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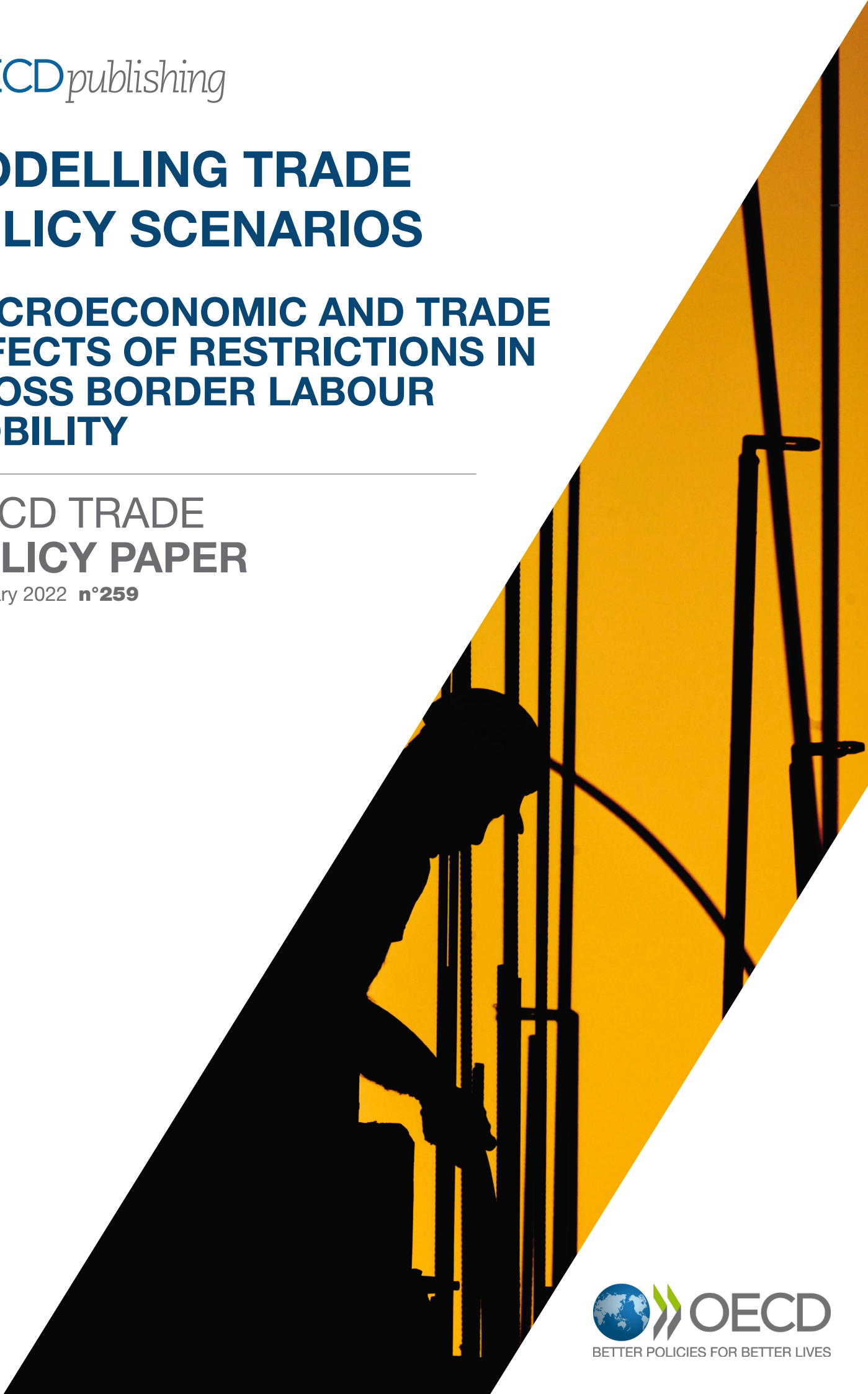

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Modelling Trade Policy Scenarios: Macroeconomic and trade effects of restrictions in cross border labour mobility

Donal Smith, Przemyslaw Kowalski and Frank van Tongeren

COVID-19 has drawn renewed attention to the economic importance of cross border mobility. Frictions in cross border mobility of labour can substantially impact the economy and international trade, by causing a long-term decrease in net migration that would alter the labour supply in many economies. To capture these macro-economic and trade effects, a global macroeconomic model (NiGEM) and a general equilibrium trade model (METRO) were used to simulate a stylised scenario equivalent to a 20% reduction in net-migration accumulated over the past ten years for all economies and regions. In OECD countries, this would translate into a reduction of the overall labour supply, and this shock would shift some economic activity towards non-OECD countries. At the sectoral level, exports of labour intensive manufacturing activities in OECD countries would contract, with electronics (13% of the total reduction of exports in the long term), automobiles (12%) and pharmaceuticals (9%) among the most affected.

Keywords: International trade, international labour mobility, sectoral economic effects, computable general equilibrium model, NIGEM macroeconometric model, METRO model

JEL codes: F22, F47, C63, E10, N10

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Executive Summary

COVID-19 has focused renewed attention on the economic issues around cross border mobility of labour. The note summarises the main insights from a modelling scenario where increased frictions on cross border mobility of labour are assumed to cause a long-term fall in net migration thereby altering labour supply in many economies.

Just as production in the global economy relies on significant and complex international flows of intermediate and final goods and services in global supply chains, it is also shaped by cross border flows of labour. Sizable shares of labour in many economies are of foreign origin. Reduced cross border mobility of labour could have lasting and varied effects on labour and product markets in both origin and recipient countries. Our simulations show that, even under conservative assumptions about the extent to which labour would be less able to move internationally in the next ten years, the shock would be large enough to weigh on macroeconomic variables such as the capital stock and could trigger a macroeconomic policy response. In addition, different sectors would be impacted to different degrees as they vary in their reliance on labour overall and on foreign-born labour in particular. Reduced cross border mobility of labour would cause strong reallocation effects between sectors with the potential to alter international trade flows.

Over the long-term, most OECD countries on net accumulate additional labour from international mobility flows. The results show that the OECD countries would suffer the most from a reduction in cross border labour mobility because for them the decline in mobility would translate into a reduction in overall labour supply. The shock would shift some economic activity away from OECD countries, with an expansion seen in many non-OECD countries. At the sectoral level, labour intensive manufacturing activities in OECD countries would experience the greatest contractions in exports of all sectors globally, with automobiles, electronics and pharmaceuticals among the most affected. The decline in exports in electronics could account for as much as 13% of the global reduction in exports in the long-term, with exports of automobiles and of pharmaceutics accounting for 12% and 9% respectively.

In order to unravel the macroeconomic and trade effects of such a scenario, the NiGEM macroeconomic model and the METRO trade model are combined in order to assess how a labour supply shock affects both long-term growth and sectoral and trade performance. The analysis underlying this note investigates a stylised scenario in which a reduction in cross border mobility is implemented as equivalent to a 20% reduction in net-migration accumulated over the past ten years for all economies and regions. The size of the shock is hypothetical but it is approximately equal to half the change in flows seen in some recent real world examples of substantial changes in mobility frictions, such as for example the increase in immigration in the five years following the 2004 enlargement of the European Union. METRO contains multiple categories of labour for each sector and bilateral product level trade flows which reflect countries' specialisation in products, including due to differences in intensities with which these require labour in their production and countries' labour endowments. NiGEM distinguishes between different types of capital and their uses and is used to capture capital stock changes that are fed into the METRO simulation.

This note therefore fulfils two purposes: (i) it presents a new modelling approach that can be used for further scenario analysis involving changes to labour and capital stocks and looking into sectoral adjustments and wider long-term economic impacts; (ii) the new modelling approach is applied and tested for a scenario of relevance for the post-COVID-19 world, i.e. a reduction in cross-border labour flows, and implications for OECD countries.

1. Introduction

This note explores the potential economic impact of long-term frictions on international mobility of labour at both the sectoral and macroeconomic level. Just as production in the global economy relies on significant and complex international flows of intermediate and final goods and services in global supply chains, it is also shaped by complex cross border flows of labour. Mobility of labour has many social and economic implications. This note concentrates on just one dimension: how a long-term decrease in cross border mobility could alter net migration flows and thus the supply of labour in internationally integrated economies, and the potential consequences for patterns of production and trade. Indeed, a situation where COVID-19 restrictions impact long-term mobility trends, and thus the overall labour supply, with a knock-on effect on the sectoral structure of economies, has been highlighted as a policy concern (OECD, 2020[1]).

The pandemic is having large consequences for cross border movements. Following the pandemic, almost all OECD countries have restricted admissions to foreign nationals. As a broad indication of one aspect of mobility, issuance of new visas and permits collapsed by 46% in the first half of 2020 relative to the same period in 2019 (OECD, 2020[2]). This represents the largest drop on record.

On the labour supply side, the new reality resulting from the pandemic is likely to discourage migration as all three classic migration costs identified for example by Borjas (1999[3]), could increase with COVID-19: (i) direct costs to transportation of goods and people; (ii) foregone earnings from unemployment during a potentially longer transition between markets; (iii) psychological costs from leaving family and social networks due to difficulty in travelling back to a home country and increased difficulty integrating due to social distancing rules. Even long established foreign-born workers, such as those holding host countries passports, can experience additional costs as they or their families located in home countries cannot travel as easily. In the aftermath of the COVID-19 pandemic, governments may in future also come under pressure to reduce admittance of foreign workers due to a combination of potentially weak labour markets and public health concerns (Abella, 2020[4]).

Foreign-born workers account for significant shares of the population and labour supply in OECD countries; indeed the numbers in OECD labour markets have increased almost everywhere over the last 15 years. While 9% of the population in employment were foreign-born in European OECD countries in 2005, that share reached 14% in 2018. The corresponding shares were 16% and 18%, respectively, in the United States and 26% and 30% in Australia (OECD, 2020[1]). This long-term trend is unlikely to continue in light of the increased costs to migration identified in the paragraph above.

This note assesses how this potential change in migration patterns is expected to affect sectoral trade and wider economic outcomes by combining two quantitative models. NiGEM focusses on aggregate dimensions of economic growth such as labour and capital stocks and their utilisation, macro policy levers, like monetary and fiscal policy, and their link with the components of GDP and does not focus on sectors.[1] The METRO model, instead, allows for a focus on sectoral adjustments whilst simplifying some aggregate and dynamic effects. The effect of a reduction in cross border mobility is proxied by a stylised 20% decline in long-term net migration which is converted to a labour supply change and administered as an exogenous shock to both METRO and NiGEM. The calibration of the shock is necessarily stylised due to the uncertainty surrounding the long-term impact of the pandemic on mobility, it is approximately equal to half the change in flows seen in some recent real world examples of substantial changes in mobility frictions, such as for example the increase in immigration in the five years following the 2004 enlargement of the European Union.

The kind of restrictions on cross border mobility of labour that were introduced during the pandemic could well have different effects on different kinds of migrants. On the one hand, frequently travelling, or “short-

[1] A full description of the NiGEM model is given in NIESR (2017[19]).

term", economic migrants could have been more impacted by travel restrictions. On the other hand, several countries had exceptions for these kind of foreign workers (i.e. for seasonal workers in agriculture). The modelling abstracts from these important – but so far scarcely documented – differences and instead focuses on potential effects of decreased cross border mobility on long-term migration. The benefit of sacrificing this feature for a more general scenario is that it allows an illustration of the potential overall long-term changes in output and global trade patterns.

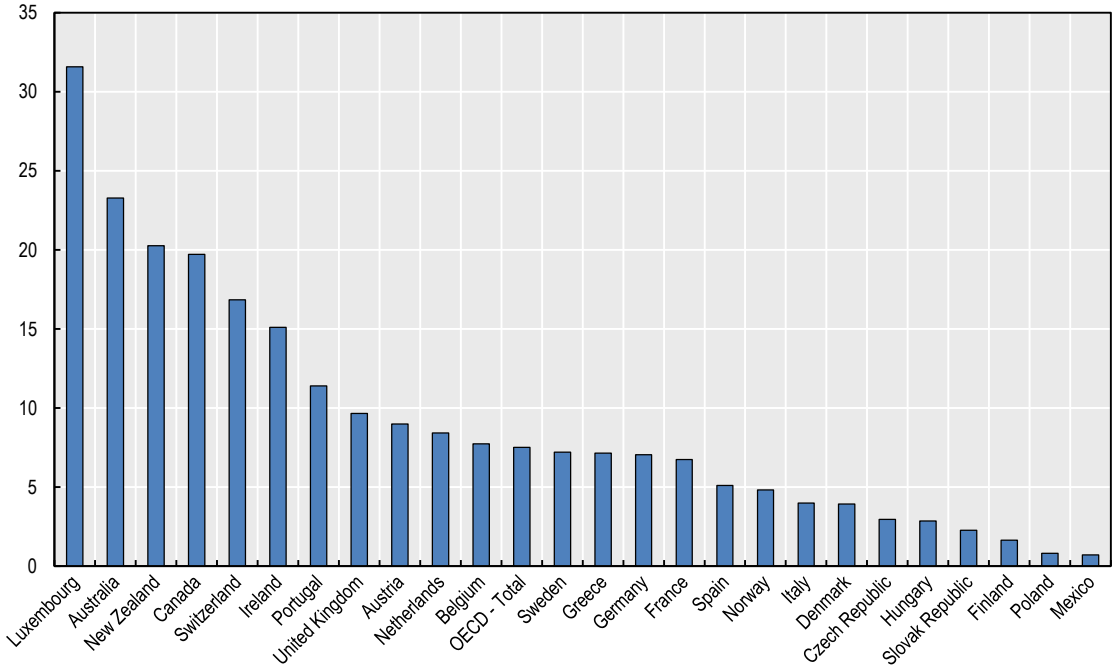
This analysis focusses on the trade and wider economic impact in a general equilibrium setting, and does not try to explain migration flows themselves. In general, the macroeconomic consequences of migration, and in particular the general equilibrium consequences are less well understood and much less studied (Smith and Thoenissen, 2019[5]). In the general equilibrium literature, the modelling of migration is typically stylised and takes the form of broadly calibrated shocks, situated in a medium- to long-run setting, with an emphasis on capturing the complexity of interactions between and within national product and labour markets. This approach has been used in a variety of policy applications. In OECD (2016[6]) an analysis of the long-term impacts of Brexit employed three migration scenarios. The shock was calibrated in the NiGEM macroeconomic model according to an optimistic, central and pessimistic scenario with a cut in net migration of 56 000, 84 000 and 116 000 persons respectively. Taking average net migration from 2006-2016 this was equivalent to – and was implemented as – respectively, a 23%, 34% and 67% cut in net migration (Sumption and Vargas-Silva, 2020[7]). Also in the Brexit context, Lisenkova et al. (2013[8]) employed an OLG-CGE model and calibrated an illustrative 50% reduction in UK net migration. The results of this study showed a strong negative economic effect through labour supply. In IMF (2020[9]) projections for future global net migration flows were estimated based on key drivers such as, geographical and cultural barriers, demographic trends, conflicts and climate change. These figures were then used to calibrate a general equilibrium macroeconomic model. To study the 2015 refugee influx into Germany Stähler (2017[10]) used a dynamic general equilibrium model. The simulation made the stylised assumption that refugees equal in number to 1% of the native German population migrate to Germany and stay long-term.

The analysis in this note complements this literature by presenting a similarly stylised shock to mobility which is global, calibrated for individual countries and regions, uses the latest international migration statistics and is differentiated by occupation and skill type. These features of the shock to international labour mobility and its application in a microfounded global trade model which reflects pre-pandemic trading relationships, allows the analysis to capture highly differentiated impacts at the sector level that subsequently translate into potential trade impacts.

The scenario takes into account the varying degrees of reliance on internationally mobile labour across sectors and OECD countries. This reliance is measured by the share of foreign-born labour in a sector's overall employment (Figures 1 and 2). International trade theory suggests that patterns of trade reveal a combination of varying intensities with which production in different industries use different factors of production and differences in countries' endowments of these factors. The differences in shares of foreign-born workers across sectors observed in the data then suggest differentiated impacts of restrictions to movement of labour across sectors and countries through changes of relative factor endowments (Rybczynski, 1955[11]). In line with this view, the size of output reductions would be greater the more a sector relies on foreign-born workers.

Figure 1. Foreign-born workforce of technicians and associate professionals

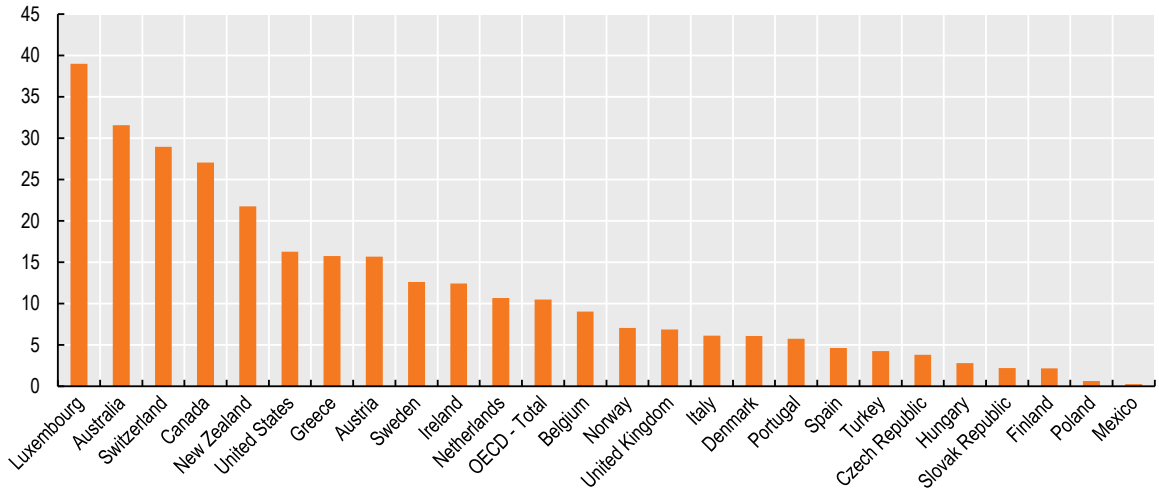
% of total



Source: OECD Database on Immigrants in OECD and non-OECD Countries (OECD DIOC, https://www.oecd.org/els/mig/dioc.htm).

Figure 2. Foreign-born workforce in manufacturing

% of total



Source: OECD Database on Immigrants in OECD and non-OECD Countries (OECD DIOC).

2. Mobile labour in the METRO trade model and in the NiGEM macroeconomic model

A long-term decline in labour mobility affecting labour supply is a scenario where the strengths of two different modelling approaches can be combined to provide a more comprehensive economic impact assessment. From a microeconomic perspective, the detail and micro foundation of METRO is well suited to provide insights in to the drivers and outcomes of the reallocation of resources and its effects at the sectoral level. METRO includes bilateral product level detail on trade in intermediate and final goods and so can trace the impact throughout the value chain. A restriction on labour mobility can be implemented in METRO at the sectoral level taking into account the proportion of mobile labour in each of five skill categories in each sector. The model can thus capture the sectoral heterogeneity of impacts of restricted mobility that arises from different reliance on foreign-born labour.

From a macroeconomic perspective, given the scale of reliance on foreign-born labour, if lower international mobility persists there are potentially large macroeconomic consequences with a response in capital accumulation and monetary policy. Past labour supply shocks have had a substantial impact on output, accounting for over 70% of output fluctuations in the United States and European Union (Smets and Wouters, 2005[12]).[2] To calibrate the adjustment of capital stocks in the scenario, the NiGEM macroeconomic model is used.[3]

The advantage of NiGEM for the applied scenario is that macro relationships for a large number of economies, at considerable detail, are already specified and the model can easily be aggregated to fit the country detail used in METRO. A further advantage is its modelling of the dynamics of the capital stock. This is important as a shock to labour will result in adjustments to capital, especially when there is enough time to adjust, so changes in the capital stock are an important adjustment mechanism (D'auria, Morrow and Pichelmann, 2008[13]; Dustmann, Glitz and Frattini, 2008[14]).

In NiGEM, the long-run equilibrium output of the economy is tied down by a production function. The production function describes the supply-side where real output depends on the total capital stock, the stock of labour (total hours worked), an index of labour augmenting technical progress and oil input.[4] Thus a shock to either capital or labour will exert a strong influence over key model variables. In the short run, GDP is driven by demand, and the model returns to equilibrium after a shock by an error-correction structure so that the supply side determines the long-run equilibrium.

The dynamic linkage between labour supply and capital stock in NiGEM runs through wage inflation and investment. A shock that reduces the supply of labour would lead to higher wages. An increased cost of hiring and upward revisions of inflation expectations will supress employment, lower consumption and lower exports and hence reduce output. Investment follows pro-cyclically and responds to those conditions in the economy, and accumulates into the capital stock. Hence, in the longer-term a reduction in labour supply reduces potential output and in its wake the long-term optimal capital stock will reduce as well.[5]

[2] The size of the labour force is also a determinant of the level of potential output which measures the economies overall capacity and is an important fiscal policy parameter (Rawdanowicz, 2014[26]).

[3] Further details on the NiGEM model are given in Annex B.

[4] For details, see Annex B.

[5] In NiGEM the capital stock is composed of private sector capital and government capital. Private sector capital contains business and housing capital. Demand for capital is determined by profit maximisation of firms, implying that the long-run capital output ratio depends on the real user cost of capital. The user cost of capital in turn is a function of, the long-term rate of interest, the investment premium, the corporation tax rate, the equity price risk premium and a depreciation rate that is specific to the type of capital. Many of these are financial variables and are not typically modelled in the CGE approach.

2.1. Combining METRO and NiGEM for a more comprehensive quantification

In METRO, simulations typically represent medium-term adjustments to shocks, under an assumption that production factors are mobile across sectors, but there is no capital accumulation. There are different mechanisms at work in the modelling approaches. In METRO, investment demand does not accumulate into a capital stock as it does in NiGEM. This feature can cause an issue for the proposed mobility scenario, as in the long-term, the adjustment of the two key components in an economies production function will be a primary transmission mechanism

The capital adjustments from NiGEM can be used in METRO. Using NiGEM to calibrate a shock in METRO is a different approach to cross calibration than previously used in analysis which combines METRO and NiGEM. In other cases, results from METRO were "plugged" into NiGEM. For example, detailed tariff and non-tariff trade shocks were implemented in METRO, and the results for imports and exports were then used to calibrate a trade shock in NiGEM (Kierzenkowski et al., 2016[6]; Arriola et al., 2018[15]).

Accounting for capital stock changes in METRO also allows a conceptual extension of the time-horizon in METRO to be of a long-term nature.[6] Another benefit is that accounting for capital stock changes will not simply alter the level of the shock in METRO, but may also change the ranking of the impact on economies. This can be due to differences in economy-specific capital accumulation effects, which in turn stem from different capital accumulation equations or from different proportions of capital types (housing, government and business) in total capital, which can reflect economies' different product specialisation. Compositional differences can dampen or amplify the impact of a labour supply shock on GDP in a given economy due to different adjustment rates. For example, with a fall in labour mobility that reduces the size of the labour force, and hence output, the housing and government capital stock can be slower to adjust than the business capital stock. This can leave the capital-labour ratio elevated, increasing productivity and cushioning the overall impact on the economy (Barrell, Fitzgerald and Riley, 2010[16]).

2.2. Model aggregation for a mobility scenario

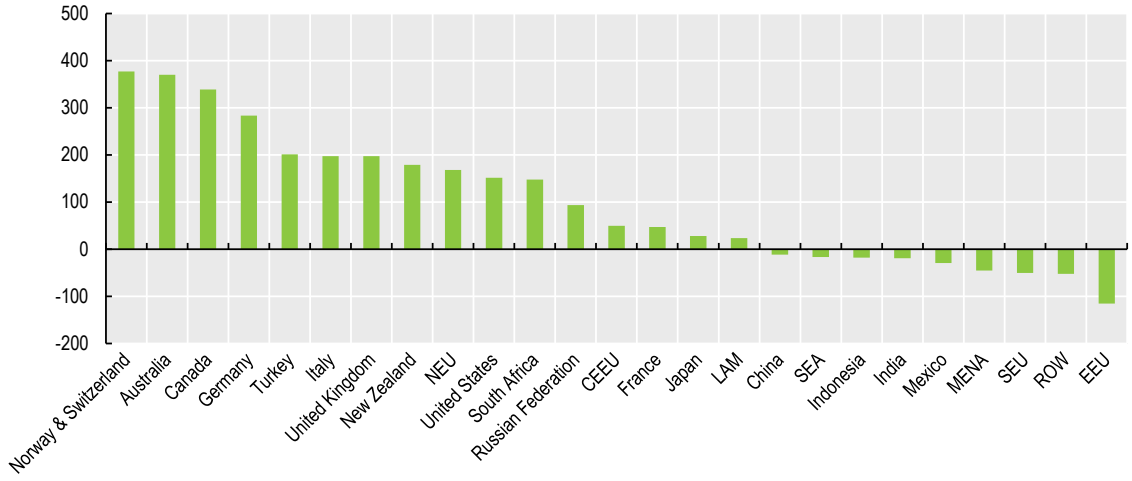
A first step in combing the models is aggregation of economies and regions. METRO is calibrated for this analysis to 18 economies and regions, 26 sectors, and 8 production factors (OECD, 2020[17]).[7] Importantly for this scenario, METRO includes five skill types of labour for each economy and region, allowing the mobility shock to be mapped in a way that will have sectoral impacts. The aggregation is chosen to group geographical areas with similar long-term patterns of net migration inflows or outflows (Figure 3). The economy and region aggregation in NiGEM closely follows METRO.[8]

[6] The static capital stock is one of the features that defines standard METRO results as medium term.

[7] The country aggregation is listed in Annex Table A1. Sectors, and their abbreviated names, are listed in Annex Table A2.

[8] NIGEM and METRO regions do not exactly match as the underlying databases do not contain the same economies. This is the case for non-OECD countries. Where there is not an exact overlap, the economies that are present are used to represent an aggregate region and, in a minority of cases, imputed values are used.

Figure 3. Net migration per 100 000 of total population, average over 10 years to 2020



Note: For details of the aggregation of regions see Annex Table A1. In the data used for calibrating the shock net migration sums to zero across economies and regions, all movement out must equal all movements in. The numbers in this figure do not sum to zero as it is scaled by population and there is a large disparity in the population sizes. For example, the absolute volume of net outflows from the People's Republic of China are larger than the combined volume of inflows in Norway, Switzerland and Australia.
Source: United Nations data and OECD staff calculations. See Annex A for more details.

2.3. Calibrating the international labour mobility shock in METRO

The long-term international mobility shock is proxied in METRO through an assumed percentage reduction of bilateral net-migration flows. This proxy is used to give the scenario a grounding in current average levels of mobility globally. The scenario is not a model of migration and does not attempt capture all the complexities of flows. The proxy does however quantify relative levels of mobility across economies and whether they are on average net senders or receivers.

The shock implemented is equivalent to a 20% reduction in bilateral net-migration accumulated over ten years for all economies and regions.[9] This stylized size of shock is chosen as it is currently not possible to provide an evidence based number for the potential longer-term impact on global mobility from disruptions related to the pandemic. This stylised shock is nevertheless in line with the migration shocks used in the literature.[10] The shock is approximately equal to half the change in flows seen in some recent examples of substantial changes in mobility frictions. For example, taking a five-year average, net immigration to the United Kingdom was found to increase by 50% after the 2004 enlargement of the European Union (Sumption and Vargas-Silva, 2020[7]). The calibration of the modelled shock is designed to reflect long-term effects and it does not capture very short-run and potentially acute seasonal movements of labour, such as for example those sometimes seen in agriculture. For economies in the European Union it is assumed that within the European Union mobility shrinks by as much as international mobility in general.

The starting point for the calculation of the long-term shock is average bilateral net migration over the past ten years as a proportion of the population in each economy and region (Figure 3). The 20% reduction in the flows is distributed back to source economies through a bilateral migration flows matrix. Any increase or decrease in these flows is allocated to source and destination economy where it, respectively, adds to

[9] Details of the sources of data used are given in Annex A.

[10] See IMF (2020[9]), Barrell et al., (2010[16]), Lisenkova et al., (2013[8]) and Kierzenkowski et al., (2016[6]).

or subtracts from labour supply, and globally the movements sum to zero.[11] Adjustments are then made according to age profile and labour market participation rates to refine the population movement into a contribution to the labour market.

The bilateral migration matrix contains data on migration flows between source and destination economies.[12] These bilateral flows are aggregated for each of the source and destination economies in METRO. In this sense, only the net effect of bilateral flows is reflected and no differentiation between different bilateral flows is made in the assumed percentage reductions. While this assumes away an important reality of the COVID-19 related mobility restrictions which varied depending on source and destination of travelling migrants (e.g. weaker restrictions on movement within the European Union Schengen area than on external movements),[13] the calculation of migration shocks on the basis of the bilateral migration matrix allows the balance of these flows at the global level to be preserved and thus allows some of the important complexity of migration flows to be captured at the shock calibration stage.

Not all migrants will enter the labour market and migrant employment rates have considerable variation within the OECD. Illustrative rates are 80% in New Zealand, 67% in France and 51% in Turkey, on average over time. Differences will have an impact on how mobility flow changes translate into labour market impacts. Age profile differences have a similar effect. The age adjustment is proxied by the proportion of migrants in the 15-64 age bracket. This varies across OECD countries with 88% of migrants to Italy being of working age as compared to 75% in Australia and 41% in Mexico.[14]

Finally, and to capture the sectoral and trade flows impact, and to better reflect the skill occupational characteristics of migration flows, the overall migration-related labour shock is mapped to five labour skill categories accounted for in METRO.[15] See Annex C, Table C1 for more details.

Mobile workers are allocated into skill categories based on the GMig2 database which quantifies the proportion of migrant labour (defined as foreign born in the database) in each skill category in each economy (Walmsley, Aguiar and Parsons, 2021[18]). For example, in an economy where a cut in mobility that results in 1 000 fewer workers and 20% of foreign-born are in the "Technical and Assistant Professionals" the labour force in this category will fall by 200 workers. The reduction is thus differentiated by skill category and economy and this manifests itself in a heterogeneity at the sector level.[16] This illustrative calibration abstracts from some important aspects of the dynamics of labour mobility. In particular, it abstracts from the dynamics of mobile workers transitioning between skill categories over time

[11] Net flows as a per cent of the total population in each economy are kept constant in the calibration. This implies a simplifying assumption that population growth rates are the same in each economy. If the population of one economy was growing relative to another this could alter the ratio of flows to population over time. For further details on the calculation of the shock, see Annex A.

[12] In Barrell et al., (2010[16]) the changes in the stock of migrants is used due to the volatility of flows data. Flows data are used here as over the longer time horizon it is found flows and changes in stock series converge. The matrix is constructed from Abel and Cohen (2019[21]). This data contains bilateral international migration flow estimates for 200 countries for five-year periods between 1990 and 2020.The advantage of flows data is it gives an up to date picture of current source and destination linkages. An economy may have a large stock from a source country that reflects movements from several decades in the past.

[13] It reflects the limits of the METRO model on international labour flows (while remittances, which are a part of a household income, can be tracked on a bilateral basis, migration *per se* is not and it can only be reflected as a plain labour supply shock).

[14] The simplifying assumption is that mobility adds a fixed amount to the labour market and entry and exit from the labour market for this cohort sum to zero.

[15] The skill categories are (1) Technical and Assistant Professionals, (2) Clerks, (3) Service and shop assistants, (4) Office managers and Professionals and (5) Agricultural and other low skilled workers.

[16] Within each of the skill categories it is assumed that migrant and native workers are equally productive and perfect substitutes.

as they become more established in host economies. It also rules out feedbacks where a movement of workers may impact on labour market conditions and these in turn change the size or direction of mobility flows.

To determine capital stock changes, the same mobility shock is simulated in NiGEM as in METRO. NiGEM does not contain the same detail of skill categories as METRO and so the shock is applied to the total population. The shock is applied gradually and accumulates to the calibrated change after ten years. The capital stock changes resulting for the NiGEM simulation are aggregated into METRO regions and translated into a capital stock shock in METRO.[17]

3. The impact on trade patterns of long-term changes in international labour mobility: A 20% reduction in net migration over 10 years

3.1. Investment and capital stock impact in the macro model

In NiGEM, the reduction in mobility results on average, in an increase of wages across the economies which are net recipients of mobile labour and a fall in wages in economies which are net senders. In the economies where past migration has increased the size of the labour force, the contraction and the rise in wages supress output. Increased wage rates contribute to a rise in inflation. Firms respond to rising wage costs by reducing employment. The fall in employment and rising inflation leads to a fall in exports and consumption, typically the largest component of GDP.

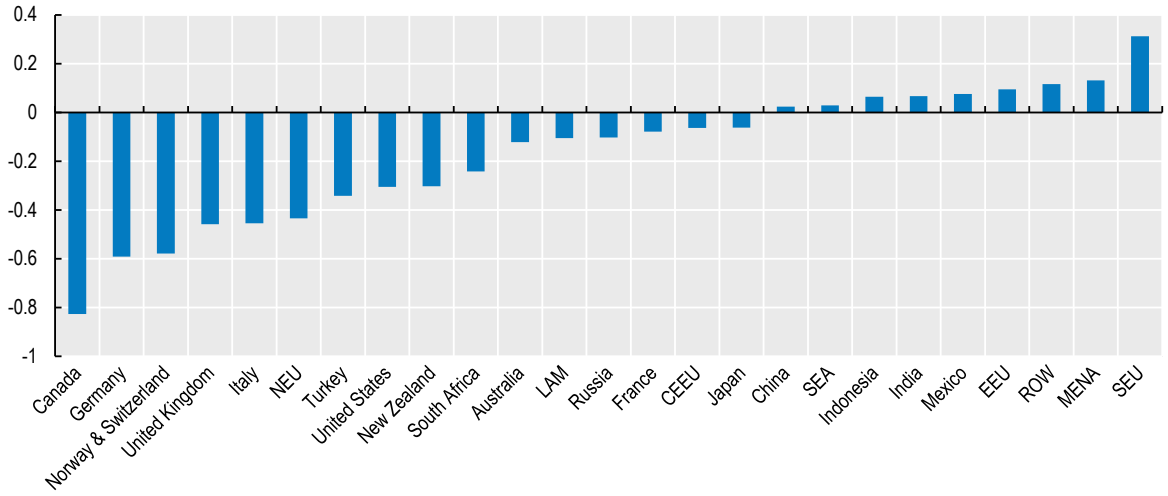
Firms react by cutting back on investment. Across the economies experiencing a reduction in labour supply, monetary policy reacts to support output. Central banks cut the interest rate and this stimulates consumption. In addition, the cut in the interest rate acts to reduce the user cost of capital. Both the consumption and capital cost effect partially mitigate the decline in investment. Over the longer-term, the reduction in labour impacts the economy's supply side and potential output declines. In highly impacted economies such as Australia, Germany and Canada the fall in potential output from base over the long-term ranges from 0.4% to 0.6%. Firms adjust their inputs in line with this change and there is a long-term reduction in the capital stock (Figure 4).[18]

[17] For a small subset of economies NiGEM does not contain a capital accumulation equation. In this case the capital stock fall is estimated based on a regression of capital stock to labour supply changes in the other economies.

[18] Private investment is not modelled specifically for all economies and regions in the METRO aggregation. In these cases values are imputed based on the average relationship between the change in labour supply and investment in other economies in NiGEM.

Figure 4. Private sector investment in NiGEM

Average % change from base after 10 years



Source: OECD, NiGEM model simulations.

3.2. Investment and capital stock impact in METRO

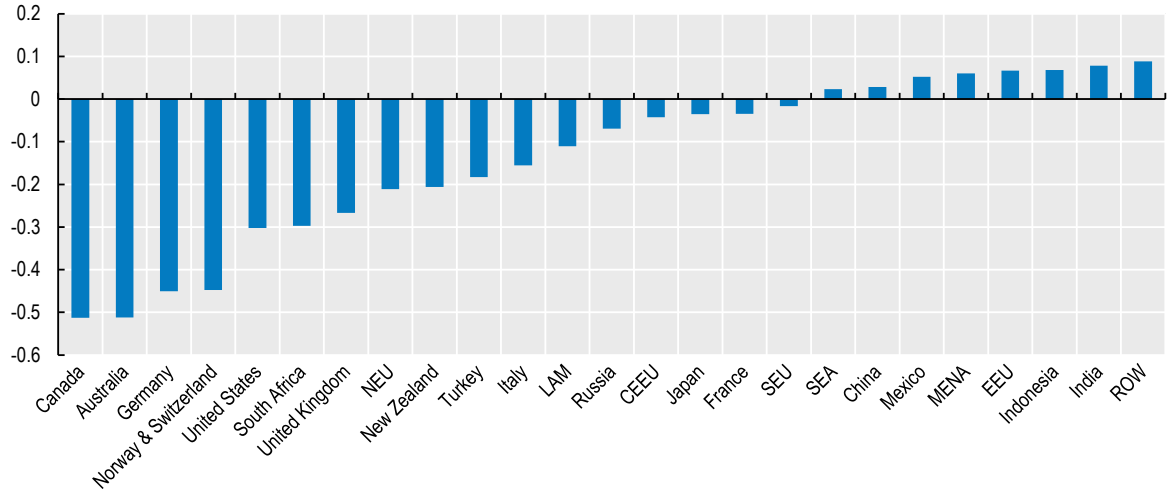
In METRO the mobility scenario produces a fall in investment demand across economies and regions, similar to that seen in NiGEM (Figures 4 and 5). However, in METRO investment and savings are tied together as an equilibrium condition. Changes in these variables depend on specific model closures where either investment or savings adjust. The closure chosen here keeps investment fixed as a share of final demand. Hence, in economies that add labour, investment increases with growing final demand, while investment declines in economies that reduce labour.[19]

However, in the standard METRO setup, investment demand does not accumulate into changes in capital stocks as in NiGEM. Therefore, to both capture the changes in capital stocks and to have their movements tied to equilibrium changes in the production function, the NiGEM results for capital are used as an additional exogenous driver in METRO to complement the labour force shock.

[19] Given the savings equals investment identity must hold, and the chosen closure stipulates that the level of investment must remain a fixed share, the increase household income and savings is met with an equal fall in the household savings rate. In effect the model imposes a counter–cyclical savings response, which is also observed during the COVID-19 crisis. Typically savings are found to be pro-cyclical (Lane and Tornell, 1998[27]).

Figure 5. Investment in METRO

% change from base after 10 years



Source: OECD, METRO model simulations.

3.3. The trade and economic impact in METRO

The overall economic impact is summarized in the change in real GDP from base levels (Figure 6). The results show that the OECD countries, the majority of which add to their stock of labour from international mobility, would suffer most economically from reduced flows. The shock would relocate economic activity away from OECD countries in the long-term, with an expansion seen in many non-OECD countries. These economies experience an increase in their stock of labour as migration flows slow down. This increases potential output and competiveness through reduced wages. A similar pattern to the GDP impact is seen for trade (Figure 7). Exports and imports decline in most OECD countries. Highly impacted economies would include trade intensive economies of Europe (Germany, Norway, Switzerland and the North EU region).

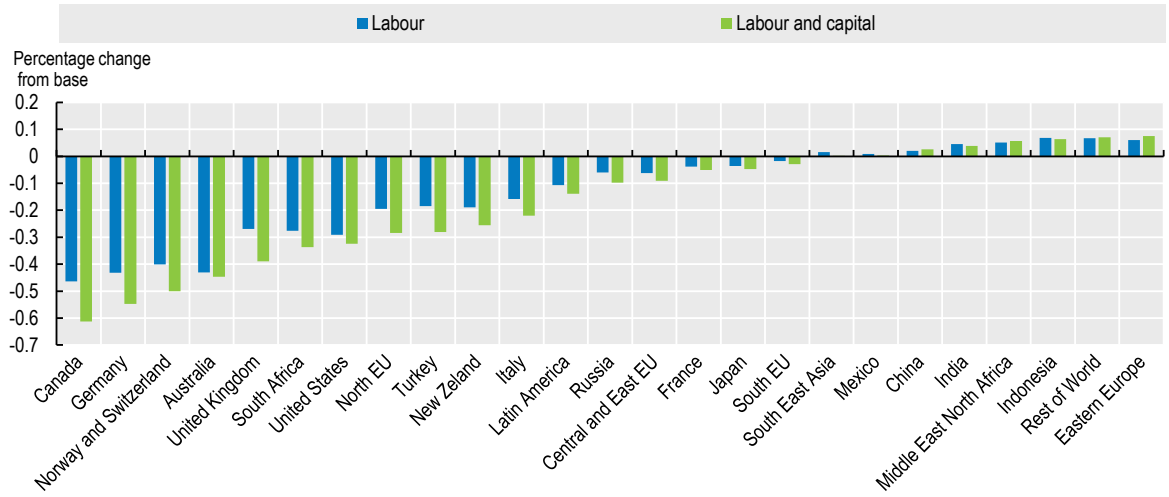
The changes in imports and exports are driven by different factors. Imports depend on consumption which in turn depends on household income. The steepest declines in imports occur in the economies with the largest reductions in the labour force, and hence the largest drop in household incomes. The distribution of the shock by labour skill category also impacts the decline. In Canada, for example, there are larger declines in the higher earning categories as compared to another economy such as Germany which also sees a comparatively large drop in labour. Exports depend on competiveness and external demand. The importance of external demand is illustrated by the results for Canada and Australia. Both experience a comparatively large reduction in mobility flows but the export decline in Australia is dampened by the fact that its largest export markets, the People's Republic of China (hereafter "China"), Rest of the World and Japan, either grow or have a comparatively small reduction in GDP. Canadas main export market, the United States experiences a relatively large contraction in GDP. Mexico is an economy that gains labour in the scenario but its imports and exports decline due to its share of exports going to the United States.

Results show the impact of the scenario with the labour calibration only, and with labour and capital. The addition of the capital channel not only increases the size of the response, but also changes the ranking of the impact on economies. In the scenario with only the labour stock change, the United States has a larger per cent reduction from base GDP than the United Kingdom (Figure 6). With the capital change included, this is reversed and the United Kingdom is more impacted, reflecting the different proportions of

government, housing and business capital in the capital stocks in both economies and the stronger estimated reaction of business capital in the United Kingdom to the scenario compared to business capital in the United States.

Figure 6. GDP impact of a reduction in labour mobility through labour and capital

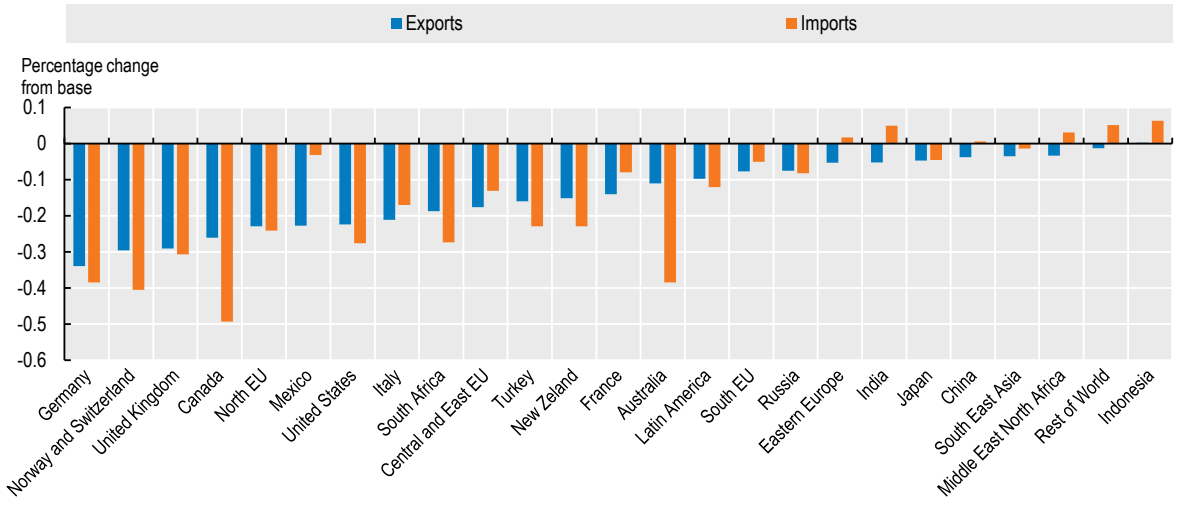
% change from base



Source: OECD, METRO model simulations.

Figure 7. Response of exports and imports to a long-term reduction in mobility

% change from base



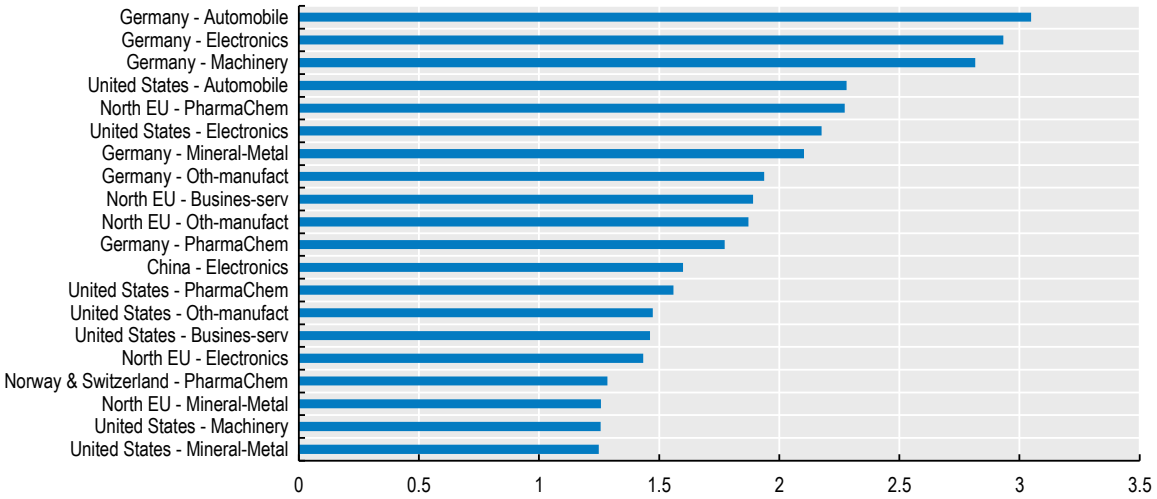
Source: OECD, METRO model simulations.

3.4. A reduction in net migration disproportionately impacts labour intensive sectors

The change in mobility has a heterogeneous impact at the sector level (Figure 8). To rank the most impacted sectors, the absolute change in exports of each sector is measured as its share of the decline in total global exports. The reduction in mobility will cause an absolute decline in exports globally. This ranking is done to eliminate sectors that may display large changes but which have a low level of trade and so focusses the results on the large scale global trends.[20] It can be seen that the most impacted sector, the German automobile sector, accounts for just over 3% of the total decline in exports globally in the scenario. The ranking highlights the scale of the absolute fall in trade in a large sector in a major trading economy. The reduction in exports is strongest in manufacturing sectors in OECD countries but there are also some knock on effects in other economies in globalised sectors such as Electronic equipment in China.[21] Consistent with the transmission in the macroeconomic model, the reduction in mobility reduces the stock of labour which in turn increases wages. The wage rise is stronger in economies with a higher concentration of foreign-born labour and historically larger inflows. For example, in the scenario, in some sectors, the wage rises seen in Germany are double those in France. Labour is assumed to be mobile across sectors in the scenario and so mobility changes will also spill over to other labour-intensive sectors which may have a low concentration of foreign-born workers.

Figure 8. Global sectoral realignment: Export impact ranking of manufacturing and service sector

% share of total global export reduction



Note: Numbers for each economy are given for the purpose of a ranking. The ranking is constructed as the decline in an economies sectoral exports from base as a share of the total decline in world exports.
Source: OECD, METRO model simulations.

[20] The ranking also eliminates smaller sectors that account for less than 2% of the share of total exports in each economy.

[21] The negative effect on exports of electronics from China is a combination of several effects. The declining GDPs in OECD economies reduce consumption of electronics which often come from China. In addition, the declining electronics production of OECD economies has a negative impact on China's exports of intermediate products in this sector.

The aforementioned comparative advantage mechanism stemming from sectoral factor intensities and economy factor endowments can be shown by the distribution of sectoral value added impacts where economies are ranked by the size of the labour shock (from positive to negative) and sectors are sorted by average rank in capital labour ratio at base (Figure 9).[22]

Figure 9. Factor intensities in practice: Effects of the COVID mobility shock by sector according to sectors' labour intensity

% change in sector's value added relative to the base, scenario with capital accumulation

	Textile and wearing apparel	Machinery and equipment	Motor vehicles and parts	Education	Electronic equipment	Hospitality	Agriculture	Pharmaceuticals Chemicals	Natural resources	Mineral and metal products	Transport services	Food and beverage	Other manufacturing	Construction	Financial services and insurance	Business services	Trade and storage	Other services	real GDP impact labour&capital
Eastern Europe	0.03%	0.08%	-0.06%	0.12%	-0.06%	0.12%	0.04%	0.00%	-0.03%	0.05%	0.06%	0.09%	0.01%	0.10%	0.10%	0.08%	0.07%	0.11%	0.07%
Rest of World	0.06%	0.11%	0.11%	0.12%	0.06%	0.11%	0.06%	0.08%	-0.05%	0.09%	0.06%	0.10%	0.08%	0.10%	0.10%	0.10%	0.09%	0.10%	0.07%
Indonesia	0.02%	0.08%	0.07%	0.12%	0.08%	0.09%	0.02%	0.04%	-0.03%	0.09%	0.06%	0.04%	0.04%	0.08%	0.08%	0.04%	0.07%	0.09%	0.06%
Middle East North Africa	0.03%	0.13%	0.06%	0.07%	0.05%	0.09%	0.05%	0.01%	-0.06%	0.07%	0.03%	0.08%	0.03%	0.07%	0.07%	0.06%	0.07%	0.07%	0.06%
India	-0.03%	0.04%	0.07%	0.07%	0.01%	0.14%	0.01%	0.04%	-0.05%	0.05%	0.04%	0.04%	0.01%	0.06%	0.06%	0.05%	0.09%	0.06%	0.04%
China	-0.02%	0.04%	0.06%	0.04%	-0.01%	0.04%	0.01%	0.02%	-0.02%	0.03%	0.02%	0.03%	0.00%	0.03%	0.03%	0.03%	0.03%	0.04%	0.03%
Mexico	-0.01%	-0.16%	-0.19%	0.01%	-0.32%	0.08%	0.00%	0.02%	-0.09%	-0.05%	0.05%	0.07%	-0.01%	0.05%	0.03%	0.02%	0.01%	0.04%	0.00%
South East Asia	-0.08%	0.02%	0.03%	0.02%	-0.03%	0.02%	0.01%	-0.01%	-0.05%	0.02%	-0.03%	0.02%	-0.03%	0.02%	0.01%	0.01%	0.01%	0.01%	0.00%
South EU	-0.06%	0.01%	-0.12%	-0.04%	-0.04%	-0.02%	-0.04%	-0.09%	-0.14%	-0.03%	-0.06%	-0.02%	-0.05%	-0.03%	-0.02%	-0.03%	-0.02%	-0.03%	-0.03%
Japan	-0.04%	-0.04%	-0.06%	-0.07%	-0.04%	-0.04%	-0.02%	-0.03%	-0.14%	-0.04%	-0.05%	-0.03%	-0.06%	-0.05%	-0.04%	-0.04%	-0.04%	-0.06%	-0.05%
France	-0.10%	-0.05%	-0.18%	-0.08%	-0.10%	-0.02%	-0.05%	-0.15%	-0.17%	-0.07%	-0.05%	-0.03%	-0.09%	-0.04%	-0.03%	-0.04%	-0.03%	-0.06%	-0.05%
Central and East EU	-0.17%	-0.15%	-0.19%	-0.11%	-0.24%	-0.05%	-0.04%	-0.11%	-0.10%	-0.15%	-0.10%	-0.02%	-0.16%	-0.06%	-0.05%	-0.07%	-0.09%	-0.08%	-0.09%
Russia	-0.15%	-0.14%	-0.10%	-0.18%	-0.18%	-0.07%	-0.07%	0.04%	-0.06%	-0.13%	-0.12%	-0.09%	-0.09%	-0.13%	-0.08%	-0.10%	-0.08%	-0.15%	-0.10%
Latin America	-0.15%	-0.14%	-0.15%	-0.20%	-0.16%	-0.14%	-0.07%	-0.12%	-0.09%	-0.15%	-0.13%	-0.11%	-0.14%	-0.15%	-0.13%	-0.13%	-0.13%	-0.17%	-0.14%
Italy	-0.23%	-0.23%	-0.22%	-0.37%	-0.24%	-0.17%	-0.18%	-0.25%	-0.12%	-0.24%	-0.18%	-0.17%	-0.24%	-0.23%	-0.18%	-0.19%	-0.17%	-0.27%	-0.22%
New Zeland	-0.31%	-0.31%	-0.28%	-0.36%	-0.32%	-0.26%	-0.12%	-0.20%	-0.10%	-0.29%	-0.25%	-0.14%	-0.28%	-0.29%	-0.25%	-0.24%	-0.25%	-0.30%	-0.26%
Turkey	-0.22%	-0.17%	-0.21%	-0.48%	-0.18%	-0.31%	-0.17%	-0.22%	-0.16%	-0.23%	-0.24%	-0.21%	-0.25%	-0.28%	-0.28%	-0.28%	-0.25%	-0.37%	-0.28%
North EU	-0.27%	-0.27%	-0.27%	-0.42%	-0.30%	-0.24%	-0.21%	-0.23%	-0.12%	-0.30%	-0.25%	-0.21%	-0.29%	-0.33%	-0.23%	-0.26%	-0.24%	-0.36%	-0.28%
United States	-0.31%	-0.31%	-0.30%	-0.38%	-0.34%	-0.33%	-0.15%	-0.26%	-0.11%	-0.32%	-0.34%	-0.26%	-0.30%	-0.34%	-0.31%	-0.31%	-0.32%	-0.35%	-0.32%
South Africa	-0.39%	-0.35%	-0.32%	-0.48%	-0.35%	-0.33%	-0.22%	-0.30%	-0.12%	-0.28%	-0.32%	-0.31%	-0.32%	-0.37%	-0.33%	-0.32%	-0.30%	-0.41%	-0.34%
United Kingdom	-0.37%	-0.35%	-0.30%	-0.57%	-0.40%	-0.33%	-0.23%	-0.35%	-0.13%	-0.38%	-0.34%	-0.32%	-0.38%	-0.39%	-0.36%	-0.37%	-0.33%	-0.47%	-0.39%
Australia	-0.47%	-0.52%	-0.52%	-0.61%	-0.57%	-0.50%	-0.22%	-0.37%	-0.07%	-0.38%	-0.47%	-0.41%	-0.48%	-0.56%	-0.44%	-0.46%	-0.47%	-0.51%	-0.45%
Norway & Switzerland	-0.36%	-0.51%	-0.57%	-0.80%	-0.48%	-0.51%	-0.20%	-0.48%	-0.08%	-0.32%	-0.40%	-0.38%	-0.48%	-0.57%	-0.44%	-0.50%	-0.48%	-0.62%	-0.50%
Germany	-0.48%	-0.52%	-0.33%	-0.83%	-0.48%	-0.51%	-0.34%	-0.33%	-0.25%	-0.52%	-0.42%	-0.43%	-0.52%	-0.62%	-0.48%	-0.48%	-0.45%	-0.73%	-0.55%
Canada	-0.59%	-0.51%	-0.42%	-0.92%	-0.60%	-0.55%	-0.25%	-0.42%	-0.13%	-0.46%	-0.53%	-0.48%	-0.51%	-0.69%	-0.55%	-0.60%	-0.54%	-0.81%	-0.61%
Labour intensity index*	15.84	14.76	14.28	13.4	13.16	12	11.6	10.96	10.72	9.56	9.08	8.64	8.64	5.68	5.56	3.24	2.72	1.16	

Note: sectors are ordered by a labour intensity index constructed as an average (across countries) rank of the sector relative to other sectors in terms of the capital to labour ratio, where the ratio is calculated on the basis of values of these factors employed in the sector at base. The higher the rank the higher the labour intensity. Countries are ordered by the size of impact on real GDP associated with the scenario. The conditional colour formatting of table cells denotes the sign and relative size of the impact.
Source: METRO database and authors' calculations.

In economies experiencing a positive labour shock, the most labour-intensive sectors grow the most, and in economies experiencing declines, these sectors tend to experience the deepest declines. Sectors with high labour intensity are typically manufacturing sectors like Machinery and equipment, Textile and wearing apparel, Other manufacturing, and Electronic equipment, but also services sectors such as Business services and Trade and storage. Agriculture and hospitality are also quite labour intensive, and are hit quite badly in economies experiencing net losses of labour, and come on top of the first order effects of COVID-19 restrictions in these sectors.

[22] Capital-labour ratio ranks are computed for each individual country/region and then averaged across all countries/regions to obtain a measure of sector's overall factor intensity.

The labour supply shock has an impact on global remittance flows. In METRO, after paying income taxes, households send a fixed share of their factor income abroad as remittances. In economies that have net positive net remittance outflows, the reduction in labour supply reduces overall household income, and hence remittances relative to base. In the top three source economies for remittance outflows the fall is 0.3% for the United States, 0.7% for Canada and 0.5% for Australia. This is reflected by a drop in net inflows in destination countries. The top three being Rest of World -0.4%, Indonesia -0.3% and China -0.2%. Globally there are less remittance transfers in the scenario with overall flows declining by 0.3%.

3.5. The trade and economic impact comparing METRO and NiGEM

In the analysis, capital stock changes from NiGEM feed into METRO. Both models do however put emphasis on different economic mechanisms which sometimes implies different assumptions and structures. It is thus instructive to compare their macroeconomic outcomes even after accounting for the capital stock adjustment feedback to investigate differences which still arise.

Beginning with a comparison of the trade impact, the level and sign of export volume changes in both models are quite closely aligned across a range of economies when the capital and labour channels are accounted for in METRO (Table 1).[23] The similarity of results for exports is striking as the models vary considerably in the level of detail at which trade flows are modelled. In NiGEM there is a single export volume for each economy. Exports are modelled as a function of external demand and price-competitiveness. External demand is a weighted average of import demand in all other economies and regions with weights derived from a bilateral trade matrix (NIESR, 2017[19]).[24] The competitiveness indicator is the export price of the home economy relative to a weighted average of export prices in the rest of the world. In METRO exports also depend on demand and relative prices but the modelling is at the bilateral product level for each economy taking into account a full network of global value chain interactions.[25] Import results for some economies are also close in both models but there is more variability than in the export numbers. This is partially explained by different domestic demand reactions in both models. This is outlined below when contrasting the GDP outcome.

In general the change in GDP in the scenario is stronger in METRO than in NiGEM (Figure 10). As the scenario operates primarily through the labour market, the differing reaction of wages and household consumption can be important. Across a number of economies that are relatively more impacted by the fall in mobility, Australia, Canada, Germany, Italy and the United States, the fall in consumption is larger in METRO than it is in NiGEM (Table 2).[26] As consumption is typically the largest component of GDP this influences the overall outcome. There are many factors that can drive this difference. An important mechanism that influences consumption in NiGEM — which is not present in METRO — is monetary policy. For economies that experience a contraction in GDP, monetary policy reacts to support activity through a cut in the policy interest rate. For affected economies the rate is cut from base throughout the period of the

[23] In comparing the macroeconomic outcomes the sample of economies is restricted to those that are present in both models and are not an agglomeration of regions. This is done to make the comparison more clear as with the calibration of the capital stock change mapping NiGEM regions to METRO requires, in some cases, a degree of imputation for missing economies.

[24] In NiGEM a unit elasticity on demand is imposed in all economies. This is to ensure approximate global consistency in export and import volumes, and also implies that the global trade share for each economy is a function of its competitiveness.

[25] With 26 economies and regions in the aggregation, 18 sectors and 4 use categories, METRO reports export results with 48 672 bilateral product and use level observations. This contrasts to a maximum 60 in NiGEM as this is the number of economies and regions in the version of the model used.

[26] It should be noted that, as stated in the description of the shock calibration, it assumed that the mobility fall within the European Union is the same as that seen internationally.

scenario. In NiGEM this operates directly to stimulate consumption through a wealth effect (Mcadam and Morgan, 2004[20]). This policy buffer is not present in METRO. These consumption differences also contribute to the more varied import response seen between the models (Table 1). While exports depend on relative prices and an external demand, imports are influenced by domestic demand and relative prices.

Table 1. Exports and Imports in METRO and NiGEM

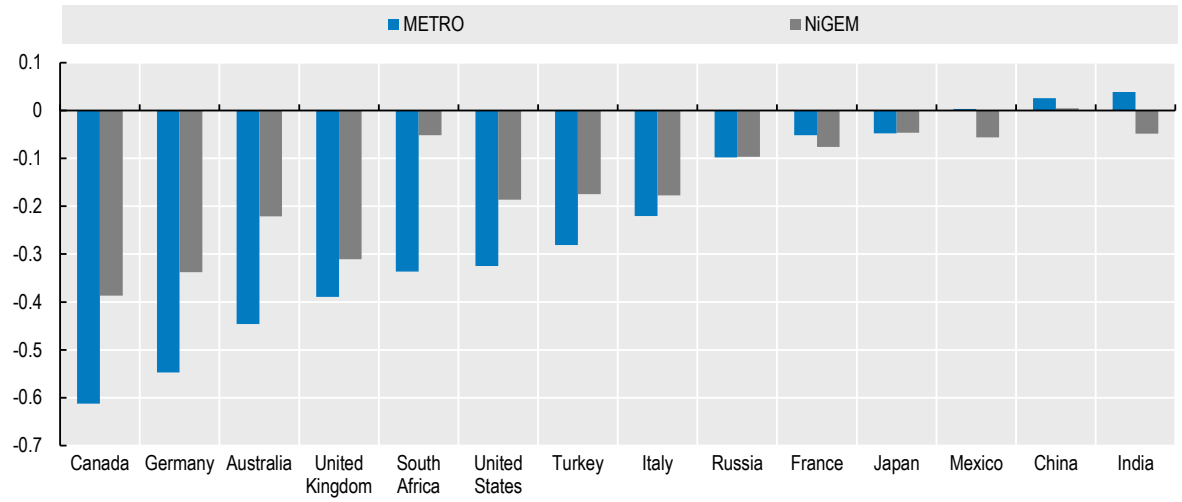
% change from base after 10 years

	Exports		Imports	
	METRO	NiGEM	METRO	NiGEM
Australia	-0.1	-0.2	-0.4	-0.2
Canada	-0.3	-0.3	-0.5	-0.6
China	0.0	-0.1	0.0	0.0
France	-0.1	-0.2	-0.1	-0.2
Germany	-0.3	-0.3	-0.4	-0.4
India	-0.1	-0.2	0.1	-0.1
Italy	-0.2	-0.2	-0.2	-0.3
Japan	0.0	-0.1	0.0	-0.1
Mexico	-0.2	-0.2	0.0	-0.2
Russia	-0.1	-0.2	-0.1	-0.1
South Africa	-0.2	-0.2	-0.3	-0.2
Turkey	-0.2	-0.2	-0.2	-0.2
United Kingdom	-0.3	-0.3	-0.3	-0.2
United States	-0.2	-0.3	-0.3	-0.2

Source: OECD, METRO and NiGEM model simulations.

Figure 10. GDP impact in METRO and NiGEM

% change from base after 10 years



Source: OECD, METRO and NiGEM model simulations.

A second driver of the difference in the GDP outcome is the change in real wages (Table 2). In general, in both models, economies where labour markets are relatively more negatively affected by the fall in mobility experience stronger wage increases in NiGEM as in METRO. The wage change in NiGEM compared to METRO is more than double in Australia and more than triple in Canada and the United States.

Part of the reason that wage differences arise is also due to a difference in the modelling of the household decision. In NiGEM an increase in wages can induce a partially offsetting increase in aggregate labour supply while overall labour endowment in METRO is fixed. The lower wages in METRO supress consumption relative to NiGEM where the stronger rise supports spending and compensates in part for the reduction in employment.

Table 2. Consumption and wages in METRO and NiGEM

% change from base after 10 years

	Consumption		Wages	
	METRO	NiGEM	METRO	NiGEM
Australia	-0.4	-0.2	0.1	0.4
Canada	-0.5	-0.4	0.0	0.1
China	0.0	0.0	0.0	0.0
France	0.0	-0.1	0.0	0.0
Germany	-0.4	-0.3	0.1	0.2
United Kingdom	-0.3	-0.2	0.0	0.1
Italy	-0.1	-0.1	0.1	0.1
Japan	0.0	-0.1	0.0	0.0
United States	-0.3	-0.1	0.0	0.1

Source: OECD, METRO and NiGEM model simulations.

4. Conclusions

This note presents a modelling approach of combining different frameworks to quantify a complex policy scenario. The scenario used to illustrate the technique is one of relevance for the post-COVID-19 world: the economic impact of a reduction in net migration flows in OECD countries. The modelling employs a CGE model, METRO, and a macroeconomic model, NiGEM, to account for changes in labour and capital stocks and uses both frameworks to report the sectoral, trade and GDP outcomes. The scenario is stylised with the reduction in mobility implemented as equivalent to a 20% reduction in net-migration accumulated over the past ten years for all economies and regions. The reduction in mobility is distributed back to source economies through a matrix of bilateral flows where they, respectively, add to, or subtract, from labour supply. Taking advantage of the sectoral detail in METRO, the economy and region level shock is then downscaled to capture potential changes at the sector level. The shock is mapped into the five labour skill categories, which contain varying degrees of local and foreign-born labour.

The results show that it is the OECD countries, the majority of which gain additional labour from international mobility flows, which would suffer the most economically from a prolonged reduction. An economic expansion is seen in many non-OECD countries where the additional labour increases both potential output and competiveness. The shock has the effect of shifting some economic activity away from OECD to non-OECD countries. For economies that on net added to their stock of labour through mobility, a reduction decreases the supply of labour. In both models this leads to a rise in wages and a deterioration in competiveness and exports. In NiGEM the factor of production loss diminishes economies potential output and there is a long-term rebalancing of inputs which involves a decrease in the capital stock. The addition of the capital channel in METRO not only changes the size of the shock but also the ranking of

the impact on economies and so adds an important source of variation to the scenario. At the sectoral level the reduction in exports is most consequential in manufacturing sectors in OECD countries, with the impact is most pronounce in economies which have had historically larger inflows.

In comparing the macroeconomic outcomes of both approaches it is seen that with the capital calibration included in METRO the change in aggregate exports is close. This is notable given the considerable difference in the detail at which both approaches model trade, METRO with bilateral product level detail that also accounts for value chain dimensions, and NIGEM with a single aggregate export value for each economy. The model results do still exhibit some variation. The GDP impact of the scenario is stronger in METRO than in NiGEM. In NiGEM monetary policy will act to buffer the labour supply shock and this will act directly on consumption through the wealth effect on the stock of household assets. In METRO there is neither a supportive monetary policy nor a stock of household wealth. A further issue is the wage adjustment that is weaker in METRO, with a sizable difference for some economies which have historically large flows. Wage adjustment to similar labour supply shocks are generally lower in METRO than in macroeconomic models in part due to the household optimisation setup. In NiGEM the reduction in labour supply leads to a wage increase that partially supports consumption. The more muted wage response in METRO leads to a bigger fall in consumption and so GDP. Developing a calibration to account for this wage effect is a possible future area for development in using the models together for complex scenarios.

In using the models collaboratively capital stock adjustment derived from NiGEM is fed into METRO. The addition of this channel benefits the quantification as a shock to labour would typically result in adjustments to capital, especially when there is enough time to adjust. Capital is an important adjustment mechanism. NiGEM has the advantage that it does link investment to change in capital stock and, in addition, the model contains different types of capital, real estate, business and government. These are endogenous and their behaviour is heterogeneous by economy. In NiGEM changes in investment are pinned down by the error-correction structure as economies return to an equilibrium level of output following the shock. The use of NiGEM thus allows the mobility scenario in METRO to capture capital adjustment and also have these changes underpinned by a different theoretical framework with a long-term stock equilibrium driven by optimization conditions. The NiGEM capital change also embodies the impact of a supportive monetary policy on the user cost of capital and economic conditions which will act to partially offset the fall in investment. From a practical perspective it is a benefit that these relevant and complex channels can be added to METRO without making any changes to the core model. In its current comparative static format, METRO focusses on the re-allocation of given resources following a shock or policy change. Future work on aligning the dynamic macro model with the CGE framework could include modelling investment and capital stock dynamics.

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Annex A.

A.1 Aggregate mobility data

As METRO and the macro model are both global models datasets with global coverage are used to construct the mobility shock calibration. Net migration and total population are taken as an average over ten years ending in 2020. The data is taken from (Abel and Cohen, 2019[21]). Migration patterns in this data are similar to those in the United Nations (UN) World Population Prospects 2019 (United Nations, 2019[22]). The proportion of migrants in the 15 to 64 age group is taken from the 2019 UN International Migrant Stock data, Percentage distribution of the international migrant stock by age and sex and by major area, region, country or area (United Nations, 2019[23]). Employment is average total employment from 2015-2019 of those over 15 years old and is taken from the International Labour Organization (ILO) database, Employment by Sex and Age – ILO Modelled Estimates (International Labour Organization (ILO), 2020[24]). The share of native and foreign-born workers in the labour force is taken as the average split between 2010-2020 and is sourced from the ILO, Labour Force by Sex, Age and Place of Birth (International Labour Organization (ILO), 2020[24]). Where there are missing values in the foreign-born workers shares data values are filled in using the average estimated relationship between the OECD and UN stock data where observations are present in both datasets. The UN data is taken from the 2019 UN International Migrant Stock data as the average value over 2015-2019, International migrant stock as a percentage of the total population by sex and by major area, region, country or area (United Nations, 2019[23]). Participation rates of foreign and domestic workers are taken the OECD Migration Outlook and are the average from 2015-2019 of participation rates by place of birth in OECD countries (OECD, 2020[2]). Where data are missing ILO data are used, the average over 2015-2019 is taken form, labour force participation rate by sex, age and place of birth (International Labour Organization (ILO), 2020[24]). Earlier years are used for shorter series. Remaining missing values for participation after combining the OECD and ILO datasets are taken from regional participation estimates in Table 2.11 Migrant Workers by Broad Sub-region (International Labour Organization (ILO), 2018[25]). Bilateral international migration flow estimates are taken from Abel and Cohen (2019[21]). The data is in five-year periods and for this analysis the 2015-2020 period is used. In line with the findings in Abel and Cohen (2019[21]), the psudo-bayesian estimates are chosen.

The aggregate migration shock

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix}, \; B = \begin{pmatrix} b_1 \\ \vdots \\ b_n \end{pmatrix}, \; S = \begin{pmatrix} s_1 \\ \vdots \\ s_n \end{pmatrix}$$

Where A is a square matrix with n rows and n columns and n is the number of countries/regions. The element a_{ij} in row i and column j is net migration from the country/region in row i to the country/region in column j. $b_i = \sum_{j=1}^{n} a_{ij} \, \forall \, a_{ij} > 0$. S is the shock to net migration. The calibration is calculated as:

$$((-S \circ B) + E) \circ (P \circ Z)$$

E is a vector where $e_i = \sum_{i=1}^{n} d_{ij}$, $D = \text{diag}(S \circ B)C$, C is an nxn matrix where $c_{ij} = \begin{cases} \frac{a_{ij}}{b_i} \forall \, a_{ij} > 0 \\ 0 \text{ otherwise} \end{cases}$. $\circ$ denotes the Hadamard product. The mobility shock is globally consistent and so the movement into and out of countries and regions balances. Taking $F = (-S \circ B)$, $\sum_{i=1}^{n} f_i = \sum_{i=1}^{n} e_i$. P and Z are vectors of participation and an adjustment for age.

A.2 Labour skill-category mobility data

There are five labour skill categories in METRO, (1) Technical and Assistant Professionals, (2) Clerks, (3) Service and shop assistants, (4) Office managers and Professionals and (5) Agricultural and other low skilled workers. Data on the foreign stock labour in each of these skill categories is taken from the GMig2 data base (Walmsley, Aguiar and Parsons, 2021[18]). This data is used to calculate the share in each skill category. This is combined with the foreign labour force share data, calculated at the aggregate level, to convert these shares into levels consistent with the METRO base data.

Table A A.1. Regional aggregation in METRO

Australia (AUS)	
Canada (CAN)	
Central and East EU (CEEU)	Czech Republic, Hungary, Slovakia, Slovenia
China (CHN)	
Eastern Europe (EEU)	Bulgaria, Estonia, Latvia, Lithuania, Poland, Romania
France (FRA)	
Germany (DEU)	
India (IND)	
Indonesia (IDN)	
Italy (ITA)	
Japan (JAP)	
Latin America (LAM)	Argentina, Brazil, Chile, Colombia, Costa Rica, Peru
Mexico (MEX)	
Middle East North Africa (MENA)	Israel, Kazakhstan, Morocco, Tunisia
New Zealand (NZL)	
North EU (NEU)	Austria, Belgium, Denmark, Finland, Ireland, Luxembourg, Netherlands, Sweden
Norway & Switzerland (ENS)	
Rest of World (ROW)	All other economies and regions
Russian Federation (RUS)	
South Africa (ZAF)	
South East Asia (SEA)	Brunei, Cambodia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
South EU (SEU)	Croatia, Cyprus, Greece, Malta, Portugal, Spain
Turkey (TUR)	
United Kingdom (UK)	
United States (USA)	

a) Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

b) Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Table A A.2. Sectors in METRO

Agriculture	Agri
Natural resources	Nat-Resource
Food and beverage	Food-bev
Textile and wearing apparel	Textile
Other manufacturing	Oth-manufact
Pharmaceuticals Chemicals	PharmaChem
Mineral and metal products	Mineral-Metal
Electronic equipment	Electronics
Machinery and equipment	Machinery
Motor vehicles and parts	Automobile
Trade and storage	Trade
Hospitality	Hospitality
Transport services	Transport
Construction	Construction
Financial services and insurance	Finance
Business services	Busines-serv
Other services	Oth-service
Education	Education

Annex B.

B.1 The NiGEM model

The NiGEM model is a global macro-econometric model.[27] It includes separate models of most advanced economies and key emerging market economies using a common theoretical structure estimated separately for each country (NIESR, 2017[19]). Other countries are aggregated and modelled using regional aggregates. The model is based around a "New Keynesian" framework with the long-run properties of the equations imposed so as to be consistent with theory. Responses to shocks are demand driven in the short-term, but determined by the supply side of the economy in the long-term, with spillovers between economies determined by trade volumes and prices, asset prices, commodity prices and competitiveness. Different dynamic adjustment patterns and parameter values for each country and region are based on estimates from historical data. The model contains forward looking financial markets and liquidity constraints, with myopic behaviour and nominal rigidities slowing the full adjustment to shocks (NIESR, 2017[19]). Both fiscal and monetary policy are endogenous in all the major economies.

B.2 NiGEM production function

The production function in NiGEM is a nested Cobb-Douglas –CES structure and is given as:

$$Q = \gamma\left\{[s(K)^{-p} + (1-s)(Le^{\lambda t})^{-p}]^{-1/p}\right\}^{a} M^{1-\alpha}$$

where the variables are, Q real output, K the total capital stock, L total hours worked, t is an index of labour augmenting technical progress, M is oil input and ρ, a, s, γ and λ are production function paramaters.

[27] For an overview, see NIESR (2017[19]).

Annex C.

Table A C.1. Labour supply shock by skill category and economy

% change from base

	Technical and assistant professionals	Clerks	Service and shop assistants	Office managers and professionals	Agricultural and other low-skilled workers
AUS	-0.95	-0.49	-0.52	-0.80	-0.75
NZL	-0.45	-0.28	-0.26	-0.42	-0.34
CAN	-0.63	-0.31	-0.40	-1.20	-0.62
CHN	0.06	0.10	0.03	0.09	0.01
FRA	-0.05	-0.06	-0.07	-0.08	-0.09
DEU	-0.64	-0.65	-0.77	-1.02	-0.82
GBR	-0.59	-0.44	-0.41	-0.63	-0.35
ITA	-0.19	-0.53	-0.61	-0.37	-0.47
NEU	-0.45	-0.42	-0.42	-0.42	-0.53
SEU	-0.03	-0.04	-0.03	-0.03	-0.03
CEEU	-0.14	-0.23	-0.14	-0.19	-0.14
EEU	0.19	0.23	0.15	0.15	0.09
EEA	-0.60	-0.71	-0.60	-0.88	-0.81
MENA	0.11	0.10	0.14	0.08	0.05
IDN	0.21	0.23	0.09	0.17	0.02
IND	0.11	0.03	0.15	0.30	0.03
JPN	-0.07	-0.03	-0.06	-0.17	-0.02
MEX	0.01	0.07	0.04	0.07	0.02
RUS	-0.12	-0.28	-0.16	-0.12	-0.22
ZAF	-0.51	-0.24	-0.27	-1.02	-0.41
TUR	-0.66	-0.68	-0.79	-0.62	-0.19
USA	-1.45	-0.24	-0.24	-0.31	-0.37
LAM	-0.17	-0.20	-0.11	-0.31	-0.14
SEA	0.05	0.03	0.04	0.06	0.01
ROW	0.16	0.17	0.18	0.21	0.09

Source: Author's calculation based on the GMig2 database (Walmsley, Aguiar and Parsons, 2021[18]).

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