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Modelling the business cycle of a small open economy: The Reserve Bank of New Zealand's DSGE model☆

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ABSTRACT

We describe the underlying structure of the new forecast and policy model used at the Reserve Bank of New Zealand and evaluate its ability to explain New Zealand data. Unlike other estimated small-open-economy DSGE models, we find that more than one third of the domestic GDP growth is driven by foreign shocks. The elevated contribution of foreign shocks to the domestic economy is driven by our decision to exclude mapping export demand to data on world GDP. Estimating our model without any foreign demand data limits the response of exports to the real exchange variations. This feature makes exports and, consequently, domestic GDP much more sensitive to variations to foreign demand and raises the importance of foreign shocks to the domestic business cycle. Furthermore, our analysis suggests that a model with "adaptive" expectations is preferred by the data relative to the version of the model with "rational" expectations. In that case, the model explains nominal variables using on average much smaller shocks.

1. Introduction

In this paper we introduce the main elements of the Reserve Bank of New Zealand's economic forecasting and policy analysis model (NZSIM).[1] This model is one of the tools used to create the forecasts published in the Reserve Bank's Monetary Policy Statements. It also underlies some of the internal and externally published policy analysis conducted at the RBNZ. We summarise key features of the framework and outline the approach we have taken in designing it.[2]

Our model has been designed to articulate the structure of the monetary transmission mechanism and to incorporate interactions between the wide range of variables we use in the process of policy decision-making. The model gives a credible account of key relationships present in the data and replicates the salient features of the business cycle. Moreover it is flexible enough to easily examine the consequences of various economic developments and counterfactual scenarios while keeping the whole structure sufficiently tractable, easy to understand and to communicate. Over time, we use our model to express and store our institutional research, experience and knowledge.

The design of the NZSIM framework builds upon the lessons and experience from the development and use of macroeconomic models at the Bank. The central model is a small open economy New

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[1] NZSIM stands for New Zealand structural inflation model.

[2] Other than the model we document here, the forecast process remains as described in other previous Bank publications.

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Keynesian model.[3] As such, it builds on the already well-established literature on structural models of New Zealand, especially on its predecessors at the Reserve Bank.[4] This model provides theoretical underpinnings to match and understand the key correlations in New Zealand economic data. The DSGE centre is deliberately kept small relative to previous models used at the RBNZ. This parsimonious structure is more transparent and easier to communicate. However, this simplicity and tractability is not entirely costless since restricting the coverage of the model's structure reduces the insights it can add in articulating the drivers of the New Zealand business cycle.

Our approach is to expand our DSGE centre by incorporating additional simple auxiliary relationships. These relationships are based on empirical or theoretical research and reflect our institutional experience. These auxiliary equations enable us to represent our institutional views on a large number of important economic channels clearly and concisely. Our criteria for deciding how a feature should be introduced into our framework (either with full theoretical detail or based on empirical research) is to consider the complexity introduced and empirical gain achieved from various modelling methods.[5] The theoretically consistent centre allows us to view the auxiliary relationships as essentially correlated exogenous drivers and maintains our ability to produce credible counterfactuals.

Naturally our approach contains risks. Our auxiliary reduced-form relationships are affected by our DSGE centre and in some cases influence that centre in turn. Adding such additional features into the framework may, if one is not careful, produce unexpected interactions with the remainder of the system, contradicting existing features of the model or violating the general equilibrium accounting conditions or constraints. We adopt and outline a systematic approach to ensure that the theoretical and general equilibrium implications of each feature we are including are acceptable and as desired and that the feature improves the fit of the model. In Section 5, we illustrate, with an example, the details of our approach for selecting and assessing an additional feature to incorporate into our framework.

An attractive feature of our baseline model – which many open-economy DSGE models do not achieve (see Justiniano and Preston, 2010a) – is that foreign shocks explain more than one third of the variance of the domestic GDP growth.[6] Furthermore, during the "Great Recession", the model attributes much of the weakness of the domestic GDP growth to foreign demand shocks. Adverse global conditions reduce the foreign demand for New Zealand exports pulling down on domestic output. As the world recovers during the post crisis period, exports expand and the domestic economy returns to its steady-state growth.

Furthermore, we find that the introduction of "adaptive" expectations for inflation – a deviation from rational expectations – improves the fit of our model (by about 50 log points relative to our baseline model). This primarily occurs through a reduction in the size the shocks required to explain the behaviour of GDP and CPI inflation observed in the data. Under the "adaptive" expectations specification, the Phillips curves as well as the consumption Euler schedule become "steeper", which leads to a much more gradual responses to macroeconomic shocks as the agents in the economy become less forward looking. Fewer shocks are then required by the "adaptive" expectations model to explain the movements in the data.

Our paper is structured as follows: Section 2 presents a detailed description of the structure of the model, showing how the model dynamics are determined by economic agents' decision rules, budget constraints and market clearing conditions.

Section 3 focuses on the empirical properties of the model. First, using Bayesian econometric techniques, the parameters of the model and the dynamics of the exogenous drivers are estimated by matching the model to a number of macroeconomic aggregates. Second, using the estimated parameter values we evaluate the model's ability to account for the business cycle dynamics in New Zealand. Third, we discuss the transmission channels of the estimated model by examining model-implied behaviour of macroeconomic variables following unexpected movements in interest rates and exchange rates, respectively.

Section 4 uses an example to illustrate how knowledge of the model's transmission channels can be used to produce alternative scenarios. While technical tools exist to adjust the behaviour of model variables, the endogenous nature of the modelling framework can provide many alternative explanations for a given movement in a single variable. To reflect the desired scenario it is important to select the appropriate shock or combination of shocks to generate the desired change in model predictions. Our example demonstrates that depending on the particular lever used, the same adjustment to the path of interest rates can have different qualitative impacts on other model variables.

Section 5 presents and discusses an extension to the baseline model. Given the general equilibrium structure, a model extension can have non-trivial impacts on the model's behaviour. Being mindful of this, our adjustment process requires an investigation of these impacts and an assessment of the net benefits of systematically including additional features. To demonstrate this process, we consider the theoretical appeal and empirical gain from allowing household's and firm's expectations of inflation to be driven by an alternative partially backward looking process.

We investigate the drivers of the New Zealand business cycles through the lens of the model in Section 6 using forecast error variance decompositions and historical shock decompositions. We show that the "Great Recession" is identified by the model as large foreign shocks which trigger a fall in demand for New Zealand exports. Section 7 concludes.

2. Technical description of the model

This section provides the details of NZSIM, including a description of the optimisation problems faced by the agents in this economy. The first order conditions of these problems describe the evolution of the model's variables. The baseline version of this model assumes that agents in this economy have full information about the structure and the state of the economy.

The economy is comprised of three optimising agents: households, domestic firms and import distributing firms. Households sell

[3] Such as Benigno and Thoenissen (2003), Gali and Monacelli (2005), Lubik and Schorfheide (2005), Adolfson et al. (2007), Justiniano and Preston (2010a) and Justiniano and Preston (2010b).

[4] The RBNZ has employed a range of forecasting models including large macroeconometric models (Brooks and Gibbs, 1994; Clements et al., 1988), a model of overlapping generations in a one-good, small open economy (Hunt et al., 2000) and more recently a large scale DSGE model (Lees, 2009). There are also a number of more recent DSGE based research using New Zealand data. See for example Albertini et al. (2012, 05), Kam et al. (2009), Lees et al. (2011), Lubik and Schorfheide (2007) and Matheson (2010).

[5] Alternative approaches exist to incorporate missing channels or to allow the analysis of off-model variables in conjunction with the output from a central model. We are not the first to face this constraint and several methods to manage this problem are discussed in the literature. Burgess et al. (2013) suggest using multiple models – each simple and tractable – to obtain comprehensive coverage of economic channels. Caldara et al. (2014) (and others) suggest augmenting (via correlated shocks) a DSGE model with simple factor relationships to connect new variables and transmission channels quickly into the DSGE. In addition, when the implications of monetary policy for off-model variables are of interest to policymakers, Schorfheide et al. (2010) propose a method where DSGE variables are connected to large numbers of off-model variables as if the DSGE variables were dynamic factors.

[6] According to Justiniano and Preston (2010a) small open economy models fail to attribute the contribution of the foreign shocks to the domestic economy identified typically by VAR studies (Cushman and Zha, 1997). This appears to be true even when more sophisticated models (than the one used by Justiniano and Preston initially) are taken to the data.