Institution: University of Leicester

Unit of Assessment: Economics

Title of case study: More accurate economic forecasting for management of the world economy

1. Summary of the impact

The European Central Bank (ECB) uses forecasting tools to make predictions about the Eurozone economy as a whole. The University of Leicester has worked with the ECB to modify its main forecasting tool to improve its ability to take effective and timely action to keep inflation low and minimise deflation.

Similarly, the United Nations prepares a submission to each G8 Summit which includes forecasting and policy analysis based on the economies of the 193 member states. The forecasting tool used to create this submission has also been created in collaboration with the University of Leicester. These modelling tools help the world's most powerful leaders – both political and financial - to make informed and timely decisions about issues affecting economic stability, global food security and international safety.

2. Underpinning research

Large econometric models have been used by organisations such as the European Central Bank (ECB), IMF and World Bank to make predictions about the economy since the 1970s. These statistical frameworks can be used to analyse a scenario with multiple contributing factors, including those which contain an element of uncertainty. These econometric models can be used to analyse the potential effects of governmental actions and are therefore useful forecasting tools for policymakers, enabling them to "test out" the impact of decisions before they are made.

Stephen Hall, professor of economics at the University of Leicester, is an expert in the theory and design which underpins such models. Early econometric models were flawed in that they ignored both expectation effects and the supply side of the economy. This created serious difficulties in effectively and accurately modelling national and international economic trends. Throughout the 1980s and 1990s, academic economists played an important role finding solutions to these difficulties and Professor Hall was a key contributor to this work.

Since joining the University of Leicester in 2005, Professor Hall has continued his research in this area, working in collaboration with global organisations such as the ECB and United Nations (UN) to refine his economic theories and apply them in real-world settings. This has resulted in novel research and impact of worldwide reach and significance.

Incorporating supply side economics into an econometric model for the UN

Work in collaboration with the UN between 2007 and 2012 addressed the difficulties associated with incorporating the supply side of the economy into an econometric model. Supply side economics is concerned with the supply of goods and services within an economy. Early econometric models concentrated on the demand side of the economy. This made it impossible to analyse supply-side policies, such as the lowering of income tax and capital gains tax rates, or the reduction of regulation, making it difficult to fully understand the longer-run development of economies which is generally understood to be dominated by supply-side effects.

The solution was offered by econometrically estimating a set of equations which acted as the core of a large econometric model. These equations were based around a production function and were estimated in a consistent way with full cross equation restrictions using co-integration (see [Ref 3], [Ref 4] and [Ref 5]; the co-author of [Ref 3] is a former student of Hall's who is now based at the International Monetary Fund, the co-author of [Ref 4] is a long-time collaborator of Hall who is now retired, the co-authors of [Ref 5] are the same long-time collaborator and two former research

assistants one of whom is now at Brunel and the other at the Monetary Authority of Hong Kong).

Professor Hall's contribution to the research project with the UN was to adapt this approach to the setting of a large multi-country model. The project with the United Nations has involved the creation of a complete world model with more than 180 countries represented. Although data limitations for some countries has meant that not every country can have a fully articulated supply side, all the major developed countries were treated in this way, as well as many of the others.

Incorporating learning into an econometric model for the ECB

Early econometric models were flawed in that they largely ignored expectation effects, i.e. how previously formed expectations can alter emotional responses to an event itself. Work in the 1980s recognised that incorporating human expectations into the model was crucial when studying how a large number of individuals, firms or organisations make choices under uncertainty.

However, more recently, problems associated with the extreme assumptions required for rational expectations have become apparent. By basing their analysis on a model which used rational expectation, it was essentially impossible to analyse the possible costs of a policy which is strongly affected by the expectations of economic agents (i.e. those people whose actions affect the economy, typically producers or consumers) and where agents get their expectations wrong.

Research at Leicester conducted by Professor Hall between 2008 and 2010 in collaboration with researchers at the European Central Bank has explored the use of learning as a means to overcome these problems. Professors Hall's special contribution to this joint work was to propose the use of learning and to explain how it could be implemented in a practical way. The introduction of learning has important implications for a model's ability to analyse historical events. It also substantially improves the forecasting ability (see [Ref 1], [Ref 2] and [Ref 6]; the co-authors of [Ref 1] and [Ref 2] are all based at the ECB, the co-authors of [Ref 6] are a former long-time collaborator of Hall's who is now retired, a PhD student of Hall's who has left the academic world, and a collaborator who is now at the Barcelona Graduate school of Economics).

The concept of learning in economics has a long history dating back to the 1970s but this has almost always been conducted in the context of small, largely abstract models. The introduction of these ideas in a large model setting and their practical implementation represents an innovation. The translation of the theory from small to large models was done by setting up small auxiliary expectations equations. These equations would have time-varying parameters and the parameters were updated in a model-consistent way using a Kalman filter.

This gives the model the ability to learn over time about any change in policy or exogenous event. It has been demonstrated that this procedure converges on a rational expectations solution asymptotically but that the impact effect of a change allows agents to make mistakes as the learning procedure takes place. This gives the model much more reasonable forecasting properties (as rational expectations jumps do not occur in the initial period of the forecast). It also gives the model more reasonable policy properties as many policy questions rest on the ability to analyse the mistakes which agents make in forming their expectations.

A method for incorporating the Kalman filter into the actual econometric model was developed as part of this research, as well as the software implementing the method.

3. References to the research

1. The ECB'S New Multi-Country Model for the Euro Area NMCM – With Boundedly Rational Learning Expectations by Alistair Dieppe , Alberto González Pandiella, Stephen Hall and Alpo Willman, *ECB working paper* No1316 2011.

2. Limited information minimal state variable learning in a medium-scale multi-country model, S. Hall and A. Dieppe, A. Gonzalez Pandiella, and A. Willman, *Economic Modelling* 33

(2013) 808-825 http://dx.doi.org/10.1016/j.econmod.2013.05.003

3. Financial Crises, Effective Policy Rules and Bounded Rationality in a new Keynesian Framework, S. Hall and Ali J. Al-Eyd, *Economic Change and Restructuring*, DOI 10.1007/s10644-011-9108-x, 2011

4. The Timing of Currency Crises: The Case of the ERM, S. Hall and B. Henry, *Qualitative and Quantitative Analysis in Social Sciences*, vol 3, 1, 21-36 2009

5. Fiscal Consolidation: An Exercise in the Methodology of Coordination. S. Hall and S.G.B. Henry, M. Chui and G. Caporale, *Journal of Economic Integration*, 20, 1 1-25, 2005 awarded the Dae-Yang prize for the best paper of 2005

6. Expectations and the 1990 ERM crises, S. Hall and M. Beeby, S.G.B. Henry and A. Marcet *Estudios Economia Applicada* 2005

4. Details of the impact

Incorporating supply side economics into an econometric model for the UN

The United Nations is one of the three main organisations which help organise the world economy (along with its sister institutions of the World Bank and the International Monetary Fund). Its special brief is to enable global cooperation in areas such as international law, international security and economic development, as well as world peace. It uses an econometric model to make effective predictions based on the global economy.

In the late 1960s, Nobel Laureate Laurence Klein set up a world modelling project called Project LINK, designed to integrate independently developed national econometric models into a global econometric model. By the mid 1980s, this project had expanded considerably and was taken over by the United Nations' economic analysis department as its main forecasting and policy tool.

By 2005, the original LINK model had grown to such an extent that it had become unwieldy and was no longer fit for purpose. So, in 2007, the UN launched a project to build a new world model, called the Global Policy Model, and invited Professor Stephen Hall from the University of Leicester to act as a consultant to this project ([Source 1], [Source 2]).

The UN is currently using this new model in their twice yearly forecasting and policy analysis which forms the basis of the UN's submission for the G8 policy round each year. This is published regularly by the UN in its document, *World Economic Situation and Prospects*. This document forms the main part of the UN's briefing and submission to the G8 intergovernmental negotiations, it also is an important input into the UN's own deliberations and policy decisions ([Source 3]). Representatives from the G8 countries use the UN's submission to help them make informed decisions affecting global issues.

The Group of Eight (G8) is a forum for the governments of the world's eight wealthiest countries - France, Germany, Italy, Japan, the United Kingdom, the United States, Canada and Russia. Collectively, the G8 nations comprise 51.0% of 2011 global nominal gross domestic product.

A major focus of the G8 since 2009 has been the global supply of food. At the 2009 summit, for example, the G8's members promised to contribute $20 billion to the issue over three years. Other global issues addressed at the annual summit include health, law enforcement, labour, economic and social development, energy, environment, foreign affairs, justice, terrorism, and trade.

Incorporating learning into an econometric model for the ECB

Macroeconomic models have very real and practical benefits for large banks, in their work to

balance the economy. They can be used to analyse the likely impact of the bank's actions in a range of areas. How might the raising or lowering of interest rates, for example, affect the manufacturing sector, unemployment levels or retail spending – and how will the respective impacts on each of those sectors affect each other? Similarly, how would the raising of interest rates in Greece affect the economy in France?

An important aspect of the ECB's work is the forecasting and policy analysis of the Eurozone countries. This work is largely carried out and co-ordinated through the use of a policy model called the Multi Country Model (MCM). The first MCM model was set up at the ECB between 1994 and 2000 and has been refined over the years according to experience and new research.

In 2008, Professor Hall was asked to help to develop a new version of the MCM which would incorporate learning into the structure of the model (previous versions had only been solved under rational expectations). The European Central Bank had recognised that its approach to modelling the European countries was inadequate in an important respect. By basing their analysis on a model which used rational expectation, it was essentially impossible to analyse the possible costs of a policy which is strongly affected by economic agents' expectations, except under the assumption that agents get things right.

The new multi-country model which Professor Hall worked on incorporated learning as one of the options for exploring expectations effects. This latest version fully incorporates a consistent set of supply side equations using a nested CES production function. This model also has the ability to be solved either under the rational expectations assumption or under learning.

This project was successfully completed in 2010 and the model now constitutes the main forecasting tool for the ECB ([Source 4], [Source 5]). It is the main policy tool which is able to investigate individual country effects within the Eurozone.

These modifications to the forecasting tool enable the ECB to make more accurate predictions about the economy, improving the Bank's ability to take effective and timely action to keep inflation low and minimise deflation. The ECB works as a hub for all the Eurozone member countries, so all the constituent central banks of the Eurozone will now be contributing and using the new multi-country model. So the influence of the learning procedures has spread to all the member banks. Many of the individual member banks are also developing versions of the model for their own countries to be used in-house.

5. Sources to corroborate the impact

1. Statement by the Economic Affairs Officer at DESA/DPAD/GEMU, United Nations, confirming Prof Hall's contribution to model building philosophy and econometric methodologies utilized in the construction of the UN's World Economic Forecasting Model

2. There are a series of formal contracts which can be supplied, contracting Prof Hall to work on this model.

3. UN *World Economic Situation and Prospects* available at (http://www.un.org/en/development/desa/policy/wesp/index.shtml).

4. Statement by the Senior Economist, Directorate General Research, European Central Bank, which confirms Prof Hall's contribution to the development of the New Multi-Country Model.

5. European Central Bank Working Paper: No 1316/April 2011 – The ECB's New Multi-Country Model for the Euro Area NMCM – with Boundedly Rational Learning Expectations by Alistair Dieppe, Alberto González Pandiella, Stephen Hall and Alpo Willman, http://www.ecb.int/pub/pdf/scpwps/ecbwp1316.pdf