Skilled migration and business cycle dynamics☆

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A R T I C L E   I N F O

A B S T R A C T

Shocks to net migration matter for the business cycle. Using a structural vector autoregression and an estimated dynamic stochastic general equilibrium (DSGE) model of a small open economy, we find that migration shocks make an important contribution to the volatility of per capita GDP. Migration shocks contribute to variability in per capita consumption and investment, and to residential investment and real house prices. Despite the role of migration, other shocks remain more important drivers of these expenditure components and of housing market volatility. In the DSGE model, the level of human capital possessed by migrants relative to that of locals materially affects the business cycle impact of migration. The impact of migration shocks is larger when migrants have substantially different levels of human capital relative to locals. When the average migrant has more human capital than locals, as seems to be common for migrants into developed economies, a migration shock has an expansionary effect on per capita GDP and its components.

1. Introduction

In recent years, migration flows have been large. Very large. Flows have been large in absolute numbers and large relative to non-migrant populations in destination countries. In response to these large migration flows the United Nations drafted a 'Global Compact for Safe, Orderly and Regular Migration' in December 2018.[1] This compact commits 164 countries to improve the evidence base on the effects of international migration to guide policy-making and public discourse. Our paper contributes to this objective by providing evidence on the business cycle impact of migration flows.

According to the United Nations, the world-wide stock of migrants increased by 17 percent between 2010 and 2017.[2] In Western Europe migrant stocks rose by 18 percent, in the United States by 13 percent, in Canada by 16 percent, and by 18

[1] Informally known as the 'Marrakech Compact'. See also the New York Declaration for Refugees and Migrants, 2016, http://undocs.org/A/71/150.

[2] www.un.org/en/development/desa/population/migration/data/index.shtml, accessed 9 May 2018.

percent in Oceania.[3] In contrast, population growth in high-income countries has been a paltry 3.8 percent, much slower than the growth of migrant populations. Even population growth in the world as a whole has only been around 8.5 percent.

The economic causes and consequences of migration are complex and multi-dimensional, affecting both origin and destination countries. Kerr and Kerr (2011) and Nathan (2014) provide surveys that discuss various facets of migration, while Constant and Zimmermann (2013) and Chiswick and Miller (2015) provide handbooks on the topic. A particular focus of the literature has been on the effect of migration on the labour market (Borjas, 1999; 2014; Burstein et al., 2017; Dustmann et al., 2005). Much of this analysis has a strong microeconometric focus,[4] sometimes based on partial equilibrium models or models that exploit cross-country or within-country regional variation. The macroeconomic consequences of migration, and in particular the general equilibrium *business cycle* consequences, are less well understood and have not been researched in much depth in the international literature. One notable exception is the work by Mandelman and Zlate (2012), which focuses on international risk sharing via migrants' remittances.

In this paper, we focus on the role of skilled migrants as a driver of the business cycle in countries-of-destination. How does skilled migration affect the per capita level of gross domestic product (GDP) and its components? How does migration affect the real exchange rate, and finally, do shocks to skilled migration drive the business cycle?

To address these questions, we develop and estimate a dynamic stochastic general equilibrium model for a small open economy that experiences net migration flows. We fit this model to the New Zealand economy, because of the availability of excellent migration data. All arrivals and departures in New Zealand are subject to reporting requirements and virtually all migrants arrive or depart by air, which provides a natural bottleneck for data collection. Migration flows into New Zealand have also been substantial in recent years, providing much-needed variation for econometric analysis. For example, net migration has increased working-age population in New Zealand by 1 percent in each of the three years from 2015 to 2017, and continued at a fast pace in 2018. A further feature of migration flows into New Zealand is that work and residence permits are allocated using a points based system that biases inflows in favour of high-skilled migrants.

Our analysis enables us to determine the contribution of migration shocks to the business cycle. We illustrate that the skill level of migrants relative to locals materially influences the dynamic impact of migration on the host economy. Borjas (1999) notes that "the labour market impact of immigration hinges crucially on how the skills of migrants compare to those of natives in the host country". We show that relative skill levels also matter for macroeconomic aggregates such as consumption and investment, in addition to labour market variables such as hours worked and wages. Migration shocks account for more of the volatility of the business cycle if migrants' level of human capital differs from that of locals. If migrants have a higher level of human capital than locals, the effects of migration are expansionary on a per capita basis and migration shocks account for a large fraction of the volatility of GDP and its components. When migrants have the same human capital as locals, migration shocks account for only a small fraction of the overall volatility of GDP. While still expansionary on a per capita basis, this kind of migration causes much less volatility for the host economy.

The literature on the business cycle effects of migration can be traced back to Jerome (1926), who explored the implications of immigration into the United States in the early twentieth century. However, the modern literature on the macroeconomic effects of migration, using time series and structural macroeconomic models, is relatively sparse. Our work is related to Weiske (2017a,b), who looks at the macroeconomic effects of migration and population growth in the United States (US). Using constructed working-age net migration data for the United States in a vector autoregression, Weiske (2017a) finds that the short-run effects of migration are consistent with standard growth theory, ie real wages fall and investment increases. However, Weiske also finds that migration shocks make only a modest contribution to US business cycle dynamics. The latter result is not entirely surprising, since data from the Department of Homeland Security and the US Census Bureau suggest that the per annum migration rate for the United States has been below 1 percent since 1915 and, with two exceptions, has been below 0.4 percent since 1925.[5]

For some countries, the effects of migration shocks are more substantial. Furlanetto and Robstad (2016), for example, use Norwegian data and find that positive migration shocks are expansionary and are a major driver of the dynamics of unemployment, though they are unimportant for house prices. Barrell et al. (2010) examine a particular facet of migration, namely the migration that occurred following the accession of ten Eastern European countries into the European Union, highlighting large flows into Ireland and the United Kingdom. Stähler (2017) examines the macro impact of refugees in Germany. In Stähler (2017)'s model, refugees from the rest-of-the-world are absorbed only gradually into the labour force. Refugees initially increase output, via a demand channel, but the later dynamics depend on whether refugees accumulate more or less qualifications than locals.

In New Zealand, much of the macroeconomic literature on migration focuses on the housing market.[6] Using a structural vector autoregression, Coleman and Landon-Lane (2007) find that migration has an extremely large impact on house prices, unlike the result reported for Norway by Furlanetto and Robstad (2016). Stillman and Maré (2008) apply microeconometric techniques to New Zealand census and house sales data to examine the impact of population and migration on house prices

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[3] See Peri (2016) for more cross-country detail for a slightly earlier period.

[4] See, for example, the discussion paper series of the Centre for Research and Analysis of Migration.

[5] See https://www.dhs.gov/immigration-statistics/yearbook/2016/table1 and the Haver population series A111POPG10. These percentages are indicative since the immigration series are for fiscal years, and do not align perfectly with the Census numbers.

[6] Hodgson and Poot (2011) provide a summary of New Zealand research on migration between 2005 and 2010. Their synthesis focuses on labour market adjustment, but also discusses literature on housing, trade and tourism, fiscal impacts, and innovation.
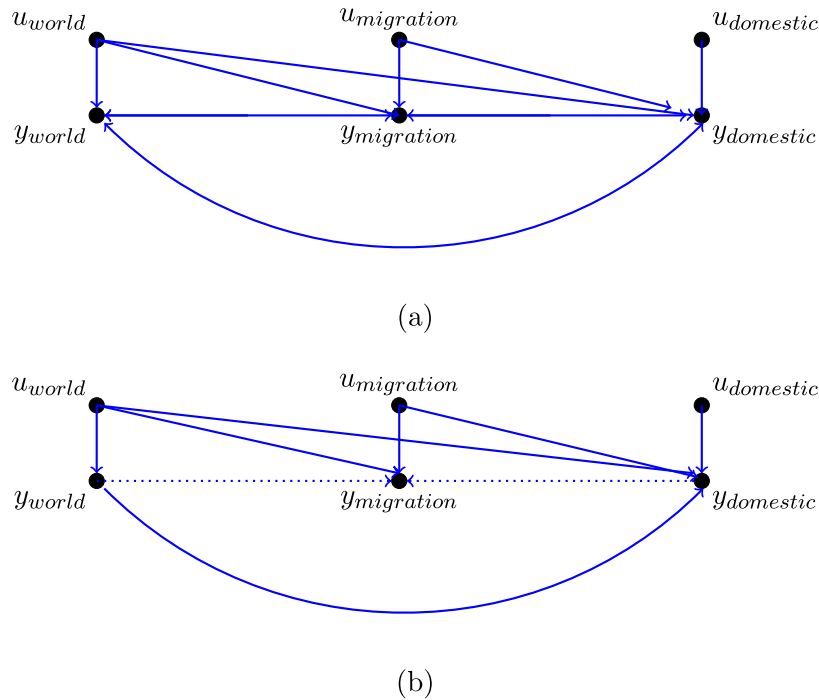
Fig. 1. Directed graph illustrating causal relationships in unrestricted/restricted VAR. Notes: u_{world} represents the structural shock to the world GDP series; $u_{migration}$ represents the structural shock to net working age migration; $u_{domestic}$ represents the remaining domestic structural shocks. y_{world} represents world GDP; $y_{migration}$ represents net working age migration; and $y_{domestic}$ represents the remaining domestic variables. Panel (a) illustrates the causal relationships of a standard vector autoregression in which all variables affect all variables in the vector. The dotted lines in panel (b) represent causal relationships that we examine using Granger causality tests. Is there feedback from domestic variables and foreign output to migration?

at a local, disaggregated level; they find no impact of foreign-born migrants on local house prices, though returning New Zealanders seem to have a statistically significant impact. In contrast, McDonald (2013) investigates the composition of New Zealand migration and finds that sub-components of net migration have different macro consequences: migrant *arrivals* are found to have more substantial impact on house prices than migrant *departures* and the citizenship of migrants also appears to have implications for the domestic (New Zealand) impact of migration. In a similar vein, Vehbi (2016) finds that the age-composition of migrants matters, with (presumably wealthier) 30–49 year old migrants having more substantial effects on consumption, house prices, rents, and residential investment than 17–29 year old migrants.

The rest of the paper analyses the business cycle effects of migration using a two-pronged approach. First, we analyse the effects of migration shocks using a structural vector autoregression (SVAR). This exercise helps to frame the DSGE model by illustrating how the observed data respond to migration shocks. Once we have analysed the data through the SVAR, we set up and estimate the DSGE model using Bayesian methods. The principal aim of our DSGE model is to shed light on the short-run macroeconomic effects of migration shocks and to assess their contribution to the dynamics of the business cycle.

2. Data

We focus our analysis on migration defined as net 'permanent and long-term' (PLT) arrivals and departures. PLT arrivals are people arriving for a stay of 12 months or more, including New Zealanders returning after an absence overseas of 12 months or more. Conversely, PLT departures are New Zealanders departing for 12 months or more and migrants leaving after a stay of 12 months or more in New Zealand. Net migration figures in New Zealand are often decomposed into net migration between New Zealand and Australia and net migration relative to the rest of the world. Australian and New Zealand citizens largely have freedom of movement between the two countries, including the right to work. In Fig. 2, net migration between New Zealand and Australia is summarised by the blue bars and that between New Zealand and the rest of the world by the red bars.[7] Over the sample, there was negative net migration between New Zealand and Australia, offset by positive migration between the rest of the world and New Zealand. Since about 2014, net migration to Australia has dried up, while net migration into New Zealand from the rest of the world has increased. As a result, annual net migration has risen to about 1.5 percent of the total resident population, while working-age migration has increased by a slightly larger percentage. In the four years 2014–2017, working age population increased by over 5.5 percent from net migration alone.

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[7] These numbers are based on the destination country and country of origin, rather than country of citizenship.
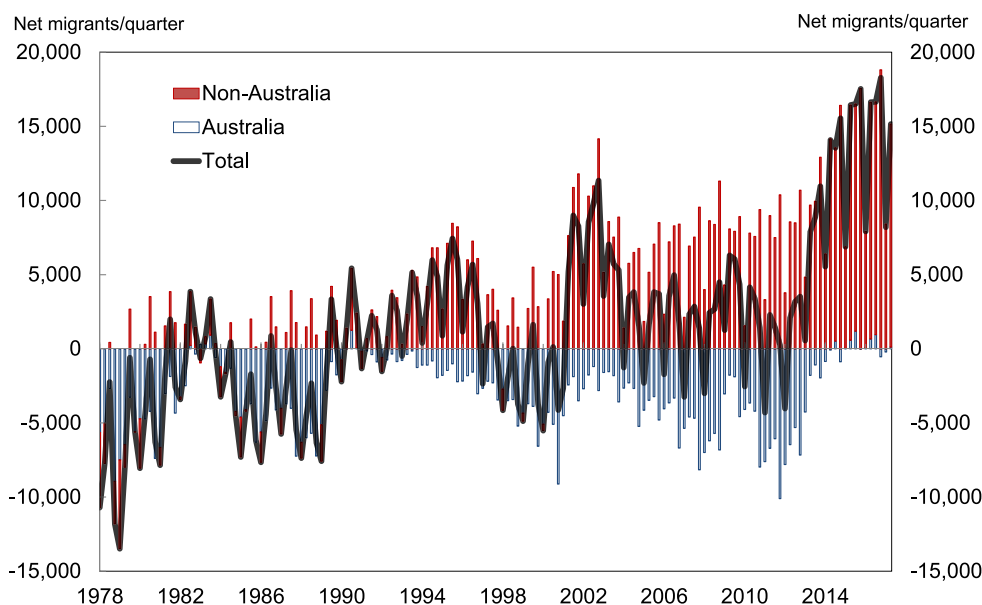
Fig. 2. Net working-age migration flows into and out of New Zealand. Note: The solid black line denotes non-seasonally adjusted working-age net migration into New Zealand. This figure is split into net migration into New Zealand from Australia (blue bars; predominantly an out-flow) and net migration into New Zealand from all countries other than Australia (red bars). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

We use national accounts data, migration data, house price data, and a trade-weighted aggregate of world gross domestic product (GDP) to estimate the model. The national account and migration data are sourced from Statistics New Zealand, while the house price data are from Quotable Value New Zealand. The trade-weighted world GDP data are compiled by the Reserve Bank of New Zealand. The data sample runs from 1992Q1-2017Q2.

GDP, residential investment, gross fixed capital formation (investment), and private consumption are sourced from the national accounts. We also use a trade-weighted measure of world GDP and working age net migration. All series are seasonally adjusted. The national accounts and migration data are transformed into per capita terms by dividing by seasonally-adjusted working age (15–65 year old) population. We take the natural logarithm of trending series and then apply the local linear projections of Hamilton (2018) to compute the trends and cycles of the data series.[8] This de-trending method is particularly straightforward to implement and consists of regressing the representative data series x_{t+h} against a constant and the data x_t, x_{t-1}, x_{t-2}, and x_{t-3}, where $h = 8$ quarters. This filter is one-sided and thus avoids the so-called 'end-point' problem commonly associated with the Hodrick–Prescott filter. The filter has the added advantage that, given that four lags are used, it simultaneously strips out seasonality. Cycles derived from seasonally adjusted data and unadjusted data are virtually indistinguishable. Furthermore, the detrended series also has a mean of zero provided that a constant is included in the local linear projection. (See Hamilton 2018 for a thorough discussion of the virtues of this detrending method.) As the filter is not yet widely used, and as our migration data are not well-known, we illustrate the detrended data in Fig. 3. As can be see in the figure, the cycles obtained from a seasonally adjusted series and from an unadjusted migration series are virtually identical.

Working age population has increased rapidly over the course of our sample, from around 2.66 million people in 1992 to 3.84 million in 2017Q2, making it difficult to translate percentage changes into the number of migrants entering the country. The largest quarterly migrant impulse in the *raw* data in percentage terms corresponded to an increase in working age population of 0.4 percent in a single quarter, in 2015Q4. In this quarter (in unofficially seasonally adjusted terms) a little more than 15,100 working age PLT migrants entered the country in raw terms.

The standard deviation of the *detrended* migration series is 0.125 in quarter-on-quarter percent terms. Thus, in an ordinary year a one standard deviation increase in population from migration corresponds to roughly a $\frac{1}{2}$ percent of working age population. The *largest* detrended seasonally adjusted migration inflow in a quarter, 0.31 percent, occurred in 2003Q1, and was nearly $2\frac{1}{2}$ times as large as the standard deviation of the detrended series. Approximately 10,500 working age migrants entered New Zealand in that particular quarter in the raw data.

The rest-of-world gross domestic product series is a trade-weighted average of the GDPs from 17 countries. We have backcast the series 2 quarters using an earlier vintage of this trade-weighted GDP, based on slightly fewer countries. Working age net migration is computed from Statistics New Zealand's permanent and long-term arrivals and departures data. The

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[8] The migration series is not logged as it takes both positive and negative values.
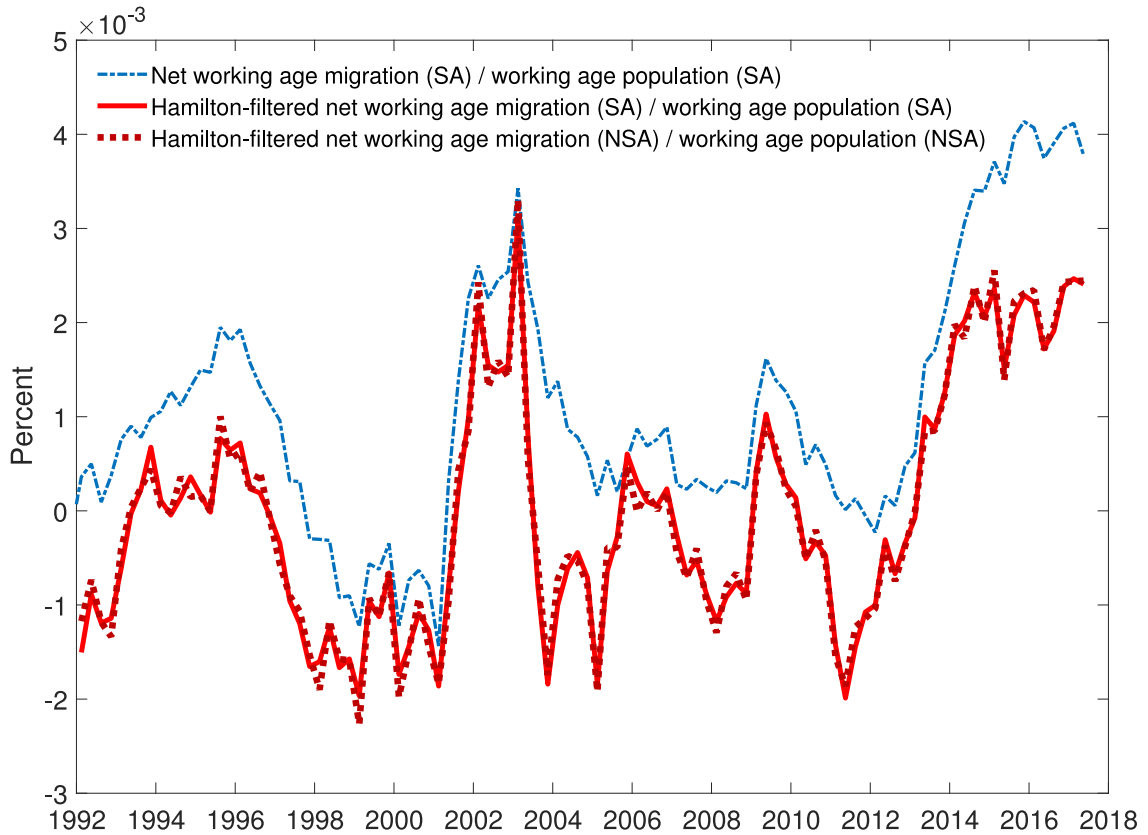
Fig. 3. Net working-age migration flows de-trended via local linear projections. Note: The dash-dot (blue) line is the net migration working age impulse relative to the size of total working age population on a quarterly basis, seasonally adjusted but not de-trended. The solid and dotted (red) lines are the cycles derived from applying the Hamilton local linear projection to the dash-dot series and to an equivalent series that has not been seasonally adjusted. These cyclically adjusted series have means of zero by construction. The latter two lines illustrate that the Hamilton local projection can be used to eliminate both trends and seasonality. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Raw data.

Symbol	Description	RBNZ identifiers
GDP	Production GDP seasonally adjusted	ngdpp_z
I^{res}	Private residential investment seasonally adjusted	nipd_z
X	Gross fixed capita formation seasonally adjusted	ni_z
C	Private consumption seasonally adjusted	ncp_z
pop^{wa}	Working age (15–65 year old) population	lhpwa_z
M	Net perm./long-term migration 15–65 year old	–[†]
q^h	Quotable Value House price index	pqhpi
CPI	Consumer price index	pcpis[‡]
GDP^*	Trade-weighted rest-of-world GDP	IWGDP_Z

[†] Arrivals less departures. [‡] The CPI series used here slightly deviates from headline CPI in the early 1990s, as it excludes interest charges, which were incorporated in headline CPI at that time. The data are available from the authors upon request.

working-age data are assembled from age cohort data. We seasonally adjust the per capita working-age net migration data using a default implementation of X12.[9]

Table 1 defines the raw data, while Table 2 describes the transformations applied to the raw data.

Table 3 reports the standard deviations, the standard deviation of variable i relative to that of GDP, and the first-order autocorrelation of the observables. New Zealand GDP per capita is considerably more volatile than our measure of World GDP. Residential investment is 5.67 times as volatile as GDP and more volatile than gross fixed capital formation (investment).

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[9] The executable file for X12 is available from the United States Census Bureau, https://www.census.gov/srd/www/x13as/. We use an implementation embedded in IRIS, https://github.com/IRIS-Solutions-Team.

Table 2
Data transformations.

Description	Symbol
Log per capita income	$y = HAM(\log(GDP/pop^{WA}))$
Log per capita residential investment	$H = HAM(\log(I^{res}/pop^{WA}))$
Log per capita gross fixed capital formation	$x = HAM(\log(X/pop^{wa}))$
Log per capita private consumption	$c = HAM(\log(C/pop^{WA}))$
Log real house prices	$q^h = HAM(\log(P^h \cdot 1000/CPI))$
Detrended migration per capita	$v = HAM(M/pop^{WA})$
Log trade-weighted foreign GDP	$y^* = HAM(\log(GDP^*))$

$HAM()$ represents the Hamilton filter used to detrend all series. $\log()$ is the natural logarithm. Migration is not logged because it can assume negative values. A Matlab file implementing these transformations is available upon request.

Table 3
Observables and model moments.

	Std Dev (σ)	σ_i/σ_y	Corr(Y_t, Y_{t-1})
GDP per capita	0.0264	1	0.8453
Residential Investment per capita	0.1496	5.67	0.8694
Investment per capita	0.1134	4.30	0.8297
Consumption per capita	0.0275	1.04	0.8408
Real House Prices	0.1006	3.81	0.8715
World GDP	0.0164	0.62	0.8864
Migration per capita	0.0013	0.05	0.8904

Note: All data, except for net migration per capita, are in logs and and all are de-trended using the Hamilton filter.

Real house prices are 3.8 times as volatile as GDP. Unlike most other developed economies, New Zealand consumption is somewhat more volatile than GDP. Net migration per capita in New Zealand is volatile by OECD standards, but is still only about 5 percent as volatile as real GDP.

3. An SVAR look at the data

Before investigating the business cycle effects of migration in the DSGE model, we first apply a structural vector autoregression to the data. Our focus is on the qualitative effects of a migration shock on the variables in our data set and on whether treating migration as an exogenous AR(1) process can be justified.

We develop an SVAR from the same observable variables that are used to estimate the DSGE model, but augmented with the real wage and the real exchange rate, both logged and detrended as previously described. We specify the VAR as follows

$$A_0(y_t - \mu) = A(L)(y_{t-1} - \mu) + u_t. \tag{1}$$

where A_0 is a $k \times k$ matrix; y_t is a $k \times 1$ vector of variables; μ is a $k \times 1$ vector of expected values for the stationary vector y_t; and $A(L) \equiv A_1 L + A_2 L^2 + \ldots A_p L^p$ denotes a lag polynomial where L is the lag operator, such that $Ly_t = y_{t-1}$. The vector u_t represents the mean-zero, serially uncorrelated exogenous shocks with diagonal variance-covariance matrix equal to the identity matrix, $\Sigma_u = I_k$. The reduced form errors thus have a variance covariance matrix $A_0^{-1} \Sigma_u (A_0^{-1})'$.

To begin the VAR analysis we check for the optimal lag length of the reduced form VAR using information criteria, as per Lütkepohl (2006) and Hayashi (2000). Hannan–Quinn and Schwarz Bayesian information criteria (HQIC and SBIC respectively) both suggest one lag for an unrestricted VAR, when lagged domestic and foreign variables are allowed to affect both domestic and foreign variables, including migration.

Our structural vector autoregression implies causal linkages between the foreign, migration, and domestic structural shocks, and the foreign, migration and domestic variables. To explicate these causal linkages, Pearl (2009), and more informally Pearl and MacKenzie (2018), argues that it is important to illustrate the causal linkages using directed graphs. Fig. 1 illustrates a directed graph for our model. To simplify the figures the dynamics have been collapsed, so that the variables y_{world}, $y_{migration}$ and $y_{domestic}$ represent both lagged and current values. Panel (a) illustrates that the orthogonal world shock instantly propagates through to world GDP, to migration and to all domestic variables. The orthogonal migration shock propagates through to migration and to the domestic variables, but does not feed through to foreign output. The lack of causal influence from New Zealand migration to world output is consistent with New Zealand being a small open economy, with little impact on the rest of the world. Lastly, domestic structural shocks only feed through to domestic variables. Panel (a) illustrates the causal relations of a conventional vector autoregression identified using a Cholesky decomposition. The dashed lines in panel (b) illustrate restrictions on causal linkages that we test – checking whether working age migration is unrelated to lags of world GDP and the domestic variables in the model.

Table 4
VAR lag length and Wald test.

Migration type	Lag length	Prob $> \chi^2$
Total Net	HQIC(1), SBIC(1)	0.324
Trans-Tasman	HQIC(1), SBIC(1)	0.208
Non-Tasman	HQIC(1), SBIC(1)	0.248

The VAR contains the following variables: World GDP, Migration, GDP, Consumption, Investment, Residential Investment, Real House Prices, Real Exchange Rate, Private Sector Wages. All data series are in per capita terms (except real wages) logged and de-trended using the Hamilton (2018) filter. Information criteria computed by STATA suggest an optimal lag length of 1 according to HQIC and SBIC
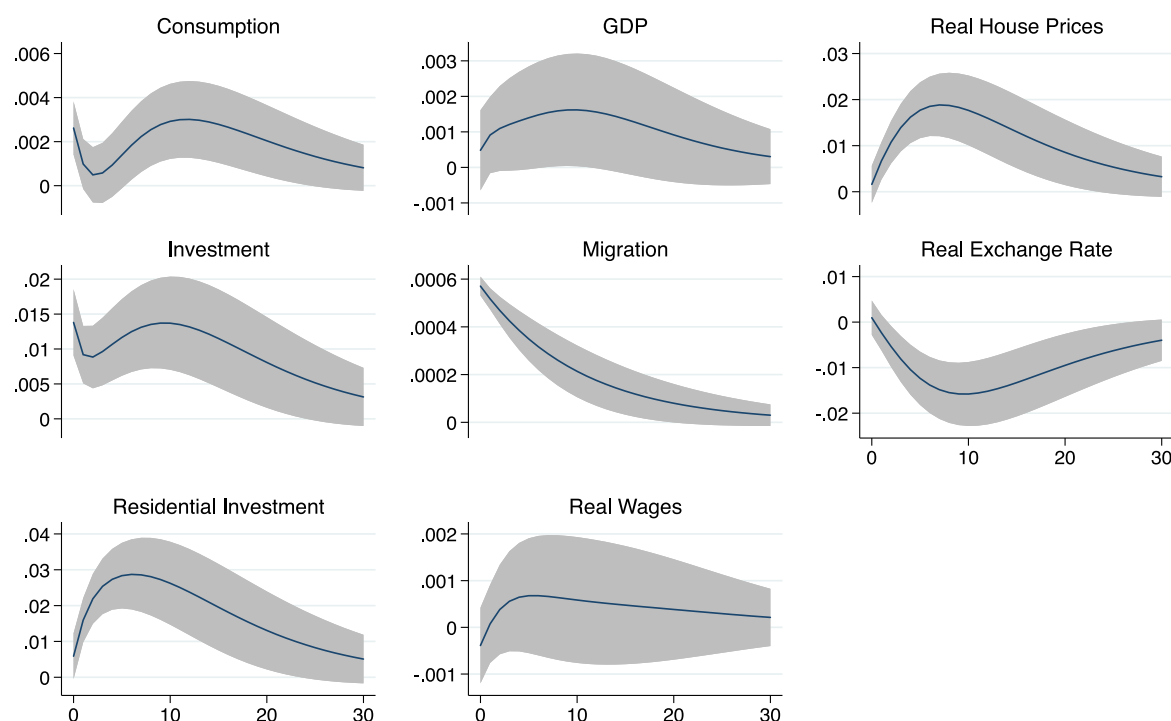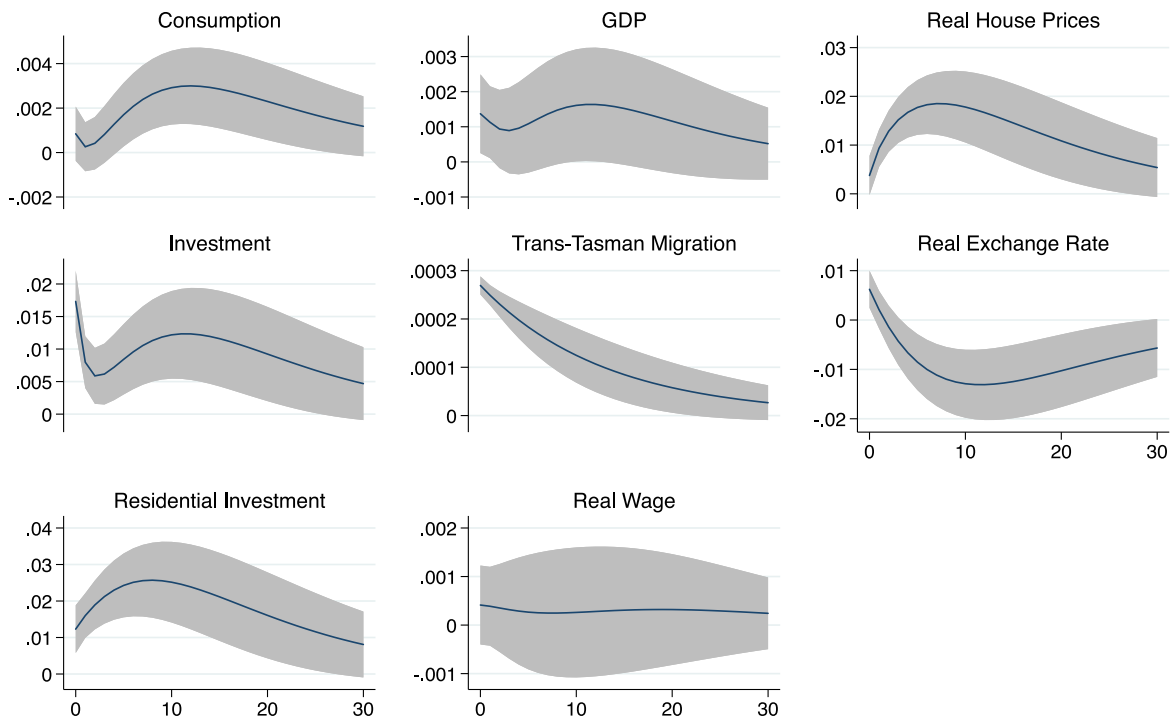

Fig. 4. A shock to net migration in a VAR. Notes: An increase in migration in a small open economy. The migration shock in the VAR(1) is identified by imposing block exogeneity on the migration per capita series. All data series are logged and de-trended using the Hamilton (2018) filter, as in Bayesian estimation. The shaded areas are the 68% confidence intervals. A decline in the real exchange rate series denotes a real appreciation.

To explore whether domestic (NZ) economic conditions and world GDP are material explanators of our migration series we conduct a simple Granger-causality test for the migration equation. We compute χ^2 test statistics to evaluate whether domestic variables are useful explanators of net migration. The test statistics are insignificant at the 10 percent level, both individually, and collectively, implying that the exclusion restrictions cannot be rejected. In other words, net migration is not Granger-caused by domestic variables. The results for the joint exclusion hypothesis are reported in the last column of Table 4.

To be consistent with our DSGE model, we impose exclusion restrictions on both world GDP and net migration, making these variables block exogeneous to the domestic variables. We use a lag length of one for the system, as per the information criteria results reported in Table 4. The restricted model is estimated using one-step seemingly unrelated regressions (SUR). We then proceed to orthogonalise the shocks using a standard Cholesky decomposition. World GDP is ordered first, per capita net migration is ordered second, and the remaining variables are ordered arbitrarily. The order of the latter variables has no impact on the impulse responses of the structural (orthogonal) migration shock. We argue that the lack of contemporaneous correlation between domestic variables and net migration is a plausible identifying assumption given that obtaining a visa and navigating the logistics of leaving a job and moving from one country is a lengthy process. As a cross-check, we consider Cholesky identification schemes where the migration structural shock is ordered first, second and last, and the responses of domestic variables to such shocks are qualitatively very similar.

Fig. 4 report the impulse responses to a shock to net migration. The independent and identically distributed net migration shock has a standard deviation of 0.00059. In the long-run this shock to total net migration corresponds to $\frac{1}{2}$ percent of working age population. This is larger than the simple standard deviation of the working age migration series, but

Fig. 5. A shock to Trans-Tasman migration in a VAR. Notes: An increase in migration in a small open economy. The migration shock in the VAR(1) is identified by imposing block exogeneity on the net trans-Tasman migration per capita series. All data series are logged and de-trended using the Hamilton (2018) filter, as in Bayesian estimation. The shaded areas are the 68% confidence intervals. A decline in the real exchange rate series denotes a real appreciation.

reflects the fact that migration impulses exhibit a strong degree of autocorrelation. The migration shock is associated with a statistically significant increase in consumption, investment, residential investment, and house prices. GDP per capita also increases, but is not significantly different from zero on impact. The VAR impulse response also suggest a key role for the real exchange rate in the transmission mechanisms of a migration shock.

Figs. 5 and 6 depict the impulse responses of a VAR using only data on trans-Tasman (between New Zealand and Australia) migration and on total net migration *excluding* trans-Tasman migration. Qualitatively, the macroeconomic responses to the different types of migration are very similar. Trans-Tasman migration is associated with a small initial depreciation of the real exchange rate, whereas total net migration and non-Tasman migration leads to an initial appreciation of the real exchange rate. The initial response of the real wage, although not statistically significant, is positive for trans-Tasman migration whereas it is negative for both non-Tasman and total net migration per capita.

The results discussed here have imposed block exogeneity restrictions on world GDP and migration, making these two variables independent of lagged domestic (New Zealand) variables. The identification scheme also makes world GDP and migration contemporaneously uncorrelated with New Zealand variables. The block exogeneity restrictions are qualitatively innocuous. The migration impulse responses have the same shapes and similar magnitudes if migration is allowed to be correlated with New Zealand lagged variables.

4. A model of migration in a small open economy

We analyse the effects of migration shocks on business cycle dynamics using a dynamic stochastic general equilibrium (DSGE) model of a small open economy. The standard small open economy model is augmented with two features that have non-trivial implications for the economy's dynamic response to migration shocks. First, we allow for human capital accumulation, and migration thus affects both the stock of physical and human capital per person. Importantly, the two forms of capital need not be affected by a migration shock in the same way. Second, we introduce a residential housing sector into the model. This addition allows us to analyse the effect of migration on residential real estate prices and sectoral labour flows. In other words, does migration cause labour to flow from the production of goods into the production of houses? We briefly discuss these two modelling choices in relation to the macroeconomic environment in New Zealand.

New Zealand's Immigration Act 2009 provides the current framework for migration into New Zealand. This legislation is augmented with regulations that specify application requirements for different visa categories. Visas are available for entrepreneurs, investors, skilled migrants, refugees, Pacific Islanders, and others. Of most note, in the context of our analysis,
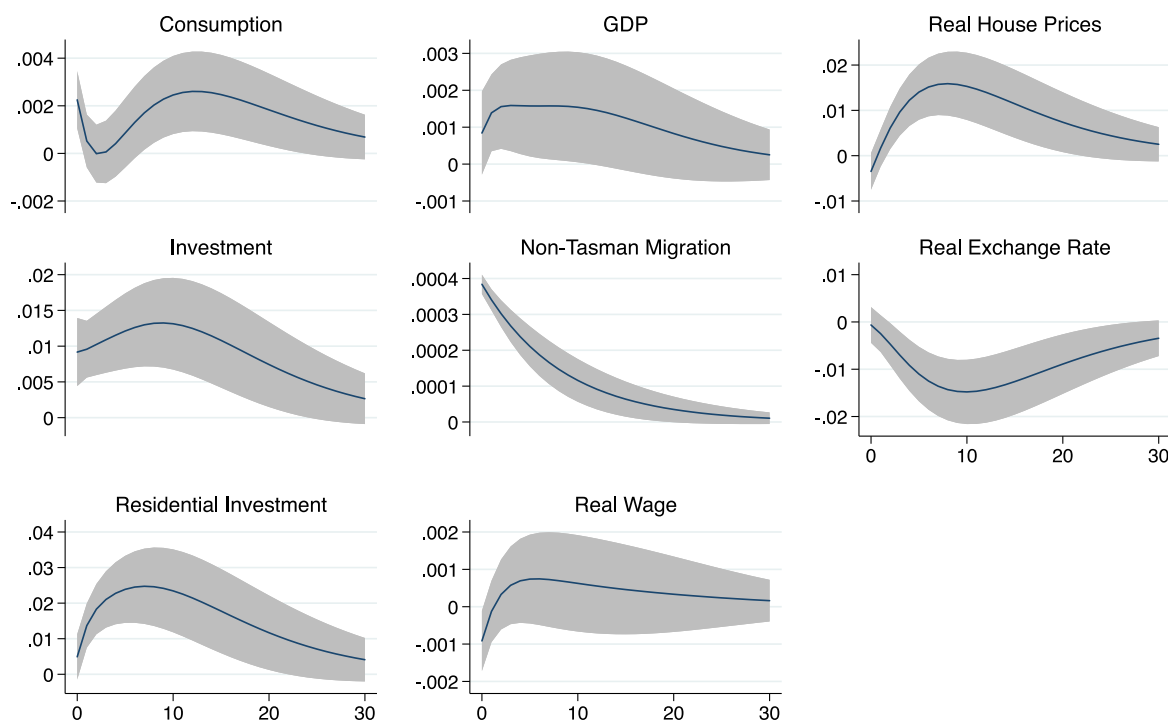
Fig. 6. A shock to Non-Tasman migration in a VAR. Notes: An increase in migration in a small open economy. The migration shock in the VAR(1) is identified by imposing block exogeneity on the net non-Tasman migration per capita series. All data series are logged and de-trended using the Hamilton (2018) filter, as in Bayesian estimation. The shaded areas are the 68% confidence intervals. A decline in the real exchange rate series denotes a real appreciation.

is the use of points-based criteria to rank applicants for many visa categories. Comparatively little use is made of visa ballots,[10] such as those used to allocate 'Diversity Immigrant Visas' (green cards) in the United States. In the ten and a half years from fiscal year 2007/8, roughly 463 thousand migrants have had visa applications approved by New Zealand immigration authorities.[11] Some 263 thousand successful applicants (circa 57 percent of successful applicants) entered New Zealand as 'Skilled Migrants' or via investor, entrepreneur or other skill-related categories. A further 163 thousand migrants (35 percent) were approved for family-related reasons, around 15 thousand visas (3.2 percent) were granted for refugees, 16 thousand visas were approved for people from the Pacific (3.5 percent); and a little over 5 thousand people were provided visas for various other reasons (primarily by ministerial direction). While the measurement of human capital is clearly fraught, the importance of skilled, investor, and entrepreneurial migrants supports the view that the 'average' migrant might have more human capital than the average domestic resident.

As mentioned above, we also explicitly model the housing sector. We incorporate housing into our analysis because housing is an important component of the capital stock, and demand for houses is directly and immediately affected by an increase in population. Residential investment is also one of the most volatile components of gross domestic product, contributing to business cycle fluctuations. Furthermore, construction is an important sector of the New Zealand labour market. According to the Quarterly Employment Survey, the proportion of full-time equivalents employed in construction has increased from below 5 percent in the early 1990s to around 9 percent in the most recent data in 2017. The links between house values and consumption, and therefore aggregate demand, also receives continued emphasis in the monetary policy statements of the Reserve Bank of New Zealand, in part reflecting the fact that a substantial proportion of New Zealanders' wealth is tied up in home ownership.

4.1. Households

To avoid tracking the dynamics of different vintages of migrants in the model, we assume that migrants become part of the representative household upon arrival. As such, the per capita terms entering the utility function and the budget constraints are aggregates divided by working age population, with no distinction being made between migrants and locals.

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[10] There are exceptions to this generalisation: Gibson et al. (2018) discuss a lottery for Tongan migrants into New Zealand, which is used to identify the income accruing to migrants relative to those unsuccessful in the lottery.

[11] See https://www.immigration.govt.nz/documents/statistics/r1residencedecisionsbyfy.zip, downloaded 8 February 2018.

This modelling approach has both benefits and drawbacks. The main benefit is that it is consistent with the data, which does not differentiate between locals and newly arrived migrants; it also avoids the issue as to when a migrant becomes a local.[12] The main drawback is that our model does not allow us to address important distributional or welfare questions. For example, we show that migration has a positive effect on per capital GDP, but we cannot address whether this increase accrues to locals or to newly arrived migrants.

Households maximise expected utility defined over consumption, housing services, labour effort, and skill accumulation. The period utility function is

$$U_t = \left(j_t^c \ln c_t + j_t \ln h_t - \frac{\phi_0}{1 + \eta} (n_t + s_t)^{1+\eta} \right) \tag{2}$$

where c_t is consumption per capita, h_t are housing services per capita, j_t^c and j_t are shocks that affects the utility agents derive from consumption and housing services, respectively. n_t denotes working hours, and s_t is training hours per capita. The final consumption good, c_t, consists of a domestically produced good, c_t^h, and an imported good, c_t^f. More precisely, the final good is defined as a constant elasticity of substitution (CES) aggregate:

$$c_t = \left[\omega^{\frac{1}{\theta}} \left(c_t^h \right)^{\frac{\theta-1}{\theta}} + (1 - \omega)^{\frac{1}{\theta}} \left(c_t^f \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}. \tag{3}$$

Here θ denotes the elasticity of substitution between the two types of goods and ω is the share of the domestically produced good in final consumption. The price index of the final good, P_t, is chosen to be the numeraire. Consequently, all other prices are expressed relative to the home final good. For example, the relative price of domestically produced goods, p_t^h, denotes the ratio $\frac{p_t^h}{P_t}$.

Households maximise expected utility subject to the flow budget constraint:

$$c_t + p_t^f b_t + q_t^H h_t + p_t^l l_t = (1 + r_{t-1}) p_t^f \frac{N_{t-1}}{N_t} b_{t-1} + q_t^H (1 - \delta_h) \frac{N_{t-1}}{N_t} h_{t-1}$$
$$+ w_t n_t d_{t-1} \frac{N_{t-1}}{N_t} g_t + (p_t^l + R_t^l) \frac{N_{t-1}}{N_t} l_{t-1} + \pi_t \tag{4}$$

Households consume goods, c_t, buy bonds that pay out in units of foreign-produced goods, b_t, buy housing services, h_t at price q_t^H, and buy land, l_t at price p_t^l. Households finance these expenditures through wage income, $w_t n_t d_{t-1}$ (reflecting both hours n_t and existing human capital d_{t-1}); the return they receive from the bonds purchased in the previous period, $(1 + r_{t-1}) b_{t-1}$; from the rental returns to their land holdings, $R_t^l l_{t-1}$; from selling the un-depreciated housing services purchased last period, $(1 - \delta_h) h_{t-1}$; and through dividend income, π_t that accrues to households as owners of the production sector.

The size of the working-age population at time t is denoted by N_t. Abstracting from natural population growth, the only way in which the size of the working-age population can change is via migration. Expressing all variables in the model on a per capita basis implies that all carried-over stocks, such as housing, bonds, human capital and land in Eq. (4) are deflated by the term $\frac{N_{t-1}}{N_t}$, which is the inverse of the gross growth rate of working-age population.

The amount of human capital that the representative household carries forward into period t is denoted by d_{t-1}. Whereas new migrants are assumed to arrive without physical capital, bonds, land, or housing stock, they do bring with them their human capital. Hence, migration affects the per capita stock of human capital differently than the per capita stocks of other assets. Indeed, if migrants have a greater human capital stock than locals, the available per capita stock of human capital that can be used in production in period t rises following a migration inflow. We capture this effect with the term g_t which accounts for the amount by which the per capita stock of human capital changes due to the relative skill of migrants. The variable g_t is related to $\frac{N_{t-1}}{N_t}$ in such a way that if migrants bring with them a level of human capital identical to the per capita human capital of locals, then $\frac{N_{t-1}}{N_t} g_t$ will be one. In this case, migration will have no direct effect on the available human capital per worker. When migrants bring with them a higher level of human capital than is available to locals, the per capita level of human capital per worker rises in response to an increase in migration. In the extreme case where migrants arrive without human capita, $g_t = 1$.

The stock of per capita human capital, evolves according to the following law of motion:

$$d_t = \left(\frac{N_{t-1}}{N_t} g_t d_{t-1} s_t \right)^{\phi_s} N_t^{2\phi_s - 1} + \left(1 - \delta^d \right) \frac{N_{t-1}}{N_t} g_t d_{t-1} \tag{5}$$

where, in the absence of migration, $(d_{t-1} s_t)^{\phi_s}$ denotes the production technology that converts effective time investment, combining training s_t with the existing stock of human capital, into new human capital. The coefficient δ^d denotes the depreciation rate of human capital. In modelling the accumulation of human capital we largely follow Kim and Lee (2007). Setting the parameter $\phi_s < 1$ ensures that growth is exogenous. In our case with exogenous population growth we have to set $\phi_s = 1/2$ to rule out a scale effect from population growth.

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[12] Interestingly, even permanent residents are eligible to vote in New Zealand elections, suggesting that migrants become 'local' relatively quickly.

4.2. Household first order conditions

Eqs. (6) –(12) are the optimality conditions for consumption, hours worked, hours spent training, the accumulation of human capital, bonds, housing, and land. The marginal utility of consumption at time t in these equations is denoted μ_t, the multiplier on the accumulation constraint for human capital is denoted λ_t and the discount factor by β.

$$j_t^c/c_t - \mu_t = 0 \tag{6}$$

$$-\phi_0(n_t + s_t)^\eta + \mu_t w_t \frac{N_{t-1}}{N_t} g_t d_{t-1} = 0 \tag{7}$$

$$-\phi_0(n_t + s_t)^\eta + \lambda_t \phi_s \frac{\left(\frac{N_{t-1}}{N_t} g_t d_{t-1} s_t\right)^{\phi_s}}{s_t} = 0 \tag{8}$$

$$-\lambda_t + \mu_t w_t n_t + \beta E_t \lambda_{t+1}\left[\phi_s \frac{(s_{t+1}\frac{N_t}{N_{t+1}}g_{t+1}d_t)^{\phi_s}}{d_t} + (1 - \delta^d)\frac{N_t}{N_{t+1}}g_{t+1}\right] = 0 \tag{9}$$

$$-\mu_t + \beta E_t \mu_{t+1} \frac{p_{t+1}^f}{p_t^f} \frac{N_t}{N_{t+1}}(1 + r_t) = 0 \tag{10}$$

$$-q_t^H + j_t \frac{1}{(h_t \mu_t)} + \beta E_t \frac{N_t}{N_{t+1}} \frac{\mu_{t+1}}{\mu_t}\left((1 - \delta_h)q_{t+1}^H\right) = 0 \tag{11}$$

$$-p_t^l + \beta E_t \frac{N_t}{N_{t+1}} \frac{\mu_{t+1}}{\mu_t}\left(p_{t+1}^l + R_{t+1}^l\right) = 0 \tag{12}$$

4.3. Firms

Households supply firms with *effective labour*, defined as $n_t d_{t-1}\frac{N_{t-1}}{N_t}g_t = en_t$, which is remunerated with the real wage w_t. Note that the opportunity cost of investing in human capital is borne exclusively by the household and not the firm. Households divide total effective labour, en_t, between the goods producing sector, supplying en_t^y units of labour, and the construction sector, supplying en_t^H units of labour.

$$en_t = en_t^y + en_t^H \tag{13}$$

4.3.1. Goods sector

Goods-producing firms produce a tradable good y_t whose price in terms of the numeraire good is p_t^h. Firms maximise cash-flow defined as the difference between the value of output and expenditure on wages and investment, x_t:

$$\pi_t^y = p_t^h y_t - w_t en_t^y - x_t \tag{14}$$

subject to a production technology that combines effective labour and utilised capital:

$$y_t = a_t\left(u_t \frac{N_{t-1}}{N_t} k_{t-1}\right)^\alpha (en_t^y)^{1-\alpha}. \tag{15}$$

The usual law of motion of the capital stock is defined as:

$$k_t = (1 - \delta(u_t))k_{t-1}\frac{N_{t-1}}{N_t} + a_t^i \iota(x_t/x_{t-1}). \tag{16}$$

where the depreciation rate $\delta()$ is a function of the utilisation rate, u_t. The function $\iota(x_t/x_{t-1})$ represents investment adjustment costs, as per Christiano et al. (2005), and a^i denotes a shock to the marginal efficiency of investment (MEI). The standard optimality condition for capital and investment are:

$$q_t = E_t \beta \frac{N_t}{N_{t+1}} \frac{\mu_{t+1}}{\mu_t}\left(p_{t+1}^h \frac{\partial y_{t+1}}{\partial k_t} + q_{t+1}(1 - \delta(u_{t+1}))\right) \tag{17}$$

$$1/a_t^i = q_t \frac{\partial \iota(x_t, x_{t-1})}{\partial x_t} + \beta E_t\left(\frac{\mu_{t+1}}{\mu_t} q_{t+1} \frac{\partial \iota(x_{t+1}, x_t)}{\partial x_t}\right) \tag{18}$$

$$\alpha p_t^h \frac{y_t}{u_t} = q_t \delta'(u_t)k_t \tag{19}$$

4.3.2. Construction sector

Our housing and construction sector is based on Iacoviello (2005). Housing stock is built using effective labour, land and home-produced intermediate goods, m_t. Profits in the construction sector at time t are defined as π_t^H, with

$$\pi_t^H = q_t^H H_t - w_t en_t^H - R_t^l l_{t-1} - p_t^h m_t \tag{20}$$

where q_t^H denotes the price of newly built housing stock. Labour mobility across sectors ensures that construction firms face the same wage costs as do goods producing firms, w_t. The rental rate of land faced by the construction sector is denoted by R_t^l. The total amount of land in the economy is fixed, but as the population grows the supply of land per household diminishes. A temporary increase in migration, or indeed just natural population growth, would imply an ever decreasing amount of land per household. From a modelling perspective, the steady state around which we are linearising the model would therefore not be deterministic. We get around this problem by assuming that land is re-zoned for building purposes as the population grows. As the supply of building land grows along with the population, the *per capita* supply of land per household remains constant.[13] If L_t denotes total building land, then the condition that building land per capita remains constant implies

$$\frac{L_t}{N_t} = \frac{L_{t-1}}{N_{t-1}} \tag{21}$$

such that the supply of total building land evolves according to $L_t = L_{t-1}\frac{N_t}{N_{t-1}}$ to ensure a constant supply of land per capita. Profits are maximised subject to the following production technology for new housing:

$$H_t = a_t^H \left(\frac{N_{t-1}}{N_t} l_{t-1}\right)^{\xi_l} en_t^{H^{1-\xi_l-\xi_m}} m_t^{\xi_m} \tag{22}$$

The production of houses is, like the production of goods, subject to an AR(1) technology shock, a_t^H. The construction firm maximises profits by choosing effective labour, land and intermediate inputs optimally:

$$(1 - \xi - \xi_m)q_t^H \frac{H_t}{en_t^H} = w_t \tag{23}$$

$$\xi_l q_t^H \frac{H_t}{l_{t-1}} = R_t^l \tag{24}$$

$$\xi_m q_t^H \frac{H_t}{m_t} = p_t^h \tag{25}$$

Every period, households sell their un-depreciated housing stock and purchase new homes with the proceeds. Market clearing implies that the supply of new houses equals the net increase in the housing stock.

$$H_t = h_t - (1 - \delta_h)\frac{N_{t-1}}{N_t} h_{t-1} \tag{26}$$

4.4. Current account

Having described the household and production sectors above, this section presents the final equations needed to close the model. Market clearing in the goods market is described by Eq. (27):

$$y_t - m_t = \omega \left(p_t^h\right)^{-\theta}(c_t + x_t) + ex_t^h. \tag{27}$$

The home produced good is used in the production of the domestically consumed final good and the domestically used investment good, and is also exported and used in construction. Export demand from abroad is assumed to be of the form:

$$ex_t^h = \omega^* \left(\frac{rer_t}{p_t^h}\right)^{\theta^*} y_t^* \tag{28}$$

with y_t^* denoting total foreign demand for the domestic good. Substituting the market clearing conditions from the goods and labour markets into the household budget constraints yields the economy-wide current account equation:

$$y_t = c_t + x_t + m_t + p_t^f b_t - p_t^f (1 + r_{t-1})\frac{N_{t-1}}{N_t} b_{t-1} \tag{29}$$

Finally, following Schmitt-Grohé and Uribe (2003) we close the model by introducing a debt elastic interest rate premium that allows for small deviations of the domestic real interest rate from the world rate when the domestic net foreign asset position deviates from its steady state level. This assumption eliminates the unit-root in bond holdings:

$$1 + r_t = (1 + r_t^*)e^{-\phi_b(b_t - \bar{b})} \tag{30}$$

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[13] We have experimented with various lags in the availability of building land, but these have not affected our results, including the contribution of migration to house price growth, in a significant way.

4.5. Driving processes

The model economy is driven by seven shocks all of which are AR(1) processes:

$$a_t = \rho_a a_{t-1} + \epsilon_{at} \tag{31}$$

$$a_t^H = \rho_h a_{t-1}^H + \epsilon_{ht} \tag{32}$$

$$j_t = \rho_j j_{t-1} + \epsilon_{j_t} \tag{33}$$

$$j_t^c = \rho_{jc} j_{t-1}^c + \epsilon_{jc_t} \tag{34}$$

$$a_t^i = \rho_i a_{t-1}^i + \epsilon_{it} \tag{35}$$

$$y_t^f = \rho_y y_{t-1}^f + \epsilon_{yf_t} \tag{36}$$

$$v_t = \rho_v v_{t-1} + \epsilon_{vt} \tag{37}$$

Eqs. (31) and (32) are total factor productivity processes in goods production and construction, respectively. Eqs. (33) and (34) represent preference shocks for housing and consumption, while (35) denotes the marginal efficiency of investment shock process. World output and net migration follow the processes denoted in (36) and (37). Specifically, the migration process is defined as $v_t \equiv \ln(N_t/N_{t-1})$.

Modelling migration as an exogenous process is a simplifying assumption, with some empirical support in our reduced form analysis. The literature also provides a degree of support for this assumption. Mitchell et al. (2011) find that simple autoregressive models can provide more accurate forecasts of migration in the United Kingdom than models that include economic or policy factors – in part because policy factors are hard to forecast.[14]

4.6. Modelling migration

What is the key difference between migration and natural population increase? In the model, the main effect of population growth is to dilute existing stocks of physical capital, housing, human capital, and net foreign assets on a per capita basis. What differentiates migration from natural population growth is that migration need not reduce the average level of human capital. Indeed, migration *raises* the average human capital level in the economy if migrants have accumulated more human capital than their domestic counterparts. To simplify our analysis we abstract from natural population increase, and focus solely on the impact of migration flows on the population.

To illustrate the effect of migrants arriving with human capital, consider the log-linearised evolution of d_t over time when migrants arrive with no human capital, e.g. when $g_t = 1$.

$$\hat{d}_t = \phi_s \delta^d \left[\hat{d}_{t-1} - v_t + \hat{s}_t \right] + (1 - \delta^d) \left[\hat{d}_{t-1} - v_t \right] \tag{38}$$

In the previous equation, variables with hats are log-deviations from their steady-state counterparts, and $v_t \equiv \ln(N_t/N_{t-1})$ is the log change in population. This equation illustrates that unskilled migration reduces the per capita stock of human capital in the economy. When migrants arrive with usable human capital, such that $\hat{g}_t > 0$ the stock of human capital evolves as follows:

$$\hat{d}_t = \phi_s \delta^d \left[\hat{d}_{t-1} + \hat{g}_t - v_t + \hat{s}_t \right] + (1 - \delta^d) \left[\hat{d}_{t-1} + \hat{g}_t - v_t \right] \tag{39}$$

It is convenient to formally link the log deviation in g_t to the growth rate of migration: $\hat{g}_t = \chi v_t$ so that we can re-write (39) as:

$$\hat{d}_t = \phi_s \delta^d \left[\hat{d}_{t-1} - (1 - \chi) v_t + \hat{s}_t \right] + (1 - \delta^d) \left[\hat{d}_{t-1} - (1 - \chi) v_t \right] \tag{40}$$

where χ is strictly positive and takes the value of 1 when migrants possess the same level of human capital as natives, or greater than 1 when migrants have a higher average level of human capital. In our model, migration differs from natural population growth via its effect on the existing stock of human capital.[15]

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[14] Conversely, theory emphasizes that migration should be endogenous to domestic and foreign conditions, see for example Borjas (1999). Alternative empirical methodologies do uncover endogenous effects at some frequencies: Mayda (2010), for example, conducts a panel data analysis based on annual data from 14 developed countries and finds that 'pull' factors in destination economies, such as relative income levels, do affect migration flows, though 'push' factors have only small effects.

[15] Another key difference between migration shocks and shocks to the natural growth rate of the population is that the former are unexpected and have an immediate effect on the stocks per worker, whereas the latter are anticipated as it takes 15 years to enter the working age population.

Table 5
Estimated parameters values.

| Symbol	Description	Prior	Mean	Std Dev	Posterior Mean	(5%	95%)
α	Share of capital	N	0.330	0.010	0.330	0.314	0.346
α_h	Share of land in housing	N	0.700	0.050	0.614	0.561	0.667
δ	Depreciation rate capital	N	2.500	0.500	2.748	1.944	3.538
η	Frisch elasticity	Γ	2.000	0.750	3.733	2.211	5.251
θ	Intratemp. subst. elasticity	N	1.000	0.250	2.550	2.498	2.590
γ	Openness	β	0.300	0.010	0.337	0.321	0.353
acu	Capacity-U curvature	β	0.500	0.150	0.669	0.479	0.865
ac	Investment adjustment costs	N	4.000	1.500	6.313	4.433	8.131
$100 \cdot \phi^b$	Bond adjustment costs	Γ^{-1}	1.000	5.000	0.205	0.152	0.256
ρ_a	Persistence tech.	β	0.500	0.200	0.762	0.710	0.814
ρ_{ah}	Persistence housing tech.	β	0.500	0.200	0.718	0.613	0.826
ρ_y	Persistence foreign demand.	β	0.886	0.010	0.887	0.871	0.903
ρ_j	Persistence housing pref.	β	0.500	0.200	0.860	0.806	0.917
ρ_{jc}	Persistence consumption pref.	β	0.500	0.200	0.830	0.780	0.879
ρ_i	Persistence investment-specific	β	0.500	0.150	0.272	0.145	0.397
ρ_v	Persistence migration	β	0.890	0.010	0.890	0.874	0.906
ϵ_a	Std dev. tech.	Γ^{-1}	0.004	1.500	0.030	0.026	0.034
ϵ_h	Std dev. housing tech.	Γ^{-1}	0.005	1.500	0.038	0.032	0.043
ϵ_{yf}	Std dev. foreign demand	Γ^{-1}	0.007	1.500	0.007	0.006	0.008
ϵ_j	Std dev. housing pref.	Γ^{-1}	0.005	0.500	0.535	0.335	0.728
ϵ_i	Std dev. investment-specific	Γ^{-1}	0.005	1.500	0.366	0.244	0.483
ϵ_{jc}	Std dev. consumption pref.	Γ^{-1}	0.004	1.500	0.034	0.030	0.039
ϵ_v	Std dev. migration	Γ^{-1}	0.001	1.500	0.001	0.001	0.001
	Calibrated						
χ	Relative human cap of migrants		1.85				
$100 \cdot \delta_h$	Depreciation rate housing		1				
β	Discount rate		1/1.01				
δ_d	Depreciation rate human cap.		0.01				
ϕ_s	Skill accumulation		0.5				
$\bar{j}$	Steady-state j		0.7				
$n + s$	Hours worked + training		1/3				
ξ_m	Share of traded goods in housing		0.1				
H/c	H - C ratio		0.12				

4.7. Migration dynamics

We treat net migration as the sole driver of population increase and map v_t to the decimal (percent) change in the population stemming from net migration (i.e. we set v_t equal to net working age migration divided by working age population). We model this series as an exogenous AR(1) process. Theoretically, we justify the lack of contemporaneous correlation between net migration and macroeconomic variables to implimentation lags involved in moving between the rest of the world and New Zealand. Whereas an individual's decision to migrate to New Zealand may be related to the state of the macroeconomy at the time, the lengthy administrative processes involved in obtaining a work or residence permit ensures that the state of the business cycle at the time of arrival of the migrant plays only a minor role. The following analysis suggests that both an AR(1) structure as well as our exogeneity assumption at one lag are supported by the data.

5. Bayesian estimation of the DSGE model

The results from the VAR exercise suggest that the effect of migration on the real wage is small and not significantly different from zero. Hence, we start by dropping the real wage from the data set used to estimate the DSGE model. As a sensitivity check in Section 7.2, we add a labour supply shock to the model and either real wages or hours as an observable to the data set. We also drop the real exchange rate from our data set because our model does not contain features that allow it to successfully reproduce the dynamics of the real exchange rate.

Columns 3–5 of Table 5 report the priors, means and the standard deviations of the parameters to be estimated. Most of our priors are fairly standard, see for instance Kamber et al. (2015). We do however, differ from the literature along several dimensions. Specifically, we attach a very tight prior to the share of capital, α, with a prior mean of 0.33, as is standard in the real business cycle literature. Likewise, the AR(1) coefficients for world GDP and net migration, ρ_{yf} and ρ_v respectively, have a prior that corresponds to estimates of these coefficients from single equation methods, as do the standard errors of these two shocks, ϵ_{yf} and ϵ_v. In each case, we estimate the parameter, but choose a relatively small standard error for our prior. These tight priors are implemented to prevent biases in the domestic equations from contaminating our estimates of these foreign impulses via the systems estimation of the model.
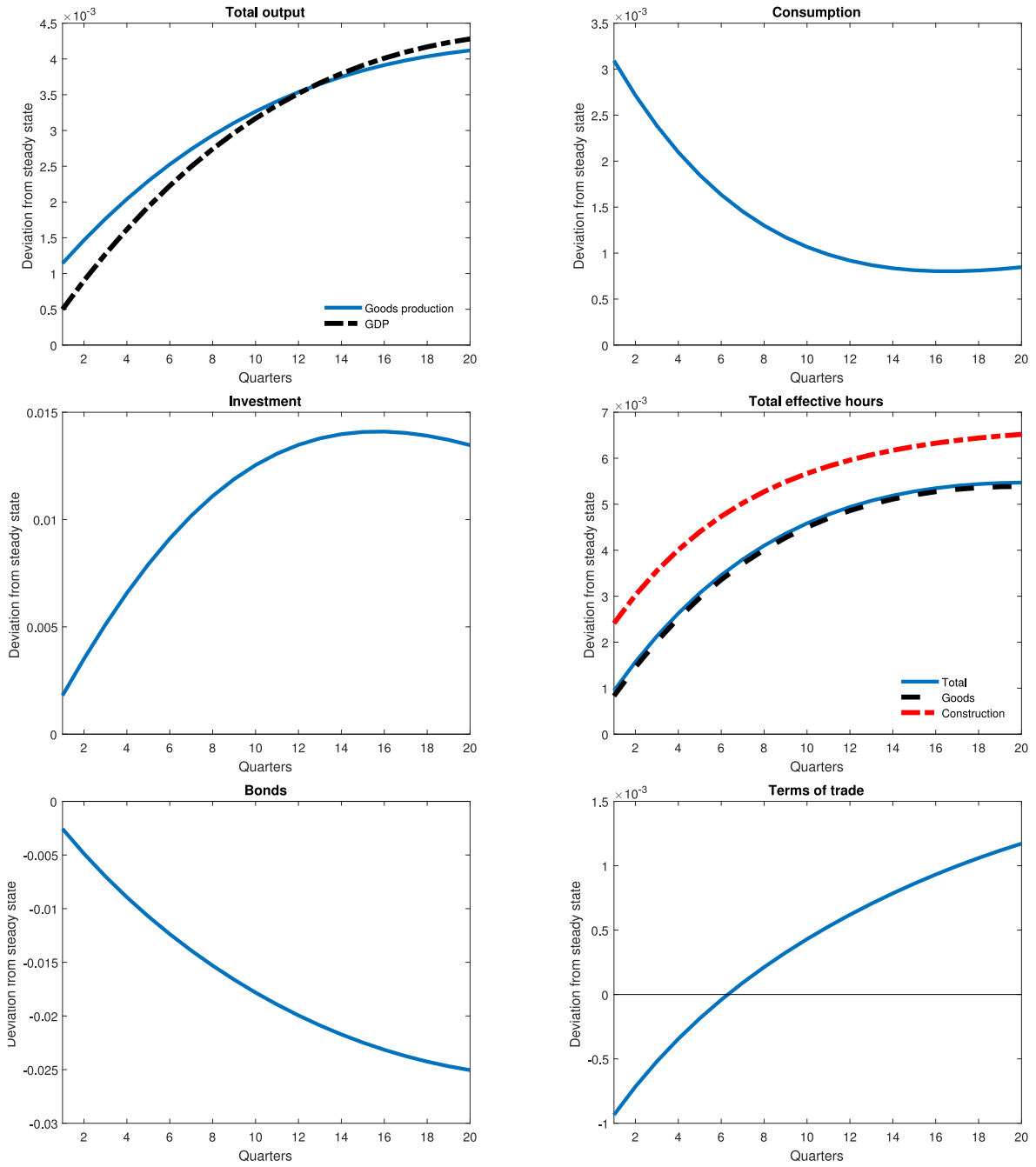
Fig. 7. A migration shock (Panel A). Note: An increase in migration in a small open economy. In the 'output' panel, the blue solid line denotes GDP, while the black dashed line denotes the log-deviation of home-produced traded goods. In the 'Hours' panel, the blue line denotes total effective hours supplied by households, the black line denotes effective hours devoted to goods production, while the dashed-dotted line denotes effective hours in construction. In the panel GDP growth, the blue line denotes growth of total GDP, while the black line denotes growth of GDP per capita. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Our baseline dataset, consisting of migration and national accounts data, is not informative on the ratio of human capital for migrants relative to domestic residents, χ. We therefore calibrate this parameter and later report a sensitivity analysis in Section 7 to illustrate how the dynamics of the model are affected by this parameter. The bottom half of Table 5 reports the calibrated parameters. Most of these are standard and only two parameters merit a special mention: the ratio of residential investment to consumption, which we set at 0.12 to match New Zealand data, and the above mentioned parameter χ, which we set at 1.85. The latter value is the relative level of human capital of migrants into New Zealand reported in
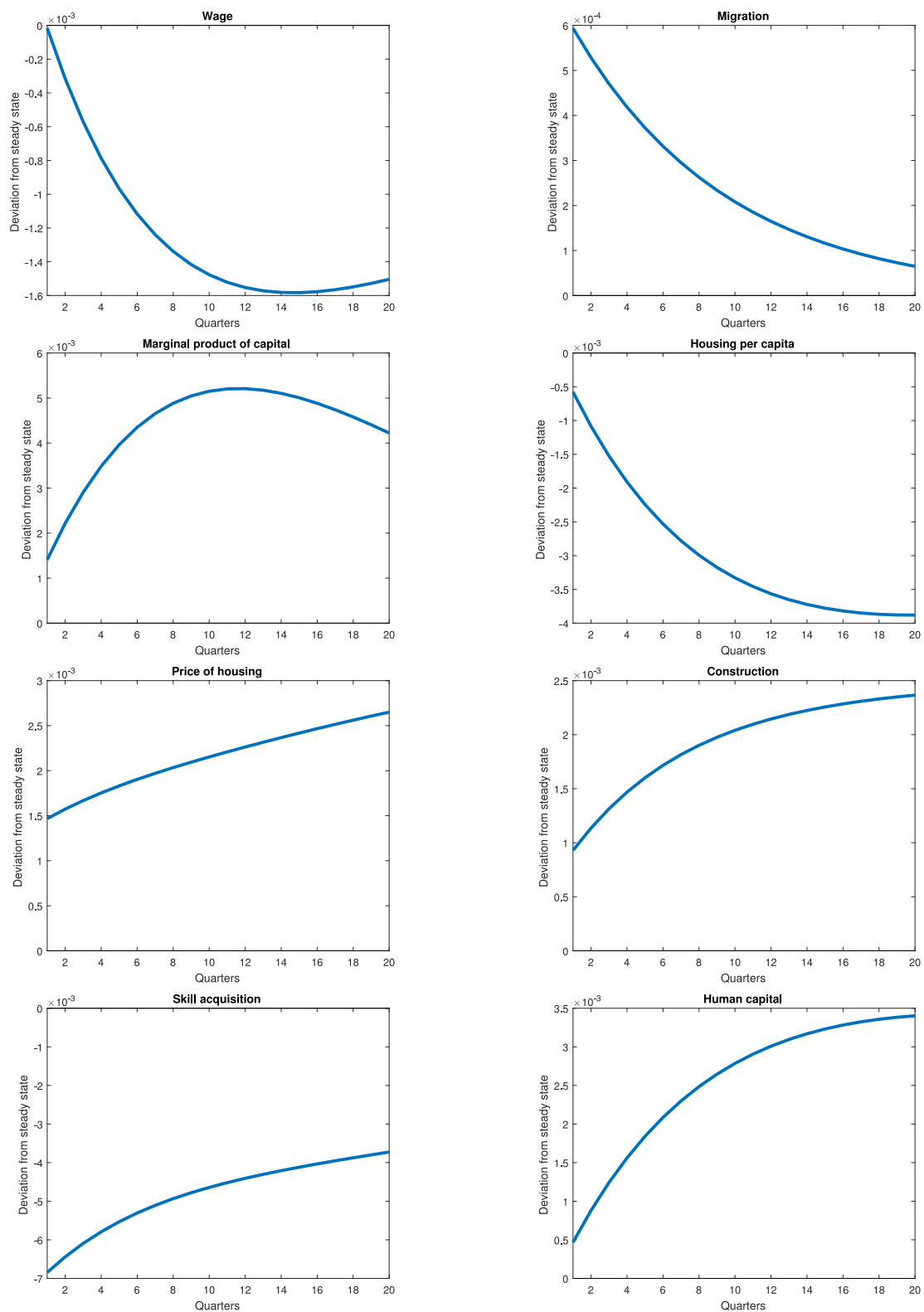
Fig. 8. A migration shock (Panel B). Note: An increase in migration in a small open economy.

Boubtane et al. (2016). In Section 7.2, we attempt estimate χ using real wage and hours data, but find that our estimates are subject to large error bands that incorporate our baseline calibrated value.

5.1. Estimation results

Columns 6–8 of Table 5 report the posterior mean and lower and upper limits of 90% Bayesian confidence intervals from the posterior distribution. The share of capital in the production of goods has a posterior mean of 0.33 and the share of land in the housing sector one of 0.61. Capital depreciates 2.7 percent per quarter. The inverse of the labour supply elasticity, η, has a posterior mean of 3.7. The trade elasticity or the intra-temporal elasticity of substitution between home and foreign produced goods is estimated at 2.55, which implies that home and foreign-produced goods are highly substitutable for one another. The openness parameter, γ, also has a tight prior and corresponds to the ratio of exports plus imports to GDP. For New Zealand, this value is around 0.33.[16] Parameters *acu* and *ac* are the capacity utilisation elasticity and the investment adjustment cost parameter, respectively. ϕ^b measures the bond holding costs. The data suggests a low mean value 0.2 of one percent.

Total factor productivity (TFP) in goods production and housing is persistent, with estimated AR(1) coefficients of 0.76 and 0.72, respectively. The corresponding standard deviations of the innovations are 0.03 and 0.04, respectively. The shocks to preferences for housing and consumption have AR(1) coefficients of 0.86 and 0.83, respectively. While these two shocks have a similar persistence, the housing preference shock is more volatile than the consumption shock. In contrast, the investment specific technology shock has a low autocorrelation coefficient and large standard deviation. The magnitude of this shock process is similar to estimates from Kamber et al. (2015). Working age migration per capita, estimated with a tight prior, is persistent with an associated AR(1) coefficient of 0.89 and a standard deviation of the migration impulse of 0.001.

6. A migration shock

A migration inflow increases both a country's population and its labour supply. As a result, a positive migration shock, initially at least, reduces the *per capita* value of stocks such as capital, housing and bond holdings. As our calibration assumes that migrants have a higher stock of human capital than locals, the per capita stock of human capital rises in response to a migration shock. Much of the transitional dynamics of the model economy are therefore driven by the reversion of these stocks to their steady-state values following a shock to migration.

Another key driver of the model's dynamics following a migration shock is the response of the real exchange rate or (near-synonymously) the terms of trade. Figs. 7–8, which shows the impulse responses of the model using the mean of the estimated parameters, suggest that the terms of trade, defined as the price of foreign to home-produced goods, appreciate following an unexpected increase in migration. The terms of trade appreciate because a migration shock raises absorption of home-produced goods. The estimation results suggest that agents have a significant degree of home-bias in both consumption and investment expenditure (the smaller is the openness parameter γ, the greater is home bias), which raises demand for domestically produced goods by more than the demand for imports, and hence leads to an appreciation of the terms of trade. An appreciation of the terms of trade raises the return to domestic factors of production and increases the purchasing power of domestic consumers. The real appreciation, caused by the positive migration shock, thus has a positive wealth effect on consumption.

An increase in migration lowers the per capita physical capital stock. This reduction in capital per capita, along with the appreciation in the terms of trade, has the effect of raising the marginal product of capital. Thus owners of installed capital unambiguously benefit from an increase in migration. The increased return on capital stock raises investment. At the same time, an increase in migration raises the utilisation rate of capital. As Brunow et al. (2015, p. 1030) note, a constant returns to scale technology implies that per capita income declines when labour supply increases are not accompanied by corresponding increases in capital. In our model, however, changes in capacity utilisation partially offset the movements in capital per capita that arise with migration inflows and outflows.

Boubtane et al. (2016) estimate that the relative stock of human capital for migrants into New Zealand is 1.85 times that of the average domestic resident for the 1986–2006 period. Only the United States, with an estimated ratio of 0.97, has a ratio below 1; the remaining countries examined by Boubtane et al. have ratios from $1.01 - 2.87$ (Greece and Ireland respectively). Using census data, Poot and Stillman (2016) find that migrants into New Zealand have 12.81 years of education on average, whereas New Zealand born individuals average a little less at 12.44 years of education. In 2006, 34 percent of migrants had bachelor degrees, while only 18 percent of New Zealand-born residents had such degrees.[17] The mapping between different measures of schooling and human capital is difficult to resolve, so later we explore the sensitivity of our results to this key ratio.

Because the empirical evidence suggests that migrants have a higher stock of human capital than New Zealand locals, we observe an increase in the per capita human capital stock following an increase in migration. As the transitional dynamics

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[16] γ is a useful transformation of the share of home-produced goods in home consumption, such that $\gamma = 1 - \omega$ measures the openness of the home economy.

[17] See DOL (2009) and the 2006 New Zealand Census data, http://archive.stats.govt.nz/Census.aspx?.

Table 6
Variance decomposition at the posterior mean.

Observables	ϵ_a	ϵ_h	Shocks				
			ϵ_{yf}	ϵ_j	ϵ_i	ϵ_{jc}	ϵ_v
GDP	0.36	0.04	0.00	0.35	0.04	0.02	0.19
	[0.22, 0.49]	[0.02, 0.06]	[0.00, 0.00]	[0.12, 0.56]	[0.01, 0.07]	[0.01, 0.02]	[0.11, 0.27]
Investment	0.12	0.00	0.00	0.01	0.70	0.00	0.17
	[0.05, 0.18]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.01]	[0.55, 0.85]	[0.00, 0.00]	[0.07, 0.27]
Residential	0.00	0.46	0.00	0.50	0.00	0.01	0.03
investment	[0.00, 0.00]	[0.23, 0.72]	[0.00, 0.00]	[0.25, 0.76]	[0.00, 0.00]	[0.00, 0.01]	[0.01, 0.04]
Consumption	0.24	0.00	0.00	0.02	0.07	0.56	0.12
	[0.18, 0.29]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.04]	[0.04, 0.10]	[0.48, 0.62]	[0.09, 0.15]
Real house	0.05	0.00	0.00	0.88	0.01	0.02	0.04
prices	[0.01, 0.08]	[0.00, 0.01]	[0.00, 0.00]	[0.79, 0.98]	[0.00, 0.02]	[0.00, 0.03]	[0.01, 0.07]

The table reports the theoretical variance decomposition at the posterior mean in percent for the baseline model with migrant human capital in excess of local $\chi = 1.85$. The numbers in brackets are are the 5% and 95% confidence intervals. All observables are defined as per data transformations.

are characterised by a reversion to the pre-migration mean, the representative household reduces investment in skill acquisition. Less time spent training, means more time spent on hours worked. As a result, effective hours per capita increase following a rise in migration. The combination of a lower capital stock and an increased supply of effective labour, pushes down the wage rate. On impact, this effect is offset by the appreciation of the terms of trade, which raises the real wage expressed in terms of the consumption good. After a couple of quarters, when the terms of trade appreciation starts to reverse, the real wage rate falls, reverting back to the initial steady state in the medium run. The increase in effective hours plus the increase in capacity utilisation allow output per head to rise in response to a positive migration shock.

In the housing market, the per capita stock of housing is reduced by a sudden increase in migration. Given that migrants have the same preferences over housing and consumption as locals, the demand for new houses as well as the price of housing rises and the return on land increases. The increase in the price of housing stock stimulates construction activity. Building houses requires land, labour and intermediate goods. Although total effective hours per worker increase, there is some reallocation of labour effort from the goods into the construction sector. This reallocation of effort occurs because the price of housing relative to that of intermediate goods increases. Thus, effective hours in the construction sector increase by more than in the goods producing sector. To ensure that the post-migration steady-state is the same as the pre-migration steady state, we assume that the supply of building land is allowed to grow with the population.

GDP is the sum of goods production and construction denoted by the solid (blue) line in the top left panel of Fig. 7. In the estimated model, goods production initially grows faster than overall GDP, though construction in the housing market overtakes around the three year mark. In summary, an increase in skilled migrants is expansionary in our model of a small open economy.[18] Even though the wage rate falls, per capita consumption, investment and GDP rises. Migration raises the return to stocks of physical capital and land and can temporarily reduce the return to human capital if migrants bring with them higher stocks of human capital. Our business cycle results contrast with the cross-country panel data analysis of Brunow et al. (2015), who find that decadal averages of per capita GDP are unrelated to decadal movements in net migration.

6.1. DSGE versus SVAR

The impulse responses of the DSGE model, Figs. 7–8, confirm the insights from the SVAR. Per capita GDP and its components increase in response to an unexpected increase in migration. Residential investment and real house prices increase and the real exchange rate appreciates in both the estimated DSGE model and in the SVAR. The only point of departure of the model from the SVAR is the dynamics of the real wage. The model suggests a small fall in the real wage, whereas there is no significant effect in the SVAR. Fig. 9 plots the shocks to migration derived from the VAR and from the DSGE model. Both series are are highly correlated reflecting the tight prior deliberately imposed in the DSGE model.

6.2. Does migration drive the business cycle?

Having analysed the dynamics of a migration shock in the model, we now consider whether migration is an important driver of the business cycle. Table 6 presents the variance decomposition at the posterior mean of our estimated model, with the lower and upper limit of the 90 percent Bayesian confidence intervals in square brackets underneath.

Over our sample, the median contribution of the migration shock is 19 percent of the variance of observed GDP per capita. The rest of the variance is accounted for, in roughly equal parts, by the TFP shock and the preference for housing shock. Recall that GDP consists of output of goods as well as housing. Migration is thus one of the main drivers of the variance of New Zealand GDP. For per capita consumption, migration is the third most important driver accounting for on

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[18] Labour market frictions, which slow down the rate at which newly arrived labour becomes productive may potentially offset some of the expansionary effects.
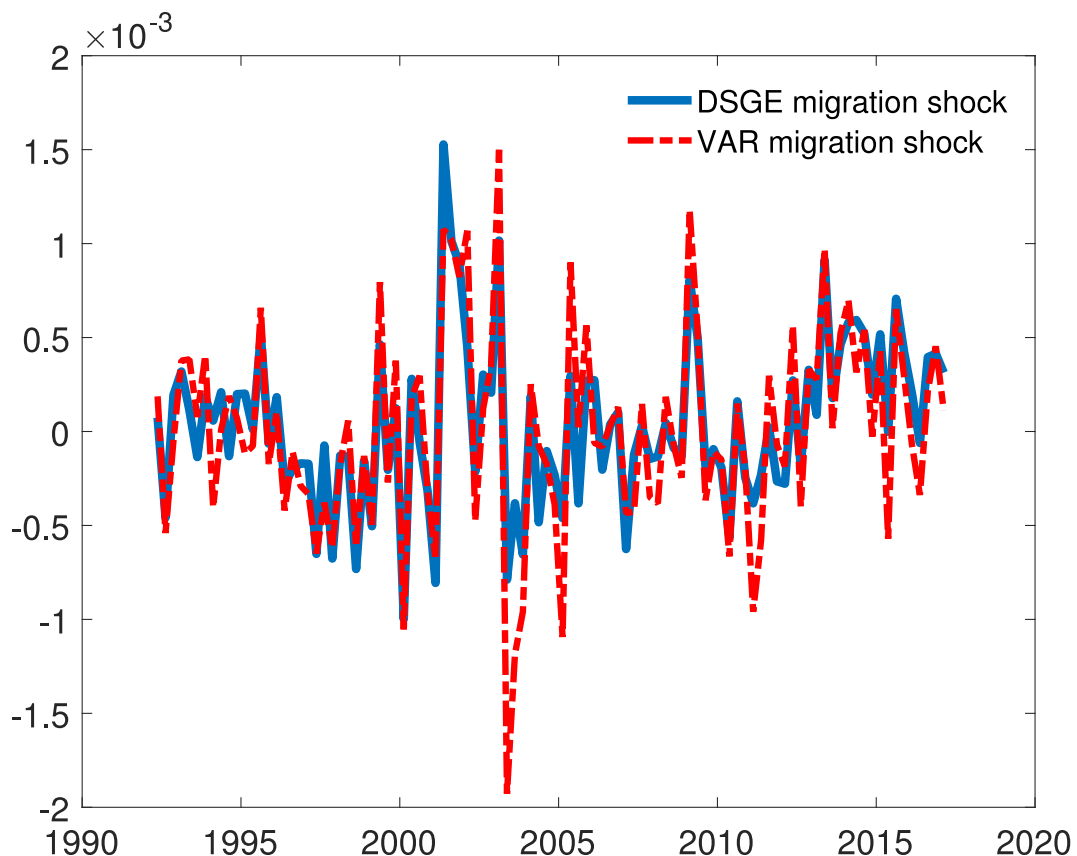
Fig. 9. Migration shocks - Model versus SVAR. Note: This figure compares the migration shocks from the DSGE model to those from the VAR.

average 12 percent of the variance, behind the consumption preference shock and the productivity shock. For investment, the migration shock accounts for on average 17 percent, which makes it the second most important driver behind the MEI (marginal efficiency of investment) shock. The role of migration shocks for the volatility of the housing market variables is modest, between 4 percent for real house prices and 3 percent for residential investment. The variance of residential investment is split relatively even between the housing sector productivity shock and the demand for housing shock, with a further 3% accounted for by migration. The variance of house prices is largely accounted for by the housing demand shock, which contributes 88% to the variability of real house prices. Migration accounts for 4%, which is more than is accounted for by the housing supply shock.

Given the relatively low degree of trade openness and the ability of the terms of trade to insulate the economy against foreign shocks, it is not surprising that the shock to world GDP has virtually no effect on the variances of our observables.

7. Sensitivity analysis: The relative human capital of migrants

One of the key assumptions of our DSGE model is that, on average, migrants have higher human capital levels than locals. As our data is not informative about this parameter, we calibrated this parameter χ to a baseline value of 1.85, which is the value estimated by Boubtane et al. (2016) for New Zealand for the period from 1986 to 2006. We justified this claim by noting that skilled and entrepreneurial migrants are a large proportion of total migration into New Zealand. To gain an understanding of how this assumption affects our results, we re-estimate the model under the assumption that migrants' human capital stock does not differ from that of locals, and explore the contribution that migration shocks then make to the variability of our observables.

The parameter estimates for the model where χ has been set to 1 are not affected in any significant way, hence we do not report them. Cancelling out the effects of migration on the stock of human capital does, however, significantly reduce the contribution of the migration shock to the variance of our observables. Table 7 shows that for per capita GDP, the contribution of the migration shock falls from around 19 percent to 0.2 percent, for residential investment the figure drops from 3 percent to 0 percent. For consumption per capita the migration shock's contribution of the total variance falls from 12% to just 3% and for house prices from 4% down to 1%. Our results thus imply that migration has less of an effect on the business cycle when migrants are closer to the local population in terms of their human capital. Our business cycle results

Table 7
Variance decomposition at the posterior mean when $\chi = 1$.

Observables	Shocks						
	ϵ_a	ϵ_h	ϵ_{yf}	ϵ_j	ϵ_i	ϵ_{jc}	ϵ_v
GDP	0.46	0.06	0.00	0.35	0.10	0.03	0.00
	[0.28, 0.62]	[0.03, 0.09]	[0.00, 0.00]	[0.13, 0.56]	[0.03, 0.16]	[0.02, 0.04]	[0.00, 0.00]
Investment	0.08	0.00	0.00	0.00	0.88	0.00	0.03
	[0.03, 0.14]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.01]	[0.81, 0.95]	[0.00, 0.00]	[0.01, 0.05]
Residential investment	0.00	0.56	0.00	0.42	0.00	0.01	0.00
	[0.00, 0.00]	[0.32, 0.81]	[0.00, 0.00]	[0.16, 0.66]	[0.00, 0.01]	[0.00, 0.02]	[0.00, 0.01]
Consumption	0.20	0.00	0.00	0.01	0.11	0.66	0.03
	[0.15, 0.25]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.02]	[0.06, 0.15]	[0.59, 0.73]	[0.02, 0.04]
Real house prices	0.06	0.01	0.00	0.87	0.03	0.03	0.01
	[0.01, 0.10]	[0.00, 0.01]	[0.00, 0.00]	[0.77, 0.98]	[0.00, 0.05]	[0.00, 0.06]	[0.00, 0.01]

The table reports the theoretical variance decomposition at the posterior mean in percent for the baseline model with migrant human capital in excess of local $\chi = 1$. The numbers in brackets are are the 5% and 95% confidence intervals. All observables are defined as per data transformations.

Table 8
Variance decomposition at the posterior mean - Non Tasman migration.

Observables	ϵ_a	ϵ_h	Shocks				
			ϵ_{yf}	ϵ_j	ϵ_i	ϵ_{jc}	ϵ_v
GDP	0.46	0.06	0.00	0.31	0.07	0.02	0.08
	[0.30, 0.61]	[0.04, 0.08]	[0.00, 0.00]	[0.11, 0.53]	[0.03, 0.12]	[0.01, 0.02]	[0.05, 0.12]
Investment	0.11	0.00	0.00	0.00	0.83	0.00	0.06
	[0.04, 0.17]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.01]	[0.74, 0.93]	[0.00, 0.00]	[0.02, 0.09]
Residential investment	0.00	0.56	0.00	0.42	0.00	0.01	0.01
	[0.00, 0.00]	[0.30, 0.78]	[0.00, 0.00]	[0.18, 0.68]	[0.00, 0.01]	[0.00, 0.01]	[0.00, 0.02]
Consumption	0.28	0.00	0.00	0.02	0.11	0.55	0.05
	[0.22, 0.34]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.03]	[0.06, 0.15]	[0.48, 0.63]	[0.03, 0.06]
Real house prices	0.07	0.01	0.00	0.87	0.02	0.02	0.02
	[0.01, 0.12]	[0.00, 0.01]	[0.00, 0.00]	[0.76, 0.98]	[0.00, 0.04]	[0.00, 0.04]	[0.00, 0.04]

The table reports the theoretical variance decomposition at the posterior mean in percent for the baseline model with migrant human capital in excess of local $\chi = 1.85$. The numbers in brackets are are the 5% and 95% confidence intervals. Migration defined as net non-Tasman (between AUS and NZ) migration. All observables are defined as per data transformations.

Table 9
Variance decomposition at the posterior mean - Trans-Tasman migration.

Observables	ϵ_a	ϵ_h	Shocks				
			ϵ_{yf}	ϵ_j	ϵ_i	ϵ_{jc}	ϵ_v
GDP	0.45	0.06	0.00	0.30	0.08	0.02	0.08
	[0.31, 0.59]	[0.03, 0.08]	[0.00, 0.00]	[0.10, 0.48]	[0.03, 0.14]	[0.01, 0.03]	[0.05, 0.12]
Investment	0.09	0.00	0.00	0.00	0.85	0.00	0.05
	[0.03, 0.15]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.01]	[0.77, 0.94]	[0.00, 0.00]	[0.01, 0.08]
Residential investment	0.00	0.57	0.00	0.40	0.00	0.01	0.01
	[0.00, 0.00]	[0.36, 0.81]	[0.00, 0.00]	[0.16, 0.63]	[0.00, 0.01]	[0.00, 0.01]	[0.01, 0.02]
Consumption	0.25	0.00	0.00	0.01	0.12	0.57	0.04
	[0.20, 0.31]	[0.00, 0.00]	[0.00, 0.00]	[0.00, 0.03]	[0.07, 0.17]	[0.50, 0.65]	[0.03, 0.06]
Real house prices	0.07	0.01	0.00	0.86	0.03	0.02	0.02
	[0.01, 0.12]	[0.00, 0.01]	[0.00, 0.00]	[0.75, 0.97]	[0.00, 0.05]	[0.00, 0.05]	[0.00, 0.04]

The table reports the theoretical variance decomposition at the posterior mean in percent for the baseline model with migrant human capital in excess of local $\chi = 1.85$. The numbers in brackets are are the 5% and 95% confidence intervals. Migration defined as net Trans-Tasman (between AUS and NZ) migration. All observables are defined as per data transformations.

thus cohere with an observation by Dustmann et al. (2005, p. F324), namely that "labour market effects of immigration depend most importantly on the structure of the receiving economy, as well as the skill mix of immigrants, relative to the resident population." Fig. 10 illustrates how the contribution of migration shocks varies with the parameter χ. The relationship is U-shaped, with minima for $\chi \in (0.5, 1)$, ie, where migrants have lower or equivalent levels of human capital relative to locals. The larger is the difference between migrants and locals in terms of human capital, the more the migration shock contributes to the dynamics of macroeconomic aggregates.

Fig. 11 reports selected impulse responses of the model for different values of χ. When migrants arrive with significantly less human capital than locals, the per capita level of human capital declines. Effective hours also decline which leads to a reduction in per capita output and consumption. As migration always reduces the per capita capital stock, investment per worker rises irrespective of the skill level of migrants. Unlike in the high skilled migration case, an increase in relatively low
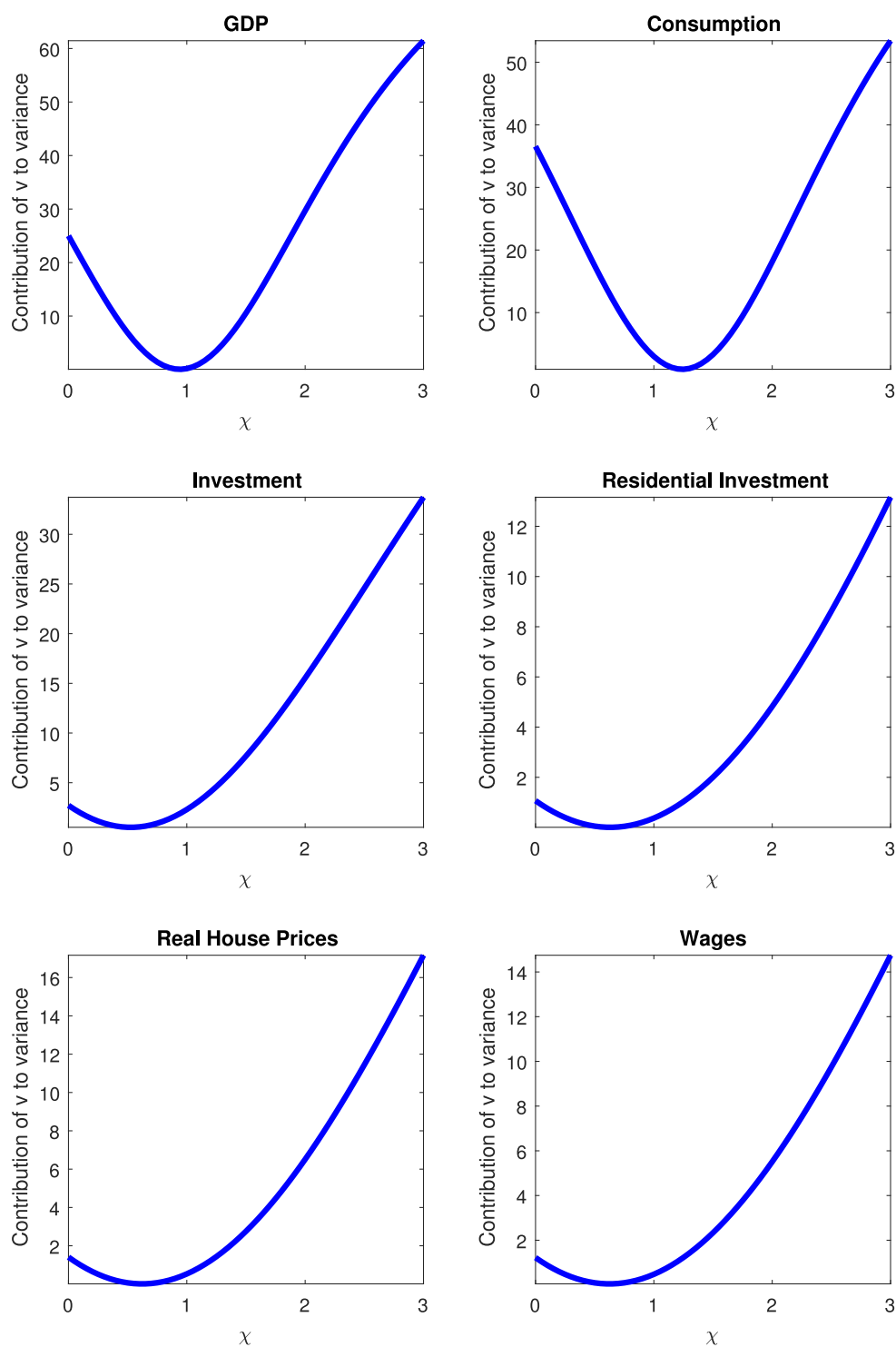
Fig. 10. The role of migration shocks as a function of χ. Note: This figure reports the variance contributions of the migration shock for different values of the relative human capital parameter χ, migrant capital to local, with all other parameters held constant at the mean posterior values.
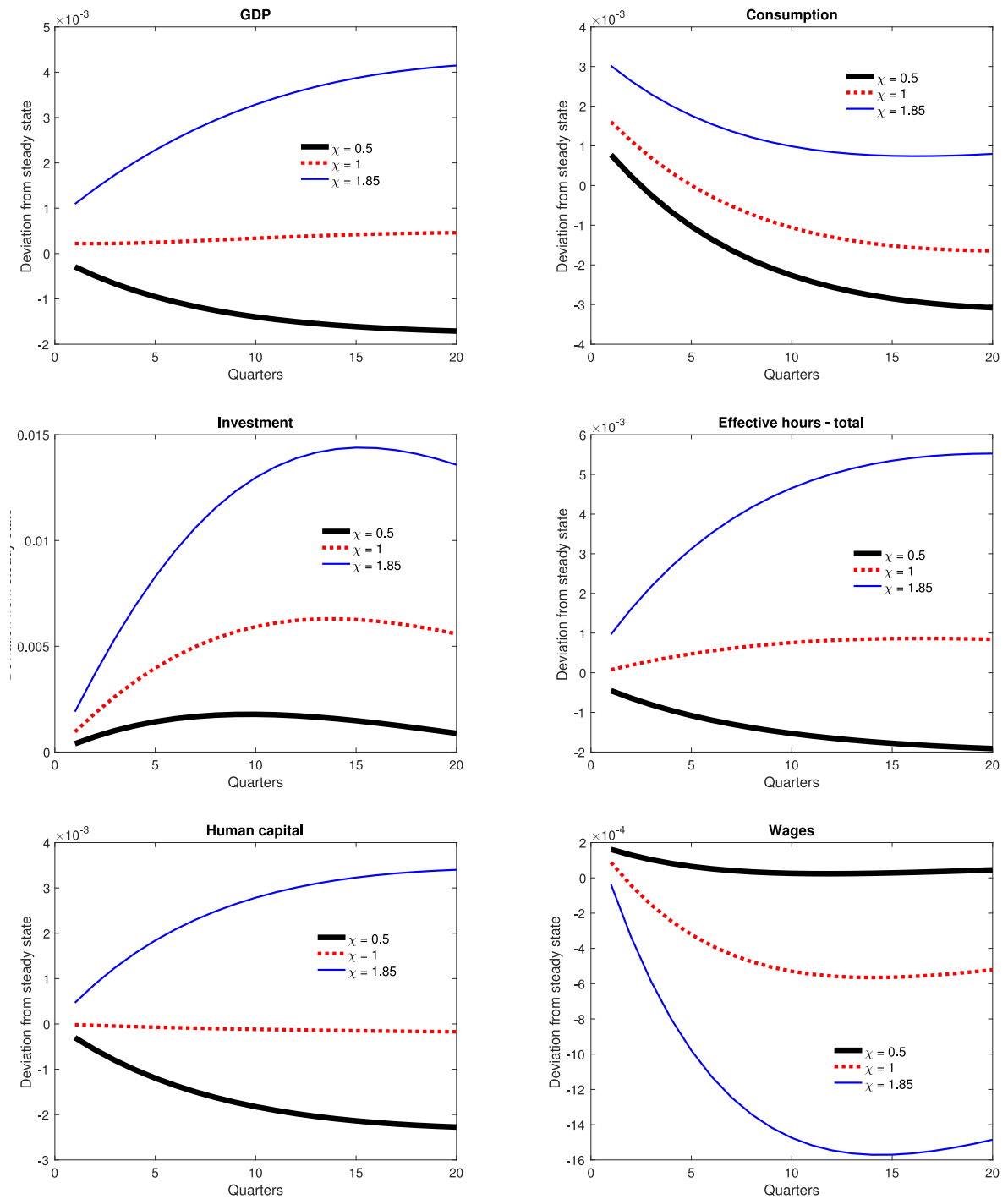
Fig. 11. A migration shock under various values of χ. Note: An increase in migration in a small open economy. The model parameters correspond to estimated posterior means of the baseline model, except for χ which takes the values of 1.85, 1.00 and 0.5. The impact of the migration shock depends on the relative human capital of migrants to local residents.

Table 10
Variance decomposition of GDP at the posterior mean - sensitivity analysis.

Observables	ϵ_a	ϵ_h	ϵ_{yf}	Shocks				
				ϵ_j	ϵ_i	ϵ_{jc}	ϵ_v	ϵ_{jn}
Labour supply wages	0.10	0.04	0.00	0.45	0.07	0.02	0.20	0.12
	[0.03, 0.15]	[0.02, 0.06]	[0.00, 0.00]	[0.20, 0.72]	[0.02, 0.11]	[0.01, 0.02]	[0.08, 0.32]	[0.00, 0.32]
Labour supply wages	0.15	0.05	0.00	0.28	0.04	0.02	0.11	0.34
χ estim.	[0.04, 0.26]	[0.01, 0.09]	[0.00, 0.00]	[0.03, 0.51]	[0.01, 0.08]	[0.01, 0.03]	[0.00, 0.28]	[0.02, 0.72]
Labour supply hours	0.33	0.06	0.00	0.15	0.05	0.01	0.20	0.19
	[0.17, 0.47]	[0.03, 0.09]	[0.00, 0.00]	[0.02, 0.29]	[0.01, 0.09]	[0.01, 0.02]	[0.09, 0.28]	[0.01, 0.50]
Labour supply hours	0.20	0.08	0.00	0.35	0.11	0.02	0.10	0.13
χ estim.	[0.08, 0.30]	[0.03, 0.13]	[0.00, 0.00]	[0.11, 0.59]	[0.03, 0.19]	[0.01, 0.03]	[0.00, 0.28]	[0.00, 0.34]
Growth affects	0.22	0.02	0.00	0.35	0.06	0.01	0.33	
migration	[0.13, 0.31]	[0.01, 0.04]	[0.00, 0.00]	[0.14, 0.58]	[0.02, 0.10]	[0.00, 0.01]	[0.20, 0.47]	

The table reports the theoretical variance decomposition of GDP at the posterior mean in percent for alternative models. The numbers in brackets are are the 5% and 95% confidence intervals. 'Labour supply wages' adds a labour supply shock and real private sector wages as an observable. 'Labour supply wages χ estim.' repeats the exercise in row 1 but also estimates the relative level of human capital of migrants. We find an estimate of χ with a posterior mean of 1.520 and a confidence interval from 0.794 to 2.214. 'Labour supply hours', is identical to the exercise in line 2, but uses average paid weekly hours as an observable to identify the labour supply shock. Using hours, we find an estimate of χ with a posterior mean of 1.358 and a confidence interval from 0.802 to 1.915. Row 4 reports the variance decomposition of GDP for a baseline estimation where we allow the lagged growth rate of domestic GDP to affect the migration process. We find an estimated feedback parameter of just 0.012. All observables are defined as per data transformations.

skilled migrants tends to increase to economy-wide wage level in the economy by reducing the per capita level of effective labour.

7.1. Sensitivity analysis: Trans-Tasman and non-Tasman migration

The VAR analysis explores the effects of different types of migration, distinguishing between net trans-Tasman, net Non-Tasman and total net migration flows. In this section, we re-estimate the DSGE model using both non-Tasman and Trans-Tasman migration. The posterior mean of the parameter values of the models are largely unchanged, except for the standard deviation of the migration shock, which in both cases is now only about 1/2 as volatile as in the baseline case of total net migration.[19] With migration smaller and less volatile than before, it is not surprising that the contribution of the migration shock to the volatility of GDP is lower in these specifications of the model. Shocks to non-Tasman and to Trans-Tasman migration account for between 5% and 12% of the volatility of GDP. In terms fo the forecast error variance decomposition, non-Tasman and trans-Tasman migration make very similar contributions the variable in our estimation exercise.

7.2. Labour supply versus migration shocks

In this section, we examine whether the migration shock can be identified independently from a labour supply shock. A labour supply shock is introduced in the model as a shock that affects the dis-utility of labour; entering the household's utility function as j_t^n, which is assumed to follow an AR(1) process similar to the other driving factors of the model.

$$U_t = \left(j_t^c \ln c_t + j_t \ln h_t - j_t^n \frac{\phi_0}{1+\eta} (n_t + s_t)^{1+\eta} \right) \tag{41}$$

The additional shock requires an additional observable. We examine both data on real private sector wages and average weekly paid hours as observables. Using data on wages and hours, we also attempt to estimate χ, the relative level of migrants' human capital. The estimation results of our sensitivity exercises are summarised in Table 10 which reports the variance decomposition of GDP at the posterior mean for the various estimated models.

Adding a labour supply shock and either real wages or hours as an observable does not affect the contribution of migration shocks to the variance of GDP. As in the baseline model, migration shocks account for about a 1/5 of the variance of GDP. Estimating χ, using either real wages or weekly hours as an observable does, however, result in a reduced contribution of GDP. In both cases, the mean contribution of migration shocks the variance of GDP drops to about 10%. Using wages data, the mean posterior estimate of χ is 1.52 and 1.36 using data on hours. Fig. 10 shows that for largely unchanged model parameters, a lower χ implies a smaller role of migration shocks to the dynamics of the business cycle. The estimates of χ are, however, subject to very large error bands and include our initial calibrated value in the 90% confidence interval.

The final row in Table 10 explores the consequences of letting migration be affected by the lag of domestic GDP growth. Our VAR analysis suggests a coefficient on lagged GDP growth of 0.014, which we take as our prior in the estimation. Allowing for modest feedback from GDP growth to migration raises the contribution of migration shocks to the variance of GDP from a mean of 19% in the baseline model to 33%

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[19] The tables containing the estimated parameter values for this estimation is available upon request.

8. Conclusion

Migration shocks matter for the business cycle. Using a dynamic stochastic general equilibrium model of a small open economy estimated on data for New Zealand, we find that migration shocks account for a considerable proportion of the variability of per capita GDP. For the components of per capita GDP, migration shocks matter, but are not the key drivers. Even for residential investment and real house prices, migration shocks are important, but by no means the key driver of the variation in these variables.

An unexpected positive migration shock is found to be expansionary in terms of per capita real GDP and its components and is associated with an initial appreciation of the terms of trade. As expected, migration benefits the owners of fixed assets such as capital or housing: the returns on these assets rise with an influx of migrants. The return on human capital is also affected by the relative human capital of migrants versus locals. If, as in our case, migrants have an initially higher level of human capital than locals, the real wage, or the return on effective labour falls.

T he relative level of human capital of migrants also affects the extent to which migration shocks contribute to the volatility of per capita GDP. We conduct a sensitivity analysis on the relative level of human capital. We find that the impact of migration shocks for the business cycle is much diminished if new migrants and locals have similar levels of human capital. When we assume that migrants have the same level of human capital as locals, migration shocks make only a minor contribution to the variances of per capita GDP and other macro variables.

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