two-way conversations with model developers and planned visits to foreign institutions. Prior to these visits, the project team at the National Institute of Economic Research studied the model documentation and sent lists of questions two weeks before departure. The aim of this was to increase the likelihood of the content of the visits being appropriate.

The following seminars were held at the National Institute of Economic Research in Sweden:

- *Empirical adaptation of KIMOD*: The National Institute of Economic Research gave a presentation and the Riksbank was invited to comment.
- *RAMSES II*: Vesna Corbo, Stefan Laséen and Ingvar Stridh from the Riksbank gave a presentation.
- *KOOMA*: Mika Kuismanen and Meri Obstbaum from Finland's Ministry of Finance gave a presentation.
- *MOSES*: Ard den Reijer from the Riksbank gave a presentation.

The following visits to foreign institutions took place (speakers in brackets):

- Bank of England (Matthew Waldron)
- Office for Budget Responsibility (United Kingdom, Tom Pybus)
- National Institute of Social and Economic Research (United Kingdom, Dawn Holland and Ian Hurst, Simon Kirby)
- Central Planning Bureau (Netherlands, Adam C. Elbourne, Albert van der Horst and Henk Kranendonk)
- Bank of Norway (Leif Brubakk)
- The EU Commission (Werner Roeger and Jan in't Veld)

- European Central Bank (Kai Christoffel and Günter Coenen)

The following people (besides the people who contributed at seminars and during visits to the above foreign institutions) have shared particularly valuable insights during conversations relating to the development and usage of macromodels in policy environments:

- Hess Chung, Jean-Philippe Laforte and Thomas Laubach (Federal Reserve Board)
- Benjamin Hunt and Douglas Laxton (IMF)
- Pierre Leblanc (Ministry of Finance, France)
- Jesper Lindé (Federal Reserve Board and the Riksbank, Sweden)
- Henrik Lundvall, Christina Nyman and Karl Walentin (the Riksbank, Sweden)
- Martin Nygaard Jørgensen (the Ministry of Economic Affairs, Denmark)
- Maarten C.J. van Rooji (De Nederlandsche Bank)

The models analysed in the study are listed in section 3 (see Tables 2 and 3).

## 2.3 Restrictions

The commission took place over 13 months (1 January 2014 – 31 January 2015), and preliminary conclusions were submitted in an interim report on 17 October 2014. This time frame involved certain restrictions in terms of both the breadth and the depth of the analysis.

Given the time of the interim report, it was thought that central seminars in Sweden and visits to other institutions abroad would be completed by mid-September. After a broad but general study, it was deemed reasonable to carry out two trips in the spring and two in the autumn. This constitutes a restriction as it would have been desirable to visit more foreign institutions had the time been available.

Another restriction (or trade-off) is that between "breadth" and "depth" in the analysis of appropriate model type and model content. Emphasis was placed there on "breadth" in a number of senses. The pilot study illustrates the *model types* (e.g. the DSGE model) of a relatively large number of institutions and the institution-specific factors which control these choices, rather than describing options in respect of each model type. The emphasis has been on "breadth" rather than "depth" for each model type as well. For example, more emphasis was placed on analysing the mechanisms included in a model type (e.g. financial frictions) rather than looking at which modelling of a specific mechanism is deemed to be the best.

Given this analysis, conclusions are drawn on which types of mechanism would be desirable in the selected model, but no precise recommendations are given on the exact modelling of these. The latter is viewed as a natural element for when any work begins on building a new model.

## 2.4 Structure

The report is structured as follows. Section 1 summarises the conclusions of the report. Section 3 presents a schematic breakdown of the model types currently in use at Swedish and international institutions. It also describes the primary content and usage of various model types, as well as discussing criteria that provided guidance for various institutions when selecting their models. Section 4 analyses the criteria that are important to take into account when selecting a model for the Ministry of Finance and the National Institute of Economic Research and ranks these in order of priority. It then describes the advantages and disadvantages of various model choices in respect of both these criteria and the experiences from other institutions as described in section 3. Section 5 compiles a list of four – in the opinion of the National Institute of Economic Research – appropriate model choices depending on resource availability.

### 3 Model choices and their criteria at world institutions

There are many policy-oriented institutions in the world – not least ministries of finance and central banks – which develop and regularly use macroeconomic models. Some models have existed for a long time, while others have been developed or revived over the last few years. Understanding the criteria that were important when choosing these models is an important part of the project as regards the model selection operation facing the Ministry of Finance and the National Institute of Economic Research.

"Choosing a model" does not merely involve selecting a specific model. In slightly simplified terms, "choosing a model" involves three elements.

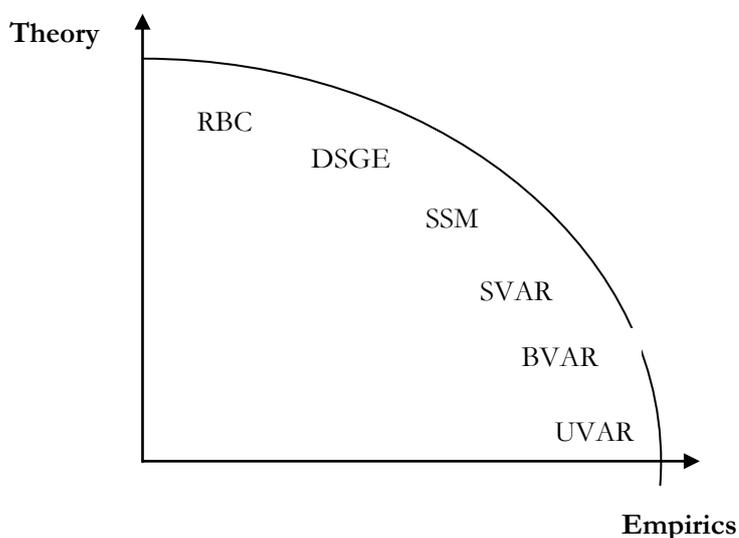
1. *Model type*
2. *Model content* with a selected model type
3. *Model usage* with a selected model type and selected model content

Sections 3.1-3.3 describe fundamental selections within these three elements. Section 3.4 then discusses which criteria affected the three elements of the choice of model at institutions in Sweden and elsewhere.

#### 3.1 Division into *model types*

Although there is a "sliding scale" as regards model types, in practice it is appropriate to generally categorise the types with a view to describing similarities and differences. Often this kind of division is based on how the model in question relates to theoretical and empirical foundations (see, for example, Baccini et al., 2013). Figure 1 shows how common macromodels can be divided on the basis of their establishment in theory and empirical data.

**Figure 1:** The relative theoretical and empirical foundations of model types



**RBC** stands for Real Business Cycle, and this model tradition began with Kydland and Prescott (1982). These models are based on microeconomic theory and are characterised by full competition, complete markets, rational expectations and flexible prices. No policy institutions are using RBC models in their forecast or policy analysis. Instead, these are being mentioned here as reference objects, and partly as predecessors to what are known as the DSGE models.

**DSGE** stands for Dynamic Stochastic General Equilibrium, and this model tradition began with Smets and Wouters (2003). The DSGE models are also based on the RBC literature by assuming complete markets and – with a small number of exceptions in later years – rational expectations. Compared with the RBC models, the DSGE literature has introduced incomplete competition and slow-moving prices. Another difference is the fact that the microfoundations included in the DSGE models are less based on economic theory than RBC, and occasionally they are even ad hoc in nature (Chari et al., 2009). Therefore, it is not always easy to interpret the shocks which DSGE models identify as structural. The aim of achieving a better empirical root is an important reason as to why decisions were made to "tamper" slightly with the microfoundations.

The first generation of DSGE models were built to analyse cyclical variations and the effects of monetary policy. This is why they rapidly became popular among central banks. Over the last few years, DSGE models have been developed for analysis of other issues such as financial policy, financial frictions and formation of expectations.

**SSM** stands for Semi-Structural Macromodels, but this is not an accepted term. Another designation sometimes found is "Macroeconometric models". A number of models in this category date back to the 1970s and 1980s. However, the current empirical applications can be said to have been formulated by the literature on cointegration (Engle and Granger, 1987, and Johansen, 1988). Unlike RBC and DSGE models, which have well-defined theoretical and empirical structures, SSM is made up of a more heterogeneous mix of models. However, these model types can be said to have a number of ingredients in common. They are based on microeconomic foundations to only a limited extent, and they often have no well-defined steady state. They are not estimated simultaneously, but normally via a combination of estimates of individual equations and blocks of equations.

The residuals of these equations cannot be interpreted structurally due to the lack of theoretical foundations. The number of variables and the degree of disaggregation are normally greater in SSM models than in DSGE models. This is probably due to both a desire and an opportunity (in that there are fewer demands on theoretical foundations) to describe more market mechanisms.

SSM models are common at ministries of finance, but they are also used at independent institutions (such as CPB in the Netherlands and NIESR in the United Kingdom) and central banks (e.g. Denmark, the Netherlands, Spain and the USA).

**SVAR**, **BVAR** and **UVAR** stand for Structural, Bayesian and Unrestricted Vector AutoRegressive (VAR) models. The VAR literature began with Sims (1980). Bernanke (1986) and Blanchard and Watson (1986) are early contributions in respect of SVAR and Litterman (1980) and Doan et al. (1984) are early contributions in respect of

BVAR. In general, the strength of VAR models is that they describe data and – as regards BVAR, at least – can be used as forecasting tools.

However, restricting a VAR model permits theoretical interpretation of outcome and forecast in SVAR models. This resembles the form of analyses which can be carried out using DSGE models. The endogenous forecast from a SVAR model is the same as from a VAR model and therefore suffers from the same shortcomings. Above all, these models are generally overparameterised, which increases the uncertainty in the estimates, i.e. wider confidence band.

One model type has seen a significant increase in use over the last few years; what is known as Bayesian VAR (BVAR). It has been possible to incorporate what are known as steady state priors since Villani (2009), which means that the model variables converge towards desired values in the long term. This has proven to be useful within policy institutions. Moreover, the introduction of steady state priors has proven to improve forecasting ability (Beechey and Österholm, 2010).

Although these models are used frequently at the majority of policy organisations, they do not constitute a "primary model" on which forecasting and policy analysis is centred.

Table 1 documents the types of model used by institutions around the world as primary models for forecast and/or policy tools.

**Table 1:** Primary model type selection at various institutions

	<b>DSGE</b>	<b>SSM</b>
<b>Ministry of Finance</b>	Finland*	Denmark
		France
		Canada
		Norway
		New Zealand
		Sweden (KIMOD)
<b>Central banks</b>	ECB	Danmarks Nationalbank
	Bank of Finland	De Nederlandsche Bank
	Bank of Canada	Bank of Spain
	Federal reserve bank of New Zealand	Federal reserve, USA
	Bank of Norway	
	Bank of England	
	The Riksbank, Sweden (RAMSES)	
<b>Other institutions</b>	EU-commission**	Belgium (FPB)
	IMF***	Ireland (ESRI)****
		OECD
		Netherlands (CPB)
		Sweden (NIER)
		UK (NIESR)
		UK (OBR)

\* Still under development. Has been used on occasions as a calibrated policy model, not as a forecast model.

\*\* Used as a policy model, not as a forecast model.

\*\*\* This refers to the forecast model GPM of which equations are inspired by the DSGE literature and the policy analysis models GIMF and GEM, which are DSGE models.

\*\*\*\* Under development.

## 3.2 Similarities and differences in *model content*

Different institutions have different objectives with their models, and this is very much dependent on the questions which the institution is expected to be able to answer. This means that the models – even within one and the same model type – may differ in terms of both size and content. As discussed further in section 3.4, in addition there are also a range of other factors alongside this which may influence both the choice of model and the model content. This section describes differences in model content on an aggregated level with the purpose to provide a comprehensive picture.

### **DSGE models**

The core of the DSGE literature is represented in more or less all the DSGE models studied in the pilot study. This core can be said to comprise the RBC assumptions of complete markets and rationality, as well as the new Keynesian assumptions of incomplete competition and slow-moving prices and wages. Moreover, the modelling of monetary policy is central (except in countries which are part of a currency union).

In addition to this core, different choices are available concerning the following central elements:

- *Financial markets/frictions.* The financial crisis which erupted with the fall of Lehman Brothers in the autumn of 2008 resulted in a demand to include channels from the financial sector; this had not been done to date. Formal modelling along these lines has been carried out at a number of institutions (see Table 2).<sup>8</sup>

However, there does not appear to be any consensus on which modelling of the financial sector is most appropriate. Therefore, it is not possible to state which of the approaches will be regarded in future as part of the core of the DSGE models in the same way as, for example, Calvo pricing.

- *Fiscal channels.* The financial crisis can also be said to be one reason as to why fiscal modelling, like modelling of the financial sector, has taken on a more prominent role in the DSGE literature. The subsequent recession meant, among other things, that the central banks' key interest rates were reduced to almost zero, which accentuates the analysis of the role of financial policy.

DSGE models generally have a number of fiscal *variables*, such as public consumption and indebtedness. Considerably fewer models have fiscal *channels* via which financial policy can have non-negligible macroeconomic effects. To put it another way, the fiscal transmission mechanism is often weak. Still fewer models have estimated reaction functions for different fiscal variables, i.e. how public investments – for example – are affected by the economic situation and public debt. Table 2 indicates which ones have included fiscal chan-

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<sup>8</sup> To be assigned a "Yes" in the table, it is not enough for the model to include credit-limited households, for example, even though this could be said to be an approximation of a financial friction. Formal modelling relates to an endogenous mechanism where the financial system influences the analysis. One example of this is Bernanke et al. (1999).

nels among the DSGE models specifically studied in this report. However, the bar has been set low, and it is sufficient for the model in question to have a percentage of households consuming their entire income in order to receive a "Yes", for example. However, there are examples of considerably more sophisticated modelling of fiscal channels, see for instance Coenen et al., 2012.

- *Modelling of unemployment.* When DSGE models were introduced at policy institutions, not only was there no modelling of the causes of unemployment, but the variable *unemployment* itself was not included in the models. Naturally, this was deemed to be unsatisfactory, not least in respect of internal communication at policy institutions whereby unemployment is often in focus.

However, it has proven difficult for both theoretical and empirical reasons to include a model for unemployment in DSGE models, and few institutions have this in their core models (see Table 2). Institutions such as CPB in the Netherlands and Bank of Norway have described their own unsuccessful attempts. Others, such as the Bank of England and ECB, have pointed out that nobody has managed to include unemployment in a satisfactory manner. Consequently, this is a factor for research and the Riksbank is working on developing its labour market model, which it has not yet been possible to use fully for forecasting.

**Table 2:** DSGE models at various institutions

				CONTENTS BEYOND CORE-MODEL*		
	Model	Reference	Used in	Financial	Fiscal policy	Modeling of
	name		forecasting	channels	channels	unemployment
<b>Central banks</b>						
ECB 1	NAWM	Christoffel et al (2008)	Yes**	No	No	No
ECB 2	NAWM	Coenen et al (2012)	No	No	Yes	No
Finland	AINO	Kiplonen et al (2006)	Yes	No	No	No
Canada	TOTEM	Dorich et al (2013)	Yes	No	Yes	No
Norway	NEMO	Brubakk et al (2006)	Yes	No	No	No
New Zealand	KITT	Benes et al (2009)	Yes	Yes	No	No
UK	COMPASS	Burgess et al (2013)	Yes	No	No	No
Sweden	RAMSES II	Adolfson et al (2013)	Yes	Yes	No	Yes
USA 1	SIGMA	Erceg et al (2006)	No	No	Yes	No
USA 2	EDO	Chung et al (2010)	No	No	No	No
<b>Other institutions</b>						
EU-comm.	QUEST III	Ratto et al(2008)	No	No	Yes	No
OECD	(none)	Cacciatore et al (2012)	No	No	No	Yes
IMF	GIMF	Anderson et al (2013)	No	Yes	Yes	No
IMF	GPM***	Carabenciov et al (2013)	Yes	Yes	No	No
<b>Ministry of Finance</b>						
Finland	KOOMA	No documentation	No	No	Yes	Yes

\* "Core model" refers to slow-moving prices and wages, incomplete competition, complete markets and rational expectations. See, among others, Smets and Wouters (2003) and Christiano et al. (2005).

\*\* NAWM is currently used only for policy analysis.

\*\*\* GPM is not really a DSGE model, but its equations are inspired by the literature and the parameters are estimated using Bayesian methods.

### SSM models

Compared with DSGE models, it is more difficult to define a core among SSM models. As they are not derived from microeconomic theory, there is no "manual" on how SSM models "should" be structured, which variables and mechanisms should be included, etc. Despite this, there are common denominators which gives them a place in the group of SSM models. These include the fact that they consist of an often relatively large number of estimated macroeconomic relations. They can also be said to have Keynesian elements in the short term, while neoclassical elements dominate in the longer term. Furthermore, the SSM models are often large and detailed, which is due in part to the fact that they constitute input for public financial calculations.

As for the DSGE models above, a general picture of various institutions' priorities is provided in respect of the content of the SSM models. Table 3 summarises the following areas:

- *Year.* As stated in section 3.1, many SSM models have existed for a long time. At the same time, the models – and, not least, the estimates – have been gradually updated. Table 3 indicates the year of the latest model version. Information has primarily been gleaned from available documentation.
- *Endogenous monetary and financial policy.* How these policy areas are modelled is dependent in part on the primary purpose of an institution. At the same time, there does not appear to be a clear pattern among SSM models in this field. Table 3 shows whether monetary and/or financial policy is determined by other variables in the model, or if they are provided exogenously.
- *Estimated relationships.* The number of equations estimated. SSM models are often made up of many equations and endogenous variables, sometimes several thousand of them. Most of these relate only to identity, and they are included because they constitute input for public financial calculations. Moreover, there are behavioural equations which determine central endogenous variables. These are the kind of estimated equations referred to in Table 3.
- *Expectation formation.* Expectation formation in the DSGE literature is forward-looking and rational. This is not the case in the majority of SSM models. Instead, the expectations are often backward-looking, but in exceptional cases they constitute a combination of backward and forward-looking elements (see Table 3).

**Table 3:** SSM models at various institutions

	<b>Model name</b>	<b>Reference (latest documentation)</b>	<b>Estimated equations (approx)</b>	<b>Endogenous monetary pol.</b>	<b>Endogenous fiscal pol.</b>	<b>Forward looking exp.</b>
<b>Central banks</b>						
Denmark	MONA	Danmarks centralbank (2003)	40	No	Yes	No
Netherlands	DELFI	Nederländska centralbanken (2011)	60	No	Yes	No
Spain	MTBE	Hurtado (2014)	15	No	No	No
Sweden	MOSES	Bårdsen et al (2012)	15	Yes	Yes	No
USA	FRBUS	Bryton et al (1996) Federal reserve (2014)	70	Yes	Yes	Yes
<b>Ministry of Finance</b>						
Denmark	ADAM	Danmarks statistik (2012)	90	No	No	No
France	OPALE	Bardaji et al (2010)	15	No	No	No
Canada	CEFM	Robidoux/Wong (1998)	80	No	No	No
Norway	MODAG	Boug/Dyvi (2008)	>50	Yes	No	No
New Zealand	NZTM	Ryan/Szeto (2009)	10	Yes	Yes	Yes
Sweden	KIMOD	Bergvall et al (2007)	5	Yes	Yes	Yes
<b>Other institutes</b>						
Belgium	MODTRIM	Ketelbutter et al (2014)	15	No	No	No
Netherlands	SAFFIER	Kranandonk / Verbryggen (2007)	15	No	No	No
OECD	NIGEM	Hurst et al (2014)	25	Yes	Yes	Yes
Sweden	KIMOD	Bergvall et al (2007)	5	Yes	Yes	Yes
UK	(none)	OBR (2013)	25	No	No	No

### 3.3 Different types of *model usage*

Besides the selection of model type and model content, there are also different ways in which to use models in practice as forecast and policy tools. The type of use which an institution believes itself to need most can itself affect the choice of model type. Below is a description of the areas of application which can be distinguished.

#### **Historical decomposition**

Historical decomposition means using a model to interpret historical data. This is done using residuals which are normally included in the model's behavioural equations. These residuals (or shocks) constitute the difference between the model's prediction and actual data, which in a best case scenario can be given a structural interpretation.

As DSGE models aim to be based on microeconomic foundations, it is possible to carry out a structural interpretation of the residuals of these models. The model's structural interpretation of economic development is provided by allowing the model to replicate data using these residuals. To put it another way, the development of all of the model's endogenous variables can be decomposed (explained) using the model's residuals. For example, a positive residual in a household consumption expression can be interpreted as an offset (or "shock") to household preferences. This application may be useful in both internal and external communication.

In an SSM model, it is more difficult to give the residuals a structural interpretation. In the example above, the interpretation becomes (for the model) an unexplained change (or "shock") to consumption. Therefore, it is more difficult to use an SSM model to create a structural interpretation of economic development in general and individual variables in particular.

Structural VAR approaches (SVAR) can be said to be a hybrid of DSGE and SSM models as regards the interpretation of residuals. Given the identification of the models, structural interpretations can also be carried out even if these are more loosely based on economic theory. This allows the same type of historical decomposition to be carried out as for DSGE models.

#### **Decomposition of forecasts**

Besides decomposing the history, one closely related modern usage involves also decomposing a model forecast or assessment forecast. A DSGE model or SVAR model can be used in the ways described above to interpret which driving forces – according to the model – determine the projected development of the variables. This can be helpful for both internal and external communication.

#### **Forecast**

Another application for a macromodel involves using it as a forecasting tool. The clear advantage of a macromodel like DSGE and SSM (and, to an extent, VAR models) is that a consistent, relatively comprehensive macroeconomic forecast is obtained simultaneously, compared with partial models.

There are different ways in which a macromodel can constitute a forecasting tool.

- Of course, the most obvious is to calculate an endogenous forecast based on the latest outcome, as well as the assumed development of exogenous variables.
- An alternative usage involves calculating what are known as revision tendencies. This then analyses how the macromodel will alter the forecast given new criteria, the latter potentially consisting of new input data, possibly a new short-term forecast and/or new development of exogenous variables. This usage is common at policy institutions. This is primarily due to the fact that macromodels' forecasts on central elements in general do not match the institution's assessment forecast. This means that when new outcomes arise and/or when new assumptions are made relating to the development of exogenous variables, the primary information value lies in how the model forecast is changed: this is usually referred to as revision tendency. Calculation of revision tendencies is closely linked with what are known as impulse response functions (IRFs). A revision tendency based on an altered view of the development of an exogenous variable is the same as calculating the model's IRF for the current variable if the macromodel is linear.
- A further model usage for forecasting purposes can be termed "sequential model analysis". This means that various assessments are gradually incorporated into the model, and the development of the remaining endogenous variables of this model are studied. For example, how is the labour market developing in the model for an exogenous (assessment-related) development of GDP? This process may take various forms at different institutions. For example, the model forecast may initially be dependent on a short-term forecast of, say, two quarters, which means that the model forecast will not commence until the third quarter. Then when the assessment forecast for GDP and the usage side of things is complete, it is exogenised in the model and its endogenous development of remaining variables is studied (such as prices and pay). When the assessment forecast is ready for nominal variables, the model forecast can be conditioned for these with a view to studying the endogenous model forecast of monetary and/or financial policy.

### **Alternative scenarios**

A further application involves using the macromodel for what are known as alternative scenarios. This involves calculating how the forecast as per the model would be changed if one or more exogenous variables and/or shocks were to be changed. This can essentially be calculated in two ways, which are equivalent if the model is linear. Either the model replicates the present forecast and works on the basis of this to calculate an alternative scenario, or else that scenario is based on the model's impulse response functions, the effects of which are "pasted onto" the existing forecast.

### **Calculation tools**

A model may also be designed to function as a "binding element" for the forecasting process. This may involve gradually incorporating various assessment forecasts into the model, which in turn generates forecasts for other variables. These forecasts are iterated, and finally the assessment forecasts for these are also added to the model, etc. This is described as "sequential model analysis" above.

If little or negligible notice is taken of the endogenous model forecasts in the process described above, the model can be said only to constitute a calculation tool. The model still being used in a process of this kind is probably due to the fact that a relatively large number of SSM models are used as direct input for detailed public financial calculations, i.e. similar to the calculations for which FIMO is used at the National Institute of Economic Research.

**DSGE, SSM and VAR models: a summary**

As specified above, there are important differences between DSGE, SSM and VAR models in terms of content and model usage. Table 4 provides a general summary of the differences using the factors listed by Burgess et al. (2013).

**Table 4:** A general comparison between different model types

	<b>DSGE</b>	<b>SSM</b>	<b>VAR</b>
<b>Theoretical foundation</b>	General equilibrium	Partial	Relatively weak
<b>Empirical foundation</b>	Bayesian system estimation	Error-correction estimation	VAR estimation
<b>Tractability</b>	Structural decomposition	Error-correction analysis	Structural decomposition (SVAR)
<b>Flexibility</b>	Relatively small	Relatively large	In between
<b>Comprehensiveness</b>	Relatively small	Relatively large	Relatively small

### 3.4 Factors which affected the choice of model at international institutions

The model or "suite of models" selected by institutions the world over are dependent on a number of different factors. Some of these result from the institutions' different tasks and functions. Other factors are more difficult to categorise and are due to qualitative, institution-specific considerations. The latter may mean that institutions with similar tasks (such as central banks) will sometimes select different types of model.

Although there are exceptions, there is a clear pattern whereby ministries of finance and independent institutes largely choose SSM models (see Table 1). Central banks, on the other hand, have largely selected DSGE models, although there are a number of exceptions to this as well (see Table 1).

A number of factors which were important in the selection of models at foreign institutions are discussed below.

### **The institution's tasks – the primary purpose of the model**

It is natural for both model *selection* and model *content* to reflect the primary job of an institution. As regards central banks, the emphasis is on monetary policy, which is why the emphasis is on the modelling and evaluation of monetary policy – irrespective of whether the model selected is DSGE or SSM. Other mechanisms, such as fiscal channels, are not taken into account as much.

*Example:*

- Central banks largely select DSGE models (see Table 1). These models, like central banks, focus on cyclical analysis and the role of monetary policy in stabilisation policy, including the meeting of inflation targets. These reasons have specifically cited as crucial by parties such as the Bank of England, Bank of Norway and the Riksbank in Sweden.
- Ministries of finance essentially select SSM models only and normally have a broader purpose for their models. They want to be able to analyse both monetary and fiscal policy, and often with a greater degree of detail; either as an objective in itself, or as input for public finance calculations.
- Large countries and international organisations such as the ECB, the EU Commission, the Federal Reserve and the IMF have a broad mandate in which many different questions have to be answered. Their strategy has led them to have a number of alternative macromodels used for specific questions, in addition to a core model.
  - The Federal Reserve has selected an SSM model as its core model, but at the same time it has developed and used a number of DSGE models (Chung et al., 2010, Erceg et al., 2006)
  - Both the ECB and the EU Commission opted for a relatively small core DSGE model which then developed into larger DSGE models as specific questions had to be answered (Coenen et al., 2012, Roeger and in't Veld, 2010).
  - The IMF has a number of major macromodels which are used to answer various questions. GPM (Global Projection Model) is a small forecast model which approximates DSGE-like macroeconomic relationships (Carabenciov et al., 2013). Calibrated DSGE models, including GIMF (Anderson et al., 2013) and GEM (Bayoumi, 2004), are used to calculate alternative scenarios and analyse policy-relevant questions.

### **Forecast model or policy model**

Whether a model is used as a forecasting tool or simply for policy analysis has a significant impact on its content and size. Forecast models always have a significant element of estimation, while policy models are calibrated to a greater extent. Furthermore, forecast models are generally smaller than models used for policy analysis. A number of institutions have pointed out that it is more difficult to carry out empirical adaptation and identification of larger models in the DSGE tradition. An increased number of mechanisms also means that forecasts are more difficult to interpret, particularly in

DSGE models, as further forward-looking expectation elements increase their complexity.

In models which are used only for policy analysis – and the ones that are calibrated in particular – attention does not need to be paid to the fact that forecast and estimation interpretation is made more difficult with bigger model sizes. This is why policy models are often bigger and richer in terms of mechanisms than forecast models.

*Example:*

- The ECB's forecast model is a DSGE model which includes none of the developments discussed in connection with Table 2 above (Christoffel et al., 2008). With this core as a basis, they have incorporated and analysed questions concerning financial frictions (Christiano et al., 2010), fiscal policy (Coenen et al., 2012) and restricted rationality (Dieppe et al., 2011).
- The OBR (Office for Budget Responsibility) has a large SSM model which is used as a forecasting tool, as well as input for public finance calculations (Office for Budget Responsibility, 2013). To analyse alternative monetary policy, they have developed a small DSGE model which is used to calculate alternative scenarios (Murray, 2011).
- The IMF has developed and estimated a small forecast model, GPM, the equations of which are inspired by the DSGE literature (Carabenciov et al., 2013). Moreover, a number of large policy models (many countries and mechanisms) have been developed and calibrated, as stated above; including GIMF (Anderson et al., 2013) and GEM (Bayoumi, 2004), which is used to study fiscal questions, among other things.

#### **Trends in preferences among decision-makers**

Ultimately, models are used to constitute a basis for economic policymakers. Sometimes events take place and questions arise which necessarily ought not to involve changes to the content of the model from a model perspective, but which need to do so as a consequence of the preferences of the decision-maker.

*Example:*

- The aftermath of the financial crisis has shone a spotlight on the lack of financial channels in macromodels. As a result of this, both DSGE and SSM models have incorporated such channels over the past few years (such as the Riksbank in Sweden and the EU Commission). Although these channels do not necessarily involve a reasonable improvement to the analysis of monetary policy at central banks, the models have still been supplemented so as to be able to answer the questions of decision-makers (or, rather, to calm their anxiety).
- Another example is the unemployment variable, which is not present in the standard model in the DSGE literature. However, decision-makers demand forecasting and analysis of this variable, which has resulted in attempts to in-

corporate it into DSGE paradigms. These attempts not been particularly fruitful to date. Experiences from the central banks in the United Kingdom, Norway and Sweden, as well as CPB in the Netherlands, have indicated difficulties.

### **Standpoints in respect of the national economy**

The institutional factors above may – rightly or wrongly – be perceived as dominating standpoints in respect of economic considerations. Although there is probably something in this, economic considerations have also had a part to play when institutions have selected model types of model content. This is primarily expressed when institutions have had projects within which the existing choice of model was put to the test.

*Example:*

- In the Netherlands, both CPB and the central bank have had projects aimed at determining whether current SSM models – SAFFIER (Kranendonk and Verbryggen, 2007) and DELFI (De Nederlandsche Bank, 2011) – should be replaced with DSGE models. They opted not to change the model type as the DSGE models were not thought to be capable of providing a sufficiently useful contribution to the economic analysis.
- The Bank of England implemented the same type of project as in the Netherlands and came to the opposite conclusion, i.e. switching the existing SSM model (Harrison et al., 2005) for a DSGE model (Burgess et al., 2013).
- Statistics Norway is working actively to examine whether the Norwegian economy would best be modelled according to the new Keynesian paradigm which governs the DSGE models. According to them, there is data to indicate that this is not the case (see, among others, Boug et al., 2010). This is being used as an argument for keeping their SSM model, MODAG (Boug and Dyvi, 2008).
- In this context, it may also be noted that the Federal Reserve has retained and developed its SSM model, FRBUS (Federal Reserve, 2014), even though they have produced a number of DSGE models (Chung et al., 2010, and Erceg et al., 2006). The same is true of the central bank in Spain, which is continuing to develop and use its SSM model, MTBE (Hurtado et al., 2014), instead of the DSGE models they produced in parallel (Burriel et al., 2009).
- Experienced model developers at the IMF, such as Benjamin Hunt and Douglas Laxton, have in correspondence expressed a great deal of scepticism towards the use of DSGE models as forecasting tools including historical decomposition. On the other hand, they consider well selected applications for policy analysis to be appropriate.

### **Need for exchanges with others**

One general observation is that two central elements in the decision to select DSGE models among central banks are (i) the need for exchanges with others and (ii) credibility. DSGE models are "state-of-the-art" among central banks, and so a DSGE

model provides both an opportunity for exchanges with like-minded parties and a hallmark of quality and credibility. These exchanges involve two-way contact, conferences, software and model code.

### **Resources**

If an institution only has the resources to develop and maintain one model, this may be reflected in its choice of model; compared with the situation when resources are available for a number of models.

*Example:*

- When developing a DSGE model, the Bank of England invested major resources in an infrastructure with other models and significant IT support with a view to supporting the new DSGE approach (Burgess et al., 2013).
- The ECB has a number of DSGE models, one of which is used for forecasting purposes (Christoffel et al., 2008) while others have been developed for policy analysis (see, for example, Coenen et al., 2012). Similarly, the EU Commission has a range of DSGE models which have been produced in order to illustrate various issues (see, for example, Roeger and in't Veld, 2010).
- The IMF is devoting considerable resources to the development and use of macromodels. Besides the ones mentioned above (GPM, GIMF and GEM), attempts are currently being made to develop G20MOD, which will be used for medium-term forecasts in the World Economic Outlook.
- Alongside its primary model, FRBUS, the Federal Reserve has developed a number of DSGE models for policy analysis (Chung et al., 2010, and Erceg et al., 2006).
- Bank of Norway has developed an SSM model which includes financial channels alongside its primary model, NEMO (Brubakk et al., 2006).
- Alongside its DSGE model, the Riksbank has developed an SSM model, MOSES (Bårdsen et al., 2012).

### **History and dependency on individuals**

Model development is an investment, which involves taking the time to develop such models and using these models for a fairly long time. All models have a "history", therefore, which may be one reason for the choice of models currently in existence. The fact that an existing model has existed for a long time may be reason enough to ensure that it is still used – simply because it takes time and resources to develop a new one.

Models also have a history as regards individuals. Model development and usage at institutions are hard work, and not infrequently is the model's "adaptation" to the institutions work dependent on individuals. The person or people who (further) developed the model have a significant part to play in it continuing to exist.

All in all, this may mean that the choice of model is not obvious when these people leave the institution.

*Example:*

- The Federal Reserve has been using the SSM model FRBUS (Brayton and Tinsley, 1996, Federal Reserve, 2014) for many years. Although many central banks have switched to DSGE models, the Federal Reserve is keeping hold of its model. Lately, it has also been introduced in EViews, with free model code on the Internet. It is dependent on people at the same time, and a number of the people who helped to produce the model are still there. How the position of the model will be affected when these senior people disappear is an open question.
- NiGEM is another example, where founder Ray Barrell helped to develop the model from its beginnings in 1987 (Hurst et al., 2014). Now he has left NIESR, a number of staff remain who have worked with the model for a long time. There is an enormous amount of dependency on these people, and they point out that they are having problems recruiting staff who are interested in the model.

## 4 Choice of model for the Ministry of Finance and the National Institute of Economic Research

The previous section described factors which affected the choices of model made at international institutions. Specifying the conditions prevailing at these institutions is central to assessing potential model choices for the Ministry of Finance and the National Institute of Economic Research (NIER). The conditions for the Ministry of Finance and the NIER largely coincide, but there are differences; particularly as regards allocation of resources. To date, the NIER has earmarked considerably greater resources for model usage. Section 5 discusses how this may affect appropriate model selection.

The section begins with a number of criteria which, according to the NIER, are deemed to be important for the Ministry of Finance and the NIER to take into account. The strengths and weaknesses of a number of different models in respect of these criteria will then be analysed.

### 4.1 Model selection criteria

How various criteria should be weighted is not obvious – many trade-offs are required. Despite this, it is necessary to make an attempt at placing the criteria in order of priority as this is significant to the final model selection. Based on the appropriation directions (see section 2), the consultation meetings and other experiences from the Ministry of Finance and the NIER, desirable model properties are described below in the form of criteria. This sequence reflects the opinion of the NIER concerning the relative importance of the criteria. Section 4.2 compares different model types (DSGE, SSM and VAR) and specific models within these, with the criteria below.

#### **Exchanges with others**

Compared with many other institutions (not least central banks and international organisations such as the EU Commission, the IMF and the OECD), the Ministry of Finance and the NIER has very limited resources for model development and model usage. "Basing" its approach on prominent institutions and functioning model strategies, they can keep their own development costs down while also obtaining credibility.

There are further advantages to selecting a model which facilitates exchanges with other model users in the world. What is known as a "community" facilitates the exchange of experiences, opportunities for skills development, participation in conferences, etc. Active exchanges with other model developers probably promote recruitment as well.<sup>9</sup>

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<sup>9</sup> The fact that this criterion (exchanges with others) is given top priority does not, of course, mean that any model type could be selected simply because other institutions have selected it. This prioritisation is conditional upon the model types studied in the report – DSGE, SSM and VAR – being reasonable candidates.

### **Comprehensiveness**

Any model to be used for forecasts and alternative scenarios at the Ministry of Finance and the NIER should have a sufficiently comprehensive "core". This core should include international variables, GDP and its demand side, labour market variables, inflation, wages, interest rates and exchange rates. The work at the NIER in particular but the Ministry of Finance as well also requires the core to be extended by means of an appropriate modelling of monetary and fiscal policy.

### **Theoretical foundations**

The model should be the primary "workhorse" for medium-term scenarios over 1 to 10 years, with emphasis on cyclical analysis 2 to 5 years ahead in time. It is well-known that forecasts further than approximately one year ahead have no real accuracy, which is why the choice of model must be determined on the basis of other criteria to a significant degree. One such factor involves being able to assist with what is known as "storytelling" via the theoretical mechanisms of the model. A model with theoretical foundations permitting explanation of both the history (known as historical decomposition; see section 3.3) and the forecast can perform a function of this type.

Besides the forecast and the history decomposition, a model with theoretical foundations facilitates illustration of economic relationships by means of what are known as alternative scenarios. The latter, i.e. the option of calculating alternative scenarios using the structural model, is emphasised to an extent by the Consultation Group.

### **Empirical foundations**

Estimation of the model is a central ingredient, whether it is to be used for forecasts or merely for alternative scenarios. If the model is to be used for short-term forecasts, forecast evaluation should also be carried out. Even though the empirical root is probably supplemented with a certain degree of calibration, estimation involves greater transparency and hence improved credibility for the model.

### **Time-varying equilibria**

Both the Ministry of Finance and the NIER use time-varying equilibria in their analyses. Examples include unemployment, productivity growth, real exchange rates, relative prices and net export percentages. It ought to be emphasised that most of (or, in many cases, all) these equilibria are not calculated within the current model, KIMOD. They are calculated and/or assessed instead outside the model, the model forecast is then conditional upon this exogenous information. In general, it is simpler to make the forecasts of the SSM models conditional upon these exogenous equilibrium pathways compared with DSGE models. If the latter model type were to be selected, attempts would need to be made with a view to paying the relevant attention to such trends when forecast results are analysed and presented.

### **Flexibility**

Both the Ministry of Finance and the NIER find themselves in an environment in which new questions are always arising, sometimes with relatively short notice. Therefore, it is an advantage if the model type selected can be adapted relatively quickly in order to carry out analyses of areas new to the model.

### **Resource usage**

Besides the six model-based criteria above, it is of course also important in practice to assess which resources will be required for the various model choices. This is applicable for both the development and use of a model. The fact that "Resource requirement" – in terms of both development and usage – is listed last does not mean it is considered less important. Quite the opposite: as discussed for the criterion "Exchanges with others", resources are a restriction which can have a major influence on the choice of model. The model-based criteria and the issue of resources are kept separate in this section with a view to refining the analysis before then being brought together in section 5, where various realistic alternative models are concretised and estimated resource usage is specified for each alternative.

## **4.2 Strengths and weaknesses of various model selections**

As specified in section 3, an institution's choice of model type, model content and model usage is dependent not only on its primary tasks, but also on institution-specific criteria such as decision-makers' preferences, resources, history and standpoints in respect of the national economy. To determine an appropriate model selection for the Ministry of Finance and the National Institute of Economic Research, therefore, it is crucial to identify the most important criteria, as in section 4.1 above.

This section analyses a number of potential model selections for the Ministry of Finance and the National Institute of Economic Research on the basis of criteria listed above. The models analysed are selected from our selection of the ones referred to in section 3 (Tables 2 and 3). This selection is based on an assessment of which models are deemed to provide potential starting points for model development at the Ministry of Finance and the National Institute of Economic Research. Not least the factor "Exchanges with others" has been taken into account in the selection, including with regard to extensive potential use of ideas from existing models and software.

Table 5 summarises how different model types and individual models relate to the factors listed above. Although it is difficult, for natural reasons, to identify precise differences, the designations "A", "B" and "C" are used to simplify the description. "A" indicates that a model meets a criterion relatively well, "C" indicates that a model meets a criterion relatively poorly, and "B" is somewhere between the two.

First, a description is provided of how the three model types in section 3 – SSM, DSGE and VAR – relate to the criteria listed above (excluding resource usage, which is discussed in section 5). The present macromodel KIMOD is then related to the criteria. Finally, a number of specific models within each model type (SSM, DSGE and VAR) are analysed.

**Table 5:** Model types and models in relation to identified criteria

	Exchanges with others	Comprehen- siveness	Theoretical foundations	Empirical foundations	Time-varying equilibria	Flexibility	Resource req. Develop.	Use
<b>Model type</b>								
SSM	C	A	B	B	A	B	B	C
DSGE	A	B	A	B	C	C	C	C
VAR	A	C	C	A	C	A	A	A
<b>SSM</b>								
KIMOD	C	A	B	C	A	C	B	C
FRBUS	B	A	B	B	A	B	C	C
NiGEM	A	A	B	B	B	B	A	B
MOSES	B	B	B	B	B	B	A	B
<b>DSGE</b>								
RAMSES II	A	B	A	B	C	C	B	C
NAWM*	A	A	A	B	C	C	C	C
Quest III	A	A	A	B	C	C	C	C
KOOMA	A	B	A	B	C	C	C	C
<b>VAR</b>								
Gap-BVAR	B	C	C	A	A	A	A	A
SVAR	B	C	B	A	C	B	A	A

\* This refers to NAWN with fiscal channels (Coenen et al., 2012).

## SSM MODELS

As specified in Table 5, the strongest sides of these models ("A") are deemed to be:

- Comprehensiveness
- Time-varying equilibria

There are major options for including many variables and mechanisms in the SSM models. This is due to both their relative shortage of theoretical structure and partial empirical methods. Moreover, it is possible to include both monetary and fiscal variables/reaction functions, even though this is not always done in existing SSM models. At the same time, it should be emphasised that optimum economic policy cannot generally be analysed, partly because utility functions are not normally specified. Finally, there are major opportunities to include time-varying equilibria. These are essentially solely exogenous and based on assessments and/or other models available to the institution in question.

The weaker sides of the SSM models ("C") are deemed to be:

- Exchanges with others

Although there are a number of shared features among SSM models, they are nowhere near as standardised as the DSGE and VAR models. There are also major differences in how SSM models are used in practical forecasting work, which impedes exchanges with others. There are a number of reasons for this. One is the fact that there are major differences in the size and content of the models. Another is that it is unclear how various model users take into account and incorporate time-varying equilibria, which are central to the models' cyclical adaptation.

The SSM models are deemed to fall somewhere in the middle ("B") as regards the following factors:

- Theoretical foundations
- Empirical foundations
- Flexibility

SSM models can be said to be a mixture of neoclassical, new Keynesian and Keynesian theory, the equilibrium relationships being based on neoclassical theory and the cyclical relationships being based on the last two. Although the SSM models are not based explicitly on microeconomic theory, they are still on a theoretical foundation in the sense that the equations adapted often have theoretical foundations. The most important difference compared with the DSGE models, however, is the fact that the SSM models are not derived as a general equilibrium; instead, the theoretical foundations are partial in nature.

The empirical foundations are relatively strong and involve relatively rigorous partial error correction models. Most SSM models have existed for a long time, and the empirical relationships appear in most cases to be changed and re-estimated on a regular basis.

The SSM models are relatively flexible as regards adding new variables and mechanisms. This is a consequence of the fact that the theoretical structure is not always a general equilibrium.

As regards resources available, significant resources generally need to be earmarked for developing, using and maintaining the SSM models. This is due not least to the fact that new equilibria need to be computed and incorporated in the models in an appropriate manner.

### **DSGE MODELS**

DSGE models are deemed to have the following strong sides ("A" in Table 5):

- Exchanges with others
- Theoretical foundations

Unlike SSM and VAR models, the aggregated relationships in DSGE models are based on microeconomic theory. The theoretical structure means that the DSGE models can escape the Lucas criticism (Lucas, 1976). At the same time, it should be emphasised that the microtheoretical basis is at the same time supplemented with more or less ad hoc elements, which have also been criticised (Chari et al., 2009). However, given the existing assumptions, structural interpretations can be made of the shocks (residuals) of the DSGE models. This permits a structural explanation of the model's forecasts, mechanisms and alternative scenarios.

Furthermore, exchanges with others are of significance. DSGE models are used by many central banks and international organisations, and even though the models may differ slightly, the core is the same. There is extensive exchanging of ideas, along with plenty of conferences and standard programs.

The weaker sides of the DSGE models ("C") are deemed to be:

- Time-varying equilibria
- Flexibility

As stated above, DSGE models are linearised around a given steady state. This results in difficulties with incorporating time-varying equilibria for productivity growth, unemployment, real exchange rates and relative prices, for example. There are examples which include exogenous trends, as exemplified below when discussing specific DSGE models.

The DSGE models are inflexible in the short term. As they are general equilibrium models, new ideas, mechanisms and variables cannot be added with ease in the manner possible with SSM and VAR models. Development of the model takes a relatively long time as both new theoretical derivations and empirical adaptations need to be implemented.

The DSGE models are deemed to fall somewhere in the middle ("B") as regards the following factors:

- Empirical foundations
- Comprehensiveness

The DSGE models are assessed using Bayesian methods, where parameter estimates are a combination of educated guesses (known as priors) and data. Moreover, it is common for a (sometimes fairly large) number of parameters to be calibrated or restricted "hard" by allowing major emphasis to be placed on priors.<sup>10</sup> The latter, together with the fact that data is "inflicted on" the theoretical model means that the DSGE model can be said to be more empirically limited than VAR approaches.

DSGE models, relative to SSM models, have few endogenous variables. Moreover, most DSGE models are produced in order to study the effects of monetary policy. This is a central reason as to why no DSGE forecast model studied has fiscal channels which permit a realistic analysis of fiscal questions. However, the latter are available for DSGE models used for policy analysis.

Although standard programs exist for generating forecasts, effectively using a DSGE model in a forecasting environment is generally a relatively time-consuming operation. Analyses of structural shocks, interaction with sector experts and alternative calculations with regard to factors not taken into account by the model are labour-intensive. However, the results can be very useful if such effort is put in.

DSGE models are also resource-intensive as regards development: not least, a number of institutions have emphasised the fact that the empirical adaptation can take a lot of time. At the same time, it should be noted that there is now significant experience among model builders the world over, which means that the quantity of resources for developing a DSGE model is now lower than 5-10 years ago.

#### **VAR MODELS**

VAR models are deemed to have the following strong sides ("A" in Table 5):

- Exchanges with others
- Empirical foundations
- Flexibility

VAR models in the form of UVAR, BVAR and SVAR (see section 3) have a number of strong sides thanks to their simple, empirical structure. These models are used at many institutions – more or less everyone who creates forecasts for central banks has access to a number of VAR models – which involves opportunities for exchanges. Moreover, they are largely controlled by data (however, see footnote 10 with regard to BVAR), which is why there is generally a thorough empirical foundation.

As VAR models have insignificant theoretical foundations, they are flexible in relation to other model types when it comes to adding new variables. However, it should be emphasised that the latter is not without problems, as the model's properties can be affected undesirably.

The weaker sides of the VAR models ("C") are deemed to be:

- Comprehensiveness
- 

<sup>10</sup> Major emphasis is placed on a prior by applying a small variance to the guess, which is the same as giving the guess value high probability. The reality (data) then has less influence as the prior and information from data are weighed together.

- Theoretical foundations
- Time-varying equilibria

VAR models are generally small, normally fewer than ten variables. It is unusual for both monetary and fiscal channels to be included in the same VAR model. Moreover, monetary or fiscal reaction functions cannot be included with contemporary or future explanatory variables due to the autoregressive structure. All in all, therefore, the comprehensiveness for VAR models is relatively weak.

Although a certain theoretical structure can be applied to VAR models via restrictions to the empirical adaptation, the theoretical foundations are still weak. The empirical relationships are made up of a reduced form, even if structural shocks – via restrictions – can be identified. The interpretation of the latter can be verified to an extent by comparing the model's impulse response functions with the same from more structural models.

Structural VAR approaches (SVAR) can be used, via restrictions, to calculate endogenous time-varying equilibria (in a statistical sense) such as potential GDP. Experiences of such estimates indicate that they often differ significantly from institutions' own assessments. Incorporating institutions' own exogenous, time-varying equilibria in VAR models has not been common in the VAR literature. At the end of the section, an outline is provided of a BVAR application which could head in that direction.

Finally, as regards resources, VAR models are simple to use and so use limited resources. Resource usage for development, compared with SSM and DSGE models, is also limited.

#### **CURRENT MACROECONOMIC MODEL KIMOD**

As indicated in the introduction to the report (section 2.1), KIMOD began to be developed in 2002 and is what is known as an SSM model (see Bergvall et al., 2007, and the National Institute of Economic Research, 2013). As KIMOD is the model currently being used by the Ministry of Finance and the National Institute of Economic Research for forecasting and policy analysis, it is described in a little more detail in relation to both other SSM models and the criteria in Table 5.

#### **Relative strengths**

Like other SSM models, KIMOD has a neoclassical core to which the economy is converging by means of a Keynesian demand-determined development in the short term. However, the neoclassical core is more extensive and more stringent than the other SSM models studied in this report. KIMOD comprises a consistent dynamic neoclassical model (referred to below as an "equilibrium model") with a well-defined steady state. The equilibrium model (towards which the business cycle convergence takes place) is characterised by assumptions of flexible prices, rational expectations and complete markets. Actual installation costs for investments and a search model for the labour market are two real rigidities which give the neoclassical model true dynamics. All in all, this permits consistent, time-varying equilibria developments for all real variables, as well as relative prices. This sets KIMOD apart from other SSM models, including the ones used by CPB in the Netherlands (SAFFIER), NIESR in the United Kingdom (NiGEM) and Statistics Norway (MODAG). These models have

no well-defined steady state or consistent equilibrium developments for the production and application side of the economy, or for relative prices.

It can also be noted that KIMOD's various equilibrium pathways can be replaced by assessments, which is an advantage in forecasting work. This means, for example, that the model can be conditional upon the user's/institute's assessment of equilibrium unemployment. The cyclical adjustment will thus take place against the equilibria deemed to exist. The equilibrium model ensures that the assessments are mutually consistent and can be used at the same time to analyse whether separate (partial) assessments are reasonable, given the endogenous equilibrium pathways inherent in these.

As regards cyclical adjustment, KIMOD – like FRBUS (Federal Reserve, USA) and NZTM (Ministry of Finance, New Zealand) – has a mix of backward-looking and forward-looking expectations. Other SSM models studied have only backward-looking expectations.<sup>11</sup> Moreover, KIMOD has both endogenous monetary and financial policy, which is unusual.

Given the above, the strong sides of KIMOD compared with other SSM models are deemed to be "Comprehensiveness" (as it includes both endogenous monetary and financial policy) and, for the reasons specified above, "Theoretical foundations".

#### **Relative weaknesses**

Unfortunately, the relative strengths of KIMOD above can also be said to be its relative weaknesses. Compared with the categorisation of the SSM models in Table 5, KIMOD is allocated a "C" rating instead of "B" in the categories *Empirical foundations* and *Flexibility*.

KIMOD has less of an empirical foundation than SSM models in general (see Table 3). Given the fact that the strategy of partial estimates found in other SSM models should be followed, KIMOD's empirical ground could be improved. However, this is not without its complications as KIMOD, unlike most other SSM models, has a combination of backward-looking and forward-looking formation of expectations. An ambitious alternative would be to estimate KIMOD in a system using Bayesian methods. The National Institute of Economic Research has worked hard on this, but it has proven to be very complicated and no institutions equivalent to the National Institute of Economic Research have done this for SSM models, which is why there are no role models to learn from.

Moreover, there is deemed to be less flexibility – in the sense of how easy it is to add new mechanisms/variables – in KIMOD compared with SSM models in general. This is mainly due to two factors. Firstly, KIMOD's theoretical structure is consistent, primarily via the general equilibrium model which constitutes an attractor for the cyclical analysis. Secondly, the formation of expectations is more advanced in KIMOD's business cycle element, which is a complicating factor.

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<sup>11</sup> NiGEM (NIESR, United Kingdom) can be based on forward-looking expectations in policy analysis. However, only backward-looking expectations are used in forecasts.

Like others, KIMOD is assigned a "C" rating for "Exchanges with others". KIMOD, as described above, also differs from other SSM models in a number of regards, which is why there is even less opportunity for exchanges.

#### **Overall assessment of KIMOD**

There are many elements to KIMOD which mean that it could potentially continue to constitute a useful macromodel for the Ministry of Finance and the National Institute of Economic Research. These include the options for consistent processing of endogenous and exogenous equilibrium pathways, analysing effects of forward-looking expectations and endogenous monetary and financial policy. However, this model approach suffers from two fundamental weaknesses in respect of opportunities for system estimation and exchange with other model developers.

#### **VARIOUS SSM MODELS (BESIDES KIMOD)**

SSM models as a group were analysed above on the basis of the criteria deemed important for the Ministry of Finance and the National Institute of Economic Research. As stated, the different SSM models vary widely. This section describes a selection of these deemed to be of potential interest to the Ministry of Finance and the National Institute of Economic Research.

#### **FRBUS**

FRBUS is the American central bank's main model for forecasts and policy analyses (Brayton and Tinsley, 1996, and Federal Reserve, 2014). Although FRBUS is deemed to have approximately the same weaknesses and strengths as the SSM models on average (see Table 5), there are a number of factors which ought to be highlighted.

A number of the model's mechanisms are specified relatively rigorously. These real rigidities in consumption, investment and production factors are derived, for example, from a general form of adaptation costs, the structure of which is based on published works (Tinsley, 2002). Formation of expectations is flexible and can be based on backward-looking, VAR-based expectations or model-consistent expectations. A new Keynesian Phillips curve is based on Cogley and Sbordone (2008).

Moreover, the model has recently been made available in its entirety on the Federal Reserve website together with the EViews code. The latter both resolves and estimates the forward-looking model. This means that the factor "Exchanges with others" is ranked more highly ("B") than for SSM models in general ("C"), see Table 5. It can also be stated that the Bank of Canada has a smaller version of FRBUS, known as MUSE (Gosselin and Lalonde, 2005), which provides an opportunity for exchange.

In relation to KIMOD, it can be stated that the theoretical structure is similar, while the FRBUS empirical structure is clearly more rigorous. Finally, FRBUS is clearly bigger and includes more variables and mechanisms, although these would not necessarily all need to be transferred to a Swedish version of the model.

#### **MOSES**

MOSES (MOdel for Studying the Economy of Sweden; Bårdsen et al., 2012) is a model developed by the Riksbank which it uses in the forecasting environment to a

certain extent. It originates from a model developed in Norway (Bårdsen and Nymoen, 2001, 2009). There is also a similar model in use at Bank of Norway. This is not used as a forecasting tool, however, but as an aid at the financial stability department. It can also be noted that the Norwegian original (NAM, Bårdsen and Nymoen, 2001, 2009) is used regularly by Gunnar Bårdsen to carry out forecasts for the Norwegian economy.<sup>12</sup>

As this model type is used both in Norway and at the Riksbank, the opportunities for direct exchange are greater than is common among SSM models. The model is therefore deemed to be slightly stronger in respect of the criterion "Exchanges with others" (see Table 5).

Like many SSM models, it is made up of partial econometric relationships estimated in two steps. EViews is used as software. Moreover, it can be stated that the model is estimated in *Autometrics*, which is straightforward as this – as the name of the program suggests – takes place automatically to a significant extent.

MOSES is deemed to be slightly weaker in the following areas:

- Comprehensiveness
- Time-varying equilibria

However, it is clearly smaller (approximately 20 endogenous variables). Further, fiscal analysis in the present model is limited to public consumption, and as private consumption is not included in the model there are no central fiscal channels. However, there should be no major difficulties with extending the model to add more fiscal variables and channels.

One important difference compared with other SSM models is that equilibria such as potential GDP and equilibrium unemployment are calculated endogenously in the model. At the same time, there are opportunities to adjust the model so that it is more in line with the judgements of equilibria at the institution in question.

Resource usage in forecasts is deemed to be less extensive than in SSM models on average. This is partly due to the fact that the model is a lot smaller (approximately 20 endogenous variables) and partly because EViews is used as software. Moreover, as stated above, the model is estimated in *Autometrics*.

Resource usage for the development of the model is naturally much smaller than for the (further) development of KIMOD or a Swedish version of FRBUS.

## **NiGEM**

NiGEM (National Institute Global Economic Model; Hurst et al., 2014) is the model developed by NIESR in the United Kingdom, starting in 1987. Among the SSM models, it is similar to KIMOD in several respects (see Table 3); the monetary and finan-

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<sup>12</sup> The forecasts are updated on the Gunnar Bårdsen's website: <http://www.svt.ntnu.no/iso/gunnar.bardsen/>.

cial policy are endogenous, expectations can be forward-looking<sup>13</sup>, and an error correction structure returns the economy to (time-varying) equilibria.

NiGEM essentially consists of all OECD countries (including Sweden), as well as many non-OECD countries. As is customary in the SSM tradition, the equations have been estimated using methods for partial error correction models.

Compared with SSM models in general, NiGEM is deemed to be much stronger in respect of "Exchanges with others". NiGEM is used by a large number of institutions the world over, and there are great opportunities for interaction with these and NIESR.

NiGEM is deemed to be weaker than SSM models in general in the following areas:

- Time-varying equilibria
- Flexibility

As regards the former, it is unclear at the time of writing whether it would be possible to incorporate own time-varying equilibria in NiGEM, and if so how. This needs to be examined further if so required. Otherwise, NiGEM is less flexible than SSM models in general. NIESR stands for model development, and it will probably be difficult to influence this more than marginally.

As the model is ready to use, the resource usage for development is small compared with the average among SSM models. The resource usage for forecasts is also relatively small as standardised programs are supplied with a subscription to the model.

## **VARIOUS DSGE MODELS**

As stated in Table 5, there are essentially no differences in how the DSGE models meet various criteria. This is because the DSGE models – unlike the SSM models – have a homogeneous core and hence the same advantages and disadvantages to a greater extent. At the same time, there are of course certain differences. Aspects of a number of DSGE models deemed to be of particular interest to the Ministry of Finance and the National Institute of Economic Research if a DSGE approach were to be selected are discussed below.

### **RAMSES I and II**

The Riksbank has been developing and using a DSGE model, RAMSES, for forecasting and policy analysis for many years. The first version of the model, besides parts relevant to Sweden which follow on from a small, open economy, consists of the core which many DSGE models have, i.e. nominal and real rigidities, incomplete competition and rational expectations (Adolfsson et al., 2008). The new version of the model, RAMSES II, has been extended to include financial frictions and search labour market (Adolfsson et al., 2013). It can be noted that neither RAMSES nor RAMSES II has any developed modelling of financial policy, nor do they have fiscal channels which permit a realistic fiscal transmission mechanism.

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<sup>13</sup> Only in policy analysis, however, not in the case of forecasts.

In Table 5, RAMSES is essentially given the same rating as DSGE models in general. However, it should be noted that "Exchanges with others" would probably become even more frequent and effective if a RAMSES-like structure were to be selected.

However, it should be emphasised that using the same version of RAMSES as the Riksbank is probably not an appropriate alternative. This is mainly due to the fact that RAMSES has no realistic channels for the fiscal transmission mechanism. Moreover, a choice of this kind would mean that the Riksbank, the Ministry of Finance and the National Institute of Economic Research would be using the same model for analysis of economic policy. This could inhibit diversified discussion within Sweden on the driving forces behind the economy and appropriate economic policy.

#### **New Area Wide Model with financial policy (NAWM, ECB)**

The ECB uses a DSGE model for forecasting and policy analysis (New Area Wide Model, NAWM) which was developed in 2008 (Christoffel et al., 2008). This is similar to the first version of RAMSES, as mentioned above, as regards the lack of realistic fiscal modelling and macroeconomic channels for fiscal effects.

However, the ECB has developed and estimated NAWM and other fiscal variables and channels (Coenen et al., 2012). The fiscal variables include consumption, investments, transfers, distorting consumption and payroll taxes and lump sum taxes. All fiscal variables are modelled as reaction functions, their development being dependent on lagged values, debt level and GDP. This is the model referred to in Table 5. The only difference in rating compared with DSGE models on average is an "A" in the "Comprehensiveness" column. The reason for this is that financial policy is included in a more explicit manner.

Furthermore, three macroeconomic channels are modelled via which the fiscal instruments can take effect. The significance of these channels is determined, like other mechanisms in the model, by the Bayesian estimation. First of all, households are divided up into "Ricardians" and "Rule of thumb", the latter consuming only their disposable income (Galí et al., 2007). Secondly, public consumption is included in individuals' utility function, which means that it can provide a complement to private consumption (Leeper et al., 2009). Thirdly, public capital stock is included in the production function for the private sector, which means that public investments can influence private production and productivity.

#### **QUEST III (European Commission)**

The EU Commission frequently uses DSGE models for policy-related analysis. Their primary model, QUEST III (Ratto et al., 2008), includes fiscal channels (credit-limited households) and can be used to analyse both temporary and permanent fiscal measures. The EU Commission is working extensively on the development of DSGE models for various issues. Housing investments (Roeger and in't Veld, 2010) and the banking sector (Kollman et al., 2013), among others, have been included.

However, the EU Commission does not use its DSGE models for forecasting. That said, its modelling of fiscal policy is more detailed than DSGE models on average, which explains the "A" rating for "Comprehensiveness" in Table 5.

### **KOOMA (Finland's Ministry of Finance)**

As mentioned in section 3, the Ministry of Finance in Finland is the only ministry of finance which has produced a DSGE model with the purpose to using it for both forecasting and policy analysis. This is the most important reason as to why the model is being mentioned here. The option of exchanging ideas in respect of both model content and model usage at the respective ministries of finance will probably be beneficial. To date, however, KOOMA has only been used externally for policy analysis and the model has not yet been estimated or documented.

Besides a standard DSGE core for a country with a fixed exchange rate, KOOMA consists of a labour market modelled on the basis of modern search and matching theory (Pissarides, 2000). This provides financial policy with another channel for influencing the macroeconomy via companies' tendency to issue more vacancies when demand increases. However, it should be emphasised that a number of the problems encountered by other model developers when implementing search and matching theory have not been encountered yet as the model has not been estimated.

### **VARIOUS VAR MODELS**

As described above, VAR models generally differ widely from both SSM and DSGE models. They are often smaller, have a relatively weak theoretical foundation but at the same time a strong empirical ground, and are flexible and resource-efficient in terms of both development and usage.

This model type will probably not be able to bear full responsibility alone for both forecasting and policy analysis. The central issue is whether this model type can be used as a complement to other model approaches at the Ministry of Finance and the National Institute of Economic Research, and if so how. Examples of potentially fruitful combinations of model types (known as "suite of models") are discussed in section 5. Two types of VAR models which could be included in a future suite of models are described below.

### **Gap-based Bayesian VAR (Gap-BVAR)**

As specified in section 3, BVAR models are used extensively in forecasting environments, not least at central banks. The emphasis is often on short-term forecasts (up to approximately one year). GDP and hours worked are specified in growth rates, and these normally return relatively quickly to the historically normal growth rate. The development of the method proposed by Villani (2009) means that the forecast from a BVAR, via a prior distribution, can be "steered" towards a value other than the historical average of the series, which is useful in a forecasting environment.

In forecasting environment such as the ones at the Ministry of Finance and the National Institute of Economic Research, the emphasis is on rectifying various imbalances (or "gaps") during the forecast period. This gap is often closed by assumption when the forecasting ability from short-term models/indicators comes to an end, normally after just over a year. As GDP and hours worked in BVAR models are often ex-

pressed in growth rates, there is no inherent gap closure.<sup>14</sup> This is why the usefulness is limited in terms of periods extending over more than approximately one year.

One idea which has emerged while work has been in progress involves expressing a BVAR model with several variables expressed in gap form instead of in growth rates (e.g. by including foreign and domestic GDP gaps and unemployment gaps). International variables should also be included together with financial and monetary policy with the aim to achieving a consistent model for a primary scenario for – say – two to five years ahead. Together with the method devised by Villanis (2009) to steer the asymptotic value of forecasts using prior distributions, this method could be helpful for medium-term analysis. The following are examples of variables which would be interesting to include:

- A number of international variables (GDP gap, interest rate, inflation)
- Fiscal variables (cyclically adjusted saving, public consumption growth)
- One or more Swedish gap variables (BNP gap, unemployment gap)
- Monetary policy (repo rate)
- Inflation
- Exchange rate

History for the gap variables can be taken from the user's assessment. The model's forecast will then show how quickly the economy has closed gaps on average, given the institutions' definition. Moreover, the domestic forecast can be conditional upon simultaneously projected developments in the world and of economic policy. The latter can also be used to calculate alternative scenarios in which uncertainty can be illustrated using confidence bands thanks to the BVAR estimation technique.

In relation to VAR models in general, gap-based BVAR could potentially contribute to cyclical analysis. This is because the central gap analysis for the Ministry of Finance and the National Institute of Economic Research may be included in the medium-term forecast from BVAR. Moreover, gap-BVAR has the potential to take into account time-varying equilibria more effectively than VAR models in general. The model's forecast of included gaps (e.g. GDP gap) can be converted into a GDP forecast together with an exogenously assessed development of potential growth. Various users' assessments of the development of potential variables will thus be included.

Compared with standard BVAR approaches, exchanges with others will probably be less extensive, at least initially, as applications similar to the one outlined above do not appear to have been used for this purpose previously.

### **Structural VAR (SVAR)**

As described in section 3, VAR models in standard form have no economic interpretation of the residuals for (or shocks to) the system. What are known as structural VAR models (SVAR) will remedy this and can be used for historical decomposition of both history and forecasts (see section 3.3). In other words, the structural form per-

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<sup>14</sup> BVAR models may include the unemployment variable, which can be said to include gap-related information; partly because it is stationary, and partly because its projected asymptotic value can be controlled via a prior distribution.

mits the same type of decomposition as can be carried out by DSGE models. Moreover, SVAR models can be used to calculate alternative scenarios.

Thanks to their better opportunity for structural interpretation, SVAR models have stronger theoretical foundations than VAR models in general (see Table 5). At the same time, they are less flexible as more/other variables require new assumptions and reasonable impulse response functions. Exchanges with others are also less extensive compared with standard (B)VAR.

## 5 Potential model selections and estimated resource usage

This section compiles three proposals for potential model approaches for the Ministry of Finance and the National Institute of Economic Research. These are based on the criteria listed in section 4.1 and the analysis in section 4.2 in respect of how different model types and specific models meet these criteria.

The three proposals are discussed in the order deemed most appropriate by the National Institute of Economic Research, i.e. with the best model selection first. An assessment of the resource usage involved in the model selection is also provided with each model selection.

### 5.1 DSGE model for forecasting and policy analysis, plus VAR models

In this alternative, a DSGE approach for forecasting and policy analysis constitutes the core model. It is proposed that a number of VAR models will be developed to support this model. Below is an outline of such a solution, including arguments as to why this would be an appropriate approach for the National Institute of Economic Research and the Ministry of Finance.

#### **DSGE model**

The core of the DSGE model could be made up of the core characterising traditional DSGE models, for example:

- The Riksbank's first model version of RAMSES (Adolfson et al., 2008)
- The Bank of England's COMPASS (Burgess et al., 2013)
- The ECB's NAWM (Christoffel et al., 2008)

However, it is deemed necessary to extend the core to include fiscal variables and fiscal channels. For the latter, the following two specific masters – among others – are available from which to take ideas:

- The ECB (Coenen et al., 2012)
- The EU Commission (Ratto et al., 2008)

Whether the core should also include financial frictions and/or a banking sector, e.g. in line with RAMSES II (Adolfson et al., 2013), is an open question.

This alternative aims to use a DSGE model for both forecasting and policy analysis. In the long run, however, it may be possible to develop the core model to various policy models, subject to demand and resources. This may, for example, take place by including financial frictions and/or a search-theoretical labour market in one policy model, an alternative formation of expectations in another, etc. These future editions need not (and should probably not) be included in the forecast model. As discussed in section 3, a number of institutions have stated that the disadvantages often outweigh the advantages as regards model size in forecasting work.

## REASONS TO SELECT DSGE AS THE PRIMARY ALTERNATIVE

It should be emphasised that this alternative means that the Ministry of Finance and the National Institute of Economic Research will deviate from the pattern in respect of model selection as described in section 3. None of the ministries of finance or institutions (excluding central banks) examined while working on this report are using a DSGE model as a forecasting tool. There may be several reasons for this, as discussed in section 3.4. Although "non-economic" factors such as history and dependency on individuals may have been of significance, the impression given by Ireland (ESRI), the Netherlands (CPB), Norway (Statistics Norway) and the USA (Federal Reserve) is that standpoints in respect of the national economy have played an important part. This needs to be taken seriously when determining the model selection for the Ministry of Finance and the National Institute of Economic Research.

The fact that a DSGE approach is being suggested for both forecasting and policy analysis despite a lack of predecessors at similar institutions is due mainly to the following factors (see also the text on KIMOD in section 4.2):

- The criterion "Exchanges with others" came out on top in section 4, which strongly supports a DSGE approach. As SSM models do not have a shared core, it is more difficult to achieve a diversified exchange with others. Instead, the exchange is specific to a certain model and a certain institution, such as the Federal Reserve (FRBUS) or the Riksbank (MOSES). This exchange may also disappear if the institution in question decides not to continue using its model (which is not unlikely). An SSM approach is also thought to involve difficulties when it comes to recruiting new PhD holders who specialise in macroeconomics and/or econometrics.
- Forecasting activities at the Ministry of Finance and the National Institute of Economic Research are not dependent on a large model with a high degree of detail. Moreover, the forecast model selected does not need to provide direct input for public financial calculations, which is the case at several institutions surveyed. Therefore, it is thought that the existing forecasting organisation can be adapted with no major problems to the smaller number of variables included in a DSGE model compared with the present KIMOD model, for example.
- The term "model maturity" is related to the above point. This refers to how accustomed various institutes and their management teams are to models, their areas of application and restrictions. With a high degree of model maturity, model usage may differ depending on the current situation, for example; and the precise model forecast is not always the factor of most interest or significance to the analysis. Model maturity is deemed to exist at the National Institute of Economic Research and, to a degree, at the Ministry of Finance, which will facilitate the introduction of a DSGE approach.
- The choice made by the National Institute of Economic Research will also be based on the assessment that the DSGE models will continue to be developed in future in a manner which is beneficial, according to the National Institute of Economic Research. This is particularly true of the progress made over the last few years with alternatives to rational expectations (Milani, 2012)

and financial policy (Coenen et al., 2012). It is hoped that it will be possible to include these and other realistic elements in the future.

- Finally, the present KIMOD model is deemed not to meet the requirements and requests of the Ministry of Finance and the National Institute of Economic Research. This is due to the difficulties with estimating the model as a system, and to the lack of opportunities to maintain exchanges with other model users. Moreover, analysing the consequences of KIMOD's many equilibria (including relative prices, see section 4.2) is a laborious and relatively complex task.

### **VAR models as support**

This alternative also includes VAR models, the intention being to use these as support for forecasting and policy analysis alongside the DSGE model. There are several reasons for this. One is the difference in resources allocated to model-based forecasting work to date at the Ministry of Finance and the National Institute of Economic Research. As discussed in section 3, DSGE models are relatively time-consuming to use effectively in a forecasting environment. If there is deemed to be insufficient time to fully utilise a DSGE model, VAR-based model support may be an alternative tool to fall back on. In this case, the DSGE model would be used as a policy tool for the institution in question. Another reason to include VAR models as well is that several institutions have indicated that forecasts and forecasting work with DSGE models does not always mean that a significant contribution is made to the actual forecast. When the model's interpretations of shocks and forecasting properties are not deemed sufficient, a supplementary model may be useful.

Several of the following three VAR model variants may be appropriate to develop as support to the DSGE-based analysis.

*Bayesian VAR (BVAR)*: One or more BVAR models can be used as alternatives to/support for DSGE-based short-term forecasts. BVAR models are used extensively for short-term forecasts in the main, but they are also used for policy analysis at international institutions (see section 3.1). The National Institute of Economic Research has developed three BVAR models over the past few years (Beechey and Österholm, 2010, Stockhammar and Österholm, 2014a, b).

*Structural VAR (SVAR)*: One or more SVAR models can be used as alternatives to/support for the DSGE model's structural interpretation of data (known as historical decomposition, see section 3.3). An SVAR model can also be used for policy analysis.<sup>15</sup>

*Gap-BVAR*: A gap-based BVAR model can be used as an alternative to/support for the DSGE model's medium-term forecasts (2-5 years, say). As described in section 4.2, there appear to be no masters on an international level, but the principle is the same as for the development of "ordinary" BVAR models.

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<sup>15</sup> However, the forecasting ability is normally weak due to the large number of parameters; a BVAR is better for this purpose.

### **Advantages**

The following criteria are met in this alternative, with a DSGE model as the primary model and VAR models for support:

- Exchanges with others
- Theoretical foundations
- Empirical foundations
- Comprehensiveness
- Flexibility

"Flexibility" here refers to the potential use of information from both the DSGE model and the supplementary VAR models, it is also possible to adapt the latter relatively quickly to new requirements.

### **Disadvantages**

DSGE models have more difficulties with the following criteria:

- Time-varying equilibria

However, it is thought that the proposed Gap-VAR approach will be able to eliminate this disadvantage to an extent.

### **Resource usage**

Developing, estimating and introducing a DSGE model for forecasting and policy analysis for Sweden is a resource-intensive task. However, it should require fewer resources than when such DSGE projects (like RAMSES) were initiated and implemented in the mid-2000s. As stated above, masters exist in the shape of both models and software. With the help of input from organisations such as the Riksbank, the National Institute of Economic Research estimates that 5 man-years will be required, divided over a period of 2 years, to develop an appropriate DSGE model for policy analysis (i.e. not estimation and forecasting). An estimated DSGE model, including adaptation to an existing forecasting environment, is thought to require a further 4 man-years, divided over a further 2 years. All in all, this alternative is estimated to require 9 man-years, with potential completion in 4 years. These assessments are of course subject to significant uncertainty due to the nature of the work.

It is thought that developing appropriate BVAR, SVAR and Gap-BVAR models will take up relatively limited resources. As stated above, a number of BVAR models have already been developed at the National Institute of Economic Research. It is thought that it will take approximately 0.5 man-years in each case to develop appropriate SVAR and Gap-BVAR models.

## **5.2 DSGE model for policy analysis, plus VAR models**

In this alternative, a DSGE model will be developed for policy analysis only, not for forecasts. This then raises the question of which type of model should constitute the primary forecasting tool – SSM or VAR. The alternative above proposed three types of VAR models to support forecasting work: BVAR, SVAR and Gap-BVAR. As re-

guards SSM models, three potential candidates – besides the present KIMOD model – have been identified. For all these candidates there exists an opportunity to take advantage of previous work by others and a certain degree of exchange: FRBUS, NiGEM and MOSES (see the previous section).

The view of the National Institute of Economic Research is that the policy-based DSGE model should be supplemented with the types of VAR model discussed in section 5.1 above, i.e. not an SSM model. However, this is not an obvious choice. According to the National Institute of Economic Research, the advantage of the VAR models is that they are both less resource-intensive and individual-specific compared with the SSM alternatives. This is particularly important in this alternative as a DSGE model is to be developed, used and maintained, which will require significant resources.

#### **Advantages**

The following criteria in particular in the (selected VAR-based) forecasting environment will be met with this alternative:

- Empirical foundations
- Exchanges with others
- Flexibility

The DSGE approach will provide significant theoretical foundations in the policy environment.

#### **Disadvantages**

In the forecasting environment, the VAR-based model approaches will present difficulties with the following criteria:

- Theoretical foundations
- Comprehensiveness
- Time-varying equilibria (but with a certain contribution from Gap-BVAR)

#### **Resource usage**

As stated in section 5.1, an appropriate DSGE-based policy model is thought to require 5 man-years, divided over a period of 2 years. The VAR models (SVAR and-BVAR) are thought to require 0.5 man-years each.

### **5.3 SSM and VAR models for forecasting and policy analysis**

In this alternative, no DSGE model will be developed for either forecasting or policy analysis. There may be a number of reasons for this, including the fact that – as stated – both developing and using a DSGE model is relatively resource-intensive, particularly in a forecasting environment. Other methods will have to be selected if it is not possible to procure these resources.

In this alternative, the resources allocated will be assigned to developing and using SSM and VAR models for forecasting and policy analysis. The VAR models are the same as those specified above (BVAR, SVAR and Gap-BVAR). As regards the choice of SSM model, it is important to achieve exchanges with other model users. As discussed in section 4.2, this is not a simple task as the SSM models are relatively institution-specific. FRBUS, NiGEM and MOSES are the SSM models deemed to be the most likely to be used as a "basis" and have an active exchange with model users. Moreover, the current KIMOD model is an alternative even though the opportunity for exchanges with others is limited (see section 4.2).

*FRBUS* is a large model with a relatively high degree of detail (see section 4.2). As discussed above, the Ministry of Finance and the National Institute of Economic Research do not need this *per se*. That said, the model approach represented by *FRBUS*, including its interfaces and solution algorithms in EViews, may present an opportunity to transfer a smaller version for Swedish conditions. Despite this, a "Swedish" *FRBUS*, compared with both *NiGEM* and *MOSES*, would be resource-intensive in terms of both development and usage.

*NiGEM* is a lot less resource-intensive than *FRBUS* as a forecasting and policy model for Sweden has already been estimated and completed in the model (including the same for more or less all OECD countries and a large number of non-OECD countries). There are extensive opportunities for exchange as there are many users of *NiGEM* the world over, including extensive usage at the NIESR. One major restriction with *NiGEM* is that NIESR owns the model code, and the chances of influencing this are small.

*MOSES* is estimated for Swedish conditions and is available in EViews. This means that relatively small resources will be required to operationalise usage at the Ministry of Finance and the National Institute of Economic Research. That said, as discussed in section 4.2, *MOSES* is a relatively resource-intensive SSM model in the forecasting environment.

The advantages and disadvantages of *KIMOD* were described in section 4.2. Its primary advantages are its consistent theoretical structure, flexible formation of expectations and endogenous monetary and financial policy. The biggest disadvantages are the limited options for exchanges with others and the difficulty with estimating the model as a system.

Of these four alternatives, developing a "Swedish *FRBUS*" is by far the most resource-intensive, followed by *KIMOD* and *MOSES*. *NiGEM* is the least resource-intensive.

In the opinion of the National Institute of Economic Research, *MOSES* would be the best choice when selecting from the SSM models referred to above. It has already been developed for Swedish conditions, it is relatively flexible and there is a "community", albeit a small one.

#### **Advantages**

The following criteria in particular will be met with this alternative:

- Empirical foundations

- Time-varying equilibria
- Flexibility
- (Some) exchanges with others

**Disadvantages**

This alternative has more difficulties with the following criteria:

- Theoretical foundations (but with a certain contribution from SVAR)
- Time-varying equilibria (but with a certain contribution from Gap-BVAR)

**Resource usage**

It is thought that adapting MOSES to suit the forecasting and policy environments of the Ministry of Finance and the National Institute of Economic Research will require 0.5-1 man-year.

It is thought that it will take approximately 0.5 man-years in each case to develop appropriate SVAR and Gap-BVAR models.

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