

<b>Institution:</b> University of Strathclyde		
<b>Unit of Assessment:</b> C17 Business and Management Studies		
<b>Title of case study:</b> Improving policy-relevant analysis in the UK, Europe and USA through novel macroeconometric methods		
<b>Period when the underpinning research was undertaken:</b> 2006 - 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Gary Koop	Professor	1 January 2006 - present
Stuart McIntyre	Senior Lecturer	1 January 2013 - present
<b>Period when the claimed impact occurred:</b> 2014 – December 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		
<p><b>1. Summary of the impact</b></p> <p>Financial institutions and government bodies have used the macroeconometric methods created by Strathclyde researchers to enhance regional and national policymaking in the UK, Europe and the USA. The new methods produced more accurate and timelier estimates of macroeconomic variables, including regional economic activity and inflation. Applications of the methods have strengthened the economic analysis undertaken by the UK Office for National Statistics, Scottish Fiscal Commission, Bank of England, European Central Bank, European Commission and US Federal Reserve Banks. Decision-making within and beyond these bodies has been informed. Aspects of the research also augmented economic analysis and commentary disseminated to stakeholders and the public by global businesses (e.g. PricewaterhouseCoopers) and media outlets (e.g. Financial Times).</p>		
<p><b>2. Underpinning research</b></p> <p>In the last twenty years, Macroeconometrics has been revolutionised to address two main challenges: the need to model changing relationships in the economy in unstable times; and the requirement to incorporate Big Data, the large and diverse data sources which are increasingly available in a digitised world. Responding to this, Strathclyde Business School has undertaken research to develop methods to forecast, to estimate the impact of policy interventions and, given the delays involved in collecting official data, to nowcast key indicators such as economic output and inflation.</p> <p>This body of research uses the statistical modelling method called Vector Autoregression (VAR) which captures the relationship between different macroeconomic variables as they change over time. As VAR models impose few <i>a priori</i> restrictions on the interactions between macroeconomic variables, they are very flexible and typically exhibit good forecast performance. These models are therefore very popular with economists in government and central banks. However, new challenges have arisen in recent years as the size of VAR models has increased to capture dozens or even hundreds of variables. Given the large number of model parameters to be estimated, this leads to over-parameterisation problems which diminishes the accuracy of forecasts produced and can make the model challenging to estimate.</p> <p>In collaboration with co-researchers, Professor Gary Koop created new Bayesian estimation methods based on shrinkage priors to overcome over-parameterisation problems. This approach was found to perform well in a substantive empirical evaluation of its forecast accuracy [R1]. Alongside this, Koop established alternative approaches to address the over-parameterisation problem using data compression. A notable example of this was the creation (working with Professor Korobilis, University of Glasgow) of a new financial conditions index (FCI) to accurately track expectations about growth in key US macroeconomic variables. This was achieved using factor augmented VAR models with time-varying coefficients and stochastic volatility which allowed information in a large number of financial variables to be compressed into a smaller number of variables [R2]. A subsequent empirical comparison study involving data sets with up to 129 macroeconomic variables, demonstrated that compressed VAR methods had computational</p>		

advantages and forecast at least as well as either factor methods or large VAR methods involving prior shrinkage [R3].

Responding to the particular challenges of non-traditional Big Data sources, such as internet search data, Koop collaborated with the European Central Bank to develop a novel dynamic model selection (DMS) methodology. This allows for model switching (when a set of models exist and one is selected real-time from the set to make forecasts) to be controlled by variables constructed using Google data (termed 'Google probabilities' to indicate their active role). Tested through an empirical exercise involving nine major monthly US macroeconomic variables, the results showed that, in general, DMS methods provide large improvements in nowcasting and the use of Google probabilities often further increases performance [R4]. Within the context of unstable economic conditions, further research with Korobilis demonstrated that building parameter and volatility change into a large VAR model can result in well-calibrated predictive densities providing important information about forecast uncertainty.

Motivated by a need for timelier and more frequent estimates of regional economic growth for policymakers, Strathclyde led an Economic Statistics Centre of Excellence (ESCoE) project to develop VAR modelling methods which enabled the ONS to produce faster estimates of regional GDP in response to fiscal devolution and the 'levelling-up' agenda. In undertaking VAR modelling at regional, rather than national, level two key challenges arise. First regional GDP data is released at a lower frequency (e.g. quarterly or annually), with a release delay of around 6-12 months. Second, there is a relatively short time-series of regional data available. To address these challenges, Koop and McIntyre developed VAR models capable of handling data of different frequencies. These mixed-frequency VAR models embodied new features unique to this situation and provide a means of producing faster indicators of regional economic activity at a higher frequency [R5,R6]. Further, through application of the new methods to historical data, this research also produced estimates of quarterly regional growth dating back to 1970 and commented on the evolution of this growth across the UK regions.

### 3. References to the research (Strathclyde affiliated authors in **bold**)

- R1** J. Chan, E. Eisenstat and **G. Koop** (2016) Large Bayesian VARMA, *Journal of Econometrics*, 192: 374-390 <https://doi.org/10.1016/j.jeconom.2016.02.005> [REF2]
- R2** **G. Koop** and D. Korobilis (2014) A new index of financial conditions, *European Economic Review*, 71: 101-116 <https://doi.org/10.1016/j.eurocorev.2014.07.002> [REF2]
- R3** **G. Koop**, D. Korobilis and D. Pettenuzzo, D. (2019). Bayesian compressed vector autoregressions, *Journal of Econometrics*, 210: 135-154 <https://doi.org/10.1016/j.jeconom.2018.11.009> [REF2]
- R4** **G. Koop** and L. Onorante (2019) Macroeconomic nowcasting using Google probabilities, *Advances in Econometrics*, 40a: 17-40 <https://doi.org/10.1108/S0731-90532019000040A003>
- R5** **G. Koop**, **S. McIntyre**, J. Mitchell and **A. Poon** (2020) Reconciled estimates and nowcasts of regional output in the UK, *National Institute Economic Review*, 253: R44-R59 <https://doi.org/10.1017/nie.2020.29>. Article draws on: 1 **G. Koop**, **S. McIntyre**, J. Mitchell (2018) [UK Regional Nowcasting using a Mixed Frequency Vector Autoregressive Model](#), ESCoE Discussion Paper 2018-07
- R6** **G. Koop**, **S. McIntyre**, J. Mitchell and **A. Poon** (2020) Regional output growth in the United Kingdom: more timely and higher frequency estimates from 1970, *Journal of Applied Econometrics*, 35, 176-197 <https://doi.org/10.1002/jae.2748>. [REF2] Article draws on: **G. Koop**, **S. McIntyre**, J. Mitchell and **A. Poon** (2018) [Regional Output Growth in the United Kingdom: More Timely And Higher Frequency Estimates, 1970-2017](#), ESCoE Discussion Paper 2018-14.

**Notes on the quality of research:** All articles are published in peer-reviewed journals which are highly respected in the field. Key aspects of this research were supported with competitively won funding from the Economic and Social Research Council (Koop, Macroeconomic Forecasting in Turbulent Times, 01/10/2010– 30/09/2013, GBP325,755) and the UK Statistics Authority including ONS (Lisenkova, Koop, McIntyre, Roy, ESCoE, 01/07/2017-31/03/21, GBP660,866).

#### 4. Details of the impact

By advancing macroeconometric methods to provide more accurate and timely information, Strathclyde has enhanced regional and national policymaking in the UK, Europe and USA. Specifically, the research led by Professor Koop and Dr McIntyre has:

- Supported analysis and decision-making to address regional imbalances in the UK economy by creating improved estimates of regional economic activity;
- Enhanced national and regional economic policy-making by strengthening macroeconometric analysis within UK, European and US financial institutions and government bodies.

##### Improved estimates of regional economic activity in the UK

As reflected in recent parliamentary inquiries, regional inequality is a pressing concern in the UK. With the Covid-19 pandemic exacerbating existing imbalances, the levelling up agenda has become firmly established and the demand for timely regional statistics to inform decision-making has increased. Seeking to support policymakers to drive and direct economic development at regional and devolved levels, over the last five years the **Office for National Statistics** has expanded its data sources and outputs. This includes producing regional GDP figures to provide a more granular breakdown of the UK economy. Initially released annually with a lag of almost a year, the ONS drew on VAT administrative data and other sources to produce quarterly regional estimates from 2019, reducing the lag in data acquisition to six months. It then drew on Strathclyde's established research expertise through an ESCoE project to improve the timeliness and frequency of regional growth estimates further [R5,R6]. Confirming this, the ONS notes: *'to demonstrate that ONS can adapt to the needs of the modern user and help policymaking...we made the decision to adopt the approach developed by the Strathclyde team, to help produce faster estimates of regional growth using their econometric model, and all of the regional growth data that we produce (both annual and quarterly). What this has meant in practice is that we have worked with the Strathclyde team to embed their research and model within our methods. Specifically, and as part of the Levelling up strategy, the ONS has replicated the Strathclyde approach within the ONS production environment, with detailed plans to bring the nowcasting work of Strathclyde University into regular production'* [S1]. As well as meeting with the ONS monthly *'to discuss feasibility aspects and clarify any points around the method and outputs'*, Strathclyde has *'delivered comprehensive tailored training to explain the approach in detail to the ONS staff'* [S1].

The importance of this new approach to estimating regional growth is apparent in the written submissions made by ONS to the **Treasury** Committee's inquiry on regional imbalances in the UK economy (2019) and the **Business, Energy and Industrial Strategy** Committee's inquiry on post-pandemic economic growth: levelling up local and regional structures and the delivery of economic growth (2020). Setting out the range of regional economic data that are currently available as an evidence base for regional policymaking, both sets of evidence refer to the Strathclyde-led ESCoE project (the outputs from which underpin R5 and R6), explaining that it *'has developed a model-based approach to provide early views of regional economic activity, known as "nowcasts" which will enable the ONS to 'provide a "flash" estimate similar to the UK's early estimate of GDP' in support of the levelling up agenda* [S2a,S3]. The value of this work is further emphasised by the Director General of the **Office of Statistics Regulation** who wrote to the Chair of the Treasury Committee following his inquiry appearance to outline *'the pathways towards providing enhanced regional economic statistics and their inclusion in official publication'*. Listing nowcasts of regional GDP as one of four *'building blocks for improved regional economic statistics'*, he highlighted the fact that *'HM Treasury does not currently include much by way of regional economic breakdowns in their budget report'* and suggested that *'there might be considerable public good served by publishing some regional economic forecasts'* [S2b].

This research also benefitted the devolved nations directly. For instance, Strathclyde's nowcasting model [R5,R6] has been used by the **Scottish Fiscal Commission** since 2017 to produce regular economic forecasts for Scotland. According to the Commission's Chief Executive, *"now casting" the Scottish economy has helped us bridge the ragged edge between outturn data and the forecasts produced by our structural economic model. Since we started producing economic forecasts in 2017*

*we have made use of now casts produced by a model based on the Strathclyde approach' [S4].* Stressing that *'it has been reassuring to know that the work is based on rigorous econometric foundations developed at Strathclyde'*, he notes how much the Commission *'appreciated the initial conversations with the Strathclyde team when we were building the now casting model' [S4].*

In addition, the ESCoE research [R5,R6] was used by businesses, broadcasters and the press to produce economic analysis and commentary to increase public and stakeholder understanding of regional economic growth. For instance, the macroeconomics team at **PricewaterhouseCoopers (PwC)**, utilised the *'new set of estimates of quarterly and annual regional growth dating back as far as 1972 that has been published by ESCoE'* alongside ONS data on real output growth by region to explain the *'increasing economic growth divide between London and other regions' [S5a].* This was published in PwC's UK Economic Outlook report which is circulated to the company's global network of firms as part of its Connected Intelligence programme. The **Financial Times** also drew on the estimates, emphasising *'the importance of the ESCoE exercise'* in addressing the limitations of existing regional economic data which is no longer relevant by the time it is published [S5b]. Referring to the regional recession which hit the north east of England in 2016, commentary produced in November 2018 observed that *'policymakers did not learn about this contraction until December last year and, even then, only a growth figure for the year as a whole was published'*. Outlining how *'ESCoE have tried to solve this problem by using econometric techniques to develop a "nowcast"*, the article draws attention to the fact that *'just two weeks after official data suggested the UK was growing at an annual rate of 1.6 per cent, the ESCoE nowcast indicates the north east is growing at roughly half that rate, or 0.8 per cent' [S5b].* The value of these nowcasts to policymakers, if they choose to act, was stressed.

#### **Strengthened econometric analysis within financial institutions and government bodies**

As illustrated by the following examples, application of Strathclyde's modelling methods by financial institutions and government bodies in the UK, Europe and the USA has enhanced national and regional economic policy-making. Strengthening inflation trend analysis and forecasting has been particularly beneficial, enabling timely interventions to be made.

##### ***Bank of England***

To support ongoing analysis of global economic trends, the Bank of England drew directly on Koop's index of financial conditions research [R2] to calculate its own Financial Conditions Indices (FCIs) *'to summarise information from the following financial series: term spreads, Interbank spreads, corporate spreads, sovereign spreads, long-term interest rates, policy rates, equity price returns, equity volatility, house price returns and credit growth' [S6a,b].* This has enabled it to conduct analyses to monitor global economic and financial market developments. For example, in 2018 the FCIs based on Koop's index were used to analyse global financial conditions (showing they had tightened but remained accommodative overall) [S6a, pp.3,7] and to calculate financial conditions in non-China emerging market economies (evidencing a tightening) [S6a pp.6-8]. These findings were set out in the Bank's inflation reports for August and November which informed the interest rate decisions of the Monetary Policy Committee.

##### ***European Central Bank and European Commission***

Building on earlier ESRC-funded collaborative research [S7a], in 2019 Professor Koop worked with the European Central Bank (ECB) Business Cycle Analysis Division to evaluate the importance of the Phillips curve, the standard theoretical and empirical benchmark showing the relationship between real activity and inflation, following the financial crisis. Published in a ECB working paper to support policy deliberations and decision-making within European institutions, this research confirmed the existence of a Phillips curve in the euro area and provided reassurance that it *'is still a valid policy instrument once it is robustly estimated' [S7b].* Reflecting on the importance of this work, the ECB Senior Economist who was involved (now a project leader at the European Commission) notes that *'Prof. Koop has contributed to a major breakthrough in forecasting and modelling' [S5].* As well as being used *'routinely to handle large quantities of data'*, his techniques have and continue to be *'directly applied to the analysis of the Phillips curve and price dynamics, and provide an important and increasing contribution to the forecasting framework of the ECB, more and more relying on Big Data frameworks'*. Significantly, *'the ECB's forecasting*

framework is the main process that informs policy reports and Central Bank communication, and provides advice to the Executive Board' [S8]. The recognised value of Koop's research [R3,R4] to European policy-making is also apparent from his inclusion in a 'specially constituted Nowcasting group currently monitoring economic developments in real time during the COVID-19 crisis' [S8]. The Project Lead at the European Commission (formerly the ECB Senior Economist) confirms that Koop's 'Model Averaging techniques are at the moment the backbone of our Nowcasting framework, and they allow to combine the information stemming from different models and from the use of traditional and large quantities of Big Data to produce a weekly update of the nowcast to be sent to DG-ECFIN and to the Cabinets' [S8]. The Directorate-General for Economic and Financial Affairs (DG-ECFIN) is the Commission department responsible for EU policies promoting economic growth and recovery, higher employment, stable public finances and financial stability. Attesting to its broader relevance and application, aspects of this work have recently been published in a European Central Bank working paper to inform analysis and policy-making [S7c].

#### **Federal Reserve Banks of Cleveland and New York**

Koop's research [R1,R2] has also supported econometric analysis and policy-making within two of the twelve Federal Reserve Banks in the USA. These form part of the Federal Reserve System which serves as a central bank for the USA with the aim of providing stable monetary policy and a safe and flexible financial system. According to the former Director of Economic Research at the Federal Reserve Bank of New York (1998-2019) who 'was responsible for briefing the Bank President for the Federal Open Market Committee meetings, the policy meeting of the Federal Reserve', inflation research conducted with Koop 'allowed me to provide timely and insightful analysis of a number of critical issues' [S9]. The Head of the Macroeconomics Group within the Research Department of the Federal Reserve Bank of Cleveland, also acknowledges the 'tremendous value and influence' of Koop's research, specifically the development of a new model 'for assessing trends in inflation and forecasting future inflation' [S10]. Stretching its influence nationally, he notes that, 'our model has also been used in a number of other central bank studies of inflation trends and forecasts' to inform economic policy-making [S10].

#### **5. Sources to corroborate the impact**

- S1** Factual statement from Head of VAT and Regional Outputs, Surveys and Economic Indicators, Office for National Statistics, dated 6 October 2020.
- S2 a.** Office for National Statistics (2019) [Written evidence to the Treasury Committee's inquiry on regional imbalances in the UK economy](#) **b.** Office for Statistics Regulation, [Follow-up written evidence to the Treasury Committee's inquiry on regional imbalances in the UK economy](#), dated 10 January 2020.
- S3** Office for National Statistics (2020) [Written evidence to the Business, Energy and Industrial Strategy Committee's inquiry on post-pandemic economic growth: levelling up local and regional structures and the delivery of economic growth](#), dated 22 September 2020.
- S4** Factual statement from Chief Executive, Scottish Fiscal Commission, dated 18 January 2021.
- S5 a.** PwC, 'Regional growth trends and prospects', [UK Economic Outlook: March 2019](#) pp.28-39 **b.** Gavin Jackson, 'Fog on the Tyne', *Financial Times*, 21 November 2018.
- S6** Bank of England Inflation reports **a.** [August 2018](#) **b.** [November 2018](#).
- S7** European Central Bank working papers **a.** [Estimating Phillips curves in turbulent times using the ECB's survey of professional forecasters](#), WP1422 (February 2012) **b.** [Phillips curves in the euro area](#), WP2295 (July 2019) **c.** [Nowcasting in a pandemic using non-parametric mixed frequency VARs](#), WP2510 (Jan 2021).
- S8** Factual statement from Project Leader (unit B1), European Commission Joint Research Centre, dated October 2020.
- S9** Factual statement from former Director of Economic Research, Federal Reserve Bank of New York, dated 12 October 2020.
- S10** Factual statement from Senior Vice President, Economic Research Department, Federal Reserve Bank of Cleveland, dated 5 October 2020, with details of the model developed.