Modelling the Consequences of the U.S.-China Trade War and Related Trade Frictions for the U.S., Chinese, Australian and Global Economies

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Modelling the consequences of the U.S.-China trade war and related trade frictions for the U.S., Chinese, Australian and global economies

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Abstract

We model the U.S.-China trade war, a potential U.S.-China trade deal, and the effects of import restrictions on Australian coal. We begin by examining the effects of the bilateral tariff exchange on the economies of the U.S., China, Australia and the rest of the world. We then go on to examine a scenario in which a U.S.-China trade deal is struck involving removal of the trade war tariffs and an undertaking by China to reduce its bilateral trade surplus with the U.S. by eliminating all pre-trade war tariffs on U.S. goods. We end by noting that there are dimensions to the U.S.-China tariff exchange that go beyond concerns on the part of the U.S. that are purely economic. In this context, the tariff exchange can be viewed in part as a continuation of a wider recent pattern of use of trade instruments to advance political aims. Australia itself appears to have been subject to such instruments, with reports of a slowdown in processing of Australian coal imports through Chinese ports. We simulate the effects on Australia and China of a rise in Chinese barriers to Australian coal imports.

JEL Classification: F13, F17, C68

Keywords: trade policy, trade war, coal embargo, multi-region CGE model

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1 Introduction

This paper presents results from three sets of trade policy simulations. The first is the most detailed, modelling the recent bilateral tariff exchanges of the U.S. and China and prospective future tariff increases into 2020 (see Section 4). The second and third are more speculative. The second examines a scenario in which a U.S.-China trade deal is struck in which China undertakes to reduce its bilateral trade surplus with the U.S. by eliminating all pre-trade war tariffs on U.S. goods (see Section 5). The third simulation shifts focus to Australia. Motivated by recent reports of processing delays for Australian coal through Chinese ports, we examine the impacts of China restricting imports of Australian coal (see Section 6). The simulations are undertaken with a variant of the Global Trade Analysis Project (GTAP) model that embodies dynamic mechanisms covering regional industry specific capital accumulation, lagged regional employment adjustment, national income accounting, and an explicit baseline forecast for how the global economy will evolve in the absence of the trade policy shocks (see Section 3).

Tables A-C below summarise key results from the three simulations.

Turning first to the results of the trade war simulation (Table A), we see that the economic effects of the tariffs build over 2018, 2019 and 2020. This reflects the growing tariff rates and coverage of tariffed commodities. The peak employment losses in the U.S. and China occur in 2020, the year in which we assume that both the U.S. and China have applied comprehensive tariffs of 25% on each other's products, consistent with the current threat by the US to extend Section 301 tariffs to a further US$300b of imports from China. Employment losses attenuate thereafter, reflecting our assumption of gradual return of unemployment rates to baseline levels via real wage adjustment. Despite the return of employment in both the U.S. and China to baseline, the tariff exchange imposes permanent costs on each country, arising from both the allocative efficiency distortions created by the tariffs, and the tariff-induced reductions in the terms of trade of each country.

The table distinguishes the separate effects of the U.S. and retaliatory tariffs. Turning first to the U.S., we see that the tariffs it imposes on Chinese imports generate substantial economic costs for the U.S. The U.S. employment deviation reaches its lowest point in 2020, at -0.27 per cent. If this were to be expressed entirely in job losses (i.e., if hours per worker were to remain unaffected by the tariffs) this would represent approximately 0.41 m. lost positions. The loss in U.S. real consumption (private and public) reaches its lowest point in 2020, at -0.31 per cent relative to baseline. This is a loss of approximately $USD 53 b., or $USD 163 per person. Thereafter, the real consumption loss attenuates, falling to approximately $USD 27 b., or $USD 81 per person in 2025. Over the five years 2020-25, the average annual consumption loss in the U.S. generated by U.S. tariffs is $USD 34 b., or $USD 105 per person.

Table A: Impacts of the trade war (% deviation from baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
U.S.' tariffs in isolation								
U.S. real GDP	-0.02	-0.10	-0.43	-0.35	-0.32	-0.30	-0.30	-0.30
U.S. employment	-0.02	-0.08	-0.27	-0.14	-0.07	-0.03	-0.02	-0.01
U.S. real consumption	0.00	-0.04	-0.31	-0.22	-0.18	-0.16	-0.16	-0.15
China real GDP	-0.06	-0.17	-0.45	-0.42	-0.37	-0.35	-0.36	-0.38
China employment	-0.08	-0.18	-0.50	-0.36	-0.18	-0.09	-0.05	-0.02
China real consumption	-0.10	-0.26	-0.66	-0.63	-0.56	-0.53	-0.52	-0.53
Australia real GDP	0.00	0.00	0.03	0.02	0.01	0.01	0.01	0.01
Australia employment	0.00	0.00	0.05	0.02	0.01	0.00	0.00	0.00
Australia real consumption	-0.02	-0.02	0.02	0.01	0.01	0.01	0.00	-0.01
China's tariffs in isolation								
U.S. real GDP	-0.02	-0.06	-0.11	-0.07	-0.05	-0.04	-0.04	-0.04
U.S. employment	-0.02	-0.08	-0.13	-0.07	-0.04	-0.02	-0.01	-0.01
U.S. real consumption	-0.03	-0.10	-0.17	-0.14	-0.12	-0.11	-0.11	-0.12
China real GDP	-0.09	-0.21	-0.28	-0.27	-0.26	-0.25	-0.26	-0.26
China employment	-0.11	-0.18	-0.15	-0.11	-0.05	-0.03	-0.01	-0.01
China real consumption	-0.09	-0.20	-0.23	-0.22	-0.20	-0.19	-0.19	-0.19
Australia real GDP	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Australia employment	0.01	0.03	0.04	0.02	0.01	0.00	0.00	0.00
Australia real consumption	0.00	0.04	0.06	0.05	0.05	0.05	0.05	0.06
Joint effects of tariff exchange								
U.S. real GDP	-0.03	-0.16	-0.52	-0.42	-0.37	-0.34	-0.34	-0.34
U.S. employment	-0.04	-0.16	-0.39	-0.21	-0.10	-0.05	-0.03	-0.02
U.S. real consumption	-0.03	-0.14	-0.46	-0.35	-0.30	-0.27	-0.26	-0.26
China real GDP	-0.15	-0.37	-0.71	-0.67	-0.60	-0.59	-0.60	-0.62
China employment	-0.18	-0.36	-0.63	-0.45	-0.22	-0.11	-0.06	-0.03
China real consumption	-0.19	-0.45	-0.87	-0.82	-0.73	-0.70	-0.69	-0.69
Australia real GDP	0.00	0.02	0.07	0.05	0.04	0.04	0.04	0.04
Australia employment	0.00	0.03	0.09	0.04	0.02	0.01	0.00	0.00
Australia real consumption	-0.01	0.02	0.08	0.06	0.06	0.06	0.06	0.05

China’s retaliatory tariffs add to the costs to the U.S. of the tariff war. The U.S. employment losses caused by China’s tariffs reach their highest point in 2020, at -0.13 per cent. If this was expressed entirely in lost positions, it would represent approximately 0.20 m. jobs. China's retaliatory tariffs inflict their largest consumption losses on the U.S. in 2020, at -0.17 per cent relative to baseline, a loss of $USD 30 b., or $USD 90 per person. Thereafter, the consumption losses attenuate somewhat, as U.S. employment returns to baseline. By 2025, annual U.S. real consumption losses caused by China's retaliatory tariffs level off at approximately $USD 20 b., or $USD 62 per person. The average annual U.S. real consumption loss for the period 2020-25 caused by China's tariffs is $USD 22 b. or $USD 69 per person.

Taken together, the U.S. and Chinese tariffs generate a 2020 employment low for the U.S. of -0.39 per cent, or approximately 0.59 m. positions if fully expressed as job losses rather than movements in hours worked per worker. U.S. consumption losses from the joint impact of the U.S. and Chinese tariffs also reach their peak in 2020, at -0.46 per cent (approximately $USD 80 b., or $USD 246 per person). By 2025, the U.S. annual real consumption loss generated by the U.S. and Chinese tariffs levels off at approximately -0.26 per cent (approximately $USD 46 b., or $USD 140 per person). Over 2020-25, the annual average U.S. real consumption loss is approximately $USD 56 b., or $USD 170 per person.

Turning to the results for China, we find that the U.S.' tariffs inflict their largest loss on Chinese employment in 2020, at -0.50 per cent relative to baseline. If this were to be expressed entirely in job losses (that is, if hours worked per worker were unaffected by the tariffs), this would translate to approximately 3.9 m. positions. In 2020, the U.S. tariffs impose their largest loss on Chinese consumption, at -0.66 per cent ($USD 43 b., or $USD 31 per person). By 2025, the annual real consumption loss in China caused by U.S. tariffs levels off at approximately -0.52 per cent ($USD 34 b., or $USD 24 per person). Over 2020-25, the annual average consumption loss in China caused by the U.S. tariffs is $USD 37 b., or $USD 27 per person.

China's retaliatory tariffs add to the costs of the tariff war for China. The peak year for Chinese job losses from China's tariffs is 2019 (-0.18 per cent relative to baseline). If this were to be expressed as job losses, it would represent 1.4 m. positions. The peak consumption loss for China from its own tariffs occurs in 2020, at -0.23 per cent ($USD 15 b., or $USD 11 per person). Thereafter, the annual real consumption loss attenuates, levelling off at approximately -0.19 per cent ($USD 12 b., or $USD 8.70 per person). Over 2020-25, the average annual real consumption loss in China generated by China's tariffs on U.S. goods is $USD 13 b., or $USD 9.5 per person.

Taken together, the U.S. and Chinese tariffs generate an employment low in China of -0.63 per cent in 2020. If this were to be expressed in job losses only, it would represent approximately 4.9 m. positions. China's real consumption losses also reach their highest level in 2020, at -0.87 per cent (approximately $USD 56 b., or $USD 40 per person). By 2025 China's annual real consumption loss is approximately -0.69 per cent ($USD 44 b., or $32 per person). Over 2020-25, the annual average loss in Chinese real consumption caused by the joint effect of the U.S. and Chinese tariffs is $USD 48 b. or $USD 35 per person.

Compared with the impacts on the U.S. and China, the effects of the trade war on Australia are small. This reflects countervailing forces on Australian economic activity created by the U.S. and Chinese tariffs. On the one hand, as discussed above, the U.S. and Chinese tariffs cause contractions in economic activity in the U.S. and China. This damps demand for Australian exports. On the other hand, both the U.S. and Chinese tariffs make Australia a relatively attractive alternative supplier of imports to the U.S. and China. This raises demand for Australian exports. Australia's terms of trade are also favourably affected (via lower import prices) by the diversion of Chinese and U.S. exports in the face of rising U.S. and Chinese tariffs. The net effect of these forces is for little economic impact on Australia. Australia experiences a positive deviation in real GDP, peaking at 0.07 per cent in 2020, before levelling off at approximately 0.04 per cent by 2025. Australian employment peaks at 0.09 per cent above baseline in 2020, before returning to baseline by 2025. Australian real consumption peaks at 0.08 per cent above baseline in 2020, and ends the simulation period at 0.05 per cent above baseline by 2025. The average consumption gain in Australia over the period 2020-25 is approximately $AUD 0.9 b., or $AUD 34 per person.

Table B: Removal of China's pre-trade war tariffs on U.S. goods (% dev'n from baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
U.S. real GDP	0.00	0.04	0.08	0.05	0.03	0.02	0.02	0.02
U.S. employment	0.00	0.05	0.10	0.05	0.03	0.01	0.01	0.00
U.S. real consumption	0.00	0.05	0.11	0.08	0.07	0.06	0.06	0.06
China real GDP	0.00	0.04	0.06	0.05	0.05	0.05	0.05	0.05
China employment	0.00	0.03	0.05	0.03	0.02	0.01	0.00	0.00
China real consumption	0.00	0.02	0.02	0.00	0.00	-0.01	-0.01	-0.02
Australia real GDP	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Australia employment	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00
Australia real consumption	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01

Table B reports key results for a hypothetical U.S.-China trade deal, involving removal by China of all (pre-tariff war) tariffs on U.S. goods. In the GTAP database, these average approximately 5 per cent. This generates a small transitory gain in U.S. employment, and a long-run consumption gain for the U.S. of approximately 0.06 per cent. Over 2020-25, the average annual gain in U.S. consumption is approximately $USD 13 b., or $USD 40 per person. For China, our hypothetical unilateral elimination of tariffs generates a small consumption loss. The pre-trade war Chinese tariffs on U.S.

goods produce a terms of trade gain for China that offsets their allocative efficiency loss. As such, the removal of these tariffs generates a small consumption loss in China, even though it raises China's real GDP. The effects on Australia are small. Like the tariff war, the trade deal between the U.S. and China has countervailing effects on Australia. The rise in Chinese real GDP caused by removal of pre-existing tariffs on U.S. imports lifts demand for Australian commodity exports, particularly those used as inputs to production and capital formation in China. However, the substitution towards the U.S. for supply of certain commodities, particularly agricultural products, reduces Australia's terms of trade. The net outcome is a small cost to Australia. The average annual real consumption loss for Australia over 2020-25 is -0.01 per cent (approximately $AUD 0.1 b., or $AUD 3.8 per person).

Table C: 25% restriction on imports of Australian coal by China (% dev'n from baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
Australia real GDP	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Australia employment	0.00	-0.01	0.00	0.01	0.00	0.00	0.00	0.00
Australia real consumption	0.00	-0.04	-0.04	-0.04	-0.04	-0.04	-0.05	-0.06
China real GDP	0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
China employment	0.00	-0.03	-0.03	-0.02	-0.01	-0.01	0.00	0.00
China real consumption	0.00	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00

The final simulation explores the effects of a permanent policy-mandated 25% reduction in imports of Australian coal by China (Table C). This simulation is motivated by reports in early 2019 of a policy of slowing processing of Australian coal through Chinese ports, possibly in retaliation to a number of national security policy actions taken by Canberra. Our modelling takes account of: (i) the capacity of the sector to find alternative markets for coal; (ii) the capacity of mobile resources within the sector to find alternative employment; (iii) the degree of foreign ownership of the sector; (iv) royalty revenue; and (v) taxation of capital and resource revenue within the sector. With these factors taken into account, we find that the average annual reduction in Australian real consumption (private and public) over 2020-25 is 0.04 per cent, or approximately $AUD 24 per person.

2 Literature review

Despite having started less than 18 months ago, the 2018 US/China trade war has already spawned a small but significant literature. Bown (2019) provides an excellent review of both the initial trade frictions between the US and China in the period leading up to 2018 as well as the escalation of tariffs that constitute the trade war of 2018. He argues that the coverage of the US tariffs of 2018 on imports from China and the retaliation by China were both unprecedented, and suggests that the US decision to act unilaterally against China resulted from a frustration with WTO rules which were viewed as increasingly ineffective against Chinese policies that included (i) non-reciprocal trade policies; (ii) subsidies that contributed to global overcapacity in industries like steel and aluminium; and (iii) a development strategy that included forced technology transfer on non-commercial grounds or the theft of technology through state-sponsored actions.

A number of studies that have attempted to analyse the impact of the 2018 US/China trade war on prices, output, trade and welfare. Amiti, Redding and Weinstein (2019) show that in the US, there has been almost complete pass-through of the tariffs into domestic prices of imported goods, resulting in a cumulative deadweight loss through 2018 of about US$6.9b. By the end of 2018, the trade war was costing the US US$1.4b per month in lost real income. Using a global computable general equilibrium (CGE) model, Balistreri, Böhringer and Rutherford (2018) and Li, Balistreri and Zhang (2018) find that the US/China trade war cost the US about $24.5b or -0.2 percent in lost welfare, while losses to China amount to US$13.8b of -0.34 percent in lost welfare. Using the MIRAGE CGE model, Bellora and Fontagne (2019) report decreases in US and Chinese real GDP of -0.3 and -0.4 percent for the US and China, respectively. These studies also find predictable impacts on US and Chinese exports. For example, Bellora and Fontagne (2019) find that US exports to China fall by 43 percent (esp. agricultural commodities like soybeans) and Chinese exports to the US fall by 33 percent (esp. electronic equipment and other machinery). Protection afforded through these tariffs results in an increase in US production of iron and steel, electronic equipment and other machinery. Charbonneau and Landry (2018) and Felbermayr and Steininger (2019) use input-output gravity approaches to model the effects of the US/China trade war. Their estimates of the loss in real GDP due to the trade war are about -0.25 and -0.33 percent to the US and China, respectively. These studies also find evidence of complete pass-through of tariffs to tariff-inclusive import prices, suggesting that the incidence of these tariffs has been borne by consumers in the US and China.

Our study contributes to this literature by providing estimates of the welfare and real GDP costs of the US/China trade war using the GTAP-MVH dynamic CGE model. The main improvements of this approach over the comparative-static approach adopted in the literature thus far are outlined in

Section 3.[1] By using a dynamic model, we are able to deconstruct the effects of the escalation of the US/China trade war since the start of 2018, and more accurately include the recent escalation in June 2019 when the US and China increased tariffs to 25 percent on US$200b and US$60b of bilateral imports, respectively.[2] We also provide results for the period 2020-2025, presuming that the US carries through on its current threat to apply 25% tariffs on virtually all imports from China and that China retaliates as it has to date. We find welfare losses in 2019 that are somewhat smaller for the US and somewhat larger for China than those reported in this literature. But welfare losses for each country are much larger in 2020, reaching -0.46 and -0.87 percent for the US and China respectively.

[1] The MIRAGE model used in Bellora and Fontagne (2019) is a dynamic CGE model with a number of the features of the GTAP-MVH model used here, though they only implement the tariffs in the US/China trade war that had been applied by the end of 2018. MIRAGE was implemented with increasing returns to scale in a number of sectors, while GTAP-MVH models all sectors as perfectly competitive with constant returns to scale production technology. They only report their changes in real GDP relative to baseline in 2030.

[2] Amiti *et al* (2019) include only the tariff escalation that was in place at the end of 2018, while other studies presume that the latest tariff escalation in June 2019 took place in Jan. 2019 as had been threatened by the US at the end of 2018.

3 The model

3.1 Overview of GTAP-MVH.

We use the GTAP-MVH model documented in Dixon *et al.* (2019). GTAP-MVH is a dynamic implementation of the GTAP (Global Trade Analysis Project) model documented in Hertel (1997) and Corong *et al.* (2017). GTAP is a comparative static multi-country multi-commodity computable general equilibrium (CGE) model with particular emphasis on the modelling of commodity-specific trade flows between countries and trade taxation instruments. The full GTAP database contains 57 sectors and 141 countries/regions (Aguiar *et al.* 2016). For this paper, we aggregate the standard database to 34 sectors and 18 regions. The 18 regions are: the U.S.A., Canada, Mexico, Australia, Japan, South Korea, China, India, Indonesia, the Philippines, Thailand, the rest of ASEAN, France, Germany, the U.K., the rest of the E.U., Russia, and the rest of the world. Table 1 reports the mapping between the full list of 57 sectors in the original database and the 34 sector aggregation used in this paper. Our sectoral aggregation was guided by a desire to preserve the identification of commodities either targeted by U.S. and China tariffs, or otherwise among the top export and import commodities of the U.S., China and Australia. Similarly, our country aggregation was guided by a desire to preserve identification of countries that are: (i) among the top export destinations and import sources for the U.S., China and Australia; (ii) of geostrategic significance to the U.S. and Australia in the Indo-Pacific region; and (iii) important coal producers or destinations for Australian coal.

As discussed in Dixon *et al.* (2019), standard GTAP has a number of attributes that limit its usefulness for investigation of the policy issues examined in this paper. In particular, standard GTAP assumes that capital is fully mobile between sectors in each region in both the short-run and long-run, and real wages are either inflexible within each region (in the short-run) or fully flexible within each region to maintain full employment (in the long-run). As discussed in Dixon *et al.* (2019), GTAP-MVH carries a number of innovations that overcome these and a number of other limitations of standard GTAP. We summarise these below, and refer the reader to Dixon *et al.* for further details.

GTAP-MVH contains the Dixon and Rimmer (2002) treatment of the labour market within a dynamic CGE model. Within GTAP-MVH, this allows region- and occupation-specific labour markets to transition from a short-run environment in which real wages are sticky to a long-run environment in which real wages are fully flexible. This allows the labour market effects of a positive economic shock (like a productivity improvement) to be manifested over the short-run as gains in both employment and real wages, with a gradual transition to a long-run in which the gains are manifested in higher real wages as the economy returns to full employment.

In standard GTAP, capital within each region has no industry-specificity. That is, the aggregate regional capital stock in year *t* is free to flow between industries in year *t*. This is unsatisfactory for generating insights into both the short-run adjustment costs of policy changes and the transition paths to long-run outcomes. If tariffs are particularly damaging to prospects for a specific industry, we want this manifested in the short-run as steep drops in rates of return and investment in the affected industry, not as an implausible instantaneous outflow of the industry's capital to other unrelated sectors. As described in Dixon *et al.* (2019), GTAP-MVH models regional capital stocks as specific to each industry. Units of new industry-specific capital are assumed to be constructed with a technology that is common to all industries (consistent with the single capital-creator assumption of standard GTAP), but are allocated to specific industries on the basis of movements in relative rates of return across industries. This allows industry-specific capital stocks within each region to gradually adjust through time in response to movements in their rates of return.

As described in Dixon *et al.* (2019), standard GTAP handles the accounting for country-specific savings / investment imbalances via a device called the Global Bank. Countries with a surplus of savings over investment are modelled as contributing funds to the Global Bank, while countries with a deficit of savings over investment are modelled as borrowing funds from the Global Bank. Aggregate borrowing from the Global Bank is constrained to equal aggregate lending to the Global Bank, ensuring enforcement of equality between global savings and global investment in each year. However, there is no accounting between years of each region's claim upon, or liability to, the Global Bank. This limits the capacity of the model to inform the welfare consequences of policy change, because it impairs the model's capacity to track the future consequences for national income of current changes in the balance of savings and investment. Ianchovichina and McDougall (2012) address this limitation of standard GTAP by introducing the concept of the Global Trust. The Global Trust facilitates a distinction between the capital assets located within a country and the country's wealth. The former depends on investment within the country while the latter depends on the country's accumulated net savings. Dixon *et al.* (2019) adapt the Ianchovichina and McDougall (2012) code for the Global Trust and include it in GTAP-MVH. This allows year-on-year tracking of the accumulation by each region of foreign assets (claims on the Global Trust) and foreign liabilities (claims by the Global Trust). With this in place, GTAP-MVH can calculate each region's net national product as GDP at market prices, less depreciation, plus the region's claims on income of the Global Trust, less the region's payments of income to the Global Trust.

The specification of net national product in GTAP-MVH facilitates establishment of a straightforward rule for determining national consumption. First, it is assumed that the ratio of nominal consumption (private and public) to nominal net national product in each region is exogenous. That is, the average propensity to consume out of net national product is exogenous in each region. Second, the ratio of real public consumption to real private consumption in each region is exogenous. That is, we assume that each region maintains constant region-specific proportions in the manner in which national consumption is split between privately purchased commodities and publicly provided commodities.

3.2 The GTAP-MVH baseline.

In our baseline forecast we exogenously determine growth in each of the model's 18 regions in: (i) real GDP at market prices; (ii) population; and (iii) the working age population (see Table 2- Table 4). Population and the working age population are naturally exogenous variables. Real GDP however is a naturally endogenous variable. To determine it exogenously in the baseline, we endogenously determine primary factor augmenting technical change within each region. As described in Dixon and Rimmer (2002), a re-run of the baseline in which region-specific primary factor technical change is exogenous and shocked (along with all other exogenous variables) with its endogenously calculated value in the baseline simulation allows the model to produce endogenous results for GDP that match target values, while leaving the model in a closure state that is ready for the imposition of policy simulations.

Our main sources for the forecast are:

1. The World Economic Outlook database, April 2019 (IMF 2019). This database contains projections of growth rates for 194 countries by year to 2024.
2. Population estimates and projections by the World Bank (2018). This database contains projections by year to 2050 of total population and population aged 15-64 for 218 countries.

Using World Bank (2018) data, we calculated the growth rates of total population and population aged 15-64 (i.e. the working age population) for the 18 regions of the model, by year, out to 2027. We assumed that, for all regions in the model, labour force participation rates remain unchanged over the forecast periods, and hence changes in the working age population were adopted as changes in labour supply. Table 3- Table 4 report these growth rates.

Using IMF (2019) data we calculated the real GDP growth rates for the 18 model regions by year to 2024. We then estimated the real GDP growth rates for the period 2025-2027, using the following procedure. For each region in the model:

1. We first calculated the growth rate of labour productivity (real GDP per worker) for the region in the period 2015-2024 using the forecast growth rates of real GDP and labour supply.

2. We then extrapolated the growth rates of labour productivity for the period 2025-2027 based on judgements about the trend movement in labour productivity.
3. Finally, we calculated the real GDP growth rate in each region for the period 2025-2027 using the forecast growth rate of labour supply and the a trend forecast growth rate of labour productivity. The resulting real GDP growth rates are reported in Table 4.

Table 2 - Table 4 show that, over the forecast period, China is projected to continue to grow rapidly, albeit at a declining rate, from 6.9% in 2015 to 5.1% in 2027. The decline is due to: (i) a declining rate of growth in labour supply (Table 4) and (ii) a reduction in the rate of growth of labour productivity (see the changes in the difference between real GDP growth rates and labour supply growth rates).

Other fast-growing regions include India, the Philippines, rest of ASEAN and Indonesia, with the average growth rates over the period 2015-2027 of 7.6%, 6.6%, 6.6% and 5.2% respectively. The high growth rates in these countries are due to (i) relatively high growth rates in working age population; and (ii) high rates of labour productivity growth. Other regions grow by less than 4% per annum. The slowest growing regions are projected to be Japan, Germany, France, and Russia. This is due mainly to the small or negative growth rates of their working age population for the forecast period.

4 U.S.-China trade war

4.1 Introduction.

In modelling the U.S.-China tariff exchange, we undertake three simulations:

1. We impose U.S. tariffs on Chinese imports, leaving Chinese tariffs unchanged.
2. We impose Chinese tariffs on U.S. imports, leaving U.S. tariffs unchanged.
3. We impose both the U.S. and Chinese tariffs.

Dividing the simulation into three in this way allows us to examine the effects of the U.S. and Chinese tariffs in isolation of each other, before considering the joint effect of the implementation of tariffs by both countries.

We begin by discussing the details of the scope, level, and timing of the U.S. and China tariff exchanges (Section 4.2). We then present a simple back-of-the-envelope (BOTE) model for understanding how the tariffs affect employment, capital, wages, rates of return and GDP in the U.S. and China **(**Section 4.4), before going on to examine the effects of the U.S. tariffs **(**Section 4.5), China's tariffs (Section 4.6) and the joint effect of both countries tariffs (Section 4.7).

4.2 Overview of the U.S.-China tariff exchanges

There has been a long history of trade friction between the United States and China. A simple search of Dispute Settlements at the World Trade Organization lists 23 cases where the US acted as complainant in a dispute against China and 15 cases where China acted as complainant against the US since China joined the WTO. But the start of the current escalation in trade tensions between the US and China dates from early 2018 when the US applied tariffs on imports of large residential washing machines and solar cells and modules. These tariffs were applied after findings from Section 201 investigations by the US International Trade Commission determined that increased imports of these commodities caused injury to US producers. They were followed by tariffs on imports of steel and aluminium after the March 2018 finding by the US Department of Commerce that the national security of the US was threatened under Section 232 of the US Trade Expansion Act. Shortly thereafter, the USTR determined under Section 301 of the Trade Act of 1974 that China's acts, policies and practices related to technology transfer, intellectual property and innovation "… negatively affect American interests, … inhibit United States exports, deprive United States citizens of fair remuneration for their innovations, divert American jobs to workers in China, contribute to our trade deficit with China, and otherwise undermine American manufacturing, services, and innovation." (see "Addressing China's Laws, Policies, Practices, and Actions Related to Intellectual Property, Innovation, and Technology", 82 Fed. Reg. 39,007, Aug. 17, 2017). The result of this Section 301 determination was the application of tariffs of 25 percent on $34b of imports from China on 6 July, on a further $16b of imports from China on 23 August, and the application of tariffs of 10 percent on a further $200b of imports from China on 24 September. The latest escalation involved an increase in these tariffs on $200b of imports from China from 10 percent to 25 percent early in June 2019. Each application and escalation of tariffs by the US on imports from China was met almost immediately by the application of retaliatory tariffs by China on imports from the US. Nor does this escalation appear to be abating: The USTR recently held Public Hearings regarding proposed tariffs on a further $300b worth of imports from China. This would extend US tariffs to virtually all imports from China, and given recent experience, would almost certainly be met by retaliatory tariffs from China on all imports from the U.S.

4.3 Calculating applied tariffs

Of the 34 aggregated GTAP sectors listed in Table 1, the tariffs detailed above in Section 4.2 are applied to the first 22 primary, processed and manufacturing commodities. The remaining 12 service sectors are not subject to the tariffs described in Section 4.2. For each of the 22 commodities which are subject to US tariffs on imports from China and Chinese retaliatory tariffs on imports from the US, Table 5 lists the share of imports of each commodity which are subject to tariffs and the tariff rate on that share of output. For example, if the 25% tariffs on US imports of steel from China that were applied at the end of March 2018 affected 43.6% of US steel imports from China, then the share of US steel imports from China in 2018 would be 0.436 and the tariff would be 18.75% (since the tariff was in place for 9 months in 2018). The rest of this subsection details the derivation of these shares and tariffs for all commodities in any given year.

We begin with UN COMTRADE data on U.S. imports from China and Chinese imports from the U.S., available from https://comtrade.un.org/data. These data are available at HS6 commodity classification.[3] In 2018, U.S. imports from China were $562,820m, and Chinese imports from the

[3] HS6 (Harmonized Commodity Description and Coding System) is an internationally standardized classification system for traded products. UN COMTRADE reports HS6 imports by the US from China of 4,578 distinct commodities. With this many commodities, the classification identifies quite specific commodities. For example: "Spices; fruits of the genus Capsicum or Pimenta, dried, neither crushed nor ground", "Pharmaceutical goods; opacifying preparations for x-ray examinations, diagnostic reagents designed to be administered to the patient" and "Scissors; tailors' shears, similar shears and blades therefore". By China from the US, 4,326 distinct commodities are identified. Again, the commodity-specificity is highly detailed, for example: "Offal, edible; of swine, (other than livers), frozen", "Cotton; not carded or combed" and "Pencil leads; black or coloured".

U.S. were $154,442m. These data are mapped from HS6 commodities to GTAP commodities using the mapping available from the GTAP website.

The next step is to identify the Chinese imported commodities that are subject to tariffs by the U.S. and the U.S. commodities that are subject to retaliatory tariffs by China. A chronology of the various U.S. tariffs and retaliatory Chinese tariffs is presented in Table 6, providing a brief summary of the commodities on which tariffs are applied. A detailed list of references for all tariffs follows Table 6. These references include lists of HS8 commodity codes for all tariffs applied by the U.S. on imports from China and all retaliatory tariffs applied by China on imports from the U.S.

These data are combined with the UN COMTRADE data to determine the share of each GTAP commodity subject to U.S. and Chinese tariffs. For example, U.S. Presidential Proclamation 9705 dated 8 March 2018 announced that as of 23 March 2018, the U.S. would apply tariffs of 25 percent on imports of "…steel articles … defined at the Harmonized Tariff Schedule (HTS) 6-digit level as: 7206.10 through 7216.50, 7216.99 through 7301.10, 7302.10, 7302.40 through 7302.90, and 7304.10 through 7306.90." According to UN COMTRADE data, U.S. imports from China of these 6-digit HS commodities in 2018 was $972,739,246. Total U.S. imports of GTAP commodity 35 "Ferrous Metals" in 2018 was $2,229,847,811. Since the 25 percent tariff on steel imports was applied on 23 March 2018, the applied U.S. Tariff on imports of steel from China in 2018 is adjusted using a multiplier of 9/12 (for 2019, this multiplier is equal to 1). As a result, the Section 232 U.S. tariffs on steel imported from China in 2018 resulted in a tariff of 18.75 percent [= 9/12 · 25%] on 43.6 percent [= 972739246/2229847811] of U.S. imports from China of GTAP commodity "Ferrous Metals" in 2018. These are modelled as an applied tariff of 8.1794 percent [= 18.75 · 43.6] on all U.S. imports of GTAP commodity "Ferrous Metals" from China in 2018. This methodology is used to produce all shares and tariffs listed in Table 5 for each of the tariff events detailed in Table 6.

For the Section 301 tariffs applied by the U.S. on imports from China on 6 July, 23 August and 24 September, 2018, as well as the ensuing Chinese retaliatory tariffs on imports from the U.S., this methodology would result in an over-estimate of imports affected by tariffs, since the tariffs are applied to commodities identified at the HS8 level while the trade data are available at the HS6 level. To identify the value of imports affected by tariffs, the HS8 commodities need to be mapped to their corresponding HS6 commodity. For example, the 818 HS8 tariff lines that make up the U.S.'s list of Section 301 tariffs applied on 6 July 2018 include commodities 8420.99.20 (Parts of calendering or rolling machines for making paper pulp, paper or paperboard) and 8420.99.90 (Parts of calendering or other rolling machines, other than for metals or glass, nesoi), but not commodity 8420.99.10 (Parts of calendering or rolling machines for processing textiles). Since we are using UN COMTRADE data on the value of imports at the HS6 commodity level, we include all U.S. imports of HS6 commodity

8420.99 from China, which was $19,501,632 in 2018. But this included some imports of commodity 8420.99.10 which was not subject to the Section 301 tariffs applied on 6 July 2018. By including all imports of HS6 commodities from which some HS8 sub-commodities were not included in the list of Section 301 tariffs, we would over-estimate the value of imports affected by tariffs applied on 6 July 2018 at $78.926b, while we know that the USTR announced that the Section 301 tariffs applied by the U.S. on 6 July 2018 affected $34b of imports from China. We correct this over-estimation by dividing the values of all HS6 imports to which Section 301 tariffs are applied by the U.S. on 6 July 2018 by 2.32 [= 78.926017933/34]. This method is used to correct the values of all Section 301 tariffs applied by the U.S. on imports from China and the ensuing Chinese retaliatory tariffs on imports from the U.S. detailed in Table 5.

4.4 A back-of-the-envelope (BOTE) model for understanding tariff impacts

Before proceeding to the discussion of results, we outline a simple back-of-the-envelope (BOTE) model of labour and capital markets for any given region within GTAP-MVH.[4] As we shall see, this will be helpful in understanding how real wages, employment, investment, capital, and real GDP in each country respond to the tariff shocks. We begin by assuming that each regional economy produces one good and imports one good. Production of the domestic good is a Cobb-Douglas (CD) function of labour (L) and capital (K). Units of consumption and investment are produced via CD functions of inputs of the domestic good and the foreign good.[5] Under zero pure profit and cost-minimising assumptions in the production and distribution of the domestic good, the consumption good, and the investment good, we have:

$$P_C = P_D^{\alpha_D^C} \cdot (P_M \cdot T_M)^{\alpha_M^C} \qquad (1)$$

$$MP_K(K/L) = T_Q \cdot (Q/P_D) \qquad (2)$$

$$P_I = P_D^{\alpha_D^I} \cdot (P_M \cdot T_M)^{\alpha_M^I} \qquad (3)$$

$$\rho = Q/P_I \qquad (4)$$

$$MP_L(K/L) = T_Q \cdot (W/P_D) \qquad (5)$$

$$W_R = W/P_C \qquad (6)$$

where P_D and P_M are the basic price of the domestic good and the c.i.f. price of the imported good; P_C and P_I are the purchaser price of a unit of consumption and investment; T_Q and T_M are the powers (1 plus the rates) of tax on production (in this case, a proxy for tariffs falling on intermediate

[4] This BOTE model is based on Dixon and Rimmer (1999). We reproduce key elements of their BOTE model.

[5] GTAP-MVH's production theory is based on nested constant returns to scale constant elasticity of substitution (CES) production functions. In constructing BOTE, CD is an effective simplification of this structure.

inputs) and imports used in consumption and investment; W_R is the nominal wage W deflated by the consumption deflator; Q is the rental price of capital; ρ is the real rate of return on capital; α_D^C and α_M^C are the cost shares of domestic and imported goods in a unit of consumption (with $\alpha_D^C + \alpha_M^C$ =1); and α_D^I and α_M^I are the cost shares of domestic and imported goods in a unit of investment (with $\alpha_D^I + \alpha_M^I$ =1). Equations (1) and (3) are CD unit cost functions. Equations (2) and (5) describe optimising demands for K and L. Equation (4) defines the rate of return to capital. Equation (6) defines the real wage. Via equations (1)– (6) we have:

$$MP_L\ (K/L) = W_R \cdot T_Q \cdot T_M^{\alpha_M^C} \cdot (P_M / P_D)^{\alpha_M^C} \tag{7}$$

$$MP_K\ (K/L) = \rho \cdot T_Q \cdot T_M^{\alpha_M^I} \cdot (P_M / P_D)^{\alpha_M^I} \tag{8}$$

Equations (7) and (8) isolate a number of factors that are relevant to understanding the labour market and capital market dynamics of the U.S.-China tariff exchange in GTAP-MVH. For example, a rise in tariffs on Chinese products in the U.S. can be viewed in the BOTE framework as increases in T_Q (reflecting tariffs on intermediate inputs) and T_M (reflecting tariffs on imports to consumption and investment) within the U.S. It will also affect the U.S. terms of trade, represented in BOTE by P_M / P_D. In the short-run, with W_R sticky, in the absence of movements in the terms of trade, equation (7) indicates that rises in T_Q and T_M must cause the marginal product of labour to rise. With K sticky in the short-run, this requires L to fall. Applying similar reasoning to equation (8), we see that a short-run fall in L, together with rises in T_Q and T_M, must cause the rate of return on capital to fall. In GTAP-MVH, this will induce a short-run negative deviation in investment. In the long-run, with L returning to baseline, equation (8) implies that a rise in T_Q and T_M must reduce K (because the long-run marginal product of capital must rise). Via equation (7), a fall in long-run K with L fixed implies a long-run fall in the real wage, an effect which will be reinforced by the long-run rises in T_Q and T_M. As we shall see, these effects from a rise in trade protection will be somewhat attenuated by a rise in the terms of trade, reflected in BOTE by the ratio P_M / P_D.

4.5 Effects of U.S. tariffs in isolation of Chinese retaliatory tariffs.

As discussed in Section 4.2, we model U.S. implementation of tariffs on Chinese imports in three tranches over 2018-2020.

Figure 1 reports deviations in U.S. real GDP (at both market prices and factor cost), and deviations in U.S. employment and capital. As discussed in Section 4.2, the first round of tariffs affects a small proportion of U.S. imports from China, and as such, the 2018 macroeconomic consequences are small. The two subsequent tariff rounds are more significant, and generate an employment trough of -0.27 per cent in the final year of tariff increases (2020). As discussed in Section 3.1**,** we describe the U.S. labour market as being characterised by short-run stickiness in the real wage. In the short-run, the tariff increases have the effect of increasing industry production costs (because the tariffs fall on inputs to production and investment as well as on consumption goods) and passing into nominal wages (via short-run real wage stickiness). Hence, the tariffs raise short-run real producer wages, leading to a fall in short-run employment. As discussed in Section 3.1, in the medium- to long-run, the model allows U.S. wages to gradually adjust to return employment to baseline. This accounts for the long-run attenuation of the employment deviation in Figure 1.

While employment gradually returns to baseline over the medium to long-run, the long-run capital deviation is negative. This reflects our assumption that capital accumulation steadily adjusts to return rates of return on capital in each industry in each region back to baseline rates of return. The tariffs fall, to some degree, on business inputs to production and investment. This means that, if rates of return are to move back to baseline levels in the long-run, then rental prices on capital must rise. This requires the long-run capital / labour ratio to fall, as is clear from Figure 1.

The deviation path for real GDP at factor cost is determined by the deviation paths for employment and capital. Over 2018-20, the growing negative deviation in employment translates into a growing negative deviation in real GDP at factor cost. From 2021 onwards, real wage adjustment gradually returns U.S. employment to baseline. This accounts for the partial recovery in U.S. real GDP at factor cost between 2020 and 2023. But the negative capital deviation continues to grow over the later years of the simulation period. This accounts for the levelling of the real GDP at factor cost deviation at around -0.08 per cent by the end of the simulation period.

The deviation path for real GDP at market prices tracks the deviation in GDP at factor cost, but with a growing gap over the period 2018-2020. The growing gap reflects the growing allocative efficiency distortion created by the three tariff tranches.[6] The largest widening of the gap between the real GDP (at factor cost) and real GDP (at market prices) deviations occurs in 2020, the year in which all Chinese goods trade is subjected to the 25 percentage point increase in tariff rates. The gap between

[6] See Mariano and Giesecke (2014) for a formal description of the difference between deviations in real GDP at market prices and at factor cost in terms of the allocative efficiency effects of indirect taxes.

real GDP at market prices and at factor cost in each year between 2020 and 2025 is approximately -0.225 per cent. With 2018 U.S. GDP at approximately $US 20.5 tn., this equates to an allocative efficiency loss of approximately $US 46 bn., or approximately $140 per capita.

Figure 2 reports deviations in the expenditure-side components of U.S. real GDP at market prices, together with the deviation in the U.S. terms of trade. The U.S. tariffs raise the cost of Chinese imports to U.S. industries and consumers. While the model allows for some substitution towards other regions of supply that are not subject to the tariffs, these substitution possibilities are not perfect, and as such, the effect of the tariffs at the macro level is to raise the price of imports to the U.S. relative to domestic goods. This induces substitution away from imports, which is manifested at the macroeconomic level as a large negative deviation in aggregate import volumes (Figure 2).

As described in Section 3.1, our macroeconomic closure within each region carries the assumption that regional propensities to consume (both private and public) out of net national product in the policy simulation are unchanged from their baseline values. The deviation in GDP at market prices is the dominant (although as we shall see, not sole) determinant of the deviation in net national product. Hence, as is clear from Figure 2, the deviation in real consumption (both private and public) closely tracks the deviation in real GDP at market prices. Because the deviation in real investment also closely tracks the real GDP deviation, the deviation in real GNE closely tracks the deviation in real GDP. This means there is only limited scope (expanded upon below) for the real balance of trade to deviate from baseline. This explains the sharp negative deviation in export volumes in Figure 2, which are forced to closely track the import deviation because the aforementioned macroeconomic assumptions allow for little deviation in the real balance of trade.

Notwithstanding that the export volume deviation closely tracks the import volume deviation, it is clear from Figure 2 that the import volume deviation lies above the export volume deviation (ie: exports are falling faster than imports). That is, the tariffs generate a movement towards real balance of trade deficit relative to baseline. There are two reasons for this. First, the negative investment deviation reduces the U.S.' reliance on net foreign capital inflow in the policy case relative to the baseline case. Hence, the U.S.' net foreign debt servicing needs in the policy case are lower than in baseline, allowing the real balance of trade deviation to move towards deficit. Second, and more importantly, the constriction of U.S. exports in the policy case relative to baseline has the effect of moving U.S. producers “up” foreign demand schedules for their exports. That is, it allows the U.S. to enjoy a rise in its terms of trade. Ceteris paribus, this allows real consumption to rise relative to real GDP, pushing the real balance of trade towards deficit. Note however from Figure 2 that it is clear that the real consumption outcome for the U.S. is negative, at approximately -0.15 per cent in the long-run. Hence, the package of tariffs against imports from China are too large to be an "optimal tariff": that is, the allocative efficiency losses from the tariff increases outweigh the terms of trade gain, generating a net negative welfare outcome. Over the six years 2020-25, the U.S. real consumption loss averages approximately -0.197 per cent. U.S. per capita consumption (private and public) was approximately $53,395 in 2018. Hence the real consumption loss from the U.S.' own tariffs is approximately $105 per person, or $34.5 bn. economy-wide.

Figure 3 reports deviations in China's real GDP (at both market prices and factor cost), and deviations in China's employment and capital. Figure 4 reports deviations in China's terms of trade and the expenditure-side components of China's real GDP at market prices. The first thing we note is that by lowering demand for Chinese goods, the U.S. tariffs generate a negative deviation in China's terms of trade (Figure 4). China's terms of trade loss occurs in three steps, following the sequence of the three tranches of U.S. tariffs discussed in Section 4.2., before levelling at approximately -2 per cent relative to baseline from 2020 onwards. As we discuss below, the negative terms of trade deviation has immediate consequences for employment in China and long-run consequences for China's capital formation.

In the short-run, with real wages sticky, the negative deviation in China's terms of trade generates a positive deviation in the real producer wage, because it lowers producer prices relative to consumer prices. As discussed in Section 4.4, a rise in the real producer wage requires the marginal product of labour to rise. That is, it requires the labour / capital ratio to fall. Because capital stocks are sticky in the short-run, the short-run fall in the labour / capital ratio is manifested as a fall in employment (see Figure 3). The employment deviation reaches its deepest point in 2020, at -0.5 per cent relative to baseline, before recovering gradually towards baseline over the remainder of the simulation period.

Capital stocks are slow to adjust in the short-run, but steadily adjust over the medium to long-run via depreciation and gross fixed capital formation. As discussed in Section 3.1, the model's processes for regional industry capital adjustment ensure that rates of return on capital gradually return towards baseline levels in the long-run. With rates of return on capital returning to baseline in the long-run, the decline in China's terms of trade requires the long-run marginal product of capital to rise. This requires the labour / capital ratio to rise. With employment returning to baseline in the long-run, the long-run rise in the labour / capital ratio requires the long-run capital stock to fall relative to baseline. This accounts for the growing negative deviation in China's capital stock (see Figure 3).

The deviation path for real GDP at factor cost is determined by the deviation paths for employment and capital. Over 2018-20, the growing negative deviation in China's employment translates into a growing negative deviation in China's real GDP at factor cost (Figure 3). From 2021 onwards, real wage adjustment gradually returns China's employment to baseline. This accounts for the partial recovery in China's real GDP at factor cost between 2020 and 2023. But the negative capital deviation continues to grow over the later years of the simulation period. This accounts for the levelling of the deviation in real GDP at factor cost at approximately -0.20 per cent by the end of the simulation period.

The deviation path for real GDP at market prices tracks the deviation in GDP at factor cost, but with a growing gap over the first three years of the simulation period. The growing gap reflects a growing allocative efficiency distortion created by the structural adjustments to China's economy caused by the U.S. tariffs. These adjustments shift resources from activities within China’s economy with relatively high rates of indirect taxation (particularly imports and exports, see discussion of Figure 4 below), towards sectors with relatively low rates of indirect taxation. By inducing a reallocation of resources away from sectors in which indirect taxes drive relatively large wedges between the value of production at market prices and at basic prices, the U.S. tariffs cause China’s GDP at market prices deviation to lie below its GDP at factor cost deviation.

Figure 4 reports the deviations in China's terms of trade and the expenditure-side components of real GDP at market prices. The reduction in China's terms of trade simultaneously represents a reduction in the prices of domestic goods relative to foreign goods. This induces substitution away from imports, and explains the comparatively large contraction in import volumes in Figure 4. As described earlier in reference to the U.S. results, the macroeconomic closure assumptions imposed on each region induce the export and import volume deviations to track together. Hence, in Figure 4, we also see a comparatively large contraction in China's export volumes, consistent with the large contraction in import volumes. Nevertheless, the export volume deviation lies above the import volume deviation, implying a movement towards balance of trade surplus relative to baseline. There are two reasons for the movement towards balance of trade surplus. First, the negative deviation in China's terms of trade causes the deviation in China's real (consumption price deflated) net national product to lie below the deviation in real GDP at market prices. Because consumption is indexed to net national product (see Section 3.1), this causes the deviation in real consumption (private and public) to lie below the deviation in GDP at market prices. This pushes the real balance of trade towards surplus. Second, the deviation in real investment lies below the deviation in real GDP. This causes China's savings / investment ratio to rise relative to baseline, contributing further to the movement towards balance of trade surplus relative to baseline. The loss in China’s real consumption (private and public) over the simulation period averages approximately -0.57 per cent. Consumption per capita in China is approximately $US 4,639. Hence the real consumption loss from U.S. tariffs is approximately $US 26.5 per person, or $US 36.9 b. economy-wide.

Figure 5 reports output deviations for U.S. industries, taking outcomes for the model's 34 industries and aggregating them to outcomes for 7 broad sectors. Consistent with the tariffs falling primarily on imports of manufactures from China, the U.S. manufacturing sector expands relative to baseline, although the effect is small (+0.3 per cent). Output of mining and agriculture contract relative to baseline. These two sectors are relatively trade exposed via export sales, but subject to little competition from Chinese imports in the domestic U.S. market. Export sales by these two sectors are adversely affected by the tariff-induced appreciation of the U.S. real exchange rate. The output deviation paths for services and dwellings broadly follow the deviation path for private and public consumption spending. Similarly, the output deviation path for the construction sector closely follows the deviation path for U.S. investment reported in Figure 2.

Figure 6, Figure 7, and Figure 8 go beyond the sectoral result reported for manufacturing as a whole in Figure 5, and report deviations in U.S. output for each of the model's 16 manufacturing industries. The 25 percentage point rise in U.S. tariffs on Chinese manufacturing imports by 2020 is comprehensive, but this does not translate to uniform positive output deviations for U.S. manufacturing industries. Indeed, for the industries reported in Figure 7, and a number of those reported in Figure 8, the U.S. tariffs generate negative output deviations. These are primarily export-oriented industries that are adversely affected by real exchange rate appreciation (such as transport equipment n.e.c., metals n.e.c., motor vehicles and parts, and chemical, rubber and plastic products) and sectors with some reliance on imported intermediate inputs with relatively high Chinese source shares.

Figure 9 reports sectoral output deviations for China, again aggregating results for the model's 34 industries to outcomes for 7 broad sectors. The output of China's manufacturing sector contracts, but not by as much as other broad sectors, particularly the services, dwellings and construction sectors, which are adversely affected by the negative deviations in China's consumption and investment. As we discuss below, in part this reflects the obscuring of impacts on particular manufacturing industries when we look at manufacturing taken as a whole. But it also reflects trade diversion opportunities available to Chinese manufacturers when the U.S. impairs access to the U.S. market via tariffs.

Figure 10, Figure 11, and Figure 12 report output deviations for 16 Chinese manufacturing industries. The five bottom-ranked (by 2025 output deviation) manufacturing industries reported in Figure 10 are characterised by high shares of their sales destined to either domestic investment (*wood products*, and *mineral products n.e.c.*) or the U.S. (*textiles, clothing & footwear*, *electronic equipment*, and *manufactures n.e.c.*). The five top-ranked (by 2025 output deviation) manufacturing sectors reported in Figure 11 are trade-exposed (in terms of selling relatively high shares of their output to export markets, or being subject to relatively high import competition within the Chinese market), but have lower proportions of their export sales to the U.S. market than the more adversely affected sectors reported in Figure 10. These industries benefit from depreciation of China's real exchange rate.

Trade diversion is also an important factor in mitigating the impact of U.S. tariffs on the output deviations of China's export industries. For example, as reported in Figure 10**,** *electronic equipment* manufacturers are among the sectors most adversely affected by U.S. tariffs. In the GTAP database, 50% of China's *electronic equipment* output is exported, and of these exports, 22% are sold in the U.S. Figure 13 reports a decomposition of the overall outcome for the Laspeyre index for the deviation in China's *electronic equipment* exports among the contributions made by changes in its *electronic equipment* exports across all destination countries. As reported in Figure 13, the U.S. tariffs cause a 5.6% fall in China's exports of electronic equipment. But this fall is the net effect of reduced export sales to the U.S., and expanded export sales to other markets. As reported in Figure 13, the reduction in export sales to the U.S. contributes approximately -15 percentage points to the deviation result for Chinese *electronic equipment* exports. The net outcome is -5.5%, because expanded export sales to other markets contribute just under +10 percentage points to the industry's net export deviation result. This trade diversion effect follows from the capacity of users of *electronic equipment* in each region to substitute between alternative regional suppliers of *electronic equipment* in response to movements in relative prices. As discussed earlier in reference to Figure 4, among the consequences for China's macro economy of the tariffs is real depreciation. This, together with short-run reductions in the rental price of capital in China's *electronic equipment* industry, allows exports of *electronic equipment* from China to expand in markets outside the U.S.

4.6 Effects of Chinese retaliatory tariffs in isolation of U.S. tariffs.

We now turn to examine the effects of China's retaliatory tariffs in isolation of the effects of the U.S.' tariffs. We being our discussion with Figure 14, which reports deviations in China's real GDP (at both market prices and factor cost), and deviations in China's employment and capital. As discussed in Section 3.1, we describe China's labour market as characterised by short-run stickiness in the real wage. In the short-run, the tariff increases have the effect of increasing industry production costs (because the tariffs fall on inputs to production and investment as well as on consumption goods) and passing into nominal wages (via short-run real wage stickiness). Hence, China's tariffs increase the short-run real producer wage in China, leading to a fall in short-run employment. As discussed in Section 3.1, in the medium- to long-run, the model allows wages in China to gradually adjust to return employment to baseline. This accounts for the long-run attenuation of the employment deviation in Figure 14.

While employment gradually returns to baseline over the medium to long-run, the long-run capital deviation is negative. This reflects our assumption that capital accumulation steadily adjusts to return rates of return on capital in each industry in each region back to baseline rates of return. The tariffs fall, to some degree, on business inputs to production and investment. This means that, if rates of return are to return to baseline levels in the long-run, then rental prices on capital must rise. This requires the long-run capital / labour ratio in China to fall, as is clear from Figure 14.

The deviation path for real GDP at factor cost is determined by the deviation paths for employment and capital. Over 2018-19, the negative deviation in employment translates to a -0.10 per cent trough in real GDP at factor cost. From 2020 onwards, real wage adjustment gradually returns China's employment to baseline. This accounts for the partial recovery in China's real GDP at factor cost between 2019 and 2022. But the negative capital deviation continues to grow over the later years of the simulation period. This accounts for the levelling of China's real GDP at factor cost deviation at around -0.07 per cent by the end of the simulation period.

The deviation path for real GDP at market prices tracks the deviation in GDP at factor cost, but with a growing gap over the period of tariff increases. The growing gap reflects the growing allocative efficiency distortion created by each round of tariff hikes on imports of U.S. goods into China. The average gap between the two real GDP measures between 2020 and 2025 is approximately -18.5 per cent. This implies an allocative efficiency cost for China's economy of approximately $25 bn. per annum, or approximately $US 18 per person.

Figure 15 reports the impacts of China's tariffs (in isolation of the U.S. tariffs) on the expenditure-side components of Chinese real GDP at market prices, together with the terms of trade. The Chinese tariffs raise the cost of U.S. imports to Chinese industries and consumers. While the model allows for some substitution towards other regions of supply that are not subject to the tariffs, these substitution possibilities are not perfect, and as such, the effect of the tariffs at the macro level is to raise the price of imports to China relative to domestically produced goods. This induces substitution away from imports, which is manifested at the macroeconomic level as a large negative deviation in aggregate import volumes (Figure 15).

As described in Section 3.1, our regional macroeconomic closure carries the assumption that regional propensities to consume (both private and public) out of net national product in the policy simulation are unchanged from their baseline values. The deviation in China's GDP at market prices is the dominant (although as we shall see, not sole) determinant of the deviation in China's net national product. Hence, as is clear from Figure 15, the deviation in China's real consumption (both private and public) closely tracks the deviation in China's real GDP at market prices. Because the deviation in

China’s real investment also tracks closely the real GDP deviation, the real GNE deviation tracks the real GDP deviation closely. This means there is only limited scope (expanded upon below) for China’s real balance of trade to deviate from baseline. This explains the sharp negative deviation in export volumes in Figure 15, which are forced to closely track the import deviation because the aforementioned macroeconomic assumptions allow for little deviation in the real balance of trade.

The constriction of China's exports in the policy case relative to baseline has the effect of moving China upwards along the demand schedules for its exports. That is, it allows China to enjoy a rise in its terms of trade. Ceteris paribus, this allows real consumption to rise relative to real GDP. Note however from Figure 15 that it is clear that the real consumption outcome for China is negative, at approximately -0.19 per cent in the long-run. As was the case for the U.S., this is not an "optimal tariff": the allocative efficiency losses and impact of long-run capital formation from the tariff increase outweigh the terms of trade gain, generating a net negative welfare outcome.

Figure 16 reports deviations in U.S. real GDP (at both market prices and factor cost), and deviations in U.S. employment and capital. Figure 17 reports deviations in the U.S.' terms of trade and the expenditure-side components of U.S. real GDP at market prices. The first thing we note is that by lowering demand for U.S. goods, China’s tariffs generate a negative deviation in the U.S.' terms of trade of approximately 1 per cent (Figure 17). As we discuss below, the negative terms of trade deviation has immediate consequences for U.S. employment and long-run consequences for U.S. capital formation.

In the short-run, with real wages sticky, the negative deviation in the U.S.' terms of trade generates a positive deviation in the real producer wage, because it lowers producer prices relative to consumer prices. A rise in the real producer wage requires the marginal product of labour to rise, that is, it requires the labour / capital ratio to fall. Because capital stocks are sticky in the short-run, the short-run fall in the labour / capital ratio is manifested as a fall in employment (see Figure 16). The U.S. employment deviation reaches its deepest point in 2020, at -0.13 per cent relative to baseline, before steadily recovering towards baseline over the remainder of the simulation period.

Capital stocks are slow to adjust in the short-run, but steadily adjust over the medium to long-run via depreciation and gross fixed capital formation. As discussed in Section 3.1, the model's processes for regional industry capital adjustment ensure that rates of return on capital gradually return towards baseline levels in the long-run. With rates of return on capital returning to baseline in the long-run, the decline in the U.S.' terms of trade requires the long-run marginal product of capital to rise. This requires the long-run U.S. labour / capital ratio to rise. With employment returning to baseline in the long-run, the long-run rise in the U.S. labour / capital ratio requires the U.S. capital stock to fall relative to baseline in the long-run. This accounts for the long-run negative deviation in the U.S.' capital stock reported in Figure 16.

The deviation path for U.S. real GDP at factor cost is determined by the deviation paths for U.S. employment and capital. Over 2018-19, the growing negative deviation in U.S. employment translates into a growing negative deviation in U.S. real GDP at factor cost. From 2020 onwards, real wage adjustment gradually returns U.S. employment to baseline. This accounts for the partial recovery in U.S. real GDP at factor cost between 2020 and 2023. However the negative capital deviation continues to grow over the later years of the simulation period. The attenuation of the long-run employment deviation, together with the growing (at a declining rate) negative deviation in the capital stock, accounts for the levelling of the U.S. real GDP at factor cost deviation at around -0.03 per cent by the end of the simulation period.

Figure 17 reports the deviations in U.S. terms of trade and the expenditure-side components of U.S. real GDP at market prices. The reduction in the U.S. terms of trade reduces the prices of domestic goods relative to foreign goods within the U.S. This induces substitution away from imports, which explains the contraction in U.S. import volumes reported in Figure 17. As described earlier, the macroeconomic closure assumptions imposed on each region allow for little movement in the balance of trade and thus exert a strong influence on the export and import volume deviations to track together. Hence, in Figure 17, we see a large contraction in U.S. export volumes matching the large contraction in U.S. import volumes. Nevertheless, the export volume deviation lies above the import volume deviation, implying a movement towards balance of trade surplus relative to baseline. There are two reasons for the movement towards balance of trade surplus. First, the negative deviation in the U.S. terms of trade causes the deviation in U.S. real (consumption price deflated) net national product to lie below the deviation in real GDP at market prices. Because consumption is indexed to net national product (see Section 3.1), this causes the deviation in real consumption (private and public) to lie below the deviation in GDP at market prices. This pushes the balance of trade towards surplus. Second, the deviation in real investment lies below the deviation in real GDP. This raises the U.S. savings / investment ratio relative to baseline, contributing to the movement towards balance of trade surplus relative to baseline.

Figure 18 reports Chinese output deviations for the model's 34 sectors aggregated to outcomes for 7 broad sectors, together with the deviation in China’s real GDP at factor cost. The output deviations for five sectors (*mining*, *manufactures*, *utilities*, *dwellings* and *services*) lie relatively close to the deviation in real GDP at factor cost, and as such are not discussed further. We focus our discussion on the two sectors (*agriculture* and *construction*) with output deviations that differ markedly from the deviation in real GDP at factor cost.

As discussed above, China's tariffs cause the long-run capital stock in China to contract relative to baseline (Figure 14). This requires a long-run negative deviation in China's real investment (Figure 15). This accounts for the negative deviation in *construction* sector output reported in Figure 18.

Agriculture experiences a comparatively large positive output deviation as a result of China's tariffs on U.S. imports. This reflects the high share of U.S. imports in China's use of agricultural commodities, in particular, *oil seeds*. China's tariffs on imports of U.S. agricultural products induces substitution by China's producers and consumers towards domestic producers of agricultural products, generating the positive deviation in output of the *agriculture* sector reported in Figure 18.

Figure 19 reports output deviations for U.S. industries aggregated to outcomes for 7 broad sectors, together with the output deviation for one of the model's 34 industries (*oil seeds*). The U.S. sector most adversely affected by Chinese retaliatory tariffs is *agriculture*, which experiences a -1.0 per cent negative output deviation by the end of the simulation period. This reflects the exposure of the U.S. *oil seeds* industry to the Chinese market. China's retaliatory tariffs cause a 12.6 per cent contraction in the *oil seeds* industry relative to baseline by 2025 (Figure 19, right hand axis). This contraction would be larger if not for the industry's capacity to replace some lost trade with China via expanded exports to other markets. As reported in Figure 20, the contraction in U.S. *oil seeds* exports is approximately 18 per cent by the end of the simulation period. Ceteris paribus, the reduction in exports to China contributes approximately -26 percentage points to the total deviation in *oil seeds* exports. However, as is clear from Figure 20, an expansion in exports to other regions offsets about one third of this loss, leaving a net deviation in U.S. *oil seeds* exports of approximately -18 per cent in the long-run.

4.7 Joint effect of U.S. and Chinese tariffs.

In the previous two sections we isolated the effects of the U.S. tariffs (Section 4.5) and the Chinese tariffs (Section 4.6). We now consider the joint effects of the U.S. and Chinese tariffs. In reporting the joint results, we decompose the joint effect into the individual contributions of the U.S. and Chinese tariffs in isolation of each other.[7]

Figure 21 - Figure 26 report real GDP, real consumption and terms of trade deviations for the U.S. and China. The economic damage done to both countries by the bilateral tariff exchange is of similar

[7] Because the model is non-linear, there is also an interaction effect between the U.S. and Chinese tariffs when they are applied to the model simultaneously. We report this as "residual" in the decomposition diagrams. The residual for variable *x* is calculated as the difference between the result for *x* in the joint simulation, and the sum of the results for *x* in the two simulations in which the U.S. and Chinese tariffs are applied independently of each other.

orders of magnitude, although slightly greater for China. This reflects China's bilateral trade surplus with the U.S., which gives the U.S. more imports to target than China. For the U.S., the lowest point in the real GDP deviation is reached in 2020 (at -0.52 per cent) with the U.S.' own tariffs by far the biggest contributor to this damage. In the longer run, the U.S. real GDP deviation stabilises at around -0.34 per cent, with the U.S.' own tariffs explaining approximately -0.30 percentage points of this. As discussed in Sections 4.5 and 4.6, the U.S. experiences a terms of trade gain via the imposition of its own tariffs, but a terms of trade loss via the imposition of China's tariffs. In Figure 23 we see that the net effect is a terms of trade loss. The U.S. real consumption deviation reaches its lowest point in 2020 (-0.46 per cent) before stabilising at approximately -0.26 per cent in the long-run.

China's real GDP deviation reaches its lowest point in 2020 (-0.7 per cent) before a small recovery leaves its long-run real GDP deviation at approximately -0.6 per cent (Figure 24). As is clear from Figure 24, the U.S. tariffs contribute most to China's real GDP deviation (approximately -0.36 per cent in the long-run) with its own tariffs contributing the remainder (approximately -0.25 per cent in the long-run). As is clear from Figure 26, while China's own tariffs generate a terms of trade gain, this is more than offset by the terms of trade loss caused by U.S. tariffs. China's net terms of trade loss explains why its real consumption deviation lies below its real GDP deviation. China's real consumption loss reaches its lowest point in 2020 (-0.87 per cent) before recovering to a long-run loss of approximately -0.69 per cent. Much of this loss is explained by the U.S. tariffs, which contribute approximately -0.53 percentage points of China's long-run real consumption deviation.

We turn now to consider impacts outside of the U.S. and China. Figure 27 reports real GDP impacts for the rest of the world, aggregating the model's regions within ASEAN and the EU. The bilateral tariff exchange generates positive deviations in real GDP for the regions identified in Figure 27. For each country, this reflects the net outcome of trade diversion effects and macroeconomic outcomes in the markets of major trade destinations (particularly the U.S. and China). For example, Mexico experiences the largest deviation in real GDP, ending the simulation 0.48 per cent above baseline. Figure 28, which decomposes Mexico's real GDP deviation into the contributions of the U.S.' and China's tariffs in isolation, shows that the tariffs of both countries raise Mexico's real GDP relative to baseline. Figure 29 shows that both the U.S.' and China's tariffs raise Mexico's terms of trade relative to baseline. This reflects Mexico's strong trade links with the U.S. By inducing U.S. producers and consumers to substitute away from Chinese goods, the U.S.' tariffs induce a rise in U.S. demand for Mexican products, raising Mexico's export price index relative to baseline. China's tariffs also make a (albeit, comparatively small) positive deviation to Mexico's terms of trade. This reflects diversion of U.S. exports when China's tariffs impair U.S. market access to China. This reduces Mexico's import price index, thus raising its terms of trade. The rise in Mexico's terms of trade causes a positive contribution to Mexico's real GDP deviation in the short-run (by lowering the marginal product of labour in an environment of sticky real wages and sluggish capital adjustment) and the long-run (by lowering the marginal product of capital in an environment of sticky rates of return and a re-equilibrated labour market).

Of the countries and regions reported in Figure 27, Australia experiences the smallest real GDP deviation. Figure 31 provides insight into why. Unlike Mexico, for which both the U.S. and China tariffs raise its terms of trade, for Australia, the bilateral tariff exchange creates countervailing terms of trade impacts. U.S. tariffs lower Australia's terms of trade by reducing economic activity in China, thus reducing demand for Australia's commodity and service exports to China. China's tariffs on U.S. products raise Australia's terms of trade by encouraging Chinese producers and consumers to substitute away from the U.S.-made goods towards Australia-made goods. Because the net impact on Australia's terms of trade is small, we expect the net impact on Australia's real GDP to also be small, which we see borne out in Figure 30. An interesting feature of the real GDP deviation is the positive contribution made by U.S. tariffs to Australia's real GDP deviation (Figure 30) despite a negative contribution to Australia's terms of trade deviation (Figure 31). This reflects compositional effects that are obscured in this case by a focus on the aggregate terms of trade outcome. The negative deviation in China's economy induced by U.S. tariffs lowers demand for Australia's capital-intensive mining products. At the same time, it raises demand in the U.S. for Australia's labour-intensive manufacturing products like *manufacturers n.e.c.*, *electronic equipment*, *mineral products n.e.c.*, *transport equipment n.e.c.*, and *textiles, clothing and footwear*.

Figure 32 reports Australia's real consumption deviation. In general, this lies slightly above Australia's real GDP deviation (Figure 30) reflecting the small positive deviation in Australia's terms of trade (Figure 31). Australia's real consumption deviation peaks in 2020, the year of peak real GDP deviation, at +0.08 per cent, before falling to +0.05 per cent by the end of the simulation period.

5 A U.S.-China trade deal

We simulate a trade deal in which China agrees to stimulate its demand for U.S. products. We implement this by removing all Chinese tariffs on U.S. imports recorded in the GTAP database, in two equal tranches over 2019 and 2020. In the GTAP database, the average rate of China's tariffs on U.S. imports (calculated as total tariff revenue on imports of U.S. goods, divided by the total c.i.f. value of imports of U.S. goods) is 5.1 per cent. The highest tariff rates are recorded on *motor vehicles and parts* (22.7%), *bovine meat products* (19.4%), *mineral products n.e.c.* (10.5%), *other food, beverage and tobacco products* (8.5%), *metal products* (8.5%), *textiles, clothing and footwear* (7.4%), *chemical, rubber and plastic products* (5.9%), *other manufacturing* (5.6%), *other machinery and equipment* (5.2%), *other agriculture* (3.9%), and *ferrous metals* (3.6%). China's tariff rates on these, and all other U.S. imports, are reduced to zero in two equal steps over 2019 and 2020.

President Trump campaigned on ending trade imbalances, which he sees as "hurting the economy very badly" (McBride and Chatzky 2019). It is interesting therefore to consider Figure 33, which reports the change in the U.S.' bilateral trade deficits as a share of U.S. GDP. The trade deal reduces China's bilateral trade surplus with the U.S. as a share of U.S. GDP by 0.0035, that is, a reduction of approximately 1/3 of one percentage point of U.S. GDP. Figure 33 confirms the standard macroeconomic proposition that the U.S.' balance of trade deficit is determined by the U.S. savings / investment balance. That is, it is determined by the U.S. savings rate and the attractiveness of investment prospects within the U.S. Both of these factors are largely independent of China's trade policy. Hence, the trade deal has little impact on the U.S.' overall balance of trade deficit as a share of U.S. GDP (Figure 33). As such, the U.S.' movement towards balance of trade surplus with China is matched by a near equivalent movement towards balance of trade deficit with other countries.

The removal of China's tariffs on U.S. imports reduces indirect taxes on business and investment inputs, and on household consumption. As discussed earlier in reference to the back-of-the-envelope model, this causes a short-run stimulus to China's employment and real GDP at factor cost (Figure 34). By removing the allocative efficiency distortion on imports, the tariff removal also raises China's real GDP at market prices relative to real GDP at factor cost (Figure 34). Over the longer run, the positive employment deviation is gradually eroded by real wage increase, but the real GDP (at market prices) deviation remains relatively steady at approximately 0.05 per cent due to a long-run positive deviation in the capital stock (Figure 34).

The removal tariffs on imports of U.S. products in China generates a positive deviation in China's aggregate import volumes of approximately 1.1 per cent, which must be funded by a positive deviation in exports of similar magnitude (Figure 35). The positive export volume deviation generates a negative terms of trade deviation of approximately 0.16 per cent. This explains why the real consumption deviation is close to zero, despite the positive deviation in real GDP at market prices.

The rise in China's demand for U.S. products raises the U.S. terms of trade (Figure 36), generating positive deviations in short-run employment, long-run capital, and real GDP at factor cost and at market prices (Figure 37). The positive deviation the U.S. terms of trade generates a positive deviation in U.S. real consumption (Figure 36), which is 0.06 per cent higher than baseline by the end of the simulation period.

We turn now to results for U.S. industries. Figure 38 reports U.S. industry output deviations aggregated to outcomes for seven broad sectors, while Figure 39 looks behind these aggregates to report the output deviations in the U.S. for the top 5 (ranked by output deviations in the simulation's final year) of the model's 34 industries. The manufacturing sector experiences the largest positive output deviation, at approximately 0.3 per cent. This reflects the removal of high Chinese tariffs on a number of U.S. imports (particularly *motor vehicles and parts, mineral products n.e.c.*, and *metal products,* see Figure 39). Two sectors, *services* and *mining*, experience negative output deviations (Figure 38). Products produced by these industries are not subject to high tariffs in China, and in general, these industries do not sell significant proportions of their output in China. Hence, they benefit little from the removal of China's tariffs on U.S. imports. They are however trade-exposed, and thus are affected by the appreciation of the real exchange caused by removal of China's tariffs on U.S. products (see Figure 36). The industry experiencing the largest positive deviation in output is *oil seeds* (Figure 39). U.S. *oil seeds* are not subject to a high tariff in China in the GTAP database (3%), but sales to China are a high share (at 40%) of total sales of the U.S. *oil seeds* industry.

We turn now to consider impacts on countries other than the U.S. and China. The removal of tariffs on U.S. products by China induces economic agents within China to substitute away from non-U.S. suppliers. At the same time, it encourages U.S. exporters to expand the proportion of their export sales destined for China. For countries other than the U.S. and China, both factors act to reduce their terms of trade relative to baseline. In these countries, this generates negative employment deviations in the short-run and negative capital deviations in the long-run. This accounts for the negative real GDP deviations for countries other than the U.S. and China reported in Figure 40. South Korea and Japan experience the largest negative real GDP deviations (-0.04 per cent and -0.03 per cent respectively in the long-run). This reflects substitution by firms and households in China away from these countries as suppliers of *motor vehicles and parts*, the U.S. commodity with the highest import tariff in China (22.7%). The contractions in the *motor vehicles and parts* sectors in South Korea and Japan are -0.66 per cent and -1.0 per cent respectively (not reported in the figures).

We conclude this section by examining impacts on Australia. Of the regions reported in Figure 40, Australia experiences the smallest negative real GDP deviations. This reflects two countervailing forces on Australia’s terms of trade. First, substitution by firms and consumers in China towards U.S. products damps Australia’s terms of trade. This accounts for relatively large 2026 export price deviations for Australian *oil seeds* (-0.17%), *textiles, clothing and footwear* (-0.15%), *cereal grains* (-0.15%) and *other agriculture* (-0.14%). Second, the removal of China’s tariffs on U.S. imports raises China’s GDP, lifting Australia’s terms of trade. This accounts for the muted negative export price deviations for Australian exports of *oil and gas* (-0.06%), and *petroleum and coal products* (-0.06%) (in comparison, Australia’s 2026 GDP deflator deviation is -0.13%). The net outcome is a small negative deviation in Australia’s terms of trade, which generates a short-run run negative employment deviation and a long-run negative capital deviation, which together generate a deviation in real GDP of approximately -0.01 per cent (Figure 41). The long-run negative terms of trade deviation generates a long-run negative deviation in Australia’s real consumption of -0.01 per cent (Figure 42).

6 Restriction on imports of Australian coal by China

As discussed in Section 1, while the U.S. tariffs have been imposed in response to economic concerns (distortions in China's markets, intellectual property issues, market access), an additional element is Washington's concerns over China's state-led push for rapid development in high-technology sectors in which the U.S. has traditionally led. The Trump Administration's willingness to use trade instruments for non-economic ends was most recently displayed with the threat of tariffs on Mexico over border control issues. Beijing has also made use of trade restriction measures to advance non-economic aims. Some countries to have been subject to such restrictions include: (i) Canada (revocation of import permits on canola imports, suspension of pork imports),[8,9] (ii) Australia (delays in the processing of coal imports, exaggerated travel advisory warnings to Chinese visitors to Australia, threats of tariffs on Australian barley); [10,11,12] (iii) New Zealand (cancelation of a tourism initiative and delays in processing of fresh food imports);[13] (iv) South Korea (suspension of Chinese tour groups and shut-down of Korean-owned supermarkets within China);[14] (v) Palau (ban on Chinese tourists);[15] and Norway (cessation of salmon imports).[16]

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[8] Gregory Meyer and Lucy Hornby (2019), "China blocks imports of canola from Canadian exporter", Financial Times, March 6th, 2019, https://www.ft.com/content/fc981bb2-3fa9-11e9-b896-fe36ec32aece.

[9] Rod Nickel and David Ljunggren ([2019]), "China blocks imports from Canadian pork producers", *Australian Financial Review*, Friday 3rd May 2019, p. 14.

[10] Thompson, B. and M. Smith ([2019]) "Australia barly faces China tariffs in Beijing's latest threat to exports", Australian Financial Review, Feb. 27th, https://www.afr.com/markets/commodities/agriculture/australia-barley-faces-china-tariffs-in-beijings-latest-threat-to-exports-20190227-h1brj6

[11] Stephen Letts (2019), "China's policy on Australian coal is 'as dark and impenetrable as night' and that's how it wants it", *Australian Broadcasting Commission*, February 25th 2019, https://www.abc.net.au/news/2019-02-25/china-policy-on-australian-coal-dark-and-impenetrable/10843148.

[12] Smith, M. (2018), "China warns tourists about security risks in Australia", *Australian Financial Review*, May 1st 2018. https://www.afr.com/news/politics/world/china-warns-tourists-about-security-risks-in-australia-20180501-h0zi9u.

[13] Charlotte Graham-McLay (2019), "New Zealand fears fraying ties with China, its biggest customer",

[14] Adam Taylor (2017), "South Korea and China move to normalize relations after THAAD dispute", *The Washington Post*, October 31st 2017, https://www.washingtonpost.com/world/south-korea-and-china-move-to-normalize-relations-after-thaad-conflict/2017/10/31/60f2bad8-bde0-11e7-af84-d3e2ee4b2af1_story.html?noredirect=on&utm_term=.0cb2260239d5.

[15] Lauren Beldi, (2018), "China's 'tourist ban' leaves Palau struggling to fill hotels and an airline in limbo", *Australian Broadcasting Commission*, https://www.abc.net.au/news/2018-08-26/china-tourist-ban-leaves-palau-tourism-in-peril/10160020.

[16] Sewell Chan (2016), "Norway and China restore ties, 6 years after Nobel Prize dispute", *The New York Times*, December 19th, 2016, https://www.nytimes.com/2016/12/19/world/europe/china-norway-nobel-liu-xiaobo.html.

Beijing has imposed these trade restrictions in response to decisions made by governments and institutions within the target countries across such areas as: security (passage of foreign interference laws, the limiting of access by Chinese firms to critical infrastructure provision, emplacement of missile defence systems); diplomacy (honouring established extradition protocols, maintenance of diplomatic relations with Taiwan); and recognition of individual achievement advancing fundamental human rights (award of the 2010 Nobel Peace Prize).

In this section we examine a scenario in which the Chinese government permanently reduces imports of Australian thermal and metallurgical coal by 25%. The simulation is motivated by reports in early 2019 that processing of Australian coal imports through Chinese ports was being delayed, generating significant demurrage charges on coal carriers. Walker (2019) suggests that politics was likely a factor, with only Australian coal targeted, probably in response to a variety of matters, including the blocking of Huawei from Australia's 5G network, the denial of a re-entry permit to Huang Xiangmo and the removal of his permanent residency status on the grounds of his CPC links, Canberra's outspokenness on China's militarisation of artificial islands in the South China Sea, and the attribution to China by security analysts of the major cyber-attack on Federal Parliament. Bloomberg News reported in late April that sources in China with knowledge of the plan said that the slowdown in Australian coal imports were to continue until Beijing had assessed Canberra's policies after the May federal government elections.[17]

We conjecture that there are five main elements to understanding the impact on the Australian economy of a restriction on imports of Australian products into China: (i) the capacity of mobile resources within the sectors adversely affected by the trade restriction to move to other sectors; (ii) the inability of immobile natural resource assets in the directly affected sectors to move to other sectors; (iii) the capacity of the target sector to divert export sales to markets other than China; (iv) the extent of foreign ownership of the target sector's physical capital and natural resource; and (v) the effective rate of taxation of the foreign-owned returns to capital and natural resources in the target sector. For elements (i) - (iii), the GTAP-MVH model contains familiar general equilibrium theory providing for: (a) the gradual movement of mobile resources (labour and capital) between sectors within each region; (b) the immobility of sector-specific natural resources (like the coal sector's sub-soil asset); and (c) the capacity of agents within each region to substitute between alternative sources of supply for each commodity. Elements (iv) and (v) relate to measuring the impact of the trade restriction on net national product. As discussed in Section 3.1, GTAP-MVH's accounting for net national product

[17] Steven Yang, Jason Scott and Jing Yang (2019) "China Will Continue Slowdown in Australia Coal Until After Elections", Bloomberg News, April 24, 2019.

recognises foreign claims on Australian capital income, and Australian claims on global capital incomes. However, a limitation of this theory for the application in this section is that these claims do not include an industry dimension. To remedy this, we adjust GTAP-MVH's calculation of income accruing to foreigners from each region to take account of industry-specific capital ownership, and effective rates of taxation of industry-specific foreign owned capital.

To our knowledge, estimates for foreign ownership and capital tax parameters for the coal industry in particular are not readily available, and an independent estimation was beyond the scope of the present study. Campbell (2014) estimates the foreign ownership share for Hunter Valley coal at approximately 90%. Edwards (2011) estimates the foreign ownership share for the Australian mining sector in general at 83%. In this paper, we assume that 80% of the Australian coal sector is foreign owned. Dixon and Nassios (2018) calculate the effective rate of corporate taxation of foreign owned capital in Australia at 17%. On this basis, we set the tax rate on foreign capital and natural resource income in the Australian coal sector at 17%. Using ABS (2019), we estimate that the average royalty rate on coal production between 2015/16-2017/18 was 8 per cent, and as such, we set the value for the production tax rate on Australian coal in the model's database at this value. These assumptions are clearly an approximation of a more complex system in which, for example, mining royalties can be based on step-functions of price (as in Queensland), and in which they are tax-deductable against corporate income tax expense. These matters could be modelled in a more detailed study, along with better estimates of foreign capital ownership and effective corporate tax rates specific to the coal sector. Hence we caution that both the assumed foreign ownership share and the level and modelling of the rate of tax on foreign income are illustrative, and can be improved in future work.

We begin by examining the impact on Australian coal exports. Figure 43 reports a decomposition of the deviation in the Laspeyre index for Australia's coal exports into the individual contributions made by changes in Australian coal exports to destination countries. In the baseline forecast for 2018, 80.9% of Australian coal is exported, and of this, 22% is destined for China.[18] This accounts for the -6 percentage point contribution made by China to the coal export deviation reported in the year the import restriction is imposed (Figure 43). However, when China reduces its demand for Australian

[18] The export share is close to that reported for thermal coal, but below that reported for metallurgical coal, in Department of Industry (2019) *Resources and Energy Quarterly* (March 2019). Department of Industry (2019) reports that approximately 80% of Australia's production of thermal coal (valued at approximately $29 b.) is exported, and 100% of Australia's metallurgical coal (valued at approximately $43 b.) is exported. This suggests a weighted average export share of 92 per cent. Department of Industry (2019) reports China's share of Australia's metallurgical and thermal coal exports at 22% and 21% respectively, close to the GTAP share. In future work, the initial solution to the GTAP-MVH model and the baseline forecast can be made to track Department of Industry and other relevant data.

coal, it must meet its coal requirements by raising its demand for coal from other suppliers. For countries that are net coal importers, the fall in the price of Australian coal relative to the price of coal from countries that are now expanding export sales to China, induces substitution towards Australian coal. This offsets much of the lost export sales to China (Figure 43).

In Figure 44 we see that Australia's terms of trade falls by approximately 0.75 per cent by 2025, and that this is due almost entirely to a fall in Australia's export price index (the import price deviation is close to zero). Figure 45, which decomposes the deviation in Australia's f.o.b. export price index into the contributions made by sector-specific export price changes, makes clear that the main contributor to this is coal, the Australian f.o.b. price of which falls by approximately 2.7% (Figure 44).

Figure 46 reports deviations in Australia's employment, capital stock, and real GDP. The coal import restriction generates a negative deviation in employment in 2019 of -0.013 per cent, but the employment deviation attenuates over the remainder of the simulation as real wages adjust to return employment to baseline. The decline in the terms of trade reduces long-run capital formation by approximately 0.015 per cent. Together, the short-run deviation in employment and the long-run deviation in capital generate a deviation in real GDP at market prices of approximately -0.008 per cent.

The real consumption deviation (Figure 47) provides insight into the welfare consequences of the coal import restriction. These are not the same as the value of coal exports directly affected by the import restriction. Nor are they the same as might be calculated from a standard inspection of the economy-wide terms of trade outcome. For example, as reported earlier, approximately 22% of Australian coal exports in the GTAP database are destined for China, and as reported in Table 7, coal exports as a share of GDP in 2025 are projected to be 4.5%. But we note that in Figure 47, the long-run real consumption deviation is -0.056 per cent, not -0.34 per cent (= -0.25 * 0.22 * 0.045 / 0.74 * 100). If we ignore foreign ownership and taxation of capital, a back-of-the-envelope approximation for the impact of a decline in the terms of trade on domestic consumption is $S_X/S_C * tot$, where S_X and S_C are the shares of exports and consumption (private and public) in GDP, and *tot* is the percentage change in the terms of trade. As reported in Table 7, the 2025 values for S_X and S_C are approximately 0.18 and 0.74 respectively. Hence, a back-of-the-envelope estimate for the consumption impact of a 0.75 per cent fall in Australia's terms of trade is approximately -0.18 per cent. However, in Figure 47 we see that the year 2025 deviation in real consumption is less than 1/3 this figure, at -0.056 per cent. Table 8, using parameters and results from Table 7, explains the 2025 real consumption outcome in terms of five effects:

1. Savings on domestic use of the foreign-owned component of supply of local coal. The restriction on Australian coal imports lowers the price of Australian coal by approximately 2.7 per cent. To the extent that Australian coal production is foreign owned, this price reduction represents a benefit to local users of domestic coal. As reported in Table 7, local use of domestic coal as a share of GDP is 0.01. With 80% of this supplied by foreign owners, the -2.7% price reduction represents a gain to domestic agents of 0.00021 of GDP (=-2.7/100*0.01*0.8). When expressed as a proportion of consumption (private and public), this represents a gain of 0.028 per cent (=100* 0.00021/0.74) (see Table 8).

2. Export revenue loss attributable to local coal owners. Australian agents must absorb the loss associated with reduced export revenue on their share (20%) of coal exports. As reported in Table 7, coal exports as a share of GDP are 0.045. Noting the 2.7% price fall, and the 20% domestic ownership share, the loss to domestic agents expressed as a share of GDP is -0.00025 (=0.045*-2.7/100*0.2). Expressed as a proportion of consumption (private and public), this represents a loss of -0.033 per cent (=-0.00025/0.74 * 100) (see Table 8).

3. Royalty revenue loss on foreign-owned component of coal production. As discussed above, we set the royalty rate on coal production at 8%. The coal import restriction lowers coal prices and coal output volumes, and thus lowers coal royalty payments. Australia must absorb the loss associated with the lost royalty revenues collected on the foreign-owned share of coal production. The deviation in 2025 coal output is -0.36 per cent, and thus the 2025 deviation in coal sales is -3.05 per cent (Table 7). Noting that coal output as a share of GDP is 0.055, and that 80% of this is foreign owned, with the royalty rate at 8% the loss as a share of GDP is -0.00011 (= -3.05 / 100 * 0.055 * 0.8 * 0.08). Expressed as a proportion of consumption (private and public), this represents a loss of -0.015 per cent (=-0.00011 / 0.74 * 100) (see Table 8).

4. Corporate tax loss on foreign-owned share of coal sector profits. Australian tax payers must bear the loss associated with reduced capital income tax receipts on the foreign owned share of the coal sector. Fixed factors represent approximately 57% of the costs of the coal sector. Hence, the 2.7% price reduction translates to a fall in fixed factor returns in the coal sector of approximately 4.8% (=2.7/0.57). Noting that the coal sector is projected to be approximately 5.5% of the 2025 economy, with the foreign ownership share at 80%, and the effective tax rate on fixed factors at 17%, the loss to domestic agents associated with reduced income tax receipts from the foreign-owned proportion of coal capital is estimated to be -0.0002 as a share of GDP. Expressed as a proportion of consumption (private and public), this represents a loss of -0.027 per cent (=-0.0002 / 0.74 * 100) (see Table 8).

5. Generalised loss from fall in terms of trade outside the coal sector. As discussed with reference to Figure 45, the fall in the coal price is the chief contributor to the terms of trade fall. However, it is also clear from Figure 45 that price falls in other export sectors make a small contribution to the terms of trade decline (-0.044 percentage point contribution, see Table 7). This terms of trade loss outside of coal arises because of the need to expand exports of other commodities when coal export revenue falls. With non-coal exports and consumption as a share of GDP at approximately 0.14 and 0.74 respectively, this translates to a real consumption loss of -0.0081 per cent (see Table 8).

Taken together, the five effects anticipate a 2025 real consumption loss of -0.055 per cent (Table 8). This is very close to the GTAP-MVH model outcome of -0.0563 (Figure 47). To put this loss in context, we note that in 2018 consumption per capita in Australia was approximately $55,200. A -0.0563 per cent consumption loss is thus equivalent to approximately $31 per person.

We turn now to the macro impacts on China. Restricting importation of Australian coal produces an allocative efficiency loss in China because coal users in the country are forced to switch to more costly coal sources. This allocative efficiency loss is expressed in Figure 48 by the real GDP (at market prices) deviation lying below the real GDP (at factor cost) deviation. The introduction of the allocative efficiency distortion creates a transitory negative deviation in employment, and a permanent negative deviation in the capital stock. The negative deviations in employment and capital together with the costs of the allocative efficiency distortion create a real GDP deviation of approximately -0.02 per cent over the simulation period (Figure 48).

Figure 48 also reports China's terms of trade and real consumption deviations. The coal import restriction improves China's terms of trade slightly (up by 0.03 per cent by 2025). This reflects the reduction in the price of Australian coal, and the general Chinese trade contracting effects of the coal import restriction. The rise in the terms of trade offsets much of the national income loss created by the allocative efficiency distortion from restricting Australian coal imports, leaving little change from baseline in China's real consumption by 2025.

7 Concluding remarks

In future work, we hope to develop further the simulations reported in this paper in a number of ways.

First, we note that an important element missing from the modelling is the impact of policy uncertainty on global investment and supply chain decisions. Recent actions by Washington and Beijing are likely to have created considerable trade and investment uncertainty, and raised the costs for international business transacting with the U.S. and China. The U.S.-China trade war is the biggest element of this picture, but important too is the wider use by both countries of trade policy instruments to pursue political ends. For example, not modelled in this paper is the threat of tariffs on Mexico by the Trump administration over border control issues around illegal immigration. Imposition and threats of tariffs on Canada and Mexico are likely to have raised investment uncertainties in the integrated North-American manufacturing system created under NAFTA. The threat of tariffs on Mexico over border control adds to uncertainties over the Trump administration’s long term views over how manufacturing firms are to configure their supply chains in the face of rising U.S. and Chinese tariffs, given that Mexico would likely have otherwise figured prominently in such considerations.

Second, further uncertainties, and the risk of a spread of tariff barriers beyond the U.S. and China, could be counted as part of the costs of the current trade conflict and modelled in future work. Further investment risks and more business decision uncertainties in configuring global manufacturing supply chains are possibly being created by the Trump administration’s threat of using its national security economic powers to place tariffs on Japanese and EU automobiles. In this regard, it is important to see that the trade war extends beyond the U.S.-China tariff exchange modelled in this paper. Further study of the trade diversion impacts of the U.S. and China tariffs could also elucidate the risks of the trade war spreading. Diversion of U.S. and Chinese exports to other markets caused by rising U.S. and Chinese tariffs raises the possibility of expansion of the trade war, as industries in countries experiencing a rise in imports of diverted U.S. and Chinese products seek import protection measures from their governments.

Third, in the U.S.-China trade war simulation, we have confined the shocks to actual and prospective tariff rate increases. However, there are other trade and investment measures that could potentially be deployed in the conflict. For example, while the U.S. has a greater value of imports to target with tariffs than does China, this is to ignore the significant sales within China of majority-owned U.S. affiliates. If the trade conflict were to widen, it is possible that the activities of these firms would be targeted by the Chinese government. China has threatened to restrict exports of so-called rare earth metals, used in the production of the electric motors of hybrid and electric vehicles, generators in wind turbines, and fuel cells and nickel-metal hydride batteries. Such a restriction would have important implications for industries using these inputs since the availability of substitutes (either by product or by source/supplier) is limited.

Fourth, the simulations of the issues studied in this paper would benefit from further investigation and improvement of the initial GTAP database and the baseline simulation. With respect to the GTAP database, there are at least two matters warranting further investigation. First, one of the concerns of the U.S. in instigating the trade war is the allegation of China's subsidisation of key export-oriented manufacturing sectors. The promulgation of the "Made in China 2025" strategy, which targets many sectors in which the U.S. leads, is an important element of these concerns. However, on a preliminary inspection, the GTAP database does not appear to carry any information expressing distortionary effects from subsidisation of export-oriented manufacturing. For the Chinese economy taken as a whole, production tax rates are close to zero in the GTAP database. For manufacturing, production tax rates range between around 1 and 10 per cent. No production subsidies in Chinese manufacturing are recorded. Similarly, GTAP records no subsidies on Chinese exports. Indeed, the database records export taxes on Chinese manufactured goods, with rates ranging between around 2 and 10 per cent. A more comprehensive future study would identify and value the distortionary effects of Chinese and U.S. industry policy, and ensure that they are recognised in the GTAP database. This will improve the estimation of the economic impacts of U.S. and Chinese tariffs, and also aid future investigation of the effects of any trade deal involving removal of distortionary industry protection policies.

Another element of the GTAP database that might benefit from further investigation in future work are the default values for elasticities of substitution across commodities. An interesting element of the GTAP database is that manufactured products tend to have higher elasticities of substitution than primary products. Because U.S. imports from China tend to have a heavier weighting towards manufactures, while China's imports from the U.S. tend to have a heavier weighting towards primary products, the trade diversion capabilities of the Chinese economy in the face of U.S. tariffs are potentially higher than those available to the U.S. economy in the face of Chinese tariffs. However it would be reasonable to question whether higher substitution possibilities for the model's manufacturing commodities, which subsume a variety of heterogeneous products, relative to primary products, which subsume a variety of more homogeneous products, is correct, particularly in the long-run. This is also relevant to the coal simulation, in which Australia's capacity to redirect to coal exports to other countries is regulated by the coal Armington elasticity, which is 6.1 in the standard GTAP database. In future work for the coal simulation, it would be appropriate to investigate and possibly re-estimate this elasticity explicitly. Model development to accommodate a transition from a short-run environment in which the coal Armington elasticity is low, reflecting short-run frictions in finding new markets, to a long-run environment in which the coal Armington elasticity is higher, might be helpful in elucidating the short-run and long-run consequences of the coal scenario.

Finally, the modelling would benefit from a more detailed specification of the baseline. At present, we impose independent forecasts for region-specific growth in real GDP, labour supply and population. Together with our investment theory and closure assumptions governing private and public consumption, this provides plausible regional macroeconomic outcomes in each region, and together with the GTAP bilateral trade data and theory, produces a plausible path for commodity-specific inter-regional trade patterns. However, our policy shocks relate to particular commodities and particular regions. In the U.S.-China trade war simulation, manufacturing commodities figure prominently. In the coal import restriction simulation, coal figures prominently. In future work, the simulations would benefit from incorporating more forecast detail for these commodities. For example, in the case of Australian coal, distinguishing between metallurgical and thermal coal would be appropriate, as would imposing Department of Industry data on forecast production and export volumes and prices. For Chinese and U.S. manufacturing, baseline details on industry-specific shifts in productivity, industry policy, and taste changes would complement the already rich detail embodied in the tariff shocks.

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Table 1: Mapping between GTAP's 57 industries and the 34 industry classification in this paper

	Model name	Short description	Long description	34 industry classification
1	**GRO**	Cereal grains n.e.c.[19]	Other Grains: maize (corn), barley, rye, oats, other cereals	1. Cereal grains n.e.c
2	**OSD**	Oil seeds	Oil Seeds: oil seeds and oleaginous fruit; soy beans, copra	2. Oil Seeds
3	**PDR**	Paddy rice	Paddy Rice: rice, husked and unhusked	3. Other agriculture, forestry and fishery products
4	**WHT**	Wheat	Wheat: wheat and meslin	
5	**V_F**	Vegetables, fruit, nuts	Veg & Fruit: vegetables, fruit and nuts, potatoes, cassava, truffles,	
6	**C_B**	Sugar cane, sugar beet	Cane & Beet: sugar cane and sugar beet	
7	**PFB**	Plant-based fibers	Plant Fibres: cotton, flax, hemp, sisal and other raw vegetable materials used in textiles	
8	**OCR**	Crops n.e.c.	Other Crops: live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds, beverage and spice crops, unmanufactured tobacco, cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets, plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes, sugar beet seed and seeds of forage plants, other raw vegetable materials	
9	**CTL**	Bovine cattle, sheep and goats, horses	Cattle: cattle, sheep, goats, horses, asses, mules, and hinnies; and semen thereof	
10	**OAP**	Animal products n.e.c.	Other Animal Products: swine, poultry and other live animals; eggs, in shell (fresh or cooked), natural honey, snails (fresh or preserved) except sea snails; frogs' legs, edible products of animal origin n.e.c., hides, skins and furskins, raw , insect waxes and spermaceti, whether or not refined or coloured	
11	**RMK**	Raw milk	Raw milk	
12	**WOL**	Wool, silk-worm cocoons	Wool: wool, silk, and other raw animal materials used in textile	

[19] n.e.c. stands for 'not elsewhere classified'.

13	**FRS**	Forestry	Forestry: forestry, logging and related service activities	
14	**FSH**	Fishing	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing	
15	**COA**	Coal	Coal: mining and agglomeration of hard coal, lignite and peat	4. Coal
16	**OIL**	Oil	Oil: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part)	5. Oil and gas
17	**GAS**	Gas	Gas: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part)	
18	**OMN**	Minerals n.e.c.	Other Mining: mining of metal ores, uranium, gems. other mining and quarrying	6. Other mining products
19	**CMT**	Bovine meat products	Cattle Meat: fresh or chilled meat and edible offal of cattle, sheep, goats, horses, asses, mules, and hinnies. raw fats or grease from any animal or bird.	7. Bovine meat products
20	**OMT**	Meat products n.e.c.	Other Meat: pig meat and offal. preserves and preparations of meat, meat offal or blood, flours, meals and pellets of meat or inedible meat offal; greaves	8. Other food, beverage and tobacco products
21	**VOL**	Vegetable oils and fats	Vegetable Oils: crude and refined oils of soya-bean, maize (corn),olive, sesame, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and canola, mustard, coconut palm, palm kernel, castor, tung jojoba, babassu and linseed, perhaps partly or wholly hydrogenated,inter-esterified, re-esterified or elaidinised. Also margarine and similar preparations, animal or vegetable waxes, fats and oils and their fractions, cotton linters, oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; degras and other residues resulting from the treatment of fatty substances or animal or vegetable waxes.	
22	**MIL**	Dairy products	Milk: dairy products	
23	**PCR**	Processed rice	Processed Rice: rice, semi- or wholly milled	
24	**SGR**	Sugar	Sugar	
25	**OFD**	Food products n.e.c.	Other Food: prepared and preserved fish or vegetables, fruit juices and vegetable juices, prepared and preserved fruit and nuts, all cereal flours, groats, meal and pellets of wheat, cereal groats, meal and pellets n.e.c., other cereal grain products (including corn flakes), other vegetable flours and meals, mixes and doughs for the preparation of bakers' wares, starches and starch products; sugars and sugar syrups n.e.c., preparations used in animal feeding, bakery products, cocoa, chocolate and sugar confectionery, macaroni, noodles, couscous and similar farinaceous products, food products n.e.c.	

26	**B_T**	Beverages and tobacco products	Beverages and Tobacco products	
27	**TEX**	Textiles	Textiles: textiles and man-made fibres	9. Textile, clothing and footwear
28	**WAP**	Wearing apparel	Wearing Apparel: Clothing, dressing and dyeing of fur	
29	**LEA**	Leather products	Leather: tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear	
30	**LUM**	Wood products	Lumber: wood and products of wood and cork, except furniture; articles of straw and plaiting materials	10. Wood products
31	**PPP**	Paper products, publishing	Paper & Paper Products: includes publishing, printing and reproduction of recorded media	11. Paper products, publishing
32	**P_C**	Petroleum, coal products	Petroleum & Coke: coke oven products, refined petroleum products, processing of nuclear fuel	12. Petroleum, coal products
33	**CRP**	Chemical, rubber, plastic products	Chemical Rubber Products: basic chemicals, other chemical products, rubber and plastics products	13. Chemical, rubber, plastic products
34	**NMM**	Mineral products n.e.c.	Non-Metallic Minerals: cement, plaster, lime, gravel, concrete	14. Mineral products n.e.c.
35	**I_S**	Ferrous metals	Iron & Steel: basic production and casting	15. Ferrous metals
36	**NFM**	Metals n.e.c.	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver	16. Non-ferrous metals
37	**FMP**	Metal products	Fabricated Metal Products: Sheet metal products, but not machinery and equipment	17. Metal products
38	**MVH**	Motor vehicles and parts	Motor vehicles and parts: cars, lorries, trailers and semi-trailers	18. Motor vehicles and parts
39	**OTN**	Transport equipment n.e.c.	Other Transport Equipment: Manufacture of other transport equipment	19. Transport equipment n.e.c.
40	**ELE**	Electronic equipment	Electronic Equipment: office, accounting and computing machinery, radio, television and communication equipment and apparatus	20. Electronic equipment
41	**OME**	Machinery and equipment n.e.c.	Other Machinery & Equipment: electrical machinery and apparatus n.e.c., medical, precision and optical instruments, watches and clocks	21. Machinery and equipment n.e.c.
42	**OMF**	Manufactures n.e.c.	Other Manufacturing: includes recycling	22. Manufactures n.e.c.
43	**ELY**	Electricity	Electricity: production, collection and distribution	23. Electricity

44	**GDT**	Gas manufacture, distribution	Gas Distribution: distribution of gaseous fuels through mains; steam and hot water supply	24. Gas manufacture, distribution
45	**WTR**	Water	Water: collection, purification and distribution	25. Water
46	**CNS**	Construction	Construction: building houses factories offices and roads	26. Construction
47	**TRD**	Trade	Trade: all retail sales; wholesale trade and commission trade; hotels and restaurants; repairs of motor vehicles and personal and household goods; retail sale of automotive fuel	27. Trade
48	**OTP**	Transport n.e.c.	Other Transport: road, rail ; pipelines, auxiliary transport activities; travel agencies	28. Transport
49	**WTP**	Water transport	Water transport	
50	**ATP**	Air transport	Air transport	
51	**CMN**	Communication	Communications: post and telecommunications	29. Communication
52	**OFI**	Financial services n.e.c.	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding (see next)	30. Financial and insurance services
53	**ISR**	Insurance	Insurance: includes pension funding, except compulsory social security	
54	**OBS**	Business services n.e.c.	Other Business Services: real estate, renting and business activities	31. Business services n.e.c
55	**ROS**	Recreational and other services	Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants)	32. Recreational and other services
56	**OSG**	Public Administration, Defence, Education, Health	Other Services (Government): public administration and defence; compulsory social security, education, health and social work, sewage and refuse disposal, sanitation and similar activities, activities of membership organizations n.e.c., extra-territorial organizations and bodies	33. Public administration, defence, education, health
57	**DWE**	Dwellings	Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)	34. Dwellings

Table 2: Baseline growth rates in real GDP (% change on previous year)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
1 USA	2.9	1.6	2.2	2.9	2.3	1.9	1.8	1.6	1.6	1.6	1.5	1.5	1.4
2 Canada	0.7	1.1	3.0	1.8	1.5	1.9	1.8	1.6	1.6	1.6	1.6	1.6	1.6
3 Mexico	3.3	2.9	2.1	2.0	1.6	1.9	2.4	2.6	2.7	2.7	2.8	2.8	2.8
4 Australia	2.5	2.8	2.4	2.8	2.1	2.8	2.8	2.6	2.7	2.6	2.6	2.6	2.6
5 Japan	1.2	0.6	1.9	0.8	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6 South Korea	2.8	2.9	3.1	2.7	2.6	2.8	2.9	2.8	2.9	2.9	2.9	3.0	3.0
7 China	6.9	6.7	6.8	6.6	6.3	6.1	6.0	5.8	5.6	5.5	5.4	5.2	5.1
8 India	8.0	8.2	7.2	7.1	7.3	7.5	7.7	7.7	7.7	7.7	7.7	7.7	7.7
9 Indonesia	4.9	5.0	5.1	5.2	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.2	5.2
10 Philippines	6.1	6.9	6.7	6.2	6.5	6.6	6.7	6.7	6.8	6.8	6.8	6.8	6.8
11 Thailand	3.1	3.4	4.0	4.1	3.5	3.5	3.5	3.5	3.6	3.6	3.8	3.9	4.0
12 Rest of ASEAN	6.7	6.2	6.8	7.1	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
13 France	1.1	1.2	2.2	1.5	1.3	1.4	1.5	1.5	1.5	1.6	1.5	1.6	1.6
14 Germany	1.5	2.2	2.5	1.5	0.8	1.4	1.5	1.4	1.3	1.2	1.0	0.9	0.8
15 UK	2.3	1.8	1.8	1.4	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6
16 Ro EU	2.9	2.2	2.8	2.4	1.7	1.8	1.6	1.6	1.5	1.5	1.5	1.5	1.5
17 Russia	-2.5	0.3	1.6	2.3	1.6	1.7	1.7	1.6	1.6	1.6	1.7	1.5	1.6
18 RoW	1.1	1.0	2.0	1.4	1.1	2.5	2.5	2.6	2.7	2.7	2.7	2.6	2.6

Source: IMF World Economic Outlook database (IMF 2019) to 2025. Assumed labour productivity growth and World Bank labour supply estimate thereafter.

Table 3: Baseline growth rates in population (% change on previous year)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
1 USA	0.76	0.74	0.72	0.74	0.74	0.73	0.73	0.72	0.71	0.70	0.68	0.66	0.64
2 Canada	0.84	1.21	1.22	0.88	0.85	0.82	0.79	0.77	0.75	0.73	0.72	0.69	0.66
3 Mexico	1.34	1.31	1.27	1.24	1.20	1.17	1.13	1.10	1.06	1.03	0.99	0.96	0.92
4 Australia	1.48	1.51	1.60	1.28	1.25	1.21	1.17	1.14	1.12	1.09	1.07	1.04	1.02
5 Japan	-0.11	-0.12	-0.16	-0.30	-0.31	-0.33	-0.35	-0.37	-0.39	-0.41	-0.42	-0.45	-0.47
6 South Korea	0.53	0.45	0.43	0.35	0.33	0.32	0.30	0.28	0.27	0.26	0.24	0.23	0.21
7 China	0.51	0.54	0.56	0.34	0.30	0.26	0.22	0.18	0.15	0.12	0.09	0.06	0.04
8 India	1.17	1.16	1.13	1.11	1.09	1.06	1.03	1.00	0.97	0.95	0.92	0.89	0.86
9 Indonesia	1.19	1.14	1.10	1.06	1.03	1.00	0.97	0.94	0.90	0.87	0.84	0.81	0.78
10 Philippines	1.61	1.58	1.55	1.52	1.50	1.48	1.46	1.44	1.41	1.39	1.36	1.33	1.30
11 Thailand	0.35	0.30	0.25	0.21	0.18	0.15	0.13	0.10	0.08	0.06	0.04	0.02	0.00
12 Rest of ASEAN	1.19	1.15	1.09	1.09	1.06	1.03	1.01	0.98	0.95	0.92	0.89	0.85	0.81
13 France	0.42	0.40	0.39	0.36	0.37	0.36	0.35	0.35	0.34	0.34	0.33	0.32	0.31
14 Germany	0.87	0.81	0.42	-0.11	-0.12	-0.12	-0.12	-0.11	-0.11	-0.11	-0.11	-0.12	-0.12
15 UK	0.80	0.72	0.65	0.56	0.56	0.55	0.53	0.51	0.50	0.48	0.46	0.44	0.42
16 Ro EU	0.01	0.04	0.07	-0.03	-0.03	-0.05	-0.06	-0.06	-0.08	-0.09	-0.10	-0.11	-0.12
17 Russia	0.19	0.17	0.11	-0.12	-0.15	-0.18	-0.21	-0.23	-0.24	-0.26	-0.28	-0.31	-0.34
18 RoW	1.91	1.88	1.84	1.79	1.77	1.75	1.72	1.70	1.68	1.65	1.63	1.60	1.58

Source: World Bank population estimates and projections (World Bank 2018).

Table 4: Baseline growth rates in labour supply (% change on previous year)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
1 USA	0.45	0.42	0.31	0.27	0.26	0.27	0.15	0.21	0.22	0.18	0.12	0.10	0.06
2 Canada	0.28	0.58	0.52	0.14	0.12	0.11	0.03	0.06	0.08	0.05	0.01	-0.04	-0.07
3 Mexico	1.80	1.64	1.60	1.53	1.46	1.37	1.34	1.25	1.18	1.15	1.12	1.09	1.06
4 Australia	1.01	0.99	1.04	0.71	0.72	0.74	0.67	0.74	0.78	0.76	0.71	0.73	0.68
5 Japan	-1.06	-0.92	-0.88	-0.93	-0.87	-0.82	-0.69	-0.63	-0.60	-0.61	-0.67	-0.65	-0.70
6 South Korea	0.31	0.15	0.02	-0.20	-0.36	-0.53	-0.66	-0.81	-0.93	-1.00	-1.04	-0.99	-1.02
7 China	-0.00	-0.10	-0.13	-0.35	-0.34	-0.28	-0.20	-0.15	-0.14	-0.17	-0.24	-0.32	-0.37
8 India	1.67	1.60	1.49	1.42	1.40	1.41	1.25	1.29	1.29	1.22	1.12	1.02	0.94
9 Indonesia	1.49	1.29	1.37	1.38	1.30	1.18	1.12	0.99	0.91	0.90	0.93	0.83	0.86
10 Philippines	1.93	1.82	1.76	1.72	1.68	1.66	1.59	1.57	1.55	1.53	1.52	1.45	1.44
11 Thailand	0.19	0.23	0.13	0.03	-0.08	-0.18	-0.23	-0.35	-0.45	-0.51	-0.55	-0.62	-0.64
12 Rest of ASEAN	1.34	1.20	1.08	1.04	0.98	0.93	0.87	0.83	0.80	0.77	0.75	0.68	0.67
13 France	-0.21	-0.10	-0.06	-0.03	0.01	0.01	0.02	0.05	0.04	0.01	-0.05	-0.05	-0.09
14 Germany	0.74	0.62	0.16	-0.44	-0.51	-0.56	-0.70	-0.75	-0.80	-0.87	-0.94	-1.00	-1.04
15 UK	0.31	0.31	0.24	0.17	0.20	0.22	0.19	0.23	0.23	0.19	0.13	0.07	0.03
16 Ro EU	-0.54	-0.42	-0.42	-0.52	-0.50	-0.48	-0.52	-0.48	-0.45	-0.48	-0.53	-0.55	-0.58
17 Russia	-0.62	-0.92	-0.91	-1.07	-1.08	-1.09	-1.06	-1.07	-1.03	-0.91	-0.76	-0.82	-0.67
18 RoW	2.07	1.96	1.96	1.93	1.92	1.90	1.87	1.84	1.83	1.83	1.84	1.77	1.78

Source: World Bank population estimates and projections (World Bank 2018).

Table 5: Tariffs and the shares of commodities affected by tariffs

	US tariffs on imports from China						Chinese tariffs on imports from US					
	2018		2019		2020		2018		2019		2020	
	share	tariff (%)	share	tariff (%)	share	tariff (%)	share	tariff (%)	share	tariff (%)	share	tariff (%)
1 Cereal grains n.e.c	0.86	2.50	0.86	18.75	1.00	25.00	1.00	12.50	1.00	25.00	1.00	25.00
2 Oil Seeds	0.88	2.50	0.88	18.75	1.00	25.00	1.00	12.47	1.00	24.97	1.00	25.00
3 Other agric, forest and fish prods	0.57	2.50	0.57	18.75	1.00	25.00	1.00	8.48	1.00	20.29	1.00	25.00
4 Coal	0.88	2.50	0.88	18.75	1.00	25.00	1.00	12.50	1.00	25.00	1.00	25.00
5 Oil and gas	0.00	0.00	0.00	0.00	0.00	0.00	0.94	11.36	0.94	24.95	1.00	25.00
6 Other mining products	0.22	2.50	0.22	18.75	1.00	25.00	0.69	2.08	0.69	19.82	1.00	25.00
7 Bovine meat products	0.00	0.00	0.00	0.00	1.00	25.00	1.00	9.28	1.00	24.87	1.00	25.00
8 Other food, bever and tobacco prods	0.72	2.50	0.72	18.75	1.00	25.00	1.00	10.99	1.00	22.89	1.00	25.00
9 Textile, clothing and footwear	0.18	2.50	0.18	18.75	1.00	25.00	0.79	1.80	0.79	16.10	1.00	25.00
10 Wood products	0.70	2.50	0.70	18.75	1.00	25.00	0.97	2.29	0.97	20.84	1.00	25.00
11 Paper products, publishing	0.48	2.50	0.48	18.75	1.00	25.00	0.38	1.48	0.38	10.48	1.00	25.00
12 Petroleum, coal products	0.67	2.87	0.67	17.56	1.00	25.00	1.00	12.50	1.00	25.00	1.00	25.00
13 Chemical, rubber, plastic products	0.60	2.91	0.60	17.45	1.00	25.00	0.88	5.89	0.88	19.29	1.00	25.00
14 Mineral products n.e.c.	0.62	2.51	0.62	18.71	1.00	25.00	0.78	1.64	0.78	13.94	1.00	25.00
15 Ferrous metals	0.93	4.85	0.93	21.68	1.00	25.00	0.91	3.64	0.91	16.45	1.00	25.00
16 Non-ferrous metals	1.00	5.54	1.00	13.39	1.00	25.00	0.65	4.79	0.65	20.91	1.00	25.00
17 Metal products	0.66	3.04	0.66	17.32	1.00	25.00	0.83	1.78	0.83	15.87	1.00	25.00
18 Motor vehicles and parts	0.83	3.11	0.83	17.54	1.00	25.00	0.92	12.08	0.92	24.49	1.00	25.00
19 Transport equipment n.e.c.	0.46	6.56	0.46	8.96	1.00	25.00	0.04	1.72	0.04	14.18	1.00	25.00
20 Electronic equipment	0.21	5.55	0.21	15.31	1.00	25.00	0.49	2.43	0.49	15.16	1.00	25.00
21 Machinery and equipment n.e.c.	0.88	5.52	0.88	12.54	1.00	25.00	0.97	2.00	0.97	17.74	1.00	25.00
22 Manufactures n.e.c.	0.27	2.65	0.27	18.47	1.00	25.00	1.00	3.80	1.00	15.31	1.00	25.00

Table 6: Chronology of the U.S.-China tariff exchange

Date tariffs applied	Description of tariffs
22 January 2018	US announces Section 201 tariffs on washing machines and solar panels
23 March 2018	US imposes Section 232 tariffs of 25 percent on imports of steel and 10 percent on imports of aluminium from China
2 April 2018	China imposes tariffs of 15 to 25 percent on $2.4 billion of imports from US in retaliation to US steel and aluminum tariffs
6 July 2018	US imposes Section 301 tariffs of 25 percent on revised list of $34 billion of imports from China
6 July 2018	China imposes tariffs of 25 percent on revised list of $34 billion of imports from US in retaliation to US Section 301 tariffs of July 6
23 August 2018	US imposes Section 301 tariffs of 25 percent on revised list of $16 billion of imports from China. Combined with July 6 action, this completes imposition of tariffs on the first $50 billion of Chinese imports
23 August 2018	China imposes tariffs of 25 percent on revised list of $16 billion of imports from US in retaliation to Section 301 tariffs of August 23.
24 September 2018	US imposes Section 301 tariffs of 10 percent on $200 billion of imports from China.
24 September 2018	China imposes tariffs of 5 to 10 percent on $60 billion of imports from US in retaliation to US Section 301 tariffs of September 24
1 June 2019	US increases Section 301 tariffs from 10 percent to 25 percent on $200 billion of imports from China.
1 June 2019	China increases tariffs by 5 to 15 percent on $60 billion of imports from US in retaliation to US Section 301 tariffs of June 1

References for US Tariffs on imports from China:

22 Jan. 2018: Office of the US Trade Representative Press Release of 22 January 2018, "President Trump Approves Relief for U.S. Washing Machine and Solar Cell Manufacturers".

23 Mar. 2018: Presidential Documents 15 March 2018, "Adjusting Imports of Steel Into the United States", Federal Register 83(51), item (1) on p.11627, and Presidential Documents 15 March 2018, "Adjusting Imports of Aluminum Into the United States", Federal Register 83(51), item (1) on p.11621.

6 Jul. 2018: Office of the US Trade Representative Press Release of 15 Jun. 2018, "USTR Issues Tariffs on Chinese Products in Response to Unfair Trade Practices". List of tariffs

23 Aug. 2018: Office of the US Trade Representative Press Release of 7 Aug. 2018, "USTR Finalizes Second Tranche of Tariffs on Chinese Products in Response to China's Unfair Trade Practices". List of tariffs

24 Sep. 2018: Office of the US Trade Representative Press Release of 18 September 2018, "USTR Finalizes Tariffs on $200 Billion of Chinese Imports in Response to China's Unfair Trade Practices". Final tariff list

1 Jun. 2019: Office of the US Trade Representative Press Release of 10 May 2018, "Statement By U.S. Trade Representative Robert Lighthizer on Section 301 Action"; and Office of the US Trade Representative Press Release of 31 May 2018, "Notice Regarding Application of Section 301 Action"

References for Chinese Tariffs on imports from the US:

2 Apr. 2018: Baker McKenzie International Trade Compliance Update of April 2018, p.50, "China issues statement on its response to the US section 232 tariffs on steel and aluminium", suspended concession product list

6 Jul. 2018: Baker McKenzie International Trade Compliance Update of July 2018, p.50, "China responds to US tariffs announced June 15", Annex 1 tariffs on $34b of imports; Annex 2 tariffs on $16b of imports

23 Aug. 2018: Baker McKenzie International Trade Compliance Update of August 2018, p.50, "China retaliates against 545 US products worth $34 Billion", list of Chinese retaliatory tariffs

24 Sep. 2018: Baker McKenzie International Trade Compliance Update of September 2018, p.51, "Tariffs on second batch of US originating goods announced", 25% tariffs; 20% tariffs; 10% tariffs; 5% tariffs.

1 Jun. 2019: Baker McKenzie International Trade Compliance Blog of 16 May 2019, "China announces increased tariffs on certain US origin goods", 25% tariffs; 20% tariffs; 10% tariffs; 5% tariffs.

Table 7: Key parameters and results related to 2025 back-of-the-envelope consumption calculation for the coal simulation

Key parameters from 2025 economy	
(1) Foreign ownership of coal sector	0.8
(2) Local ownership of coal sector	0.2
(3) Production tax rate	8%
(4) Effective capital tax rate	17%
(5) Coal output as a share of GDP	0.055
(6) Coal exports as a share of GDP	0.045
(7) Local use of coal as a share of GDP	0.010
(8) Coal fixed factor returns as share of coal costs	0.57
(9) Consumption (private and public) as share of GDP	0.74
(10) Exports as share of GDP	0.18

Key 2025 simulation results (% deviation from baseline)	
(11) Coal price	-2.7
(12) Coal output	-0.36
(13) Coal sales	-3.05
(14) Export price index	-0.734
(15) Coal contribution to export price index	-0.69
(16) Generalised terms of trade loss outside coal sector	-0.044

Table 8: Back-of-the-envelope calculation of real consumption loss for the coal simulation

1. Savings on domestic use of foreign-owned supply of local coal	
(A) Local use of domestic coal as share of GDP	0.010
(B) Foreign ownership of coal sector	0.8
(C) Coal purchase from foreign owner as share of GDP (A x B)	0.008
(D) Price saving (%)	-2.7
(E) Saving by domestic coal users, as share of GDP (C x D / 100)	0.00021
(F) Consumption as share of GDP	0.74
(1) Saving by domestic coal users, expressed as % of consumption (E / F x 100)	***0.028***
2. Export revenue loss attributable to local coal owners	
(A) Coal exports as share of GDP	0.045
(B) Local ownership share	0.2
(C) Export sales attributable to local owners as share of GDP (A x B)	0.0091
(D) Price loss (%)	-2.7
(E) Export sale loss attributable to local owners as share of GDP (C x D/100)	-0.00025
(F) Consumption as share of GDP	0.74
(2) Export sale loss attributable to domestic owners, expressed as % of consumption (E/F x 100)	***-0.033***
3. Royalty revenue loss on foreign-owned component of coal production	
(A) Coal output as share of GDP	0.055
(B) Foreign ownership of coal sector	0.8
(C) Revenue loss (%)	-3.05
(D) Production tax rate (%)	8.0
(E) Royalty loss on foreign owned share as % GDP (AxB/100xC/100xD)	-0.00011
(F) Consumption as share of GDP	0.74
(3) Royalty loss on foreign owned share expressed as % of consumption (E / F x 100)	***-0.015***
4. Income tax loss on foreign owned share of coal sector profits	
(A) Coal output as share of GDP	0.055
(B) Coal sector fixed factor income as share of coal costs	0.57
(C) Coal fixed factor income as share of GDP (A x B)	0.031
(D) Foreign ownership of coal sector	0.8
(E) Coal price (%)	-2.7
(E) Return on fixed factors (E / B) (%)	-4.8
(F) Loss to foreign owners expressed as share of GDP (E/100 x D x C)	-0.0012
(G) Tax rate	0.17
(H) Tax revenue loss as share of GDP (F x G)	-0.0002

(G) Consumption as share of GDP	0.74
(4) Lost income tax on foreign owned capital expressed as share of consumption (H / G x 100)	***-0.027***
5. Net loss to domestic agent from coal-related tax and price changes, as share of consumption (1+2+3+4)	**-0.047**
6. Generalised terms of trade loss effect	
(A) Terms of trade loss attributable to export price movements outside coal	-0.044
(B) Non-coal exports as share of GDP	0.14
(C) Consumption as share of GDP	0.74
(6) Consumption loss via generalised terms of trade loss	**-0.008**
Real consumption loss (%) via back-of-the-envelope calculation (5+6)	**-0.0550**
Real consumption loss (%) via GTAP-MVH	**-0.0563**

Figure 1: U.S. employment, capital stock and real GDP (at market prices and at factor cost) (U.S. tariffs only) (% deviation from baseline)

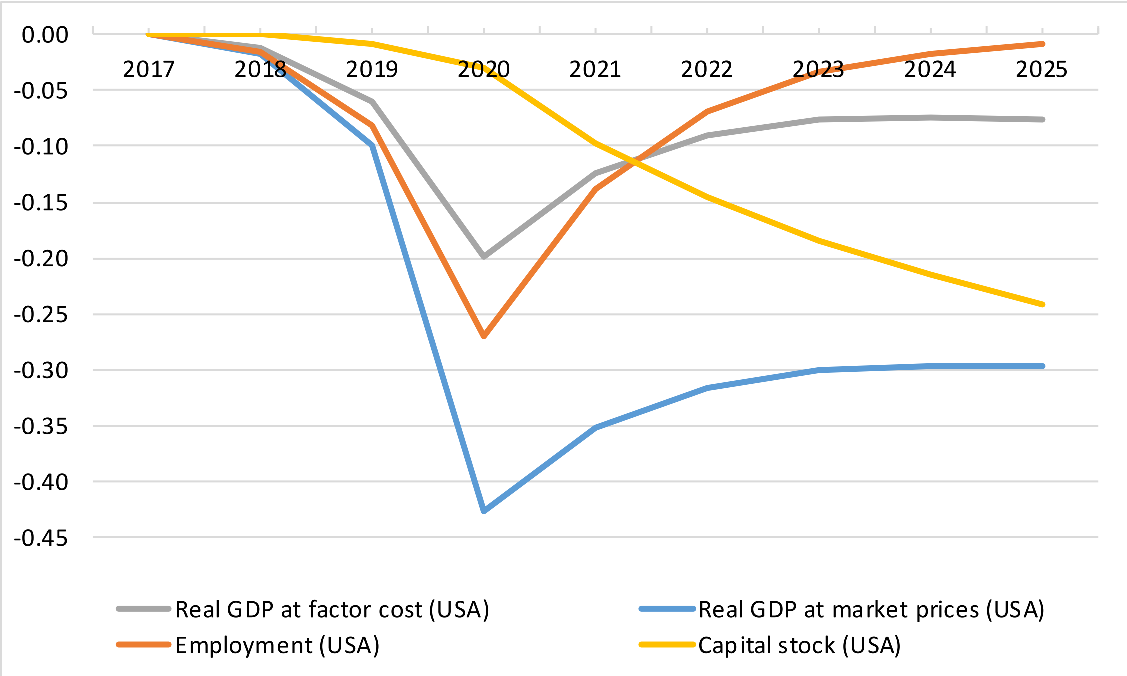

Figure 2: U.S. terms of trade, real exchange rate, and expenditure-side components of real GDP (U.S. tariffs only) (% deviation from baseline) "R:\CoPS\Rob\19_US_China_tariffs\Trade war results -27June2019.xlsx"

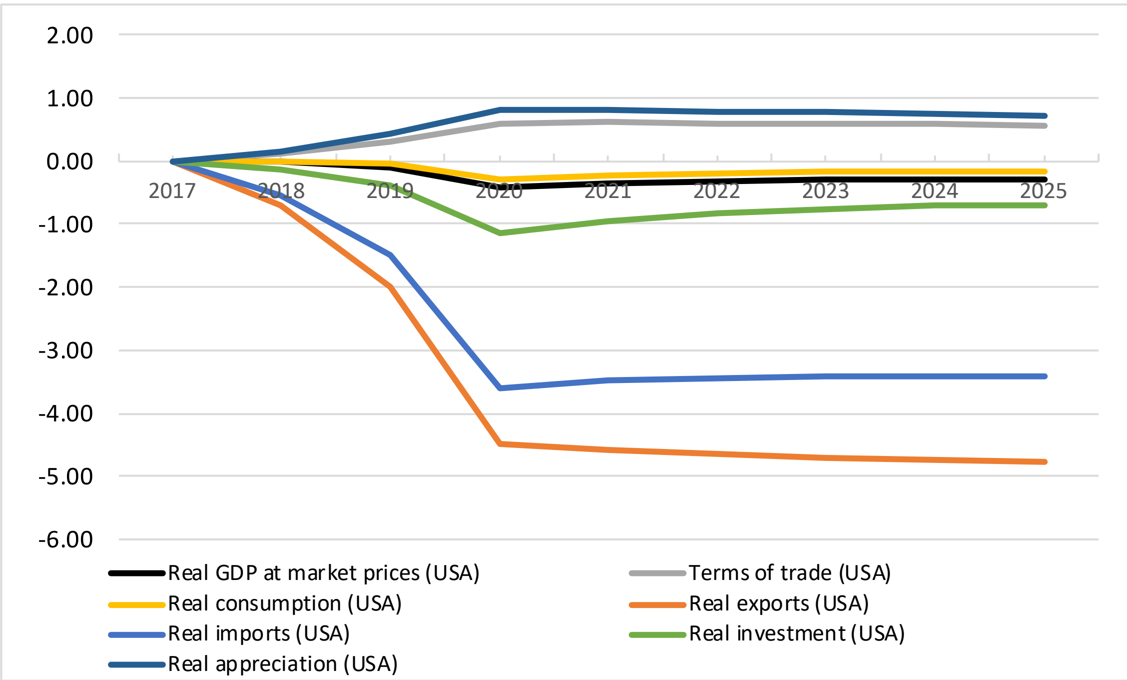

Figure 3: China's employment, capital, and real GDP (at factor cost and at market prices) (U.S. tariffs only) (% deviation from baseline)

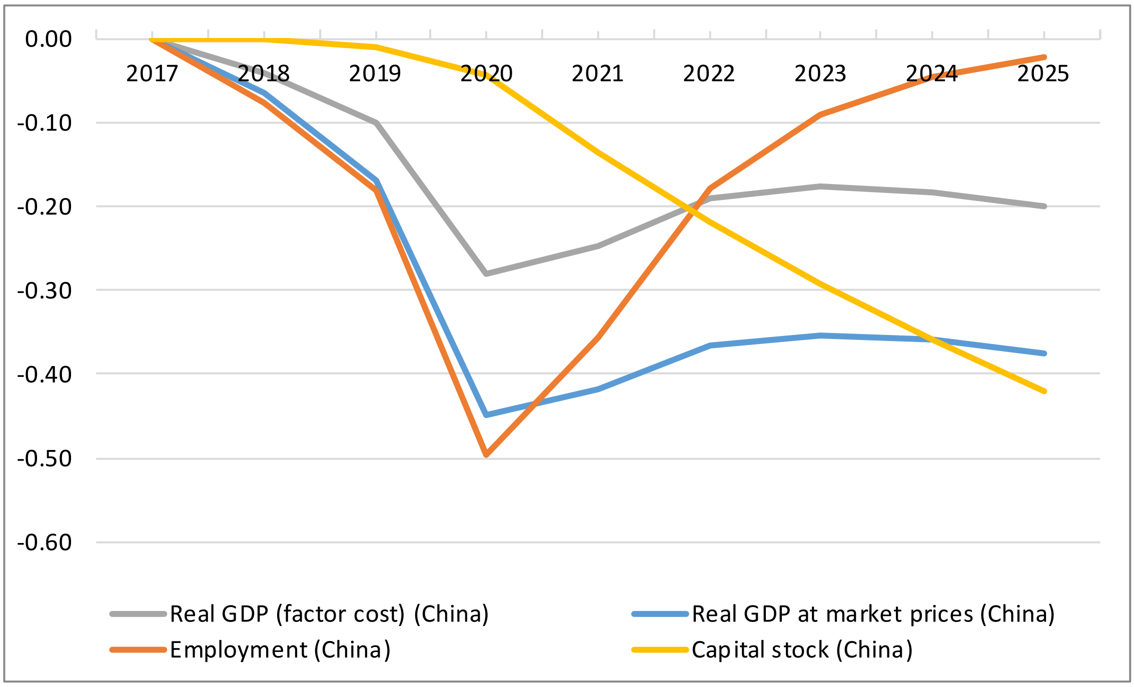

Figure 4: China's terms of trade, real exchange rate, and expenditure-side components of real GDP (U.S. tariffs only) (% deviation from baseline)

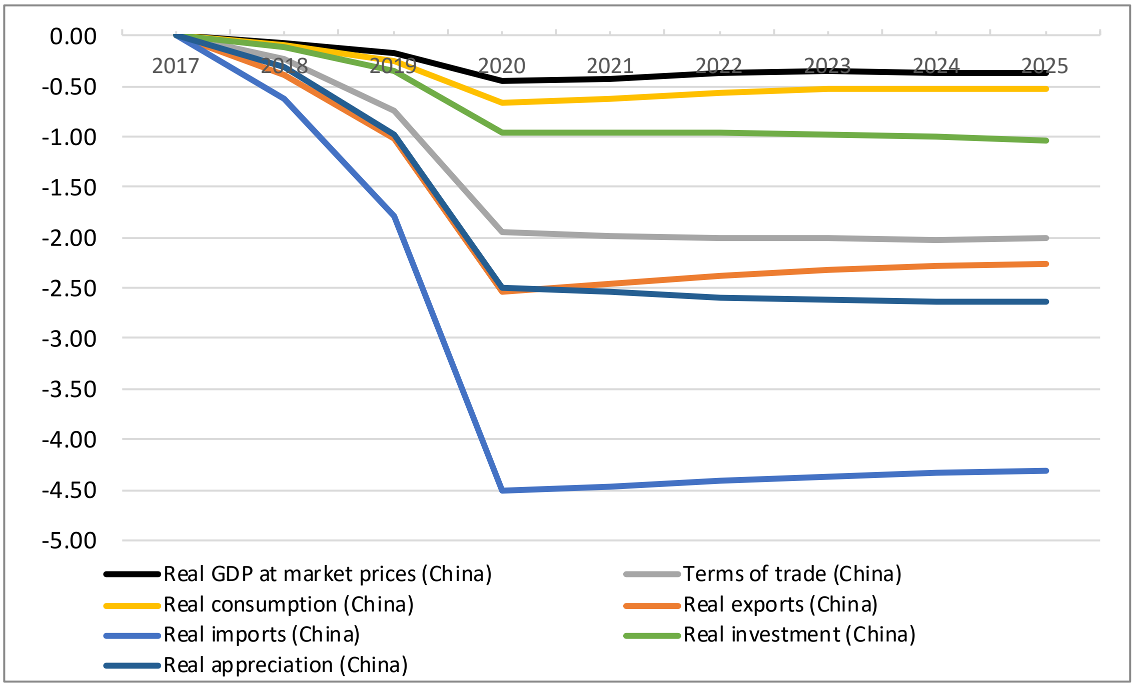

Figure 5: U.S. output deviations by seven broad sectors (U.S. tariffs only) (% deviation from baseline)

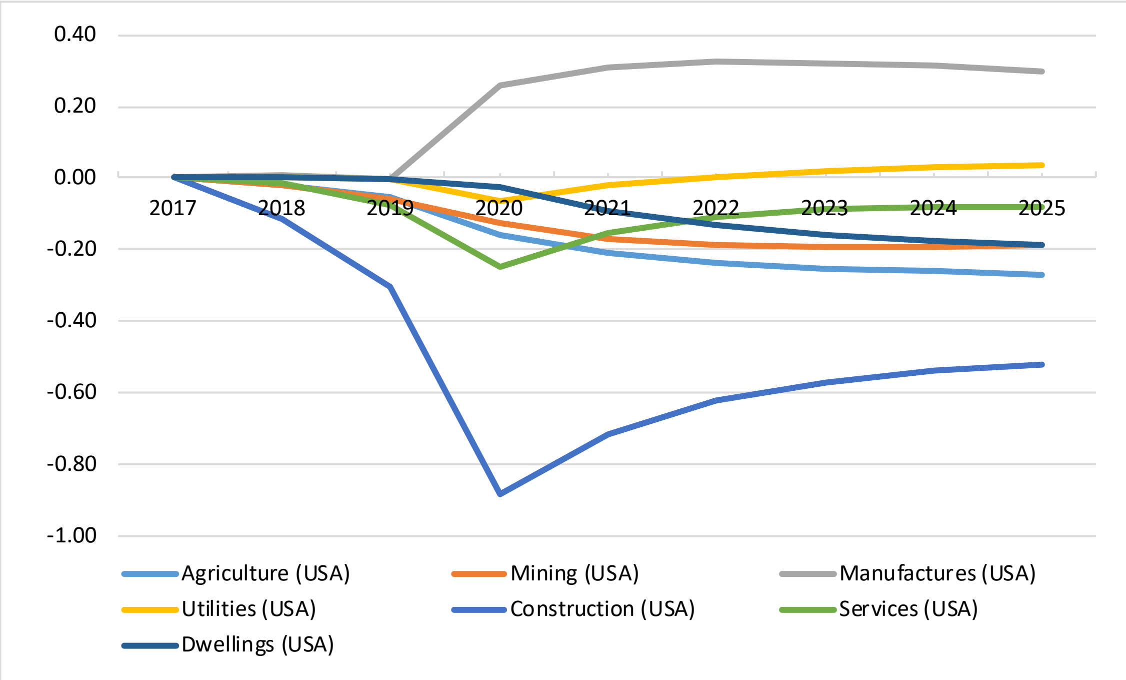

Figure 6: Output of U.S. manufacturing industries (top 5 by 2025 output dev'n) (U.S. tariffs only) (% dev'n from baseline)

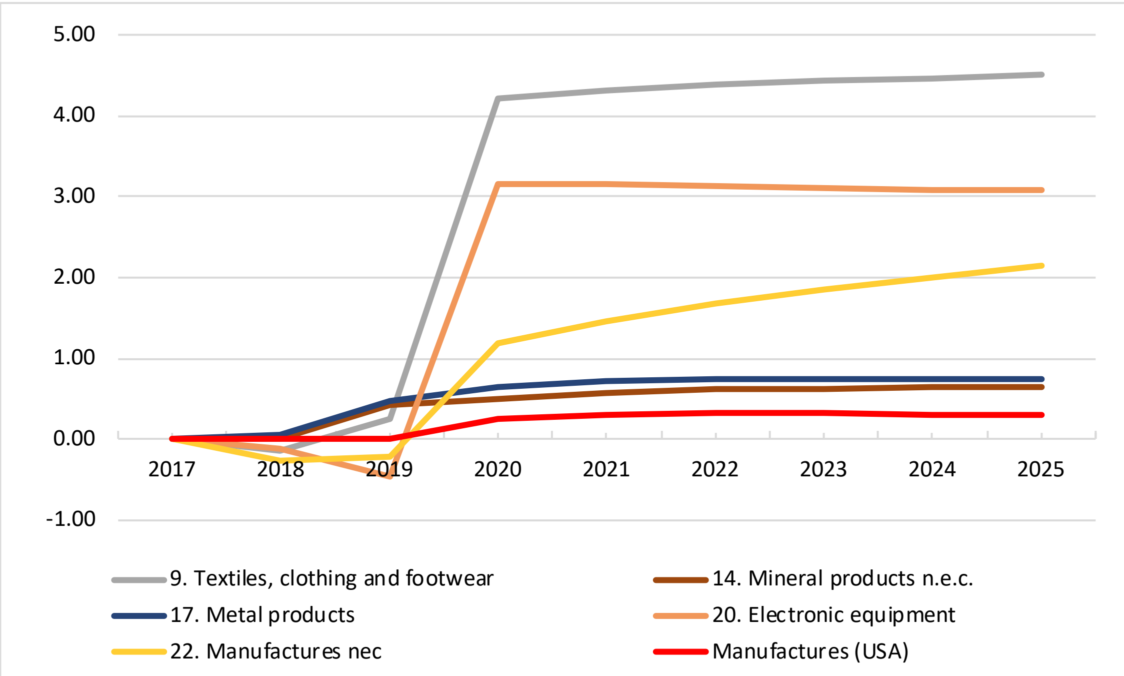

Figure 7: Output of U.S. manufacturing industries (bottom 5 by 2025 output dev'n) (U.S. tariffs only) (% dev'n from baseline)

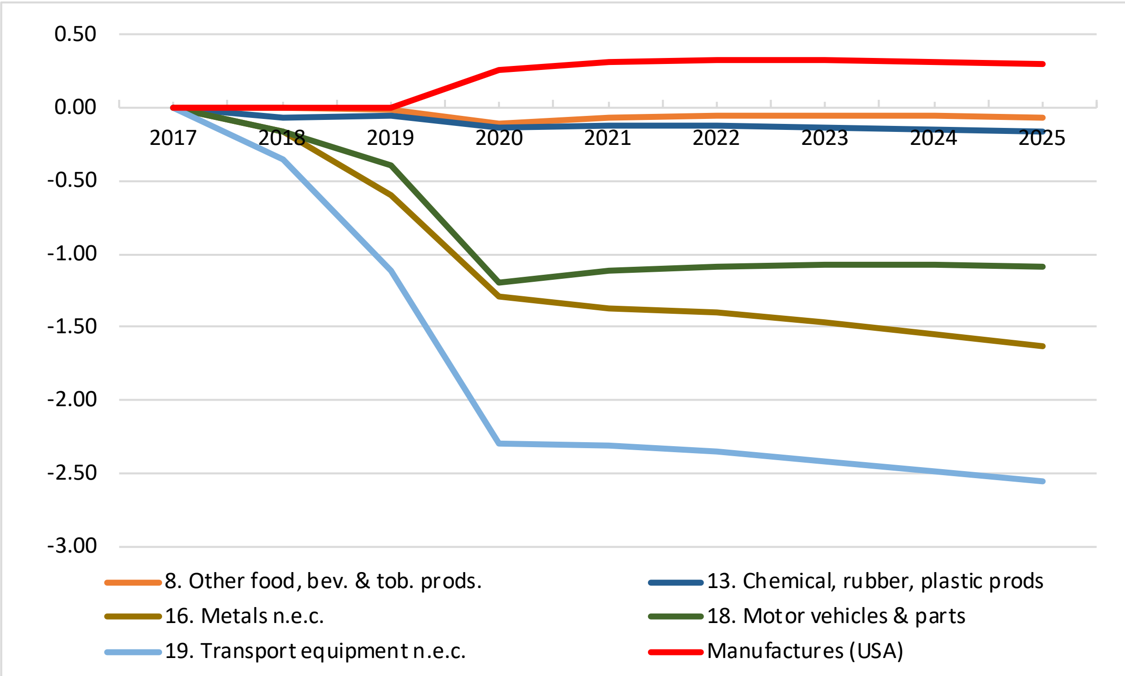

Figure 8: Output of U.S. manufacturing industries (middle 6 by 2025 output dev'n) (U.S. tariffs only) (% dev'n from baseline)

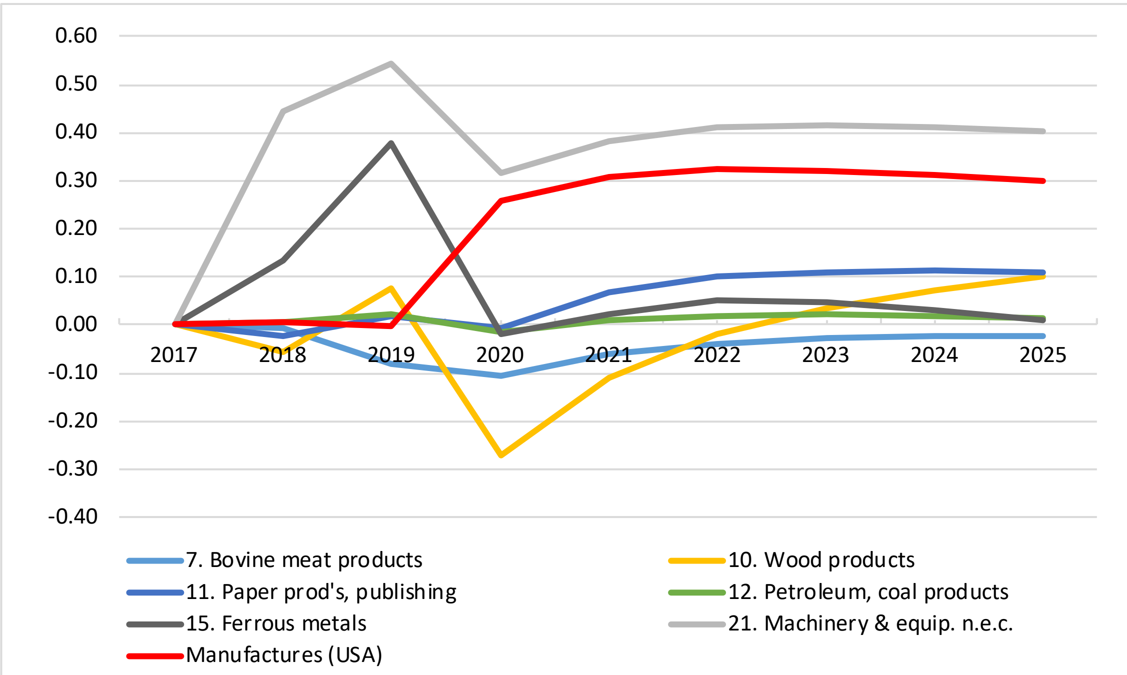

Figure 9: China's output deviations by seven broad sectors (U.S. tariffs only) (% deviation from baseline)

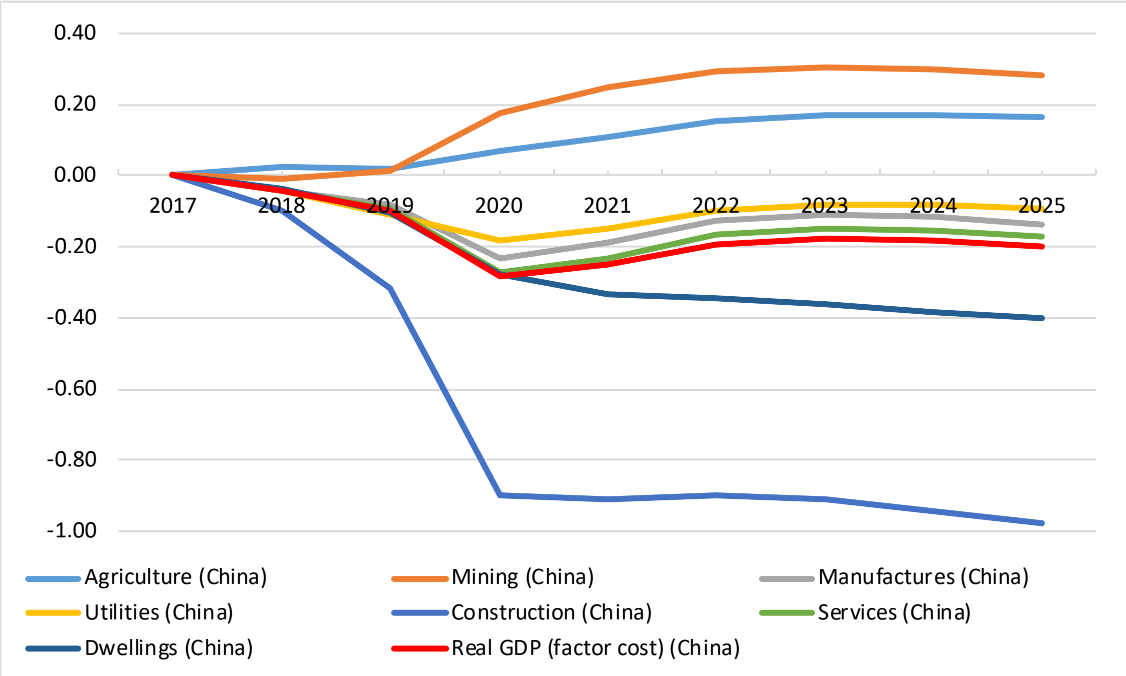

Figure 10: Output of China's manufacturing industries (bottom 5 by 2025 output dev'n) (U.S. tariffs only) (% dev'n from baseline)

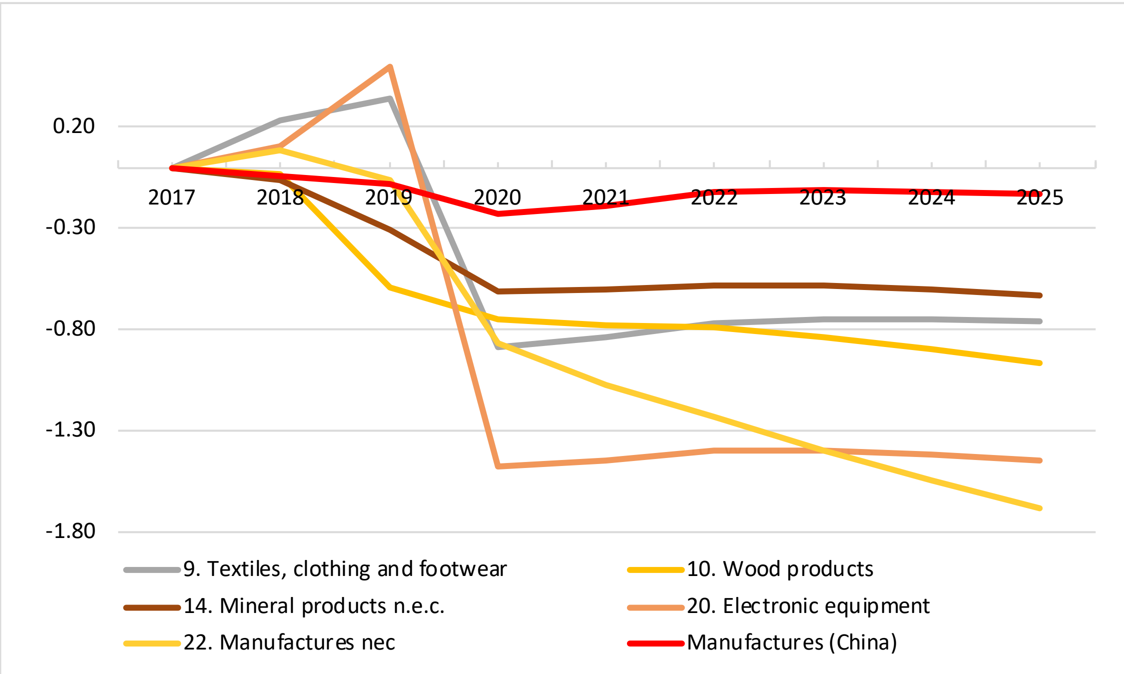

Figure 11: Output of China's manufacturing industries (top 5 by 2025 output dev'n) (U.S. tariffs only) (% dev'n from baseline)

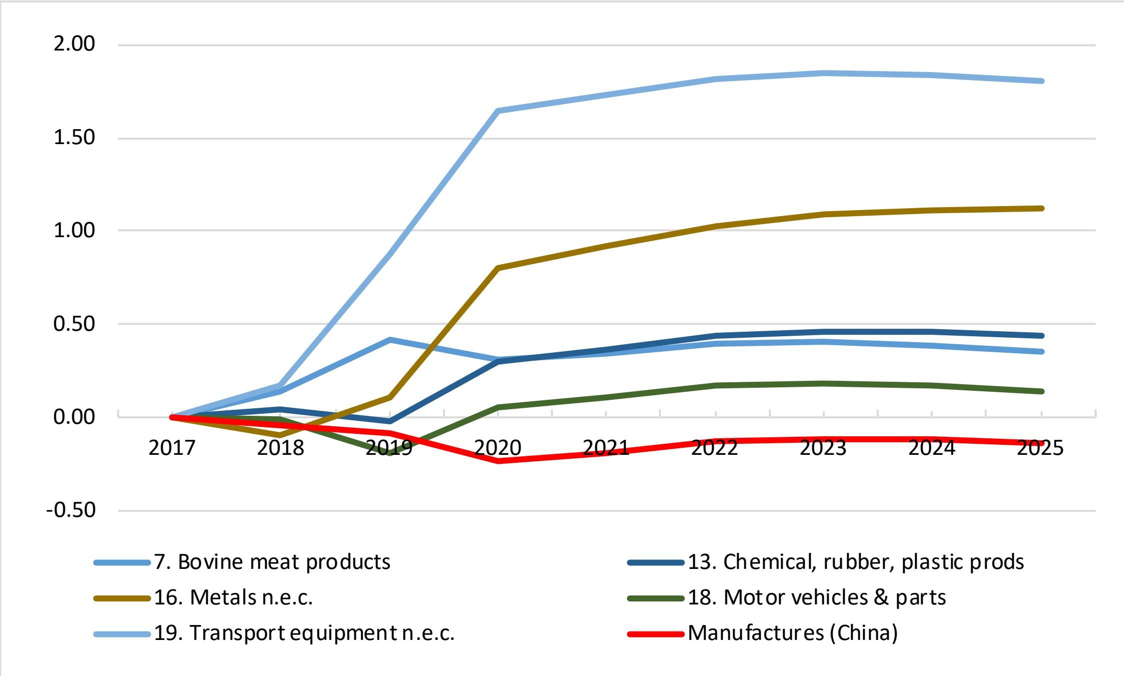

Figure 12: Output of China's manufacturing industries (middle 6 by 2025 output dev'n) (U.S. tariffs only) (% dev'n from baseline)

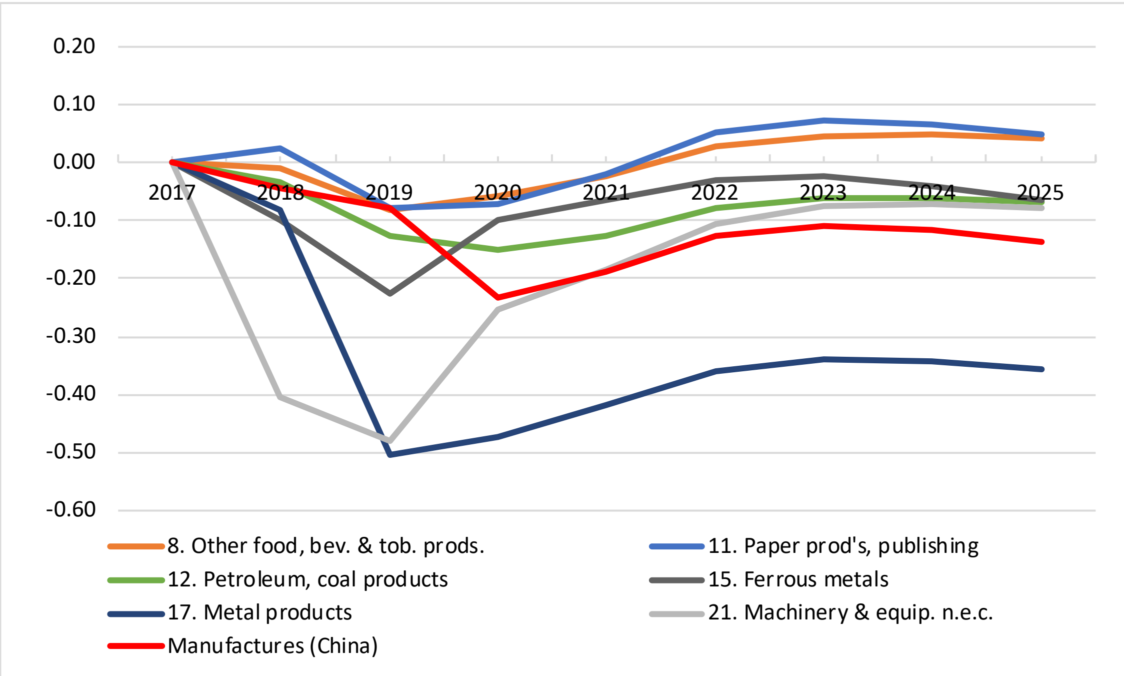

Figure 13: Trade diversion: decomposition (by destination) of deviation in China's exports of* Electronic equipment *exports (U.S. tariffs only) (% deviation from baseline)

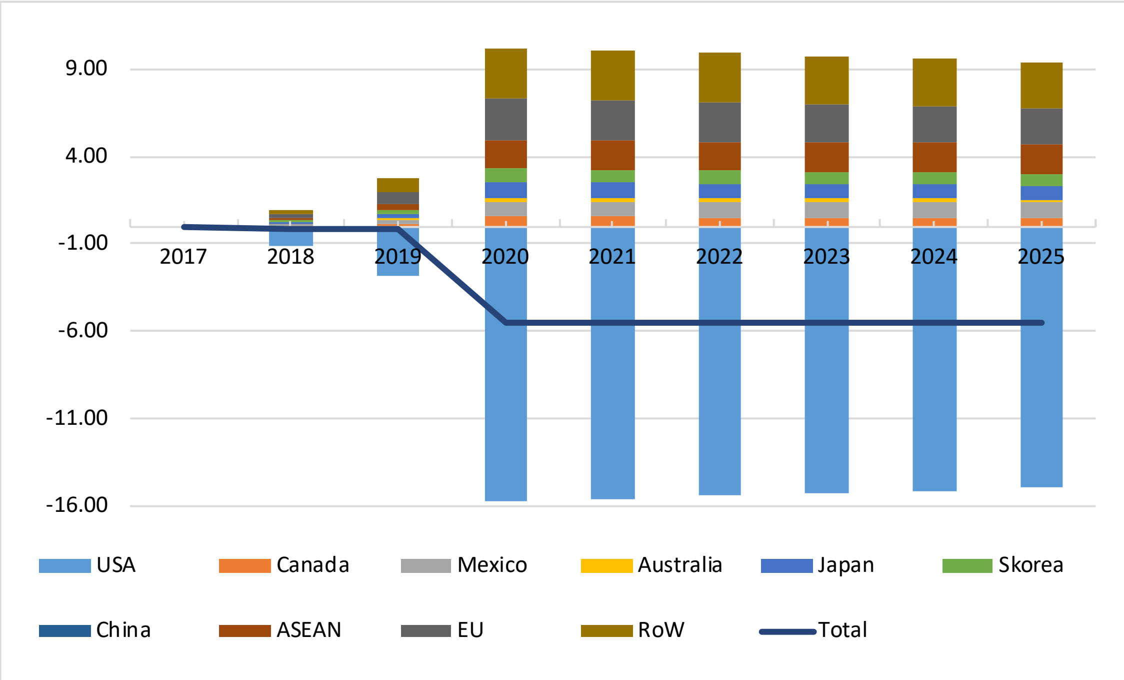

Figure 14: China's employment, capital stock and real GDP (at market prices and at factor cost) (China's tariffs only) (% deviation from baseline)

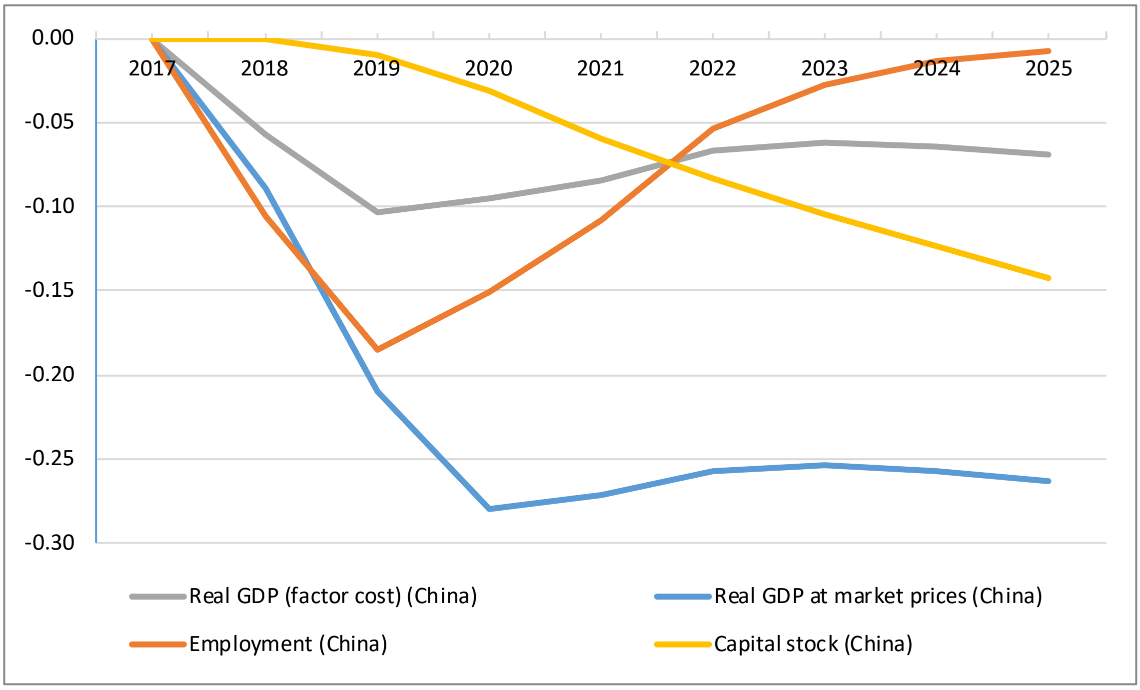

Figure 15: China's terms of trade, real exchange rate and expenditure-side components of real GDP (China's tariffs only) (% deviation from baseline)

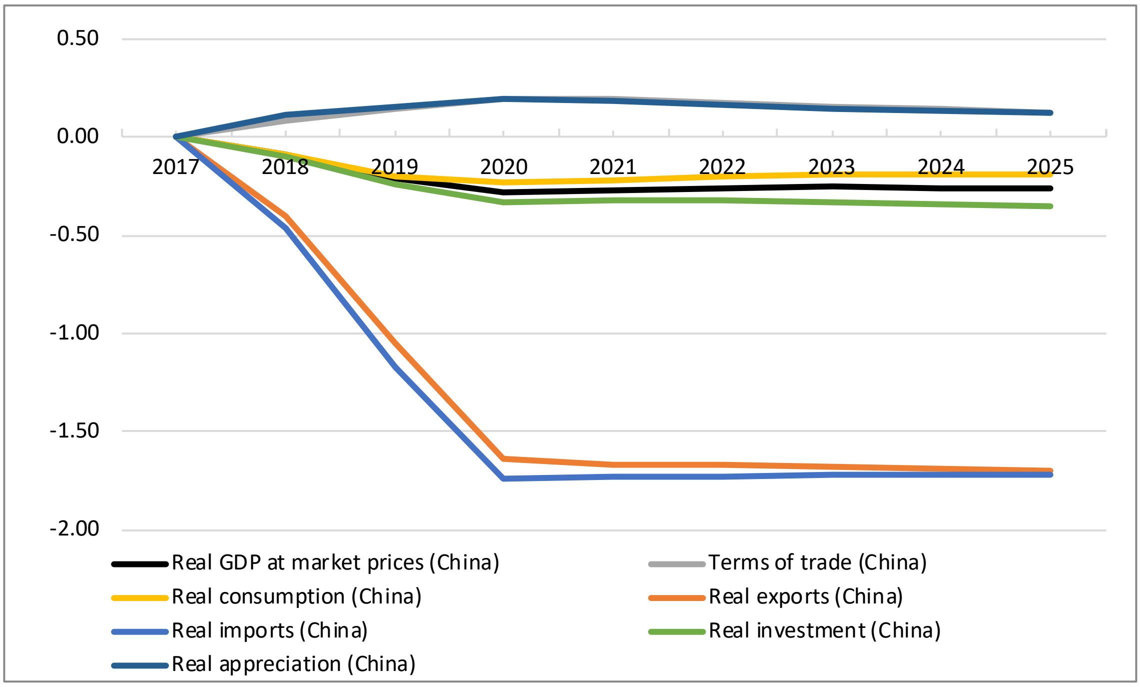

Figure 16: U.S. employment, capital, and real GDP (at factor cost and at market prices) (China's tariffs only) (% deviation from baseline)

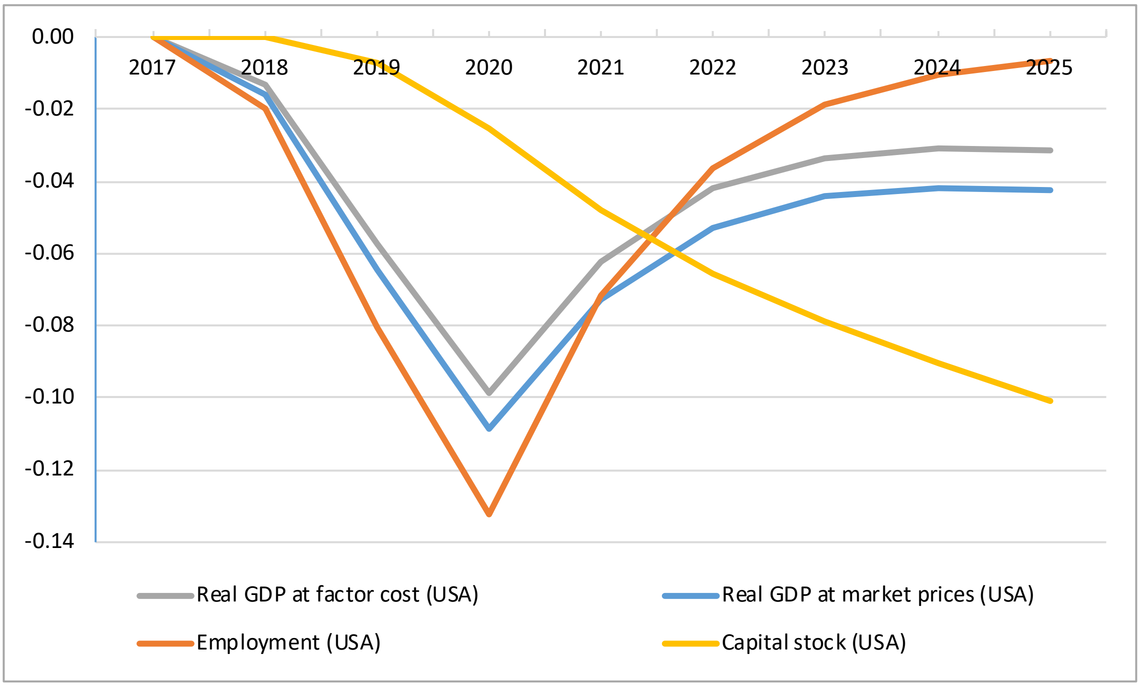

Figure 17: U.S. terms of trade, real exchange rate, and expenditure-side components of real GDP (China's tariffs only) (% deviation from baseline)

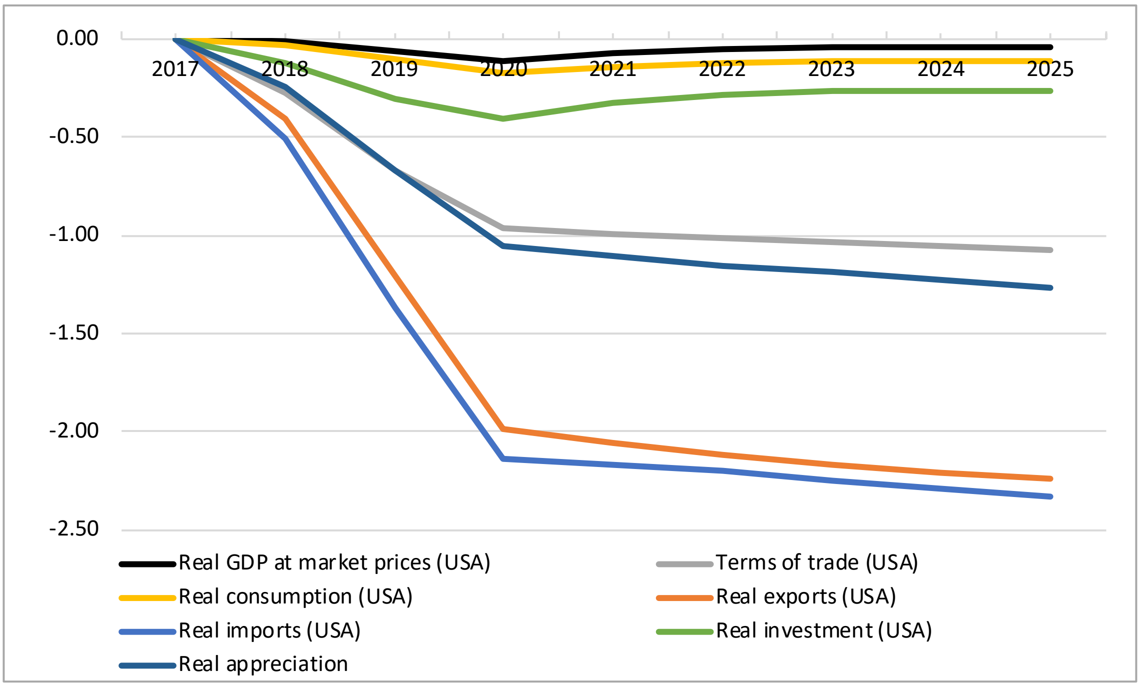

Figure 18: China's output deviations by seven broad sectors (China's tariffs only) (% deviation from baseline)

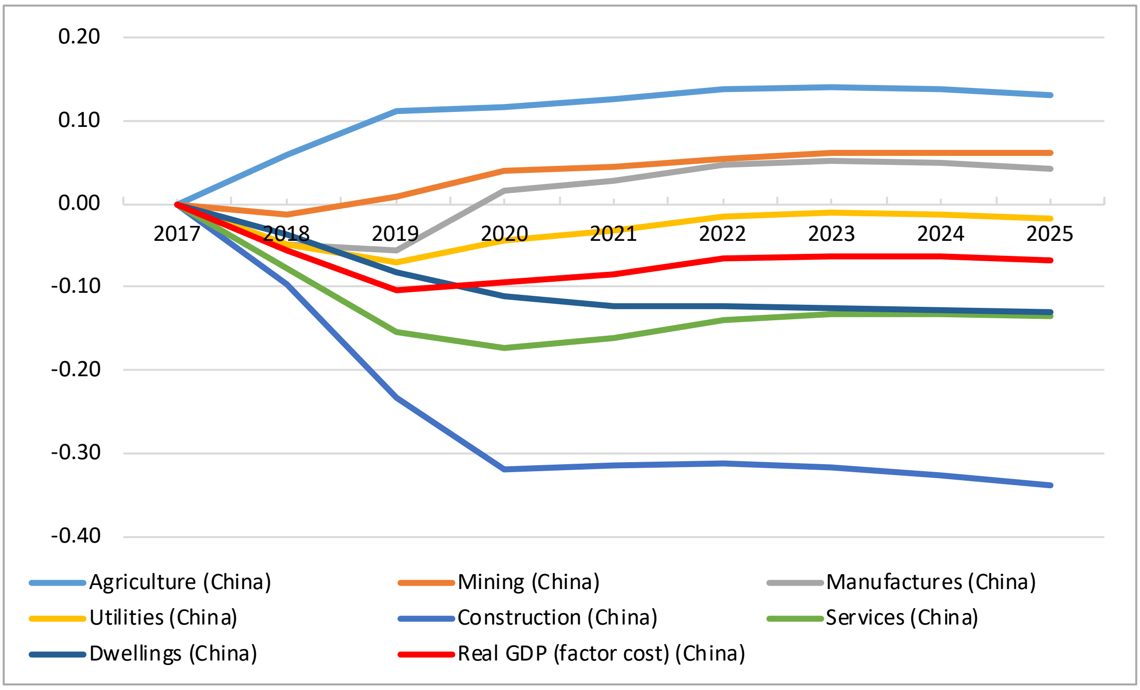

Figure 19: U.S. output deviations by seven broad sectors and the oil seeds *industry (China's tariffs only) (% deviation from baseline)*

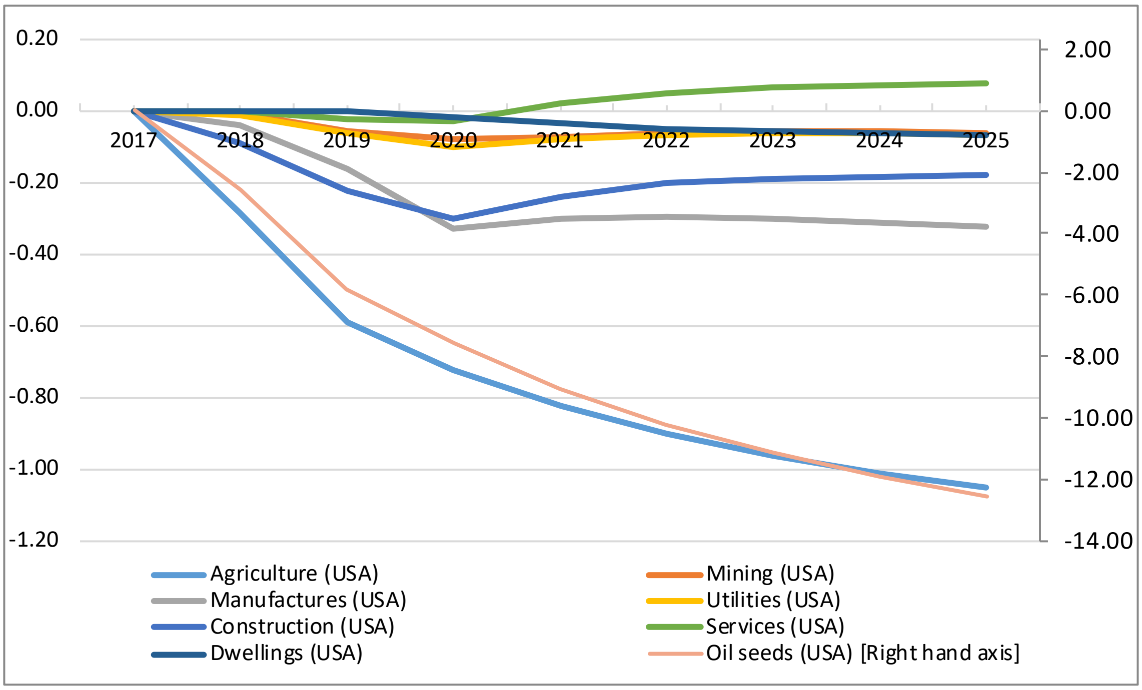

Figure 20: Trade diversion: decomposition (by destination) of deviation in U.S. exports of Oil seeds *(China's tariffs only) (% deviation from baseline)*

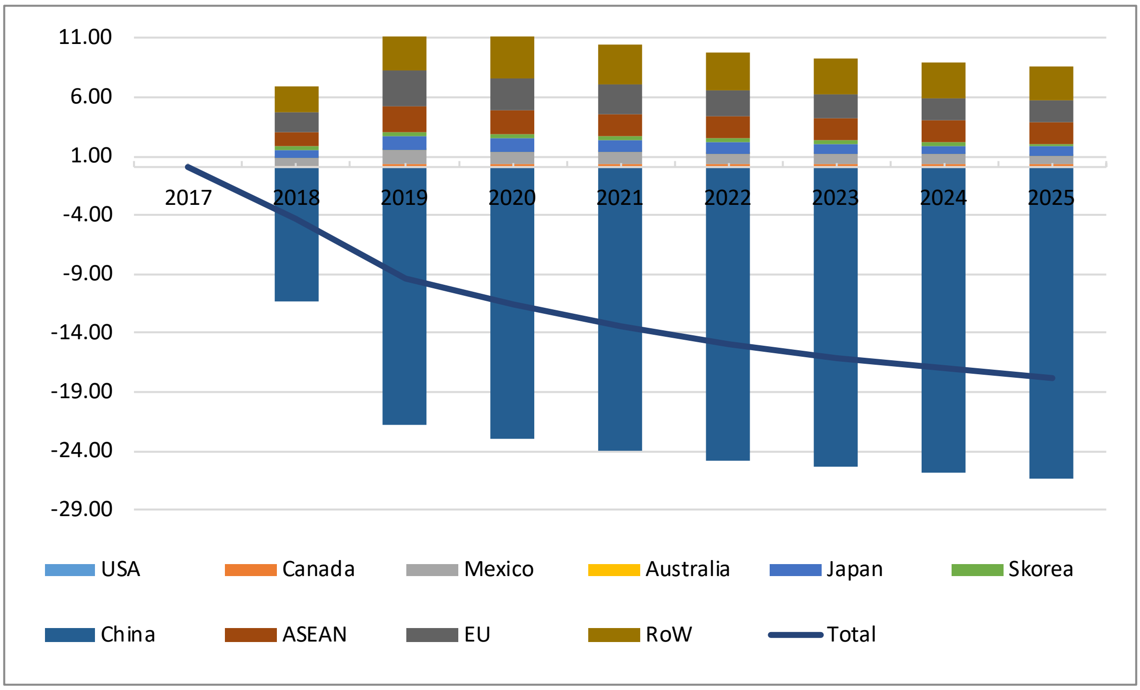

Figure 21: U.S. real GDP (market prices) deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

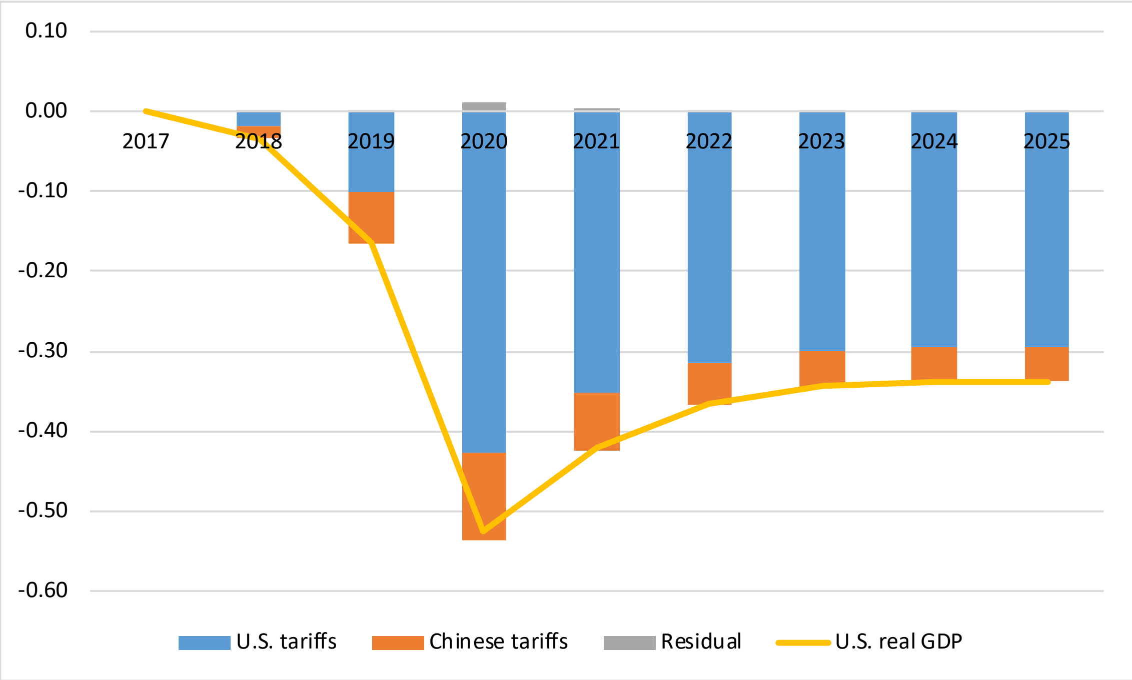

Figure 22: U.S. real consumption deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

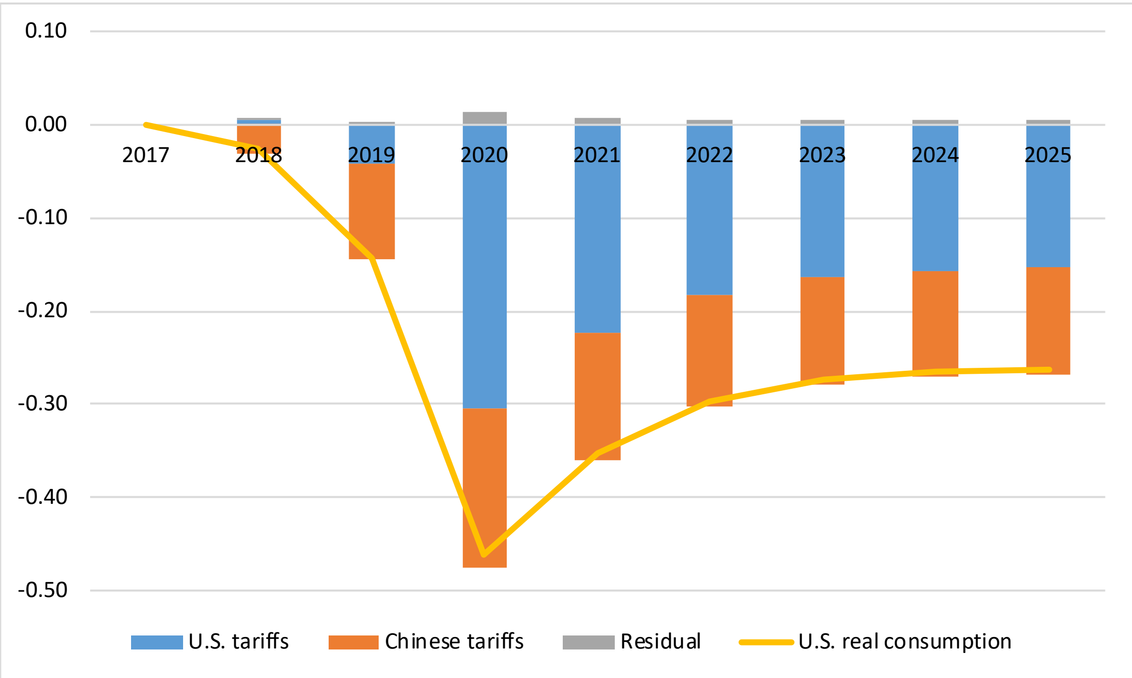

Figure 23: U.S. terms of trade deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

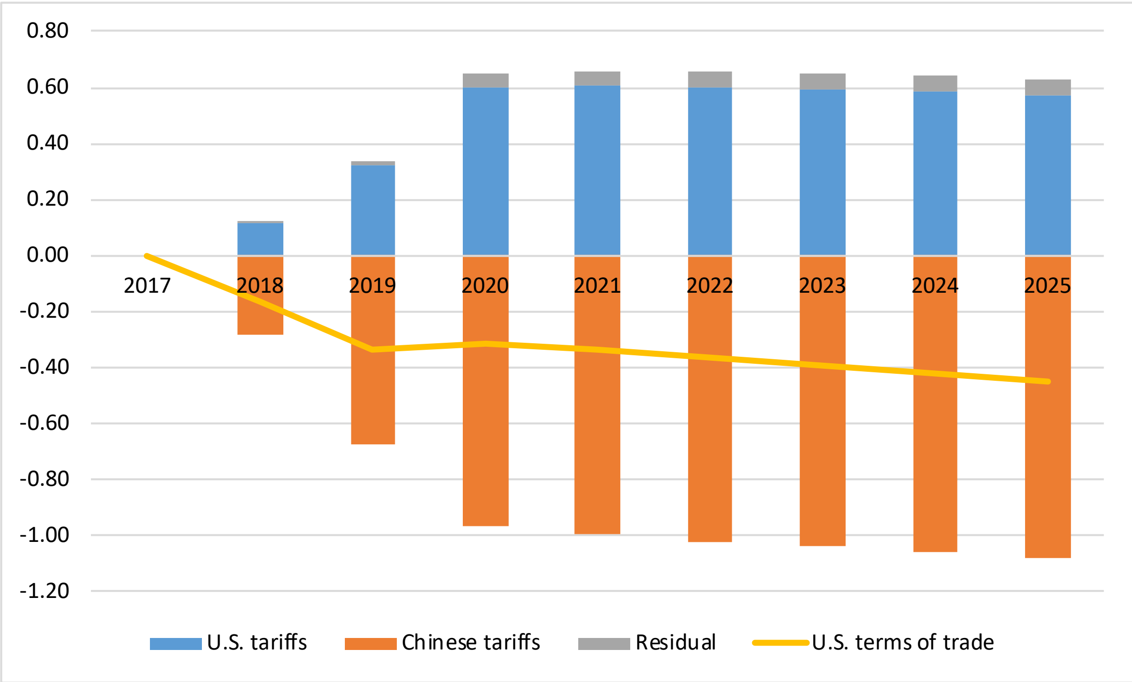

Figure 24: China's real GDP (market prices) deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

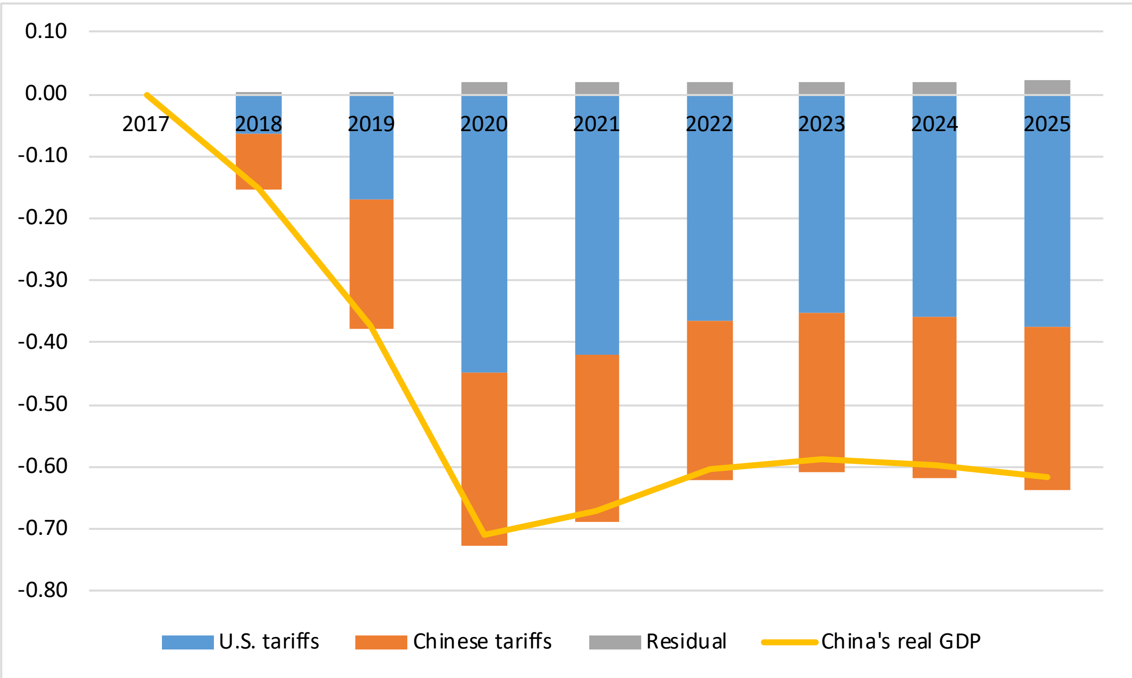

Figure 25: China's real consumption deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

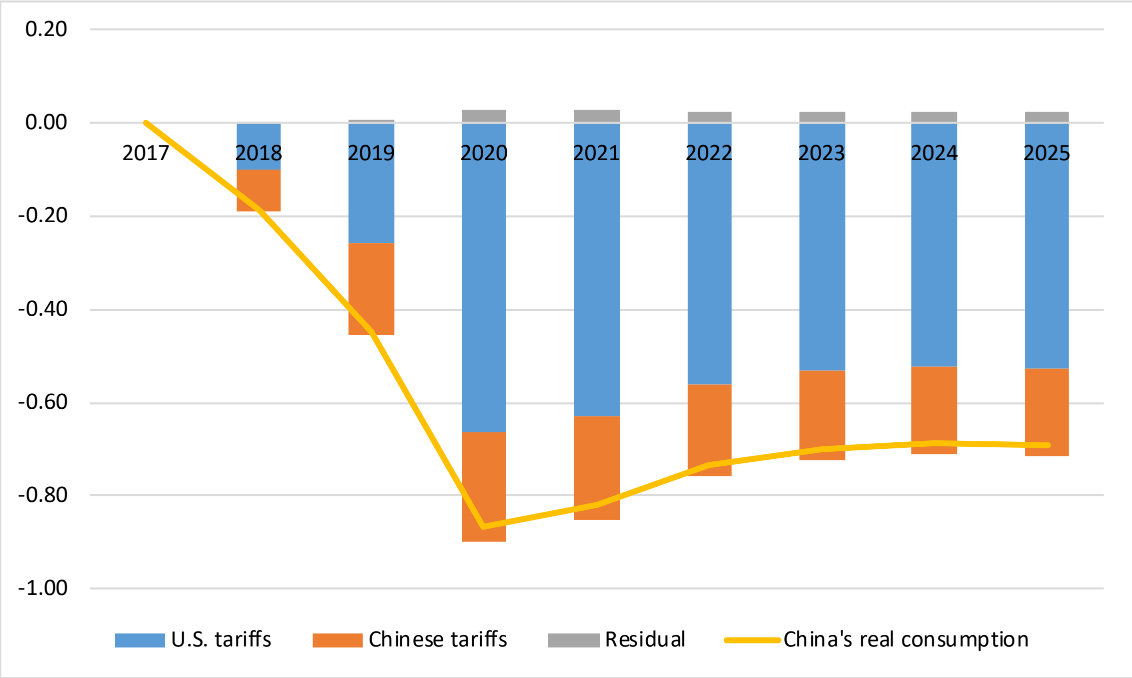

Figure 26: China's terms of trade deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

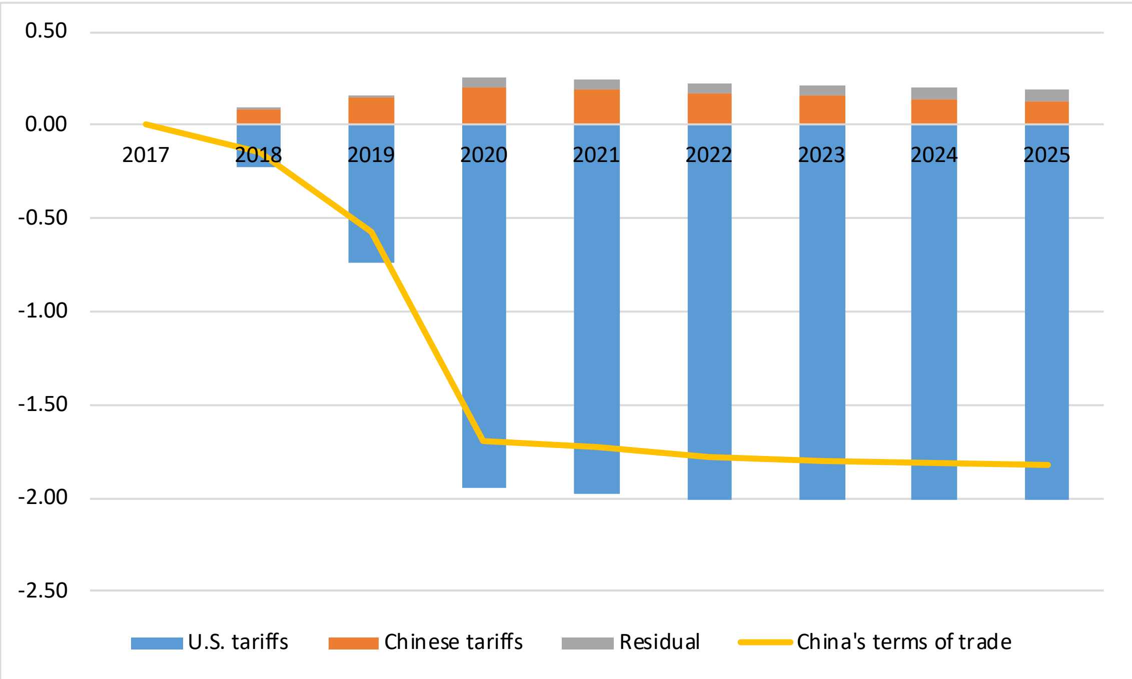

Figure 27: Real GDP impacts outside of the U.S. and China (joint effect of U.S. and China tariffs) (% deviation from baseline)

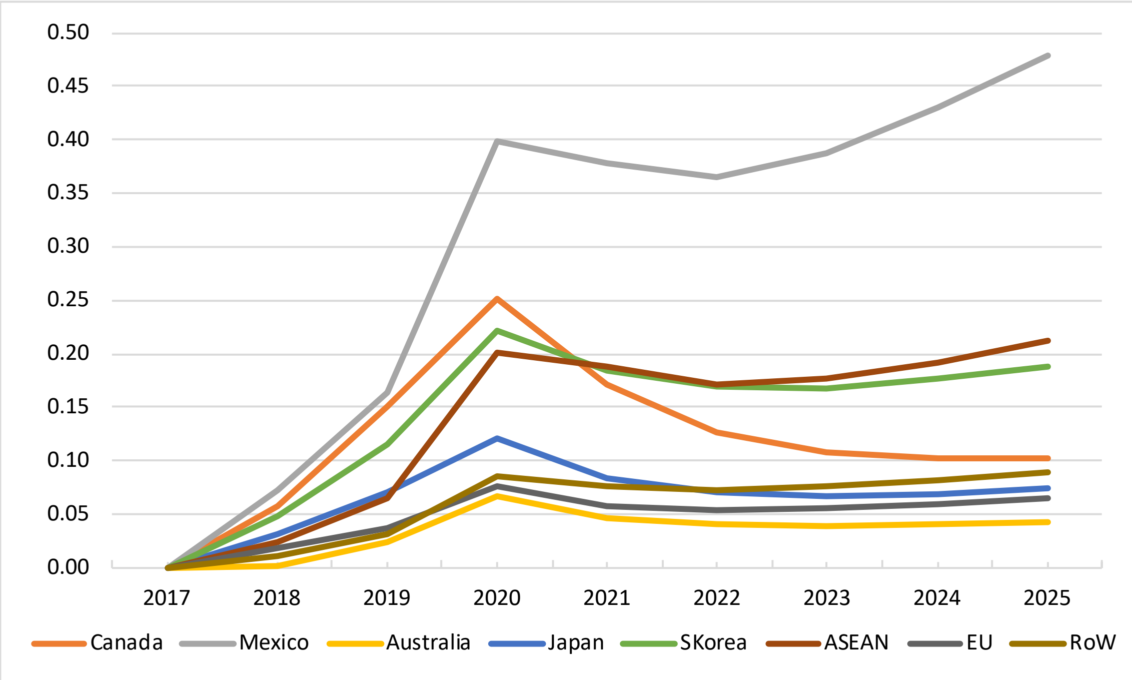

Figure 28: Mexico's real GDP deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

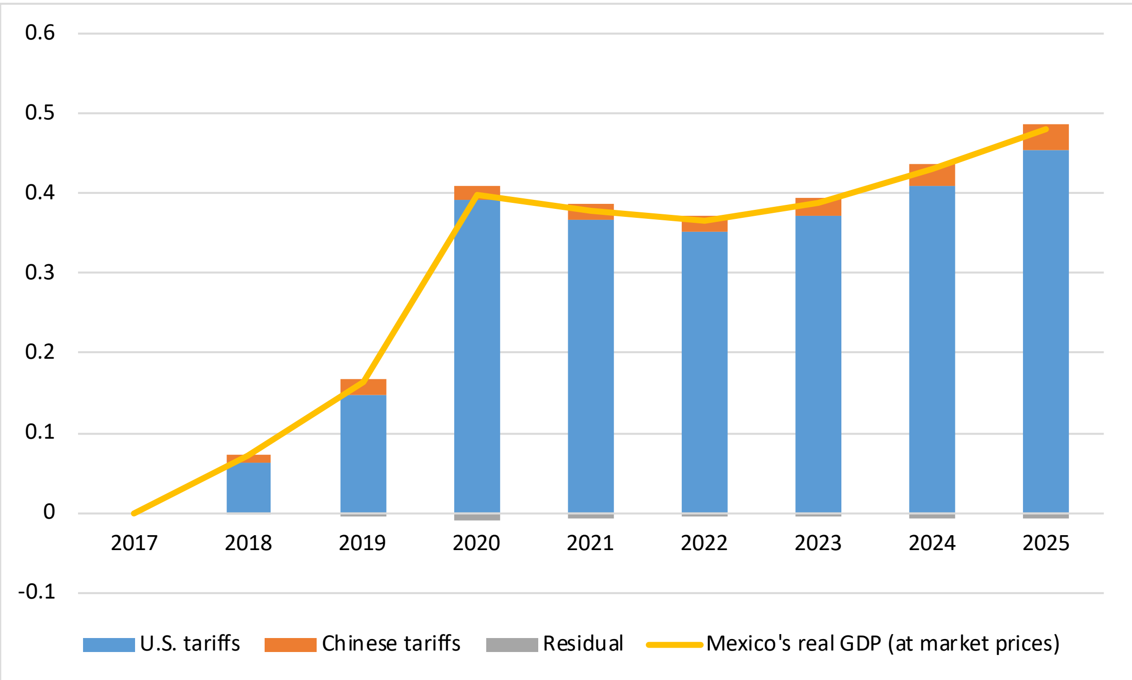

Figure 29: Mexico's terms of trade deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

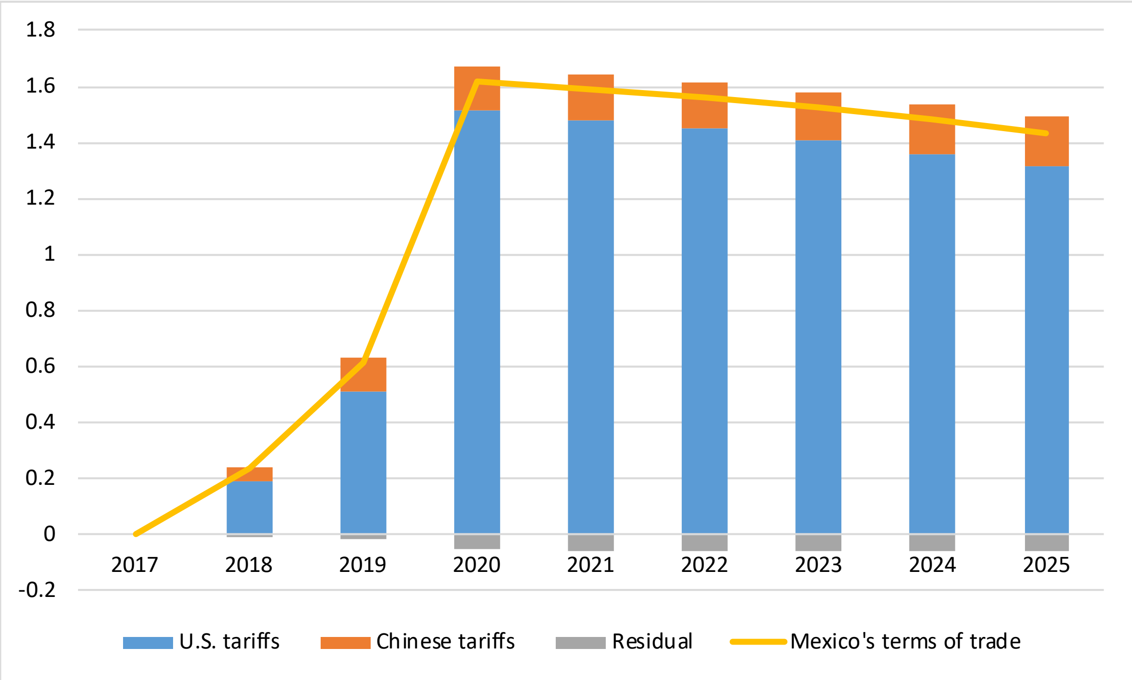

Figure 30: Australia's real GDP deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

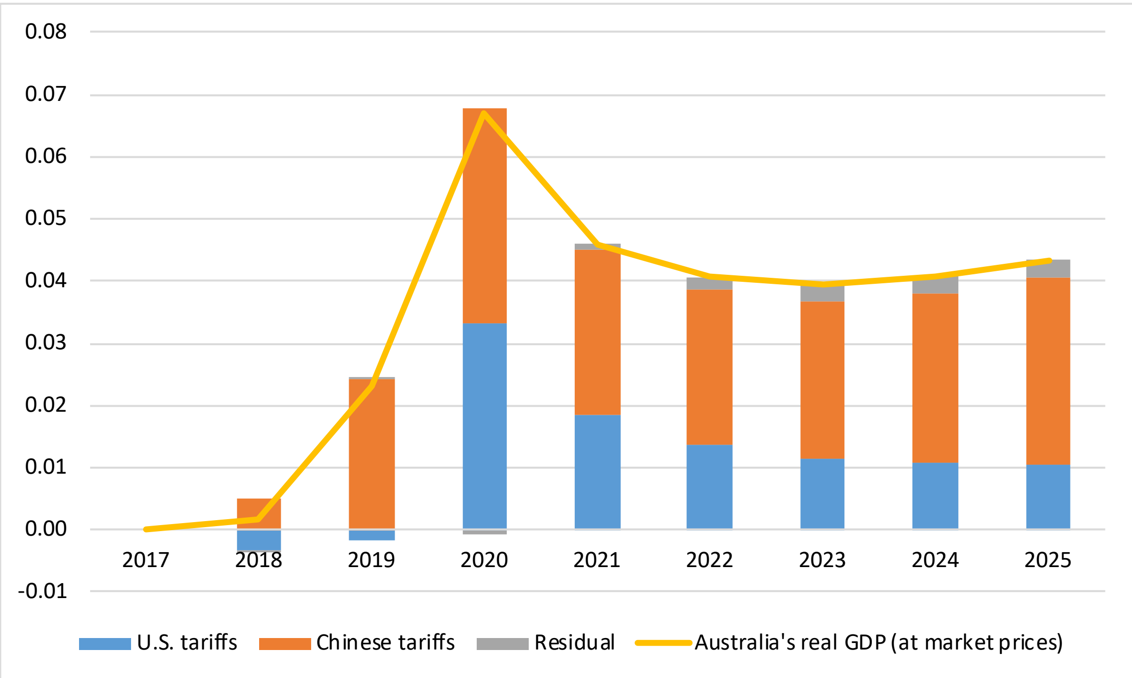

Figure 31: Australia's terms of trade deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

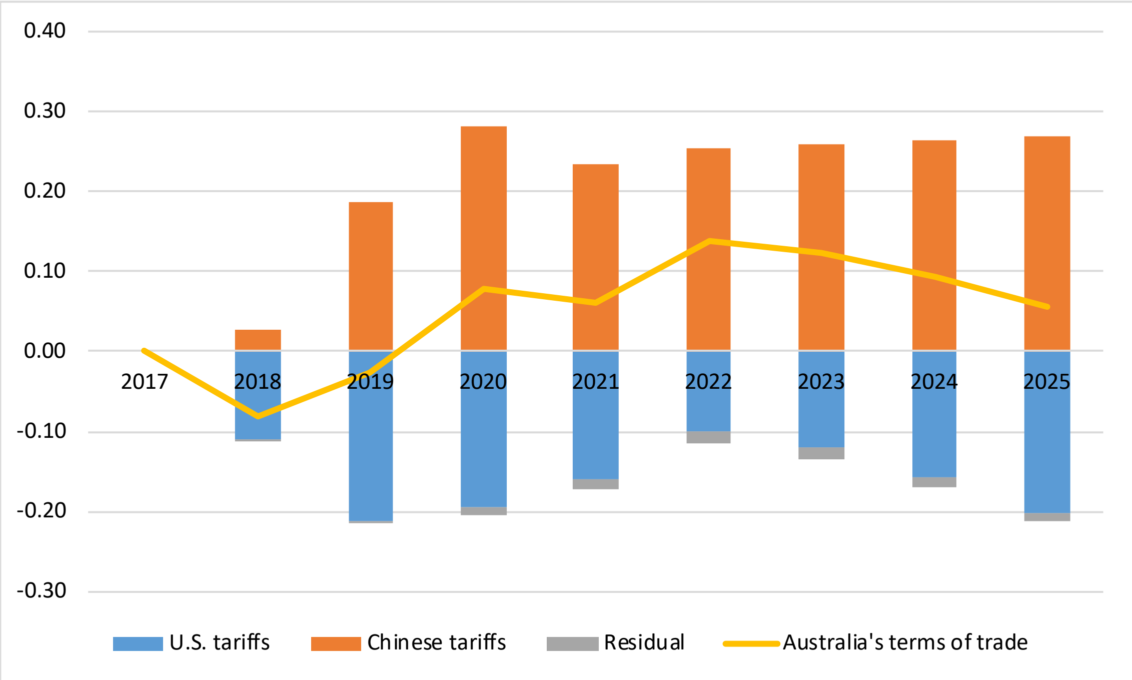

Figure 32: Australia's real consumption deviation (joint effect of U.S. and China tariffs) (% deviation from baseline)

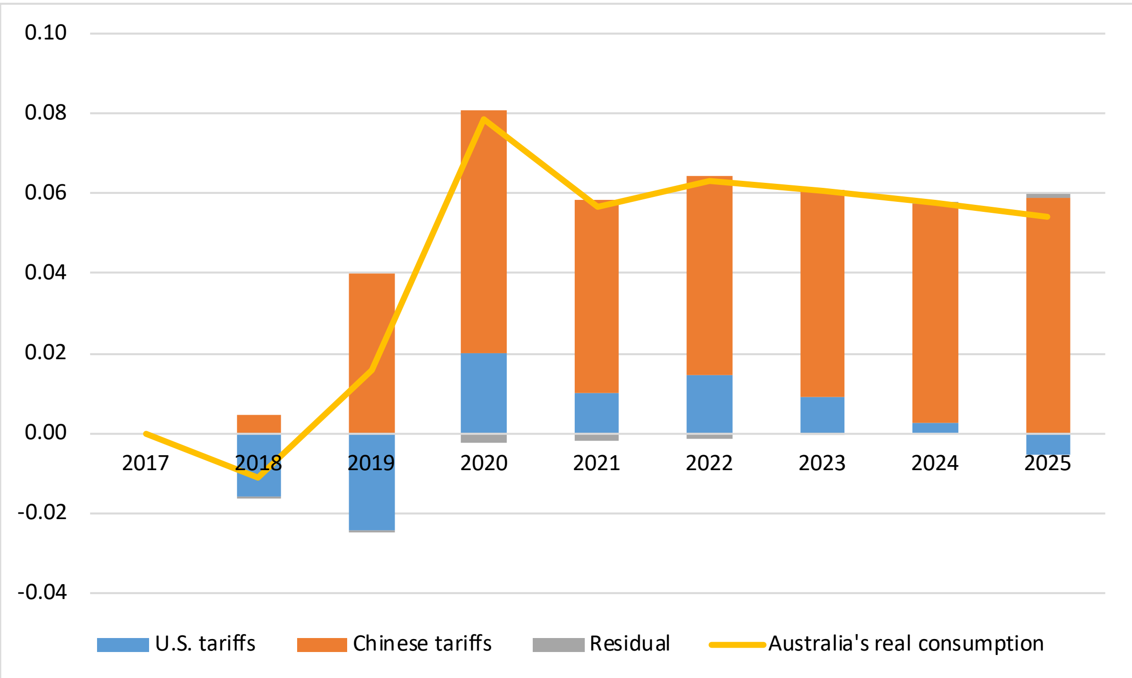

Figure 33: U.S. bilateral trade deficits as share of U.S. GDP, and total U.S. trade deficit as share of GDP (U.S.-China trade deal) (change from baseline)

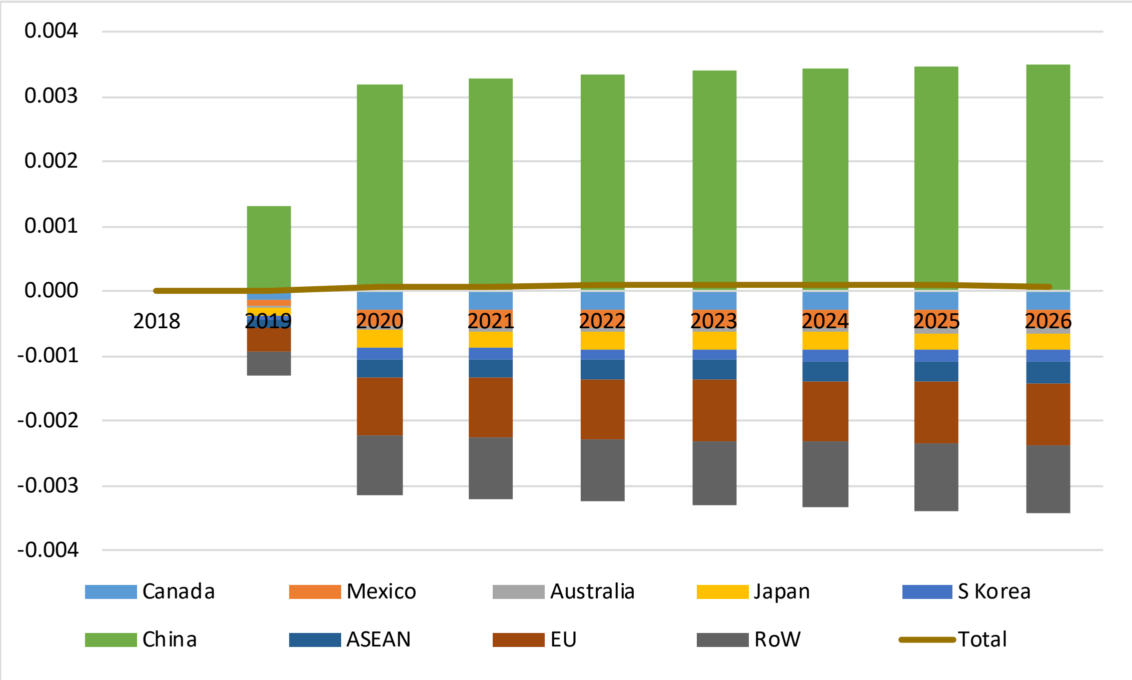

Figure 34: China's employment, capital, and real GDP (U.S.-China trade deal) (% deviation from baseline)

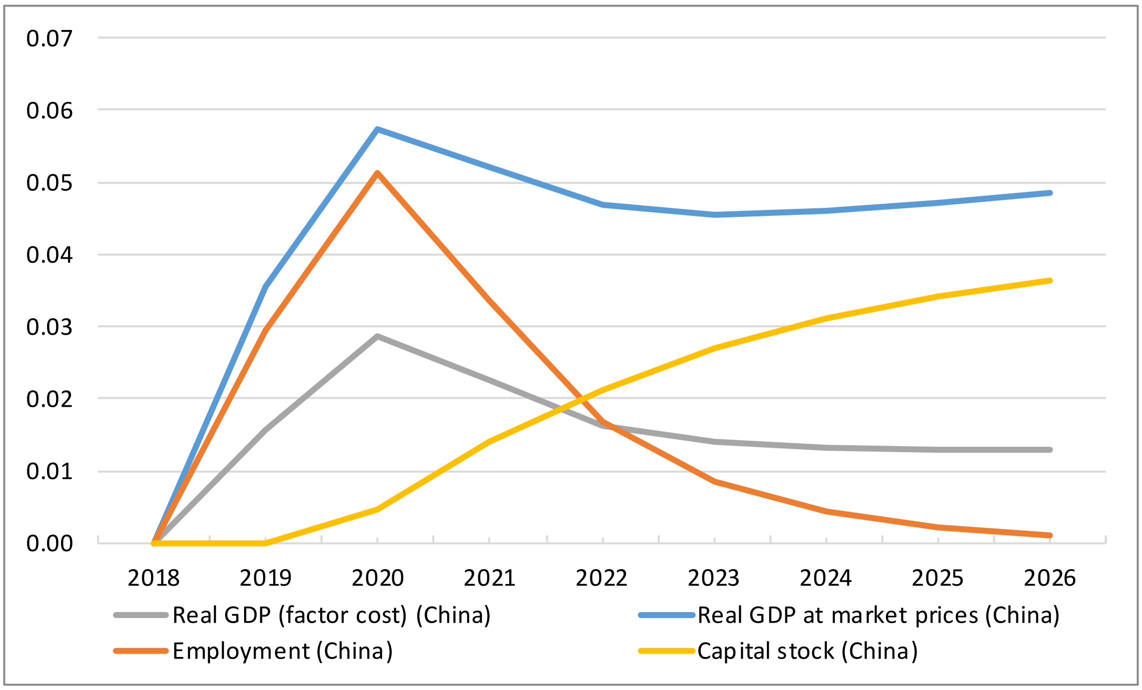

Figure 35: China's terms of trade, real exchange rate, and expenditure-side components of real GDP (U.S.-China trade deal) (% deviation from baseline)

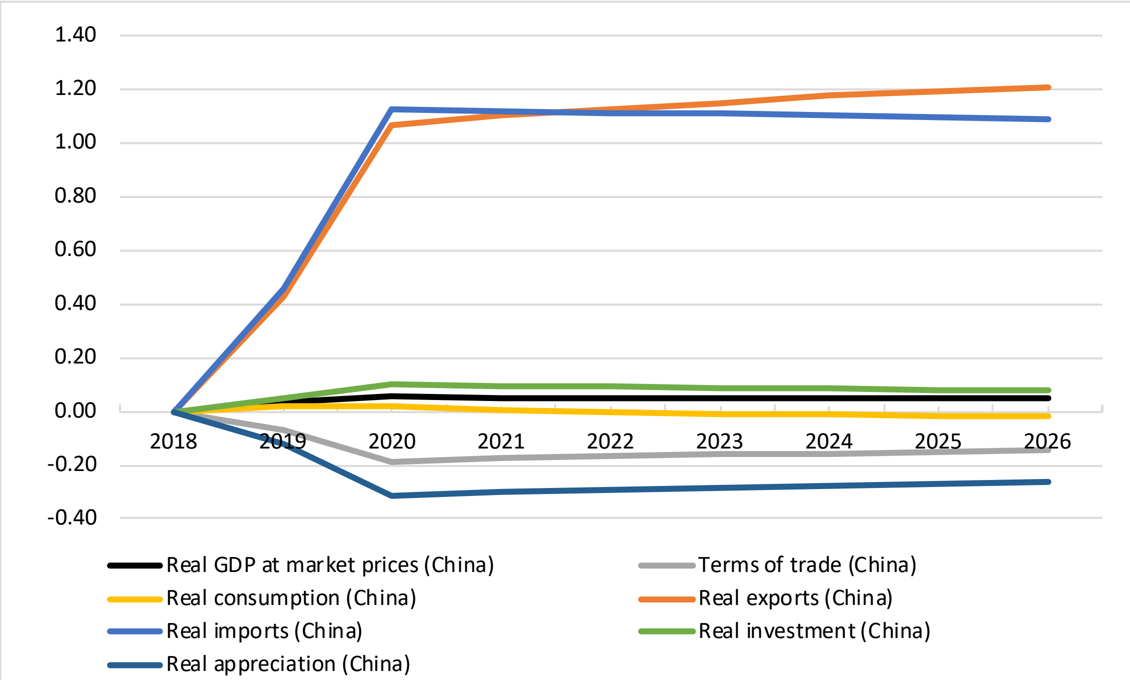

Figure 36: U.S. terms of trade, real exchange rate, and expenditure-side components of real GDP (U.S.-China trade deal) (% deviation from baseline)

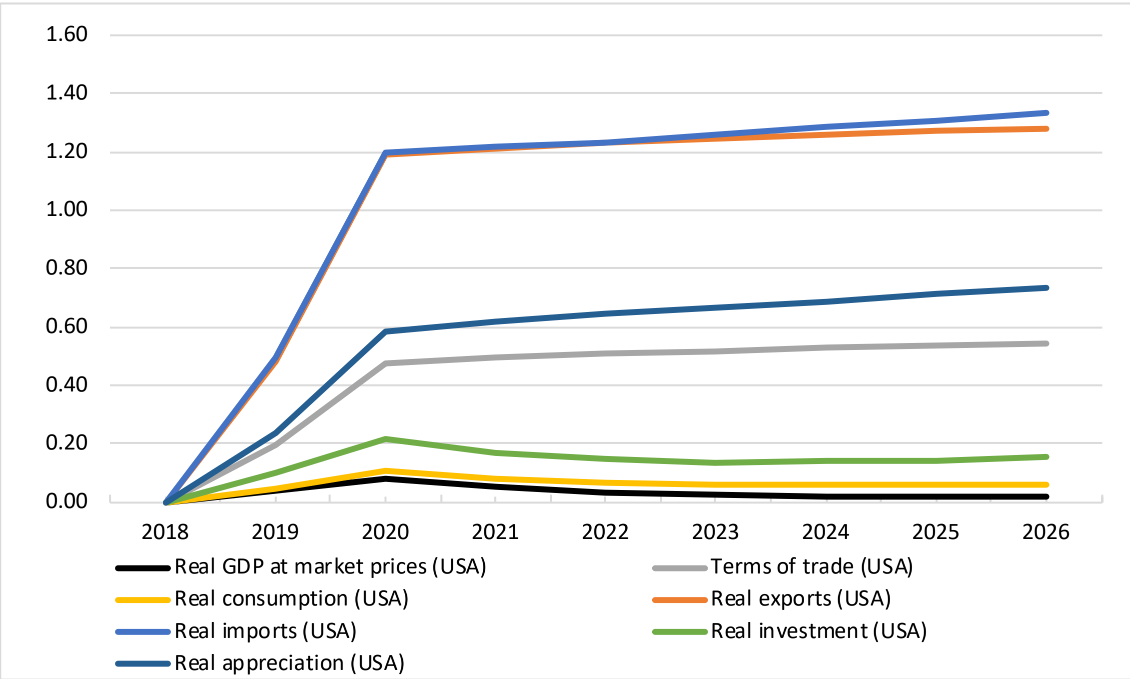

Figure 37: U.S. employment, capital, and real GDP (U.S.-China trade deal) (% deviation from baseline)

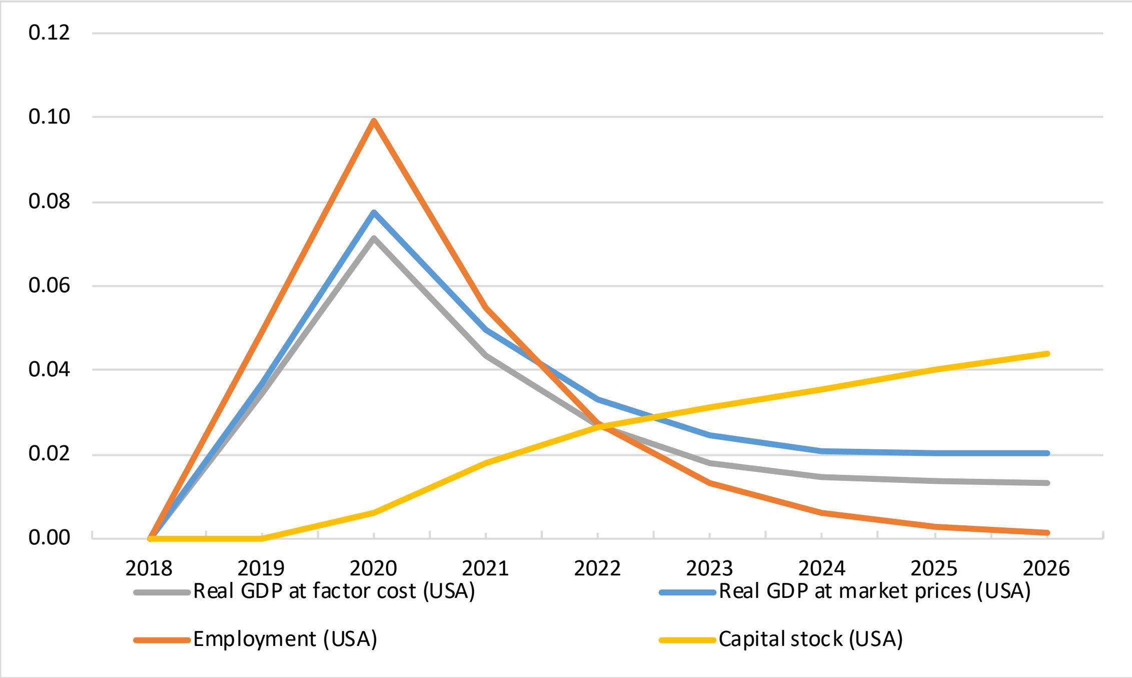

Figure 38: U.S. output deviations for 7 broad sectors (U.S.-China trade deal) (% deviation from baseline)

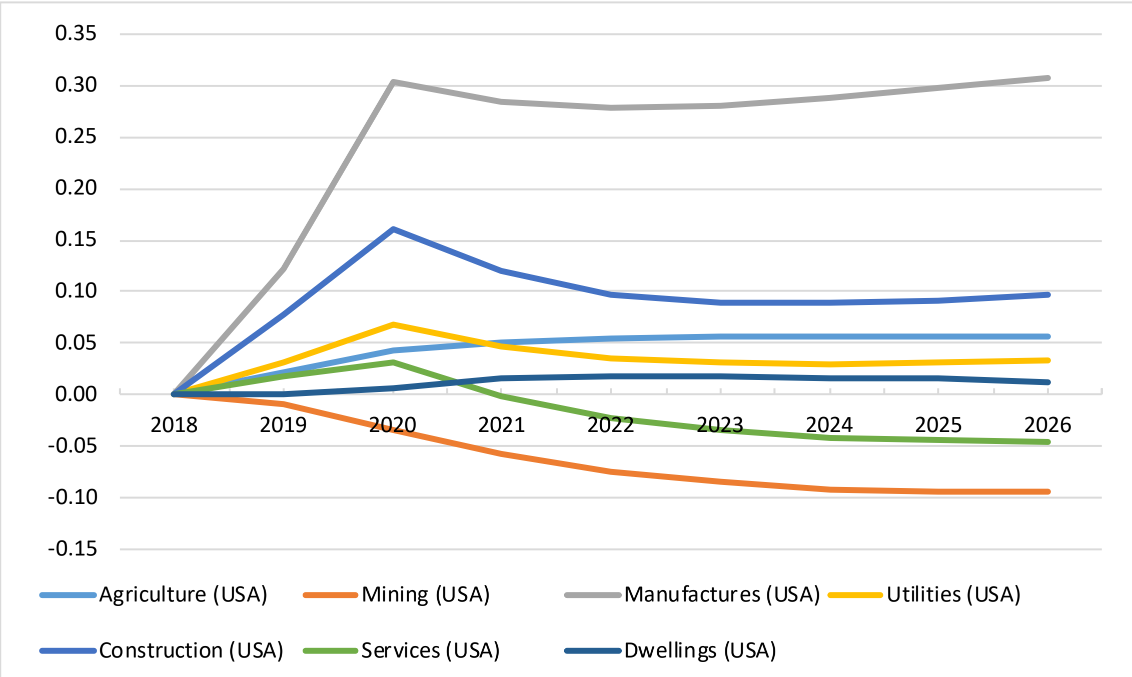

Figure 39: Top 5 U.S. industries ranked by 2026 output deviation (U.S.-China trade deal) (% deviation from baseline)

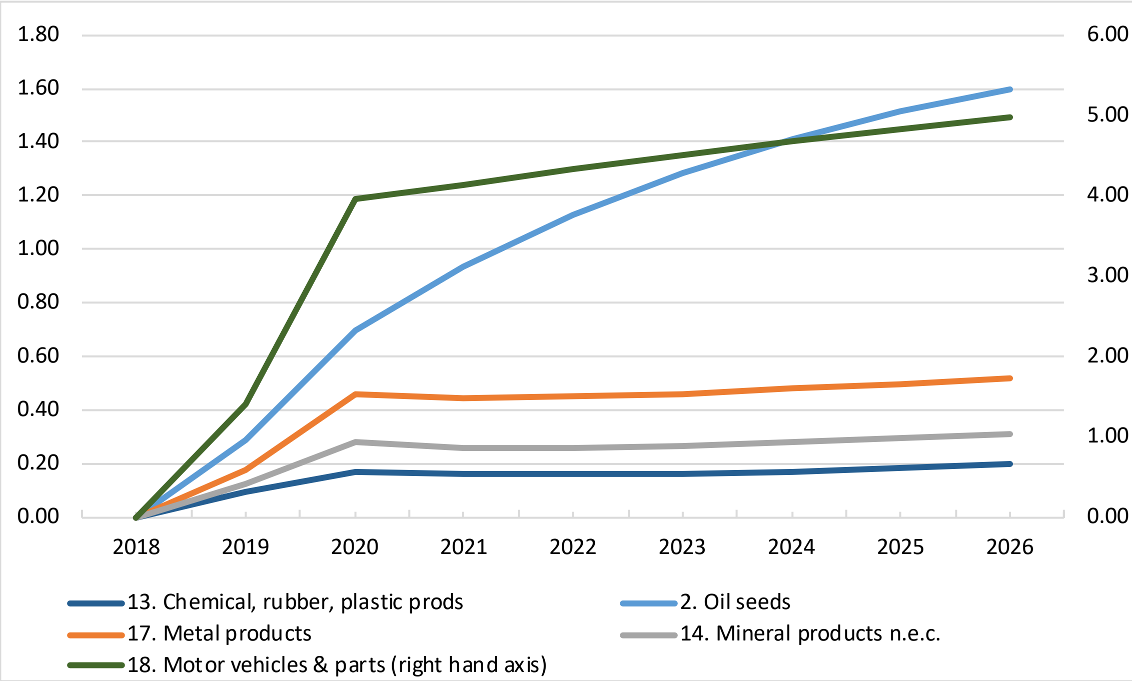

Figure 40: Real GDP (at market prices) outside of the U.S. and China (U.S.-China trade deal) (% deviation from baseline)

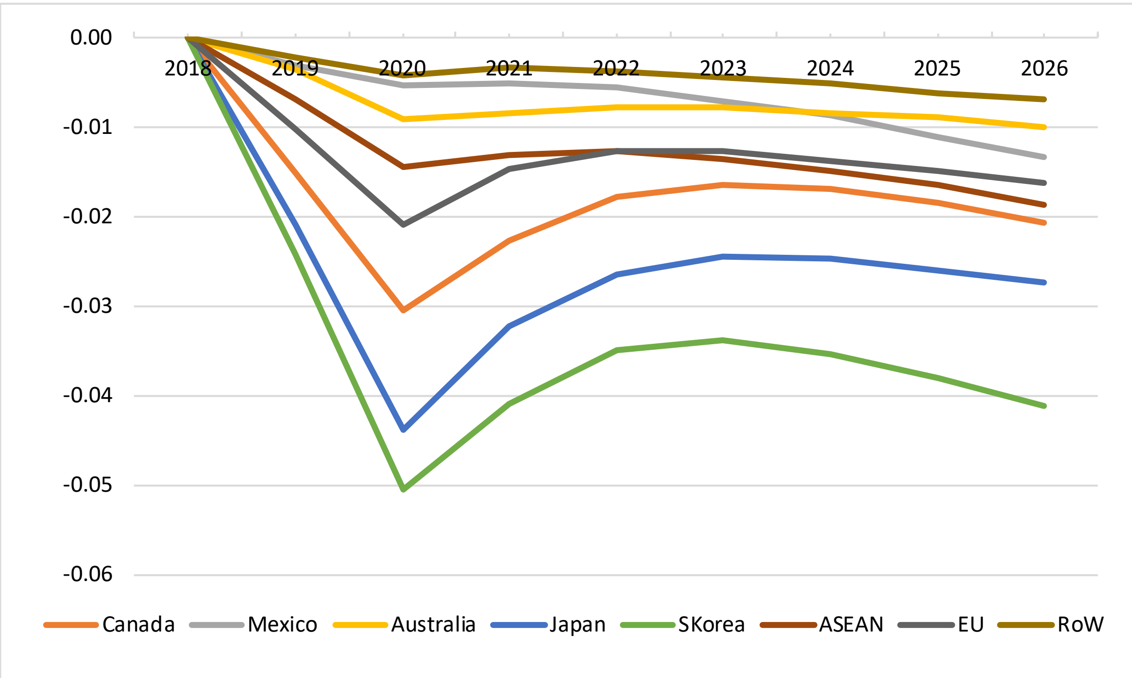

Figure 41: Australia's employment, capital stock and real GDP (U.S.-China trade deal) (% deviation from baseline)

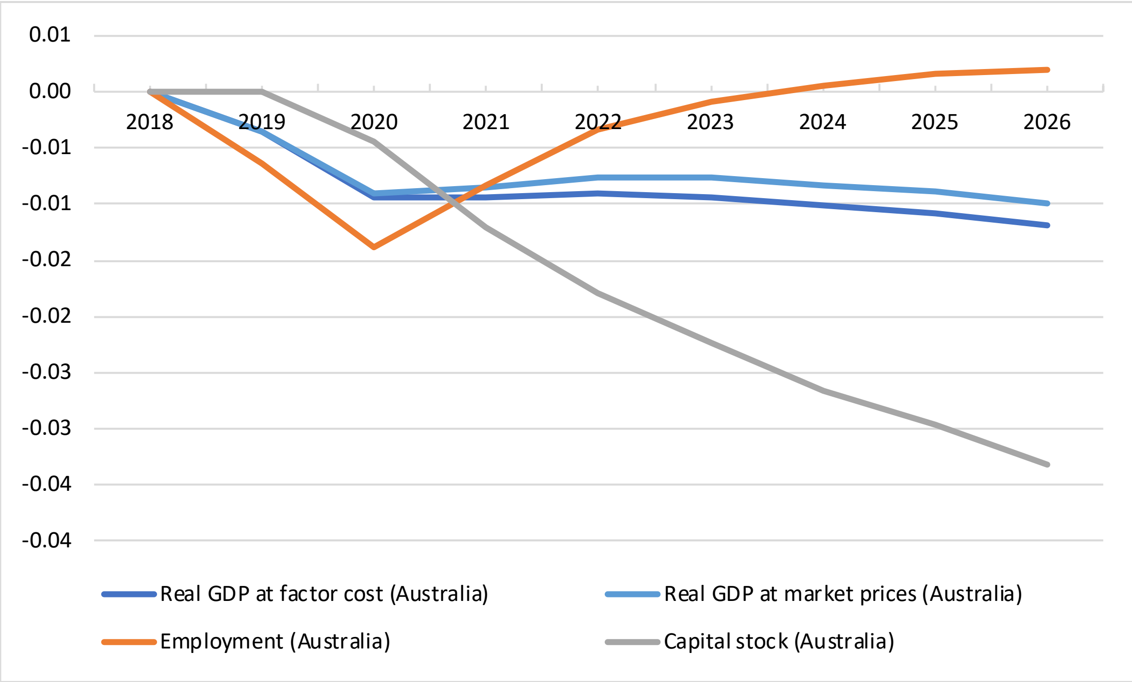

Figure 42: Australia's terms of trade, real exchange rate, and expenditure-side components of real GDP (U.S.-China trade deal) (% deviation from baseline)

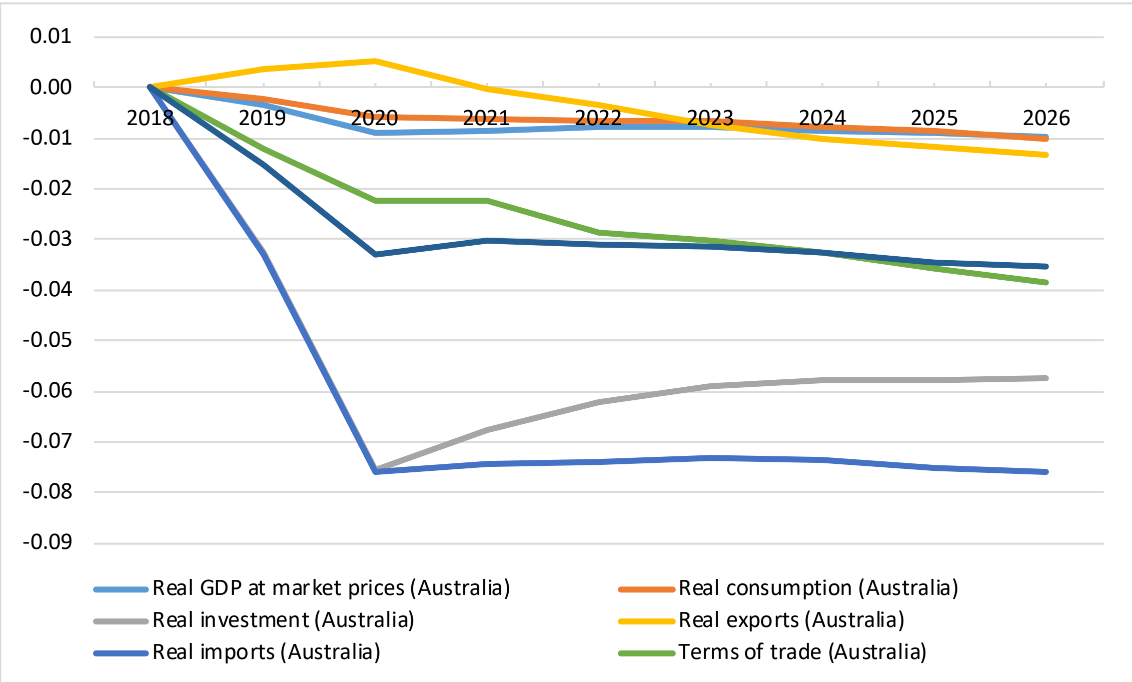

Figure 43: Trade diversion: decomposition of deviation in Australia's coal *exports, by destination (restriction on imports of Australian coal) (% deviation from baseline)*

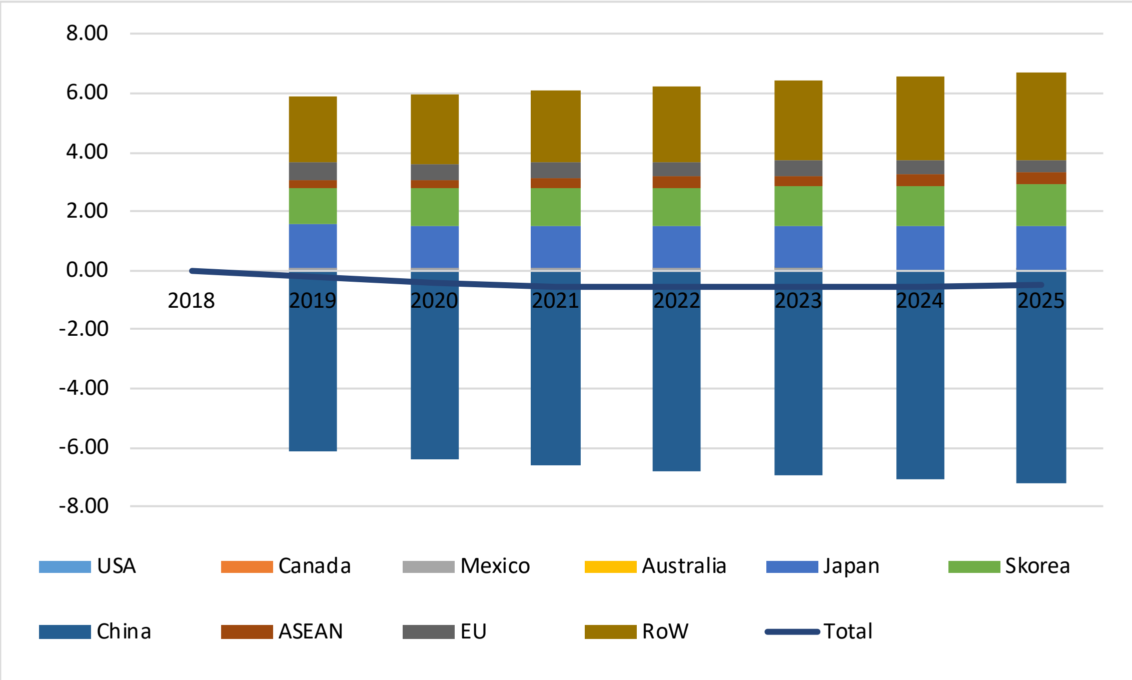

Figure 44: Australia's terms of trade, f.o.b. export price index, c.i.f. import price index, and f.o.b. coal export price index (restriction on imports of Australian coal) (% deviation from baseline)

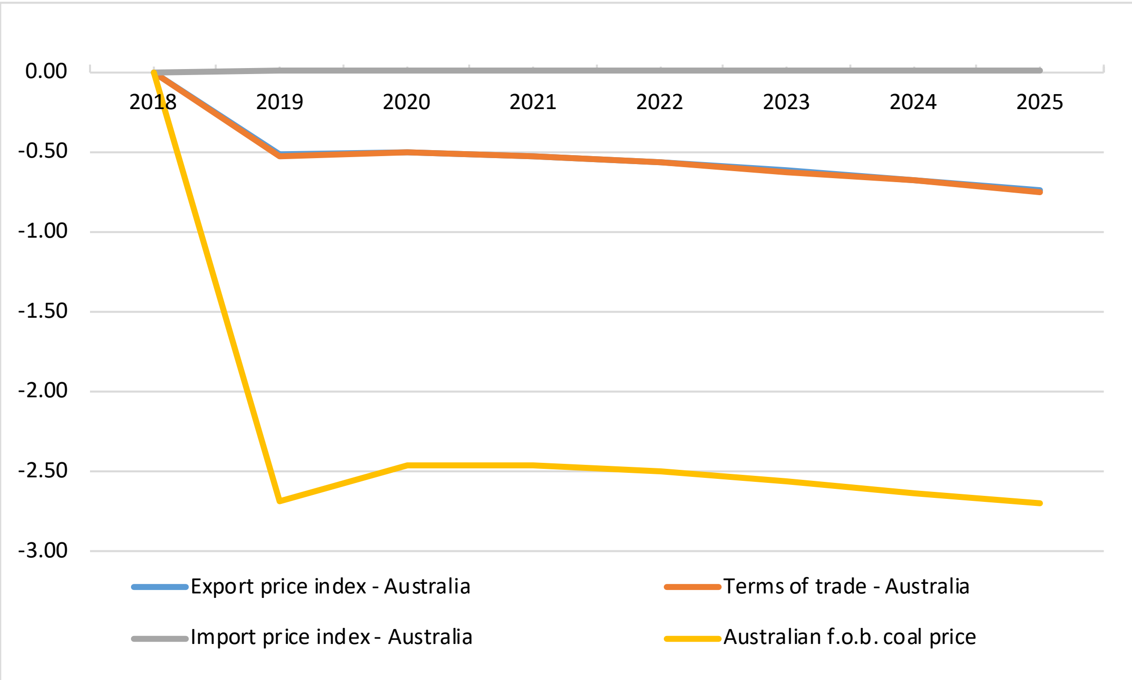

Figure 45: Decomposition (by commodity) of deviation in Australia's f.o.b. export price index (restriction on imports of Australian coal) (% deviation from baseline)

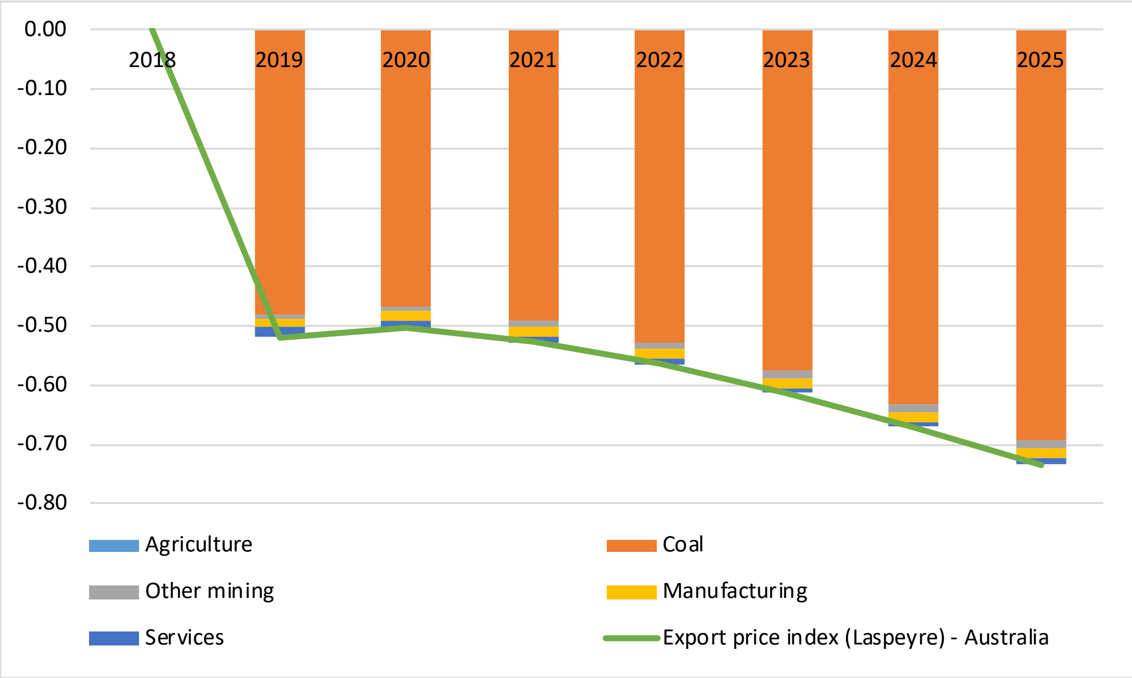

Figure 46: Australia's employment, capital stock and real GDP (restriction on imports of Australian coal) (% deviation from baseline)

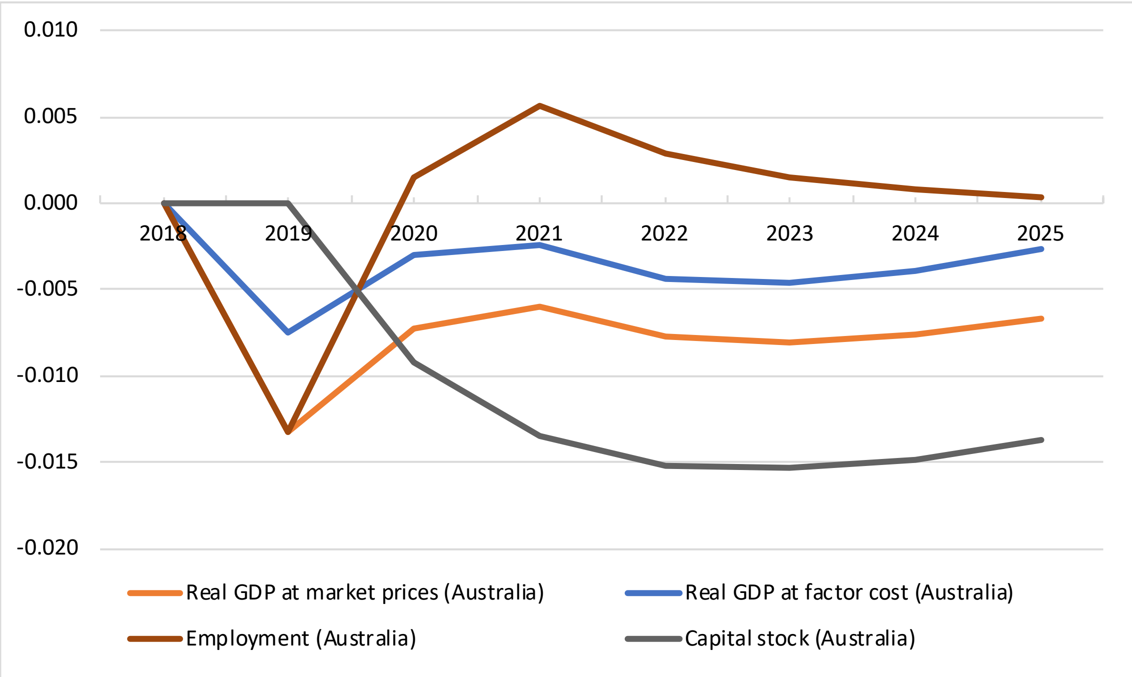

Figure 47: Australia's expenditure-side components of real GDP (restriction on imports of Australian coal) (% deviation from baseline)

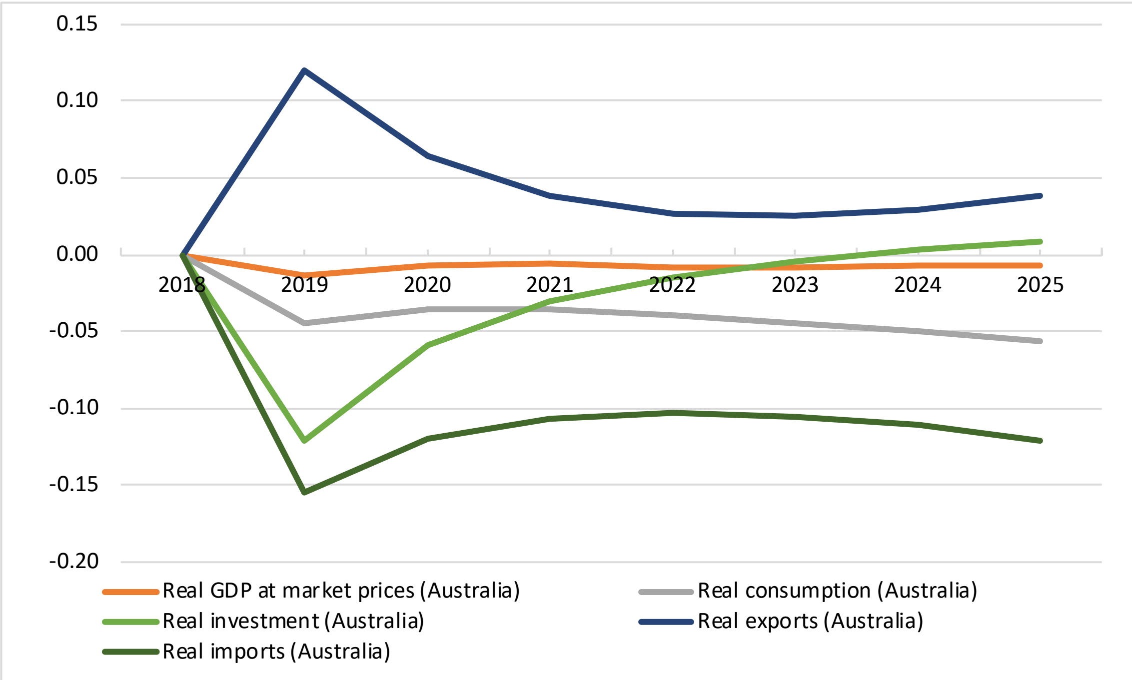

Figure 48: China's employment, capital, real GDP, real consumption, and terms of trade (restriction on imports of Australian coal) (% deviation from baseline)