Historical validation of saving and trade intensities using the GDyn-FS model and historically informed baseline projections

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Abstract

Following the GFC growth in global trade has been sluggish with recent trade tension providing doubt as to whether these trends will change any time soon. This paper looks at possible alternative future trade growth scenarios and what these may mean for trade policy formation at the national, regional and global levels. To support the formation of the baseline for this analysis, the capabilities of the dynamic GDyn-FS model are enhanced to: (i) target saving and trade intensities over the historical period; and (ii) gradually adjust to longer-run target values based on historical trends and theoretical projections. The projections suggest global exports could expand to reach around 35 percent of global output by 2050 from the current level of around 30 percent. Such an increase is consistent with an estimated trade to income elasticity of nearly 1.2. Projections of the Brown-Kojima-Drysdale regional trade intensity indexes indicate a potential for substantial re-orientation of the trading relationship between regions. Effective domestic reform and non-discriminatory trading protocols are likely to be most beneficial for realizing potential trade and associated income growth.

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Keywords: Computable General Equilibrium Modelling, Trade Policy Analysis, Economic Growth, Foreign Investment, Dynamic Baselines.

1. Introduction

Following the GFC growth in global trade has been sluggish with recent trade tension providing doubt as to whether these trends will change any time soon. This paper looks at possible alternative future trade growth scenarios and what these may mean for trade policy formation at the national, regional and global levels.

To support the formation of the baseline for this analysis, the capabilities of the dynamic GDyn-FS model (Ianchovichina and McDougall 2012, Gretton 2018 and Gretton 2019) are enhanced to: (i) target saving and trade intensities over the historical period to estimates provided by the World Bank in its World Development Indicators; and (ii) gradually adjust to longer-run target measures based on historical trends, empirical analysis and theory. The measures so targeted for each region are gross saving to GDP, exports and imports to GDP and thereby the balance of trade in goods and services. To facilitate the targeting of gross saving on a System of National Accounts basis, savings are adjusted from a GTAP basis (Hertel and Tsigas 1997:53, McDougall et al. 2012:131, Corong et al. 2017:8) to align with gross saving to GDP estimates provided on a System of National Accounts basis in the World Development Indicators. For the study, historical estimates are drawn from the World Development Indicators and ILO labour market data. Over the forward period, projections are drawn from IMF World Economic Outlook estimates, ILO labour market projections

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together with long-run projections that follow the medium growth scenario of Shared Socioeconomic Pathway projections (SSP2) (Dellink et al. 2017).

The projections trace the progress of globalization with the assumed rates of saving within regions, import tolerance and permitted trade balances. The projections suggest global exports could expand to reach around 35 percent of global output by 2050 from the current level of around 30 percent. Such an increase is consistent with an estimated trade to income elasticity of about 1.2, which compares to an average over the period 1950 to 2017 of 1.54 and a projection over the period 2011 to 2040 of 1.1 (Bekkers et al. 2020:305). Stronger assumptions about the trade potential of regions and scope for lowering trade costs could lead to higher projected proportions, approaching 40 percent or above of global output. On the other hand, trade tensions and increases in trade costs could be associated with continuation or erosion of the current proportion. At the regional level, the baseline includes gradual convergence of trade shares for China to the neighbourhood of those for Japan and the United States and convergence of trade shares for the multi-country ROW region towards EU28 shares. Against these new projections, this study uses the Brown-Kojima-Drysdale trade intensity index of regions (Drysdale and Garnaut 1982) to assess the implications of the trade growth scenarios on the trade relationship between regions. The potential for change is most stark for small to medium sized trade-exposed countries such as Australia, for which a re-orientation in connectedness from China and Japan towards the faster growing ROW region is projected. The relative connectedness within the faster growing multi-country ROW region is projected to increase.

There is clear potential for economic gravity to shift towards the ROW bloc as well as changes in the balance of trade connectedness between other regions. This places a policy premium on domestic policies that: (i) increases competitiveness of domestic firms in existing and new global markets; (ii) lowers the cost of trade in a non-discriminatory manner across markets; and (iii) avoids undue impediments to trade (such as bilateral and regional trade conflicts and preferential rules of origin). It also highlights the importance of non-discriminatory multi-lateral, plurilateral and open regional arrangements versus preferential bilateral and regional arrangements.

The GDyn-FS model used as the foundation for this study: (i) includes a capability to project a stable long-run base line with non-convex adjustment costs; (ii) introduces a rate-of-return rule for the allocation of saving between regions (capital-finance flows), (iii) provides for the rebalancing of capital ownership between regions to allow for changes in portfolio preferences, other structural changes and policy interventions not explicitly modelled; (iv) relaxes the assumption of fixed shares (the Cobb-Douglas assumption) in the consumption-saving decisions of national households; and (v) provides for the modelling of changes in national consumption-saving choices. These features provide for model stability over the long run and enhance its usefulness as a tool for the analysis of structural change, and policy and other economic developments affecting the real economy at levels of sectoral and regional detail selected by the analyst. The tops-down methods introduced in this paper provide additional capabilities for calibrating baseline trajectories and undertaking policy analysis.

Section 2 provides background to the study while section 3 outlines a composite full adjustment-partial adjustment and complementary modelling enhancements adopted in the study. The approach allows key structural ratios to be targeted for an individual year (such as for historical validation) or over time (such as to reach long-run targets) according to user specification. Section 4 provides the longer-run target saving rates and trade shares by region and key baseline assumptions with respect to population, labour and output growth. Section 5 then reports key results with section 6 reporting the model projections of the Brown-Kojima-Drysdale inter-regional trade intensity index projections. Section 7 concludes the study.

2. Background

The growth in international trade in the post-World War 2 period has benefited from global institutions that have supported economic cooperation and development and domestic policies that have allowed countries' to open themselves to international trade and investment. This environment has allowed mutually beneficial trade with foreign firms competing in domestic markets, domestic firms growing through exports and the transfer of technology and ways of working between countries and regions.

The positive effects of global trade liberalization and domestic reform have seen the share of trade in global value added increase from around 12 percent in 1960 to 30 percent pre-GFC (Figure 1). This increase has been associated with major trade liberalizations including the conclusion of the Tokyo Round in 1979, the formation of APEC in 1989, the dissolution of the former Soviet Union in 1991, the conclusion of the Uruguay Round and the APEC Bogor Declaration in 1994, the conclusion of the WTO IT Agreement in 1996, China's accession into the WTO in 2001 and expansion of the EEC in 2004. Despite the signing of the WTO Bali Package in 2013 and the continued formation of bilateral and regional preferential trading agreements since the GFC, growth in trade has only just kept pace with the growth in global output (Figure 1).

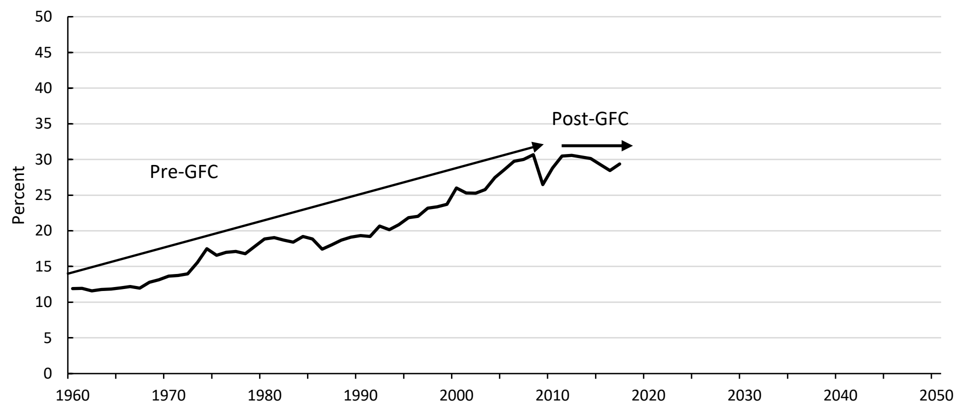


Figure 1: Global Exports to Global Product

Source: World Bank 2020, World Development Indicators. Author estimates.

During periods of rapid growth value adding output has increased ahead of domestic consumption for some economies so that saving of national households as a proportion of output has risen substantially. This was so for Japan during its growth spurt during the 1960s and 1970s and for China particularly after its accession to the WTO in 2001 (Figure 2). Where the additional saving has not been fully absorbed into domestic investment, export led growth has been realized as balance of payments surpluses and foreign investment. While the saving rate for Japan has gradually moved to the neighbourhood of global averages, the latest estimates for China place its saving rate well above the historic average and above rates of other economies.

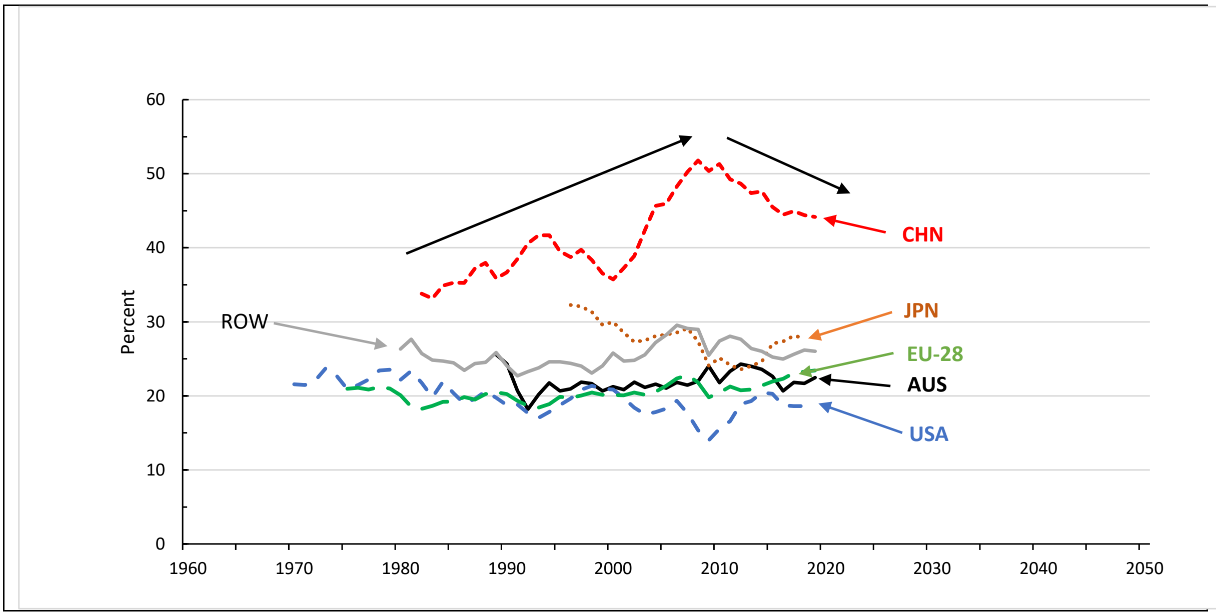


Figure 2: Gross saving to Gross Domestic Product by region

Source*: World Bank 2020, World Development Indicators. Author estimates.*

The contemporary trade tensions between China and the United States and pressures to source locally to ensure security of supplies and maintain employment in the COVID-19 era place the development strategy based on openness at risk. The incentives to shift to domestic production would afford shelter to industry support and protectionist trade policies. And while securing domestic supplies would increase the incentives for domestic inventiveness, erosion of trade openness would likely reduce the flow of disembodied and embodied technologies between countries and regions, lowering growth potential.

These and other factors suggest that there is considerable uncertainty about likely trends in the rates of saving and trading relations between countries in the post-COVID-19 era. To illustrate possible future directions in global trade, this study considers the impact on the intensity of trade between regions for three trade growth scenarios. In the scenarios, saving rates are projected to converge to country-specific rates based on historical and cross country comparisons. In particular, the saving rate for China is projected to converge to the neighborhood of rates for other regions. The analysis is supported by a number of model enhancements and an historical validation of the model over the 2011 to 2019 period. These years correspond to the benchmark year of the modelling and the latest year for which historical data are available.

3. Modelling framework

3.1 Overview of simulation model

The GDyn-FS model is a multi-sector, multi-region recursive dynamic computable general equilibrium (CGE) model of the world economy. It combines the economies of individual regions through multilateral trade, associated transport services and the capital-finance flows. GDyn extends the comparative static version of GTAP (Hertel 1997, Corong et al. 2017) by the inclusion of imperfect mobility of capital finance between regions, endogenous capital accumulation and an adaptive expectations theory of investment (Ianchovichina and McDougall 2012 in Ianchovichina and Walmsley 2012). The GDyn-FS model used as the foundation for this study: (i) includes a capability to project a stable long-run baseline with non-convex adjustment costs; (ii) introduces a rate-of-return rule for the allocation of saving between regions (capital-finance flows), (iii) provides for the rebalancing of capital ownership between regions to allow for changes in portfolio preferences, other structural changes and policy interventions not explicitly modelled; (iv) relaxes the assumption of fixed shares (the Cobb-Douglas assumption) in the consumption-saving decisions of national households; and (v) provides for the modelling of changes in national consumption-saving choices. These features provide for model stability over the long run and enhance its usefulness as a tool for the analysis of structural change, and policy and other economic developments affecting the real economy at levels of sectoral and regional detail selected by the analyst (Gretton 2018, 2019).

In the core of the model, producers in each region are divided into industries that are assumed to minimize costs subject to a constant returns to scale technology. Capital and labour are treated as being imperfectly mobile between industries while agricultural land and natural resources are used by rural and extractive industries, respectively. Industries are treated as having flexibility in the use of intermediate and value adding inputs.

The representative regional household receives income generated from labour services and the ownership of capital, land and natural resources. Income from product and factor taxes also accrues to the regional household. With this income, the region households maximise utility through private consumption, government consumption and savings. Total household consumption is distributed across products in accordance with product price and aggregate consumption expenditure while government consumption is distributed across products in fixed proportions. Regional household savings are distributed back to investment at home and abroad (via foreign investment in a 'global trust' which acts as a notional clearing house for foreign investment across regions).

Products used as intermediate inputs, consumption and investment are sourced domestically and from imports (by product and region). The demand for transport services is attached to international trade flows with supply by region being pooled in constant proportions. Regional firms' source finance from the regional household and from global saving (via the 'global trust').

As a real-economy model, GDyn-FS does not include money or bond markets, and assumes that all real changes are accommodated by broader monetary policies. While the model separately delineates government consumption and taxes on products and primary factors of production, it does not model the net fiscal position of governments and associated impacts on bond markets.

3.2 Simulation environment and model enhancements

Simulations begin with an observed database for the initial period. It would only be by coincidence that this database is representative of future periods. Baselines are therefore simulated in order to provide a reference case against which the impacts of policy or other economic change are assessed. Reference cases in modelling generally incorporate standard assumptions about population, productivity and consumer tastes. They may also include changes in investment, structural changes and factors related to changes in the physical environment. Under a dynamic approach, 'policy' scenarios then apply shocks to the baseline to project the potential impacts of the policy or other change being assessed. The difference between the policy scenario and the baseline represents the economic effect of the change over time.

To support analysis of evolving saving and trade intensities, this paper enhances the GDyn-FS model though the incorporation of flexible lagged adjustment processes to: (i) target saving and trade intensities over the historical period; and (ii) gradually adjust to longer-run target measures based on historical trends and theory. To facilitate the targeting of gross saving on a System of National Accounts basis, savings are adjusted from a GTAP basis (Hertel and Tsigas 1997:53, McDougall et al. 2012:131, Corong et al. 2017:8) to align with gross saving to GDP estimates provided on a System of National Accounts basis in the World

Development Indicators. Each of the model enhancements and parameter choices is detailed below.

3.3 Targeting the saving rate

The representative household in each region is modelled as gradually drawing the proportion of its income saved towards a reference value (that is, the target rate), subject to a CET utility function. For a given level of income, an increase (decrease) in saving would be associated with a reduction (increase) in consumption. In GDyn theory, saving is net of depreciation allowances while income accruing to the regional household is net of depreciation on fixed assets. Income is inclusive of net income and current transfers from abroad.

While GDyn theory is based on measures net of depreciation, information on saving rates by country and region (for example, in World Development Indicators) is published on a gross basis. The approach adopted is therefore to focus on the gross saving rate, calculated as a proportion of GDP in which the gross rate of saving for each region ($RSAVEG_r$) is defined as:

$$RSAVEG_r = \frac{SAVEG_r}{GDP_r} \tag{1}$$

where $SAVEG_r$ is gross saving and GDP_r is gross domestic product for region r.

In equilibrium, the actual rate ($RSAVEG_r$) and independently specified reference or target rate ($RSAVEGTARG_r$) would be equal for each region, that is,

$$RSAVEG_r = RSAVEGTARG_r \tag{2}$$

Defining the required rate of growth in the gross rate of saving by regional households through a lagged adjustment process, (2) is replaced by:

Close the gap through lagged adjustment process

Test: $IF\ SAVEFLAG_r = 1,$

$$RG\_RSAVEG_r = \left(\frac{RSAVEGTARG_r}{RSAVEG_r}\right)^{LAMBSAVE_r} \tag{3a}$$

Gap targeted in annual simulation (or to satisfy endogenous year-specific target rate)

Test: $IF\ SAVEFLAG_r = 0,$

$$RG\_RSAVEG_r = \left(\frac{RSAVEGTARG_r}{RSAVEG_r}\right) \tag{3b}$$

where RG_RSAVEG_r denotes the partial adjustment factor with respect to the gross saving rate in GDP in each region to align it adaptively with the target rate and $LAMBSAVE_r$ denotes a coefficient of adjustment with a value between zero and one. The base year target rate needs to be conjectured and added to the data base. The value is updated in each simulation year with values across the historical period (2012 to 2019) being based on actual data while values after the historical period are based on theoretical or empirical-based conjectures.

In order to align the target rate with the theory of regional households' consumption-saving choice in regional income net of depreciation allowances, the target rate of saving is converted from a gross to a net basis according to:

$$RSAVEYTARG_r = {(RSAVEGTARG_r * GDP_r) - VDEP_r}/{INCOME_r} \tag{4}$$

Second, in order to avoid numeric problems associated with negative saving, the argument in the adjustment process is expressed in terms of the rate of consumption in net income, that is,

$$(1 - RSAVEYTARG_r) \Big/ (1 - RSAVEY_r) \tag{5}$$

Incorporating the gross to net saving and the saving to consumption transformations, the dynamic adjustment process in percentage change form is then:

Close the gap through the lagged adjustment process

Test: $IF\ SAVEFLAG_r = 1,$

$$RRG\_RCONS_r = 100 * LAMBSAVE_r * ERRCONY_r \tag{6a}$$

Gap targeted in annual simulation (or to satisfy endogenous year-specific target rate)

Test: $IF\ SAVEFLAG_r = 0,$

$$RRG\_RCONS_r = 100 * ERRCONY_r \tag{6b}$$

where RRG_RCONS_r is defined as the required rate of growth in the consumption share of net income and is the adjustment factor that is central to a convex adjustment mechanism that draws the actual gross rate of saving towards a target rate, and $ERRCONY_r$ is a measure of the error in the consumption to income share the defined as $ERRCONY_r = log\left(\frac{(1-RSAVEYTARG_r)}{(1-RSAVEY_r)}\right)$.

In a long-run equilibrium,

$$RSAVEYTARG_r = RSAVEY_r \text{ and } RRG\_RCONS_r = 0 \quad \forall\, r \tag{7}$$

Assuming that re-rating ratios of (i) net to gross saving and (ii) income to GDP are common between the numerator and denominator of (4), the actual and target rates of saving on a gross basis will align in a long-run equilibrium, that is:

$$RSAVEGTARG_r = RSAVEG_r \tag{8}$$

3.3.1 Projecting changes in consumption and saving

The percentage change in the value of regional household consumption and saving is determined in GDyn-FS using an indirect CES utility function (Gretton 2019). Under this approach, the percentage change in the value of consumption (yc_r) and saving (ys_r) for each region r is given by:

$$yc_r = y_r - \varphi_r\left(pc_r - \sum_i S_{i,r}p_{i,r}\right) + \left(S_{2,r} * twistcs_r\right) + scon_r + scon\_r \tag{9}$$

and

$$ys_r = y_r - \varphi_r\left(ps_r - \sum_i S_{i,r}p_{i,r}\right) - \left(S_{1,r} * twistcs_r\right) + ssave_r + ssave\_r \tag{10}$$

where y_r is the percentage change in disposable income of the representative household in region r, φ_r is the elasticity of substitution between consumption and net saving,[2] $pc_r = p_{1,r}$ and $ps_r = p_{2,r}$ are the percentage changes in the price of consumption and saving, respectively, in region r, $S_{i,r}$ $c, s \in i$, is the share of consumption and saving, respectively, in

[2] Noting the sign of φ, the substitution parameter enters as: $\varphi > 0$ for $\sigma > 1$, $\varphi = 0$ for $\sigma = 1$, and $\varphi < 0$ for $\sigma < 1$., where σ is the substitution elasticity in the direct utility function.

total expenditure such that $\sum_i S_{i,r} = 1$, $twistcs_r$ is a consumption-saving twist while $scon_r$, $scon\_r$, $ssave_r$ and $ssave\_r$ are region-specific and region-generic shift terms, respectively.

The positively signed twist term in the consumption equation (and negatively signed term in the saving equation) represents the case of a twist in favour of consumption over saving. The modelling of consumption and saving in value terms, allows the twist terms to be interpreted directly against aggregate data on consumption and saving shares in regional income or regional GDP. The shift terms allow for exogenous changes in the value of consumption or saving.

If the percentage change in the value of saving were only on account of a change in household time preference, reversion to a mean or reference share of saving in income or other factor, and the value of income is indexed to unity, the percentage change in consumption for region r is provided by:

$$yc_r = 100 * \frac{S_{c,r}^1 - S_{c,r}^0}{S_{c,r}^0} = \left((1 - S_{c,r}^0) * twistcs_r\right) \tag{11}$$

Where the superscripts represent the base period, 0, and the simulation period 1, respectively. Rearranging the right hand expressions shows that:

$$twistcs_r = 100 * \frac{S_{c,r}^1 - S_{c,r}^0}{S_{c,r}^0} * \frac{1}{1 - S_{c,r}^0} + stwistcs_r \tag{12}$$

where $stwistcs_r$ is added as a slack variable and fixed when the value of the $twistcs$ term is determined by projected changes in shares and variable otherwise (that is, when $twistcs$ is fixed). Noting the equivalence of the partial adjustment factor, RRG_RCONS_r in (6) to the first argument in (12), the consumption-saving twist can be defined for each region as:

$$twistcs_r = RRG\_RCONS_r * \frac{1}{1 - S_{c,r}^0} + stwistcs_r \tag{13}$$

This expression links the partial adjustment process for the saving rate towards a target value to changes in saving (and consumption). To activate the link, $twistcs_r$ is set as endogenous and variable while $stwistcs_r$ is set as exogenous and fixed.

3.3.2 Determining the reference gross saving rate

The reference gross saving rate for a region ($RSAVEGTARGET_r$) may be determined by: (i) GTAP database values for a single year or across years (either for the country/region or across a representative sample of countries/regions; (ii) time series values from an independent data source such as WDI; or (iii) theoretically specified values, for example, by the first approximation $s^* = \alpha * (x + n + \delta)/(\delta + \rho + \theta x)$ where α is the capital input share of gross value added, $x + n$ are technological and population growth, respectively, δ is the depreciation rate, ρ is the rate of time preference and θ is the inverse of the intertemporal elasticity of substitution (Barro and Sala-i-Martin 1995, p.78). An advantage of the first approach is that it allows (after adjustment for net foreign transfers implicitly included in the GTAP database item for saving ($SAVE$)), for data comparisons across database years. Estimates for individual reference years would align with point estimates from reference series such as WDI. The advantage of the second is that it allows for estimates to be derived from annual information over a span of years according to historical average or trend projections, while the third has the advantage of its theoretic foundations.

For five of the six regions considered, WDI data indicate that the gross saving rate is flat or trending slightly up or down across a span of years (Figure 2, above). For China, the rate increased to a peak of around 50 percent of GDP in 2008 and has been trending downwards since. On the other hand, rates for Japan, the USA and Europe28, have tended to rise in the post-2010 period.

Based on historical and first-approximation theoretical estimates, longer-run target rates of gross saving are set to values in the 20 to 30 percent range (Table 1). These estimates are close to historical averages for the countries/regions considered, apart from China. For China, the target rate represents a reversion from historically high values to a value in the neighbourhood of other economies. With the exception of China and the USA, the longer-run target rates are of a similar order of magnitude to those projected by Foure et al. (2010)[3] and Fontagne et al. (2021) for 2050.[4] In the case of China, Foure et al. (2010) and Fontagne (2021) projected a reversion to a rate of around that pertaining in the early 1980s, that is, around 35 percent of GDP. In the case of the USA, Foure et al. (2010) and Fontagne et al. (2021) projected rates of around 15 percent which are below the historical average and rates suggested by the first approximation method (Table 1). The estimate for China is also within the neighbourhood of projections by Heller and Symansky (1997).[5][6]

3.3.3 Estimating of the partial adjustment parameter

The partial regional-specific adjustment parameter $LAMBSAVE$ determines the rate at which the projected gross saving rate converges towards the target rate. Because the actual saving rate can be negative, the parameter is applied to one minus the saving rate, that is, the consumption rate in income (see (5) and (6)). Three parameter values were considered 0.2 (two years to close half the gap), 0.075 (seven years) and 0.05 (11 years). The first value accords with the capital adjustment parameters of GDyn (Ianchovichina and McDougall 2012) while the 0.05 accords with the convergence parameter in Barro and Sala-i-Martin (1995:37). For this study, the intermediate value of 0.075 is adopted. This has regard to the half-life of convergence compared to historical changes, particularly with regard to China over the 2000 to 2016 period during which the gross saving rate increased from about 36 percent in 2000 to a peak of 52 percent in 2008 returning to about 44 percent in 2016. This transition closed about half the gap between 36 and 52 in 8 years, roughly equivalent to an outcome implied by an elasticity of 0.075. While further examination of this convergence process and appropriate parameterization would be worthwhile, the partial adjustment approach and parameterization adopted should provide meaningful modelling of transition to a target value. It does not, however, seek to explain how a disequilibrium point was reached in the first place or short-run deviations from the implied longer-run adjustment path.

[3] Incorporated in Chappuis and Walmsley (2011).

[4] In both studies, national savings rates are projected based on the estimation of a life-cycle model of the gross savings' rate in which saving rates depend on the age structure of the population, the distance from the leader country in terms of GDP-per-capita, and country fixed effects.

[5] Thanks to Xiujuab Peng of Centre of Policy Studies, Victoria University for suggesting this reference.

[6] Heller and Symansky (1997), used data from Horioka (1991), Ling and Peng (1996) and Weil (1994) and own analysis of public policy effects on public saving rates to project the national savings rate for China, East Asian and Southeast Asian economies through to 2050. The projections based on Ling and Peng (1996) and Weil (1994) for China are of a similar order of magnitude and used as points of comparison in this study. The estimates are substantially above those based on Horioka (1991) which project saving rates for China of lower than 20 percent of GDP in 2050. The estimates based on Ling and Peng 1996) and similar to those based on Weil (1994) for Southeast Asia but below those for East Asia. The estimates based on Horioka (1991) are lower again. The original analysis by Horioka (1991) refers to determinants of Japan's saving rate, Ling and Peng (1996) to the saving and investment outlook in East Asia, while Weil (1994) refers to saving behaviour in industrial countries.

Table 1: Illustrative long-run target saving rates by country/region (percent)

Country/ region	Rule for illustrative long-run target saving rate	**Illustrat-ive target LR rate adopted**	Average 1980 to 2019	First approx. with targeted pop. growth (a,b)	First approx.. with targeted pop. growth & higher depn.(c)
Australia	Illustrative target rate set to be around historical average over the period 1980 to 2019	**22.0**	21.9	25.1	27.3
China	Illustrative target rate set to be around the first approximation to the LR rate (upper bound) and in neighbourhood of the average across economies in the rest of the world region	**27.0**	41.8	22.7	26.6
Japan	Illustrative target rate set to be around historical average and in the neighbourhood of the first approximation of LR rate (upper bound),	**27.0**	27.7	21.5	25.6
USA	Illustrative target rate set to be around the historical average rounded up to the first approximation of LR rate (upper bound).	**20.0**	19.1	18.1	20.0
Europe 28	Illustrative target rate set to be around the historical average and first approximation of LR rate (lower bound).	**22.0**	21.6	21.8	25.6
ROW	Illustrative target rate set close to estimates of the period average and in the neighbourhood of the illustrative target for China.	**26.0**	25.6	18.4	22.1

(a) The first approximation is based on the assumptions that the α is represented by the year-specific capital input share of gross value added at factor cost in the GTAP 10 data base for 2014, x is technological growth assumed to be 2 percent per year, n is projected population growth in 2050 (see note (b)), δ is the depreciation rate assumed to be 4 percent of the value of fixed capital, ρ is the rate of time preference represented by the net returns on fixed capital in the GTAP database, and θ is the inverse of the intertemporal elasticity of consumption assumed to be neutral and given the value of 1.
(b) Projected population growth rates adopted: 0.86 percent for Australia, -0.7 percent for China, - 0.57 percent for Japan, 0.46 percent for the USA, 0.5 percent for Europe 28, 0.55 percent for ROW.
(c) Scenario (a) with the depreciation rate set at 6 percent.

Sources: World Bank World Development Indicators (accessed December 2020); Author estimates.

3.4 Targeting trade shares

The share of imports and exports to GDP and hence the balance of trade to GDP by region varies substantially from year-to-year. Again, it would only be by coincidence that the trade shares for any one region in a reference year were representative of values that may be reasonable to expect for a region in a longer-run time horizon. There may also be debate as to whether the balance of trade for a region would converge to balance over a forward projection period or whether the balance would tend to either a surplus or deficit. For example, a balance of trade deficit for a region may persist if investment opportunities in that region consistently exceeded the availability of national saving, as has been the case for Australia. On the other hand, surpluses may persist if local saving are greater than that deployed in local investment. In addition, export led growth phases, such as occurred in China following its accession to the WTO and Japan earlier on, may lead to historically large trade surpluses while economic disruption may generate trade deficits.

This section introduces a partial adjustment method to project changes in the share of imports and exports to GDP and the balance of trade in goods and services to GDP by region. The objective of obtaining meaningful measures of trade shares in GDP, in addition to enhancing baseline projections of the global economy, is to provide a basis for alternative trade growth scenarios (Bekkers et al. 2020:280) and the projection of indexes of trade intensity between regions and their trading partners (Drysdale and Garnaut 1982).

The partial adjustment method involves the gradual adjustment of trade balances to target values assessed as relevant to the time horizon of the analysis. The rate of convergence of the actual to the target values is determined by a partial adjustment parameter specified by the user by reference to the data and other analysis. The method also includes a capability to impose year-to-year changes of imports and exports to GDP and the balance of trade in goods and services to GDP by region to regional values given by historical data. This capability is of particular relevance when there is an overlap between a modelling baseline and historical data. The cost of international trade and domestic factor augmenting technical change[7] are treated as the relevant slack (endogenous) variables to accommodate changes in trade shares, given other growth assumptions and resource constraints of the modelling baseline.

The discussion of the partial adjustment method to target the share of exports, imports and the balance of trade in GDP proceeds in parallel. This approach highlights the similarities and differences of the application of the method to each measure and integrates the discussion. The export, import and balance of trade shares in GDP are defined, respectively, as:

$$EXPTOGDP_r = \frac{VXRREGION_r}{GDP_r} \tag{14a}$$

$$IMPTOGDP_r = \frac{VIWREGION_r}{GDP_r} \tag{14b}$$

$$TBTOGDP_r = \frac{TBAL_r}{GDP_r} \tag{14c}$$

[7] An alternative is to allow holdings of regional households in the global trust to vary. This approach was adopted in an earlier version of this paper presented to the Global Trade Analysis Conference, 2021. A limitation of this previous approach, in this context, is that it breaks the equality between global saving and global investment and can result in negative outward investment and associated investment income. The closure adopted in this implementation assumes all accommodating adjustments occur in the 'real' economy and does not have those limitations. Further theoretical development would be required to focus adjustment on foreign balances of regional households.

where $VXRREGION_r$ is the value of exports fob by region, $VIWREGION_r$ is the value of imports cife by region and $TBAL_r$ is the trade balance by region. As above, GDP_r is gross domestic product by region r.

In an equilibrium, the actual trade shares ($EXPTOGDP_r$, $IMPTOGDP_r$ and $TBTOGDP_r$, respectively) would align with independently specified reference or target shares, so that:

$$EXPTOGDP_r = EXPTOGDPTARG_r \tag{15a}$$

$$IMPTOGDP_r = IMPTOGDPTARG_r \tag{15b}$$

$$TBTOGDP_r = TBTOGDPTARG_r \tag{15c}$$

Defining the required proportional change in the trade shares by each region to gradually align the actual with the target shares through a lagged adjustment process, (15) is replaced by:

$$RG\_REXPG_r = \left(\frac{EXPTOGDPTARG_r}{EXPTOGDP_r}\right)^{LAMBEXPG_r} \tag{16a}$$

$$RG\_RIMPG_r = \left(\frac{IMPTOGDPTARG_r}{IMPTOGDP_r}\right)^{LAMBIMPG_r} \tag{16b}$$

$$RG\_RTBALG_r = \left(\frac{1 + TBTOGDPTARG_r}{1 + TBTOGDP_r}\right)^{LAMBTBALG_r} \tag{16c}$$

where RG_REXPG_r, RG_RIMPG_r and RG_RTBALG_r denote the partial adjustment factors (required growth) with respect to each share to align the respective shares adaptively with the target rates, and $LAMBEXPG_r$, $LAMBIMPG_r$ and $LAMBTBALG_r$ denote the coefficients of partial adjustment such that $0 < LAMBEXPG_r, LAMBIMPG_r, LAMBTBALG_r \leq 1$. The partial adjustment factor for the BoT is indexed to 1 in 16c to avoid numerical problems associated with negative trade balances.

Allowing for partial adjustment and full adjustment scenarios, the adjustment process in percentage change form is then:

$IF\ EXPFLAG_r = 1,$

$$RRG\_REXPG_r = 100 * LAMBEXPG_r * ERREXPG_r \tag{17a,i}$$

$IF\ EXPFLAG_r = 0,$

$$RRG\_REXPG_r = 100 * ERREXPG_r \tag{17a,ii}$$

$IF\ IMPFLAG_r = 1,$

$$RRG\_RIMPG_r = 100 * LAMBIMPG_r * ERRIMPG_r \tag{17b,i}$$

$IF\ IMPFLAG_r = 0,$

$$RRG\_RIMPG_r = 100 * ERRIMPG_r \tag{17b,ii}$$

$IF\ TBALFLAG_r = 1,$

$$RRG\_RTBALG_r = 100 * LAMBTBALG_r * ERRTBALG_r \tag{17c,i}$$

$$IF\ TBALFLAG_r = 0,$$

$$RRG\_RTBALG_r = 100 * ERRTBALG_r \tag{17c,ii}$$

where RRG_REXPG_r, RRG_IMPG_r and RRG_RTBALG_r denote the percentage change in the trade share (required rate of growth) central to a convex adjustment mechanism that draws the actual trade shares towards target rates, and $ERREXPG_r = log\left(\frac{EXPTOGDPTARG_r}{EXPTOGDP_r}\right)$, $ERRIMPG_r = log\left(\frac{IMPTOGDPTARG_r}{IMPTOGDP_r}\right)$ and $ERRTBALG_r = log\left(\frac{1+TBTOGDPTARG_r}{1+TBTOGDP_r}\right)$ are measures of the proportional errors in the trade shares. The trade flags — $EXPFLAG_r$, $IMPFLAG_r$ and $TBALFLAG_r$— indicate whether a partial adjustment mode (flag value set to one) or full adjustment mode (flag value set to zero) is to be applied.

In the partial adjustment mode (that is, with trade flags set to one), the objective is to set target values such that the projected values converge to approximate the target values and the errors are small or zero over the time horizon of the analysis. Because the level of global trade, interactions between the production, income and capital accounts within regions, and interactions on each account between regions are not known in advance, full convergence of the actual with the independently specified target values is difficult to achieve in practice, although as illustrated below, meaningful approximations are possible. In year-to-year historical simulations (that is, with trade flags set to zero), the objective is to achieve projected values as close as possible to actual values in a simulation year.

3.4.1 Projecting changes in trade shares

To complete the implementation, the partial adjustment theory is integrated with the determination of percentage changes in the value of exports, imports and the balance of trade. Without any constraint on trade shares, the percentage change in the value of exports ($vxwreg_r$), imports ($viwreg_r$) and the balance of trade ($tbalreg_r$) would be determined by the relative competitiveness of regional economies and be equal to the sum of changes in the respective components so that:

$$vxwreg_r = \sum_{1}^{i} vxfob_{i,r} * {}^{VXW_{i,r}}\!\big/_{VXWREGION_r} \tag{18a}$$

$$viwreg_r = \sum_{1}^{i} vicif_{i,r} * {}^{VIW_{i,r}}\!\big/_{VIWREGION_r} \tag{18b}$$

$$vtbalreg_r = vxwreg_r * EXPSHARE_r - viwreg * IMPSHARE_r \tag{18c}$$

where $vxfob_{i,r}$ and $vicif_{i,r}$ are the percentage change in exports and imports of product i from and to region r, respectively; $VXW_{i,r}$ and $VIW_{i,r}$ are the values of exports and imports of product i in region r; while $VXWREGION_r$ and $VIWREGION_r$ are the region totals of exports and imports. The percentage change in the trade balance is the weighted difference of the percentage changes in exports and imports where $EXPSHARE_r$ and $IMPSHARE_r$ are the shares of $VXWREGION_r$ and $VIWREGION_r$, respectively, in total trade in region r (that is, $VXWREGION_r + VIWREGION_r$).[8],[9]

[8] Equations 18a and 18b are included in the original GDyn specification (equations VREGEX_r and VREGIM_s, respectively) while 18c is additional (new equation E_VTBALREG).

[9] This later equation complements equations in GTAP and GDyn which specify the change in the ratio of the trade balance to regional income (equation DTBALRATIO).

3.4.2 Integrating the partial adjustment mechanism with the Armington assumption

In order to integrate the partial adjustment mechanism introduced above with the Armington assumption, three top-level equations are introduced. These equations characterize each region's exports and imports as changing over time with: (i) the value of regional GDP, the constant share assumption; and (ii) a share weighted price-neutral twist term (Dixon and Rimmer 2015) that links required changes in trade shares with trade flows via (19a,b). Noting the equivalence of the adjustment factors — RRG_REXPG_r, RRG_RIMPG_r and RRG_RTBALG_r — to the proportional change in trade shares, the respective trade-share twist terms can be given as:

$$twistxg_r = 100 * RRG\_EXPG_r * \frac{1}{1 - EXPTOGDP_r^0} + stwistxg_r \tag{19a}$$

$$twistmg_r = 100 * RRG\_RIMPG_r * \frac{1}{1 - IMPTOGDP_r^0} + stwistmg_r \tag{19b}$$

$$twisttg_r = 100 * RRG\_RTBALG_r * \frac{1}{1 - TBPTOGDP_r^0} + stwisttg_r \qquad \text{(19c)[10]}$$

where $stwistxg_r$, $stwistmg_r$ and $stwisttg_r$are slack variables.

This expression links the partial adjustment process for the trade shares towards target coefficient values to changes in exports, imports and the balance of trade. To activate the link and invoke the partial adjustment theory (as in the consumption-saving relationship above), $twistxg_r$, $twistmg_r$ and $twisttg_r$ are set as endogenous and determined by (19) and the otherwise slack variables $stwistxg_r$, $stwistmg_r$ and $stwisttg_r$ are set exogenous and fixed.

The percentage change in exports, imports and balance of trade can then be represented as arising from a change in activity levels and a twist between components:

$$vxwreg_r = pgdp_r + qgdp_r + [(1 - EXPTOGDP_r) * twistxg_r] \tag{20a}$$

$$viwreg_r = pgdp_r + qgdp_r + [(1 - IMPTOGDP_r) * twistmg_r] \tag{20b}$$

$$vtbalreg_r = [(1 - TBTOGDP_r) * twisttg_r] \tag{20c}$$

where $pgdp_r$ and $qgdp_r$ are the percentage change in the GDP price deflator and quantity index respectively and $twistxg_r$, $twistmg_r$ and $twisttg_r$ are the price neutral twists with respect to the trade flows. Because changes in the trade balance mirrors export and import behavior, only two of the elements can be targeted in any one simulation. It is also necessary to allow at least one degree of freedom across regions. These matters will be addressed in the discussion of the model closure, below.

3.4.3 Completing the module

Exports fob, imports cife the balance of trade and GDP by region are available in the standard GDyn (and GTAP) data bases and updated across simulation years. To complete the model database, in addition to foreign remittances and transfers, target trade shares ($EXPTOGDPTARG_r$, $IMPTOGDPTARG_r$ and $TBTOGDPTARG_r$) are introduced to the data base for each region. The database value is then updated over time by the percentage change in the relevant share ($rexpgt_r$, $rimpgt_r$ and $rtbalgt_r$) defined as:

$$rexpgt_r = sexpgt_r + sexpgt\_r \tag{21a}$$

$$rimpgt_r = simpgt_r + simpgt\_r \tag{21b}$$

$$rtbalgt_r = stbalgt_r + stbalgt\_r \tag{21c}$$

[10] By 9c $ERRTBALG$ is zero when the trade balance is equal to zero, that is, when $ER\_RTBALG = 1$.

where $sexpgt_r$, $simpgt_r$ and $stbalgt_r$ are region-specific shift terms and $sexpgt\_r$, $simpgt\_r$ and $stbalgt\_r$ are region-generic shift terms. Each shift term is normally exogenous (although further enhancements could see the values set by theory within a model simulation).

3.4.4 Modelling of trade balances and model closure

In a review of practices in CGE modelling, Bekkers et al. (2020) note that there is relative consensus concerning the use of the Armington assumption for determining the utility and sourcing of products in trade, the modelling of trade balances differs between applications. Bekkers et al. (2020:293) also note that a requirement that the balance of trade converge across regions in the long run might be too restrictive since items on the current account and valuation effects also play a role in the long-run economic relationship between countries. They identify eight different trade closures employed in dynamic CGE models (Becker et al. 2020:294): (i) fix the ratio of the trade balance to GDP at the initial level; (ii) assume that the trade balance for each region converges to zero over time; (iii) assume that the trade balance for each region has a fixed value over time so that the share in GDP coincidently falls; (iv) assume that the trade balance for each region follows a Feldstein-Horioka (1980) consistent path whereby the change in the trade balance reflects proportional changes in the investment to GDP and saving to GDP ratios with country fixed effects; (v) assume a rate of return rule whereby global capital-finances are allocated across countries to equilibrate expected rates of return on capital across regions; (vi) adopt an initial-shares rule whereby global investment is allocated across countries proportionately to maintain shares; (vii) a combination of the Feldstein-Horioka based rule (that is, iv) and the rate of return rule (that is, v); and (viii) an adjusted Feldstein-Horioka based rule and the rate of return rule whereby the Feldstein-Horioka rule is adjusted to take into account of the fact that only a part of investment is accounted for by the Feldstein-Horioka relationship.

The current study, extends the Becker's et al. (2020) analysis in a number of ways. First, it embodies country-specific rates of return taken from base-period data as a means of allowing for inter-country differences in required returns on account of differences in institutions, risk and the effective rate of time preference. Second, it embodies region-specific saving rates based on a first approximation of the steady-state rates and historical data (see above). Third, it includes mobility of capital between regions conditional on a rate of return rule[11] parameterized to be consistent with the Feldstein-Horioka conclusion (Gretton 2019). The approach also allows for country-specific effects via price neutral twists, introduced above. Fourth, the approach embodies specific targeting of import and export shares and so is concerned at the national level with the level of trade relative to GDP as well as the trade balance.

In a typical simulation, therefore, the target trade shares are treated as exogenous with the projected shares transitioning to the target value in a single year over the historical validation period or adaptively across a span of years in the forward projection period. The value of the relevant year-specific twist variables $-$ $twistxs_r$, $twistms_r$ and $twisttg_r$ $-$ are determined by the theory of the model via equations (20a,b,c) and activated by setting two of the three shift terms on the targeted trade shares $-$ $stwistxg_r$, $stwistmg_r$ and $stwisttg_r$ $-$ to be exogenous and fixed. To complete the model closure and allow for the interaction between the real economy and the trade account and the capital account, it is necessary to allow for accommodating changes in: (i) the competitiveness of foreign relative to domestic supplies and (ii) productivity of domestic activities. As noted, the approach adopted in this implementation is to treat as endogenous: (i) source generic import augmenting technological change pertaining to imports to region s (via the technology variable ams_ir_s) for n regions;

[11] Via a CET function mediating between domestic and foreign investment by regional households and a CES function mediating between firms sourcing finance locally and from abroad.

and (ii) domestic factor augmenting technical change in region r (via $aoreg_r$) for n-1 regions. Over the historical validation period, imports and exports as a share of GDP are targeted, with the balance of trade share treated as the slack variable. In the forward projection period, the import and balance of trade share variables are targeted with exports treated as the slack variable (Table 2).[12]

Table 2: Summary of trade modelling closure

	Historical projection and transition periods (2012 to 2019)	Forward projection period (post-2020)
Closure change and rationale	Target export and import shares with the BoT share as a residual	Target import and BoT shares with the export share as a residual
Target the export share in GDP by linking the required change in the export share to the value of exports, allowing output augmenting technical change to vary.[a]	Endogenous: Output augmenting technical change ($aoreg$) Exogenous: Exports to GDP specific shift ($stwistxg$) For n-1 regions[b]	
Target the import share in GDP by linking the required change in the import share to the value of imports, enabled by region-specific import augmenting technical change	Endogenous: Regional generic import augmenting technical change (ams_ir) Exogenous: Imports to GDP specific shift ($stwistmg$)	As for historic simulation
Target the BoT share in GDP by linking the required change in the BoT share to the value of the BoT, allowing output augmenting technical change to vary.[a]		Endogenous: Output augmenting technical change ($aoreg$) Exogenous: Exports to GDP specific shift ($stwisttg$) For n-1 regions[b]

a An alternative is to allow holdings of regional households in the global trust to vary (via $twistft$). This approach was adopted for the Global Trade Analysis Conference presentation, 2021. As noted, a limitation of this previous approach, in this context, is that it breaks the equality between global saving and global investment and can result in negative outward investment and associated investment income. The closure adopted in this implementation assumes all accommodating adjustments occur in the 'real' economy. **b** Rest of World region endogenous.

Source: Author specification.

The flags (equation 9) specifying whether saving adjusts adaptively to a target rate or to the target rate in a single period is also determined outside of the model and entered as an additional data item.[13] The value is updated via the exogenous variables $xflag\_del\_unity_r$, $mflag\_del\_unity_r$ and $tflag\_del\_unity_r$. Updating in period t takes effect in period $t + 1$. For this reason, the value of the flag (either 1 or zero) to apply in the first year of a simulation needs to be entered in the initial data base.

[12] The Feldstein-Horioka relationship for a region may therefore vary from year-to-year depending on current conditions, and evolve to region-specific values over the time horizon of a base line simulation.

[13] These additional data items are entered into an additional data file gdatextra (under the headers XFLG, MFLG and TFLG).

3.4.5 Determining target trade shares

Using 2011 as the base year for baseline simulations, the trade shares provided by the World Bank World Development Indicators are adopted as the target values for the simulation years 2012 to 2019. Over this historical projection period, modelled trade shares are projected to align as closely as possible with target values. For years in the forward projection period, target conjectures are made about possible trade shares by reference to historical data and practices in other studies.

For each of the six regions considered, WDI data indicate that regional exports and imports as shares of regional GDP have increased but at varying rates and with substantial year-to-year variation (appendix 1). For China, exports and imports as a share of GDP increased to a peaks of around 35 and 30 percent of GDP in 2008 following accession to the WTO in 2001, with a downwards path since. On the other hand, the trade shares for Australia, Japan, the USA, EU28 and the ROW tended to continue on an upward path in the post-2010 period, albeit at different rates. Because in any one year the share of a regions exports to GDP is not equal to the share of imports to GDP for that region, regional balances of trade exhibit either surpluses or deficits as a share of their GDP. Notwithstanding substantial year-to-year variation, the regions covered have tended to record either a deficit or surplus, particularly since 1980s. Of the regions covered, Australia and the USA have tended to record deficits while the other four regions have tended to record surpluses. Against this background, and as noted in Bekkers et al. (2020:293), an assumption that trade balances converge to zero may be too restrictive, an observation borne out by the data.

Using the precedence provided by historical data, three baseline trade scenarios for targeting trade shares in the forward projection period are considered: (i) a **medium increase** in potential trade openness equivalent to the 2019 export share value uplifted by 10 percent; (ii) a **lower increase** in potential trade openness equivalent to the 2019 export share value uplifted by 2.5 percent; and (iii) a **higher increase** in potential trade openness equivalent to the 2019 export share value uplifted by 20 percent (Table 3). The lower potential scenario would be consistent with ongoing trade tensions and more inward-looking trade policies across countries. The higher potential scenario would be consistent with a reversion to non-discriminatory trade policies that favoured openness. Within these broad scenarios, separate treatments for China and the multi-country ROW region are adopted. For China, the export share in each scenario is projected to tend towards a value between Japan and the USA. This would accord with domestic policies that favour expansion of the domestic market and an increasing presence in global trade of other developing economies (Yu and Zhong 2020). For the ROW region, the medium potential scenario has the 2019 value is *uplifted by* **10** percent plus the closure of half of the projected gap with multi-country EU28 region. This represents an increasing presence in global trade both within the (broad) regional group and between the group and other regions. The second, lower potential scenario, assumes exports of the rest of the world region just keep pace with exports of other regions, while the third scenario assumes a higher than average potential reflected in a projected uplift of the export potential of 20 percent plus the closure of 75 percent of the projected gap between the ROW and the EU28 region. The medium trade potential scenario is adopted as the central, or medium case in the illustrative baseline.

Table 3: Potential increase in trade openness – three scenarios considered

Scenario 1: Medium potential increase – the central case
• Export shares
  • Common criteria except China and ROW: 2019 value *uplifted by* **10%**
  • China: Export share converges towards the average of Japan and the USA
  • ROW: the 2019 value *uplifted by* **10** percent PLUS close half projected gap with EU28
• BoT share: Average across data years (circa)1960 to 2019
• Import share: Target Export share *less* target LR BoT share

Scenario 2: Lower potential • Scenario 1 with Uplift of 2.5% (with China convergence to reference economies) and ROW does not close gap with EU28
Scenario 3: Higher potential • Scenario 1 with Uplift of 20% (with China convergence to reference economies); ROW closes 75% of gap with EU28

Source: Author specification.

The target trade balance share in GDP for the forward projection period is common across scenarios (Table 4). It is based on regional averages over the period 1970 to 2019 and reflects the fact that some regions have tended to have persistent deficits such as Australia and the USA while others have tended to have persistent surpluses including China, Japan, Europe 28 and the Rest of the World (appendix 1). The target import shares for the forward projection period then are those implied by the target export and trade balance shares. Having set the targets across the three values, it is the import shares and the balance of trade shares that are directly targeted in the forward projection period, so that economic openness evidenced by lower cost imports and the macroeconomic constraint of the target trade-balance share will determine, subject to other model constraints, export share projections. As noted, at least one degree of freedom in the trade balance share is required to avoid over determination in model simulations. The region freed is ROW.

Table 4: Illustrative long-run target trade shares by country/region across three scenarios towards 2050

	Common	Medium		Lower potential		Higher potential	
Country/ region	BoT share	Export share	Import share	Export share	Import share	Export share	Import share
Australia	-0.9	26.5	27.4	24.7	25.6	28.9	29.8
China	1.5	16.6	15.2	15.5	14.0	18.2	16.7
Japan	1.0	20.4	19.4	19.0	18.0	22.2	21.2
USA	-2.1	12.9	15.0	12.0	14.2	14.1	16.2
EU28	0.6	51.2	50.6	47.7	47.1	55.9	55.3
ROW	1.0	45.2	44.2	36.6	35.6	52.6	51.6

Source: Author specification.

3.4.6 Estimation of the partial adjustment trade share parameters

The trade-share parameters — $LAMBEXPG$, $LAMBIMPG$ and $LAMBTBALG$ — determine the rate at which the actual export, import and trade balance shares in current value GDP (in USD) converges toward the respective target rates. As in the case of the consumption-saving modelling described above, three parameter value possibilities were considered: 0.2 which is associated with a half-life of about 2 years with adjustment approaching completion after 20 years; 0.075 with a half-life of 7 years with adjustment approaching completion after 50 years; and 0.05 with a half-life of about 22 years with adjustment approaching completion after 75 years. As 50 years roughly corresponds with the period of rising trade shares across the regions modelled, the mid-range parameter value of 0.075 is adopted.

While further examination of this convergence process and appropriate parameterization would be worthwhile, the forward projection approach adopted should provide meaningful modelling of the possible future trading relations between regions.

3.5 Projecting trade intensity between regions in dynamic simulations

The intensity of bilateral trade varies substantially between countries and regions. As noted, it would therefore be only by coincidence that the share of one region's exports to another region was equal to the destination region's share in global trade. Such variation is the product of factors that would influence countries' trade potential and the intensity of trade between regions, including: regional income; patterns of demand across intermediate and final users; production capabilities; geographic separation and associated transport costs; language, cultural and heritage factors; cross-border trading conditions such as insurance, access to freight and policy measures relating to tariffs and non-tariff barriers; differences in the domestic regulatory structures of potential trading partners; impediments to cross-border investment; and the interaction of national regulatory environments with global business models.

Patterns of bilateral trade would adapt to technological and regulatory changes and changes in the business environment, with policy changes often requiring planning and, in some cases, international negotiations. They are also influenced by short-term changes in economic conditions. Patterns of resistance to bilateral trade can change over time and have substantial economic and social implications. These considerations provide a policy interest in the analysis of potential changes in trade intensities between countries/regions, and the incentives environment which may impede or facilitate the realization of that potential, that is affect trade resistances. Trade intensity indexes are part of an 'intensity approach' that seeks to explain deviations in bilateral trade flows from country averages in terms of variations in patterns of resistance (as described in the review article by Drysdale and Garnaut 1982:66).

This paper adopts a forward-looking perspective to the consideration of evolving trade intensities between regions through the introduction of indexes of trade intensity between regions into forward projections of the global economy. The indexes provide for an exploration of the implications for interregional trade of economic and trade growth scenarios.[14]

The forward projections complement historical series of bilateral trade flows and support analyses of factors influencing the level and pattern of trade, and potential benefits of effective policies to reduce resistance to trade.

[14] The indexes could also be calculated for policy scenarios in order to examine the impact of specific policies on the intensity of trade between regions. Such projections could be particularly relevant to the assessment of national, plurilateral and multilateral, as well as bilateral and regional trade reform agendas that seek to lower impediments to trade and more broadly to improve economic efficiency and productivity.

3.5.1 The trade intensity index

The index of trade intensity (also known as the Brown-Kojima-Drysdale index) measures the relative trade connectedness between trading partners and can be used as a proxy for trade resistance. The index (TII_{rs}) measures the share of one country's exports to another country as a proportion of the latter's share of world trade. The central purpose of the index is to study the possible contribution of resistances to bilateral trade (Drysdale and Garnaut 1982). The index between source region r and destination region s (TII_{rs}) is defined as:

$$TII_{rs} = \frac{X_{r,s}}{X_r} \Big/ \frac{M_s}{M} \qquad (22)$$

where $X_{r,s}$, is the exports of all products i from source region r to destination region s, X_r is the total exports of all products i to all regions s from source region r, M_s is the imports of all products i of region s from all source regions r and M is the value of global imports. The value of global imports is by definition equal to the total of imports of all products i by region s. In this implementation, the index is estimated at world prices, that is, exports and imports are valued inclusive of costs, insurance and freight (cife). Thus, a lowering of insurance and freight costs would lower the effective price of exports in a destination region and the effective cost in the importing region. The adoption of the cife valuation basis lends itself to a consideration of intermediation costs as a 'resistance' factor to international trade.

In this implementation, the index is calculated on a total trade basis, that is, inclusive of goods and services. This compares to indexes calculated from COMTRADE data which are limited in coverage to merchandise trade. The more comprehensive approach adopted in this application is facilitated by the use of the bilateral trade data in the GTAP data base.

The index values for each region would range from zero to infinity. They would have a value of one when the share one region's exports to another is equal to the importer's share of world trade. It would tend to zero when importance of the destination region, s, declines relative to its absorption of global trade. It would tend to infinity when the importance of imports by the destination region declines as a share of global trade. Because a country does not 'export' to itself, the own-region trade intensity index is zero while an index over global trade, the global 'average', is equal to one. The indexes are therefore able to concentrate attention on possible natural, economic and policy differences that could afford differential resistances to trade between countries.

The trade intensity index is comprised of two components, the export intensity index (the denominator in the TII calculation) and the import intensity index (the numerator in the TII calculations). The intensity of exports index $TIIX_{rs}$is defined over exporting regions r by destination region s and is equal to:

$$TIIX_{rs} = \frac{X_{r,s}}{X_r} \qquad (23)$$

where

$$\sum_{1}^{S} TIIX_{rs} = 1 \;\; \forall \text{ exporting regions } r$$

The intensity of imports index by importing region s is defined as:

$$TIIM_s = \frac{M_s}{M} \tag{24}$$

where

$$\sum_1^S TIIM_s = 1$$

In addition to providing a basis for the assessment of resistances to trade between regions, the trade intensity index approach has also be used in the projection of bilateral flows on the basis of stable trade intensities (as reported in the review article Drysdale and Garnaut 1982:76). Hertel, Walmsley and Itakura (2012) used trade intensity indexes to illustrate biases in trade between Japan, Korea and Singapore to suggest that biases are of the kind bilateral and regional trade agreements are intended to lower.

To date, the author is unaware of research that has incorporated index calculations into CGE forward projections of the global economy.

3. 6 Linearization errors and error management

Linearization errors can result in projected values for variables incorrectly changing sign. This can be particularly manifest in small-value trade and production items. The simulation of relatively large product or sectoral changes can also heighten the chance of such occurrences. When illegal negatives occur, the inclusion of range checks in GDyn that coefficients be equal to or greater than zero results in the simulation terminating. The incidence of negative values (and linearization errors generally) can be addressed by increasing the accuracy of the solution method adopted. However, as this may not eliminate all cases of illegal negative values, three revisions are made to GDyn for the management of negative values: (i) remove 'range' checks on detailed commodity flows; (ii) add an 'assertion' command to warn of negative flows; and (iii) introduce 'explicit' data update commands to replace illegal negative values with a small positive value (equal to 0.0001 million USD).

In order to verify that material discrepancies in data balances affecting global and national balances are not introduced by this convention (or that wider linearization problems are not present), the following broad checks were useful:

- the percentage change in global saving ($walras\_dem$) aligns with the percentage change in the global supply of capital goods ($walras\_sup$);
- the value of global imports at border prices ($\sum_r VIWREGION_r$) aligns with the value of global exports inclusive of trade costs ($\sum_r VXWREGION_r$);
- the value of expenditure on GDP by region ($GDPEXP_r$) aligns with regional income generated ($GDPINC_r$); and
- the current account balance by region (CAB_r) aligns with regional net lending ($NETLENDING_r$).

These checks were done in addition to general checks on model accuracy provided with simulation output.

4. The modelling baseline

4. 1 Key baseline assumptions

The focus of the illustrative simulations reported in this and the next section incorporates projections of GDP, population, skilled labour and unskilled labour for each of the six regions modelled. The base year for the projections is 2011 using the GDyn version 9 database.[15] Over the historical simulation period 2012 to 2019, estimates of real GDP growth for each region except ROW were drawn from the World Bank World Development Indicators. For the ROW, the Shared Social Pathways Medium Growth Scenario (SSP2) projections (Dellink et al. 2017) annualized by van der Mensbrugghe (2013) and aggregated according to Aguiar (2019) are adopted. Estimates of population growth to 2019 are based on World Development Indicators while estimates of labour input growth by the skilled and unskilled categories are based on ILO estimates (ILO 2020). Estimates of domestic investment to 2018 for each region except ROW are from the World Bank World Development Indicators. Model projections are used to estimate domestic investment for ROW and for all regions in 2019.

Forward projections of GDP for 2020 are based on the IMFs World Economic Outlook (IMF2020a) for 2020. Projections for 2021 are then drawn from IMF country reports (IMF 2019a,b, 2020b,c,d). The data sources were used in combination to provide indicative projections for the ROW region for these years. GDP projections for the period 2022 to 2100 are based on the long-term economic growth projections medium growth scenario (SSP2) provided in the Shared Economic Pathways (Dellink *et al.* (2017) as annualized by van der Mensbrugge (2013) and aggregated according to Aguiar (2019). The SSP2 growth scenario adopted assumes medium growth across the global TFP frontier, convergence of economies toward that frontier, transition to openness, population, labour force, human capital and fossil fuel resource use and prices.

Population projections from 2020 to 2100 are based on the medium growth SSP2 (Dellink *et al.* 2017), van der Mensbrugge 2013, Aguiar 2019). Projections of employment by occupational group are not available from the SSP growth projections. However, projections of population by skill and age group are provided. These population projections are used in a multi-step process to uprate ILO (2020) estimates of employment by occupational group. In the first step, ILO estimates of skilled employment are uprated from 2018 to 2022 on the basis of SSP2 population projections of skilled persons in the 15 to 65 age group (the working aged population) to provide annual estimates of skilled employment by region. Second, these estimates are deducted from the ILO employment projections to provide estimates of unskilled employment by region. From 2023 to 2100, ILO employment estimates by region are uprated by SSP2-based projections of the working aged population using the constant participation/unemployment assumption. Persons in skilled employment is then uprated by SSP2 projections of the skilled working age population. Finally, persons in unskilled employment is derived by deducting the projections of persons in skilled employment by region from projections of total employment. Estimates so derived are used to calculate population and labour-market consistent employment growth projections.

The projections to 2050 reflect an expectation that GDP growth in China and the regions covered by the Rest-of-the-World grouping will continue at rates above those for Australia, Japan, the United States, and the EU28 economies, with projected growth rates for China and Japan, in particular, tapering off (Figure 3, top left panel). Population growth rates for all regional groups are projected to decline, while growth rates for Japan are projected to be negative through the period and to turn negative for China and the EU28 economies (Figure 3, top right panel). Growth rates for skilled labour and unskilled labour inputs are also projected to decline, more so for the unskilled group (Figure 3, bottom left and right panels). For this latter group, growth rates are projected to be negative for all regions including the Rest-of-the-World region in the later part of the period (Figure 3, bottom left panel).

[15] Previous implementations of GDyn-FS adopted the CEPII projections provided with the published GDyn database are used (GTAP 2016, Gretton 2018, 2019). These projections start from 2004 and cover the 39-year period from 2011, the database year, out to 2050.

In GDyn, growth in regional populations and labour inputs are naturally exogenous.[16] With GDP usually determined by the model, that is, naturally determined endogenously, it is necessary to swap this activity variable with another in baseline simulations. Following Walmsley *et al*. (2012), across the forward projection period (that is from 2019 to 2100), GDP by region is swapped with the region-specific technological change variable for 'non-accumulable endowment commodities', that is, land, natural resources and labour.[17] Under this treatment, technological change is determined endogenously in baseline simulations. In the historical projection period, GDP by region is swapped with the region-specific technological variable for multi-factor technological change, that is, non-accumulable endowment commodities plus accumulable endowment commodities.[18] Under this treatment, the 'technology' variable absorbs slack in changes in factor utilization over the historical reference period as well as underlying technological change, as does the multifactor productivity term in growth-accounting calculations. Gross investment is also determined endogenously in the forward projection period by the investment theory of the model whereby regional firms adjust gross regional investment adaptively to: eliminate errors in expectations; align actual and target rates of return; and gradually align the actual with the normal rate of capital growth.

[16] Through model variables: pop, $qfactsup[SkLab]$ and $qfactsup[UnskLab]$.

[17] Technological change in non-accumulable endowment commodities is represented by the model variable $afenareg$. The model closure swap is therefore: $\boldsymbol{Swap}\ afenareg\ = qgdp$; $!\,en = ex$.

[18] Technological change in all endowment commodities is represented by the model variable $avareg(r)$. The model closure swap is therefore: $\boldsymbol{swap}\ avareg\ = qgdp$; $!\,en = ex$.

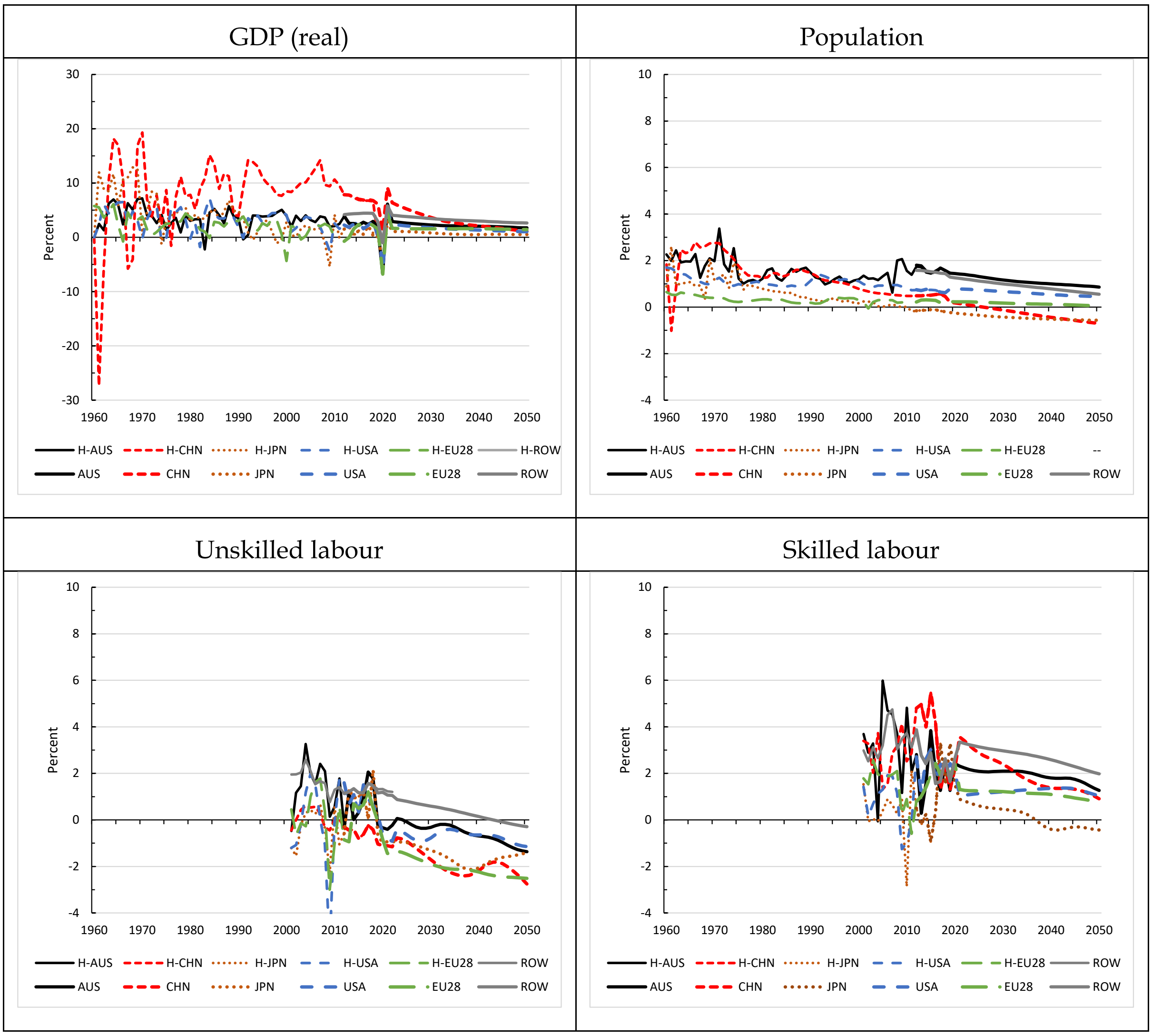


Figure 3: Historical estimates and baseline projections of GDP, population and labour input growth by region, 1960 to 2050, percentage change

Sources: World Bank World Development Indicators (2020), IMF (various), ILO (2020), Dellink et al. 2017, Author GDyn-FS projections.

4.2 Gross saving to GDP

In projecting a baseline the simulations depart from the traditional approach adopted in traditional CGE models such as GTAP and models in the same family which are based on simple structures where the saving rate is often exogenous and fixed at database values. Over a simulation, this assumption would flow through to trade intensities via the relation $I - S = X - M + R$ (Hertel and Tsigas 1997 and Corrong et al. 2017). The baseline projected in this paper relaxes the fixed saving rate in two stages. First, over the historical validation period (2012 to 2019) the actual saving rate is targeted. Then a long-run target rate based on historical data and theory (Table 1) is introduced (in 2020) with economies modelled as gradually adjusting to that rate through the partial adjustment method introduced above. All regions are targeted while the saving rate is varied though changes in the consumption-saving mix. The forward projections extend from 2020 to 2100 to correspond to the time horizon of the SSP projections (Dellink et al. 2017) with projections to 2050 reported against historic data (Figure 4, left panel).

As described above, in the projections, the consumption rate in net income is targeted to avoid numerical errors associated with negative value saving. The error in the estimates is therefore measured with respect to the consumption to income ratio and projected to be gradually eliminated over time. For most regions, the long-run target rate is an approximate business-as-usual and the errors are low across the projection period. For China, which is projected to gradually adjust from an historically high saving rate to the neighbourhood of other relatively high saving regions modelled (Japan and ROW), the gap between the long-run target and actual rate is initially large (Figure 4, right panel). The gap is then gradually eliminated with most of the difference being eliminated by 2050.

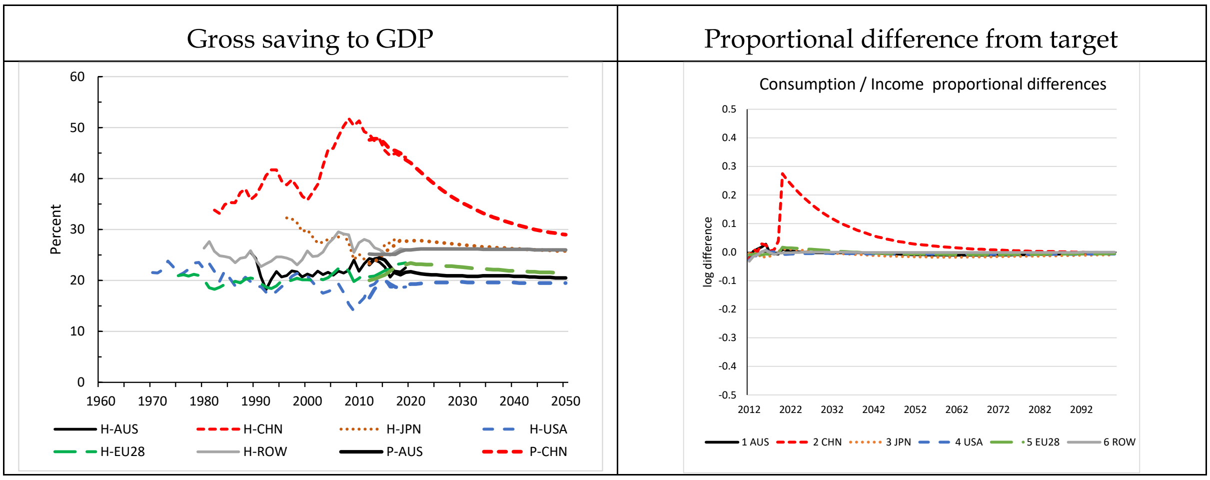


Figure 4: Historical estimates and baseline projections of gross saving to GDP by region, 1960 to 2050, percent

Sources: World Bank, World Development Indicators (accessed October 2020); Author GDyn-FS projections.

4.3 Projections of global trade to global product

There is considerable uncertainty surrounding how global trade may evolve over the time horizon of long-run baselines. Recognising this uncertainly the approach adopted is to specify three trade growth scenarios benchmarked to the trade shares in regional product in 2019 (Table 4). The forward projection period in focus is 2020 to 2050 although, as noted, the baseline projections extend to 2100. Under the medium trade-growth scenario, it is assumed that: (i) the value of trade as a share of GDP for Australia, Japan, the USA, and Europe 28 would be uplifted by 10 percent from 2019 levels; (ii) there would be a convergence of trade shares for China to the levels in the neighbourhood of Japan and the USA and the multi-country region ROW to Europe 28, and (iii) the Balance of Trade shares approach target rates (see Table 3), global exports could reach around 35% of global product by 2050 (Figure 5). As will be shown below, the convergence of trade shares towards Japan and USA levels is important to this outcome pointing to the importance of country-specific assumptions to the outcome of projections. The lower trade-potential scenario assumes a 2.5 percent uplift in trade shares and forfeits convergence of the ROW with Europe 28 (see Table 3), the share of global trade in global product is projected to be held constant at around 2019 levels, that is, around 30 percent of global product. The higher trade-potential scenario assumes that trade across regions would be uplifted by 20 percent from 2019 levels with China projected to converge towards the higher levels of the reference economies of Japan and the USA and the multi-country ROW region is projected to move towards closing three quarters of the gap with the Europe 28 region. Under this scenario, global trade is projected to be in the neighbourhood of 40 percent of global product by 2050 along a trajectory somewhat similar to the historical path.

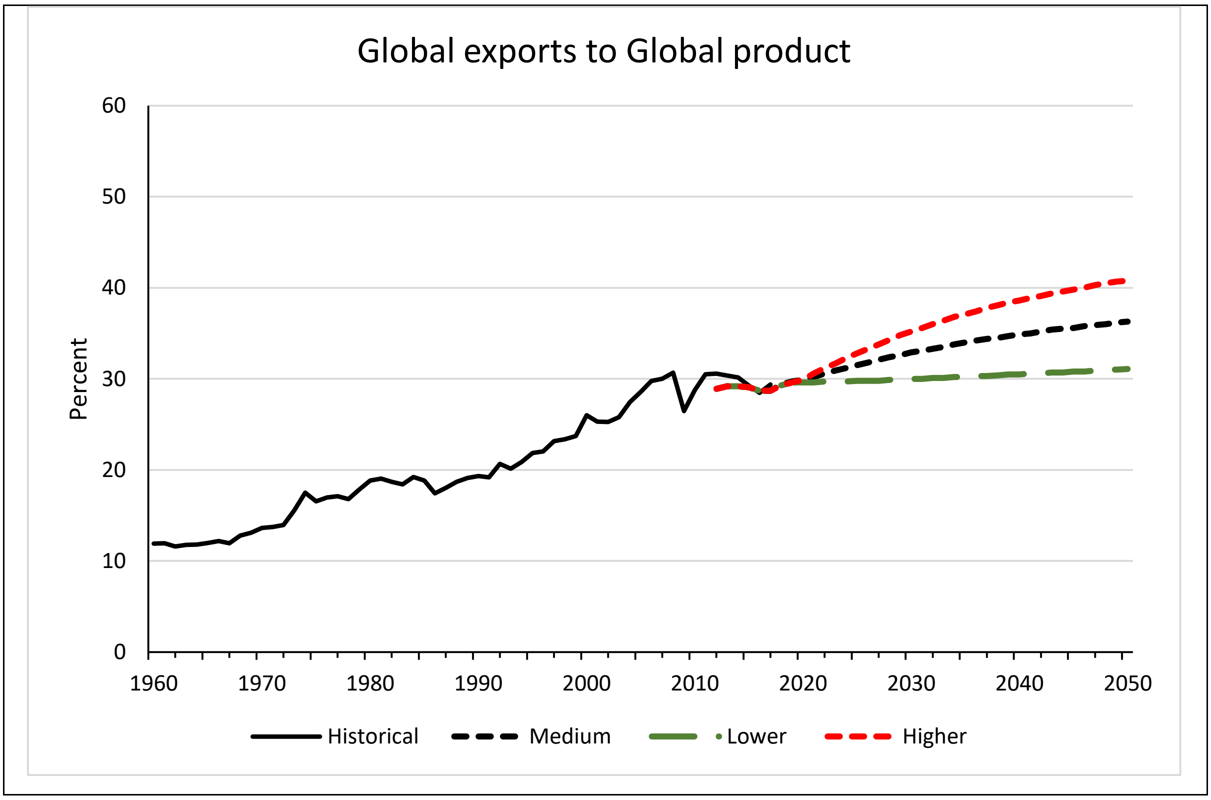


Figure 5: Historical estimates and baseline projections of global exports to global product, 1960 to 2050, percent

Source: World Bank, World Development Indicators (accessed October 2020); Author GDyn-FS projections.

It should be noted that the trajectory for each scenario tapers towards the end of the focus period. This reflects the convergence towards target shares which were brought into play in 2020 and remained fixed during the projection period. (Under the partial adjustment method, it would be possible to update/recalibrate the target share during the projection period.)

Across the historical projection period 2012 to 2019, the projected trade shares, while broadly aligned with historical data do not match that data exactly. There are a number of possible reasons for this including valuation and terms of trade effects influencing historical data measured in current USD but not captured in the baseline projections which are benchmarked to 2011 USD.

The focus of baseline credibility in regard to the trading relation between countries in this analysis is on the trade shares built up from the regional level (Table 3). These shares establish at a regional level, the world matrix of trade costs along a baseline and the reference point (or point of departure) for policy analysis. However, target shares best suited for different studies may vary. For example, if the potential impacts of trade policies is to be the focus, a relatively neutral baseline in the neighbourhood of the low to medium trade potential scenarios may be most relevant. Such a set up could provide a 'no-policy' reference against which policy scenarios could be evaluated. The lower trade potential scenario could also provide a reference point for an exploration of the implications of ongoing trade tensions and more inward-looking industry policies. However, if the policy analysis was concerned with environment/social issues where the concern was the effects of possible global trade and trajectories on the subject of interest, such as land use, plastics waste, air pollution or income distribution, projections of possible broad trends in the baseline, without consideration of detailed policies, that may be most relevant. In this case, the medium to higher trade potential scenarios, or variants thereon, may be most relevant. The higher trade potential scenario could also provide a reference point for an exploration of the implications of a more open global trade environment and associated industry policies. In either case, clarity around the evolution of the trading relations between countries and sensitivity of results to alternative baseline scenarios would be prudent.

Another test of the credibility of a trade baseline is the implied elasticity of trade to global growth measured in volume terms (Bekkers et al. 2020:305). This elasticity calculates the rate of growth in trade flows with respect to the rate of growth of global product, both measured in volume terms. Bekkers et al.(2020:305) report trade elasticity by decade over the period 1950 to 2017. The reported average for the period is 1.54 with the merchandise trade boom of the 1990s reflected in an estimated elasticity of 2.48, and periods of slower merchandise trade growth such as the 1980s accompanied by a lower trade elasticity, estimated at 1.26. This paper expands the calculation of the trade elasticity in three respects. First, it employs World Bank data to estimate the trade elasticities for goods and services by decade back to 1970. Second, it projects the trade-to-income elasticity over the historical reference period (2012 to 2019). Third, it separately projects the elasticity over the forward projection period (Table 5). The historical and forward estimates are referenced to 2011 USD.

Both sets of historical estimates report a full-period average elasticity of 1.54, while sub-period estimates differ. For example, the elasticity for goods and services for the 1990s estimated from World Bank data on goods and services trade is estimated at 2.08 which compares to the Bekkers et al.(2020) estimate for merchandise trade of 2.48. These differences suggest material compositional differences and possible methodology differences.

For the historical projection period (2012 to 2019), the estimated elasticity for goods and services based on historical data is 1.22 which compares to 1.09 in the historical model-based projections across the period (Table 5). This represents an 11 percent difference with respect to historical data which compares with about a 4 percent difference in projected shares. This gap suggests that non-trade-price effects such as changes in taste, structural change and non-tariff barriers played a material role in determining the global trade matrix during the period.

Table 5. Estimated world trade-to-income elasticity for goods and services by decade and projections to 2050 by scenario

Scenario	1971-79	1980-89	1990-99	2000-09	2010-19	1971 to 2019	2012-19	2020 to 2050
				Historical estimates				
	0.75	1.36	2.08	2.08	1.36	1.54	1.22	
				Projections				
Medium							1.06	1.16
Lower							1.06	0.99
Higher							1.06	1.29

Source: Author estimates based on World Development Indicator data and GDyn-FS projections.

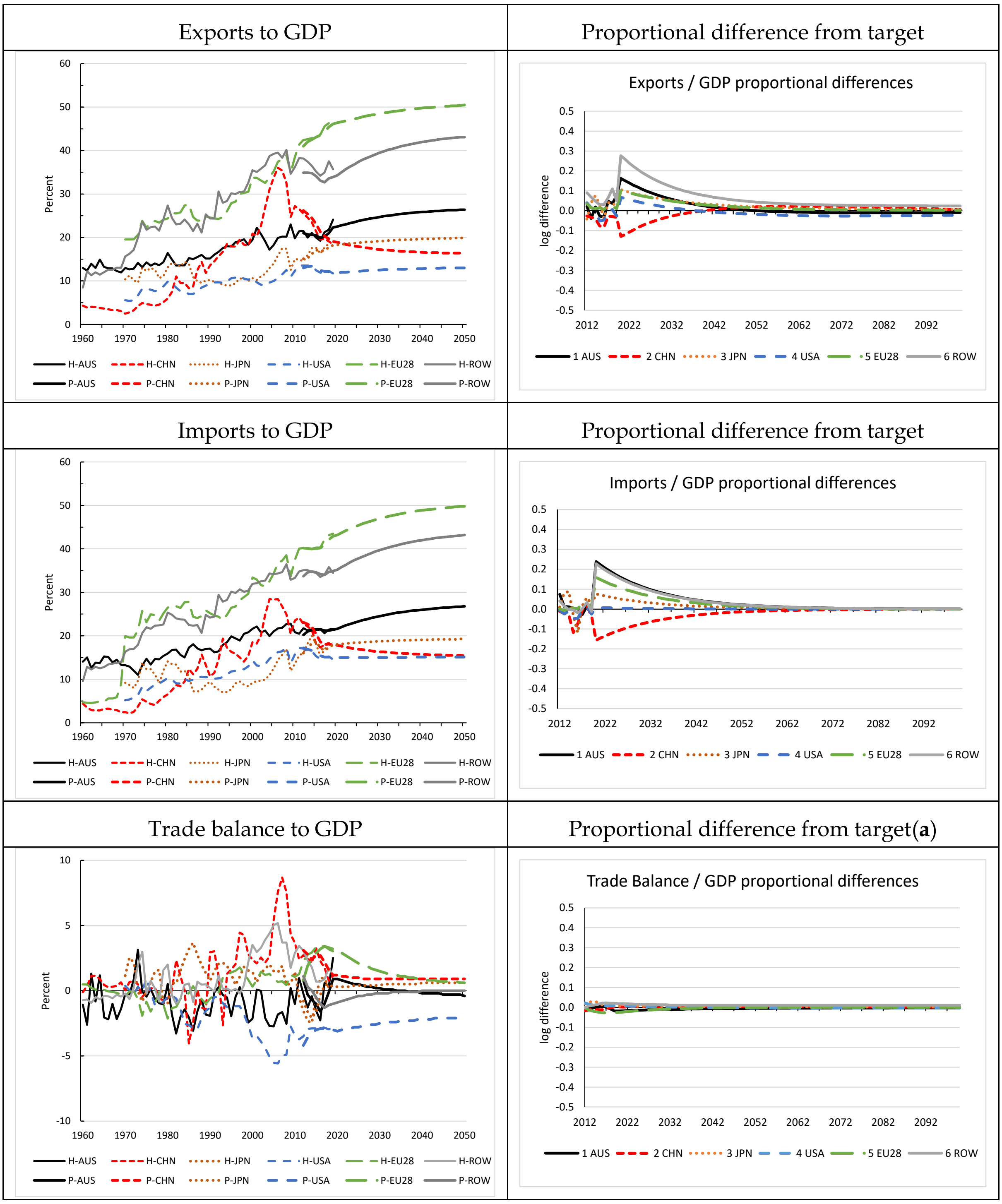
Into the forward projection period, the global trade-to-income elasticities on goods and services are projected to be 1.16 for the medium trade-growth potential case, and 1 and 1.3 for the lower and higher potential cases, respectively (Table 5). As noted above, these elasticities are influenced by opposing effects of lower trade intensity for China (from historically high levels) and an increasing trade intensity for other regions (from 'average' levels). Coincidently, the elasticities are in the neighbourhood of projections over the period 2011 to 2040 in Bekkers et al.(2020:308) using a bottoms-up method. For example, with no policy or exogenous price `changes, Bekkers et al. project a trade-to-income elasticity of 1.06 for goods and services (over the period 2011 to 2040) which compares to 1.00 for the lower trade-potential scenario (Table 5). On the other hand, a scenario with ongoing tariff reductions, lower energy prices and lower transport costs based on historical averages is associated with a trade-to-income elasticity on goods and services of 1.29 (over the period 2011 to 2040) which compares to the higher trade potential case also of 1.29 (Table 5). Bekkers et al. noted even higher estimates could be achieved via the bottoms up method had the potential impact of non-tariff measure in addition to tariffs been analyzed. Bekkers et al. did not undertake an historical validation exercise.

Against the background of the baseline trade scenarios at the global level, the next section reports the projections for the medium trade growth scenario by region.

4.4 Projections of regional trade balances to GDP

As noted, the projection of trade shares by region are divided into those for the historical projection period (2012 to 2019) and the forward projection period 2020 to 2100 (Table 2). In summary, over the historical projection period, the share of exports to GDP is targeted each year for n-1 regions, with the ROW region determined endogenously. The share of imports to GDP is targeted each year for all regions. With imports and exports so targeted the share of the balance of trade to GDP is determined endogenously for all regions. Over the forward projection period, direct focus is given to longer-run balance of trade constraints through the targeting of the balance of trade to GDP share for n-1 regions (with the ROW region determined endogenously). The underlying growth in trade is determined through the direct targeting of the import share to GDP across all regions, while regional exports are determined by the relative competitiveness of regions, subject to the regional balance of trade constraints and other baseline assumptions, including the longer-run regional saving rate.

Historical data show that the trade shares vary considerably from year-to-year across regions. Over the historical projection period, the projected export and import shares in GDP closely mirror actual values (Figure 6). The projected baseline shares widest of the mark in proportional terms across the historical period, are imports (and less so exports) to GDP for China in the years 2015 and 2016 (Figure 6, right panel). In the preceding and later projection years, the proportional difference are less suggesting that there are some elements of structural change in China in these particular years not captured in baseline assumptions. In respect of the 2015 projection though, the proportional difference is associated with a 2 percentage point difference between the actual and the target share value of 18 percent. While material, this difference does not distort broad between-country comparisons (Figure 6, left panel). The differences resolve by the end of the historical projection period so do not flow into the forward projection period. The export share for the ROW sector is endogenously determined to satisfy market clearing constraints given other baseline assumptions. Even with this caveat, projected exports shares for the region are within 10 percent of the target values (Figure 6, right panel). Noting that the proportional differences reported for the balance of trade are re-referenced to one to avoid negative value problems and not directly comparable to the proportional differences reported for exports and imports (see section 2.4), the proportional differences of the target to the projected share values lie within a 3 percent band in the historical projection period.



(a) Proportional differences referenced to 1 to avoid negative BOT problem (see equations 16c and 17c).

Figure 6: Historical estimates and baseline projections (medium trade-potential scenario) of trade shares by region, 1960 to 2050, percent

Source: World Bank, World Development Indicators (accessed October 2020); Author GDyn-FS projections.

As noted, the long-run target values for import and the balance of trade to GDP shares are introduced in 2020. This is reflected in a jump in the proportional differences between the target and actual values in that year (Figure 6, right panel). These differences are gradually eliminated through the partial adjustment process. By 2050, the projected import and export shares in GDP converge to within 3 percent of the target values for all regions, except for the

ROW region for which the projected export shares are within 5 percent of the target. This scale of converge is consistent with what would be expected on the basis of the partial adjustment parameters adopted (see section 2.4.6). Again noting that the proportional differences for the balance of trade are referenced to one, the projected differences of the target to the projected share values lie within a 1 percent band by 2050 for all regions except the ROW which is endogenously determined and which lies just outside the band (Figure 6, right panel). The difference for the ROW region is, however, persistent over time, indicating an inconsistency between projection of saving rates or current account remittances and transfers with the balance of trade targets model that accumulate in the trade balance share projected for the ROW region.

Similar findings occur with respect to the convergence of actual to target trade shares for the lower trade-potential and the higher trade potential scenarios. Overall, the baseline projections extended to include projections of trade shares based on historical data strengthen the baseline for analysis of the possible evolution of the intensity of trade between regions and wider policy analysis.

5 Projections of indexes of trade intensity

This section utilizes the baseline described above to examine the flow-on effects for trade intensities between regions. This is done through the introduction of indexes of trade intensity between regions into baseline projections of the global economy and regional trade (sections 2.5.1 and section 3, respectively). The forward-looking indexes provide for the evaluation of policy approaches most likely to encourage mutually beneficial trade between regions in the global economy. The analysis first focuses on the trade intensity implications of the medium trade-potential scenario introduced into the baseline. The implications of the low and higher trade-potential scenarios are then discussed.

This section reports first on the regional share of global imports, the denominator of the trade intensity index calculation, then on the shares of each region's exports absorbed by trading-partner regions, the numerator in index calculations. Against this background, the trade intensity index for each exporting region with respect to its trading partners is reported. As noted, an index value of one is the neutral case in which a region absorbs exports from a trading partner in the same proportion to its absorption of global imports (section 2.5.1).

For comparison and validation of projections over the historical period, each index element is calculated for 2004, 2007, 2011 and 2014 using the GTAP 10 database. The comparison data cover the growth and peaking of the trade share of GDP for China as well as contemporary growth in the relative importance of trade for the Europe 28, the ROW and other regions (Figure 6, above).

All indexes are calculated for goods and services. Data from the GTAP 10 database in is USD for the respective database years. Model projections are referenced to the GTAP9a database for 2011 and based on 2011 USD.

5.1 Regional trade share of global imports

Historical data from 2004 to 2014 show the share of global imports absorbed by China and the ROW regions to have expanded relative to other regions (Figure 7). The other side of the increased footprint of these regions was a declining footprint of the slower growing, including the USA and EU 28. With the trends in the historical data closely followed by baseline projections over the historical period, those projections provide a useful foundation for forward projections of trade intensities.

The most notable feature of the baseline projections in the forward period is the on-going expansion of the footprint of the ROW region (Figure 7). This reflects: (i) a relatively high GDP growth (raising import demand) in the SSP2 (medium) growth scenario adopted (Figure 3);

and (ii) the assumed convergence of the import share in regional product toward that of the multi-country EU28 region, including via higher levels of intraregional trade. With the increase in the trade footprint of the ROW region, the footprint of other regions in global imports is projected to decline over the forward projection period. This effect while applying across all regions is most evident for the slower growing EU28 region. The growth in the trade footprint of China is projected to taper off and decline as: (i) China's GDP growth rate converges towards OECD-economy rates towards 2050 in the SSP2 growth scenario (Figure 3); and (ii) China's imports as a share of its GDP converges to the neighbourhood of shares characteristic of Japan and the USA (Figure 6). Under these assumptions, the gap between the share of global imports absorbed by China and the USA is projected to gradually close and to be of a similar order (at around 7 percent of global imports) by 2030 (Figure 7).

With no change in the share of one region's exports to another region, an increase in the home region's share of global imports would be associated with a decline in the relative connectedness between those trading partners. The next section examines the shares of regions' exports to other regions and estimates how those changes combine to affect the relative trade connectedness between regions as measured by the index of trade intensity (section 2.5.1).

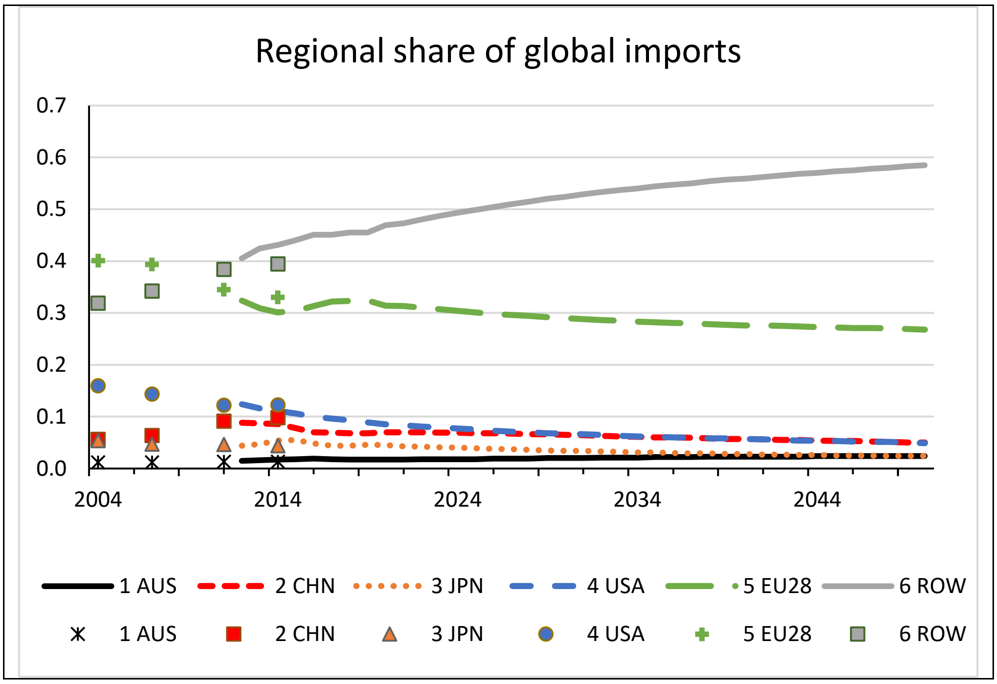


Figure 7: Historical estimates and baseline projections (medium trade-potential scenario) of regional shares of global imports, 2004 to 2050, proportions

Source: Author estimates based on GTAP 10 data; Author GDyn-FS projections.

5.2 Regional export and trade intensities

As noted, export intensities are the numerators in trade intensity index calculation by region. Thus, an increase in the share of one region's exports to another region, for a given home-country share of global imports, would raise the relative connectedness between trading partners, as measured by the trade intensity index (section 2.5.1). The calculations capture: (i) changes in the size of the exporting and destination region; and (ii) changes in the matrix of world trade implied by the long-run target trade shares. The results for each region are considered in turn with reference to the medium trade potential scenario (Table 2).

For that trade scenario, for **Australia**, the share of its exports to the ROW region is projected to rise with higher growth projected for that region relative to others and a projected increase in imports as a share of regional product (Figure 8, top panel). This reverses a decline reported over the 2004 to 2014 historical period in the share of Australia's exports to the ROW coincident with the rapid increase in the share of exports absorbed by China. This increase also saw a decline in the share of Australian exports to Japan, the USA and EU28 from 2004 to 2014. In the forward projection period, further declines are projected in the share of Australian exports going to China and Japan with those declines associated with declines in the share of global imports absorbed by those regions. The share of Australian exports going to the USA and Europe 28 is projected to remain low with some erosion from historical levels.

In terms of the relative intensity of Australia's trade with its trading partners, Australia commenced the period exporting proportionately more to China and Japan than the footprint of those regions in global trade. This is reflected by high estimated indexes of trade intensity between Australia and those regions in the historical period. In the forward projection period, the balance is projected to gradually change as the intensity of trade between Australia and the ROW increases. By 2050, the ROW region is projected to be somewhat more important as an export destination for Australia than the global average (indicated by a trade intensity index value of more than one and increasing). Nevertheless, and as indicated by relatively high trade index values, China and Japan are projected to remain substantially more important destinations for Australia's exports than suggested by the regions' proportionate absorption of global imports (as indicated by projected trade intensity index of around 2 and 3 in 2050).

For the medium trade-potential scenario (Table 2), for **China**, the share of its exports to the ROW region is projected to rise over the forward projection period to over 60 percent by 2050 from around 50 percent post GFC (Figure 8, second left panel). This upward shift follows from higher growth projected for that region relative to others (Figure 3) and a projected increase in imports as a share of ROW product (Figure 6). This adds to the increase in the share of exports from China absorbed by the ROW region over 2004 to 2014 on the back of China's accession to the WTO and its focus on the intensive margin of opening (Yu and Zhong 2020). With the expansion of the ROW as the principal export destination for China, the shares of exports from China absorbed by Japan and the USA are projected to continue to decline. After an initial increase in the proportion of exports from China absorbed by EU28 over 2004 to 2007 following China's accession to the WTO and opening, the share of exports from China absorbed by EU28 declined, a trend which is projected to continue into the forward projection period. Australia absorbed a relatively small share of exports from China across the historical data period with this relativity projected to continue into the forward projection period.

In terms of the relative intensity of China's trade with its trading partners, China commenced the period exporting proportionally more to Australia and more so to Japan and the USA than the footprint of imports to those regions in global trade. This is reflected in above unity indexes of trade intensity between China and those regions in 2004 (Figure 8, second right panel). As the orientation of China's exports moved away from Japan and the USA towards the ROW region, the relative intensity of trade between China and those regions declined while the relative intensity of trade with the ROW rose over the historical period. Over the forward projection period, the relative intensity of trade between China is projected to remain above the unity for Australia, Japan, the USA and the ROW and below unity for the EU28 region. Nevertheless, as the footprint of regional trade changes the trade intensity relationship between China and other regions could tend higher or lower. For example, with the share of China's exports to EU28 estimated below Europe's share of global imports (particularly due to large interregional trade), the relative intensity of China's trading relationship with Europe is well below that of other regions. Nevertheless, as the share of imports to the slower growing EU28 region in global imports is projected to ease (Figure 7) by more than the share of China's exports to EU28 (Figure 8, second left panel), the relative intensity of China's trade with Europe could rise slightly (Figure 8, second right panel). The opposite is the case for the ROW region, for which the trade intensity relationship with China could decline.

For the medium trade-potential scenario (Table 2), for **Japan**, the share of its exports to the ROW region is also projected to rise over the forward projection period to nearly 70 percent by 2050 from about 45 percent post-GFC (Figure 8, lower panel). Again this development reflects both the influence of higher growth in the ROW region (Figure 3) and increased import demand from the region (Figure 6). In the historical data years of 2004 and 2007, the share of Japan's exports to China, the USA and the EU28 region were similar at around 20 percent. Post-GFC, there was a substantial reorientation of Japan's export trade from the USA and EU28 towards China, with China's share of exports from Japan rising to nearly 30 percent with commensurate declines in the US and EU28 shares. In the forward projection period, with the increase in the relative importance of the ROW region as an export destination for Japan, the relative importance of China, the USA and Europe 28 is projected to decline.

In terms of the relative trade intensity between Japan and its trading partners, in 2004, the share of China in Japan's exports was about four times China's share of global imports (about 0.2 compared to 0.05)). And while the share of Japan's exports to China increased substantially from the pre-GFC years (2004-2007) to the immediate post-GFC years (2011-2014), the increase did not keep pace with the increase in China's share of global imports (Figure 7). As a consequence, Japan's relative trade intensity with China, while well above the average, declined. The relative intensity of Japan's trade with Australia, the USA and the ROW region was also above the average. However, because share of global imports absorbed by those trading partners rose (or did not decline as much), the relative intensity of the trading relationship between Japan and Australia, the USA and the ROW declined. Going into the forward projection period, well above average relative connectedness between Japan and Australia and China is projected to remain but to drift lower as the share of Japan's exports to these economies declines. In the forward projection period, the USA and the ROW are projected to absorb a similar share of Japan's exports as the share of those regions in global imports, indicated by trade intensity indexes of around one, while the EU28 region is projected to absorb less, indicated by a trade intensity index of around 0.5.

For the medium trade-potential scenario (Table 2), for the **USA**, the share of its exports to the ROW region is projected to rise over the forward projection period to about 70 percent by 2050 from about 60 percent post-GFC (Figure 8a, bottom panel). Again, this development reflects both the influence of higher growth in the ROW region (Figure 3) and increased import demand from the region (Figure 6). With the increase in the share of US exports absorbed by the ROW region, the shares of US exports absorbed by EU28, Japan and less so China and Australia are projected to decline. The pivot towards exporting to the ROW region in the forward projection period, continues the trend from the historical period.

In terms of the relative trade intensity between the USA and its trading partners, in 2004, the share of the ROW in the US's exports was nearly twice the ROW share of global imports (Figure 8, fourth right panel). And while the share of the US's exports to the ROW increased substantially over the historical data period (2004-2014), the increase did not keep pace with the increase in the ROW's share of global imports (Figure 7). As a consequence, the US's relative trade intensity with the ROW declined. This was also the case for Australia and Japan. On the other hand, export growth with China outpaced the increase in the share of global imports absorbed by China, so that the relative intensity of US–China trade increased to the point where the share of US exports absorbed by China was similar to share of global imports absorbed by China (indicated by an index value of about one). Going into the forward projection period, the share of US exports absorbed by trading partners is projected to move towards the case where those shares are proportional to the share of partners' imports in global imports (that is, towards an index value of one). Nevertheless, slightly above average relative trade connectedness is projected with Australia, Japan and the ROW and below average relative connectedness is projected with China and EU28.

The baseline includes two multi-country regions – EU28 and ROW – each with substantial interregional trade. Across the historical period 2004 to 2014, this trade as a proportion of regional exports declined from about 65 percent to 58 percent of exports for EU28 and increased from about 32 percent to 40 percent of exports for the ROW region (Figure 8, fifth and sixth left panels). In the case of EU28, this re-orientation was mainly associated with an increase in the share of exports from Europe absorbed by the faster growing ROW region. For the ROW region, the re-orientation was accompanied by an increase in the share of the region's exports absorbed by China. With these expanding shares, the share of exports from the ROW absorbed by the USA and EU28 and to a lesser extent Japan declined. In the forward projection period, these trends are continued with the magnitude of changes influenced by the higher than average growth by the ROW (Figure 3) and increased import demand as a share of regional product (Figure 6). The convergence of the share of EU28 exports absorbed by the ROW towards the share of EU28 exports absorbed within the region is also influenced by the baseline assumption that half the gap between the share of exports in GDP for the ROW and the EU28 regions is closed over the projection period (Table 3).

Because of the concentration of EU28 trade within the region, the within-region relative trade intensity is above unity and high relative to the intensity of trade with other regions (Figure 8, fifth right panel). Moreover, as the EU28's share of global imports is projected to decline over the forward projection period at a rate above within-region trade, the within-region index of relative trade intensity is projected to rise. For the ROW region, the share of within-region exports is similar to the share of global imports absorbed by the region yielding a trade intensity index of around unity in the historical and forward projection periods. The pattern of connectedness between the EU28 and the ROW region with trading partners differs in important respects across the historical and forward projection periods. For the EU28, while intraregional trade is projected to be high relative to the regions share of global imports, the connectedness with other regions modelled is low. This is because the share of exports from EU28 to other regions is below the share of global imports absorbed by those regions. For the ROW region, the share of ROW exports absorbed by other regions except EU28, is more than proportional (or more so) than the share of global imports absorbed by the trading partners. This is reflected by trade intensity index values above unity. The relative connectedness of the ROW to EU28 is well below that of connectedness with other regions (as indicated by an index value of around 0.7 across the historical and forward projection periods). This arises because the share of ROW exports absorbed by the EU28 is persistently lower than the share of global imports absorbed by the EU28 (a consequence of a relatively high level of intra-regional trade in the EU28).

In summary, an important common element across the regions modelled is the increase in the share of regional exports absorbed by the ROW multi-country region. This is evident over the baseline and forward projection periods. In the historical projection period, this reflects above average economic growth and the rapid expansion of global supply chains. In the forward projection period, it reflects the baseline assumptions of both the higher than average projected output growth for the ROW and higher import demand as a shares in region product. The higher import demand is also influenced by baseline assumption of ongoing convergence of the trade share in GDP for the multi-country ROW region towards and that of the other multi-country region modelled (that is, EU28). Implicit in these baseline projections is ongoing reductions in resistances to trade and reductions in trade costs. With changes in the export intensity of regions and the share of global imports absorbed by regions varying with baseline assumptions, the relative connectedness between regions (as captured in the trade intensity index) also varies. The potential for change is most stark for small to medium sized trade-exposed countries such as Australia, for which a re-orientation in connectedness from China and Japan towards the ROW region is projected. Nevertheless, the potential for re-orientation of connectedness is not limited to such regions. For example, relative connectedness within the ROW region is projected to increase, while relative connectedness between the USA and the ROW, Japan and Australia is projected to decline. The method allows for other trajectories to be considered.

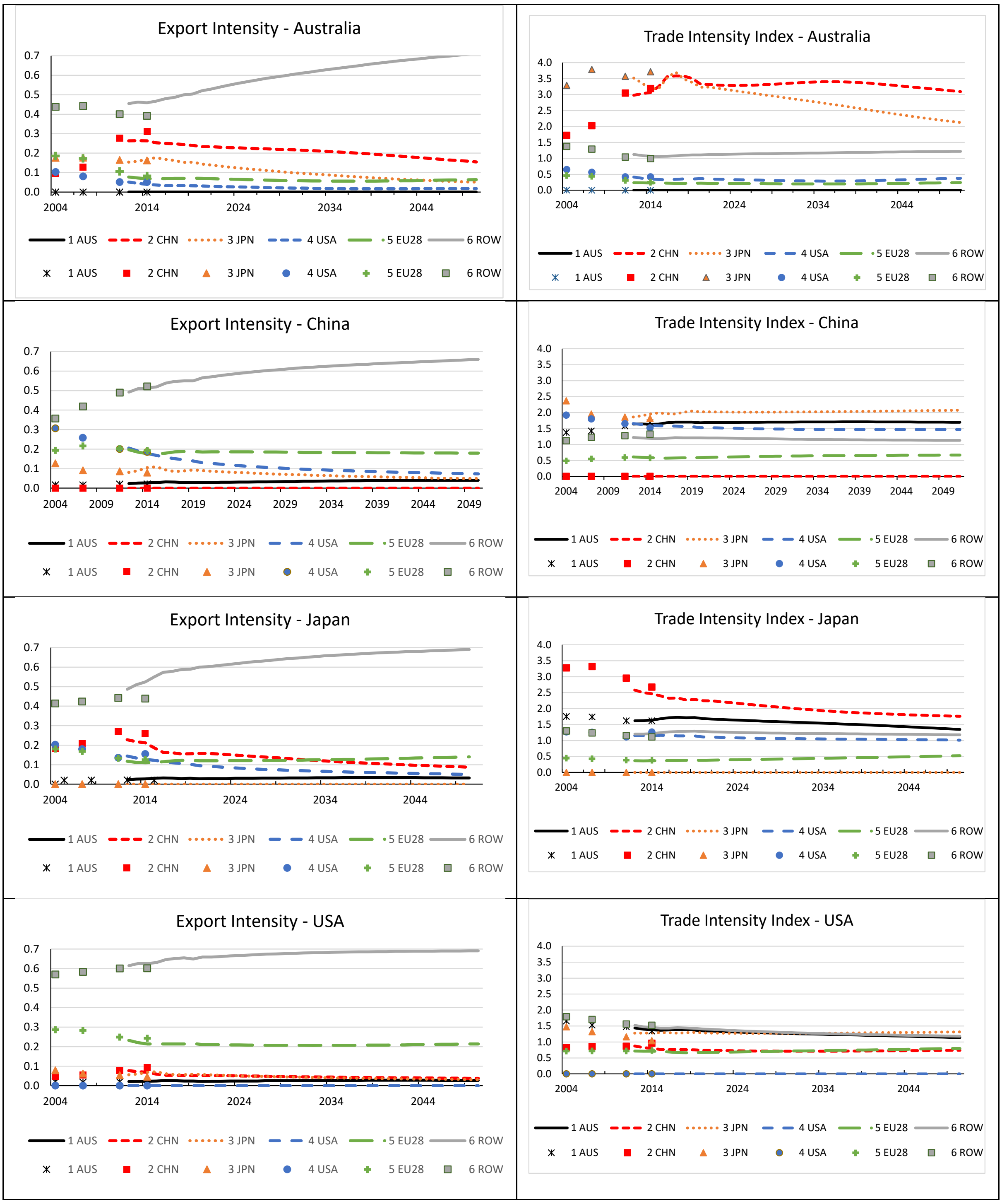


Figure 8: **Historical estimates and baseline projections (medium trade potential scenario) of export intensity and trade intensity by region, 2004 to 2050,** proportion

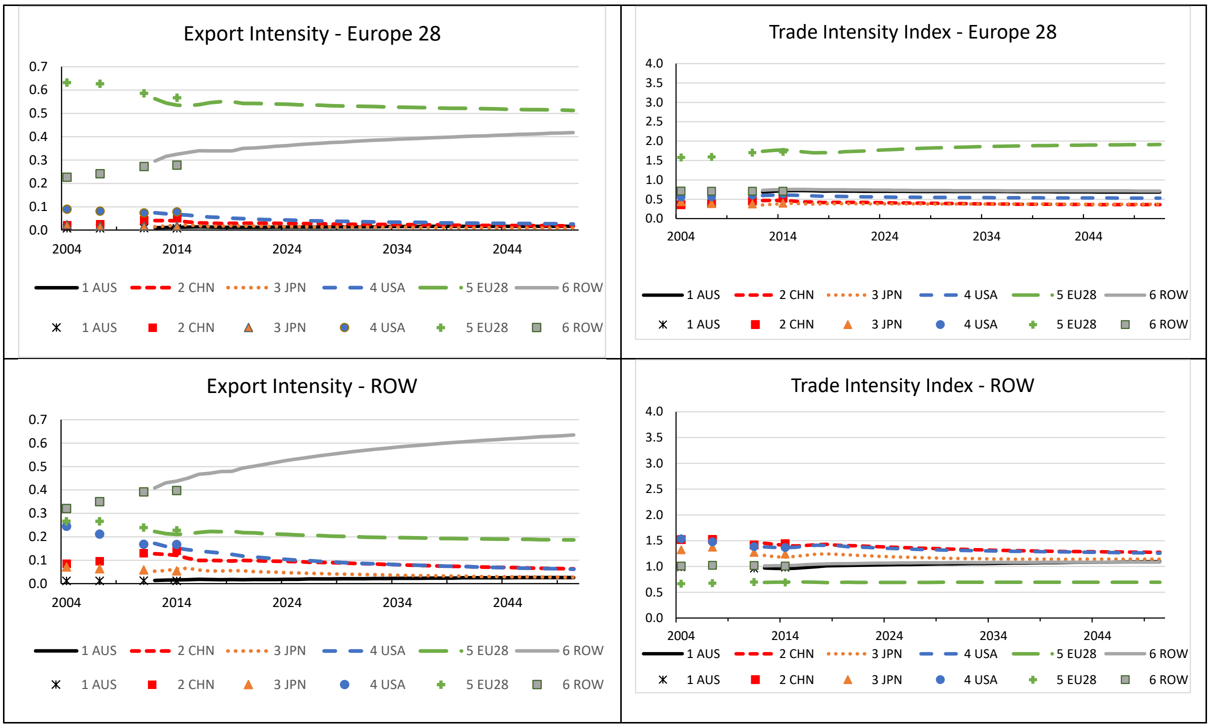


Figure 8: Historical estimates and baseline projections (medium trade potential scenario) of export intensity and trade intensity by region, 2004 to 2050, proportion **(continued)**

Source: Author estimates based on GTAP 10 data; Author GDyn-FS projections.

5.3 Sensitivity of baseline projections to trade-scenario assumptions

The sensitivity of baseline projections over the historical projection period depends on the progression of actual changes and how closely the model projections align with actual data. Historical data indicate that substantial changes in the trade connectedness between regions can occur over relatively short periods. As noted, the point estimates over the 2004 to 2014 reflect the impact of China's opening on the intensive margin exemplified by the lowering of barriers to trade associated with China's accession to the WTO, expanding market access for FDI, relaxation of restrictions on outward FDI and the establishment of free trade zones (Yu and Zhong 2020:291). The effect of these policies is evident in an increase in the share of global imports absorbed by China and a (variable) increase in the share of regions exports absorbed by China. These changes had a mixed effect on the relative connectedness of regions with China depending on the increase in the share of a regions' exports absorbed by China relative to China's share of global imports. For example, because the share of exports from Australia, the USA and EU28 absorbed by China rose ahead share of global imports absorbed by China, the overall trade connectedness of those regions with China increased to 2014 (Figure 8, point observations). On the other hand, because the share of exports from Japan absorbed by China relative to share of global imports absorbed by China's declined, the overall relative trade connectedness between Japan and China declined (Figure 8). Because the proportion of exports from the ROW absorbed by China, increased at around the same rate as the share of global imports absorbed by China, the relative trade connectedness between the ROW and China remains about unity (Figure 8). Further, the direction of change is not necessarily symmetric. For example, USA-China trade connectedness increased from 2004 to 2014 as the share of US exports absorbed by China increased relative to the share of global imports absorbed by China. By contrast, China-USA trade connectedness decreased over the same period as share of Chinese exports absorbed by the US declined in absolute terms and relative to the share of global imports absorbed by the US.

The close alignment of baseline projections over the historical projection period with the point estimates derived from the GTAP10 databases in the overlap years suggests that the historical projections of the trade connectedness between regions reflect actual change as recorded in the data, at least for the period of overlap. The substantial changes in trade connectedness over the historical period also suggests that it would be worthwhile to include an historical validation component in baseline projections.

In the forward baseline projection period, the concern is with the sensitivity of projected trade connectedness between regions to the trade-potential scenario considered. The central difference between scenarios is the degree to which the share of exports in GDP increases relative to 2019 level which ranges from 2.5 percent in the lower trade potential case to 10 percent in the medium potential case and 20 percent in the higher potential case (Table 3). If these were the only changes considered, it would be expected that while the levels of imports and exports would vary, the relative trade connectedness would remain around reference-period levels. However, the trade scenarios and baseline introduce several variations to this average case. First, in the medium and higher trade potential scenarios, it is assumed the gap between the shares of trade in GDP for the multi-country region of the ROW would converge towards the share for the multi-country EU28 region (Table 3). In the lower trade potential scenario, it is assumed that the gap remains. Second, it is assumed in each scenario that the trade shares for China converge to the neighbourhood of Japan and the USA (Table 3).

The main impact of the first variation is to raise the projected share of global imports absorbed by the ROW in 2050 from **51 to 54 to 55** percent in the low, medium and high scenarios, respectively, from 43 percent in 2019 (the last year of the historical projection period). An even higher share of global imports absorbed by the ROW could have been projected with higher assumed baseline growth in output (and hence import demand) relative to other regions or higher assumed baseline growth in trade shares for the region. Conversely, lower baseline growth in output relative to other regions or lower assumed baseline growth in trade shares would have resulted in a lower demand by the ROW for exports from other regions, lowering the share of global imports being absorbed by the ROW.

The main impact of the second variation is to break the nexus between relative output growth across scenarios. In the lower trade potential scenario, the projected share of global imports absorbed by China in 2050 is projected to remain at around 2019 levels, that is, around, **8.5** percent of global imports. The assumption bites harder in the medium and higher trade potential scenarios as global import demand expands relative to that of China. In these cases, import demand as a share of global imports is projected to decline to 8.1 to 7.9 percent, respectively, in the medium and high trade potential scenarios. Stronger trade growth potential in other regions or lower trade growth potential in China would lower these projections further. Conversely, a baseline assumption of partial convergence of trade shares for China to the neighbourhood of the reference economies could raise these projections.

While the economic and trade footprint of regions is projected to change over the forward projection period, the projected trade intensity indexes (the model measure of relative connectedness) are similar across scenarios for each region (Appendix C, Table C1). This occurs because the shares of exports from a region absorbed by another region (the TII numerator) are projected to move in similar proportions to the share of global imports absorbed by the respective trading partners (the index denominator) in each baseline scenario. In this case, the projections of export and import shares provide the strongest indicators of the footprint of a region in global trade. Nevertheless, it is possible to discern some changes in the projected relative connectedness as captured by the trade intensity index, from the lower to higher trade-potential scenarios. For example, the relative trade connectedness is projected to increase within the multi-country ROW region across scenarios. This is a reflection of both the combined effect of increased trade potential with higher growth, and the projected convergence of the export intensity of the ROW region towards that of the other multi-country region EU28 included in the medium and high trade potential scenarios (Table 3). The impact of the scenario assumptions also affects the projections of the relative trade connectedness of China with other regions. For example, the relative connectedness of China with Australia, the USA and the ROW is projected to decline across scenarios. For Australia and the US, this mainly reflects a projected decline in the share of China's exports absorbed by these regions as China becomes more domestically focused and as available exports are diverted to the faster growing ROW region, a factor that strengthens across scenarios. The relative connectedness of China with the ROW declines, however, because the share of Chinese exports destined for this region is projected to increase at a slower rate than the share of global imports absorbed by the ROW, a factor that also strengthens across scenarios as interregional trade within the ROW increases.

For applied analyses, different tops-down assumptions could also be considered in which variations in relative trade connectedness are targeted, for example, stronger growth within the ROW regions or more gradual convergence of China to the neighbourhood of benchmark regions. The multi-country regions EU28 and ROW could also be disaggregated to provide a more nuanced regional view of historical and potential changes, and reference for assessing the impact of policy, institutional and broader economic developments. The tops-down method adopted lends itself to such explorations to meet the requirements of particular analyses.

6. Concluding comments and policy implications

The baseline simulations confirm the stability of the GDyn-FS model over the long-run. This is demonstrated in this paper by the dynamic simulation in annual steps of the Shared Socio-Economic Pathways projections of the global economy (Dellink et al. 2017). These projections extend out to 2100 and are further calibrated for this paper to include exogenously determined longer-run gross saving rates, export and import shares in GDP. The baseline simulations presented show it is possible to: (i) closely track year-by-year changes in key structural ratios across an historical simulation period; and (ii) closely target those ratios over the forward projection period. The tops-down approach provides a basis for nuanced baseline projections to explore potential changes in consumption-saving choices and trading relations between regions over the longer run.

The longer-run saving rate for each region is determined by reference to historical data by region and first-approximation theory-based estimates. The estimates so derived for all regions modelled except China, fall within a plausible range around historical estimates. For China, the estimates adopted represent a convergence (over time) from historically high values to values in the neighbourhood of other regions. The possible progression of trade shares over time is considered by reference to three scenarios: (i) a lower trade-potential scenario; (ii) a medium trade-potential scenario; and (iii) a higher-trade potential scenario. These scenarios gradually raise the trade to GDP shares over the baseline by 2.5, 10 and 20 percent, respectively, from current levels for all regions except China and the multi-country ROW region. For China, its trade shares are calibrated to converge to the neighbourhood of shares for Japan and the United States. For the ROW, the shares for the medium and higher trade potential scenarios are calibrated to partially converge to projected shares for EU28, the other multi-country region modelled. The scenarios provide points of comparison for alternative views about the possible evolution of global trade, with the lower trade potential scenario representing the case of ongoing global trade tensions and more inward-looking trade policies across countries. The medium trade potential scenario could be represented as the case of some relaxation of tensions towards a more open system. The higher potential scenario is consistent with a reversion to non-discriminatory trade policies that favoured openness and represents a move towards an historic trade to income growth path.

In addition to providing baseline projections of the possible evolution of global trade, each scenario may provide a suitable starting point for further policy and economic analysis. For example, the lower to medium trade potential baselines may provide suitable reference cases for the evaluation of the impact of policies that involve the lowering of trade resistances on a bilateral, plurilateral or multilateral basis, or that promote productivity improving reform. On the other hand, baselines calibrated to the medium to higher trade potential scenarios may be most appropriate for the simulation of the impact of wider economic, social and environmental policies in which trade details are not the main focus. The tops-down method adopted lends itself to such explorations to meet the requirements of particular analyses.

There is clear potential for a shift in economic gravity towards ROW regions. In all likelihood this will be combined with an increase in trade connectedness between economies within the region. There is also the potential for changes in existing orders affecting other regions. The potential for change may be quite stark for small to medium sized trade-exposed countries such as Australia, for which a re-orientation in trade connectedness from China and Japan towards the ROW region is projected. As economic gravity moves towards the ROW region, relative connectedness of large trading economies such as the China, Japan and the USA with trading partners could also drift lower to the extent that their exports to partners do not keep pace with partner uptake of imports. Also, although not modelled, large disruptions to the existing order, such as occurred on China's accession to the WTO, could occur.

Preparedness for future shifts in economic gravity places a policy premium on domestically-led behind the border reform favouring policies that: (i) increase competitiveness of domestic firms in existing and new global markets; (ii) lower the cost of trade in a non-discriminatory manner across markets (including through lowering local MFN tariffs and NTBs); and (iii) avoid undue impediments to trade (such as bilateral and regional trade conflicts, preferential rules of origin on goods and services). It also places a premium on non-discriminatory multi-lateral, plurilateral and open regional institutions that promote cooperation and a non-discriminatory order at the global level versus institutions that focus on preferential bilateral and regional arrangements that may divert resources from their most productive use.

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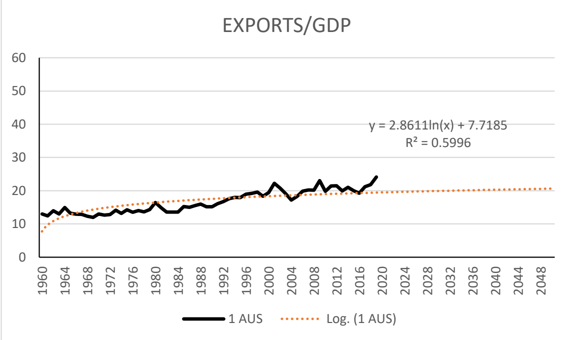
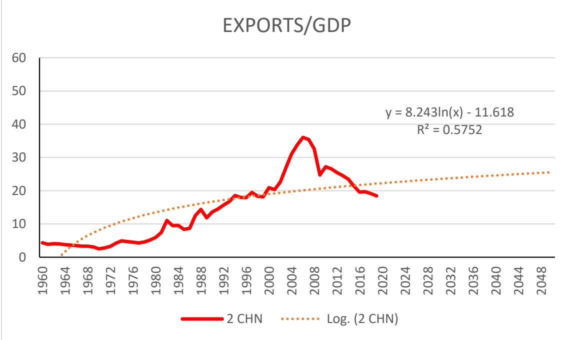
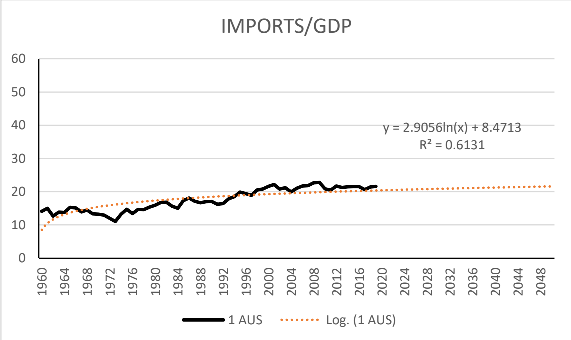
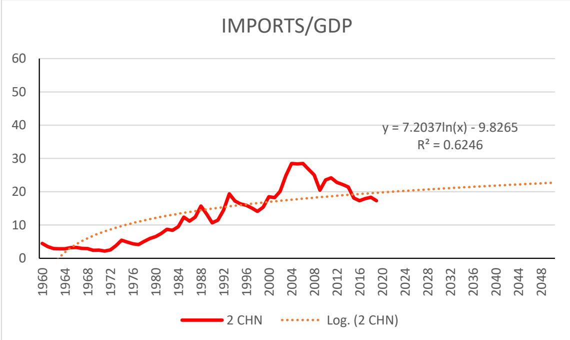
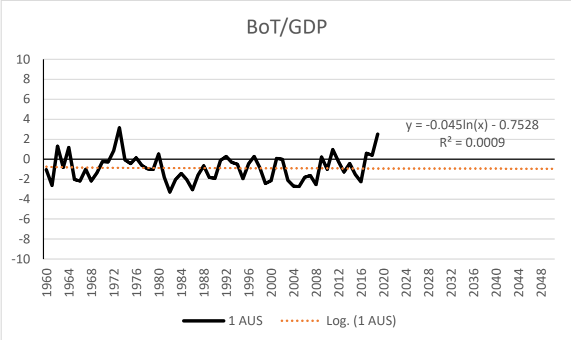
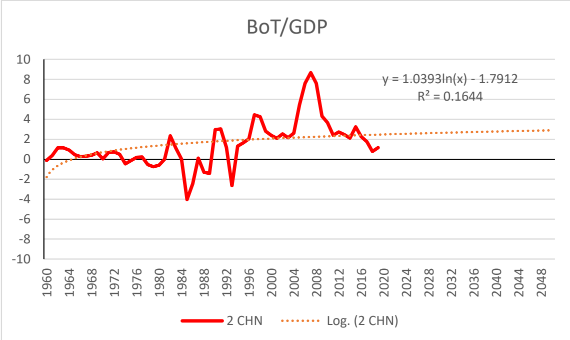
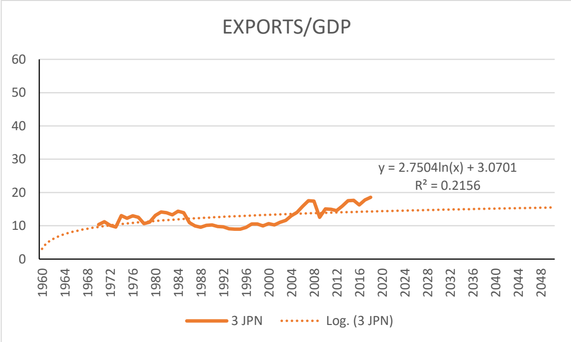
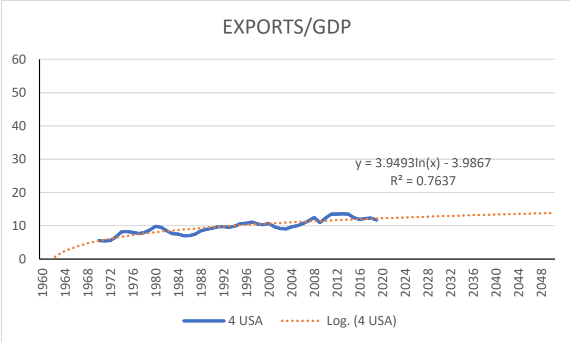
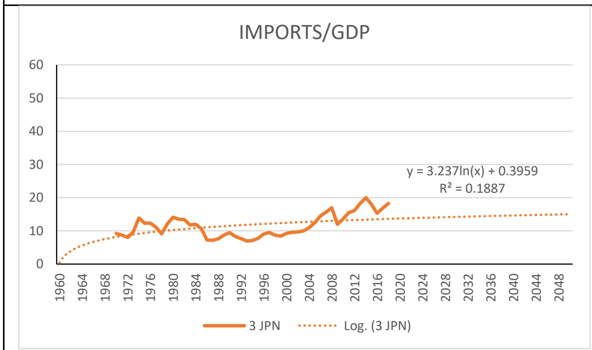
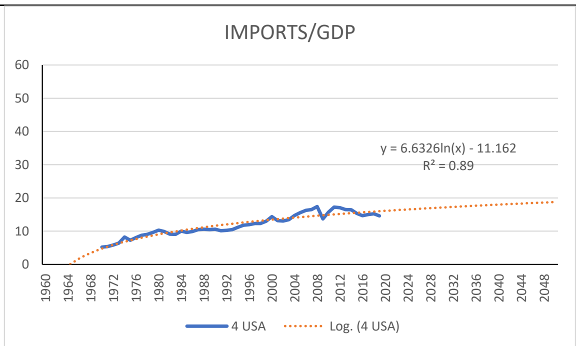
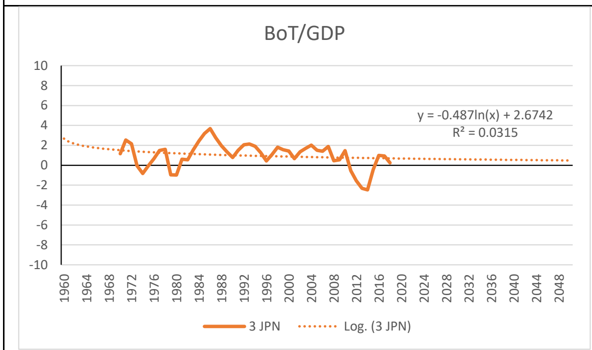
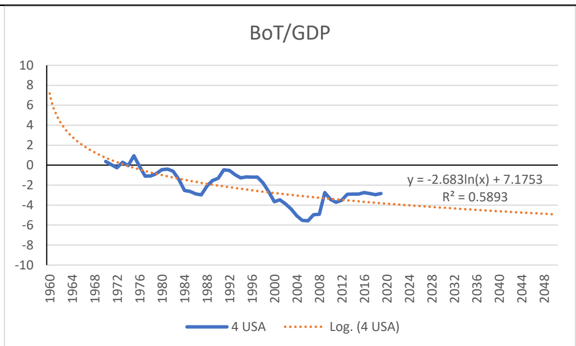
Appendix A: Trade shares by region, 1960 to 2019 and trend projections to 2050

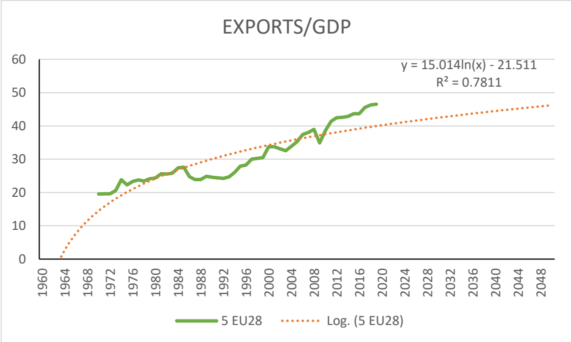
Australia	China
	
	
	

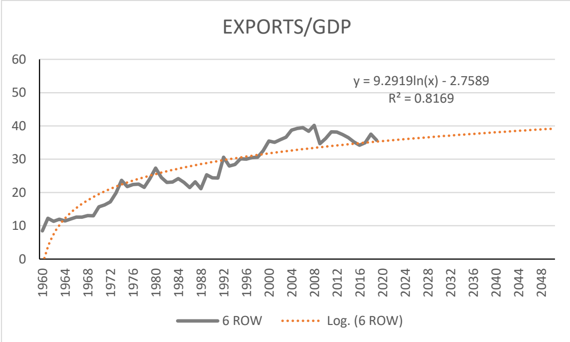
Appendix A: Trade shares by region, (continued)

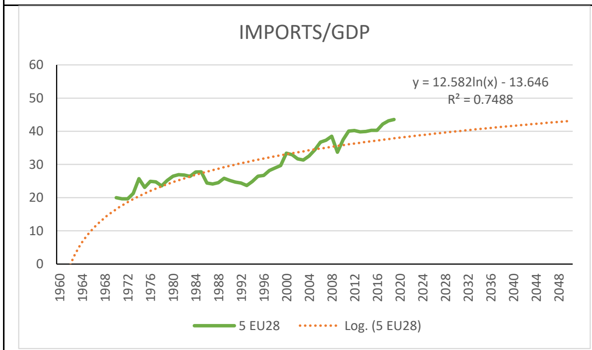
Japan	USA
	
	
	

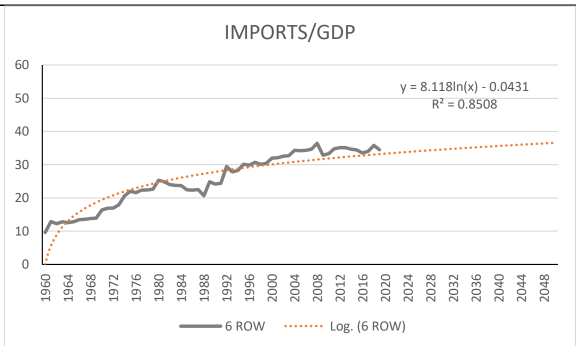
Appendix A: Trade shares by region, (continued)

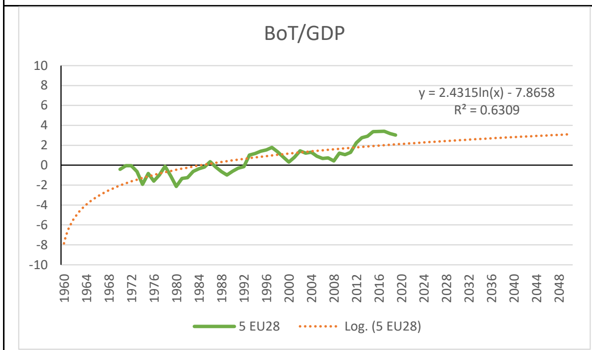
EU28[a]	Rest of world[b]

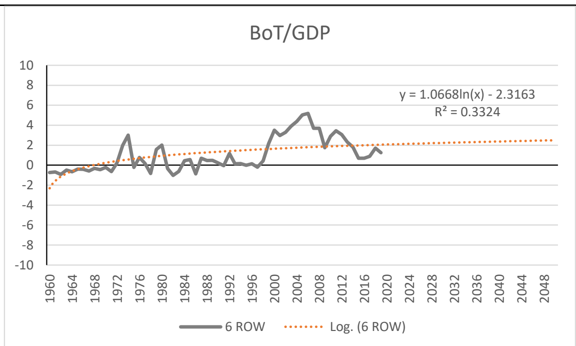








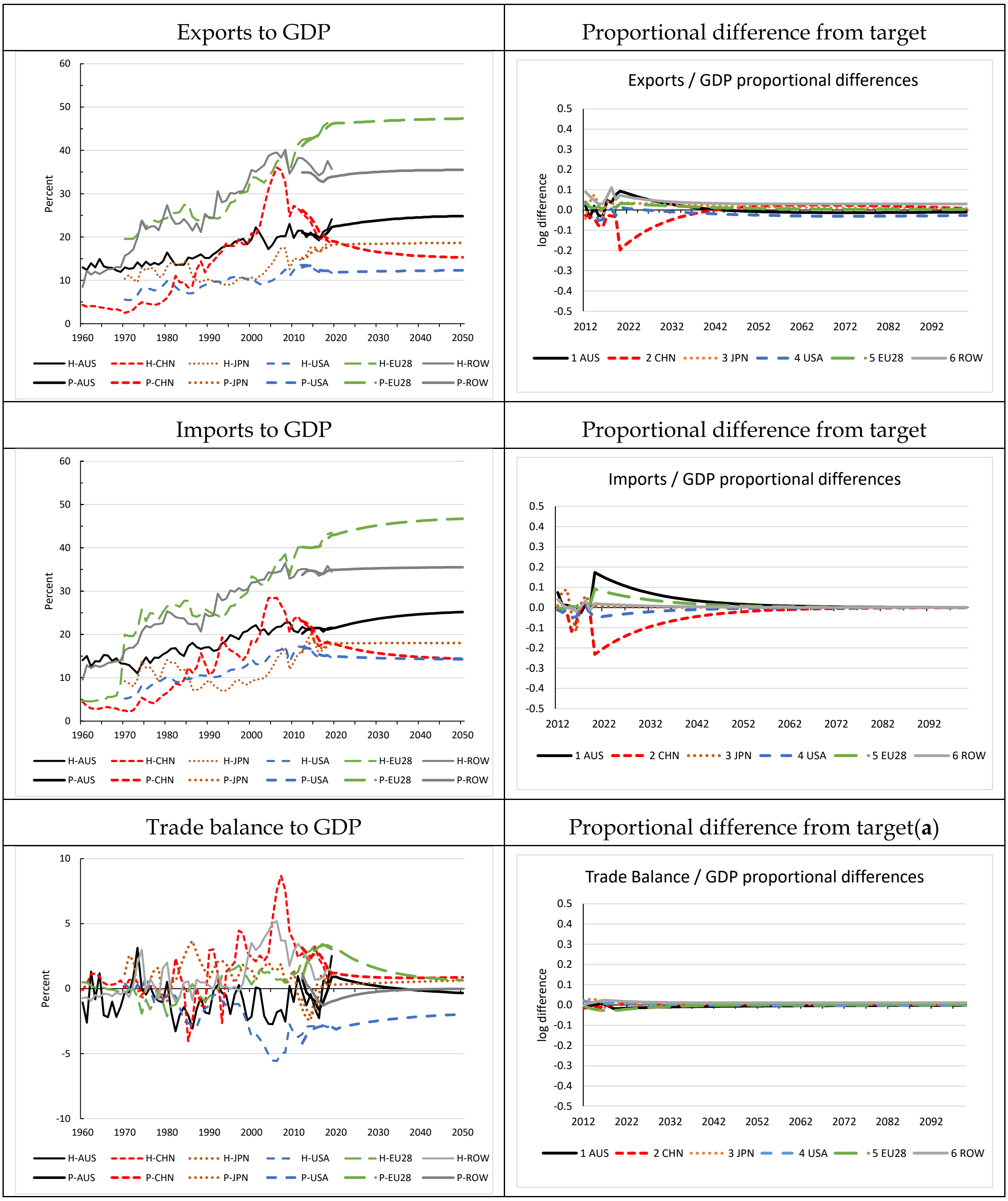




a Insufficient coverage of Europe 28 countries to report series before 1970. **b** Series affected by gaps in country coverage, in particular, European countries outside of the Europe 28 region before 1970 and Former Soviet Union countries before 1990.

Source: WB 2020, World Development Indicators (accessed December 2020), Author estimates.

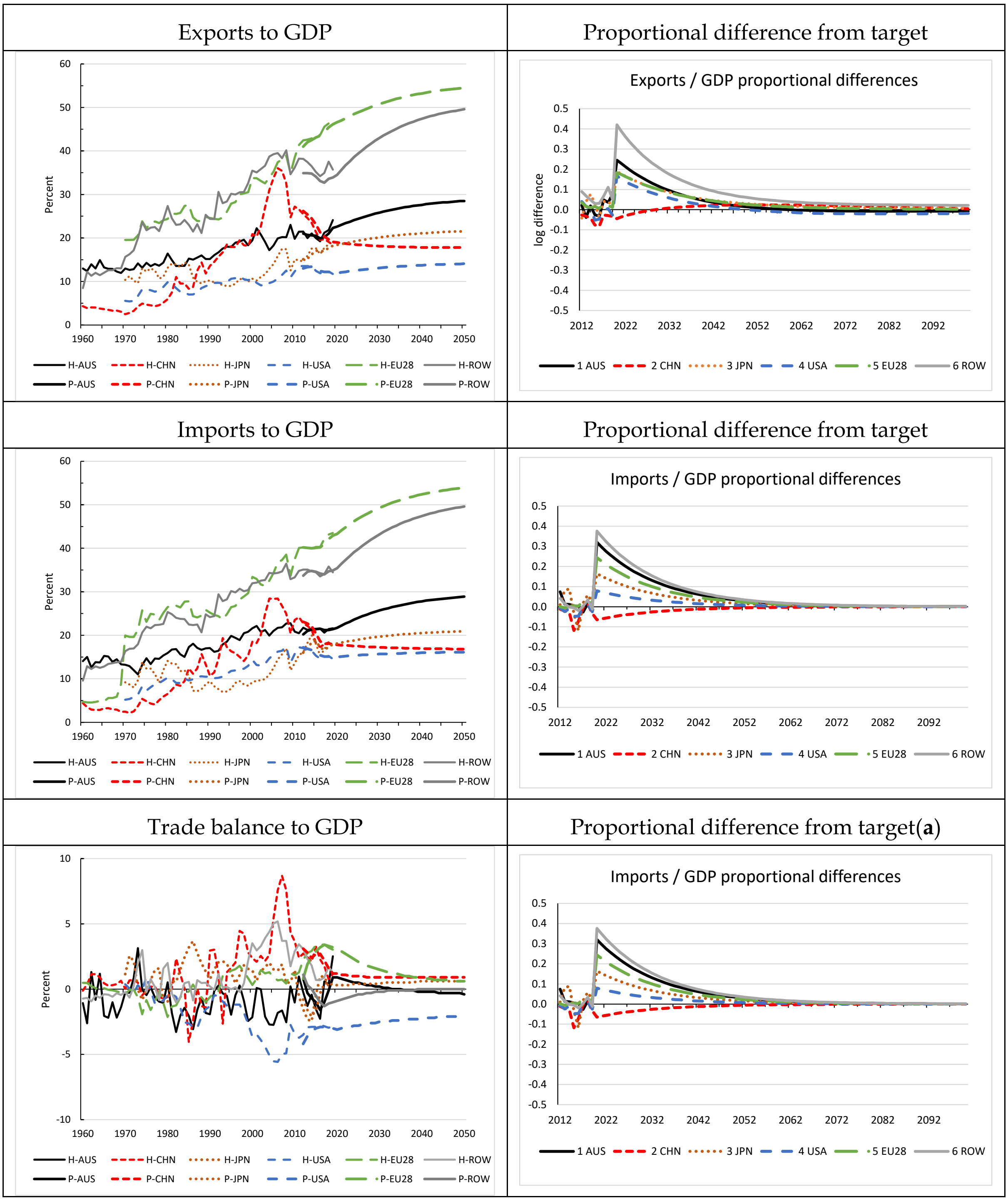
Appendix B: Historical estimates and baseline projections of trade shares, lower and higher trade potential scenarios



(a) Proportional differences referenced to 1 to avoid negative BOT problem (see equations 16c and 17c).

Figure B1: Historical estimates and baseline projections (lower trade-potential scenario) of trade balances by region, 1960 to 2050, percent, log difference

Source: World Bank, World Development Indicators (accessed October 2020); Author GDyn-FS projections.



(a) Proportional differences referenced to 1 to avoid negative BOT problem (see equations 16c and 17c).

Figure B2: Historical estimates and baseline projections (higher trade-potential scenario) of trade balances by region, 1960 to 2050, percent

Source: World Bank, World Development Indicators (accessed October 2020); Author GDyn-FS projections.

Appendix C: Regional share of global imports, export intensities and trade intensity indexes, historical estimates and baseline projections for lower and higher trade potential scenarios

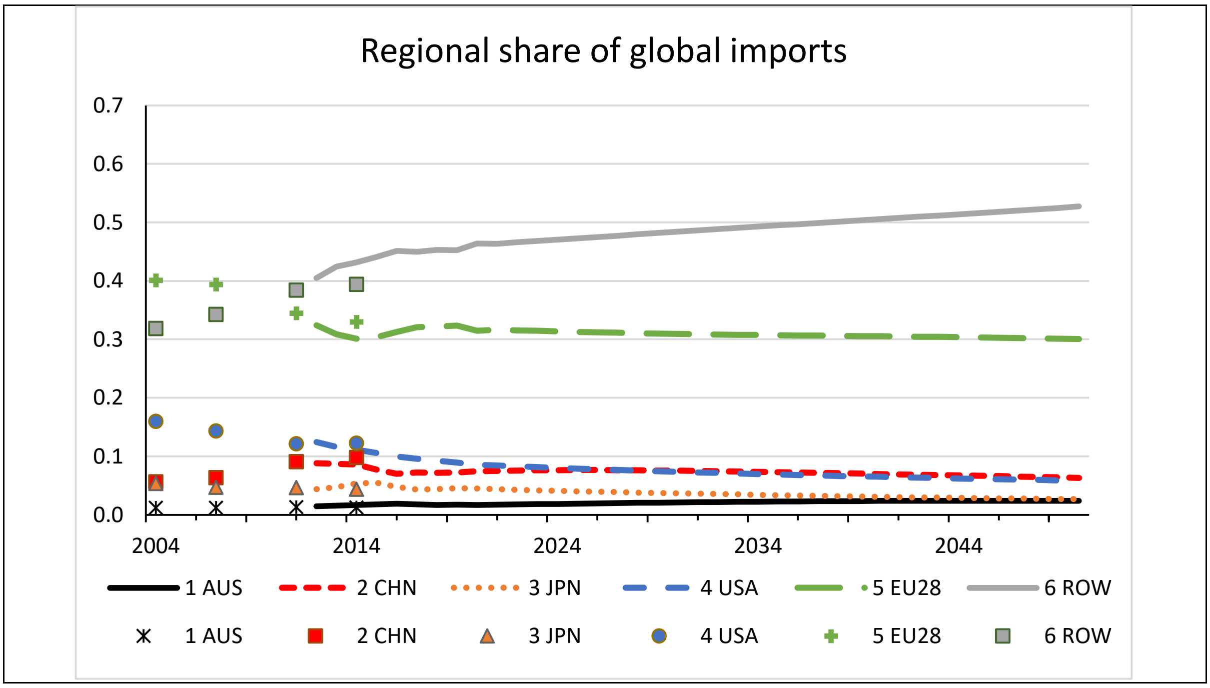


Figure C1: Historical estimates and baseline projections (lower trade-potential scenario) of regional shares of global imports, 2004 to 2050, proportions

Source: Author estimates based on GTAP 10 data; Author GDyn-FS projections.

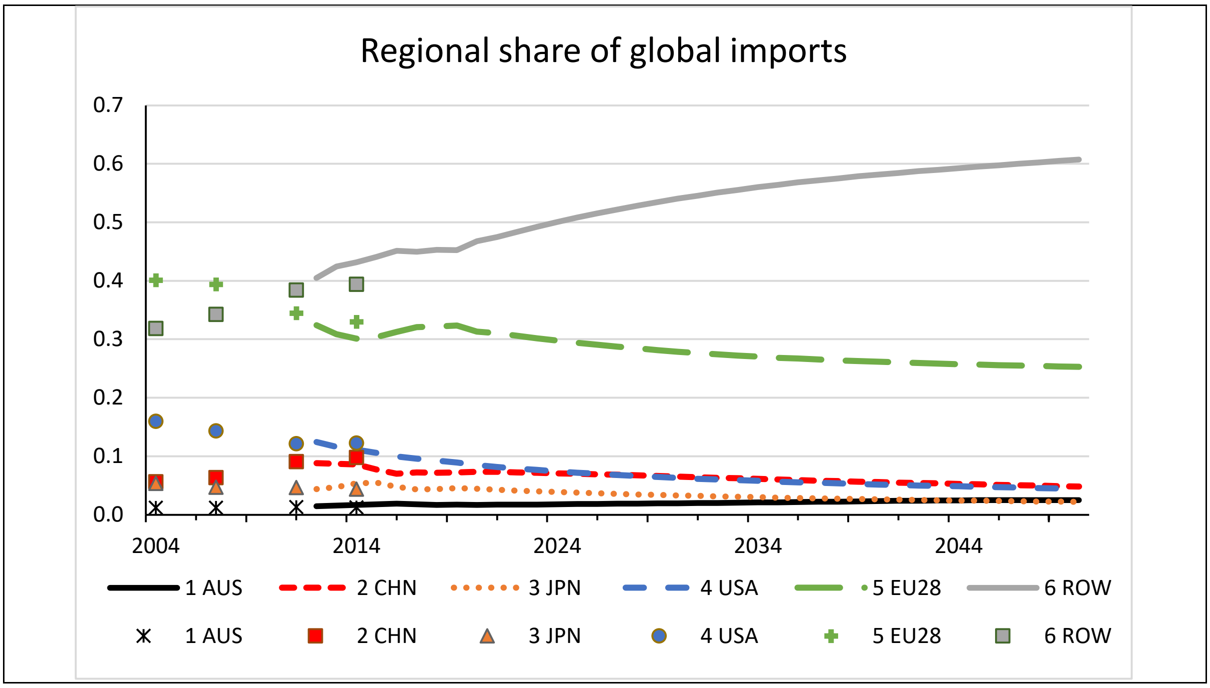


Figure C2: Historical estimates and baseline projections (higher trade-potential scenario) of regional shares of global imports, 2004 to 2050, proportions

Source: Author estimates based on GTAP 10 data; Author GDyn-FS projections.

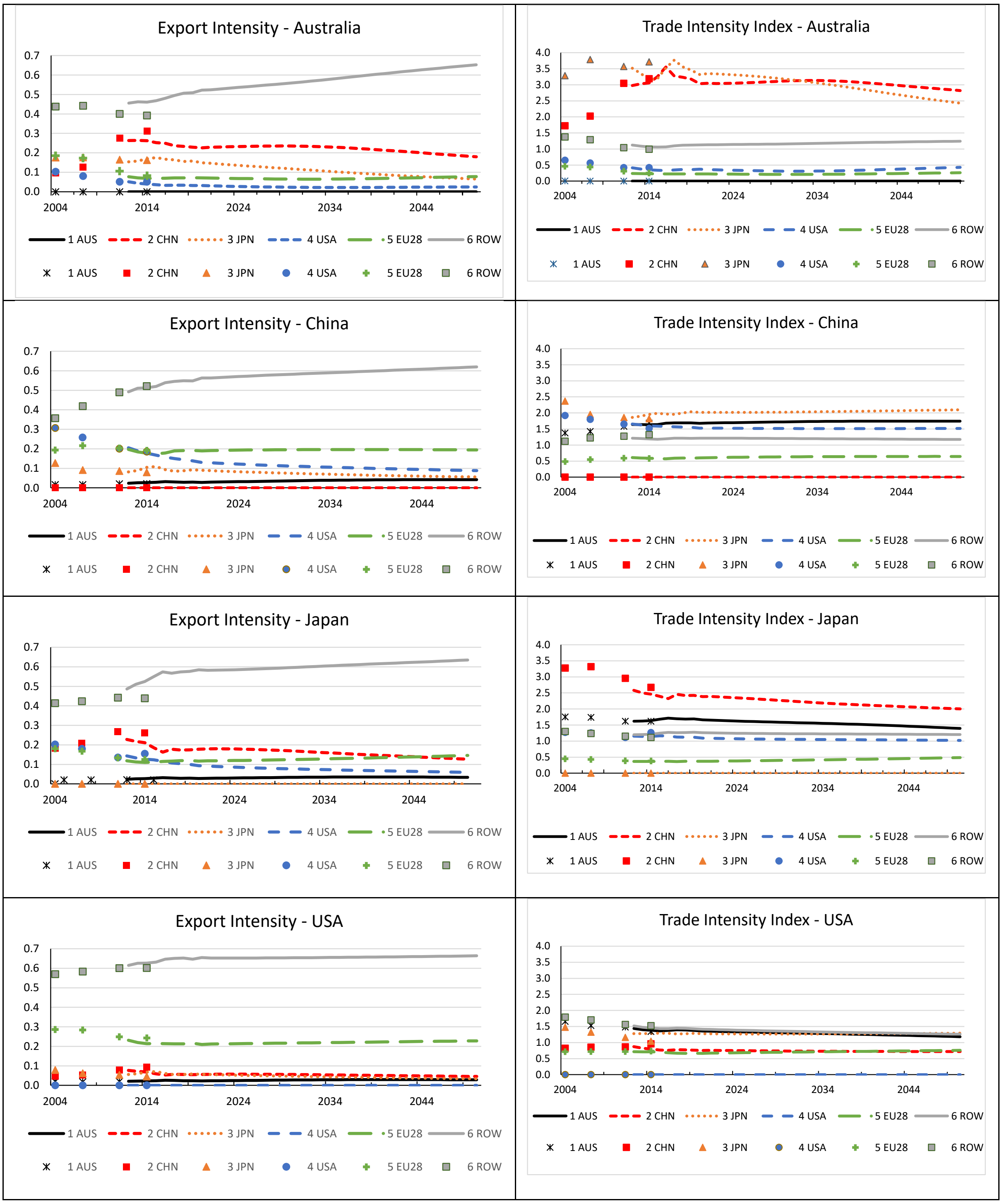


Figure C3: **Historical estimates and baseline projections (lower trade-potential scenario) of export intensity and trade intensity by region, 2004 to 2050,** proportion, index

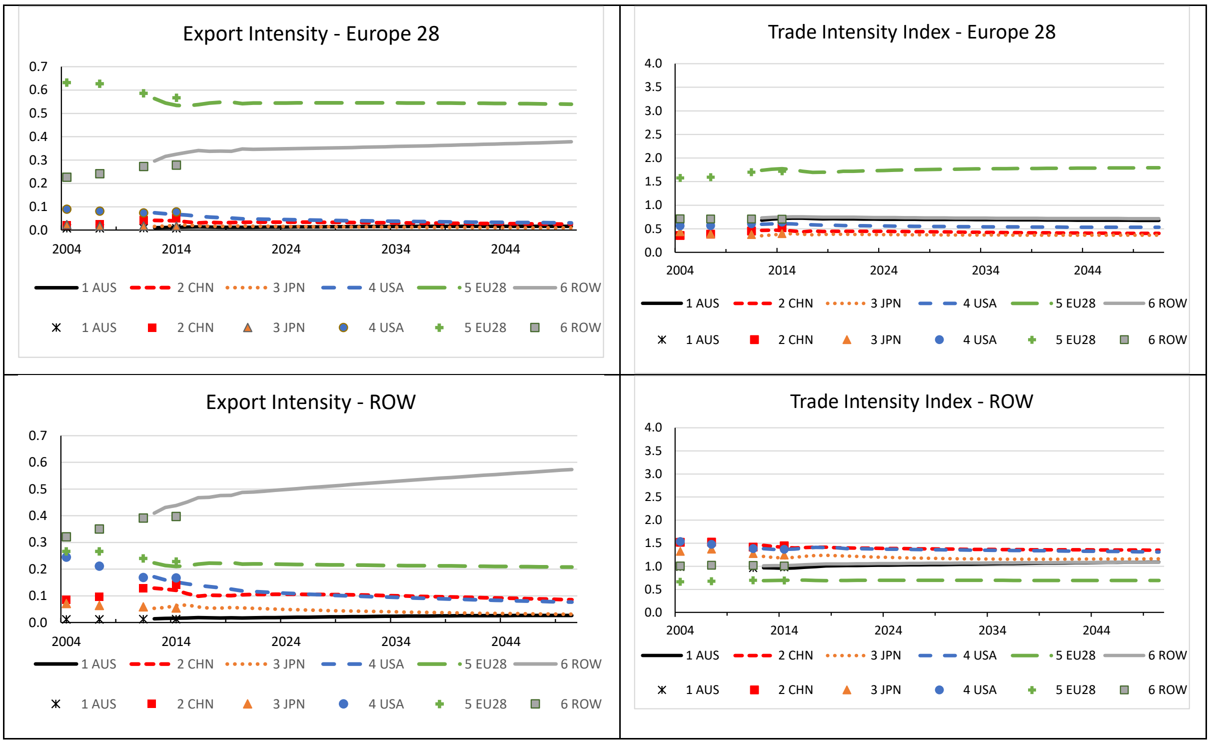


Figure C3: Historical estimates and baseline projections (lower trade-potential scenario) of export intensity and trade intensity by region, 2004 to 2050, proportion **(continued)**

Source: Author estimates based on GTAP 10 data; Author GDyn-FS projections.

Figure C4: Historical estimates and baseline projections (higher trade-potential scenario) of export intensity and trade intensity by region, 2004 to 2050, proportion, index

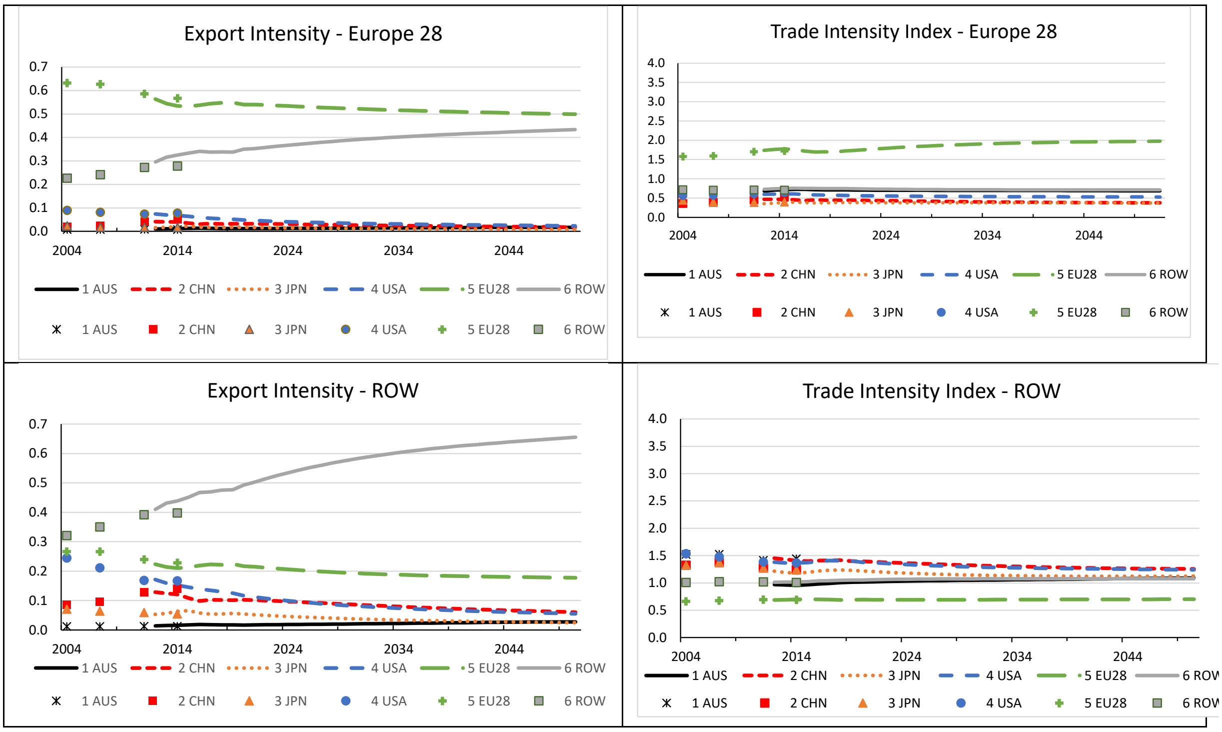


Figure C4: Historical estimates and baseline projections (higher trade-potential scenario) of export intensity and trade intensity by region, 2004 to 2050, proportion, index **(continued)**

Source: Author estimates based on GTAP 10 data; Author GDyn-FS projections.

Table C1	Baseline trade intensity indexes, by region 2019 and 2050			
		2050		
	2019	Lower trade potential	Medium trade potential	Higher trade potential
Australia with …				
Australia	0.002	0.002	**0.002**	0.001
China	3.321	2.842	**3.118**	2.560
Japan	3.232	2.462	**2.155**	2.087
USA	0.368	0.421	**0.371**	0.310
Europe 28	0.223	0.258	**0.238**	0.210
ROW	1.111	1.239	**1.217**	1.258
China with …				
Australia	1.683	1.743	**1.697**	1.678
China	0.000	0.000	**0.000**	0.000
Japan	2.023	2.094	**2.070**	2.057
USA	1.528	1.515	**1.471**	1.451
Europe 28	0.589	0.646	**0.665**	0.699
ROW	1.208	1.176	**1.128**	1.105
Japan with …				
Australia	1.684	1.394	**1.347**	1.315
China	2.246	2.002	**1.758**	1.841
Japan	0.000	0.000	**0.000**	0.000
USA	1.112	1.020	**1.012**	0.999
Europe 28	0.381	0.484	**0.523**	0.525
ROW	1.279	1.204	**1.180**	1.154
USA with …				
Australia	1.349	1.182	**1.135**	1.143
China	0.739	0.718	**0.741**	0.692
Japan	1.281	1.292	**1.315**	1.321
USA	0.000	0.000	**0.000**	0.000
Europe 28	0.667	0.758	**0.798**	0.812
ROW	1.405	1.259	**1.181**	1.158

\ continued ...

Table C1 Baseline trade intensity indexes, by region 2019 and 2050 (continued)

		2050		
	2019	Lower trade potential	Medium trade potential	Higher trade potential
EU28 with …				
Australia	0.708	0.679	**0.683**	0.686
China	0.419	0.404	**0.361**	0.379
Japan	0.386	0.364	**0.372**	0.376
USA	0.570	0.533	**0.531**	0.529
Europe 28	1.727	1.793	**1.910**	1.973
ROW	0.747	0.718	**0.714**	0.714
ROW with …				
Australia	1.018	1.093	**1.094**	1.090
China	1.406	1.350	**1.275**	1.256
Japan	1.225	1.160	**1.143**	1.124
USA	1.382	1.310	**1.259**	1.239
Europe 28	0.693	0.691	**0.695**	0.701
ROW	1.053	1.088	**1.085**	1.078

Source: Author GDyn-FS projections.