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Valtion taloudellinen tutkimuskeskus
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Abstract

In this study we use the dynamic version of the GTAP model to analyse the effects of global trade policy changes and their interaction with different global climate policy regimes from Finland's point of view, and in particular, implications for Finnish export sectors. Scenarios explore further trade liberalisation as well as effects of higher-than-current tariffs on world markets. As a complementary dimension we analyse the impact of a global climate agreement that will lead to an additional improvement in energy efficiency and impose limitations to GHG emissions.

We find a general trend towards a greater weight of services sector in Finland's total exports volume, whilst the share of traditionally important heavy industry and electronics industries declines. These trends are amplified by further trade liberalisation and slowed down by new barriers for trade. The global coverage of climate policy is particularly significant for energy-intensive industries.

Key words: trade policy, climate policy, general equilibrium model

JEL classification numbers: F13, Q58, C68

Tiivistelmä

Tässä tutkimuksessa tarkastellaan GTAP-mallin dynaamisen version avulla globaalien kauppapolitiikkamuutosten vaikutuksia Suomen näkökulmasta sekä kansainvälisten ilmastosopimusten toteuttamislaajuudesta riippuen. Erityisesti kiinnostuksen kohteena on Suomen vientiteollisuuden kehitys. Skenaarioissa tarkastellaan paitsi kaupan vapauttamisen vaikutuksia myös nykyistä korkeampien tullien seurauksia maailmanmarkkinoille. Täydentävänä ulottuvuutena analyysissä on globaali ilmastosopimus, joka asettaa kasvihuonekaasujen päästöille sitovat rajat ja jonka tuloksena energiatehokkuus maailmalaajuisesti paranee.

Suomen kokonaisviennin kehityksessä havaitaan palvelusektorin osuuden kokonaisviennistä kasvavan tasaisesti samalla, kun perinteisesti vahvojen vientialojen, kuten raskaan teollisuuden ja elektroniikkateollisuuden, osuudet viennin kokonaisarvosta laskevat. Kaupan vapauttaminen vauhdittaa ja kaupan esteet hidastavat tätä kehitystä. Ilmastopolitiikan maailmanlaajuinen kattavuus on erityisen merkityksellistä energiaintensiiviselle teollisuudelle.

Asiasanat: kauppapolitiikka, ilmastopolitiikka, yleisen tasapainon malli

JEL-luokittelu: F13, Q58, C68

Summary

In this study we present four scenarios which attempt to illustrate the impacts of trade policies under different contexts, and analyse these scenarios with the dynamic version of the GTAP model. The scenarios include two dimensions: global trade policy changes and different global climate policy regimes. We assess the effects from Finland's point of view, and in particular, implications to Finnish export sectors of further liberalisation or introduction of new trade barriers in two different climate policy regimes: a unilateral European policy, roughly corresponding to the present situation, and a globally covering agreement.

We find a general trend towards a greater weight of services sector in Finland's total exports volume, whilst the share of traditionally important heavy industry and electronics industries declines. Trade liberalisation tends to reduce the exporting volumes of the traditional manufacturing sectors whereas especially services sector benefit. Conversely, establishing new trade barriers tends to favour the old industries.

For nearly all sectors, the changes due to trade liberalisation or bloc formation are more favourable or less detrimental when a global climate policy agreement is in place. This effect is particularly clear for energy intensive industries.

Underlying drivers behind the general trends observable in all scenarios are the world markets for scarce commodities, namely energy, food and raw materials such as iron ore. These, in turn, are affected by the constantly increasing demand following the increase in global population and economic growth especially in Asia and the developing world.

The results are in line with other similar studies on trade liberalisation conducted using applied general equilibrium models, and reflect the traditional gains from trade, on one hand, and the relative competitiveness effect on industries following different climate policy regimes.

This study has been funded by the Finnish Ministry for Foreign Affairs. The views expressed herein are those of the writers and do not necessarily represent the official position of the Ministry.

Contents

1. Introduction

Integration of world markets has proceeded step by step during the past 60-odd years. Overall, the development has been positive: trade and foreign investment have increased rapidly as political barriers have been dismantled, and countries that have joined this integration have seen their economies and prosperity grow faster than those countries have remained outside the process.

Presently there remain only relatively few and low tariffs in the trade of manufactured products between industrialised countries and more generally those countries that have joined the World Trade Organization, WTO. Non-tariff barriers are a more complicated and problematic issue nowadays than actual tariffs.

In this study we use the dynamic version of the GTAP model to analyse the effects of further trade liberalisation (implementation of the Doha Round), and to analyse how higher-than-current tariffs would hit the world markets.

As a complementary dimension we analyse the impact of a global climate agreement that we assume will lead to an additional annual improvement in energy efficiency by 0.5 per cent in the EEA and to a 1 per cent annual decrease in CO2 emissions in the rest of the world with an overall improvement in energy efficiency similar to that in the EEA. These two dimensions – trade liberalisation/restrictions and a global climate agreement – allow us to compare four different scenarios to our Reference Scenario. The latter includes the climate agreement implemented within the European Union to lower CO2 emissions, the reform of the Common Agricultural Policy, and Russia's forthcoming WTO membership which is potentially important from the Finnish point of view.

Literature review

Computable General Equilibrium (CGE) models have been widely used and become a standard tool of international trade analysis. While the main purpose of the present study is not to conduct a detailed analysis of the possible WTO Doha round negotiation results, and hence the scenarios with trade liberalisation represent only a rather stylised version of tariff cuts based on earlier studies (namely Laborde and Martin 2010 a, b), the WTO negotiations provide us a useful frame of reference. Anticipated impacts of the Doha round have been analysed in a number of applied studies since the negotiations were initiated. Hess and von Cramon-Taubadel (2008) already counted more than 1200 studies that analyse some aspect of the Doha negotiating round, of which roughly 400 studies with numerical estimates. International organisations and research institutes that follow the negotiations closely are publishing numerical estimates of updated potential Doha agreements at a regular basis. Such institutes and

studies include, among others, the World Bank, International Food Policy Research Institute (IFPRI) (Berishi-Krasniqi, et al, 2008; Laborde, et al, 2012) and Centre d'Études Prospectives et d'Information Internationales (CEPII) (Decreux and Fontagné, 2008).

Recent research that applies comparable methodologies in a context similar to this study includes, inter alia, Baltzer et al. (2009) on Doha round trade liberalisation from global and Danish perspective, focusing on agricultural and NAMA liberalisation but with additional scenarios on issues such as tariff escalation in agriculture and anti-concentration in NAMA. Globally oriented CGE analyses have been conducted e.g. by Decreux and Fontaigné (2008), estimating the outcome of an agreement with detailed provisions for agricultural and NAMA liberalisation as well as a simple assumption regarding services liberalisation, and Francois et al. (2005) with more generalised assumptions. Decreux and Fontagné use a dynamic model (MIRAGE) whereas a majority of the other studies is made with static models. Differences in methodology and scenario design make comparing the results of these studies not straightforward. Also the estimates for parameter values, such as Armington elasticities, which are very important in applied trade models, greatly affect the size of economic impacts.

Though there has not so far been a thorough assessment of eventual future trade liberalisation implications for Finland based on a general equilibrium model, a handful of studies focus on a particular sector or policy question. For example, Huan-Niemi et al. (2010a) – which uses the same model and data as the present study – and Huan-Niemi et al (2009) assess WTO trade liberalisation implications to Finnish and EU agriculture and food industry. The competitiveness of energy intensive industries under different global or European climate policy regimes has been studied with the dynamic GTAP model in conjunction with VTT's energy system models in a couple of recent research projects (Lehtilä et al. 2009; Niemi and Honkatukia 2010 a,b.) Furthermore, Sulamaa and Widgren (2005) and Kaitila (2007) have analysed the effects of free trade between the EU and Russia.

2. Main features of the scenarios

Scenarios are descriptions of alternative development paths. In principle, there are an infinite number of them, and they can be constructed on the basis of several variables. For practical reasons their numbers must be limited to just some and the alternatives must be simplified and clearly differentiated. One criterion in the selection of the main variables is that they are as independent of each other as possible so that the resulting matrix of alternative scenarios will represent different future states of world with distinguishable driving forces. It is difficult, however, to find fully independent variables.

First, we construct a Reference Scenario, to which the alternative scenarios 1–4 are compared. The Reference Scenario includes the commonly accepted characteristics of the development of the world economy (see Table 1 and the annex for more specifications). One important development is the increasing shortage of at least some raw materials, and their increasing prices as a consequence. The Reference Scenario includes Russia's membership in the WTO–a potentially important factor for Finnish foreign trade – as well as the already agreed climate policy of the EU and the reform of the Common Agricultural Policy.

We sketch the alternative scenarios on the basis of two policy dimensions: 1) *world trade agreements* (global multilateralism vs. regional trade blocs) and 2) *climate policies*. Global multilateralism, e.g. via the Doha objectives of the World Trade Organization (WTO), will increase competition and improve resource allocation. International co-operation in climate policy (i.e. stricter limits to CO2 emissions etc.) will lead to the development of more energy-saving technologies and thus also to faster economic growth in an environmentally more sustainable way. These two variables (dimensions) are sufficiently independent from each other (see Figure 1).

Regulation of foreign trade and investment affects the degree of freedom in the international economic activities of firms. This in turn is related to economic growth. Multilateralism promotes the efficient allocation of resources globally. In Scenarios 1 and 2, the remaining obstacles (in terms of tariffs) to trade in manufactured goods will be dismantled, and progress will be made in lowering barriers to trade in services and agricultural goods (see Table 1). On the other hand, Scenarios 3 and 4 can be described as steps backwards for the world economy because tariffs will actually be raised from their current levels.

Development in energy efficiency is the second dimension. This results from technological development following the formation of a global climate policy (Scenarios 1 and 3). We assume that the policy will be promoted by creating

standards for firms and individuals internationally. It will be spurred further by national innovation policies.

A priori, Scenario 1 can be regarded as the best scenario at the global level and Scenario 4 as the worst from the point of view of economic development and international cooperation: Scenario 1 includes both 'good' elements and Scenario 4 neither of them. The actual consequences of these scenarios are, however, multidimensional and not as clear-cut as a priori reasoning may indicate. We will see that the effects of the international climate policy on world output will be stronger than those of further trade liberalisation. This is seen in Scenario 3, where the positive global effects of climate policy outweigh the negative effects of a halt (and indeed a turnaround) in trade liberalisation. World trade in manufactured goods is already rather free and the effects of additional steps are limited.

Figure 1 Main features of the four scenarios (see also Table 1)

		TRADE POLICIES	
		Multilateralism Lower import tariffs worldwide (Doha Round)	**Bilateralism** Restrictive and competitive trade arrangements. Higher-than-current tariffs.
CLIMATE POLICIES	**International climate policy** Global CO2 emission reduction policies Innovations for improved energy efficiency globally	**Scenario 1: Sustainable Prosperity** - Fast GDP growth - Gains from trade enhance technology improvements.	**Scenario 3: Mutual Suspicion** - Mediocre GDP growth - Technology improvements not fully exploited due to obstacles in international trade.
	No international climate policy CO2 emission reduction policies only in the EU Moderate energy efficiency improvement only in the EU	**Scenario 2: Multilateralism** - Mediocre GDP growth - Diminished competitiveness of EU energy-intensive industries - Moderate gains from trade through allocation and more efficient use of technologies.	**Scenario 4: Blocs** - Slow GDP growth - Diminished competitiveness of EU energy-intensive industries, but compensated with tariff protection

3. Description of the GTAP model and data

The simulations in this study employ the Global Trade Analysis Project (GTAP) database and the VATT version of the dynamic GTAP model, a recursive-dynamic applied general equilibrium model. General equilibrium (CGE) models are nowadays a standard tool for analysis where large economic shocks can have an impact on both the production and price levels of the economy. TAP model applications are widely used in research, particularly in a broad scope of international trade. A more detailed description of the model is provided in the technical annex to this report.

The GTAP 7.1 Database (Narayanan and Walmsley 2008) contains data for regional economies based on input-output tables, and complete bilateral trade information, transport and protection linkages among 112 regions for all 57 commodities for a single year base year (2004). The regions and commodities in the database cover, with few exceptions, the entire volume of the world (formal sector) economy. For the purposes of this study, this data has been aggregated to 18 regions and 22 commodities (see the technical annex for details). The first criterion in selecting the regions and commodities for aggregation is their importance to Finland's foreign trade, based on the current situation and recent trends or perceived potential for growth. In the regional aggregation, existing free trade arrangements and customs unions have also been taken into account, as this allows a more accurate treatment of import tariffs in the trade liberalisation scenarios. Conversely, in the commodity aggregation, primary products have been kept separate as their demand and price developments underlie global trade trends, although these products constitute only a small fraction of the total trade volume.

The GTAP model assumes current production and trade structures as starting points. These structures change endogenously in different scenarios. The model does not, however, assume any explicit policy changes beyond trade and climate policies or any strategic changes in the firm behaviour. These kinds of changes will certainly happen in the future. One aim of our study is indeed to point out outcomes of trade policy changes in different global contexts, so that also policy makers and firms can anticipate them and be prepared to change their course of action, if necessary.

4. Outcomes in different scenarios

In the following, we will present the GTAP model results in the different scenarios. We start by formulating the Reference Scenario. After that we will present, in Section 6, development in each of the Scenarios 1-4 relative to the predicted development in the Reference Scenario.

Table 1 shows the policy changes made in the four scenarios at different points in time. Trade liberalisation will proceed in steps: Russia's WTO membership in three steps between 2012 and 2018, and the Doha Round in six steps between 2013 and 2023. On the other hand, the trade restrictions in Scenarios 3 and 4 will be raised all at once in 2015. The global climate policy will be implemented all at once from the onset in 2010. Our analysis covers the years 2010–2030.

Table 1 Trade and climate policy changes in the different scenarios

			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025 →
Reference Scenario																		
	Trade policy	**Russia**			1		2		3		3							
		CAP		1														
	Climate policy	**EU**	→															
In addition to these in the other scenarios:																		
Scenario 1: Sustainable Prosperity																		
	Trade policy	**Doha**				1		2		3		4		5		6		
	Climate policy	**World**	→															
Scenario 2: Multilateralism																		
	Trade policy	**Doha**				1		2		3		4		5		6		
	Climate policy	**–**																
Scenario 3: Mutual Suspicion																		
	Trade policy	**Blocks**						→										
	Climate policy	**World**	→															
Scenario 4: Blocks																		
	Trade policy	**Blocks**						→										
	Climate policy	**–**																

Russia in WTO (In the Reference Scenario and in the other four scenarios)
Reforms required for Russian accession to WTO are implemented in three stages (2012, 2014 and 2018). In stages 1 and 2, total tariff cuts ranging from 19% to 23%, depending on sector, are implemented for all sectors not classified as sensitive, and all agricultural domestic subsidies are reduced by half. Tariff cuts for sensitive products (agriculture, motor vehicles, and other transport equipment) are implemented with a slower schedule in stages 2 and 3.

CAP reform (In the Reference Scenario and in the other four scenarios)
Removal of all remaining export subsidies for the agrifood sector as part of the 'Health check' of EU's Common Agricultural Policy reform. Implemented in 2011.

Doha round (Scenarios 1 and 2)
Import tariffs estimated by Leborde and Martin (2010 a, 2010b) and implemented in six stages. Stages 1 to 3 (2013, 2015 and 2017) consist of gradual tariff cuts in high-income countries. In stages 4 to 6 (2019, 2021 and 2023), tariffs are lowered in developing countries and newly admitted member countries. Average tariffs before and after Doha Round cuts are as follows:

	All high-income countries	*EU*	*Middle-income countries*	*Least Developed Countries*
Manufactured goods	1.6% → 1.0%	1.8% → 1.0%	6.1% → 4.6%	10.9% → 8.0%
Agricultural products	31% → 3%	24% → 2%	53% →33%	94% → 59%

Bloc tariffs (Scenarios 3 and 4)
The world is divided into four 'blocks: Western Europe (= European Economic Area, EEA), Eastern Europe (Russia and rest of the former Soviet Union), the Americas, and 'The Chinese Hegemony' (China, South-East Asia and Developing Africa). Japan and Australia are left outside the blocks. An additional and uniform 10% tariff is applied from 2015 onwards to all imports from outside the trading blocs.

EU climate policy (In the Reference Scenario and in the other four scenarios)
EU+EFTA: current policy, translating into a 1% annual decrease in CO2 emissions. An improvement in energy efficiency to allow a 20% reduction in the use of primary energy (2020 compared to 1990). No climate policy change in the rest of the world, and thus no energy efficiency improvement there. Implementation: total period.

World climate policy (Scenarios 1 and 3)
EU+EFTA: An additional annual improvement in energy efficiency by 0.5%. In the rest of the world, a 1% annual decrease in CO2 emissions and an overall improvement in energy efficiency similar to EU-EFTA. Implementation: total period.

5. Reference Scenario

5.1 Assumptions

The Reference Scenario encompasses 'normal' structural change due to changes in GDP and population growth in different regions. We use the growth projections for population, labour force, productivity and GDP by international organisations (United Nations, IMF, World Bank and ILO) and from a global economy scenario developed for use by a comparable simulation model by the French CEPII research institute (Fouré et al. 2012). Information from a baseline scenario produced by the VATTAGE model for Finland is used to adjust the Finnish economic development in the reference scenario (see the Appendix).

We assume that the EU commitments already made in terms of CO2 emissions will continue. A potentially important factor for Finland, Russia's WTO membership, is taken into account already in the Reference Scenario, because it has already been settled (see Figure 32 in the Appendix for the impact on Finnish exports to Russia following the WTO membership).

One underlying hypothesis is that population growth will lead to increasing demand for food produced with limited land resources. This will lead to increasing food prices as productivity growth is not expected to keep up with the increase in demand for food. The share of the 'agrifood' sector in total world output (in terms of both value and quantity) will nevertheless increase. The share in total value will increase more than in total quantity because of the increase in relative food prices. This logic will also apply to many raw materials (like ferrous metals). Meanwhile, also the share of services in world GDP will increase due to structural changes in demand and technology.

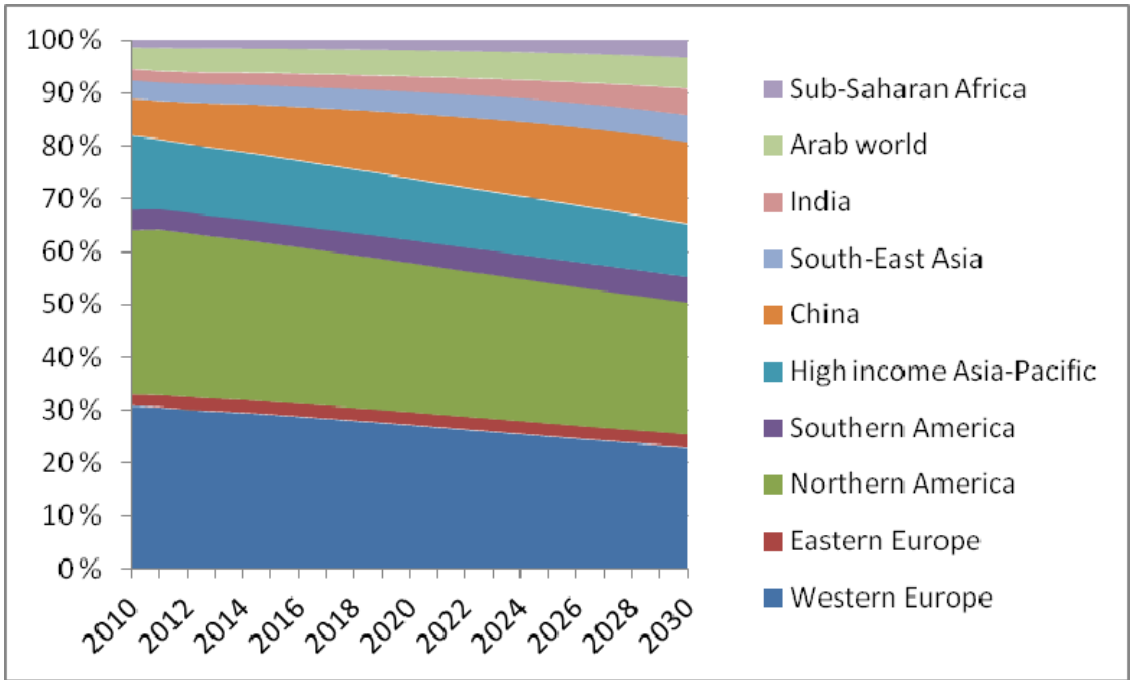
5.2 GDP

In the Reference Scenario, world GDP growth in constant prices will average 3.1 per cent over the next 20 years. Finnish GDP growth will average 1.9 per cent. Average GDP growth in the other regions ranges from 1.3 per cent in Japan to 7.7 per cent in China (see details in the Annex, Table 5.). In all regions, the GDP growth is driven by increase in productivity and capital intensity. Labour force growth in most of the developed world is very modest or even negative. In the developing world, total labour force grows on average between 1 and 3 per cent §annually. Details are presented in Table 6 in the Annex.

The share of the EEA region (EU and EFTA) in world GDP in current prices will decline from 31 per cent to 23 from 2010 to 2030 and that of North America from 31 to 25 per cent (see Figure 2). The share of the high-income Asia-Pacific region will decline from 14 to 10 per cent. On the other hand, China's share will rise from 7 to 16 % and that of India from 2 to 5 per cent.

As the economic weight of East and South Asia will increase in the world, also growth in export markets will concentrate there. Europe, as a wealthy and geographically close internal market, will remain the most important trading partner for Finland, but its share in total trade will decline in all scenarios.

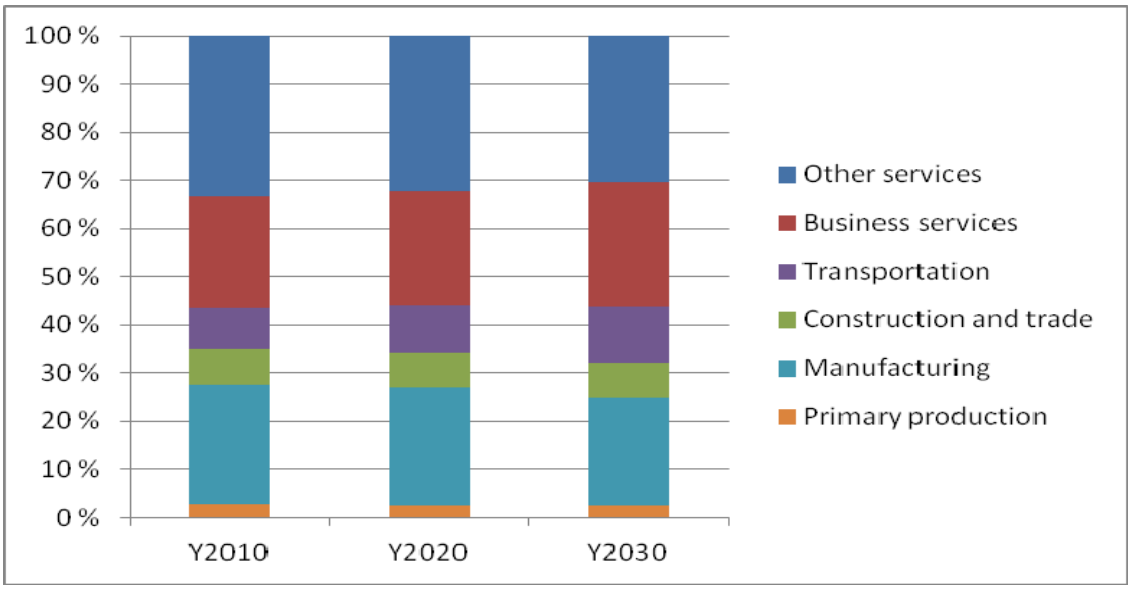
Figure 2 World GDP shares by regions, per cent, computed from current prices USD (not purchasing power)



5.3 Structure of the Finnish economy

Figure 3 presents the structure of the Finnish GDP in the Reference Scenario in 2010, 2020 and 2030 in current prices. The share of business services in total GDP will rise from the current 23 per cent to 26 per cent by 2030. Also the share of transportation will increase from 8 to 12 per cent. Meanwhile the share of manufacturing will decline from 25 to 22 per cent and that of other services, including public services, from 33 to 30 per cent (see the Appendix for detailed list of sector-wise aggregation).

Figure 3 *Decomposition of output (value added, current prices) in Finland in the Reference Scenario in 2010, 2020 and 2030*



5.4 Structure of Finnish foreign trade

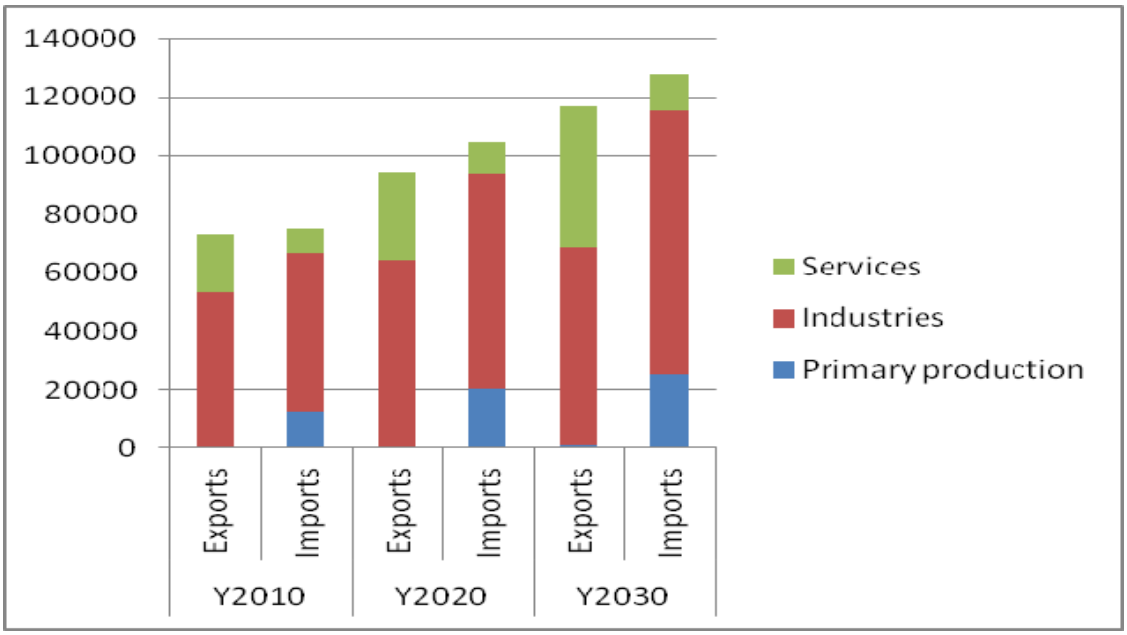
Figure 4 shows the development of Finnish total trade in the Reference Scenario, both in terms of value and share in the total. Total exports will growth at an average annual rate of 2.3 per cent and total imports by 2.7 per cent. On average, the exports in services will grow by 4.5 per cent, manufactured goods by 1.3 per cent and primary production by 2.0 per cent. Imports will grow by 1.7, 2.6 and 3.5 per cent, respectively.

As both exports from and imports from Finland grow faster than the GDP, we observe an increasing the importance of foreign trade for the Finnish economy during the simulation period. In 2010, the value of both imports and exports were around 40 per cent of the Finnish GDP. In 2030, the simulated value of exports from Finland is 55 per cent of the GDP whereas the value of imports to Finland reaches almost 70 per cent of the GDP.

Consequently, the share of services in total exports will rise from 27 per cent in 2010 to 41 per cent in 2030, while the share of manufactured goods will decline from 72 per cent to 58 per cent. A disaggregation of different types of services shows us that the share of other services will rise from 3 to 5 per cent, that of business services from 13 to 20 per cent, the share of construction and trade from 6 to 7 per cent, and the share of transportation from 5 to 9 per cent of total exports.

The shares will be much more stable in imports with the share of services declining from 12 to 10 per cent, that of manufactured goods remaining at 71 per cent and that of primary production rising from 17 to 20 per cent.

Figure 4 *Structure and value of Finnish total exports and imports by sectors in the Reference Scenario (current prices)*



Shares of total exports	2010	2020	2030
Services	27 %	32 %	41 %
Other services	3 %	4 %	5 %
Business services	13 %	14 %	20 %
Construction and trade	6 %	7 %	7 %
Transportation	5 %	7 %	9 %
Industries	72 %	67 %	58 %
Primary production	1 %	1 %	1 %

Shares of total imports	2010	2020	2030
Services	12 %	10 %	10 %
Industries	71 %	70 %	71 %
Primary production	17 %	20 %	20 %

The value of total exports to the EEA will grow by 34 per cent between 2010 and 2030 and the value of exports to non-EEA countries by 94 per cent. Exports to

Russia will grow by 83 per cent, Eastern Europe by 75 per cent, North America by 16 per cent, South America by 67 per cent, high-income Asia-Pacific by 7 per cent, China by 216 per cent, South-East Asia by 106 per cent, India by 243 per cent, the Middle East and North Africa by 74 per cent and Sub-Saharan Africa by 258 per cent.

Such diverging growth patterns will of course lead to changes in the regional structure of exports. The share of the EEA countries in total Finnish exports was 58 per cent in 2010. According to the Reference Scenario, this share will decline to 49 per cent by the year 2030. Meanwhile, the share in imports will go from 59 to 61 per cent.

The Reference Scenario then also includes the following larger changes in shares of Finnish total export destinations between 2010 and 2030: Russia from 12.8 to 14.7 per cent, North America from 6.3 to 4.6 per cent, high-income Asia-Pacific from 2.5 to 1.7 per cent, China from 4.5 to 8.9 per cent, South-East Asia from 3.3 to 4.3 per cent, India from 0.9 to 1.9 per cent, the Middle East and North Africa from 5.7 to 6.3 per cent and Sub-Saharan Africa from 2.1 to 4.7 per cent. Figure 6 shows the per cent distribution of total non-EEA exports; the figures there are of course different due to a different denominator.

Figure 5 Finnish exports by destinations in the Reference Scenario

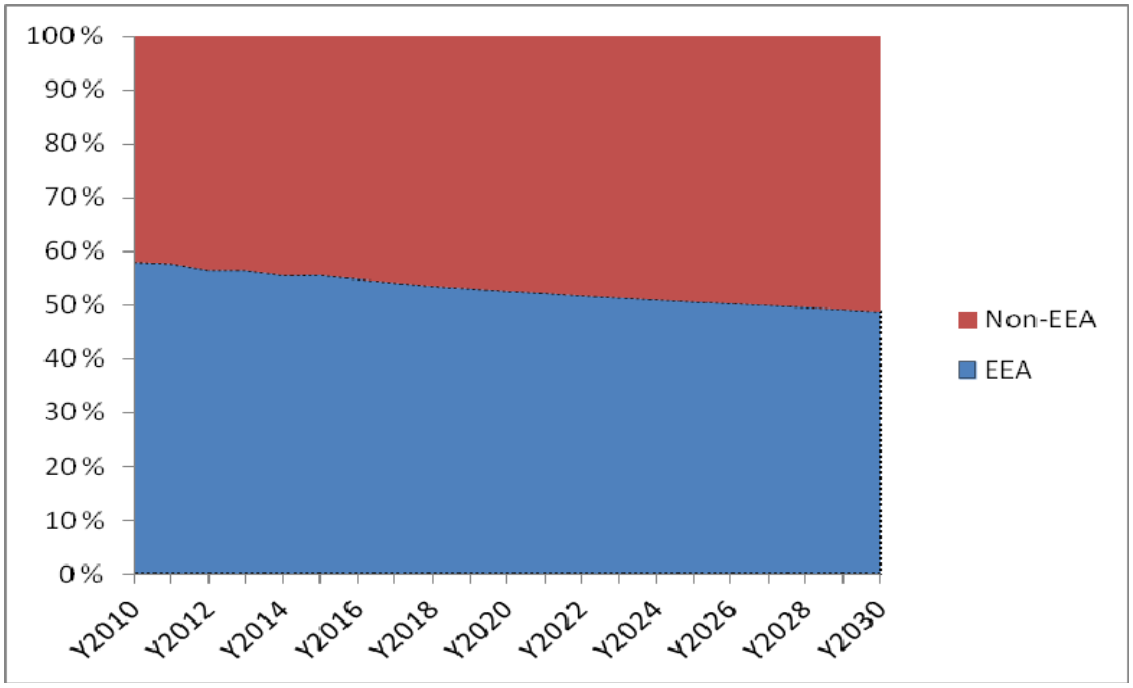
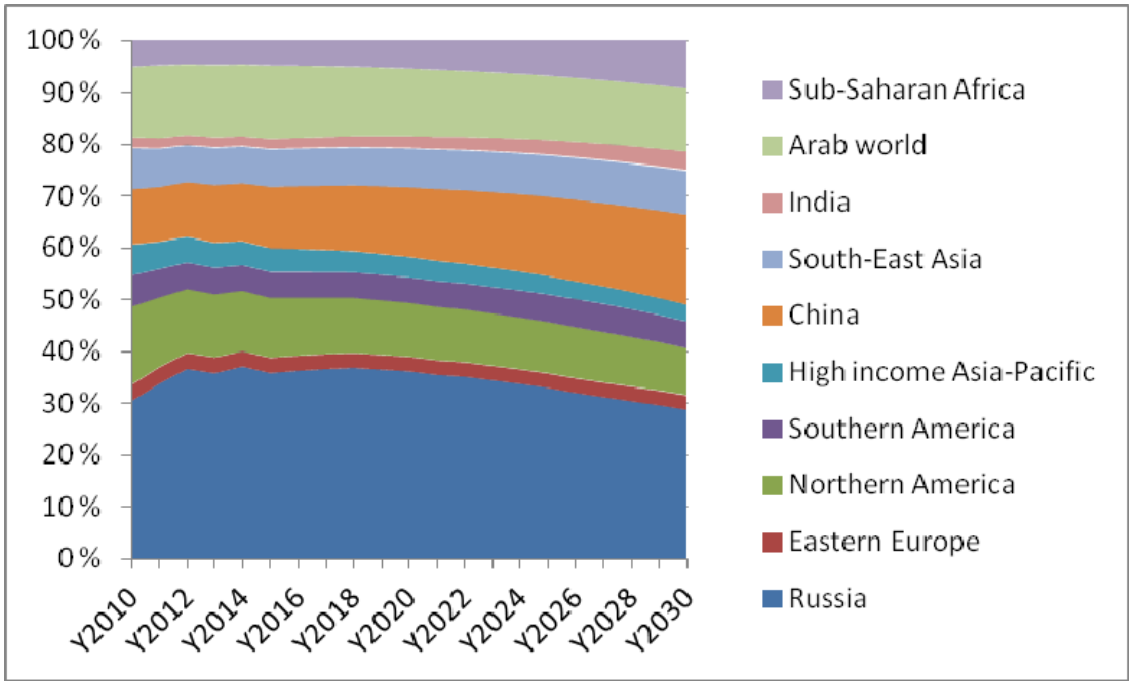


Figure 6 *Finnish exports to non-EEA countries by destinations in the Reference Scenario*



6. Four trade and climate policy scenarios

Sections 5.1 to 5.4 present the results from our four scenarios. For the most part, the results are presented as per-cent differences relative to the results in the Reference Scenario depicted above in Section 5. In broad terms, we observe similar effects of trade policies and climate policies in all scenarios. The results are presented below by scenario. Common features and overall comparisons between scenarios are discussed under the first scenario.

6.1 Scenario 1: Sustainable Prosperity

Scenario 1 differs from the Reference Scenario in that tariffs on foreign trade will be further lowered which will improve resource allocation at a global level. Furthermore, a global climate policy agreement will lead to global CO2 emission reduction policies and an improvement in energy efficiency. Both dimensions will support faster GDP growth.

6.1.1 GDP

As we can see from Figure 7a, Scenario 1, i.e. 'Sustainable Prosperity', will lead to the fastest world GDP per capita[1] growth of all the scenarios. The difference of the GDP per capita level to that in the Reference Scenario is 2.1 per cent in 2020 and 3.7 per cent in 2030. The difference grows over time and therefore the difference in terms of accumulated consumption is much larger than this.

Scenario 1 offers considerable gains for the EU, too, as can be seen from Figure 7b. GDP and GDP per capita will be 2.6 per cent higher than in the Reference Scenario in 2020 and already 7.3 per cent higher in 2030. However, as can be seen from the fact that there is hardly any difference between Scenarios 1 and 3 for the EU, further trade liberalisation has little to offer the Union. Instead, the value of global climate policy is considerable for the EU as can be seen from the difference to the other two scenarios. The difference is that the EU already has a regional climate policy in the Reference Scenario which makes output in the Union less competitive. Global climate policy would level the playing field vis-à-vis the rest of the world.

Sustainable Prosperity is the best Scenario for Finland, too. Relative to the Reference Scenario, GDP will be 2.2 per cent higher in 2020 and 4.5 per cent higher in 2030. Unlike for the EU on average, there is a difference between this scenario and Scenario 3.

[1] And also GDP, because population growth is the same in all the scenarios.

Figure 7a *World GDP per capita (constant prices) in Scenario 1 relative to Reference Scenario, %*

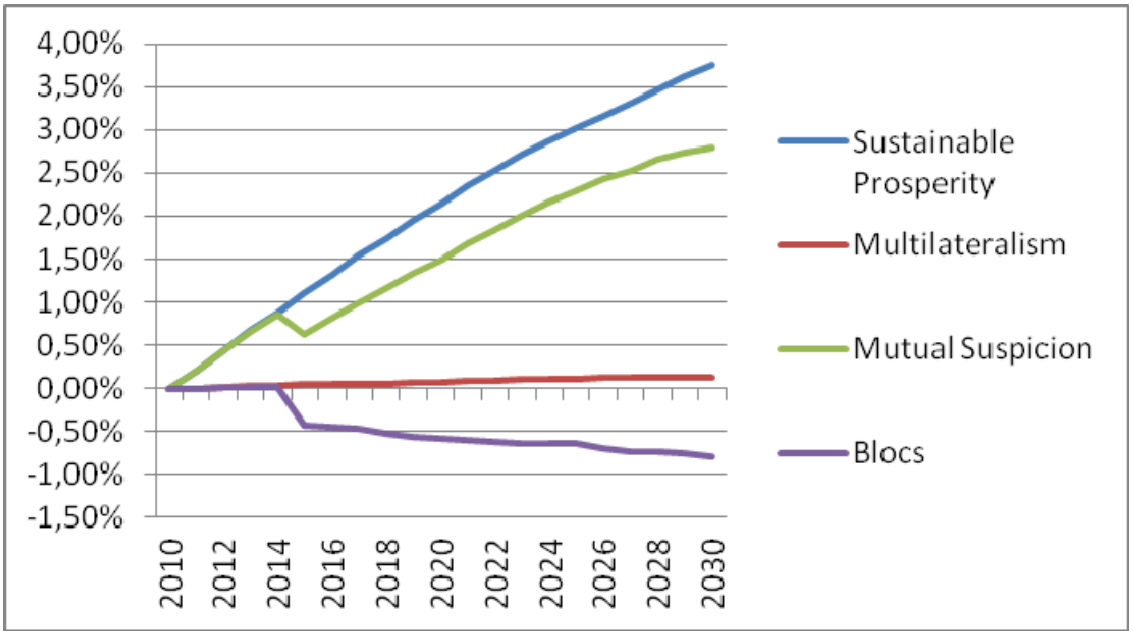


Figure 7b *EU GDP per capita (constant prices) Scenario 1 relative to Reference Scenario, %*

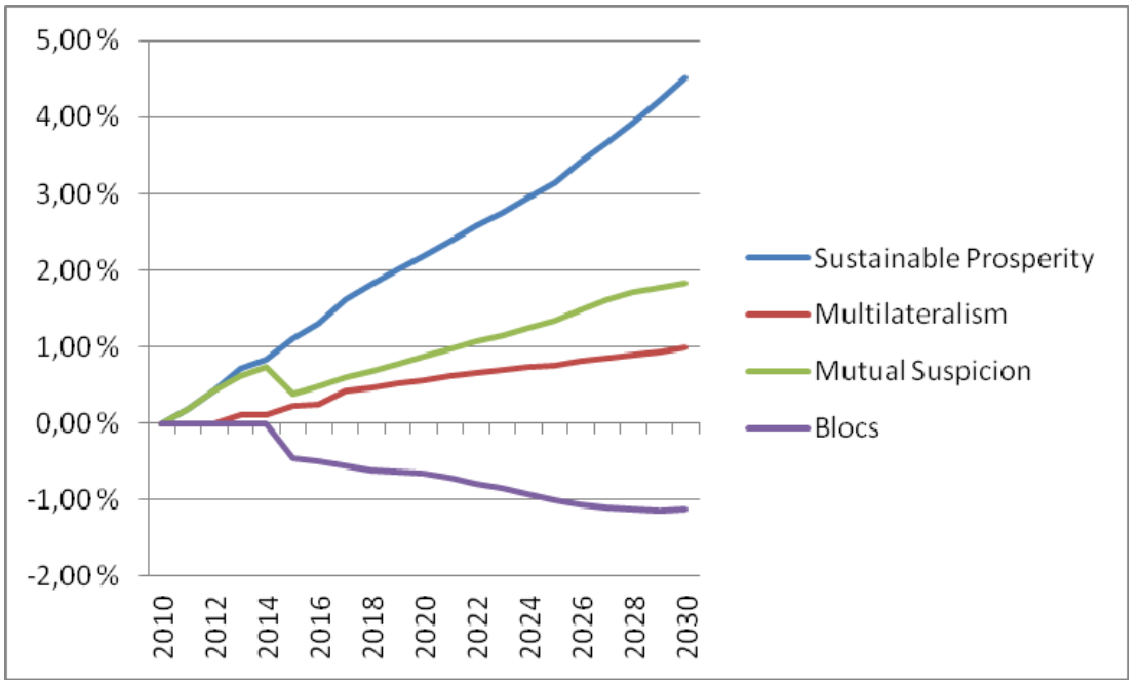
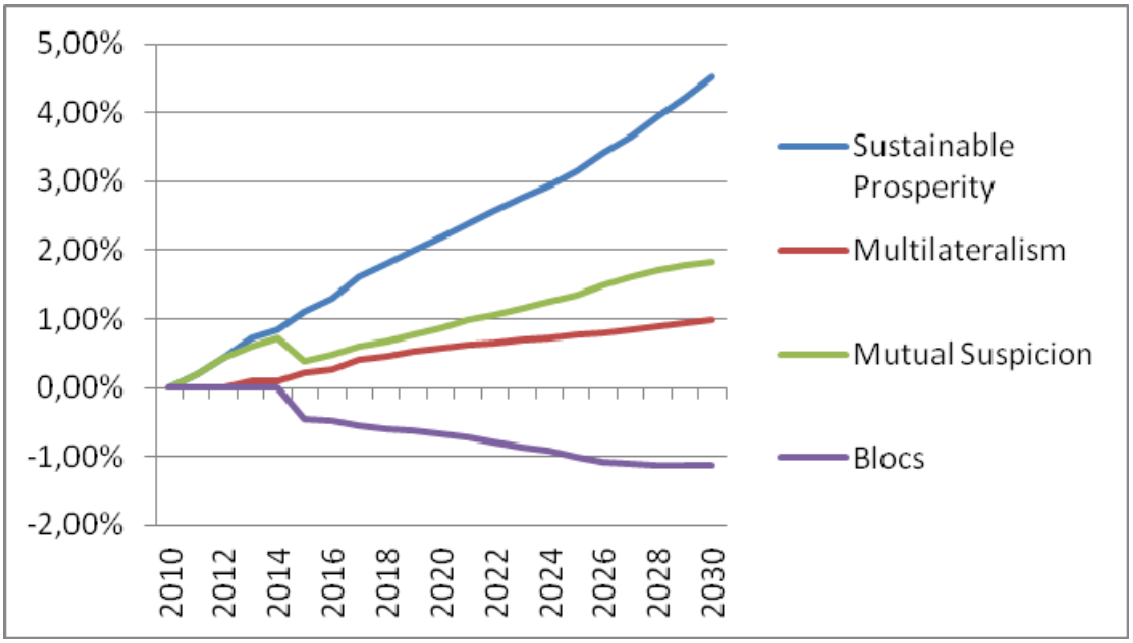


Figure 7c *Finland GDP per capita (constant prices) Scenario 1 relative to Reference Scenario, %*

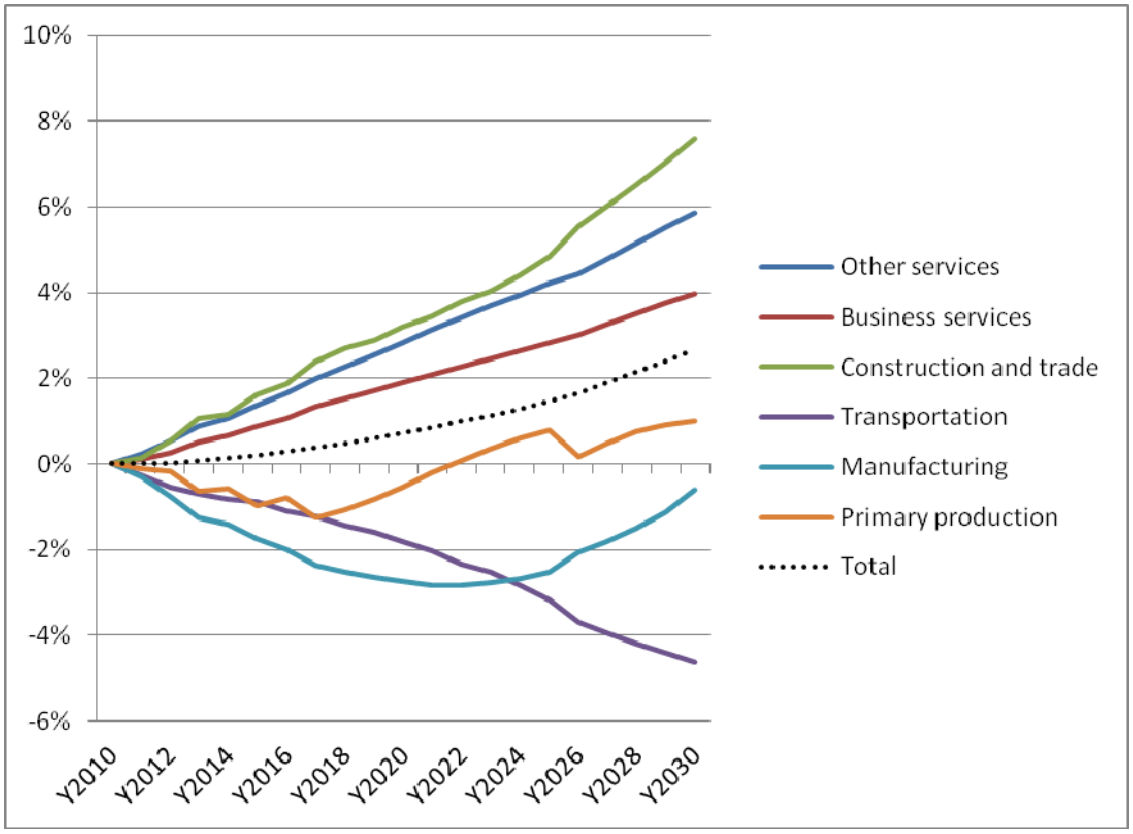


6.1.2 Sector-specific developments in Finland

In Scenario 1, growth in services (value added, constant prices) will be faster in Finland than growth in manufacturing and primary production. Overall, this is a normal and dominant trend in industrialised countries. In particular, value added will grow faster in construction and trade, other services and business services. Finnish output in primary production will be close to the Reference Scenario throughout the 20-year period. Manufacturing output will first lag behind the Reference Scenario but it will then catch up with the latter towards the end of the 2020s. Transportation will do worse than in the Reference Scenario.

The faster development in value added is due to a more efficient allocation of resources across the world following the policy changes described above.

Figure 8 Value added in constant prices in Finland in Scenario 1, difference between Scenario 1 and Reference Scenario, %



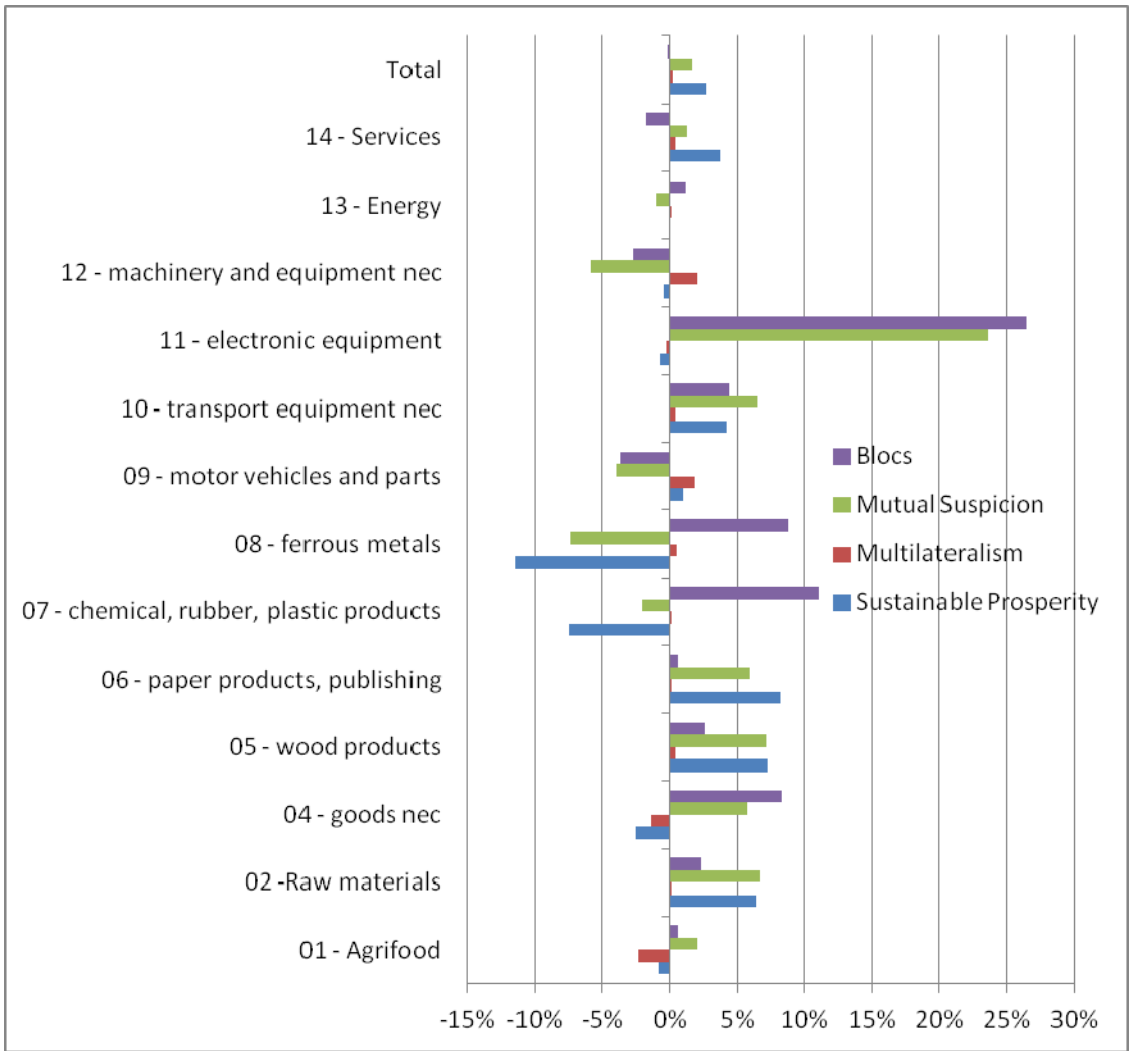
The most favourable scenario in terms of the development of Finnish value added, i.e. GDP, is Scenario 1, 'Sustainable Prosperity' (see Figure 7c). The four scenarios differ quite a lot in their sector-specific developments. This depends on the trade and competition patterns of Finnish exports in different regions of the world. The biggest changes in Figure 7c take place in Scenarios 3 and 4 where tariffs are raised. In this section we will concentrate on the impact in Scenario 1, however.

Relative to the Reference Scenario, 'Sustainable Prosperity' brings the largest gains in terms of value added in the production of paper and wood products as well as raw materials and services. On the other hand, the output of ferrous metals and chemical products fairs worse than in the Reference Scenario. Interestingly, the 'old' comparative advantage that Finland has in forest industries is strengthened in this particular scenario: Under unilateral European climate policy, energy-intensive industries suffer an additional competitive disadvantage as the energy prices increase following the emissions reduction policies. In the scenarios with global climate policy, however, producers outside Europe face similar energy price increases. Industries that are predominantly

exporting to the European market, such as forest industry (nearly 85 per cent of exports go to EEA countries) obtain only minimal gains from further trade liberalisation, as can be expected. Conversely, these same sectors are affected the most by unilateral climate policy.

On the other hand, the 'new' comparative advantage in electronic equipment is not affected by the combination of a more liberal trade and global climate policy. It instead enjoys a boost when tariffs are raised (Scenarios 3 and 4). It should be noted that this increase applies to manufactured products and can be explained by slower relocation of such production to countries with lower costs. In contrast, less labour and capital resources will available for services, which would produce higher value added, as resources are used for manufacturing in Finland.

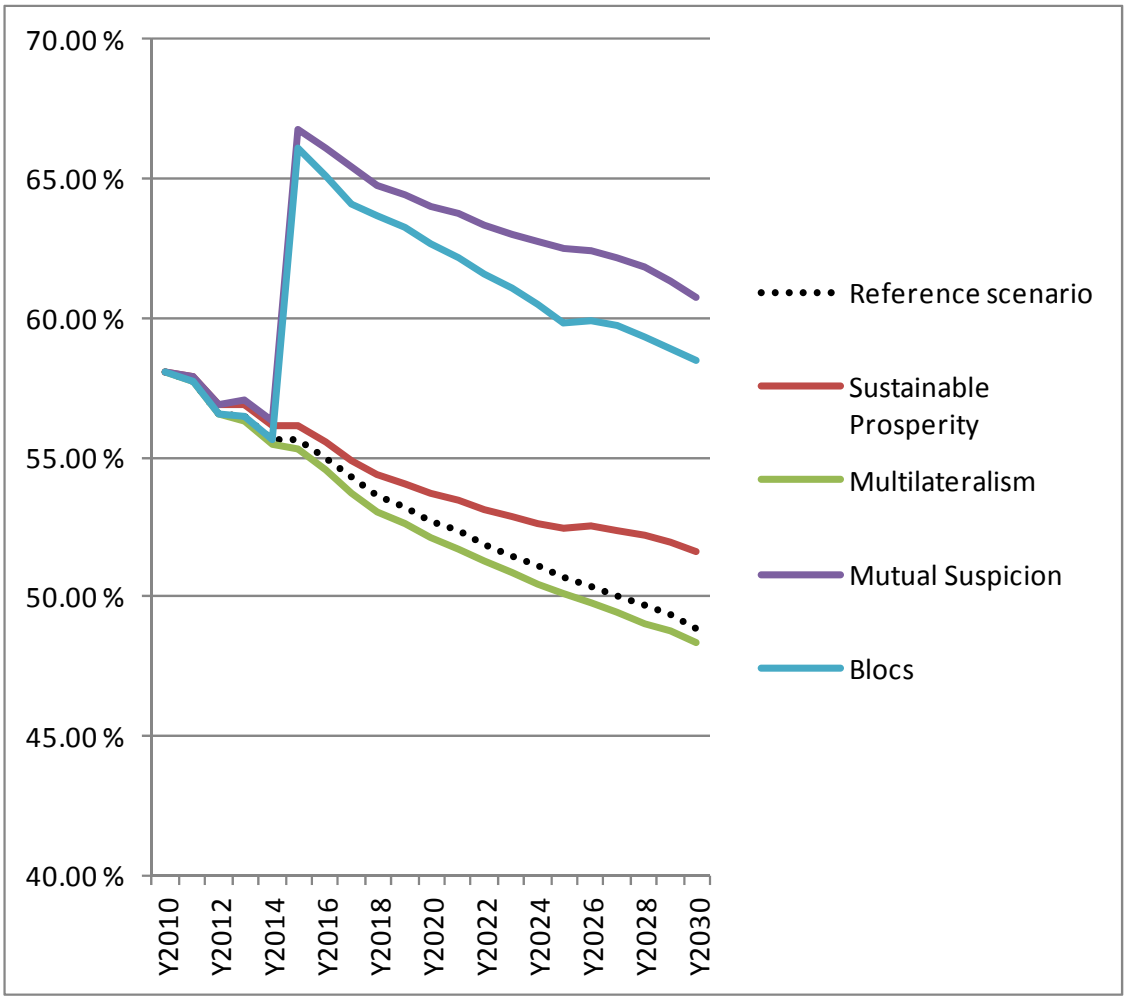
Figure 9 *Finnish value added in constant prices in 2030, difference to Reference Scenario, %*



6.1.3 Foreign trade

The share of the EEA countries in Finnish exports is expected to decline in all scenarios. This is due to faster growth in non-EEA markets (see table 4 in Appendix for the data in the Reference Scenario).The introduction of new inter-block tariffs will turn the clock backwards in this respect as can be seen from Figure 10, but after the shock the development will continue. Scenario 1 shows a little more moderate development in terms of the decline in the EEA share compared with the Reference Scenario.

Figure 10 The share of EEA countries in total Finnish exports, %



There is very little change between Scenario 1 and the Reference Scenario in terms of the value of exports to the EEA. Exports to non-EEA countries will develop somewhat worse than in the Reference scenario. Naturally, large differences with respect to the reference scenario arise in Scenarios 3 and 4, where new tariff barriers are erected between trading blocks. In those cases exports to non-EEA countries will suffer heavily, and trading with EEA countries will increase. Even though new markets are found, weaker global resource allocation will lead to lower welfare and utility levels.

The relative competitiveness of the Finnish energy-intensive industry is better when other countries, too, have ambitious climate policies, and the increase in transportation costs will favour trade with neighbouring countries.

Figure 11 Finnish exports to EEA, %-difference to Reference Scenario

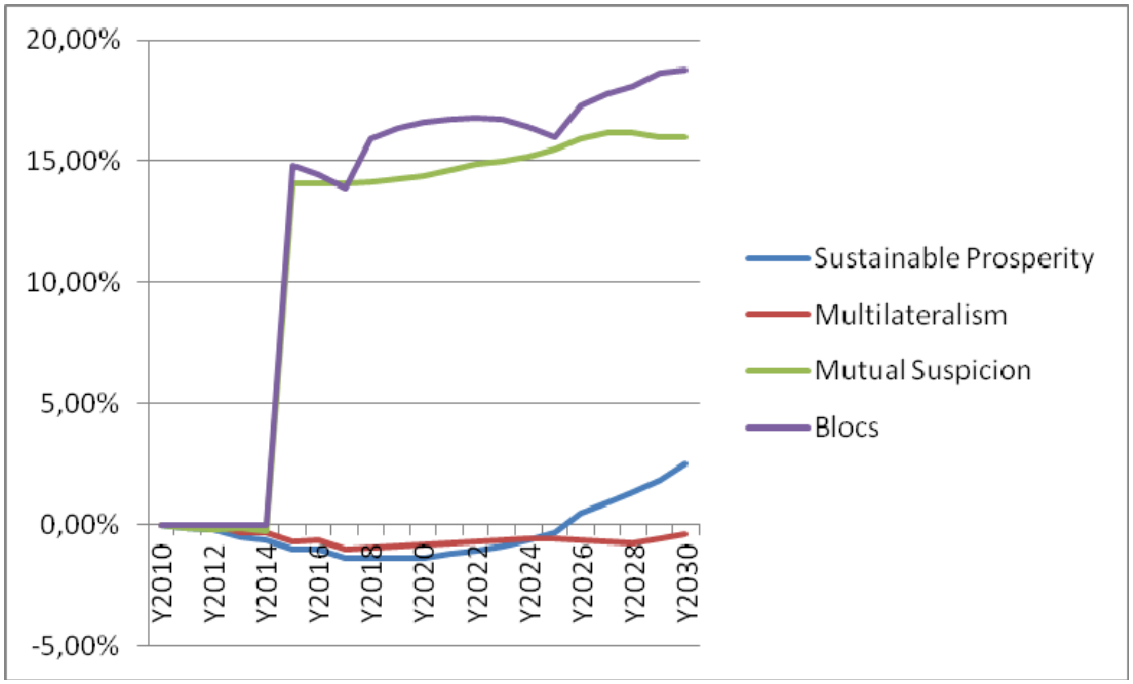
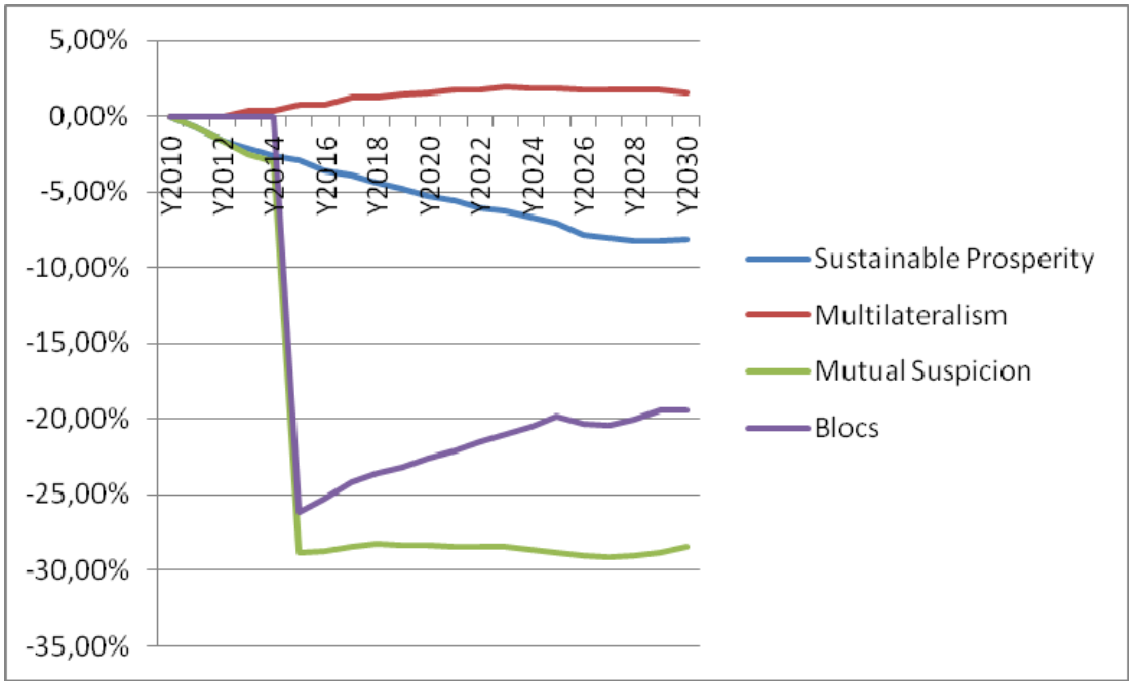


Figure 12 Finnish exports to non-EEA countries, %-difference to Reference Scenario



Compared with the Reference Scenario, the value of Finnish exports will decline by almost 4 per cent before starting a gradual catching up in the mid-2020s. This is due to a relative revival in manufactured exports. On the other hand, the value of exports of total services and primary output will continue to decline. This is due to a decline in transportation services and other services. On the other hand, the value of business services and construction and trade will increase. Note that these are all relative to the Reference Scenario. As can be seen from Figure 12 above, the value of exports does continue to grow throughout the analysis period.

Figure13 Value of total Finnish exports in Scenario 1, %-difference to Reference Scenario

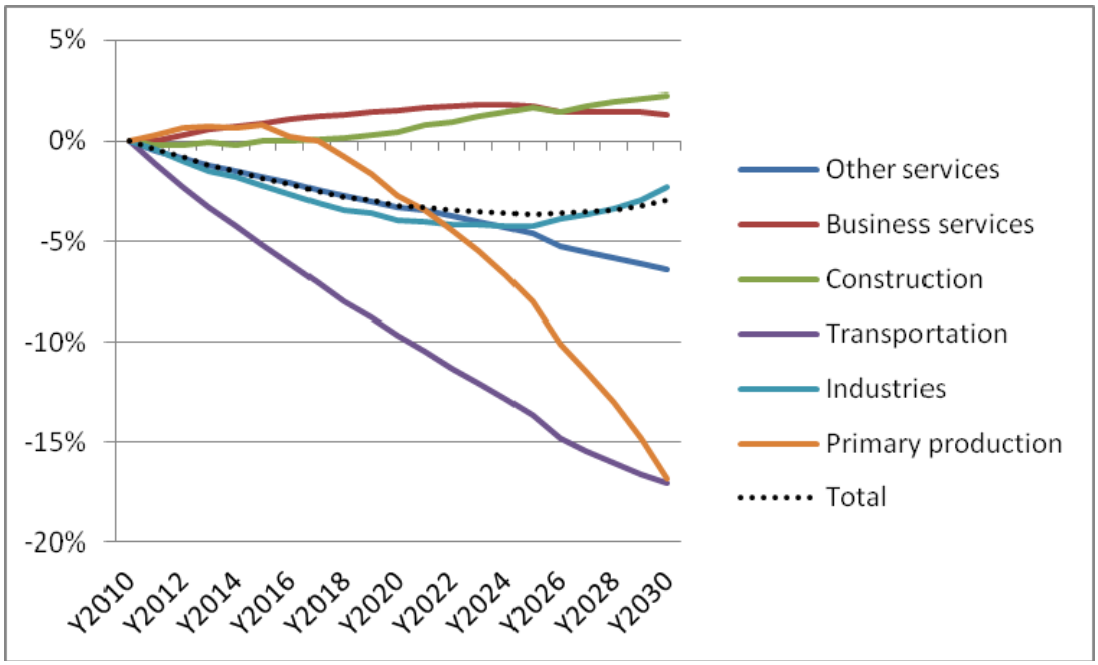
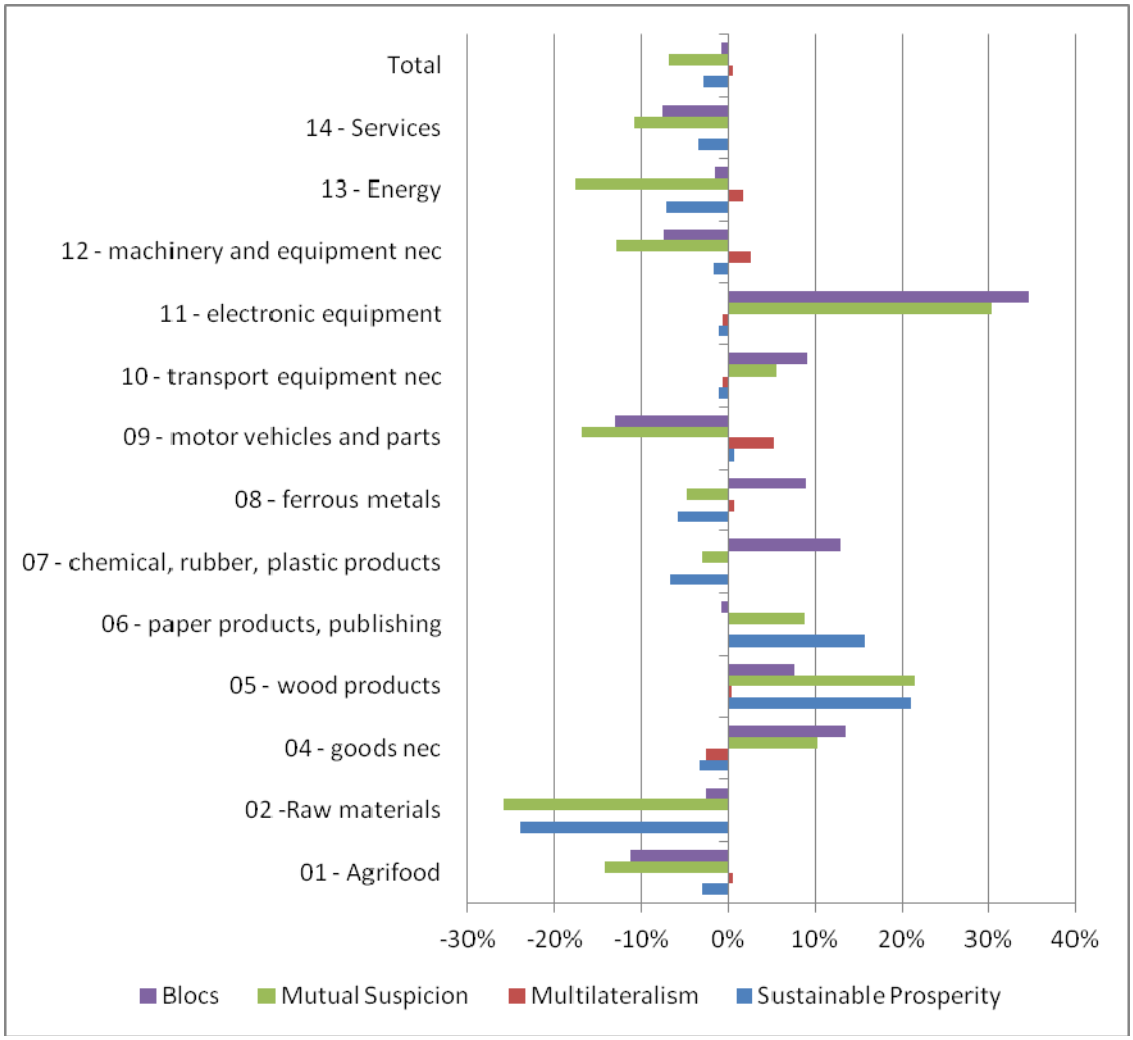


Figure 13 shows a more disaggregated picture of sector-specific developments in the value of total Finnish exports in the four scenarios. The results reflect the ones shown above for value added. Relative to the Reference Scenario, Scenario 1 is good for the exports of forest industry products. In all other sectors, the difference is either rather close to zero but negative or, in the case of raw materials, strongly negative.

Figure 14 Total Finnish exports in 2030, difference to Reference Scenario, %



As can be seen from Figure 14, the sector-specific differences to the Reference Scenario in the total exports to other EEA countries by the year 2030 are relatively small. Raw material exports gain the most, 19 per cent, followed by forest industry products (over 15 per cent), and machinery and equipment (13 per cent). The exports of chemical products decline by 7 per cent relative to the Reference Scenario.

Figure 15 Total Finnish exports to other EEA countries in 2030, difference to Reference Scenario, %

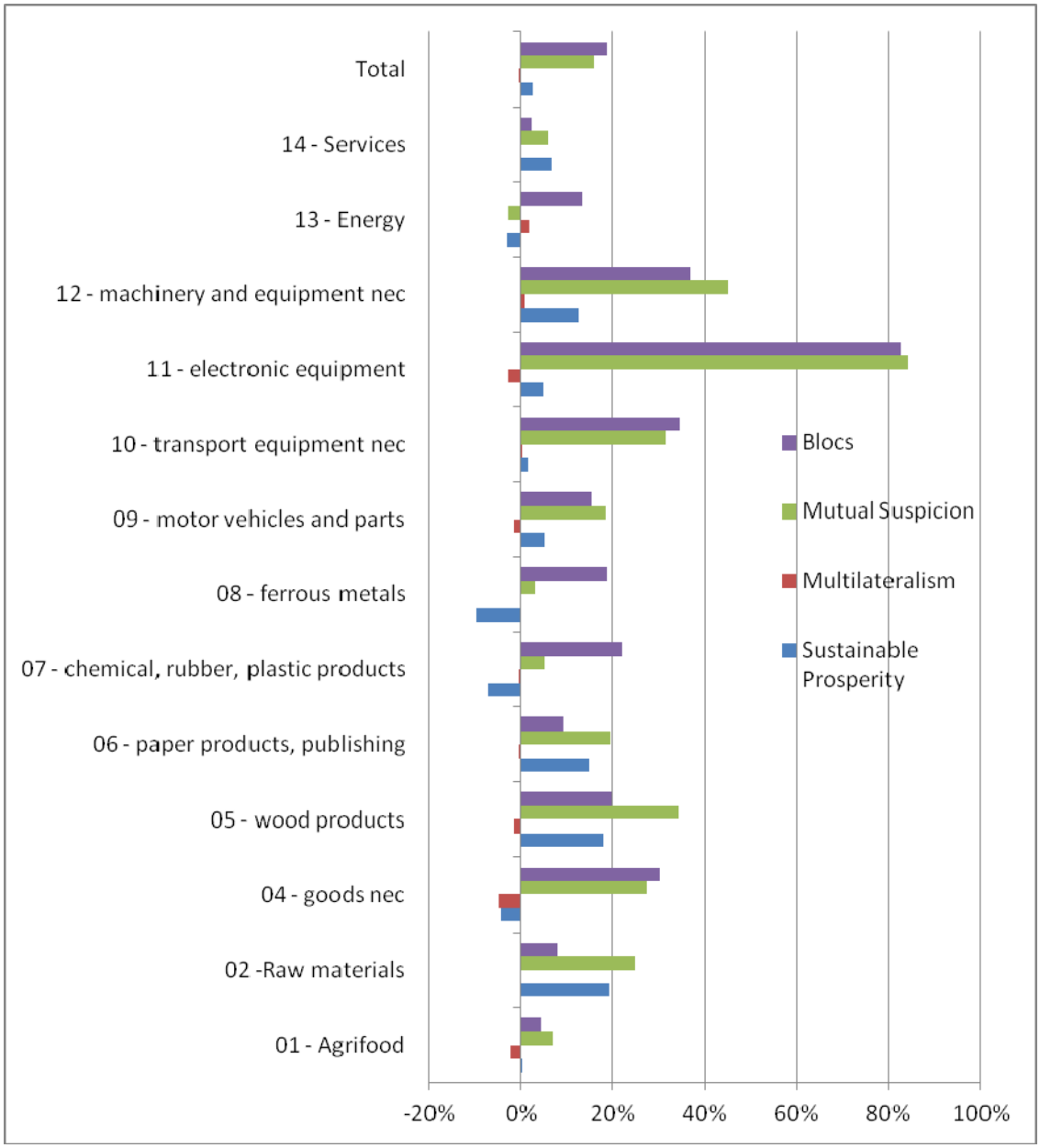
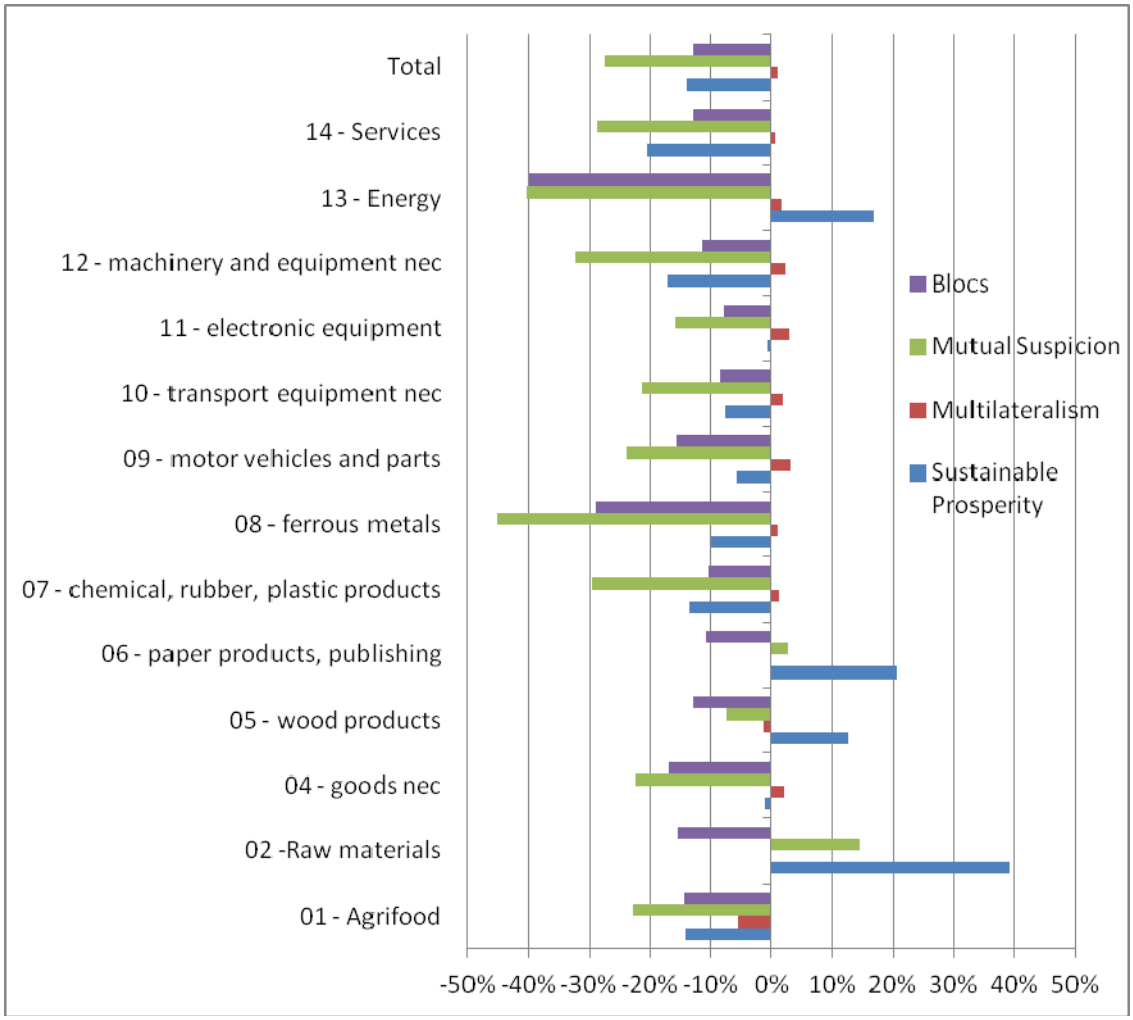


Figure 16 shows how exports to Russia will develop in the four scenarios relative to the Reference Scenario.[2] Scenario 1 has a positive impact on the exports to Russia of raw materials, energy and forest industry products. However, total exports are lower as all other sectors show weaker export developments. This is largely explained by the impacts of the policy changes on Russia's GDP and total demand, which is hit hard both by trade barriers and by emission reductions.

Figure 16 Total Finnish exports to Russia in 2030, difference to Reference Scenario, %

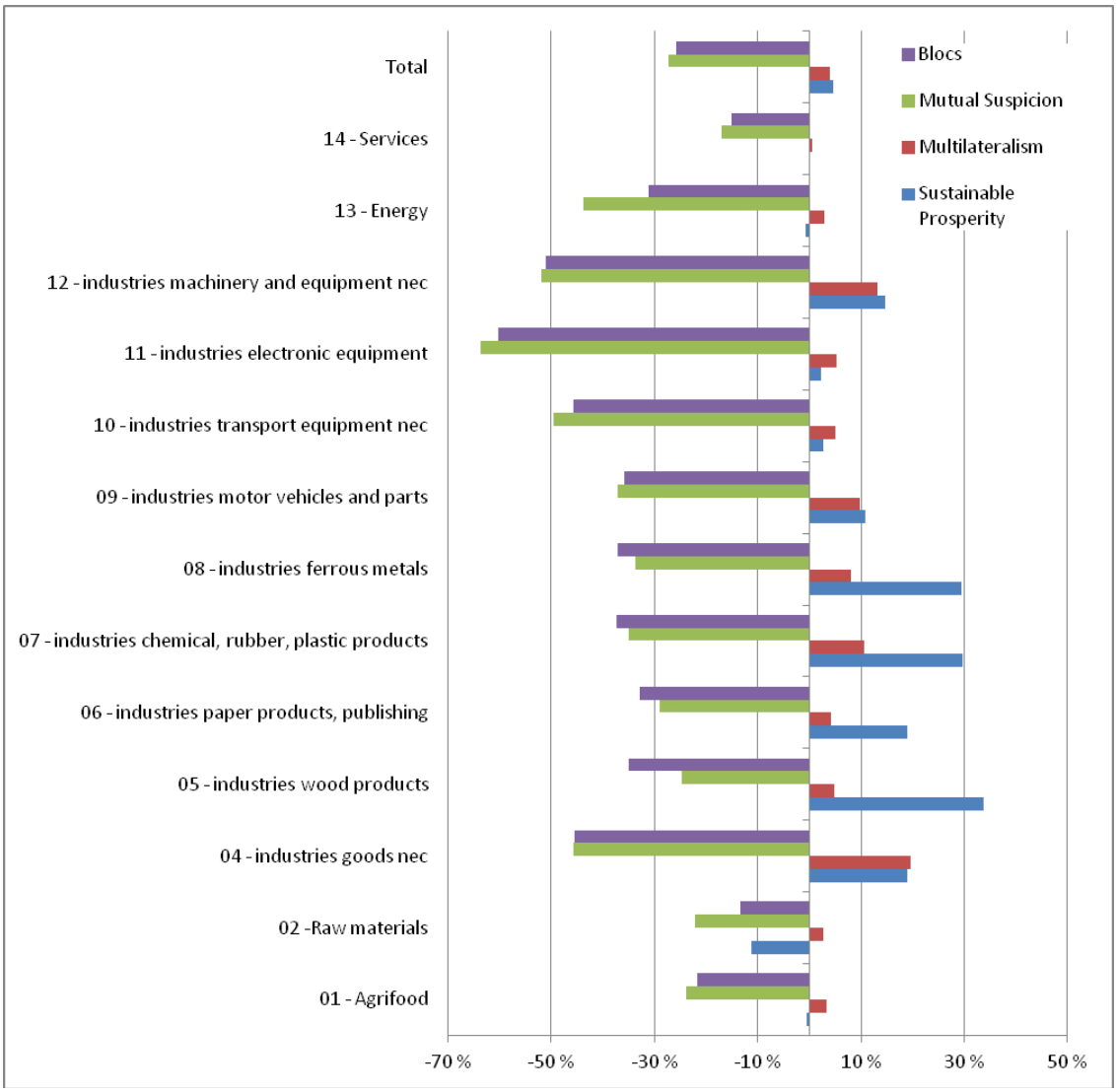


[2] The significance of the Russian WTO membership is shown separately in the Appendix, Figure …. The WTO membership is present in all the scenarios. The overall impact of the membership in 2030 is an almost 13 per cent increase in the value of total exports to Russia relative to the situation where Russia does not join the WTO. The impact is the largest in machinery and equipment nec (+20%),

motor vehicles and parts (+16%) and wood products (16%), followed by 10–12% increases in paper products, ferrous metals, transport equipment nec and electronic equipment, each.

Total exports to China grow by 5 per cent by 2030 as a result of the policy changes implemented in Scenario 1 when compared to the Reference Scenario. We witness a jump of around 30 per cent in the exports of wood products, chemical, rubber, plastic products, and ferrous metals. The implementation of additional tariffs in Scenarios 3 and 4 would have a significant negative impact on trade between Finland and China.

Figure 17 Total Finnish exports to China in 2030, difference to Reference Scenario, %



The value of imports rises slightly in Scenario 1 with respect to the Reference Scenario.

Figure 18 Value of total Finnish imports, %-difference to Reference Scenario

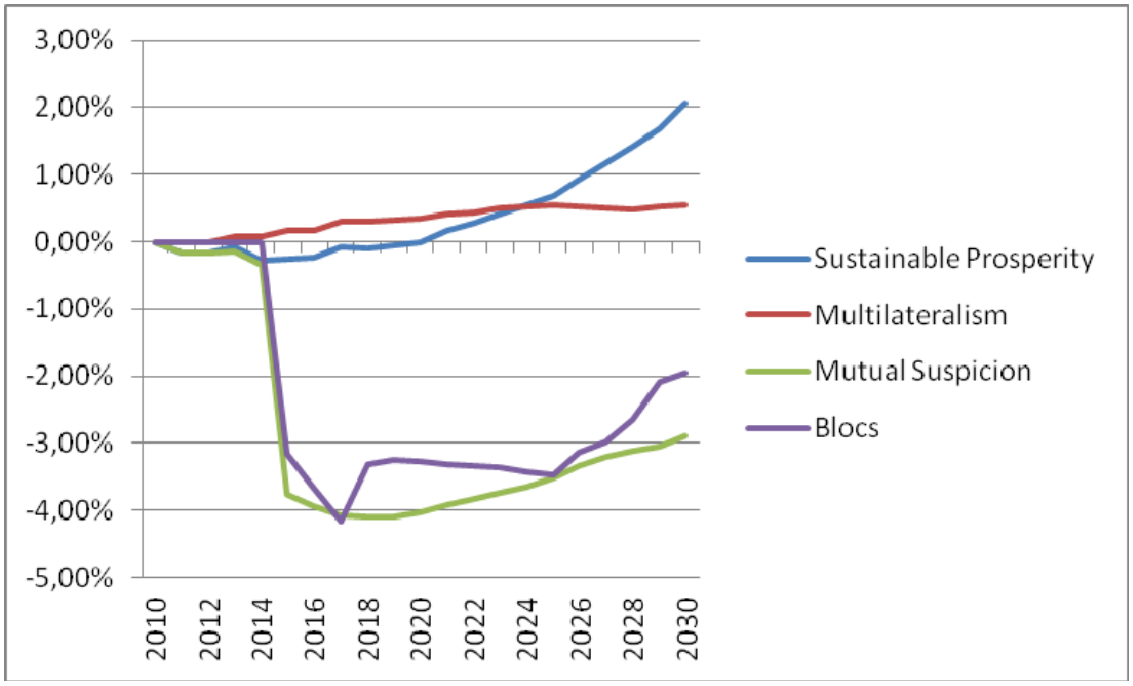
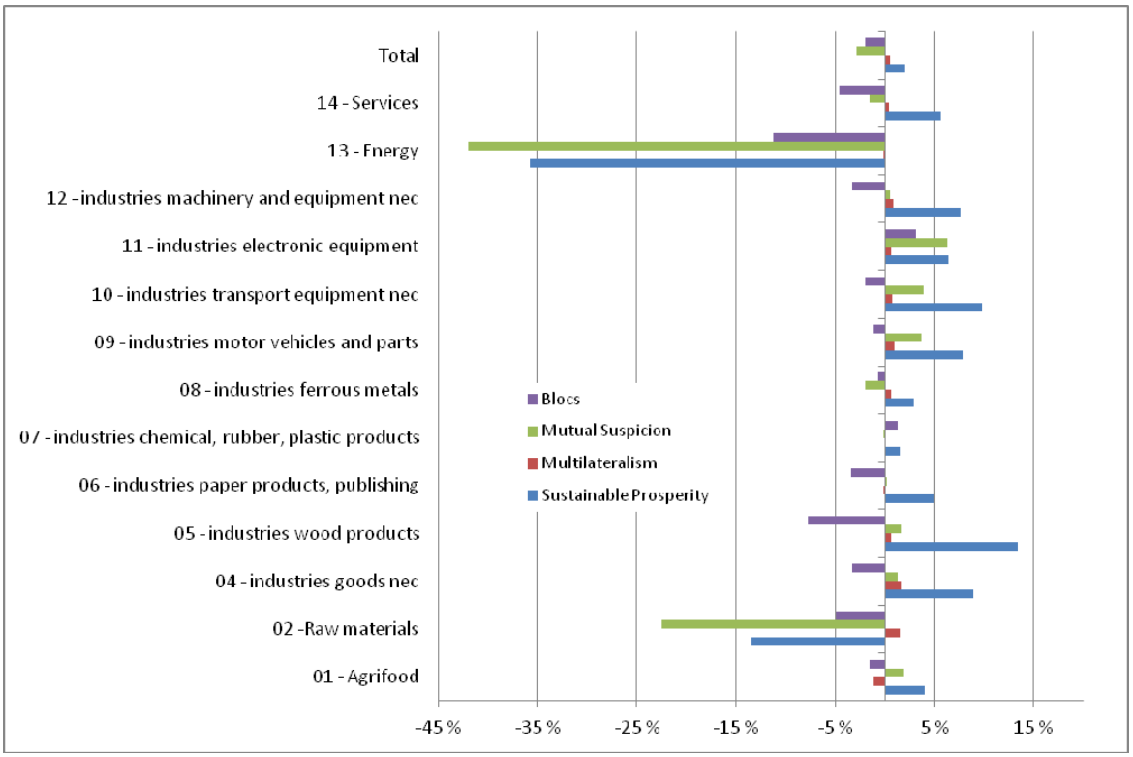
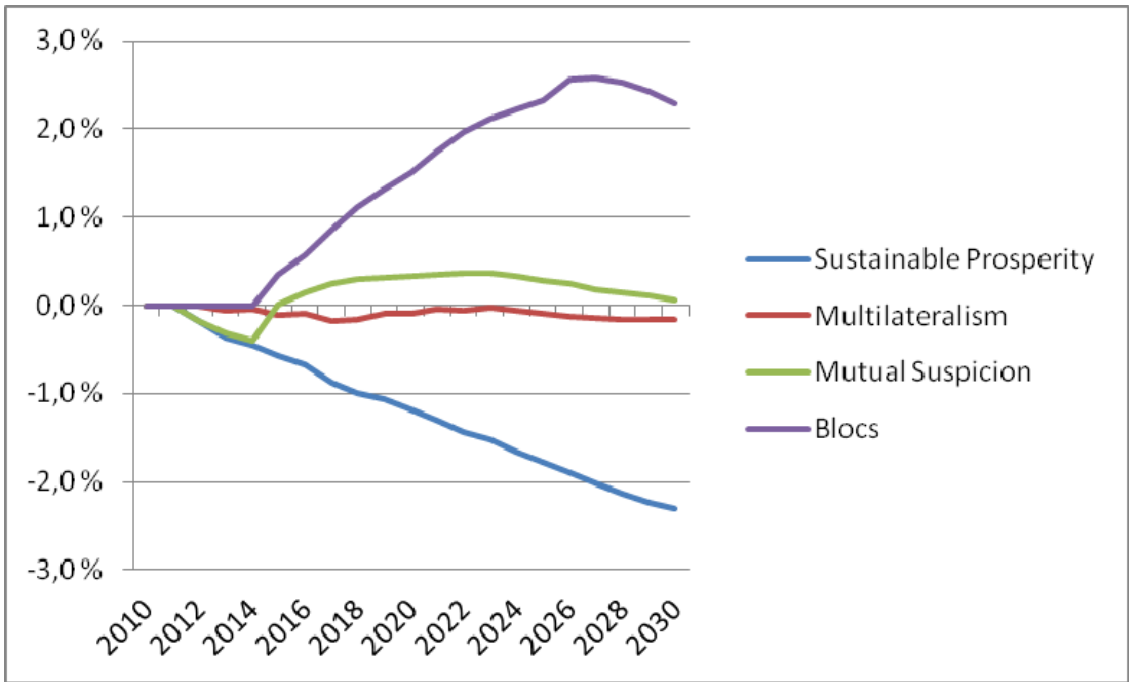


Figure 19 Total Finnish imports in 2030, %-difference to reference scenario



The Sustainable Prosperity Scenario is the worst from the point of view of the Finnish trade balance, i.e. the difference between the exports and imports of goods and services. The difference (i.e. a relative trade deficit) to the Reference Scenario increases continuously and reaches almost 2.5 per cent of GDP in 2030. Consequently, more emphasis must be put to, among other things, labour market policies to support competitiveness.[3] If this scenario seems to be the most realistic one, Finnish firms should also be prepared to adjust to the changing demand pattern. This means putting more emphasis on business services, cleantech etc. Otherwise the Finnish economy will run to problems with the external balance that will in the long run slow economic growth.

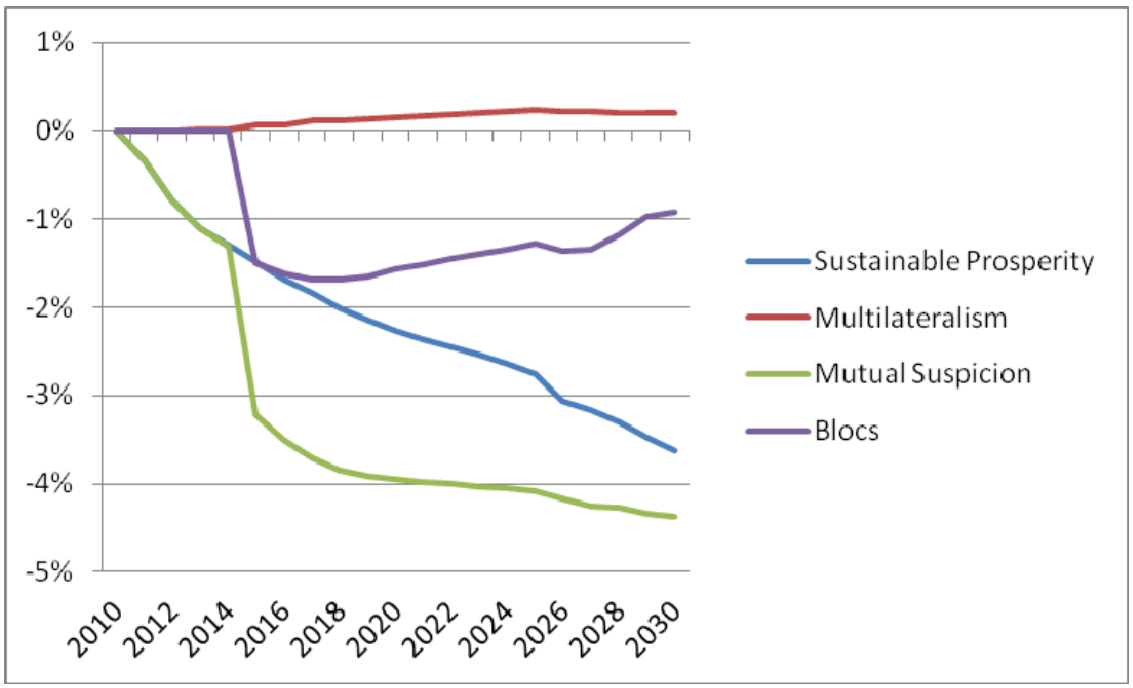
Figure 20 Finnish trade balance, difference to Reference Scenario, % of GDP



One factor that affects the trade balance is the terms of trade, i.e. the ratio of export prices to import prices. The terms of trade will deteriorate continuously in Scenario 1 relative to the Reference Scenario and the value of exports decreases steadily whilst the value of imports is affected less or increases. The volume of manufacturing production will also be lower than in the Reference Scenario. (See Figure 8.)

[3] The trade balance actually deteriorates considerably in the Reference Scenario up until the mid-2020s after which it starts to rebalance. This means that there may be a need for competitiveness-mending policies in all cases. In the GTAP model, economic instabilities will adjust over time, but as we have not considered balance of payments policies or targets, choosing to focus on trade patterns, the adjustment may be clearly slower than in reality as price competitiveness deteriorates.

Figure 21 Terms of trade, %-difference to Reference Scenario



6.1.4 Consumer utility and welfare

At the whole economy level, it is important to distinguish the impacts of a policy on welfare or consumer utility from the national accounting figures. For example, relation between GDP growth and welfare gain is not straightforward, and the economic theory shows that a policy can even be welfare-increasing while slowing down GDP growth, and vice versa.

GTAP calculates welfare gains and losses on the basis of equivalent variation (EV) for the representative consumer. It is an abstract measurement of amount of additional income needed to give the level of utility which an individual could have reached if the economic environment had changed. As such, it depends on the model parameters used in calculation of "utility" and therefore cannot be taken as a precise measure of the benefits or disadvantages from a policy. Nevertheless, it provides a more sophisticated indication on welfare impacts than for example bare GDP growth.

As we can see from Figure 22a–c, Scenario 1 is the best one from the point of view of consumer utility for the world, the EU and Finland. The welfare gain in the global climate policy scenarios, as well as the similar development in the GDP between the scenarios, can be largely attributed to the productivity increase from the energy efficiency. As this is an assumption built into the scenario design, and therefore cannot be interpreted directly as gains from climate policy implementation.

Figure 22a World: Equivalent variation (cumulative) calculation for regional household income, %-difference to Reference Scenario

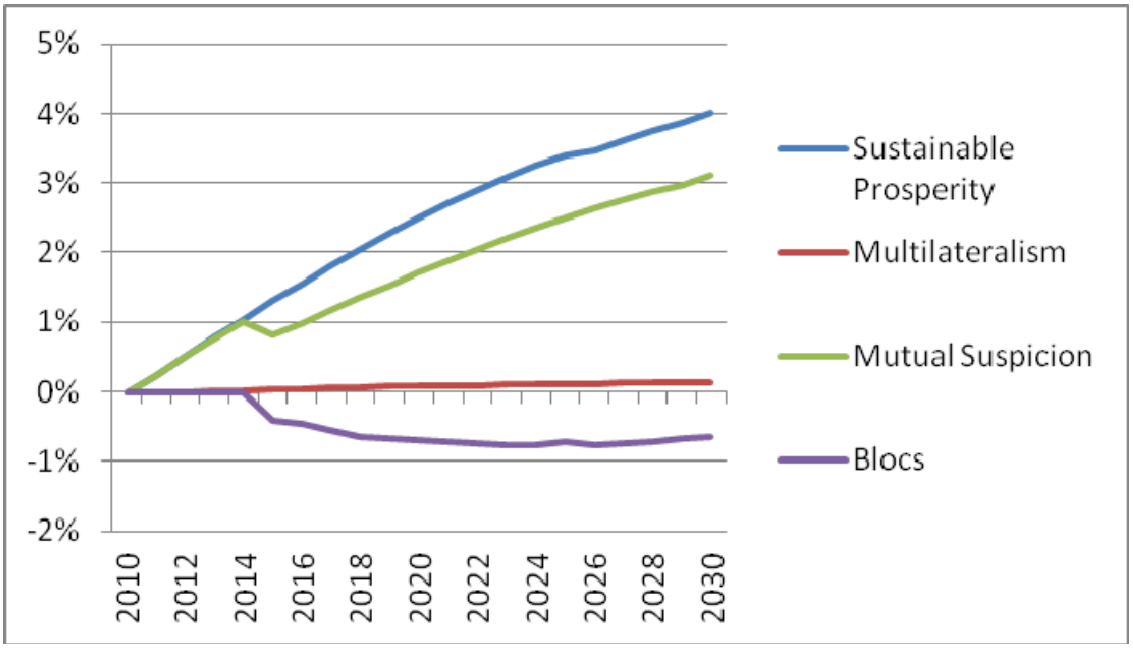


Figure 22b EU: Equivalent variation (cumulative) calculation for regional household income, %-difference to Reference Scenario

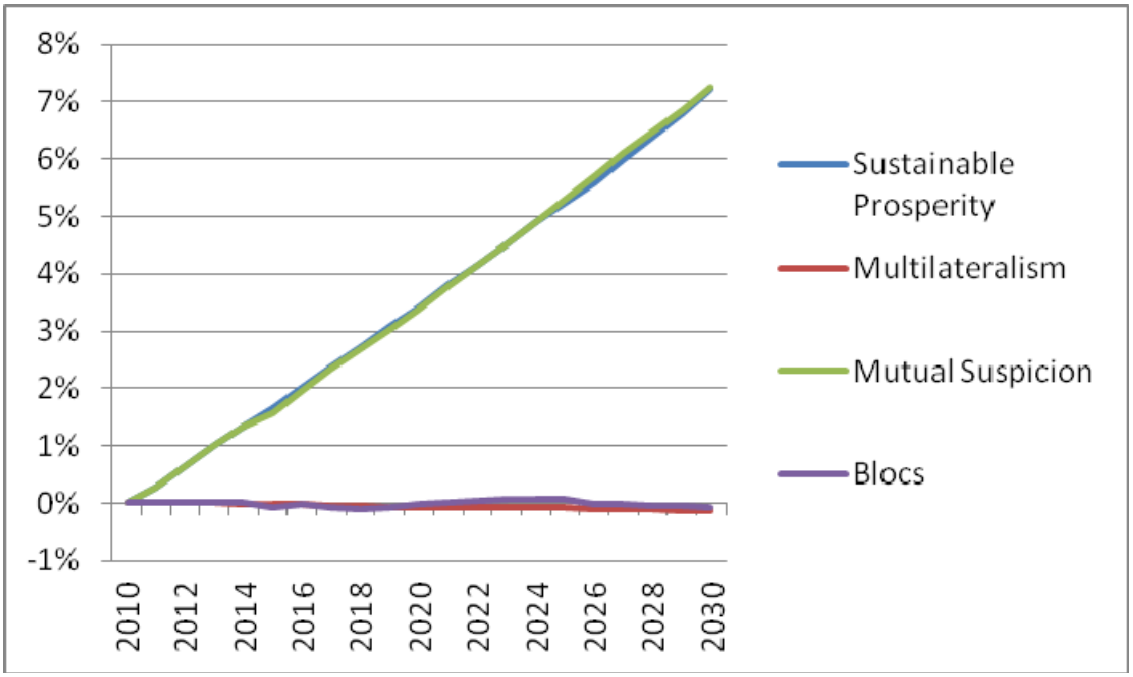
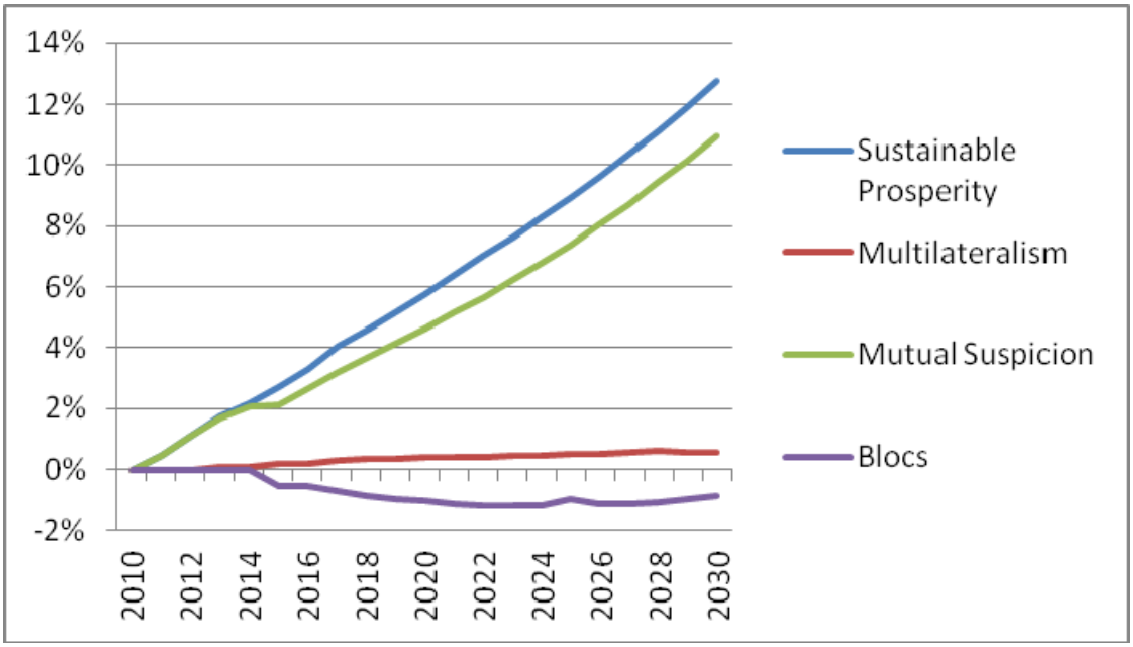


Figure 22c Finland: Equivalent variation (cumulative) calculation for regional household income, %-difference to Reference Scenario



6.2 Scenario 2: Multilateralism (without energy efficiency)

Scenario 2 includes the more liberal trade regime but no international climate policies (the EU level climate policies still stand).Because the effect of the liberalization of trade is smaller than that of an international climate policy the differences to the Reference Scenario will a priori be rather small.

6.2.1 GDP

Looking at the development of GDP per capita relative to the Reference Scenario, we see that there are very little differences with Scenario 2 (see Figures 7a-c above). The Finnish GDP per capita is 1 per cent higher in 2030, but the World and EU averages are very close to that in the Reference Scenario.. This is evidence that as trade barriers are already quite low for manufactured goods, their overall lowering has very little additional impact.[4]

These results are consistent with findings of other studies analysing the Doha agreement, which has been, indeed, criticised for its and the small size of its estimated economic effects. For example Baltzer et. al. (2009) estimated a 0.2 percent growth in global GDP due to the Doha agreement. However, the scenario

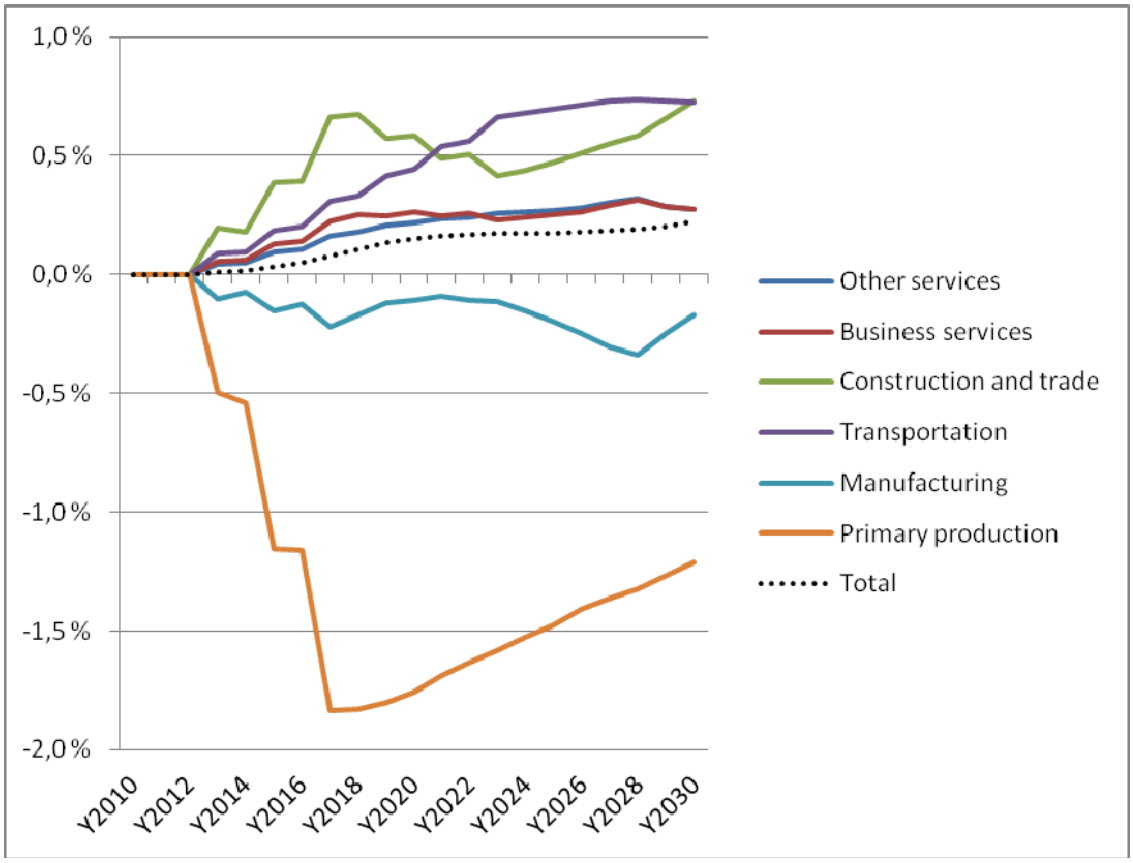
[4] On the other hand, there are considerable non-tariff barriers that we do not take into account in this analysis.

analysed in the present paper, like most of the other similar studies, do not incorporate provisions for e.g. services liberalisation and trade facilitation, which a Doha agreement is to include. For the services liberalisation, Decreux and Fontagné (2008) suggest that it could add another 25 percent to their global welfare estimates.

6.2.2 Sector-specific developments in Finland

Looking at sector-specific development in the Finnish economy, we find that–relative to the Reference Scenario–transportation, construction and trade, in particular, grow more by the year 2030, while primary production and manufacturing output will lag a little behind. However, the differences are rather small. This can also be seen in the more disaggregated Figure 9 above. The largest (but still very small) differences in constant prices in 2030 are in production of machinery and equipment, and motor vehicles[5] and parts.

Figure 23 Value added in constant prices, difference between Scenario 2 and Reference Scenario, %



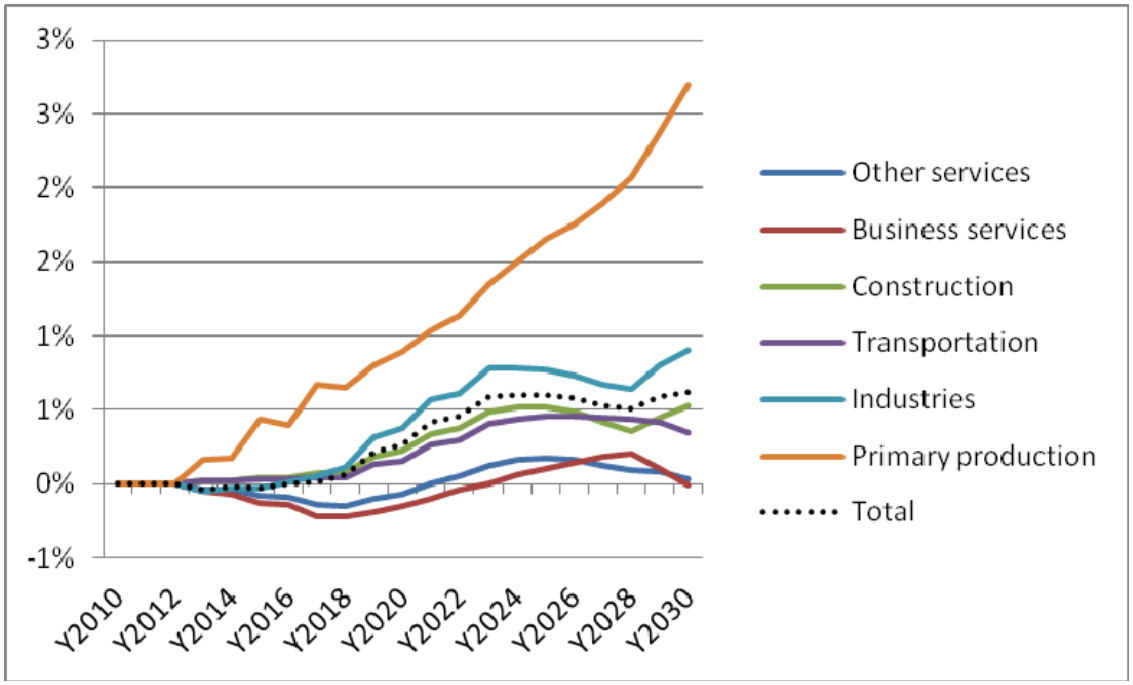
[5] The results on motor vehicles and parts must be interpreted with caution, as the trade data includes transhipments, which forms a major part of the Finnish trade in this sector.

6.2.3 Foreign trade

In line with relatively small differences in value added (always compared with the Reference Scenario), also the changes in the value of exports over the next 20 years is rather small. However, with the disaggregation presented in Figure 14, it is notable that the differences are positive. The largest ones (3 per cent) are found in primary production. However, this is due to a rise in export prices, not volumes.

There is also very little difference with respect to the destination countries.

Figure 24 Value of Finnish exports in Scenario 2, %-difference to Reference Scenario



Looking at Figure 15, 16 and 17 above, where we find the impact on exports by scenarios and industries, there is a small overall increase in the exports (value) of motor vehicles and parts by the year 2030. The exports of agrifood decline slightly in the Russian market. There are a little more developments, always positive, in the exports to China, with an around 10 per cent increase in the value of manufactured goods. The overall trade balance remains very close to the Reference Scenario. The terms of trade will also develop much like in the Reference Scenario.

6.2.4 Consumer utility and welfare

As we can see from Figure 22a–c above, Scenario 2 is very close to the Reference Scenario from the point of view of consumer utility for the world, the

EU and Finland. Consequently, the implementation of the Doha Round does not seem to have a significant impact on consumer utility.

6.3 Scenario 3: Mutual Suspicion

Scenario 3 differs from the above two scenarios in that further trade liberalisation comes to a halt, and actually turns around. The world is assumed to be divided into four regions: Western Europe (i.e. European Economic Area, EEA), Eastern Europe (Russia + former Soviet Union), the Americas, and 'The Chinese Hegemony' (China, South-East Asia, Developing Africa). Japan and Australia are left outside these blocks. An additional and uniform 10% tariff is applied from 2015 onwards to all imports from outside the trading blocs. This can be clearly seen in the graphs. As a consequence, import prices rise and trade is reduced globally.

On the other hand, we assume that despite the lifting of trade barriers, the global climate change is taken seriously and an international climate policy agreement is reached. Admittedly, this combination may seem a little far-fetched, but the scenario does show the impact of the assumed energy-saving innovations and the levelling of the playing field in this respect at the global level.

6.3.1 GDP

As a result of the rise in tariffs, inter-block trade will decrease and intra-block trade will increase. This weakens the efficient allocation of resources at a global level. As a result, GDP growth will take a hit as can be seen in Figure 7a–c. The impact on the EU seems rather small, even non-existent, while it is much more significant to the world as a whole and to Finland. Nevertheless, GDP will grow faster than in the Reference Scenario.

Consequently, the international climate agreement (i.e. improvement in energy efficiency) outweighs the negative impact of the higher tariffs. In Finland, the difference between Scenarios 1 and 3 diverges, and is approximately the same as between scenarios 2 and 4, implying that in the model the advantage for Finland of the stricter global climate regime is similar regardless of the trade policy regime in place. This may be due to the rather energy-intensive production structure of the Finnish manufacturing sector and the long transportation distances.

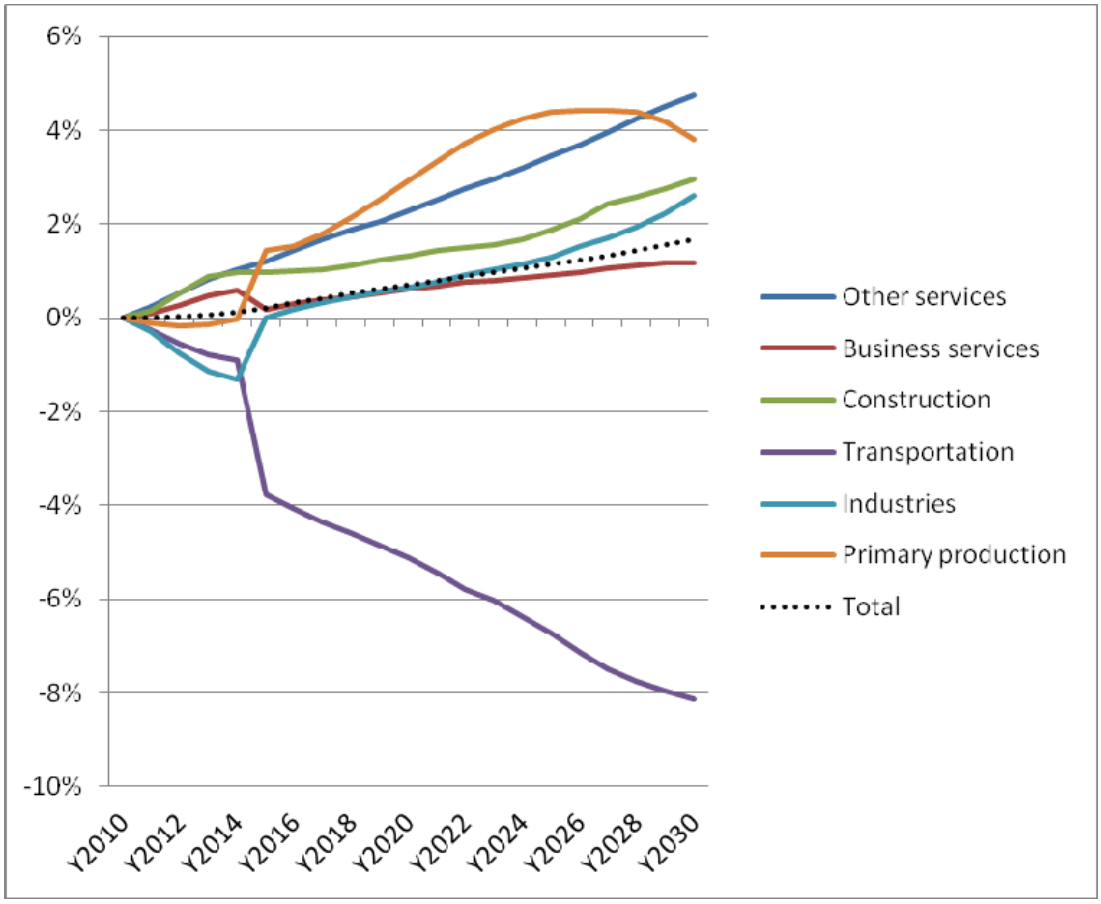
6.3.2 Sector-specific developments in Finland

Looking at the sector-specific developments in Finland, we see that transportation services take a considerable hit, but other sectors, as identified, actually grow faster than in the Reference Scenario. Business services are not much affected, but the value added of primary production and other services will

be about 4 per cent higher in the 2020s than in the Reference Scenario. The raising of the tariffs in 2015 has a positive effect on the relative value added of manufacturing and primary production.

The graph above (Figure 9) shows a more disaggregated picture of the difference between Scenario 3 and the Reference scenario in 2030. The higher tariffs will have a very positive effect on the output of electronic equipment, as they considerably slow down the relocation of the manufacturing to the countries with low production costs. This, however, is reflected in lower GDP growth as seen above, when the resources do not move to higher value added generating services sectors. The effect is also positive in forest industry products, other transport equipment and raw materials. We find a negative effect in ferrous metals as well as machinery and equipment.

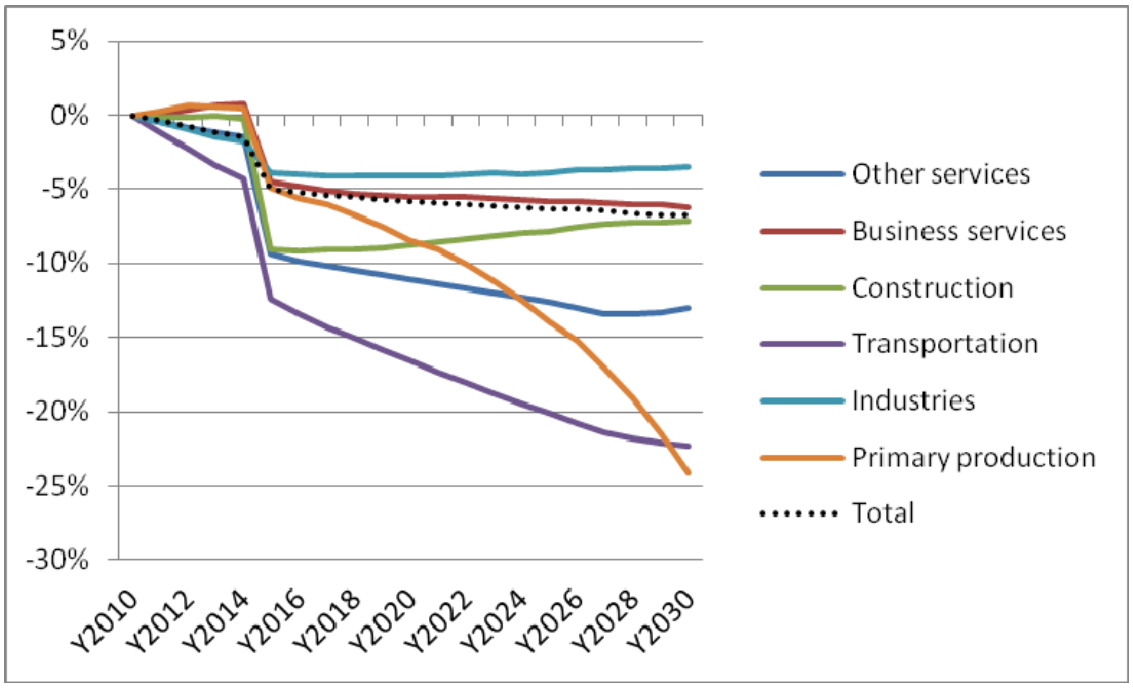
Figure 25 Value added in constant prices, difference between Scenario 3 and Reference Scenario, %



6.3.3 Foreign trade

The value of total Finnish exports declines considerably when the tariffs are raised. The immediate average effect is about 3 per cent, but service exports in particular decline much more. No sector manages to regain its lost export value relative to the Reference Scenario.

Figure 26 Value of Finnish exports in Scenario 3, %-difference to Reference scenario



As we saw in Figure 10 above, the share of the EEA countries in Finnish exports rises by over 10 percentage points immediately after the tariffs have been raised. Relative to the Reference Scenario, the value of exports to the EEA countries rises by almost 15 per cent, while the value of exports to non-EEA countries declines by almost 30 per cent.

Reflecting the changes in value added, the export value of electronic equipment will rise by 30 by the year 2030. Other positive changes vis-à-vis the Reference Scenario are found in the exports of forest industries and other transport equipment. Climate policy favours these sectors, because the global climate agreement is a relative burden for the non-EU countries. We find a negative impact on the value of exports in raw materials, energy, motor vehicles, services and the agrifood sector. To large extent, the effects on primary products can be attributed to the world price developments: especially the pre-tax prices for fossil

fuels are considerably lower in the scenarios with global climate policy (for crude oil up to 33 per cent compared to the reference scenario). A smaller world price effect to same direction is also observed for primary agricultural products and other raw materials.

As already noted, exports to other EEA countries will rise as trade is diverted away from inter-block relations. The biggest rises relative to the Reference Scenario are found in electronic equipment with an increase of about 80 per cent in value by the year 2030. Strong developments are also found in other machinery and equipment, and transport equipment, followed by forest industry products and raw materials.

The picture is of course the opposite when we look at how exports to Russia and China will develop after tariffs are raised. The biggest relative losers in the Russian market are ferrous metals and energy, as well as other machinery and equipment and chemical products. In the Chinese market, the losses are the largest in all machinery and equipment, and transport equipment.

The terms of trade in Scenario 3 will deteriorate dramatically as a result of the 2015 tariff hike relative to the Reference Scenario. The overall development in the terms of trade is the worst of all the four scenarios. On the other hand, the trade balance will actually be better than in the Reference Scenario, and the second-best of all four scenarios.

6.3.4 Consumer utility and welfare

As we can see from Figure 22a–c above, Scenario 3 is relatively close to Scenario 1 and much better than the Reference Scenario from the point of view of consumer utility for the world, the EU and Finland. Actually for the EU Scenarios 1 and 3 have very little difference.

6.4 Scenario 4: Blocs

Our worst-case scenario combines the higher inter-block tariffs as described above and no global climate policy agreement.

6.4.1 GDP

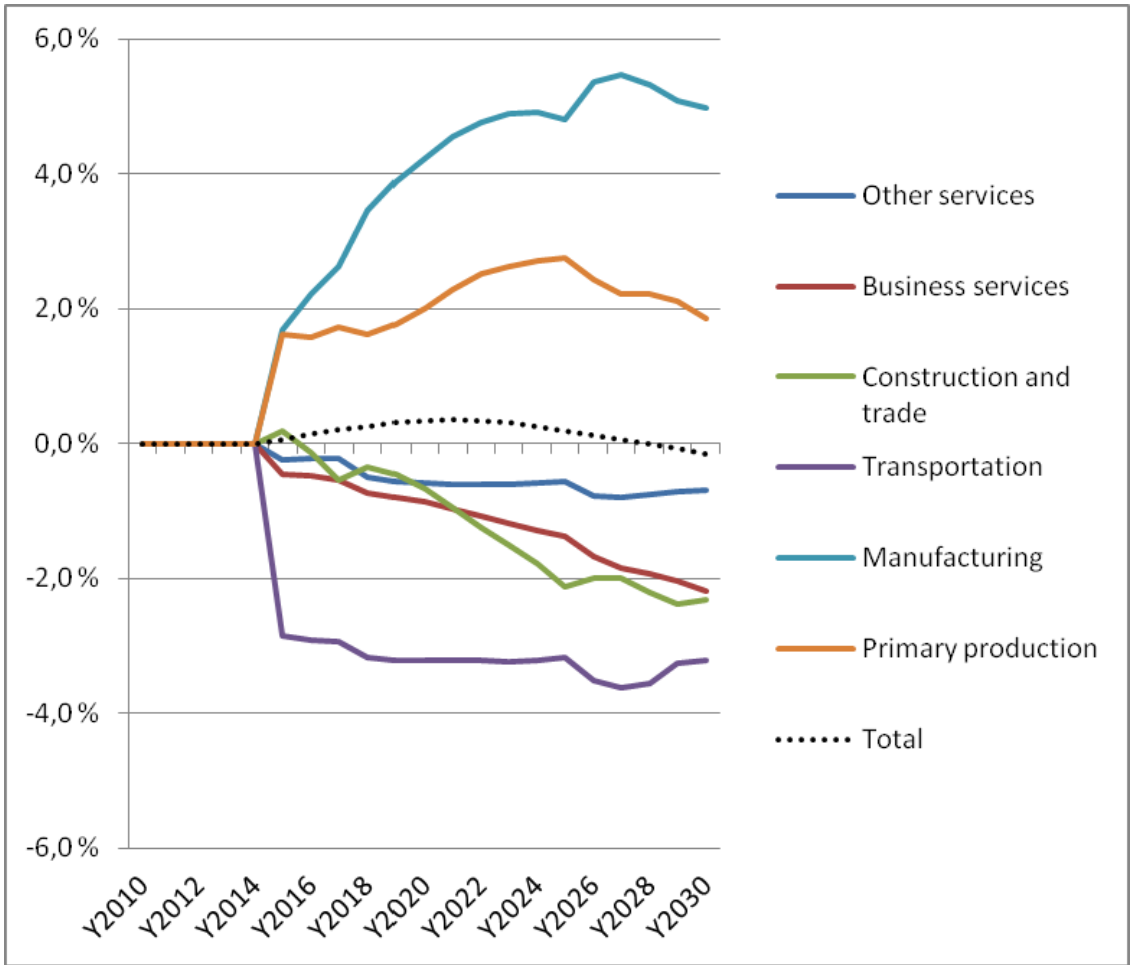
With the raising of tariffs in 2015, world GDP will immediately decline by 0.5 per cent relative to the Reference Scenario. The same will happen in Finland. On the other hand, EU GDP does not seem to be affected, and as time goes by, it actually rises higher than in the Reference Scenario. For the EU GDP, the Reference Scenario and the Multilateralism Scenario are the worst ones, while for the world and for Finland, Scenario 4 is the worst. As noted earlier, at the global level, the GDP gains in the world-wide climate policy scenarios (scenarios

1 and 3) is to a large extent explained by the assumption about energy efficiency, which leads to considerable productivity difference in favour of the climate policy scenarios.

6.4.2 Sector-specific developments in Finland

Transportation, in particular, but also business services and construction and trade do worse in Scenario 4 than in the Reference Scenario. On the other hand, manufacturing does better, and by the mid-2020s value added is 5 per cent higher than in the Reference Scenario. As in Scenario 3, the output in electronic equipment industry increases relative to the Reference Scenario. This time, chemical products and ferrous metals also gain.

Figure 27 Value added in constant prices, difference between Scenario 3 and Reference Scenario, %

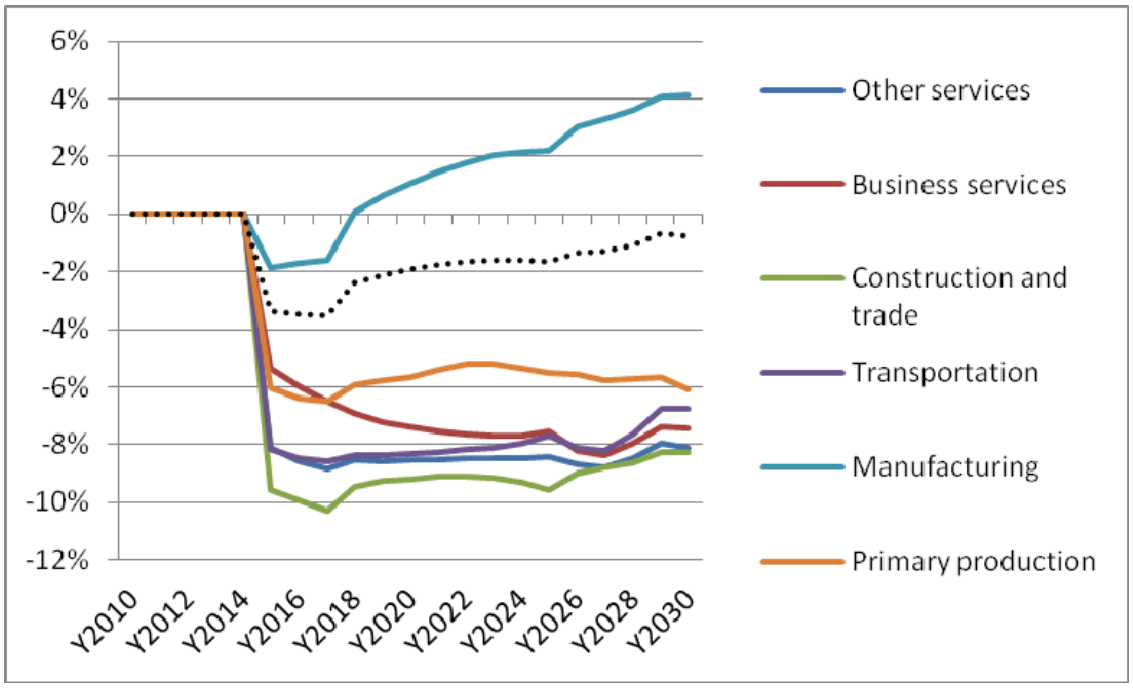


6.4.3 Foreign trade

The introduction of the tariffs raises the share of the EEA countries in Finnish exports, much like in the previous scenario. On the other hand, exports to the non-EEA region will start to recover faster now. The sectoral mix of exports corresponds better to demand than in the Reference Scenario: the EEA being the main destination of the Finnish exports, the trade barriers "protect" the staus quo of the exports structure and thus trigger less changes to the production structure. Total manufacturing exports recover quickly, while the exports of services and primary goods remain lower than in the Reference Scenario.

The trade account balance is much more positive in Scenario 4 than in the Reference Scenario. This is by far the best scenario from this perspective. Nevertheless, the terms of trade do not develop as well as they deteriorate dramatically when the higher tariffs are introduced. There is a gradual improvement in the terms of trade thereafter.

Figure 28 Value of Finnish exports in Scenario 4, %-difference to Reference scenario



6.4.4 Consumer utility and welfare

As we can see from Figure 22a–c above, Scenario 4 is the worst scenario from the point of view of consumer utility for the world, the EU and Finland. It is the

only scenario where utility drops below that in the Reference Scenario (for the world and Finland).

7. Trade creation and trade diversion

This section describes the impact of trade liberalisation on world trade under different policy regimes. We ask whether the measures create trade (and welfare) or whether they just divert trade between countries.

From the global point of view the Russian WTO membership is a rather insignificant development, but looking at Figure 32 in the Appendix we see that e.g. for Finland it has its merits.

The Doha agreement creates trade at an accelerating pace that peaks at around 1.5 per cent increase in the value of world trade, compared to no trade liberalisation, when the agreement is fully implemented. On the other hand, the scenarios with higher-than-present tariffs show how much trade will be lost from a global four-block trade war. Some 9–10 per cent of world trade is wiped out. This means, roughly, that a 1% additional import tariff between blocs results in nearly 1% decrease in world trade.

For Finland, we see from Figure 30 that the Russian WTO membership boost total trade by about 0.6 per cent. The impact of the Doha Round is about twice as large. The trade war in Scenarios 3 and 4 wipe out about 4.5 per cent of Finnish trade. Thereafter the situation improves but turns worse again in the late 2020s. Figure 31 shows the impacts of trade liberalisation or new barriers of trade for Finnish exporting industries by sector.

Figure 29 *Impact of trade liberalisation on world trade under different policy regimes: %-difference in growth from 2010 between scenarios*

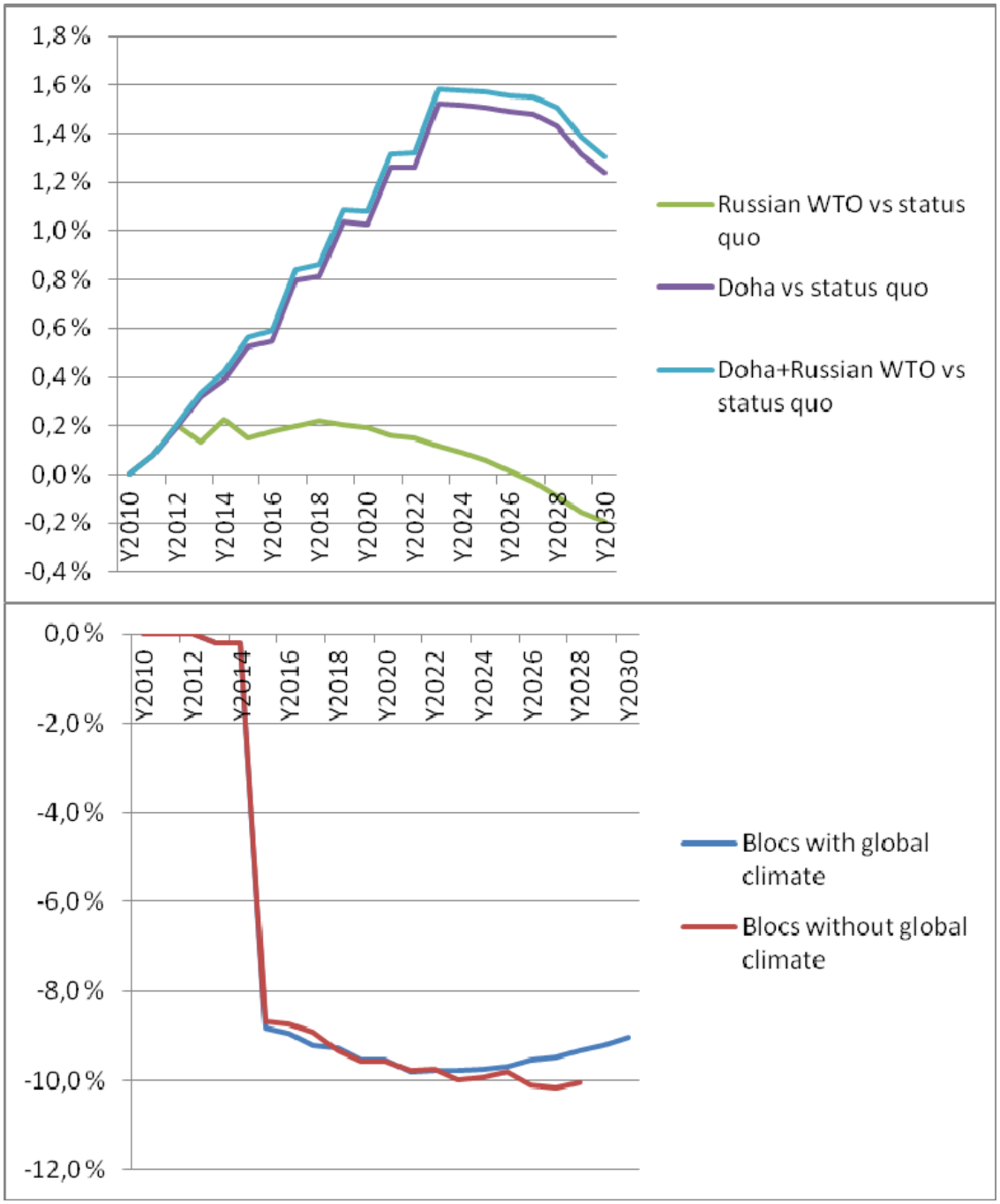


Figure 30 *Impact of trade liberalisation on Finnish trade under different policy regimes: %-difference in growth from 2010 between scenarios*

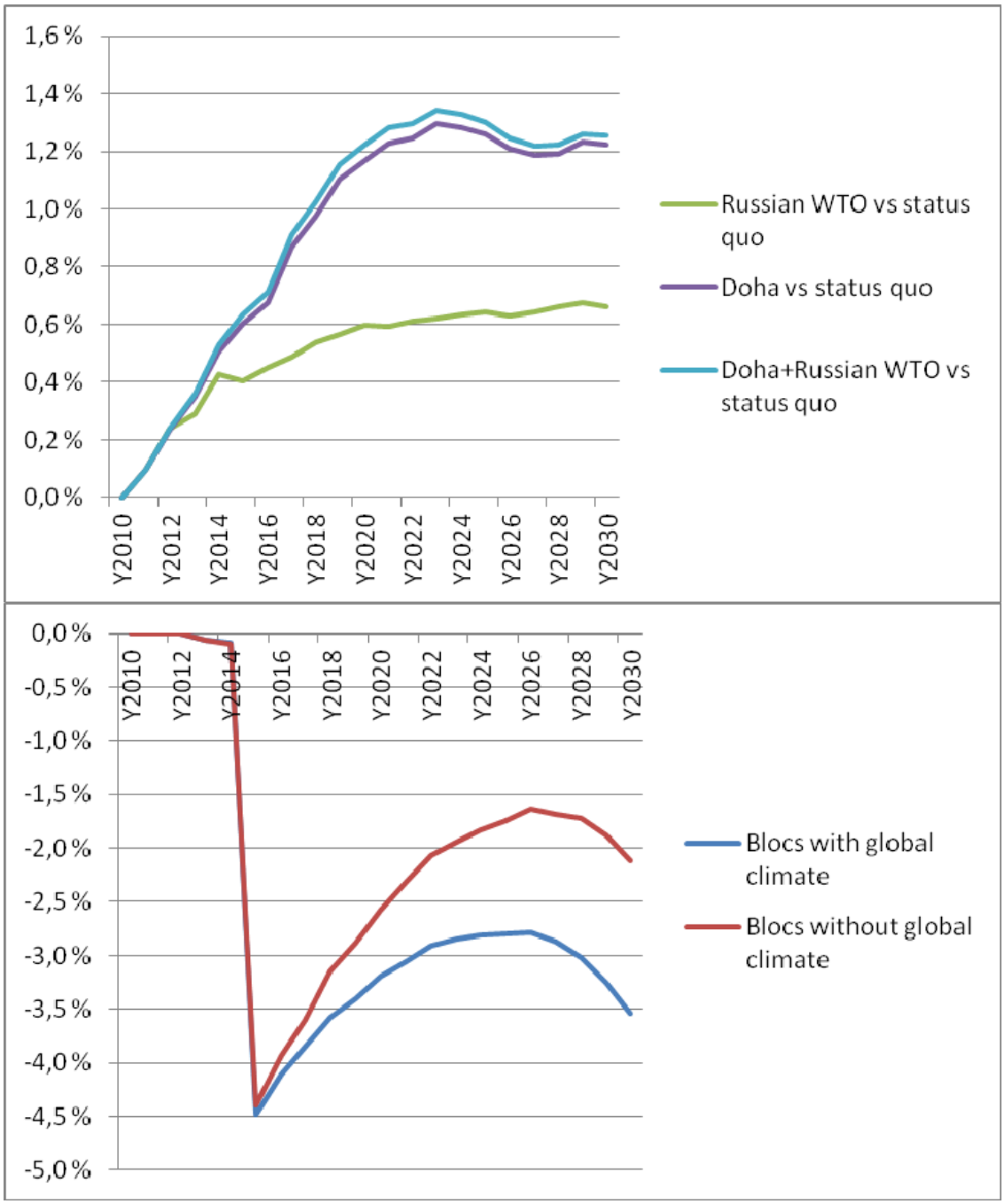
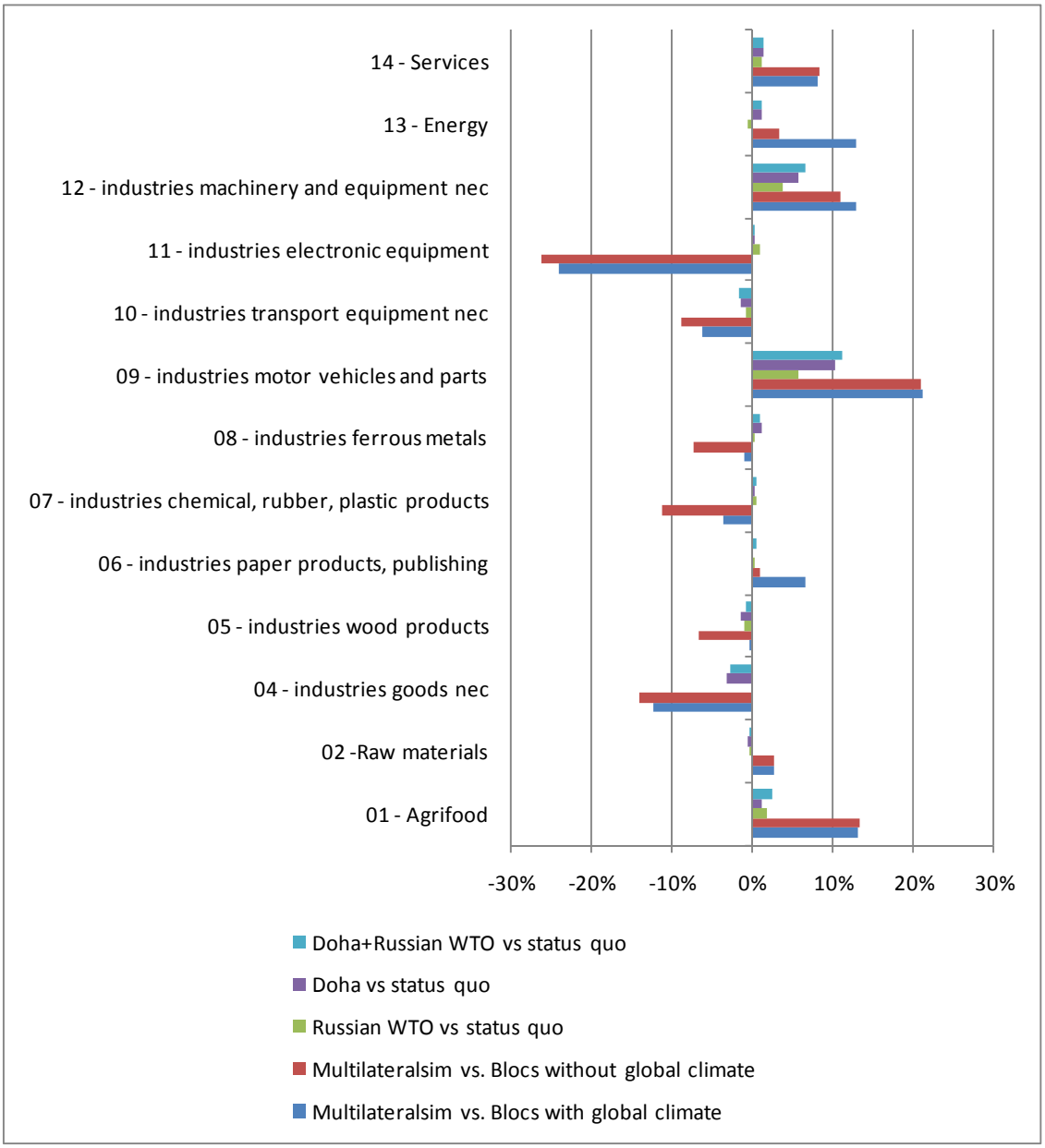


Figure 31 Impact of trade liberalisation on Finnish trade under different policy regimes – sector exports volumes



8. Discussion

We have presented four scenarios which attempt to illustrate the impacts of trade policies under different contexts. Namely, we assess the effects of further liberalisation or introduction of new trade barriers in two different climate policy regimes: a unilateral European policy, roughly corresponding to the present situation, and a globally covering agreement. For Finnish exporting industries, trade liberalisation tends to reduce the exporting volumes of the traditional manufacturing sectors whereas especially services sector, but also for example food industry, benefit. Conversely, establishing new trade barriers tends to favour the old industries.

The scenario with lower-than-current trade tariffs and a global climate policy is the best in terms of GDP and consumer utility in the world, EU and Finland. On the other hand, a global trade war with no global climate agreement is the worst scenario. For Finland the difference by 2030 between these two extreme scenarios is almost 6% of GDP and 14% of consumer utility, and increasing. On the other hand, this scenario is the worst one in terms of the Finnish trade balance.

For nearly all sectors, the changes due to trade liberalisation or bloc formation are more favourable or less detrimental when a global climate policy agreement is in place. This effect is particularly clear for energy intensive industries. Our scenarios assume an increase in energy efficiency following climate policy implementation, which leads to higher productivity.

However, there is a widespread agreement in the literature that also trade liberalisation alone leads to productivity growth. This can follow from increased imports or Foreign Direct Investment embedding new technology and thus facilitating technology transfer across borders. Exporting firms tend to be more productive than firms concentrating on domestic markets and thus, as increased exports raises the weight of exporting firms in the economy, increase of average productivity is observed. The GTAP model results reflect part of these effects, namely the more efficient allocation of production between regions, and also more efficient use of resources within a region.

Trade liberalisation may also incur additional factors, which are not accounted for in this study, that lead to improved productivity. For example, the “New Theory of Trade” suggests that increasing returns to scale and expanding markets will allow industries to raise output, average cost will be lower. These productivity gains from trade are relatively easy to identify but hard to quantify.

Technical Annex

The GTAP Model and Database

The simulations in this study employ the VATT version of the Global Trade Analysis Project (GTAP) model and database. The model is a recursive-dynamic applied general equilibrium model extended to better analyse energy and environment issues and take into account the various forms of agricultural subsidies.

The model is built on the standard GTAP model and its dynamic (GTAP-Dyn) and environmental (GTAP-E) extensions. The original standard version (Hertel and Tsigas 1997) is a general equilibrium model, assuming perfect competition and constant returns to scale, by region and by commodity. The model allows for a sophisticated treatment of consumer demands, detailed treatment of international trade and transport costs. The GTAP-E extension (Burniaux and Truong 2002) can be used to evaluate the abatement costs and spill-over effects of greenhouse-gas reduction policies through international trade and interactions between sectors. GTAP-Dyn model (Ianchovichina and McDougall 2001) model permits a recursive solution procedure, a feature that allows easy implementation of dynamics without imposing limitations on the model's size. Adding to the standard GTAP model, it incorporates international capital mobility, capital accumulation, and accounting that keep track of foreign capital ownership with an adaptive expectations theory of investment.

The VATT version of the model incorporates several additional features, including an enhanced treatment and reporting of energy commodities, which allows iterative simulation runs with VTT Times (Nordic) energy system model. In addition, an improved description of various taxes and subsidies are included.

Bilateral trade is handled via the Armington (1969) assumption. Model results are derived from assumptions of firms and consumers optimising their behaviour within constraints given by endowments (land, labour, capital, natural resources) and policies (e.g. taxes). In the equilibrium solution, all markets are in equilibrium, i.e. demand equals supply. Trade policy instruments are represented in the GTAP database as ad valorem taxes and subsidies. For agricultural commodities, domestic support levels are calculated from the OECD (2008) Producer Support Estimate (PSE), and components for market price support are excluded to avoid double counting with the tariffs in the database.

The term “general equilibrium” refers to the economy as an entity where everything affects everything and economic shocks impacting on any one component can have repercussions throughout the system. Depending on the simulation experiment (closure) different variables may be regarded as

exogenous (given to the model) or endogenous (solved within the model).GTAP model is a quite standard general equilibrium model assuming perfect competition and constant returns to scale technology. As a special feature which makes it suitable especially for studies related to developed and developing countries is the demand structure which takes into account the elasticity of demand for different commodities to be dependent on the income level.

Simulation results depend partly on the original data and e.g. the input-output structure of the model. In the numerical model the price-responsive behaviour of actors (firms, households) also affect the results. The parameters or elasticities of the behavioural functions determine the magnitude of reactions of the economy. On the size of these parameters CGE models rely on outside information of econometric studies. CGE models rely heavily on national input-output tables as their primary source of data. In GTAP data base version 7.1, input-output tables of 112 regions have been combined together with data on bilateral trade flows between each sector in each country. Bilateraltrade flows make it possible to analyse changes in trade policy when reductions are occurring in only one country. That is why it suits this study in question very well. Apart from interlinking economies, GTAP database has a detailed structure of policy parameters, which have been implemented into the model by price-wedges between the competitive price and the market price. E.g tariff data is reported in ad valorem terms.

GTAP model applications are widely used in research (Hertel et al. 2010, Valenzuela et al. 2009, Telleria et al. 2009, Martin et al. 2008, Walsh et al. 2007, Dimaranan et al. 2007) particularly in a broad scope of international trade. The GTAP 7.1 Database (Narayanan and Walmsley 2010) has been used in this study, representing the world economy for a given reference year -- 2004. For the reporting purposes, this data has been updated to 2010 values. The database comprises several types of data: behavioural parameters that include elasticities of substitution between domestic and imported goods, and elasticities of substitution between sources of imports (Armington elasticities). The main data file is derived from regional input-output tables, bilateral trade flows and protection data (taxes and subsidies). The database represents the world economy as flows of goods and services measured in millions of 2004 US dollars. Additional data is provided for capital stocks, population and savings. The database includes five endowments (i.e. production factors) -- land, skilled labour, unskilled labour, natural resources, and capital -- with 113 countries/regions and 57 commodities/sectors. In this study, the database is aggregated into 18 countries/regions and 22 commodities/sectors (Table 1).

Table 2 Aggregation by sectors and regions

Group/Type	Sector in reporting	**Aggregated sector for simulations**	GTAP sectors included
Primary agriculture			
	Agrifood	**primary agriculture**	paddy rice, wheat, cereal grains nec, vegetables, fruit, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops nec, bovine cattle, sheep and goats, horses, animal products nec, raw milk, wool, silk-worm cocoons
Primary - others			
	Primary	**primary forestry**	forestry
		primary fishing	fishing
		primary minerals (ore)	minerals nec
Primary energy			
	Energy	**primary coal**	coal
		primary petroleum	oil
		primary gas	gas
Processed food			
	Agrifood	**processed food**	bovine cattle, sheep and goat meat products, meat products, vegetable oils and fats, dairy products, processed rice, sugar, food products nec, beverages and tobacco products
Manufacturing industries			
	Energy-intensive industry	**industries - wood products**	wood products
		industries - paper products, publishing	paper products, publishing
		industries - chemical, rubber, plastic products	chemical, rubber, plastic products
		industries - ferrous metals	ferrous metals
	Machinery and equipment	**industries - motor vehicles and parts**	motor vehicles and parts
		industries - transport equipment nec	transport equipment nec
		industries - machinery and equipment nec	machinery and equipment nec

	Electronics	**industries - electronic equipment**	electronic equipment
	Other industries	**industries - goods nec**	textiles, wearing apparel, leather products, mineral products nec, metals nec, metal products, manufactures nec
	Energy	**industries – fuels**	petroleum, coal products,
		industries – electricity	electricity
		industries – gas distribution	gas manufacture, distribution
Services			
	Construction	**services - construction water trade**	water, construction, trade
	Transportation	**services - transportation**	transport nec, water transport, air transport
	Business services	**services - specialiced business services, R&D**	business services nec
	Other services	**services - specialised nec**	communication, financial services nec, insurance, recreational and other services, public admin. and defence, education, health, ownership of dwellings

Continent	Region in reporting	**Aggregated region for simulations**	GTAP regions included
Australia and Oceania			
	High-income Asia-Pacific	**Australia and New Zealand**	Australia, New Zealand, Rest of Oceania
Asia (Far East)			
	China	**China**	China, Hong Kong
	High-income Asia-Pacific	**Japan**	Japan
		Korea	Korea
	India	**India**	India
	South-East Asia	**Rest of South and East Asia**	Taiwan, Rest of East Asia, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Vietnam, Rest of Southeast Asia, Bangladesh, Pakistan, Sri Lanka, Rest of South Asia

North America			
	North America	**USA**	United States of America
		Rest of North America	Canada, Mexico, Rest of North America
South America			
	South America	**MERCOSUR**	Argentina, Brazil, Paraguay, Uruguay
		Rest of South America	Bolivia, Chile, Colombia, Ecuador, Peru, Venezuela, Rest of South America, Costa Rica, Guatemala, Nicaragua, Panama, Rest of Central America, Caribbean
Europe			
	EEA	**Finland**	Finland
		EU27	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Bulgaria, Romania
		EFTA	Switzerland, Norway, Rest of EFTA
	Eastern Europe	**Russia**	Russian Federation
		Eastern Europe etc.	Albania, Belarus, Croatia, Ukraine, Rest of Eastern Europe, Rest of Europe, Kazakhstan, Kyrgyztan, Rest of Former Soviet Union, Armenia, Azerbaijan, Georgia

Africa and Middle East			
	Middle East and North Africa	**Middle East and North Africa**	Iran, Islamic Republic of, Turkey, Rest of Western Asia, Egypt, Morocco, Tunisia, Rest of North Africa
	Sub-Saharan Africa	**Southern African Customs Union**	Botswana, South Africa, Rest of South African Customs Union
		LDCs in Africa	Nigeria, Senegal, Rest of Western Africa, Central Africa, South Central Africa, Ethiopia, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Rest of Eastern Africa

Scenario descriptions

A number of scenarios have been simulated with the GTAP model to assess the implications of various macro developments and policy options in medium and long run. All scenarios are for period 2004-2030, but the results in this report are usually reported beginning from 2010. Unless otherwise specified, the results are reported relative to the reference scenario that incorporates the European climate policies in place. Reference global growth rates follow the actual ones to date and the latest IMF projections for the rest of the simulation period

The reference case scenario aims at representing the macro-economic driver variables in a business-as-usual world. Therefore, it incorporates the actual population, labour force and GDP growth and investment figures from international sources[6] until 2010, as well as the latest available projections until 2025. GDP and investment projections beyond the data provided by IMF, as well as regional forecasts for energy efficiency improvement, have been taken from the CEPII (2010) baseline scenario. The population and labour force projections are same in all scenarios, while the GDP growth is determined (endogenously) by the model in the policy scenarios. The reference case also incorporates EU's

[6] IMF, EUROSTAT, United Nations, ILO

emission reduction commitments and the ETS, and assumes technological development required to achieve the 20% reduction in primary energy use.

Policy scenarios are chosen to illustrate the impacts on global trade policy regimes under different technological progress environments related to climate policies. The simulated policies are illustrative and include relatively extreme changes in tariff levels.

The following section describes the policies and developments included in one or more of the scenarios, as summarized in Table 3.

Table 3 Policies and developments included in the scenarios

	Macro and Technology			**Climate policies**		**Trade policies**		
	International projections and forecasts	Technology in Europe	Global technology boost	EU2020	Global climate policy	Russia in WTO	Doha round	Trading blocs
Reference Scenario	All	Yes	No	Yes	No	Yes	No	No
Scenario 1: Sustainable prosperity	All except GDP & prices	Yes	Yes	Included in global	Yes	Yes	Yes	No
Scenario 2: multilateralism	All except GDP & prices	Yes	No	Yes	No	Yes	Yes	No
Scenario 3: Mutual suspicion	All except GDP & prices	Yes	Yes	Included in global	Yes	Yes	No	Yes
Scenario 4: blocs	All except GDP & prices	Yes	No	Yes	No	Yes	No	Yes

Macro development

International projections and forecasts

GDP

Gross domestic product growth rates in the reference scenario follow the IMF projection until 2016 and the CEPII baseline scenario from there on. In policy scenarios, the GDP growth changes as a result of simulations. Annual average growth rates 2010-2030 are presented below.

Table 4 Annual GDP growth, 2010-2030 average

Finland	1.9 %	Australia and NZL	2.3 %
Rest of EU27	1.6 %	Japan	1.3 %
EFTA	1.8 %	Korea	2.2 %
Eastern Europe etc.	2.2 %	China	7.7 %
Russia	2.9 %	India	6.9 %
Rest of North America	2.9 %	Rest of S and E Asia	4.9 %
USA	2.2 %	The Arab World	4.0 %
Rest of South America	3.5 %	LDCs in Africa	6.8 %
Mercosur	3.2 %	Southern Africa Customs Union	3.3 %

Population

Regional population growth rates follow the World Population Prospects middle-scenario (United Nations 2008) in all simulated scenarios. Annual average growth rates 2010-2030 are as follows.

Table 5 Annual population growth, 2010-2030 average

Finland	0.2 %	Australia and NZL	1.1 %
Rest of EU27	0.1 %	Japan	-0.4 %
EFTA	0.5 %	Korea	0.1 %
Eastern Europe etc.	-0.4 %	China	0.4 %
Russia	-0.4 %	India	1.0 %
Rest of North America	0.7 %	Rest of S and E Asia	1.1 %
USA	0.8 %	The Arab World	1.2 %
Rest of South America	1.0 %	LDCs in Africa	2.2 %
Mercosur	0.6 %	Southern Africa Customs Union	0.5 %

Labour

Labour force growth follows the ILO (2008) projections for years and regions available. For the remaining data points, the World Population Prospects working age population projection has been used instead. The overall labour force growth rates have been allocated to unskilled and skilled labour separately using the information from the CEPII baseline scenario.

Simulations also include an exogenous component of Labour productivity growth, which follows the development similar to the CEPII baseline scenario.

Table 6 Annual labour force growth, 2010-2030 average

Finland	-0.1 %	Australia and NZL	1.1 %
Rest of EU27	0.1 %	Japan	-0.7 %
EFTA	0.6 %	Korea	0.3 %
Eastern Europe etc.	0.4 %	China	0.2 %
Russia	-0.9 %	India	1.6 %
Rest of North America	1.2 %	Rest of S and E Asia	1.8 %
USA	0.6 %	The Arab World	2.1 %
Rest of South America	1.9 %	LDCs in Africa	2.8 %
Mercosur	1.2 %	Southern Africa Customs Union	0.7 %

Energy efficiency

In the reference scenario, an annual increase or decrease in energy efficiency is assumed to follow the projections provided by the CEPII baseline scenario. These figures are relatively modest and only reflect long-term technological development trends. These growth rates are increased for regions participating in climate policy.

Table 7 Annual energy efficiency growth, 2010-2030 average

Finland	0.7 %	Australia and NZL	0.0 %
Rest of EU27	0.5 %	Japan	0.5 %
EFTA	0.2 %	Korea	1.6 %
Eastern Europe etc.	1.5 %	China	0.6 %
Russia	2.5 %	India	1.1 %
Rest of North America	1.5 %	Rest of S and E Asia	0.7 %
USA	1.1 %	The Arab World	0.9 %
Rest of South America	0.3 %	LDCs in Africa	-1.0 %
Mercosur	0.7 %	Southern Africa Customs Union	-0.3 %

Technology in Europe

Additional energy efficiency related to EU20-20-20 policies is assumed in all scenarios. The efficiency growth is adjusted so that the policy goal of reducing primary energy use by 20% compared to 1990 level is met. Reference data employs the results from simultaneous model runs with the Nordic Times Energy Systems model conducted previously in the Nordic Energy Perspectives project (NEP 2010).

Global technology boost
Accelerated energy efficiency improvement is assumed for all regions participating in climate policy. In the scenarios with global climate policy (scenarios 1 and 3), all regions benefit from an overall 0.5% additional annual increase in energy efficiency.

Primary products and food
In the reference case, world price for petroleum, ore, agricultural products and food drive the simulation results very strongly. Global output of these products has been adjusted so that the world price follows international forecasts / long term trends. The average annual world price increases in the reference case are 3.8% for primary agriculture products, 5,9% for food, 3.4% for iron ore, and 5.2% for crude oil and gas.

Climate policies

EU2020
All scenarios assume that the EU (and EFTA) maintains at least its current climate policy. Until 2020, the reductions are according to the adopted EU20-20-20 regime, i.e. reduction of all CO2 emissions by 20% compared to 1990.Between years 2010 and 2020, this requires a 1% annual decrease. In the heavy industry sectors, emissions trading possibility is assumed. On the other sectors, a CO2-tax is introduced. Same trend is assumed to continue also beyond 2020.

Global climate policy
In scenarios 1 and 3, a global commitment to GHG emissions reduction is introduced. A reduction of CO2 emissions by 1% annually is assumed in all regions outside Europe starting 2010. In EU and EFTA, a more ambitious commitment is made.

Trade policy

Russia in WTO
Russian WTO membership, which has been approved, is assumed in all scenarios. This implies cutting import tariffs to Russia by 19-23% depending on sector, and reduction of agricultural subsidies by half. Tariff cuts are implemented in three stages 2012, 2014 an 2018, where the sectors with sensitive status face liberalisation later. Market access of Russian products to other regions is improved in same proportion.

Doha round
Doha round tariff reductions follow the most liberal proposal, corresponding to "Scenario B" in Laborde and Martin (2010). As the tariff barriers for manufactured products are already low in most industrialised countries, the most

significant tariff cuts take place for agricultural commodities and in developing countries. In addition to import tariff cuts, agricultural export subsidies are abolished. Policies are implemented in 2013, 2015 and 2017 for High Income Countries, and 2019, 2021 and 2023 for developing and newly admitted countries.

Detailed descriptions of the tariffs in the GTAP data before and after the Doha implementation are available for Non Agricultural goods in http://gatt.ifpri.info/files/2010/12/NAMA_LabordeMartin_Draft.pdf; and for Agricultural goods in http://gatt.ifpri.info/files/2010/12/AMA_LabordeMartin_Draft.pdf .

Trading blocs

In this extreme trade policy vision, the world is divided into four blocks: Western Europe (=EEA), Eastern Europe (Russia + FSU), Americas, and "The Chinese Hegemony" (China, South-East Asia, Developing Africa). Australia, Japan, Korea, India and the Arab world region are left outside any bloc. All countries increase their import tariffs by 10%, except for imports from the members of the same block.

Regional adjustments

Finland

The GTAP model assumes similar behavioural parameters for firms and consumers in all regions. To better account for the special characteristics of the Finnish economy, structural developments in the Reference scenario have been partly aligned with the 2004-2025 VATTAGE (Finnish one-country AGE model) scenario, including:

- macro variables
- industrial outputs
- imports and exports from EU / Non-EU

A series of auxiliary simulations were conducted for this adjustment. The development of the sector-specific outputs in Finland were first fixed to correspond to the VATTAGE model results assuming the foreign trade development to also follow the path produced in the same results. As the VATTAGE model does not model international trade explicitly, the adjustment variables that were acquired from the first simulation for the industry outputs were used in a second simulation where the constraints on foreign trade were released.

In the reference scenario, Finland's total trade is allowed to grow /decrease more in the simulation period (2010-2030) compared to the VATTAGE model results, which does not fully account for the growth in global demand. (This affects, in

particular, raw materials / ore demand). Cumulative value (at the end of 2030) of the "trading preference" or "shadow tariff" variable, obtained by fitting Finland's trade and production changes with VATTAGE model baseline, is decrease by half.

Increase in primary energy (oil and gas) prices described above together with the adjusted production and trade Finland leads to a simulated trade balance deficit that exceeds currently observed trends. We estimate that oil price effect in the simulations accounts for USD 2.5 to 3.5 billion of annual deficits.

China

China's economy has a considerable impact on global trade, in particular on products mentioned above (Food, Fuels, Ore). Several adjustments has been made to bring the base line simulation results closer to the observed / forecasted developments:

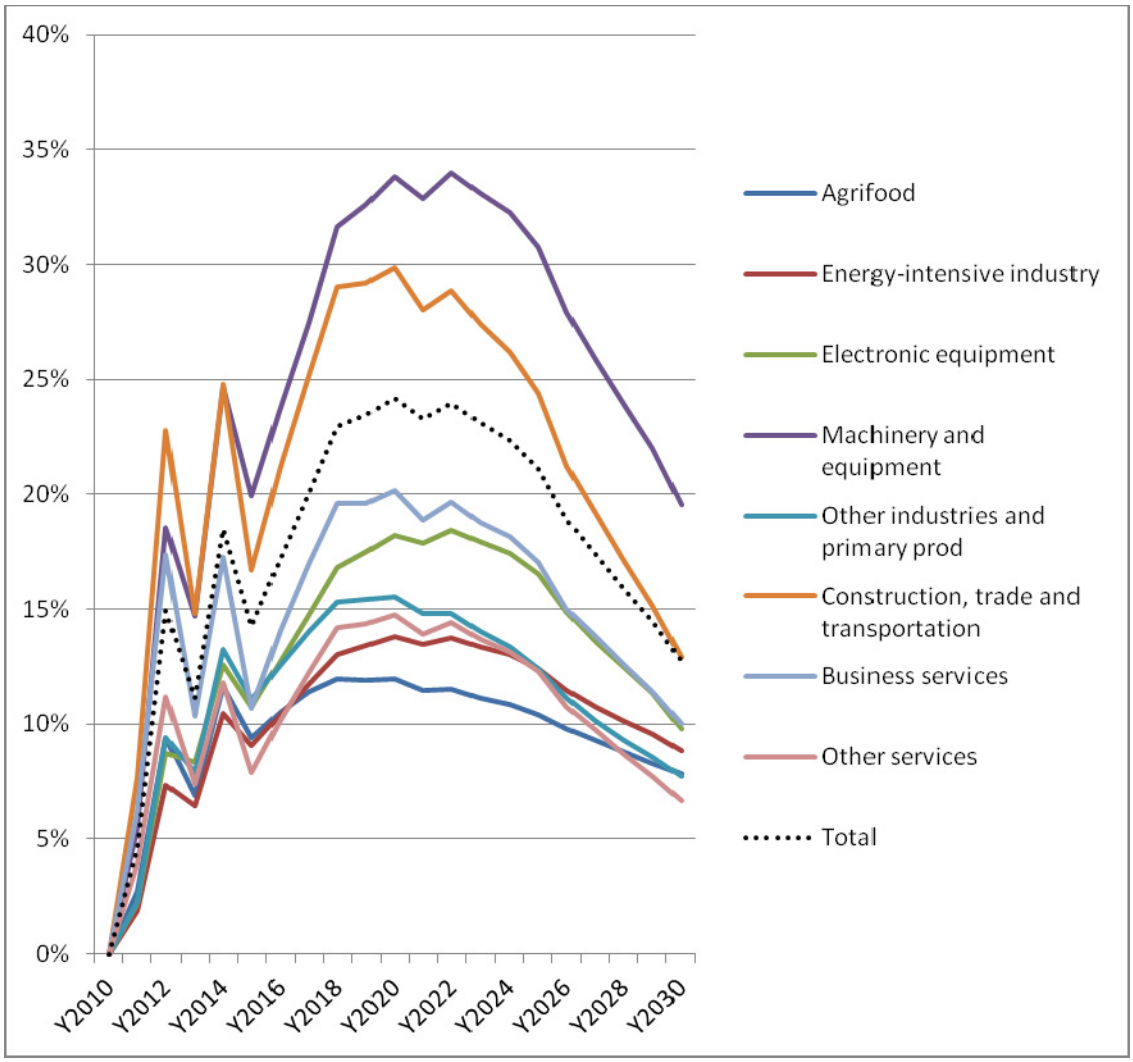
- investments has been fixed to follow the CEPII scenario
- land and natural resources availability decreases
- an arbitrary (1%) annual improvement in manufacturing sectors productivity, to reflect structural changes in the economy.

Beginning capital stock corrected to allow predicted investments levels.

Russia

Whilst the effect of the Russian WTO membership, included in the reference scenario, on global trade is relatively modest (see figure 29), it has more significance to Finnish exports. Figure 32 illustrates that most Finnish industries benefit from a 10%-25% annual increase in exports to Russia immediately following the WTO-related trade liberalisation. On the longer term, the positive effect on imports is reduced to 7%-15%.

Figure 32 Finnish exports to Russia, the impact of Russian WTO membership



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