Modelling Trade Growth for Long-Run Economic Prospects: Improving Trade to Income Elasticity Calibration in Baselines

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Abstract:

As a measure of global economic performance, the world trade to income elasticity (a ratio of trade growth to GDP growth) has been estimated to be 1.5 for merchandise trade from 1950 through 2017. Following the recession, this elasticity fell to 1.1 for 2011-2013 as global trade growth stalled, illustrating its importance in reflecting global conditions. In ex-ante research on long-run economic prospects, the projected trade to income elasticity serves as an important indicator for future anticipated global prosperity; however, even in the long-run, model mechanisms deliver an elasticity below 1, much lower than expected. In this paper, we provide a new approach to calibrating the trade to income elasticity to a ratio above 1, as implemented in a new version of the MAGNET (Modular Applied GeNeral Equilibrium Tool) model. As standard in the literature, we take as exogenous GDP growth projections; thus, in our approach we focus on trade growth calibration. Specifically, we allow the model to directly adjust trade flows across sectors, in contrast to the sector-specific targeting for transportation and oil in the literature. Further, while the current state-of the-art calibration methods target the Armington equation, we implement a cost-neutral preference shift, which greatly improves long-run production pathways in the calibrated baseline. Finally, we consider growth in both merchandise trade as well as trade in services, the latter being especially important to capture in long-run ex-ante studies where we anticipate services to play an increasingly important role in the global economy as cross-border digital services become pervasive.

1 Introduction

In this paper, we examine literature and data on the trade to GDP elasticity, and we provide a discussion of baseline calibration to trade to GDP elasticities based on our own simulations. In total, we run four experiments to examine new methods of calibrating the trade to GDP elasticity in the baseline, with the original MAGNET model as well as with two modified versions of MAGNET. Based on our findings we provide a new technical solution to calibrating the trade to GDP elasticity, though we also recommend further research into theory and empirics in order to enable more fine-tuned calibration.

Bekkers et al. (forthcoming) describe an approach to model calibration in order to achieve a world trade to income elasticity of 1.5 per cent for merchandise trade. This figure of 1.5 comes from author estimations of world merchandise trade growth to GDP growth from 1950 through 2017. This also follows reports by the European Central Bank (ECB 2014). The ECB reports a pre-crisis elasticity of total trade (goods and services) to GDP of 1.8 for 1981 to 2007 and of 1.1 for 2011-2013.

Bekkers et al. (forthcoming) target the world trade to GDP elasticity in the MIRAGE-e model through a four-tiered approach: (1) increasing productivity in the transportation sector, (2) reducing oil prices, (3) reducing tariffs, and (4) decreasing non-tariff measures. In combination, these assumptions produce the desired trade to income elasticity of 1.5 per cent. The authors caveat their approach noting that IEA projects future increases in energy prices and recently levels of tariffs have been increasing in certain cases. They also note that there is further empirical research needed to analyze trends in productivity in the transportation sector as well as trends in non-tariff measures.

2 Methods

In this paper, we explore calibration of the trade to GDP elasticity in the MAGNET model. We start with a direct analysis of recent historical trends, and we analyze four different calibration methods, testing the incorporation of two new modifications to the model. Table 1 presents a summary of the four experiments (one per calibration method tested), with an indication of the model used and the shocks implemented. Below, we describe in detail each of the experiments.

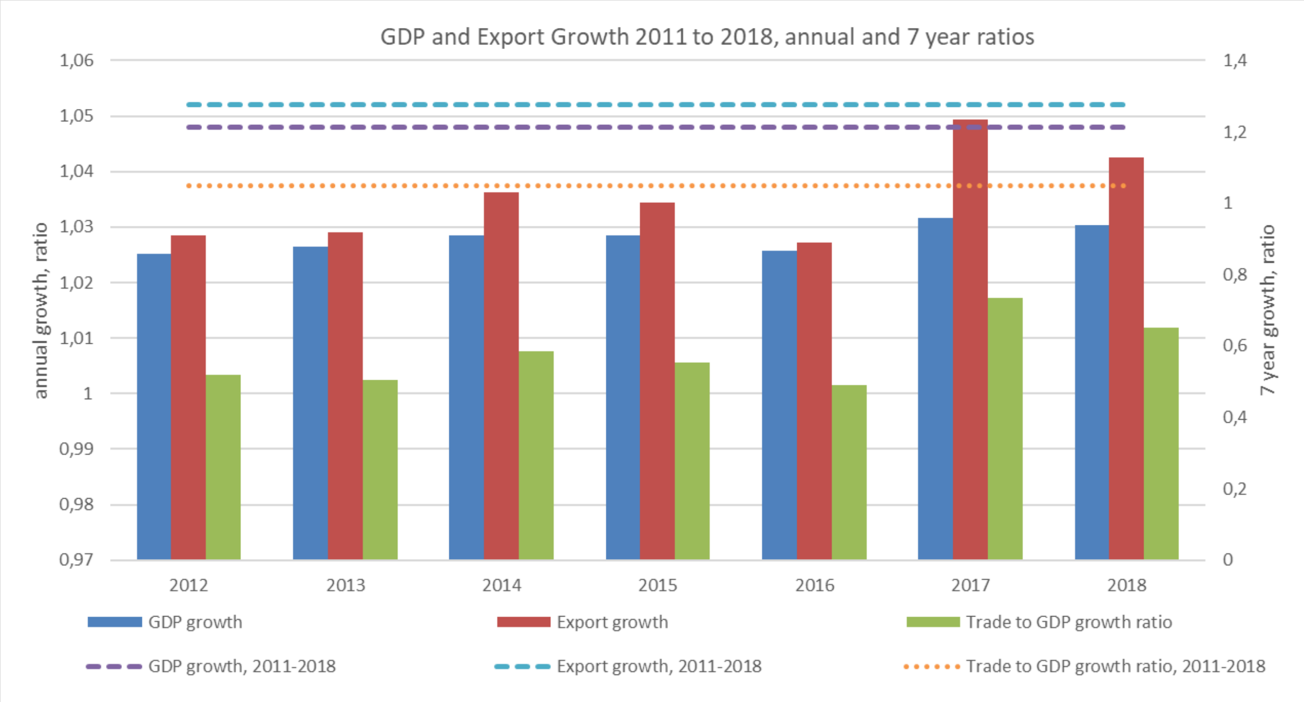
Table 1. Overview of Experiments

Experiment	Model	New Variables	Shocks
P1	MAGNET-TrV1	$qxswld$: aggregate trade $amswld$: aggregate trade efficiency	Period 1: $qxswld$=35% Period 1+t: $amswld$=14%
AP	MAGNET-TrV1	$qxswld$: aggregate trade $amswld$: aggregate trade efficiency	All periods: $qxswld$ set at % level calculated to maintain constant 1,05 trade to GDP elasticity
AS	MAGNET	None	All periods: services sectoral-input productivity (ASCALE) set to 0
AF	MAGNET-TrV2	$qxswld$: aggregate trade $afs_{i,j,r}, afs1_{i,j,r}$: sectoral twists $afswld$: aggregate twist	Period 1: $qxswld$=35% Period 1+t: $afswld$=27%

As a basis for our experiment design, we first analyze empirical trends. From World Development Indicators (WDI) data, we obtain data on GDP and export growth for the historic period of 2011 to 2018 which most closely matches our initial and historic period in our baseline (2011-2020). During this period, we examine both annual and 7 year growth ratios, as shown in Figure 1. We observe volatility in the annual trends, with the highest trade to income growth ratios in 2017 and 2018, driven by large increases in export growth during these periods.

Observing the seven year growth trend, we find an export to GDP growth ratio of 1.05 (Figure 1). This comprises export growth of 1.27 and GDP growth of 1.21 between 2011 and 2018. We take this seven year growth ratio of 1.05 as our target trade to income elasticity, considering that in the baseline we extend out this current trend.

Figure 1.



We created two modified version of the MAGNET model, MAGNET-TrV1 and MAGNET-TrV2. The first modified version, MAGNET-TrV1, incorporates two new variables, (1) an aggregate world trade variable to capture global trade ($qxswld$) and (2) a new global technology variable in the Armington equation ($amswld$), both without product or regional indices. Introducing this new technology variable into the Armington equation, we introduce a new mechanism for shifting global trade flows.

We specify the new aggregate world trade variable $QXSW$ as:

$$QXSW * qxswld = \sum_i \sum_r \sum_s Q\_VXMD_{i,r,s} * qxs_{i,r,s}$$

where $qxswld$ is the new corresponding percentage change in global trade.

We define the new global technology variable $amswld$ in percentage change terms in the Armington equation as:

$$qxs_{i,r,s} = -ams_{i,r,s} - amswld + qim_{i,s} - ESUBM_i * [pms_{i,r,s} - ams_{i,r,s} - amswld - pim_{i,s}].$$

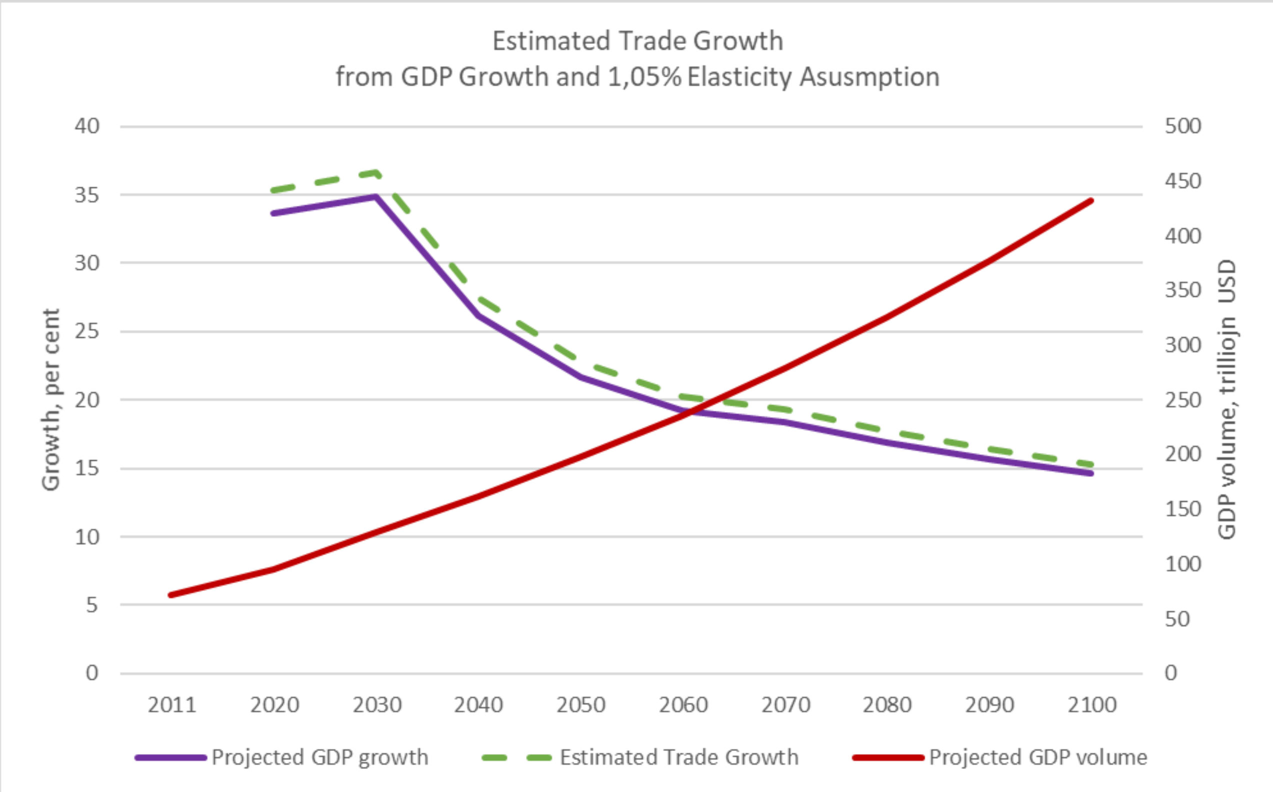
This new variable $amswld$ likewise appears in the aggregate import price function:

$$pim_{i,s} = \sum_r MSHRS_{i,r,s} [pms_{i,r,s} - ams_{i,r,s} - amswld].$$

With this modified model MAGNET-TrV1, we run two experiments. In the first experiment (P1), we calculate the necessitated growth in trade for the period 2011 to 2020 to be 35 per cent, given the projected GDP growth of 33.6 per cent during this period as well as the estimated trade to income elasticity of 1.05. We set the new aggregate global trade variable $qxswld$ to 35 per cent, endogenizing the global technology variable $amswld$ to compute an equivalent level of technological change which we estimate as 14 per cent. Then, for each subsequent model period running until 2100, we endogenize the global trade variable $qxswld$, and we set the exogenous global technology variable $amswld$ to 14.

The second experiment (AP) which we run with MAGNET-TrV1 is similar to the first (P1). In AP, we calculate the necessitated growth in trade for each period in the model, given the projected GDP growth for each corresponding period as well as the estimated trade to income elasticity of 1.05, which is assumed constant across the baseline. Figure 2. shows projected global GDP volume, projected GDP growth, and estimated trade growth, across all periods of the model. We see that initially GDP growth increases until 2030 and subsequently decreases over time. Accordingly, given an assumed fixed trade to income elasticity, trade growth follows suit. We apply this estimated trade growth to the new aggregate trade variable $qxswld$ for each corresponding period in the model.

Figure 2.



As will be discussed further below, the initial results from the first two experiments showed differing patterns of trade growth for services and manufacturing trade. Specifically, in the long-term, trade in services is increasing steadily, reaching 150 per cent growth for experiment P1 and 10 per cent for experiment AP. In manufacturing it reaches a maximum of 80 per cent for P1 and just over 60 per cent for AP in 2070. Historical data however shows that services and manufacturing trade tend to grow together. Thus, we ran a third experiment (AS) with the standard MAGNET model, exploring the effect of adjusted services demand on patterns of trade growth. Specifically, we implemented this through a modification of the underlying parameter (*ASCALE*) which distributes regional productivity growth into sector-specific input productivity growth. This parameter is zero or positive, indicating either a direct transformation of the regional growth to the sectoral-input growth or a magnified sectoral-input growth. Across all industries, the standard assumption is that this parameter is positive and that the productivity of services inputs is equivalent to a magnified regional productivity.

In experiment AS, we assume that this parameter (*ASCALE*) on services inputs is equal to zero. This means that regional productivity increases over time do not translate to increases in the productivity of services as inputs into production. Hence, the demand for services will increase over time, and we anticipate trade effects as the global economy adjusts.

Our fourth and final experiment (AF) implements the second modified version of the MAGNET model, MAGNET-TrV2, which builds off of our first modified version, retaining the new aggregate world trade variable $qxswld$. In this version of the model, we introduce a new global technology variable ($afswld$, a preference twist variable) which we relate to the two equations determining intermediate demand for foreign versus domestic products. With this method, we introduce a new mechanism for endogenously shifting producers' demand between domestic and imported intermediates inputs while maintaining cost-neutrality.

To specify the new global technology variable $afswld$, we initially define sectoral specific technology variables $afs_{i,j,r}$ and $afs1_{i,j,r}$ which are related to $afswld$ as:

$$afs_{i,j,r} = afs1_{i,j,r} + afswld.$$

Using the variable $afs_{i,j,r}$ provides us with two levers for introducing preference twists: a sector-specific lever ($afs1_{i,j,r}$) and an aggregate, global lever ($afswld$). We note that in the present application we are only concerned with the global mechanism, $afswld$.

We then modify the two equations determining intermediate demand for foreign versus domestic products to incorporate $afs_{i,j,r}$. First we modify the demand function for foreign intermediate imports as:

$$qfm_{i,j,r} = qf_{i,j,r} - ESUBDS_{i,r} * \left[pfm_{i,j,r} - pf_{i,j,r}\right] + \left[1 - FMSHR_{i,j,r}\right] * afs_{i,j,r}.$$

Second we modify the demand function for domestic intermediate inputs as:

$$qfd_{i,j,r} = qf_{i,j,r} - ESUBDS_{i,r} * \left[pfd_{i,j,r} - pf_{i,j,r}\right] - FMSHR_{i,j,r} * afs_{i,j,r}.$$

We design the introduction of these new variables to be cost-neutral, similar to Adams et al. (2010) who introduce trade preference shifting twist variables into the Monash Multi-Regional Forecasting Model. Cost-neutrality indicates that, given stable prices, the shock imposed on the twist variable transfers directly to the quantity demanded. Technically, we can see this if we rewrite the intermediate demand functions to look at the relative change in intermediate demands:

$$qfm_{i,j,r} - qfd_{i,j,r} = ESUBDS_{i,r} * \left[pfd_{i,j,r} - pfm_{i,j,r}\right] + afs_{i,j,r}.$$

Thus, if $pfd_{i,j,r} = 0$ and $pfm_{i,j,r} = 0$, then $qfm_{i,j,r} - qfd_{i,j,r} = afs_{i,j,r}$. Then considering we imposed a twist of $afs_{i,j,r} = 10$, we would consider that demand for imported intermediates ($qfm_{i,j,r}$) would increase over changes in demand for domestic intermediates ($qfd_{i,j,r}$) by 10 per cent.

We introduce these twist variables into the model in order to simulate what Horridge (2000) describes as "secular (i.e., not price-induced) trends". This means that, because the introduction of the twist variables is cost-neutral, then model results are being driven through a quantity channel rather than a price channel. This is an important concept, which contrasts with the typical ams-style variables which drive model results through both price and quantity channels.

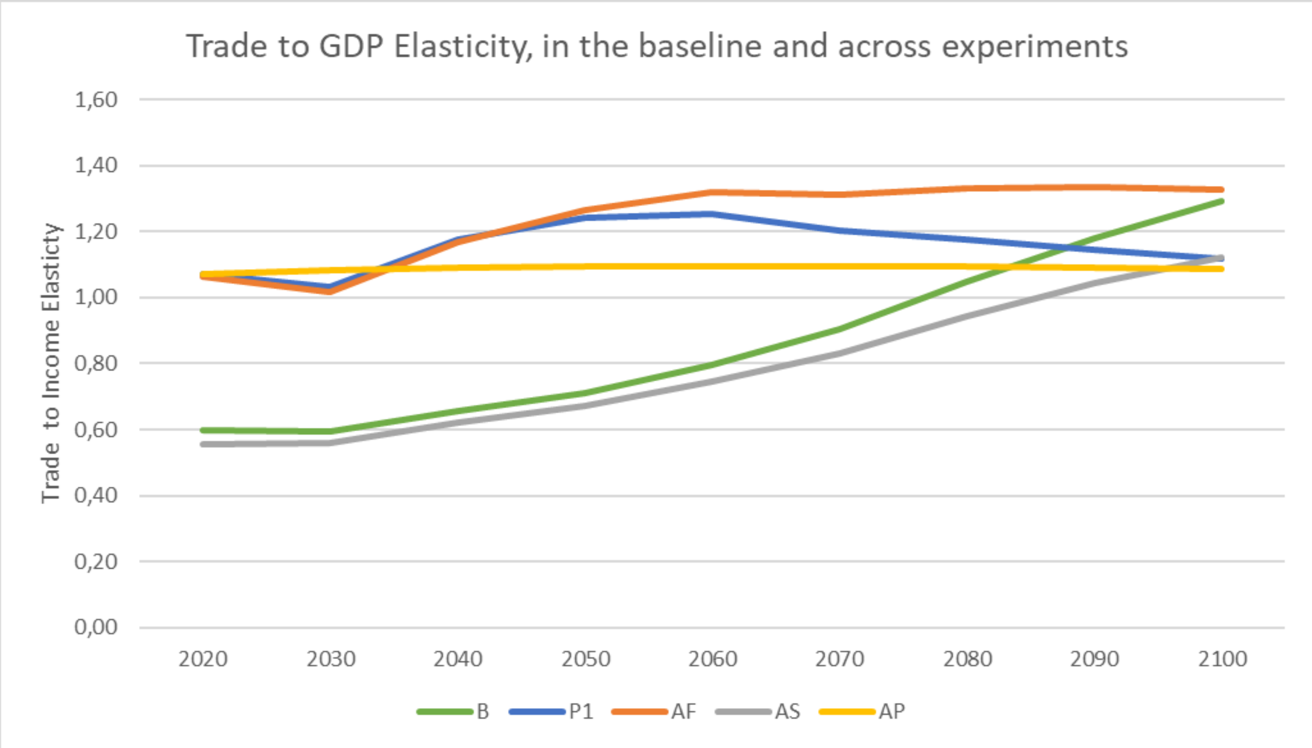
The intuition behind these modifications is that with shocks to the model enforcing increased trade (exogenous $qxswld$), this new mechanism (endogenous $afswld$) will allow the system to adjust by shifting production demand towards imported intermediate inputs. This follows the reasoning that over time we could anticipate increasing preferences for imported intermediates as global value chains deepen and cross-border digital services become increasingly pervasive.

Our AF experiment is similar in operation to our P1 experiment. Again, we start with the first period, 2011 to 2020, with projected GDP growth of 34 per cent, and we implement the estimated trade to income elasticity of 1.05 to compute implied trade growth of this period to be 35 per cent. We once more set the aggregate global trade variable $qxswld$ to 35 per cent. Then, we deviate from experiment P1, as in experiment AF we endogenize the new global technology variable $afswld$, shifting producer input sourcing. Running the first period of the model, we compute this new global technology variable to be 27 per cent. Then, for each subsequent period of the model, we endogenize aggregate global trade $qxswld$, and we exogenize the new global technology variable $afswld$ which is set equal to 27.

3 Results

Running all four experiments, we can compare our results to the baseline scenario. We begin with a comparison of trade to income elasticities, which is our primary interest, as shown in Figure 3. In the baseline experiment B, we see that the elasticity begins at around 0,6 and gradually grows to 1,29. Our experiments P1, AP, and AF all deviate from this as in these three experiments we are targeting trade explicitly and implicitly in the modified MAGNET models in order to achieve higher trade to GDP elasticities. Experiment AS, which uses the original MAGNET model and only adjusts sectoral input productivity, naturally follows most closely the elasticity path of our baseline experiment B.

Figure 3.

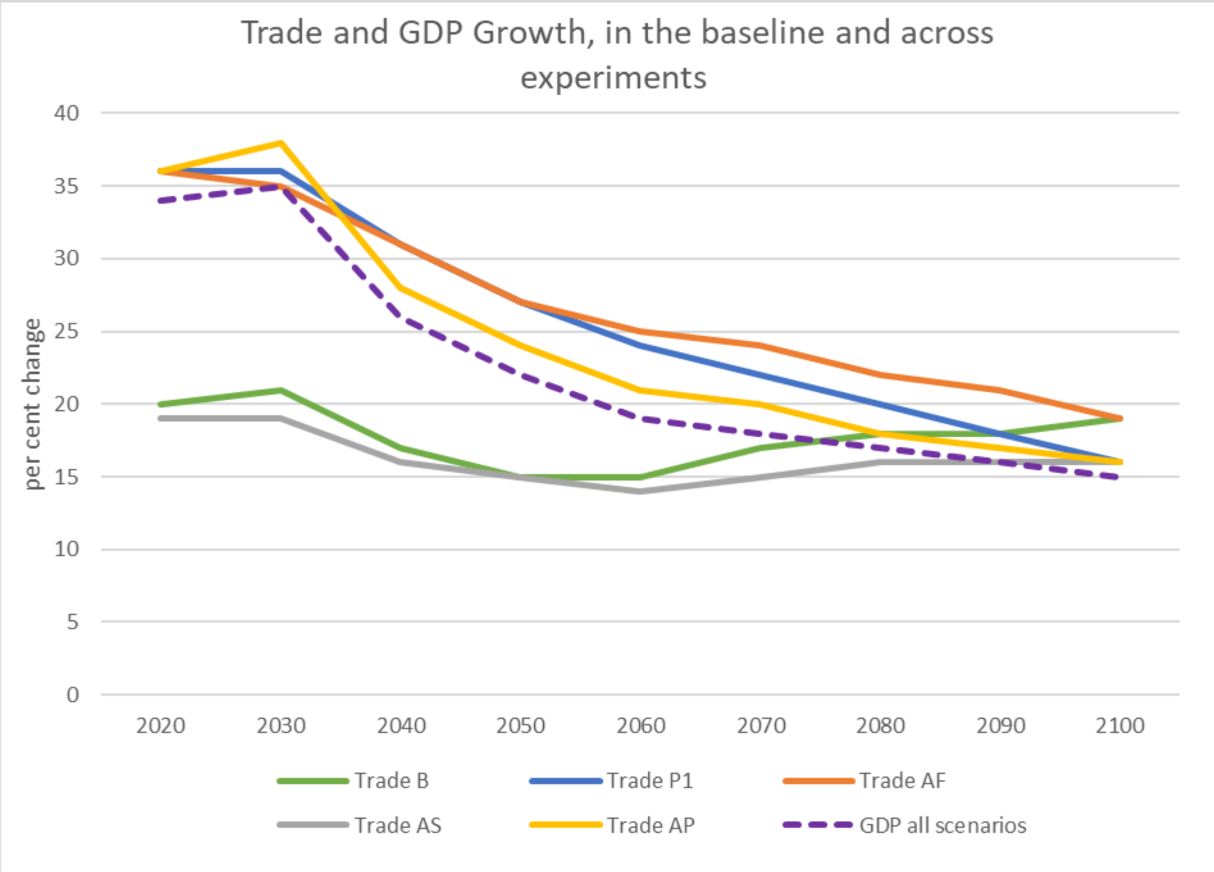


In Figure 4, we report GDP projections as well as the trade growth across all experiments. Because GDP growth remains constant across experiments, the differences between the trade to income elasticities across the experiments depend on the differences of trade growth across experiments. In the baseline experiment B, we observe trade growth of 20 per cent in 2020, decreasing to 19 per cent by 2100. The highest initial trade growth is in experiments P1, AP, and AF, in which we explicitly specified the first period trade growth to be 36 per cent. Across the rest of the periods until 2100, we explicitly specified the trade growth in experiment AP, whereas in experiments P1 and AF we implicitly target trade through new technology variables in the Armington and intermediate sourcing equations, respectively, as discussed above. In experiment AS, trade is endogenous across all periods, and we observe a lower than baseline level of trade growth of 19 per cent in the first period. By 2100, trade growth in the baseline scenario B and experiment AF reach 19 per cent whereas trade growth in the final period reaches only 16 per cent across experiments P1, AP, and AS.

We can relate these observations of trade growth from Figure 4 back to the developments of the trade to income elasticity shown in Figure 3. Starting with the baseline scenario B, we take the endogenous trade growth shown in Figure 4 as our reference level of trade typically generated in a MAGNET baseline. This trade growth of scenario B along with the projected GDP growth, gives us our reference trade to income elasticity that we observed in Figure 3. We can build from here to examine the differences across the experiments.

In Figure 4, for experiment P1, we observe the, initially exogenous, trade growth of 36 per cent remains endogenously at 36 per cent in 2030 and then subsequently endogenously decline over time to reach 16 per cent by 2100. This, combined with the GDP growth shown in Figure 4, explains the trade to income elasticity evolution observed in Figure 3. The dip in the trade elasticity from 2020 to 2030 corresponds to the projected GDP growth increasing from 2020 to 2030. From 2030 to 2100, we see that trade growth exceeds GDP growth by a margin of 5 per cent between 2040 and 2060 which declines to 1 per cent by 2100. This is reflected in the trade to income elasticities in Figure 3, as the elasticity increases to a peak of 1,25 in 2050 and then declines to 1,12 by 2100.

Figure 4.



For experiment AP, we observe a flat trade elasticity of around 1,09 across periods in Figure 3. This is anticipated because of the experiment design, as described above. Specifically, in the discussion surrounding Figure 2, we described how the trade growth was calculated to achieve a constant elasticity.[1] Thus, we see in Figure 4, the same patterns in trade growth for the AP experiment relative to the GDP growth as we saw in Figure 2. That is, we observe that, per our calibration computation, the trade growth of experiment AP maintains an even margin above the GDP growth, producing the even trade elasticity across periods until 2100.

In Figure 4, we find trade growth for experiment AS to be lower than that of the baseline scenario. Given the same projected GDP growth as the baseline, the relatively lower trade growth explains the relatively lower trade to income elasticity observed in Figure 3. This result is logical because the AS experiment keeps the same MAGNET model theory as the baseline experiment but decreases the input productivity of services for all sectors across all periods. With decreasing input productivity, non-services producers need to demand more of services

[1] The elasticity reported here of 1,09 differs slightly from the elasticity of 1,05 used in the experiment calibration. This is because the trade growth reported here is a slightly different aggregation than the one used in the experiment calibration.

to meet the same level of production, and, hence production becomes more costly and contracts. With these production contractions, trade contracts as well. Thus, the decrease in productivity is surfacing in the relatively lower trade growth observed in Figure 4.

For experiment AF, we find that trade growth is very close to that of experiment P1, as observed in Figure 4. As discussed prior, both AF and P1 begin with the same initial calibration step of fixing trade growth to 36 per cent for the first period. For both experiments, trade is then endogenized for all following periods until 2100. Thus, the deviation in the trade growth paths between experiments then depends on the theoretical differences between the alternate global technology variables which are used to target the trade to income elasticity (MAGNET-TrV1 versus MAGNET-TrV2).

As previously discussed, in MAGNET-TrV2 the new global technology variable in experiment AF is introduced through equations governing the intermediate demand for foreign versus domestic products, and thus affecting the relative quantity of intermediate input demand. In contrast, in MAGNET-TrV1 the new global technology variable in experiment P1 is implemented in the Armington function, similar to the standard *ams* variable, effecting both import prices and import quantities. The mechanism of the technology variable in the Armington equation acts such that imports become cheaper so more quantity is demanded and yet, at the same time, less product is needed to fulfill the same import demand.

Based on these differences in global technology variables between models MAGNET-TrV1 and MAGNET-TrV2, the deviation in trade growth between experiments AF and P1 can be explained. Initially, both mechanisms are achieving higher overall trade. However, in the long-run, the trade-reducing quantity effects of the global technology implemented through the Armington in MAGNET-TrV1 implemented in experiment P1 overrun the trade-increasing price effects. Hence, in Figure 4 we see the increasing margin between trade growth for experiments AF and P1, with AF outpacing P1 by 2100. This translates to the higher trade to income elasticity for AF relative to P1 observed in Figure 3.

In Figure 5, we further decompose the patterns of global trade growth reported in Figure 4, examining the dynamics of global exports across aggregate commodities (agri-food, services, and manufacturing). In the baseline scenario, we observe that the majority of global trade is in manufacturing. As such, that the evolution of global trade over time is largely driven by the changes in manufacturing trade across all periods. Nonetheless, we decompose the changes in exports by aggregate commodity. Across commodities, we see that trade is higher than the baseline for experiments P1, AP, and AF whereas it is lower than the baseline for experiment AS, with the exception of services trade. Naturally, this has to do with the experiment set-up.

As detailed above, we target trade growth explicitly and implicitly in experiments P1, AP, and AF, whereas in experiment AS, trade is not targeted, but rather input productivity of services is targeted. Hence, in experiment AS more services are necessary to produce the same products, compared to the baseline, and thus the increase in services trade observed in Figure 5 is logical. The decline in agri-food and manufacturing in experiment AS is equally logical as these producers have less services-input productivity for production and, hence, for exports, as compared to the baseline.

Trade patterns can be decomposed into supply and demand side drivers. On the supply side, we consider global production, as shown in Figure 6. In the baseline, services production is the highest of the aggregate production across all periods, followed by manufacturing and agri-food production. Across all sectors, we see that by 2100 production is decreasing relative to the baseline, with the exception of production in services for experiments AS and AF. Similar to as described above, this increase in services production can be expected in AS as all sectors are demanding more services inputs in this experiment, as compared with the baseline scenario.

In Figure 6, production in manufacutirng for experiment AS decreases relative to the baseline, which is in line with the decreased levels of manufacturing trade observed in Figure 5. However, for experiments P1 and AP, decreases in production relative to the baseline initiially may appear counterintuitive to increasing trade relative to the baseline; however, there are reasons for observed patterns. Again, we consider the experiment design for scenarios P1and AP. Recall that both scenarios implemented MAGNET-TrV1 which has a new global technology variable in the Armington equation. With increases to this global technology implemented worldwide, essentially, production "slims down" as their imported inputs become cheaper and as they have to produce less to satisfy the same level of demand from their increasingly foreign clientelle.

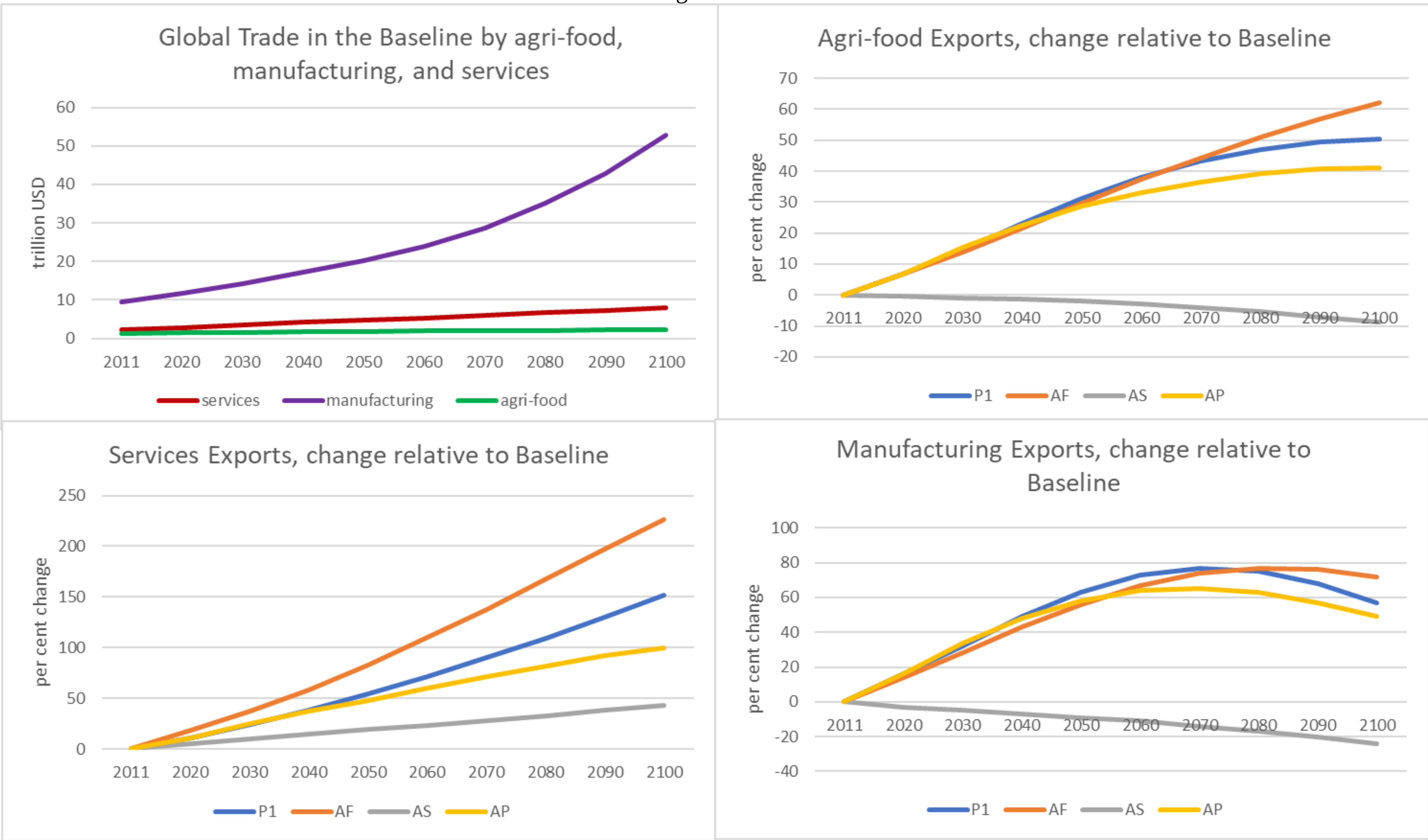
In experiment AF, manufacturing and agricultural production decrease slightly relative to the baseline (Figure 6). This is also an aritfact of experiment design. As detailed prevoisuly, in MAGNET-TrV2 the introduction of the global technology into the input sourcing equations shifts sourcing preferences through affecting relative quantities. Essentially, producers shift away from domestic inputs to use more imported intermediates, but they do not benefit from better prices on the imported goods (as would be expected in global technology shocks implemented in the Armington equation). Hence, production contraction relative to the baseline is logical.

Figures 7 and 8 present the demand side in terms of global consumption and demand for intermediates, respecitvely. In Figure 7, we see that in the baseline the highest private demand is for services whereas in Figure 8 we observe that the highest demand for intermediates is for manufacturing goods. In both figures, private consumption and intermediate demand across experiments is higher relative to the baseline for services and manufacturing, with the exception of certain cases for experiments AS and AF. For the agri-food sector, while private consumption generally increases, intermediate demand declines across experiments.

The slight relative decrease of private consumption for services in experiment AS (Figure 7) could be considered a resource constraint problem as intermediate demand for services in experiment AS is much higher than in the baseline (Figure 8) due to zero tech change associalted with intermediate services use. Production struggled to meet both private and industry demands. This leads to increase services price and causes lower private consumption of sevices The relative decrease in intermediate demand for manufacturing in experiment AS (Figure 8) is a reflection of the relative production contraction in these sectors compared to the baseline (Figure 6).

For experiment AF, the observed relative decreases in consumption of services and manufacturing in Figure 7, follow suit to the aforementioned logic behind the production contraction observed for experiment AF in Figure 6. As production costs increase relative to the baseline, consumers face higher prices, and consumption declines relative to the baseline. This is particularly notable for consumption of manufacturing goods which decline by 4 per cent by 2100 relative to the baseline (Figure 7).

Figure 5.



Global Trade in the Baseline by agri-food, manufacturing, and services
trillion USD
60
50
40
30
20
10
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
services
manufacturing
agri-food
Agri-food Exports, change relative to Baseline
per cent change
70
60
50
40
30
20
10
0
-10
-20
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Services Exports, change relative to Baseline
per cent change
250
200
150
100
50
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Manufacturing Exports, change relative to Baseline
per cent change
100
80
60
40
20
0
-20
-40
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP

Figure 6.

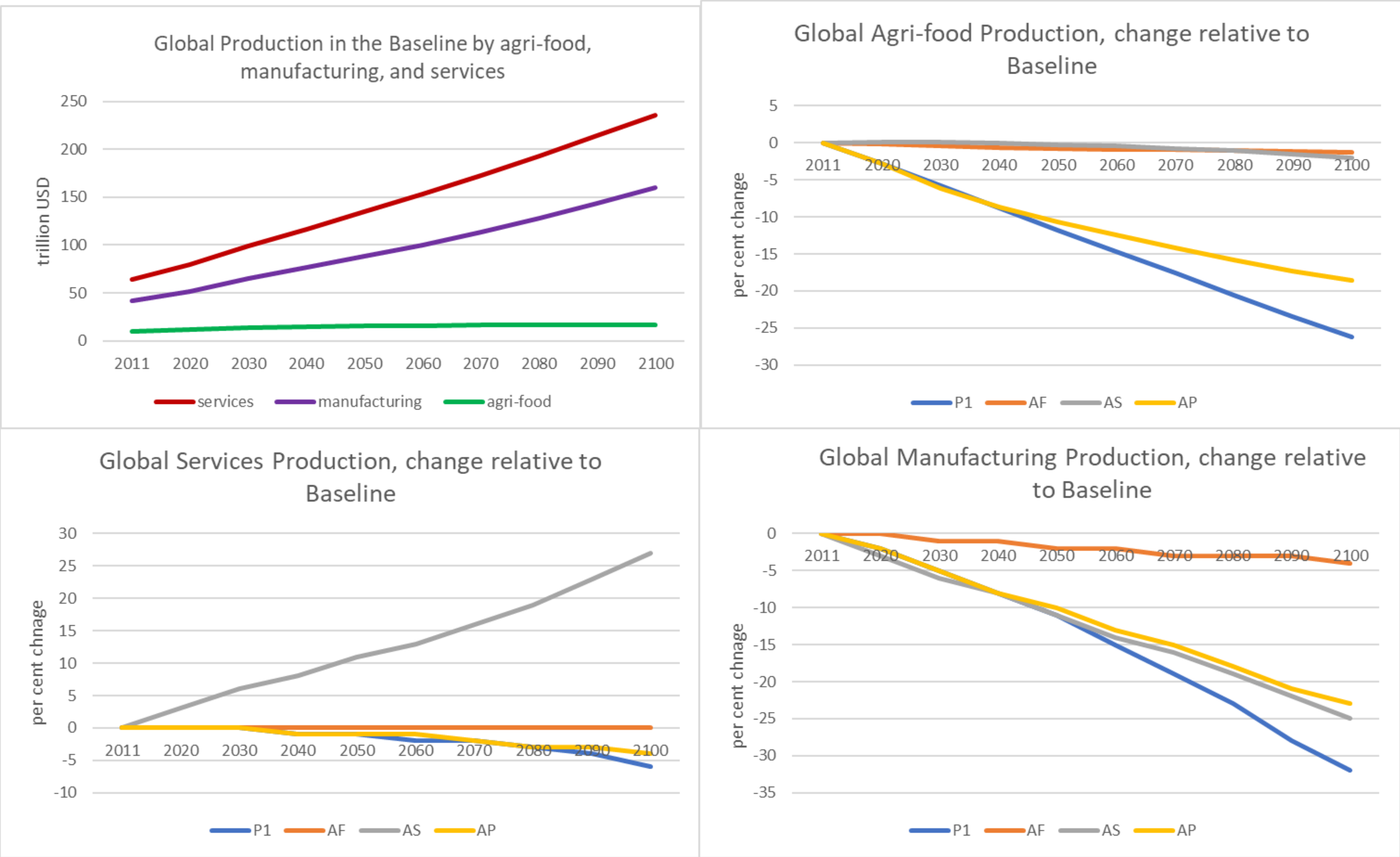

Global Production in the Baseline by agri-food, manufacturing, and services
trillion USD
250
200
150
100
50
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
services
manufacturing
agri-food
Global Agri-food Production, change relative to Baseline
per cent change
5
0
-5
-10
-15
-20
-25
-30
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Global Services Production, change relative to Baseline
per cent chnage
30
25
20
15
10
5
0
-5
-10
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Global Manufacturing Production, change relative to Baseline
per cent chnage
0
-5
-10
-15
-20
-25
-30
-35
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP

Figure 7.

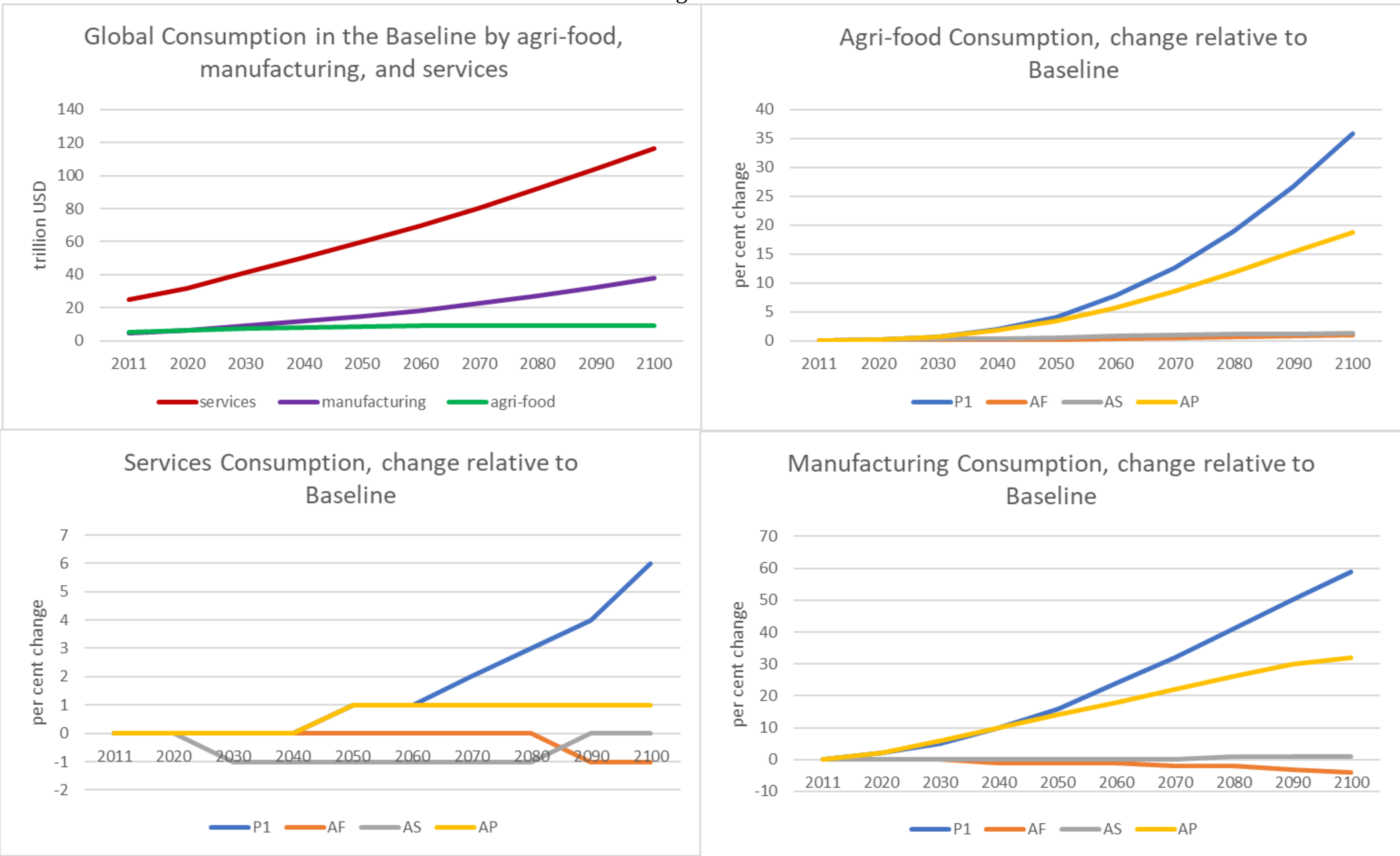
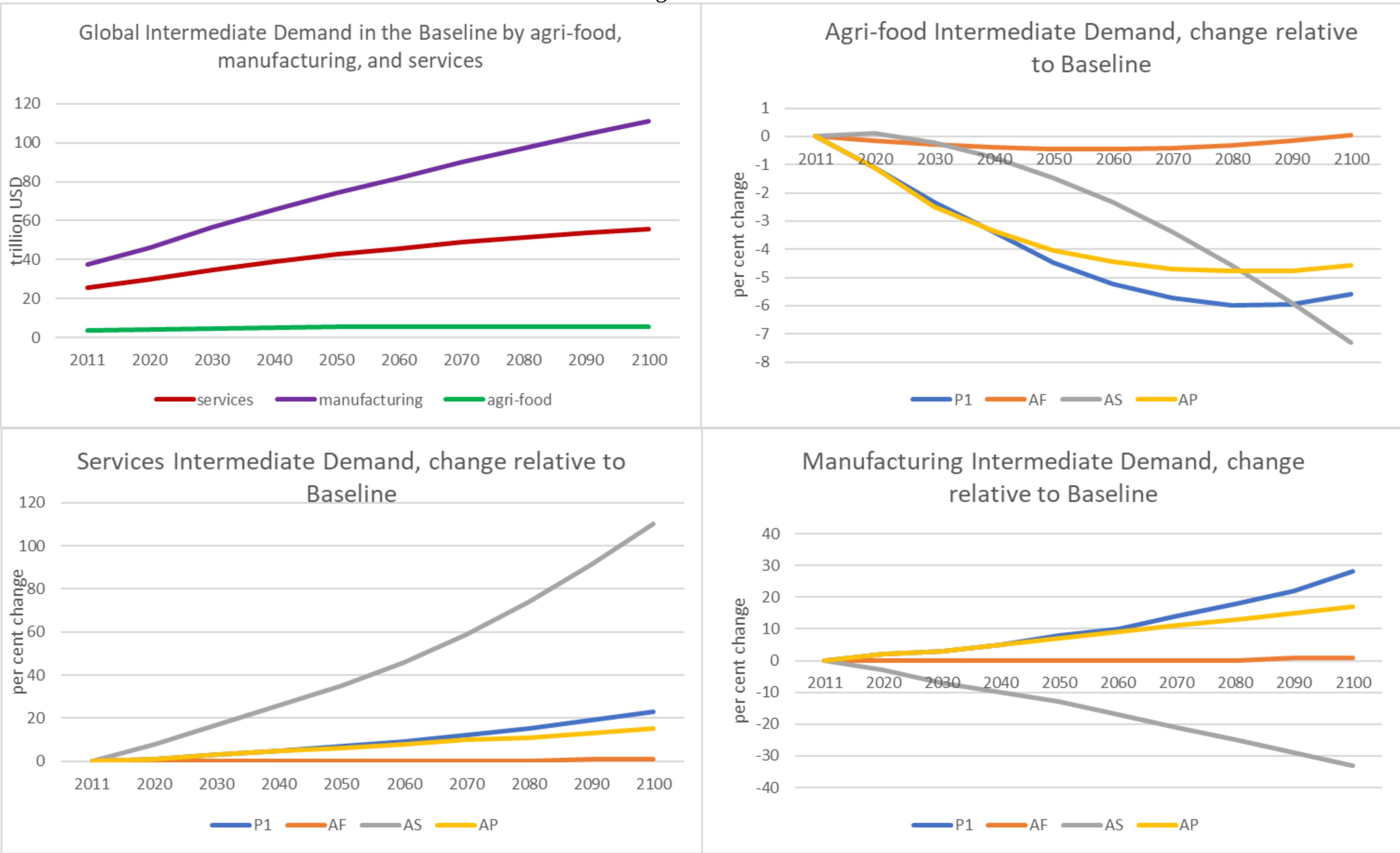

Global Consumption in the Baseline by agri-food, manufacturing, and services
trillion USD
140
120
100
80
60
40
20
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
services
manufacturing
agri-food
Agri-food Consumption, change relative to Baseline
per cent change
40
35
30
25
20
15
10
5
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Services Consumption, change relative to Baseline
per cent change
7
6
5
4
3
2
1
0
-1
-2
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Manufacturing Consumption, change relative to Baseline
per cent change
70
60
50
40
30
20
10
0
-10
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP

Figure 8.

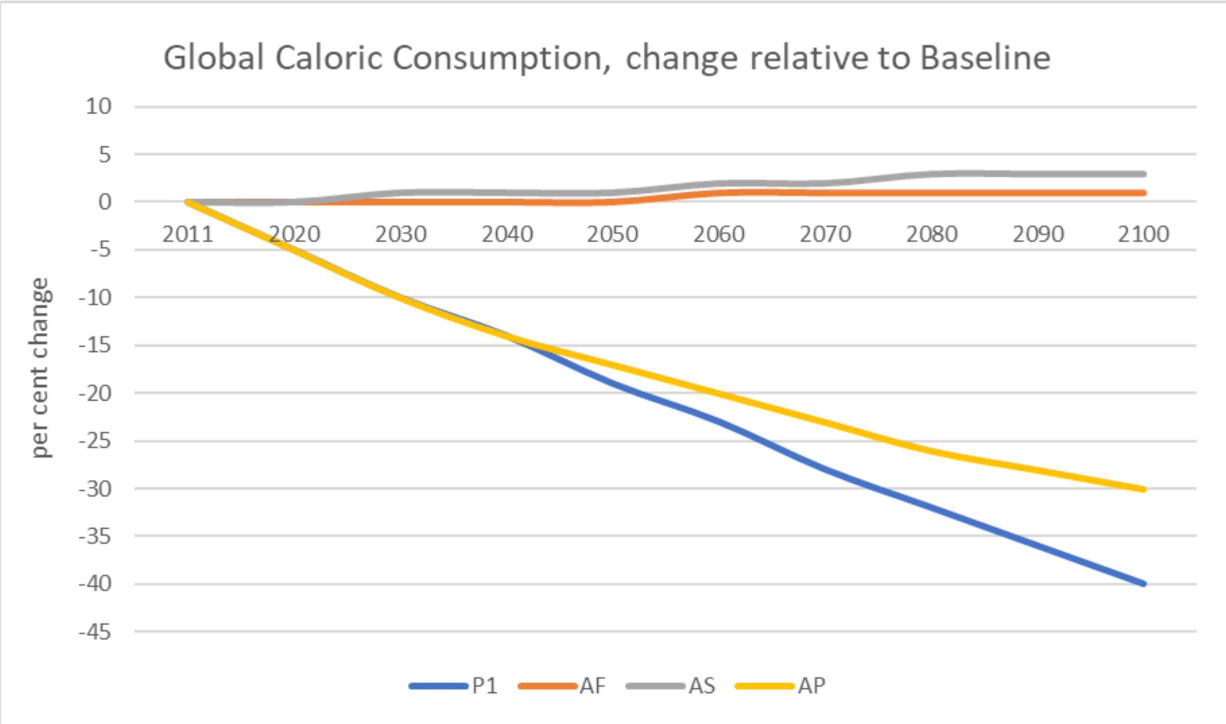


Global Intermediate Demand in the Baseline by agri-food, manufacturing, and services
trillion USD
120
100
80
60
40
20
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
services
manufacturing
agri-food
Agri-food Intermediate Demand, change relative to Baseline
per cent change
1
0
-1
-2
-3
-4
-5
-6
-7
-8
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Services Intermediate Demand, change relative to Baseline
per cent change
120
100
80
60
40
20
0
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP
Manufacturing Intermediate Demand, change relative to Baseline
per cent change
40
30
20
10
0
-10
-20
-30
-40
2011 2020 2030 2040 2050 2060 2070 2080 2090 2100
P1
AF
AS
AP

Across all experiments, demand for agri-food intermediates declines relative to the baselin (Figure 8). This follows suit to the production declines in agri-food across experiments (Figure 6). These production declines once again reflect experiment design, with the large declines in production in experiments P1 and AP due to the implementation of shocks to the ams-style global technology variable in model MAGNET-TrV1, as detailed above. Agri-food production declines due to the reduced services input productivity in AS, as mentioned above, and due to the productivity gains from preferences shifting towards imports in AF.

In terms of consumption, beyond value of consumer goods (food, merchandise, and services), we can also consider the nutriritional aspect of consumption. Figure 9 presents the change in global caloric consumption, relative to the baseline. We observe that global caloric consumption decreases for experiments P1 and AP, whereas global caloric consumption only slightly increases for experiments AF and AS. The decrease of caloric consumption in experiments P1 an AP may appear counterintuitve given the increase of agri-food consumption in experiments P1 ad AP per Figure 7. However, the root of these differences is in the experiment design for P1 and AP, with shocks implemented to the ams-style global technology variable in MAGNET-TrV2.

Figure 9.



Caloric consumption in MAGNET is calculated from sectoral output (*qo*), whereas agri-food consumption is computed from demand (*qfm*, *qfd*). With an ams-style global shock in MAGNET-TrV2, we decrease sectoral output (*qo*) due to the efficiency gains as decribed above, while increasing demand for imported goods (*qfm*). This is why we observe decreased caloric consumption as sectoral output decreases (*qo*) alongside increased agrifood consumption as import demands increase (*qfm*) in experiments P1 and AF.

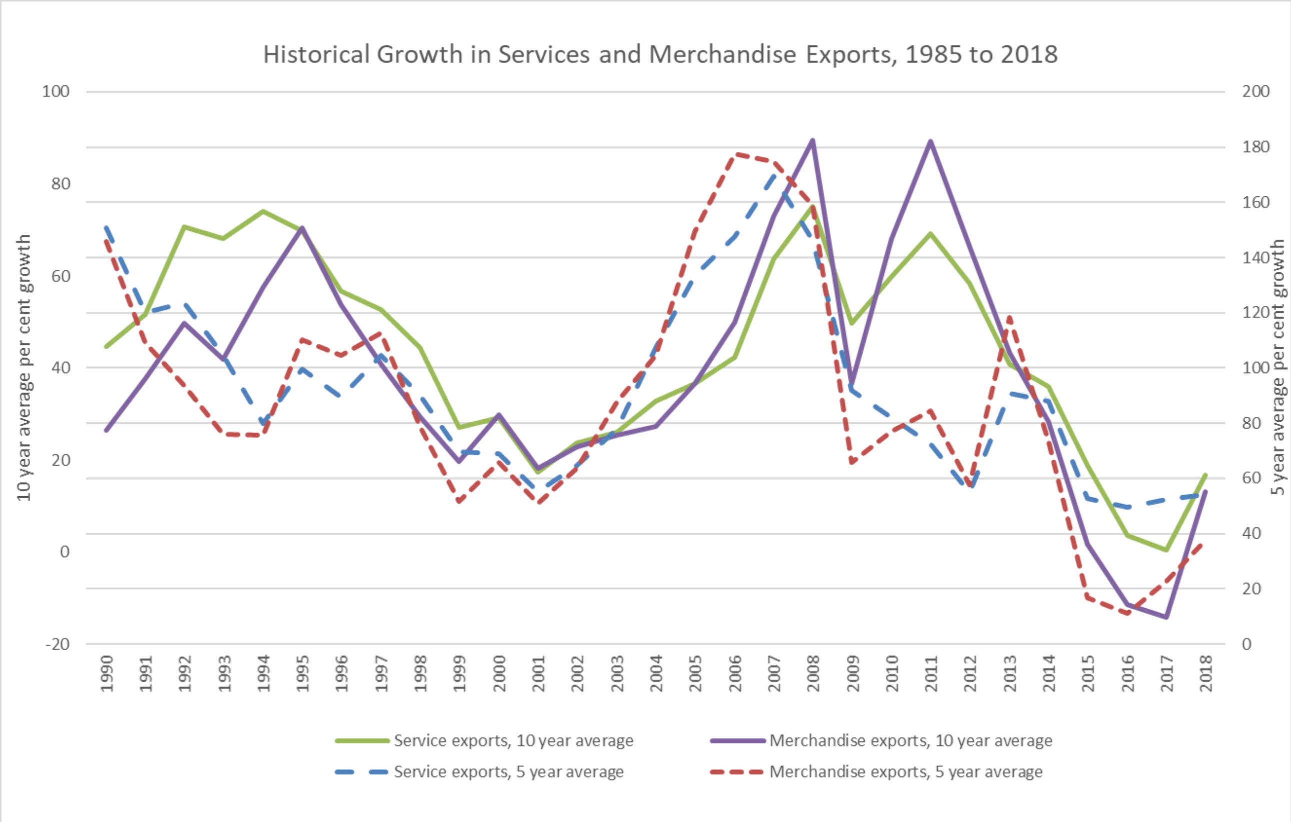
4 Discussion

In this paper, we describe four experiments which we developed to analyze various calibration techniques to target the trade to income elasticity in baseline development. For these experiments, we implement the standard model as well two modified versions of the MAGNET model, MAGNET-TrV1 and MAGNET-TrV2, each with a new global technology variable. From our analysis, we make three observations:

1. Trade to income elasticity is a gross measure to be calibrating. More tailored calibration calls for further research to decompose the underlying channels driving the trade to GDP growth dynamics over time.
2. The development of trade to income elasticity in the long-run (e.g. 100 year span) calls for further research to best implement the projection of the trade to income elasticity in baselines for longer term scenarios.
3. Traditional global technology variables affecting trade as implemented in the Armington equation can create undesired production effects relative to the baseline, similar to in wide-spread NTM implementation.

In regards to point 1, in this paper we implemented a calibrated trade to income elasticity either explicitly or implicitly in three of our experiments (P1, AP, and AF) through two modified model versions MAGNET-TrV1 and MAGNET-TrV2. In these three experiments, we are targeting global trade. The model then adjusts and equilibriates through channels implicit in the model theory. In examining the model adjustment channels in each experiment, we observe the various pathways the model takes which brings to question whether we want to be targeting a gross measure of global trade growth in the baseline or underlying drivers of global trade growth.

Figure 10.



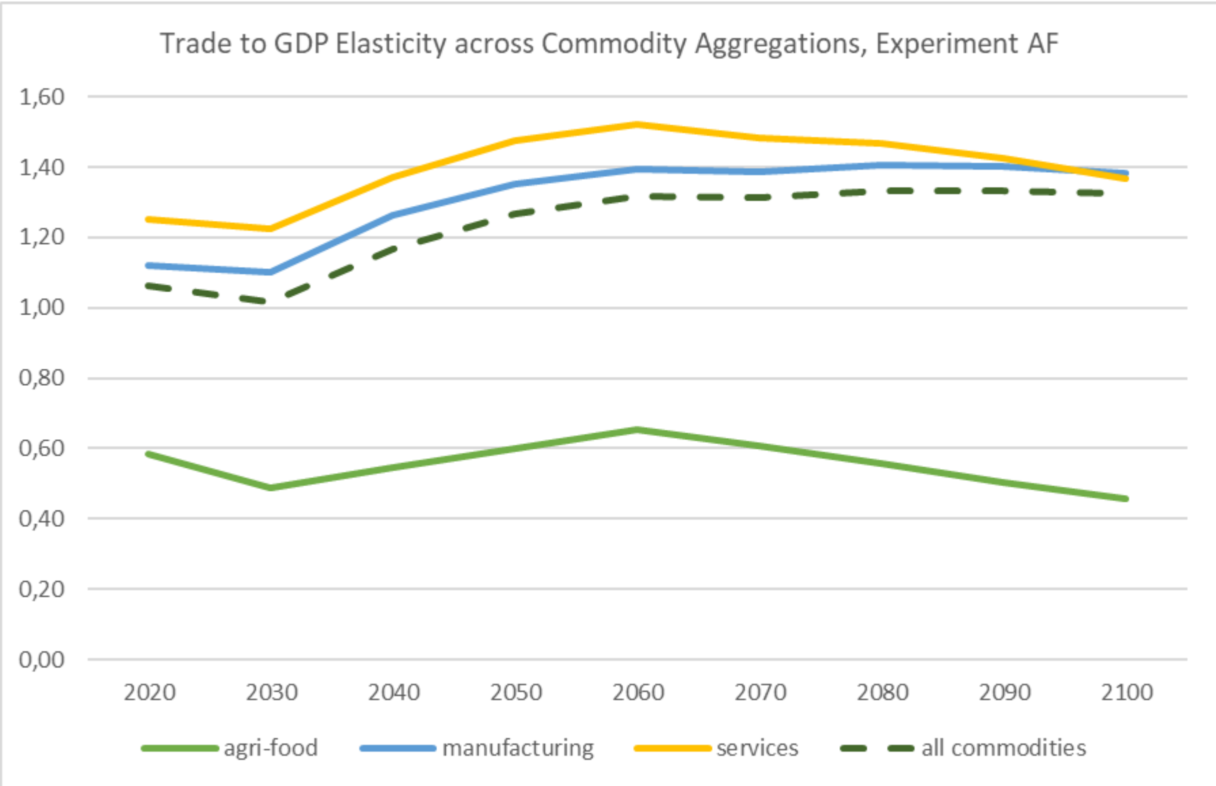
A specific consideration we had was the anticipated development of merchandise versus services trade and how these could affect overall trade growth and hence the trade to GDP elasticity; this inspired our AS experiment. Figure 10 shows historical data for merchandise and services trade from 1985 to 2018. Looking only at the past 5 years (from 2015) we see that growth in services trade has dominated growth in merchandise trade, for both 5 and ten year growth averages. However, looking back over time, we find that this is volatile, and for some periods merchandise trade growth dominates whereas for others services trade dominates. Thus, it would be hard to extrapolate based alone these historical patterns whether future services trade growth should dominate future manufacturing growth and what the impacts might be on the evolution of the trade to GDP elasticity.

Future research should further examine the decomposition of trade to GDP elasticities, through the consideration of subgroupings of global trade (services vs merchandise trade) as well as through both historical trade patterns and plausible future anticipated trade scenarios. An important underlying component of each of these is structural change. For example, we consider that structural change has underpinned the development of historical patterns that we observe, and, as we implement future scenarios to 2100 we are inherently incorporating elements of structural change through the implementation of population and income growth in the baseline, which brings us to point 2 on long-run elasticity calibration.

In calibrating a long-run baseline, we take as exogenous GDP growth projections. Thus, as discussed previously, our calibrated trade to income elasticity depends on the trade growth. In our three experiments where we targeted trade explicitly and implicitly (P1, AP, and AF), we took two approaches to calibration. In AP, we targeted a stable trade to income elasticity over time whereas in P1 and AF we targeted this only in the first period. We then implement income elasticity related shifters calculated in the first period to obtain higher than in baseline trade to income elasticity in the following periods. This brings to question what is the ideal trade to income elasticity in the long-run for a baseline.

In the baseline, is a stable trade to income elasticity preferable to trade to income elasticity which changes across periods ? Does the exact trade to income elasticity matter or is it perhaps more important that the trade to income elasticity remains above a certain level ? Should we account for possible volatility over time implicitly or explicitly ? At the time present, these questions are a matter of judgement for the economist in implementing a an exogenous trade to income elasticity. However, further research should be undertaken to move towards an endogenous mechanism, as discussed further below. This mechanism would account for the underlying drivers of long-run trade dynamics and, hence, would incorporate endogenous drivers of structural change.

Figure 11.



In regards to point 3, the results from our experiments P1 and AP, which rely on the modified MAGNET model MAGNET-TrV1 with a new global technology variable implemented in the Armington equation, demonstrate strongly decreasing production levels compared to the baseline scenario. While, this can be anticipated due to the theoretical mechanism implemented in the model, akin to productivity techniques used to model NTMs, this result is not first-best. This brought us to our second modified MAGNET model, MAGNET-TrV2, with another new global technology variable introduced as a preference twist into the intermediate input sourcing equations. Implementing this second modified model, MAGNET-TrV2, in experiment AF, we find improved results in terms of production levels relative to the baseline.

We can consider the sectoral differences in the trade to GDP elasticity for experiment AF, as observed in Figure 11. Here, we see that at the sectoral level, the highest trade to GDP elasticity is for services, followed by manufacturing. Both trade to GDP elasticities for services and manufacturing are above the broad (across all commodities) trade to GDP elasticity, while the trade to GDP elasticity for agri-food, hovering around 0.6, is far below the level of the broad, cross-commodity elasticity. While this decomposition, on the surface, addresses point 1, further research is needed to assess historical decomposition patterns and to consider future plausible patterns of the trade in order to improve the precision of the calibration of the trade to GDP elasticity across sectors.

The introduction of AF in MAGNET-TrV2 should be implemented with attention. As presented in Figure 9, the global level of caloric consumption does not drastically deviate from the baseline, reaching one per cent higher between 2060 to 2100. However, regional rates of caloric consumption differ from the baseline in experiment AF, as shown in Table 2. Here, we see that the highest differences are for the Western non-EU European region, reaching 14 per cent higher deviations by 2100, followed differences for the Eastern non-EU European region which reached -7 per cent deviation by 2100. To address these deviations in caloric consumptions, the elasticity of consumption needs to be recalibrated.

Table 2. Caloric Consumption by Region, per cent change to the base

Regions	2011	2020	2030	2040	2050	2060	2070	2080	2090	2100
NAO	0	0	1	1	1	2	3	3	3	3
SCA	0	0	0	-1	-1	-1	-2	-2	-3	-3
MEN	0	0	1	1	2	2	2	2	2	2
FSU	0	0	0	-1	-1	-1	-2	-2	-2	-3
SSA	0	0	0	0	0	1	2	3	4	5
EAS	0	0	0	0	0	0	0	0	0	0
SAS	0	0	-1	-1	-1	-1	-1	-1	-2	-2
NEU	0	0	0	1	1	1	1	2	2	2
WEU	0	0	0	-1	-1	-1	-1	-1	-1	0
EEU	0	0	0	0	-1	-1	-1	-1	-1	-1
SEU	0	0	1	2	2	3	3	3	3	3
WNEU	0	1	2	4	6	7	9	11	12	14
ENEU	0	-1	-1	-2	-3	-4	-4	-5	-6	-7
World	0	0	0	0	0	1	1	1	1	1

While we find more technically acceptable results in experiment AF from the implementation of the preference shift in MAGNET-TrV2, this only addresses point 3 in finding an alternate exogenous mechanism for targeting the trade to income elasticity. Points 1 and 2 on the underlying composition and long run dynamics of the trade to income elasticity remain necessary to address in order to introduce best practices in the calibration of the trade to income elasticity. Further, parallel to researching towards points 1 and 2, future research should assess theoretical mechanisms for endogenous achievement of higher trade to income elasticity. Both empirical and theoretical research would need to focus on the underpinnings of trade and, hence, structural change would be an important component. Thus, overall, our observations demonstrate the necessity for further investigation into both empirical underpinnings of the trade to income elasticity as well as theoretical options for endogenous implementation of trade growth targets used to calibrate the trade to income elasticities.

Therefore, based on our observations, we make two recommendations for the calibration of the trade to income elasticity:

1. We recommend using cost-neutral preference twist variables affecting intermediate input sourcing (imports vs domestic inputs) as a technical solution for the exogenous calibration of the trade to income elasticity.
2. We recommend further research into a permanent solution which would merit significant empirical investigation into the underpinnings of the trade to GDP elasticity as well as new theoretical advances such that a "realistic" level could be achieved endogenously within the model.

Thus, in conclusion, we offer an improved technical approach for targeting trade to income elasticity, and we offer guidance in areas of future work to achieve a long-term solution.

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