WORKING PAPER ILLUSTRATING THE USE of HMG's PARTIAL EQIUILIBRIUM TRADE MODELS

Abstract: This paper illustrates how the UK's Department of Business and Trade's (DBT) partial equilibrium (PE) models work by presenting results from running simulations of a notional trade agreement between two countries. It uses these to show how these models' function, what they can deliver, what are the key parameters that drive their results and how sensitive the results are to changes in these parameters.

Contents

Introduction

The Department for Business and Trade (DBT) uses economic analysis to better understand the potential impact of trade policies such as free trade agreements. Modelling is one key part of this process, which is used alongside qualitative analysis and stakeholder insights to supply evidence to policymakers.

DBT operates a suite of models to simulate possible trade policies. This fits with the recommendations of the Trade Modelling Review's Expert Panel[1] and is essential for robust and comprehensive economic analysis in line with the principles of the Government Economic Service.

Partial Equilibrium (PE) trade models are essentially a set of equations based on economic theory that incorporate a range of factors which influence the prices and sales of products, whether imported or produced domestically. They estimate the economic impact of changes in barriers to trade, such as tariff rates and non-tariff measures on a range of variables including domestic production, trade and in some of our PE models equilibrium prices and welfare.

DBTs models include several Partial Equilibrium (PE) models, including the UK Partial Equilibrium Trade (or PETRA) model and the PE Demand (or PE–D) model. The models share many features and have a common theoretical base, but PE-D is effectively a simpler, demand-driven model. Its lesser data requirements means that it can sometimes be used when using PETRA is impractical. In particular, it can be a useful tool for analysing a few sectors at a more granular level.

Other institutions and governments also make use of PE models. The USITC has a range of PE models[2] that can be used to simulate the impact of trade policies using specific industry data and policy scenarios.

DBTs PE models are part of a suite of HMG trade models that include computable general equilibrium (CGE) models, various gravity-based models such as that already used for services[3] and Defra's suite of models such as the UK Agricultural Market Model UKAMM[4]. These are not covered in this paper.

This paper illustrates how the PETRA and PE-D models work by presenting results from running simulations of a notional trade agreement between two countries. It uses these to show how these models' function, what they can deliver, the key parameters that drive their results and how sensitive these results are to changes in these parameters.

It complements the Technical Guides to the PE models[5] which set out the structure and describes the equations of the models, by:

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[1] Trade modelling review expert panel: report (Jan 2022) https://www.gov.uk/government/publications/trade-modelling-review-expert-panel-report-and-recommendations/trade-modelling-review-expert-panel-report

[2] USITC PE Modelling Portal https://www.usitc.gov/data/pe_modeling/index.htm

[3] Services trade modelling working paper (Aug 2021) https://www.gov.uk/government/publications/services-trade-modelling-working-paper

[4] UK Agricultural Market Model (UKAMM) (Feb 2021) https://www.gov.uk/government/publications/uk-agricultural-market-model-ukamm

[5] https://www.gov.uk/government/publications/partial-equilibrium-trade-pe-trade-or-petra-model-modelling-paper

https://www.gov.uk/government/publications/partial-equilibrium-d-pe-d-model-modelling-paper

- Showing the value of the PE model as a tool for HMG. One issue with modelling is that it can be unclear how to interpret the results. This paper suggests how to do so for these PE models, to illustrate what such models can (and cannot) offer.

- Encourage awareness and discussion of DBTs PE models and their uses. By lifting the lid on one of our modelling tools, we hope to promote dialogue and scrutiny that challenges our analysis to be as current and robust as possible.

- Show DBTs progress in developing PE models since the Modelling Review's Expert Panel (2022), as one of its recommendations was to use PE modelling to supplement and complement CGE modelling.

The paper provides results from several different models and versions of these models to show the sensitivity of the results to using different structural assumptions about international trade, such as the nature of competition (imperfect competition compared to Armington competition), the role of imported intermediates and international supply chains and the difficulties there can be in simulating impacts when historical trade is heavily restricted. It also reports on how sensitive results are to key parameters by showing how impacts change when a key elasticity parameter is changed.

Structure

The paper starts by outlining the scenarios and data used for these simulations, before presenting the main results from the Imperfect Competition (IC) version of PETRA, then discussing how these vary when other versions of PETRA and the PE-D model are used. It then proceeds to offer some interpretation of the results and their implications.

Central scenario

A notional scenario has been simulated of a free trade agreement between two invented countries, Arcady & Cospania. This is not intended to represent any actual or proposed trade agreement, so an artificial trade and tariff data set has been created and used.

Whilst both countries modelled produce and trade an extensive range of products (at the 4 digit ISIC sector level and 6 digit HS product lines), one of the two countries (Arcady) tends to specialise more in food and materials and the other country (Cospania) tends to specialise more in producing manufactured goods, although both have some exceptions. There are also a few sectors where there is little trade between them.

They start with a range of tariffs, ranging from zero to over 50%, with Arcady tending to have higher tariffs than Cospania. Both have a range of non-tariff measures (NTMs[6]) in place which it is assumed can be converted into ad valorem tariff equivalents (AVEs). In these PE models a change in NTMs is assumed to have a similar impact to an equivalent change in tariffs. This is adopted as a necessary simplification given the difficulties of simulating the

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[6] NTMs cover a wide range of measures other than tariffs that can act as barriers to trade such as regulations, health and safety standards, testing and certification requirements, customs procedures, rules of origin and domestic content requirements. NTMs are generally used to serve wider policy objectives. Whilst they can support trade for example by providing a signal of quality, they can increase also costs and so reduce trade.

impact of NTMs. For example, a regulation may have a binary impact either enabling or preventing a firm from accessing a market and apply to all firms rather than represent an increase in the price firms from one country face in exporting to another. For simplicity, the central scenario assumes complete tariff liberalisation and no changes in NTMs. Whilst such a level of tariff liberalisation goes further than existing trade agreements, it approximates the more ambitious agreements, that typically liberalise nearly all tariff lines. The adoption of unchanged NTMs is, again, for simplicity and to keep the focus on tariffs. If there is concern about the potential impact of varying the level of assumed tariff or NTM liberalisation then sensitivity scenarios could be run, but this has not been done in this paper.

Table 1: Examples of Bilateral Tariff Levels (percentage points)

	Arcady		Cospania	
Sectors	Base	Simulation	Base	Simulation
1010 Meats	0	0	54	0
2910 Motor Vehicles	33	0	8	0
1430 Clothing	35	0	11	0
Simple average	14.5	0	4.5	0
Max tariff	35	0	54	0
Number of sectors with 0 Tariff	3	122	16	122

Sensitivity runs

A set of sensitivity runs have been conducted to illustrate how much the simulated impacts can vary when a key parameter – the Armington elasticities - are changed. The alternative elasticity parameter values used for the sensitivity runs are loosely based on recent empirical estimates and have been chosen to clearly demonstrate the sensitivity of the results to these key assumptions.

Range of Sensitivity checks:

PE–D runs with alternative Armington elasticities based on recent estimates.

PE–D runs with elasticities based on High/Low estimates.

Data

Models are highly dependent on the data they use. For simulations using these models DBT largely draws on publicly available data sources, such as:

Table 2: Data Sources

Trade	Largely drawn from the UNs COMTRADE database; if COMTRADE data is missing for an important sector then have drawn on alternative dataset sets such as the ITCs MACMAPS, or US ITCs ITPD-S.
Tariffs	Largely drawn from World Bank's WITS database, using effectively applied AVEs. Specific, seasonal, etc tariffs have been converted into AVEs using UNCTAD method. TRQs, quotas, etc have been ignored.
Elasticities	Assumed values broadly in line with literature estimates. Sensitivity tests use alternative estimates loosely based on recent literature estimates.

For this exercise trade and tariff data has been created for the two imaginary countries; elasticities have still been sourced from the literature.

Results

The following section outlines the main impacts common across all the PE models (although the scale of the impacts varies between different versions of the PETRA model and the different models) for total and bilateral trade, consumption, production and prices.

Bilateral trade

Bilateral trade increases between the two countries following the liberalisation of their tariffs. As the relative price of Arcady's exports to Cospania falls, it will gain market share from other exporters to Cospania and from Cospania's domestic producers and vice versa for Cospania's exports to Arcady.

The rate at which market share shifts from other suppliers will depend on the size of the tariff change, the Armington elasticity of substitution (our PE models only have one Armington elasticity – it is the same for substitution from domestic producers as for exports from third countries, i.e. there is no home market preference) and those suppliers' historic market shares and prices.

This assumes full pass through of any tariff changes. However, in practice impacts may be less than suggested by the simulation results, if exporters, importers or wholesalers absorb some of the changes.

Armington Elasticities

These are a common feature of many trade models, where it is assumed for simplicity that: there are differentiated products, consumers have a preference for variety and each country produces a different variety of a good. The Armington elasticity then provides a measure of how willing consumers are to switch from the variety supplied by one country to the variety supplied by another country in response to a change in their relative prices.

The following chart (1) shows both countries see increased exports for virtually all their products (113/122 sectors). The exceptions being where their partner doesn't liberalise as its base tariff was already zero or when there were no historic exports which happens for eight sectors that Arcady exports and one that Cospania exports. Such increased bilateral trade is fully consistent with the structure of the model which is based on imperfect competition, where each country produces different varieties of products and consumers value variety. So intra-industry trade is to be expected; Arcady will export a product to Cospania even though Cospania also produces the product because they make different varieties and consumers value having both varieties.

The increases in the value of bilateral trade are generally of modest value, with 100/122 sectors seeing an increase of less than £10m (although the percentage increases can be large when the base value of exports was low). In around a sixth of sectors (22/122) there were more substantial increases:

- 3 where exports by both countries increased by >£10m,
- Another 5 where Arcady's exports increased by > £10m,
- Another 14 where Cospania's exports grew by > £10m.

In 5 of the 19 sectors where either Arcady or Cospania's bilateral exports increased by more than £10m the partners bilateral exports also increased, but by less than £10m. In the other 14 of these sectors the partners bilateral exports were effectively unchanged.

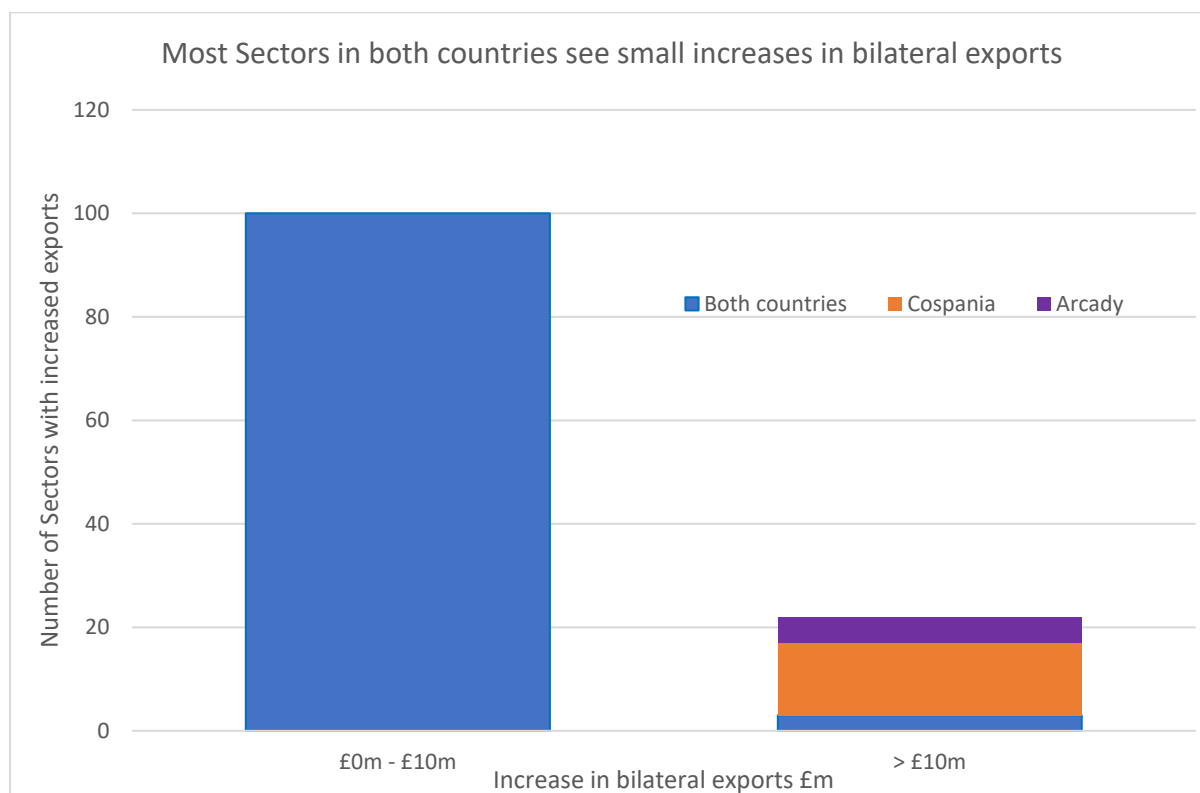Chart 1: Number of Sectors by changes in the value of their bilateral exports

Chart showing most sectors in both countries see small increases in Bilateral Exports.
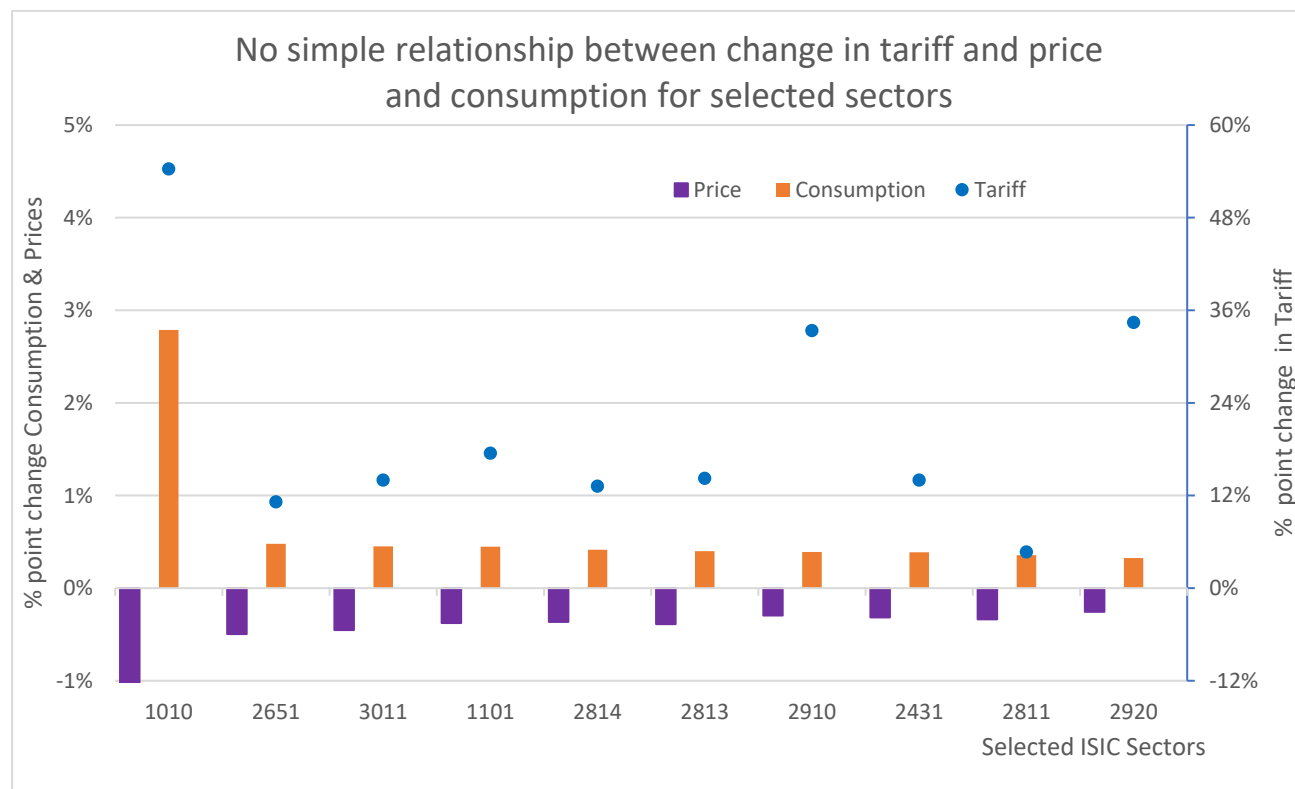
Consumption

Consumption increases in countries that liberalise. This can be interpreted as an "income effect". As the price of the product falls due to the lower tariffs, demand and hence consumption rises. This demonstrates part of the classic benefits of trade liberalisation – the small, widely distributed gain to consumers when tariffs are cut.

The impact is greater when there are larger reductions in tariffs, falling to zero if there is no change in tariffs (for example if the base tariff was already zero). And even a substantial cut in tariffs is not sufficient to guarantee a large response. The tariff cut also needs to be being applied to a supplier with a significant market share and demand must be responsive to price changes. It is also necessary for the tariff reduction to be passed through to consumers of the product. Otherwise impacts may be less than suggested by the simulations if some of the tariff change is absorbed by exporters or the distribution chain.

As the following chart (2) demonstrates large changes in consumption rarely occurred in these simulations. In these runs there is only one sector with a gain in consumption above 1% and that is Cospania's consumption of Meats (ISIC 1010) where a large tariff reduction (over 50%) and price sensitive consumers (high elasticity) boosts consumption by 2.8%. But there are other sectors, such as Vehicles (ISIC 2910) in Arcady which see large tariff

reductions 33%, but with much more modest increases in consumption and falls in prices comparable to those seen in sectors with tariff cuts of less than half their size of 5%-15% such as in the engines & turbines sector (ISIC 2811).

Chart 2: Change in Consumption related to tariff and price changes for selected sectors in Arcady and Cospania

No simple relationship between change in tariff and price and consumption for selected sectors.

Sector Key

ISIC Sector Code	Description
1010	Meats
2651	Measuring, testing and navigation instruments and equipment
3011	Ships and floating structures
1101	Spirits
2814	Bearings, gears, etc
2813	Pumps, compressors, taps, valves, etc
2910	Motor vehicles & their engines
2431	Iron & Steel
2811	Engines & turbines except those for vehicles and aircraft
2920	Vehicle bodies, trailers & semi-trailers

Consumption impact across all 122 sectors

As the following Chart (3) shows, there were widespread, but small gains in consumption across virtually all sectors in both countries. The few cases where consumption doesn't increase is because the country's base tariff was already zero, so there was no reduction in price and hence no increase in demand. Whenever a tariff is cut, prices fall and consumption will increase, so more sectors gain in Arcady where base tariffs tend to be slightly higher and there are fewer zero starting tariffs. However, the largest gain for an individual sector is for Meats in Cospania which has the greatest tariff reduction combined with significant imports from Arcady.

Summary of changes:

- Only in one sector, 1010 (Meats) in Cospania, was there an increase in consumption greater than 0.5%,
- In another 22 sectors there was an increase of consumption of between 0.1 % and 0.5% in at least one of the countries,
- In another 98 sectors consumption in both countries increased marginally – by less than 0.1%,
- Whilst in only one sector was there no change in consumption.

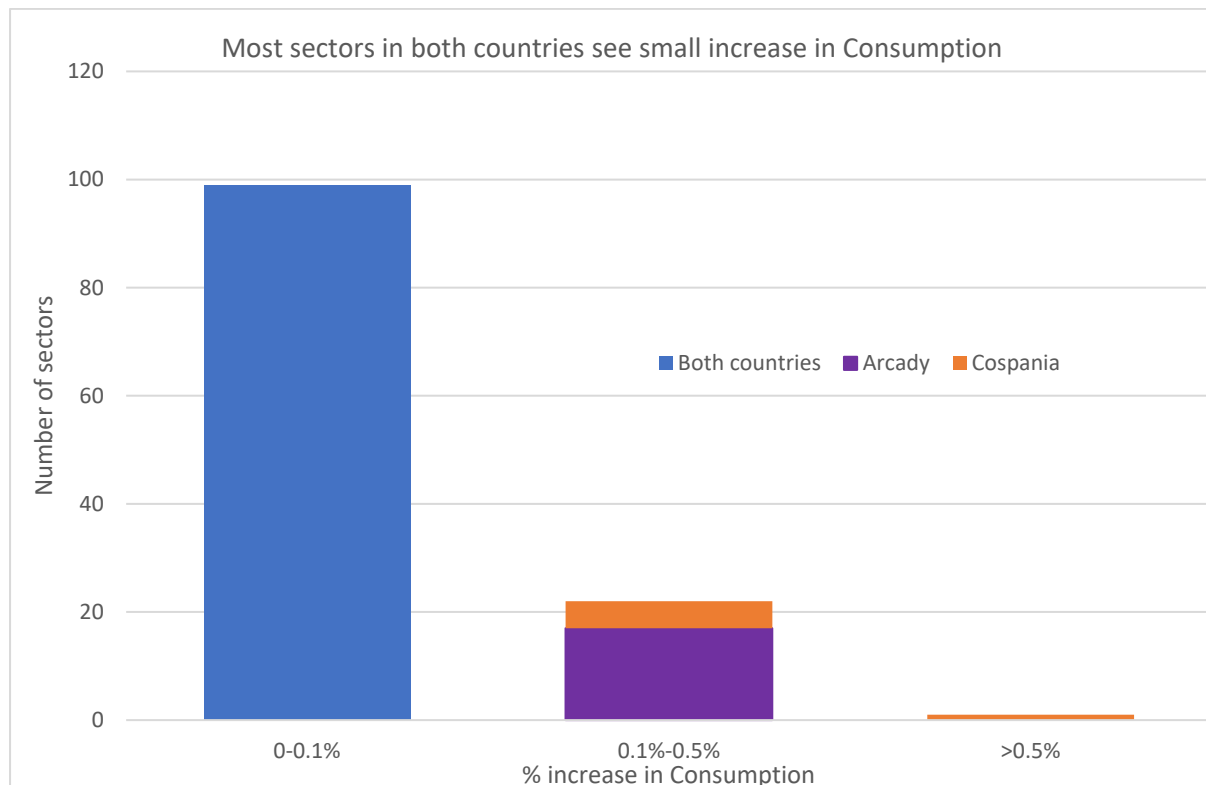Chart 3: Number of sectors by change in consumption across Arcady and Cospania

Chart shows most sectors in both countries see small increase in consumption.

Total trade

In these models, each market is solved independently. As there are no changes to the barriers to trade with third countries, there is a negligible change in Arcady and Cospania's exports to them. So the changes in Arcady and Cospania's total exports reflect the changes in their bilateral exports.

Their change in total imports is less than their change in bilateral imports as the rise in their imports from their free trade agreement partner is partially offset by the displacement this causes of their imports from third countries. However, unless the historic market share of such imports from third countries is high, this displacement is typically limited.

Overall, there is only a limited impact on third countries of the free trade agreement between Arcady and Cospania, reflecting this displacement of their exports to Arcady and Cospania. Whilst this tends to have a slight negative impact on their production, it means that consumption in third countries is effectively not affected by the free trade agreement. This is a feature of these PE models which model the direct impact of the free trade agreement and effectively doesn't incorporate general equilibrium effects or the diversion of Arcady and Cospania's exports. These effects can be significant and if required should be simulated by running other types of models such as CGE or gravity.

Production

The impact on production in Arcady and Cospania is more complex and mixed than the impact on consumption and trade. Domestic producers benefit from increased consumption and increased exports but can see some reduction in their sales due to increased competition from imports in their home market. The net impact varies from product to product and from country to country. Typically, in these models, producers are more likely to see a decline in their output if their country liberalises significantly and by more than its free trade agreement partner and vice versa, but the relationship is complex and will be affected by factors such as historic market shares.

There are some sectors where production rises in both countries. This occurs when the boost to consumption is large or increased exports are mainly displacing imports from third countries rather than domestic production. Nevertheless, in the PE models that do not include intermediates for the majority of sectors an increase in production in once country is accompanied by a fall in production in the other.

The impact can be less clear-cut in the version of PETRA that includes intermediates. In that version of the model liberalisation that leads to a significant fall in the price of imported inputs can improve the competitiveness of products that use such inputs both in their home market and in third country markets and such gains can offset the increased competition they face in their home market from cheaper imports from the free trade agreement partner.

Even in the non-intermediates versions of PETRA, most of the declines in production are modest, with only a handful, 7 cases across both countries, seeing a decline in production of 0.5% or more. However, the changes in production are typically greater than the changes in consumption. Summed over all sectors the overall increase in production was around twice

the increased value of consumption, reflecting Arcady and Cospania's displacement of imports from third countries in their respective markets.

As the following Chart (4) shows:

- 12 sectors saw increased Production in both countries.
- 16 saw increased production in Arcady, and a fall in Cospania.
- 94 saw increased production in Cospania and a fall in Arcady.
- None had a decline in production in both countries.
- Most changes in production were small (± £10m). When there were increases in one country and declines in the other country they tended to be of a similar order of magnitude, although the increases tended to be greater than the declines. Five sectors in Arcady had production grow by > £10m, whilst production fell by more than £10m in Cospania.
- 15 sectors in Cospania had production grow by >£10m. Of these two had production fall by more than £10m in Arcady, another 10 had production fall by less than £10m in Arcady, whilst the other 3 had production increase in Arcady, although by less than £10m.

Chart 4: Number of sectors by change in production in Arcady and Cospania
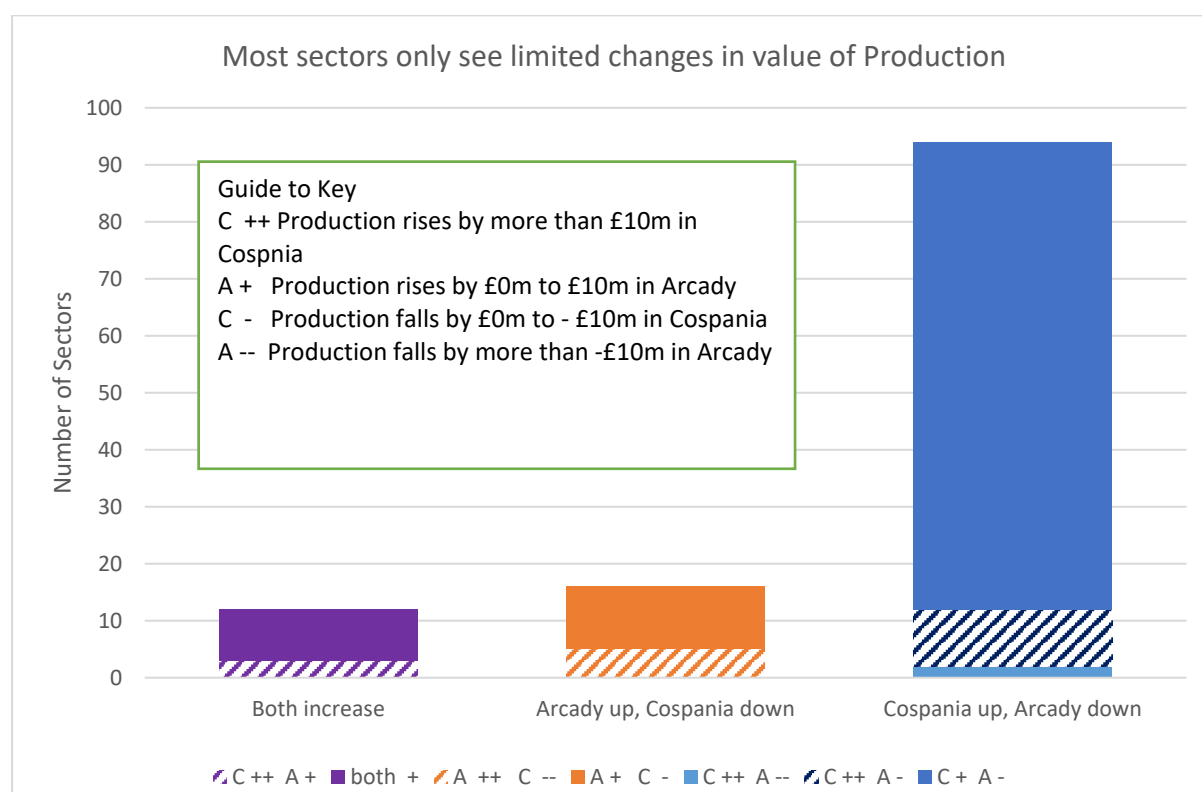

Chart shows most sectors only see limited changes in value of Production.

Although production increased in more sectors in Cospania than Arcady the largest increases in production were seen by Arcady, such that if the value of production changes was summed over all the 122 sectors it was greater for Arcady than Cospania. Indeed, the value of production summed over all sectors fell slightly in Cospania, whilst rising in Arcady.

Prices

In general, average prices fall in countries that liberalise. In these models the average price of a product in a country is a weighted average of the prices of the varieties consumed, incorporating the tariff (and NTM) in the price of imported varieties. As their imports from each other typically account for only a small fraction of Arcady and Cospania's consumption the impact of a reduction in their tariffs on their average prices is typically limited. Moreover, when there is no change in tariffs because the base tariff is already zero, then there will no changes in the products price. As this is a PE model there are no increases in prices in this scenario as there are no general equilibrium effects that could push up the price of inputs.

Welfare

PETRA can provide an approximate estimate of the impact on Welfare[7] and how this is distributed between consumers, producers and changes in government tariff revenue.

Liberalisation increases welfare if the increase in consumer surplus resulting from higher consumption and lower prices exceeds any reduction in tariff revenue and producer surplus from lower tariffs and production. Welfare will also be positive if the gains from producer surplus (which will increase if production rises, in other words growth in exports exceeds any reduction in domestic consumption of domestic production) and consumer surplus outweigh any losses in tariff revenue. It is possible for both countries welfare to increase or decrease.

In these simulations, both countries welfare increases for 15 sectors although both countries have a minimal decline in their welfare for one sector (ISIC 1910, coke oven products). For the other sectors one country's welfare increases whilst the other's falls. Typically, these changes are small, with only two sectors seeing increases in welfare of over £50m, 1010 Meats and 2420 Precious & non-ferrous metals.

For Meats, there is a contrasting route to higher welfare in the two countries. In Cospania, the gains in consumer surplus outweigh its losses in producer surplus and tariff revenue. Whilst in Arcady there is just an increase in producer surplus as there is no change in its tariff or domestic consumption.

For Precious & non-ferrous metals, again Arcady just has an increase in producer surplus. Whilst for Cospania, because it has very limited domestic production, it has little change in producer surplus but its increase in consumer surplus outweighs its loss of tariff revenue.

Chart (5) on the following page also includes a third sector, 2910, Vehicles, where the picture is reversed. In this sector, Arcady is the country making the larger tariff cut and seeing a gain in consumer surplus at the expense of producer surplus and tariff revenue, although in this case its net welfare impact is slightly negative. Whilst Cospania sees an increase in its producer surplus from its increased exports to Arcady.

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[7] 'Welfare' is a measure of well-being or utility.

Chart 5: Consumer and producer welfare impacts in selected sectors

Welfare impacts
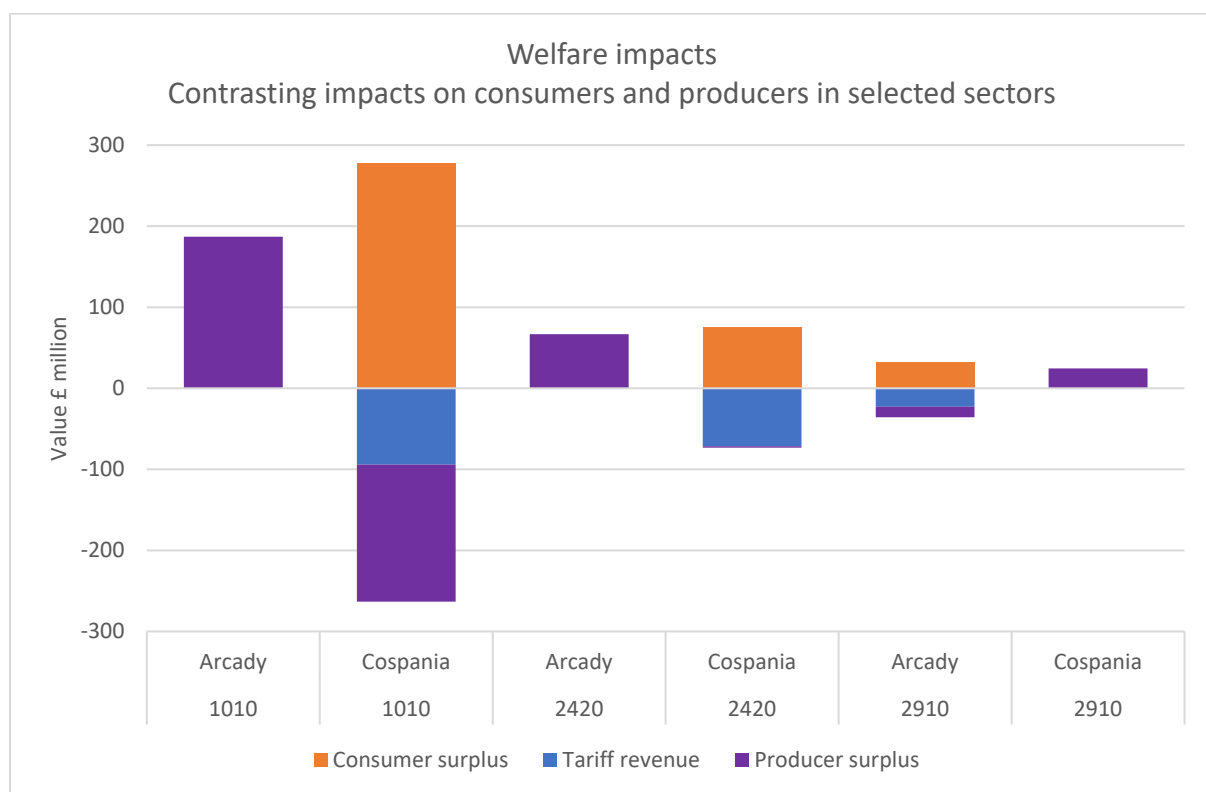Contrasting impacts on consumers and producers in selected sectors

Chart shows contrasting welfare impacts on consumers and producers in selected sectors.

Sector Key

ISIC Sector	Description
1010	Meats
2420	Precious and non-ferrous metals
2910	Motor vehicles and engines

Range of impacts

The following charts (6 and 7) show the range of impacts on: prices, production, exports and imports, showing how the percentage changes vary across all 122 sectors, first for Cospania and then for Arcady. As can be seen:

- Trade (both exports and imports) only increases or in a few cases remains constant.
- Prices fall or are unchanged for many sectors where there has been no change in tariffs (which is common for Cospania but not Arcady); most price changes are small.
- The impact on production varies from sector to sector depending on the scale of each countries respective tariff cuts, changes in consumption, historic markets shares, etc.
- Large impacts are rare.
- There are links between the impacts on Arcady and Cospania. For example, increased exports (and hence production) in one country means increased imports, lower prices and frequently, but not always, lower production in the other.

To show the range of results across all 122 sectors, individual sectors are not identified in these charts. The sectors on the the left hand side of the charts are those involving food and drink. Then the chart moves onto sectors involving materials and commodities, then to intermediate manufactured products and finally on the right hand side of the charts to finished manufactured products.

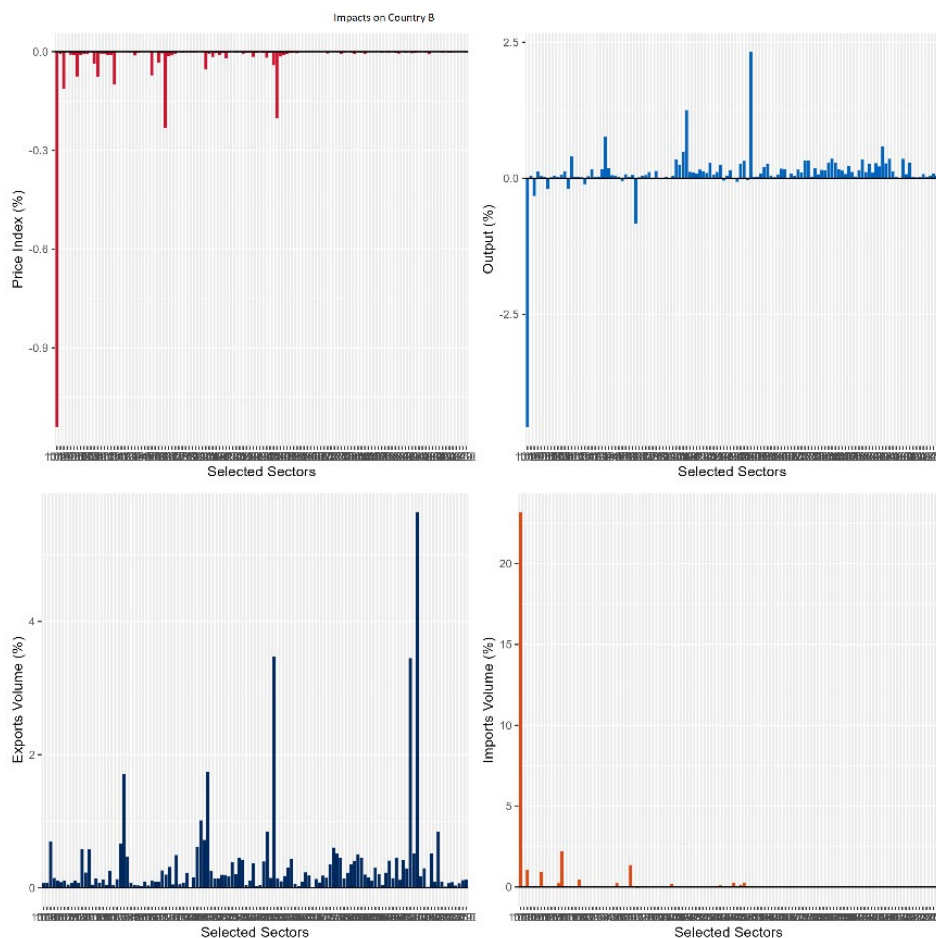Chart 6: Range of Impacts across sectors on Cospania

Chart shows a wide distribution of impacts across sectors for Cospina.

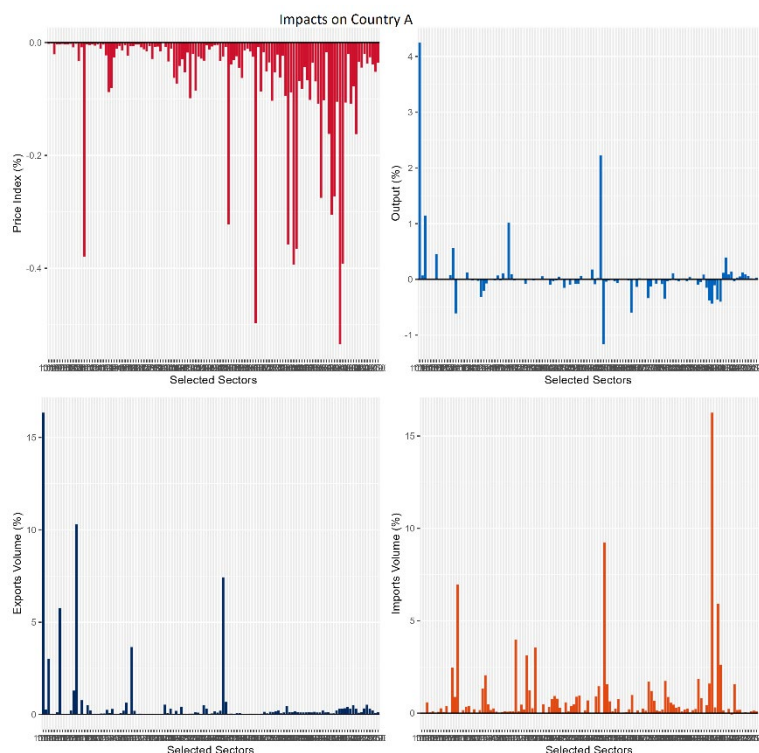Chart 7: Range of impacts over sectors on Arcady

Chart shows a wide distribution of impacts across sectors for Arcady.

Implications and interpretation illustrated by sector

A simple interpretation of comparative advantage might expect that liberalisation would reinforce Arcady and Cospania's existing pattern of specialisation. As the countries have a different pattern of specialisation (the model derives this from their historical trade patterns), this would benefit both countries. The actual simulations suggest a more complex story, suggesting that the pattern of historical specialisation is only one of several factors that drives the results.

Examining the results suggests the whilst the simulated impacts are driven by market shares in the base data and hence historical patterns of specialisation, they are also sensitive to the values of key parameters such as the elasticities and the scenarios adopted – especially the degree of liberalisation. So, in these models the value of a simulated impact will be influenced by:

- The value of historical trade,
- The size of the tariff change,
- The size of the elasticities, especially the Armington elasticity.

Typically, simulated impacts will be relatively modest unless there is either a very large tariff/price change or there was very large historical trade. If there was no or minimal historical trade, then even a large tariff cut will not generate a large change in the value of

trade – a limitation of the models which has been partially addressed by the development of a Small Shares Adjustment (SSA) Function (see page 28 for details).

Ignoring the cases where there was minimal historical trade, sectors with a greater change in tariffs will tend to see a larger impact on prices, consumption and imports. The impact on exports will depend on the change in tariffs in their partner country. And the change in production will depend on the interaction of all the changes in both free trade agreement partners.

The model does not assume a linear relationship between tariff changes and impacts on trade or production and consumption. As the following Charts (8 and 9) demonstrate, greater tariff changes tend to lead to a proportionally greater increase in trade although the effect only becomes noticeable for very large tariff changes, such as in sectors 1010 by Cospania and 1393 by Arcady.

The charts also show that the impact of tariff changes is sensitive to the level of elasticities. These scenarios have been run using two generic elasticity levels, with a lower level for more heterogeneous products reflecting the greater stickiness of consumer preferences when there are more noticeable differences between the characteristics of goods and a higher level (double) for more homogeneous products where people are more likely to switch to different varieties. Greater impacts from tariff changes are observed when the elasticities are higher (the sectors in purple are those which are assumed to have more homogeneous products and hence higher elasticities) and this effect increases the greater is the amount of liberalisation.

Given the importance of elasticities, it is sensible to conduct sensitivity tests. On page 32, results are shown for the PE-D model using (i) an alternative set of elasticities based on recent literature, including some significantly higher values for sectors that were assumed to be heterogeneous in the standard scenarios and (ii) a range of elasticities from a low to high elasticity for each sector that provides a 95% confidence interval around the alternative average elasticity values.

Chart 8: Change in Cospania's imports by sector with low/high elasticities.

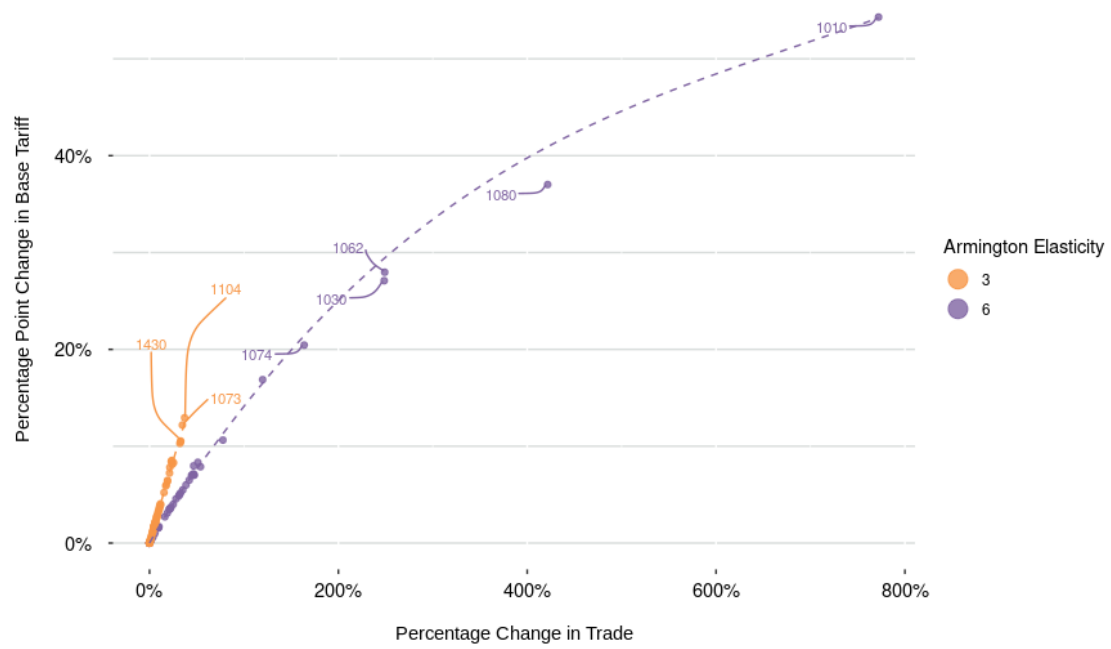Change in Cospania's imports from Acardy following tariff liberalisation, by ISIC sector

Chart shows relationship between the change in tariff liberalisation and change in Cospania's imports by sector with low/high elasticities.

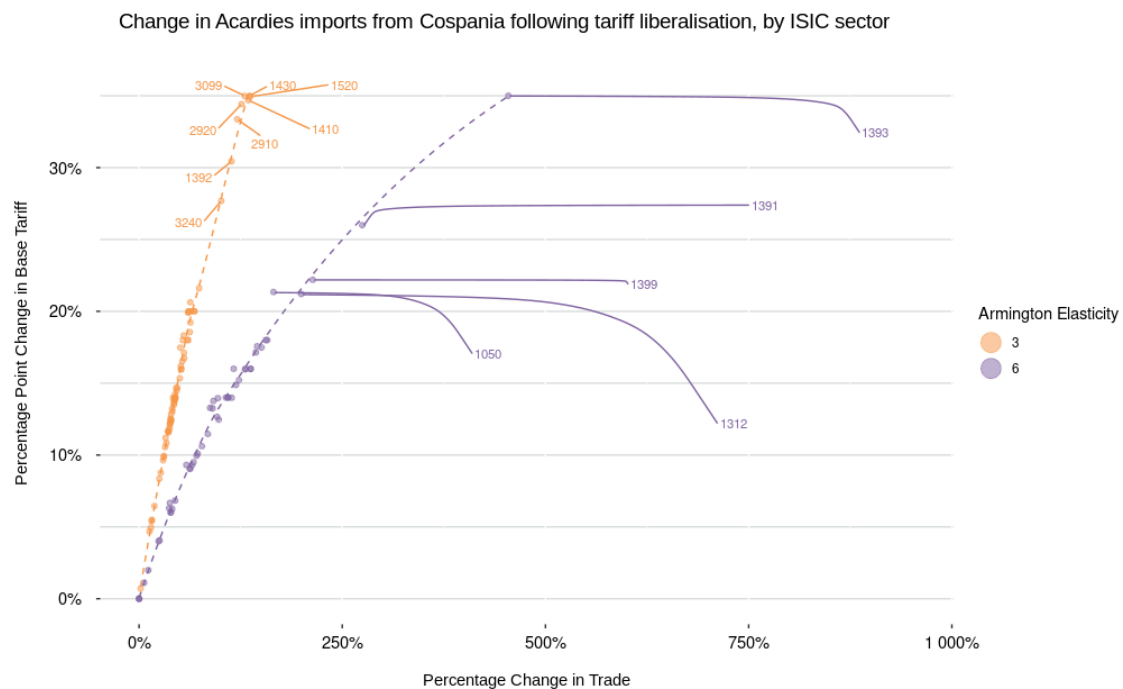Chart 9: Change in Arcady's imports by sectors with low/high elasticities.

Change in Acardies imports from Cospania following tariff liberalisation, by ISIC sector

Chart shows relationship between the change in tariff liberalisation and change in Arcady's imports by sector with low/high elasticities.

Sector Key

ISIC Sector	Description
1430	Knitted and crocheted Clothing
1520	Footwear
1410	Clothing, excluding furs & knitted/crocheted
3099	Other transport equipment eg animal driven carts, shopping carts, luggage carts & sledges
2920	Vehicle bodies, trailers and semi-trailers
2910	Motor vehicles and engines
1392	Textiles, excluding clothing. For example: curtains, blankets, bed and table linens
3240	Games & toys
1393	Carpets & rugs
1391	Knitted & crocheted fabrics
1399	Other textiles eg felt, lace, impregnated and coated fabrics
1312	Weaving of textiles
1050	Dairy
1010	Meats
1080	Animal feeds

1062	Starches and starch based products
1030	Fruit and vegetables
1074	Macaroni, noodles, couscous, etc
1073	Chocolate, cocoa, sweets
1104	Soft drinks and bottled water

The importance of the combination of these factors in driving the impacts can be further illustrated by more detailed exploration of the results for a couple of selected sectors which have seen the greatest impacts. These demonstrate that it is necessary to consider a ranger of factors and not just the levels of liberalisation to fully understand the results.

Case Study 1010 Meats

This is an example of a sector with a relatively homogeneous product and elastic demand, in other words consumers are quick to switch varieties when there are relative price changes.

As the following Chart (10) suggests, Arcady specialises in this sector as demonstrated by the fact that despite low tariffs[8] (including no tariff on its imports from Cospania), its domestic producers dominate its home market (98% market share, with import penetration of only 2%) and its high level of exports (exports account for a quarter of its production), despite facing high tariffs (averaging around 15%) in many markets.

In contrast, Cospania has high barriers on its imports from many partners, including Arcady (its tariff on its imports from Arcady is over 50%), which has limited its historical imports from these countries. Despite these barriers its producers share of its home market is around 70%, and its exports are limited, despite generally facing lower tariffs than Arcady, accounting for a bit over 10% of its production. All of which suggests a relative lack of specialisation in this sector.

Chart 10: Specialisation and tariffs uncorrelated

Specialisation Box:

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[8] Although this outcome could also be driven by prohibitive NTMs, that is not the case in this scenario. In this example, Arcady's dominance is the result of its competitiveness.
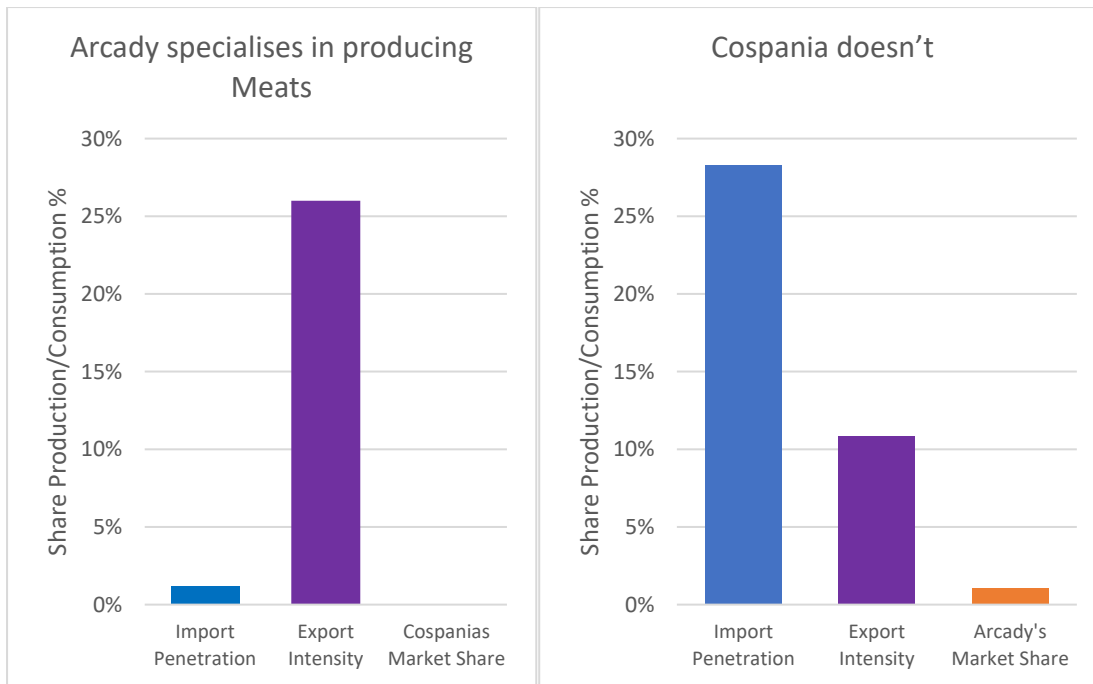
Charts shows Arcady specialises in meats but Cospania doesn't.

Tariff Box:
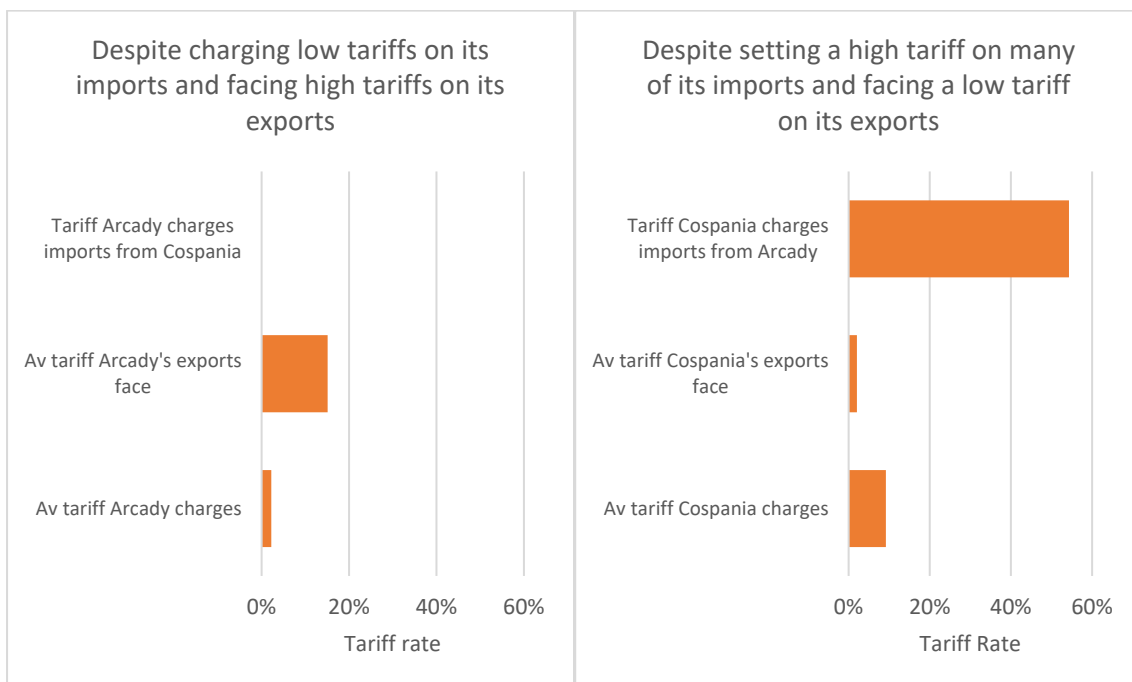
Charts show that Acady charges low tariffs on its imports and faces high tariffs on its exports. Whereas Cospania sets low tariffs on its imports and faces high tariffs on its exports.

Definitions

Import Penetration = Total Imports divided by Consumption –
the market share imports have of a country's total
consumption as opposed to the market share of domestic
producers

Export Intensity = Exports divided by Production. The
proportion of a country's total production that is exported

Given how the model works under these circumstances, when Arcady specialises and
Cospania doesn't, there would be expected to be considerable benefits from liberalisation
mainly to producers in the country that specialises in the product and to consumers through
lower prices in the country that doesn't. The scale of the impact will also depend on factors
such as the responsiveness of demand to changes in relative prices and historic market
shares.

There would also be expected to be impacts on producers in third countries through changes
in their exports to Arcady and Cospania. With a greater impact on those third countries with
significant exports to the liberalising countries. Due to the structure of the model there isn't
any impact on the domestic markets of third countries. This is because each country market
is solved independently so there isn't any diversion of exports from the countries that have
liberalised to third countries.

In this example when the model was run, there is a fall in production and exports from third
countries to the country liberalising, Cospania. The changes for third countries will depend
on each country's share of historic consumption in Cospania (slightly under 30%) and the
change in the relative price of their exports to Cospania compared to the change in relative
prices for Cospania's domestic producers. A there are low tariffs on the largest third country
exporters to Cospania their exporters face a similar challenge from the liberalisation as
Cospania's domestic suppliers. Hence slightly under 30% of Arcady's increased market
share displaces imports from third countries rather than Cospania's producers.

There is no change in Arcady's domestic market (prices, consumption or imports) which is as
expected given there was no liberalisation (as its base period tariff was 0% on imports from
Cospania) and the dominance of its domestic producers. Arcady sees a significant increase
in its exports and production because it heavily specialises in producing Meats so is well
positioned to benefit from Cospania's significant liberalisation (base tariff of >50%
eliminated). As each market is solved independently in the model the growth in its exports to
Cospania does not affect either its domestic market or its exports to third countries.

The sizable changes in Cospania's domestic market – the gains to consumers from lower
prices leading to higher consumption with a switch to imports from Arcady from imports from
third countries and domestic production – reflect Arcady's specialisation, the sizable tariff
liberalisation and the relatively high elasticity, despite Arcady's limited historical market share
in Cospania. Cospania sees no change in its exports because there is no liberalisation by
Arcady as its base tariff was already zero. Cospania sees a fall in production due to its
increased imports exceeding its increased consumption, although the impact is reduced by
the degree to which the increased imports from Arcady are displacing imports from third
countries rather than Cospania's domestic output.

These factors explain the differing impacts on Arcady and Cospania shown in Chart (11) on
the next page.

Chart 11: Differing impacts on producers and consumers in Arcady and Cospania
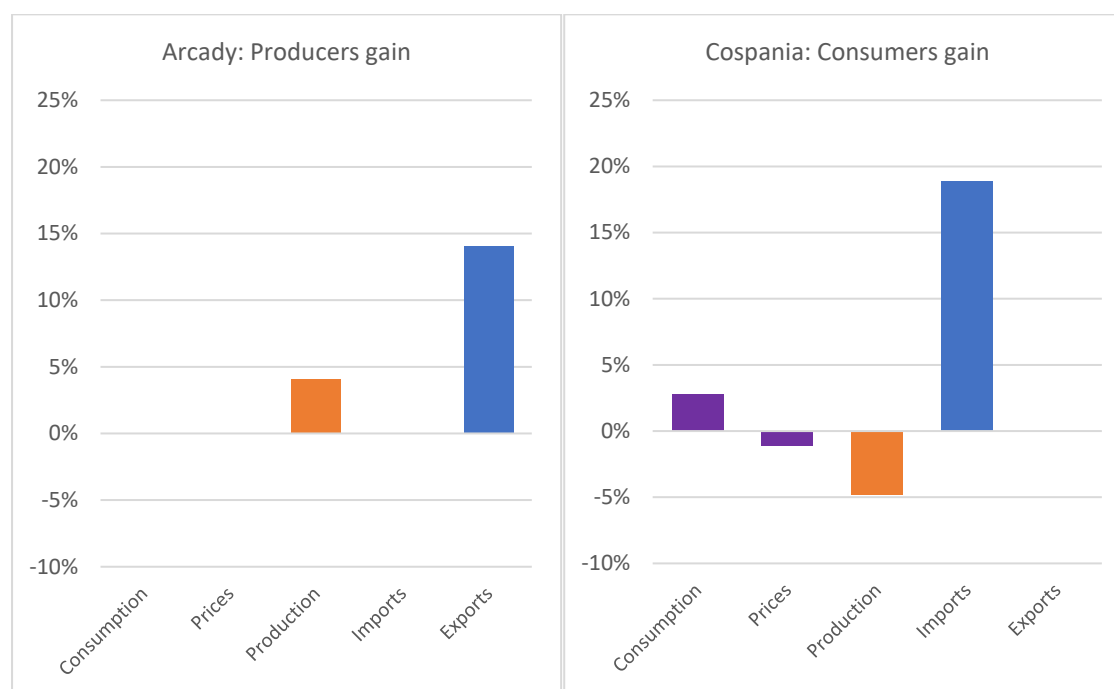
Charts show Arcady producers gain while Cospania consumers gain.

Case Study 2910 Motor vehicles

In this scenario this is an example of a sector Vehicles (ISIC 2910 which includes engines and chassis fitted with engines for vehicles as well as cars, buses, commercial vehicles) with a differentiated product subject to imperfect competition, which is therefore assumed to have a relatively low elasticity. In other words, consumers are less willing to switch varieties in response to relative price changes. It is a highly globalised sector, with considerable two-way trade (as shown by the high levels of import penetration and export intensity in both countries).

Historically, Arcady is relatively more restrictive with a higher tariff and less reliance on trade than Cospania. For both countries, their main international partners are third countries rather than each other, which limits the impact of their bilateral liberalisation. However, Cospania is a more important supplier to Arcady than Arcady is to Cospania so the impact of the free trade agreement on Cospania's producers and Arcady's consumers is greater than on Arcady's producers and Cospania's consumers.

Chart 12: Specialisation and tariffs uncorrelated

Specialisation Box:
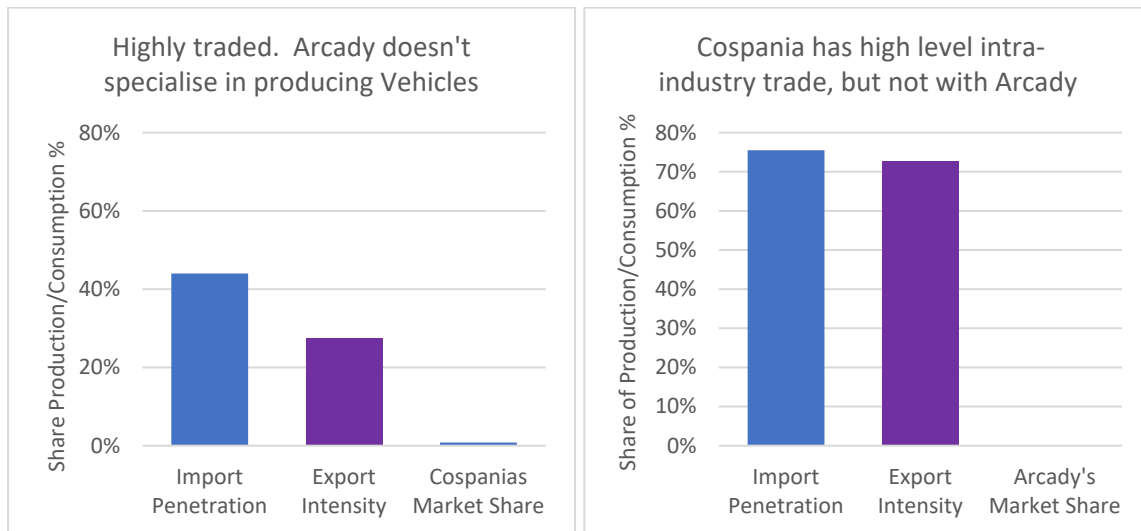
Charts shows Arcady doesn't specialise in producing Vehicles and Cospania has high level intra-industry trade, but not with Arcady.
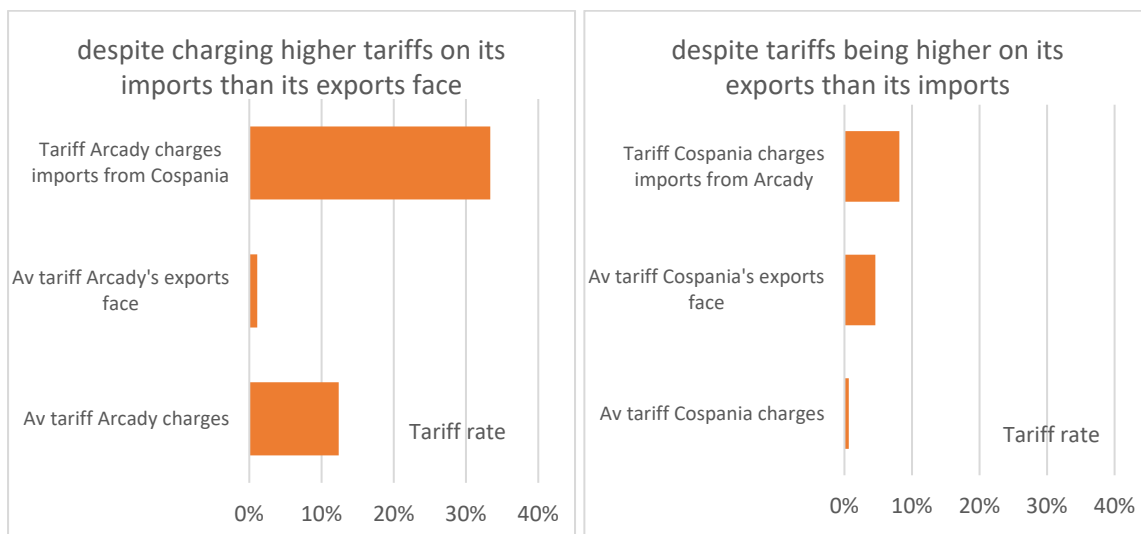
Tariff Box:

Chart shows Arcady charges higher tariffs on its imports than its exports face. Cospania tariffs are higher on its exports than imports.

 Chart 13: Differing impacts on consumers and producers in Arcady and Cospania
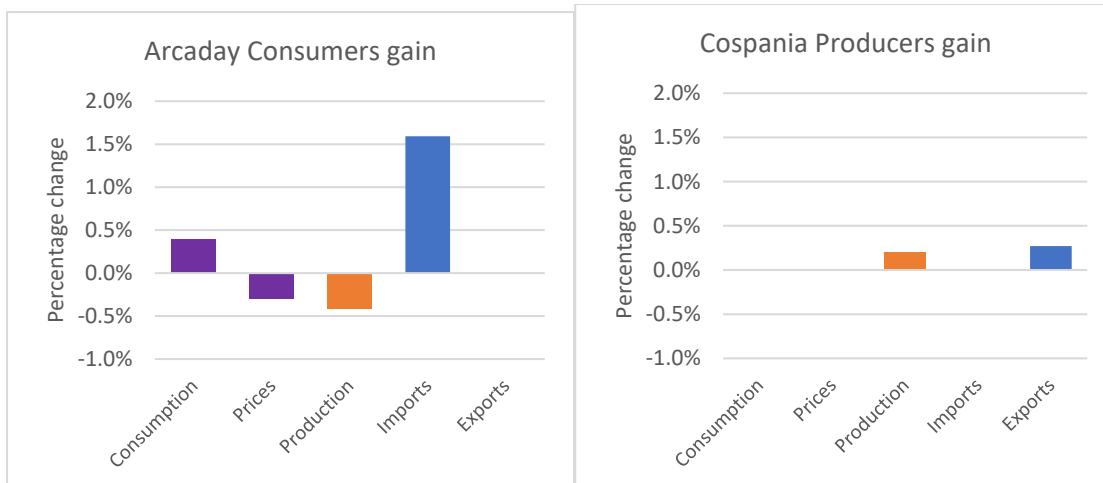
Chart shows Arcady consumers gain and Cospania producers gain.

The impacts on the motor vehicles sector illustrates several important points:

1. Tariff changes on their own are not sufficient to explain the impacts and need to be considered alongside factors such as historic market share. In this example there was virtually no change in the value of Arcady's exports to Cospania, despite the 8% tariff cut by Cospania, because the minimal level of historic exports from Arcady to Cospania limited the gains from liberalisation. So, despite this example involving tariff cuts by both countries, its impact on Cospania's domestic market is similar to those seen for the Meats sector above for Arcady, where there was no liberalisation. This may be an unrealistic result reflecting the model's reliance on historic data to calibrate preferences. If this is considered problematic, it can be addressed by running the PE-D model incorporating a small shares adjustment (see page 27), but even then, the impacts may still be limited.

2. The importance of the elasticity of demand. Whilst there was a large increase (120%) in bilateral exports from Cospania to Arcady of Vehicles, the change was much less than it was for Arcady's exports to Cospania of Meats (770%). Whilst the tariff cut was smaller (33 percentage points rather than 54 percentage points) the difference in the change in bilateral exports was not proportionate to the difference in the tariff changes. Similarly, although the historical market share was slightly smaller for Vehicles (Cospania accounted for 0.8% of Arcady's historical consumption compared with the 1% market share Arcady's Meats had of Cospania's consumption) this difference in historic market share was not proportionate to the difference in results for these two sectors. Instead, the main driver of the bigger impact seen for Meats compared to Vehicles was the higher elasticity, in other words more responsive demand, used for Meats (-6) than for Vehicles (-3), reflecting the assumption that Meats was a more homogeneous product than Vehicles. This isn't a surprise as the more likely consumers are to switch to different varieties when there is a change in relative prices then the greater should be the impact of a price change. But it is striking to see how significant it is, particularly as in these sectors, when there are large changes in tariffs.

3.   Whilst there is also a difference in income demand elasticity for the two sectors, the results are far less sensitive to this difference than they are to the Armington elasticity.

4.   The sensitivity to the Armington elasticity is one reason it is useful to consider the range of potential impacts the model suggests under different elasticities. This is explored further in pages 31-32 which shows the impact of running simulations with different Armington elasticities and with a range of elasticities.

5.   Different groups are impacted in Arcady and Cospania, reflecting their differing starting points. In the relatively more protected Arcady, the main beneficiaries of liberalisation are consumers – with lower prices leading to increased consumption, whilst producers see a small decrease in their output as in this example the gains from greater access to Cospania don't fully offset the impact of greater competition in their domestic market. By contrast in Cospania there is only a limited impact on consumers (due to Arcady's small base market share), whilst producers see a gain from increased exports to Arcady.

6.   Third country effects in these simulations are limited. As discussed earlier, due to the nature of the model the only channel through which they are effectively impacted is their potential loss of market share in the liberalising countries as a result of an unfavourable shift in relative prices. They do not face any change in their domestic market either in terms of consumption or prices.

7.   As in these simulations third country market share in Arcady and Cospania is often limited, even this channel generally only produces minor impacts. The exception is Meats, in Cospania, where their historic markets share is significant and there is a big cut in Cospania's tariff on its imports from Arcady resulting in a large shift in relative prices. In this case around half the increase in Cospania's imports from Arcady translates into a decline in production in Cospania; another third into a rise in Cospania's consumption and the final sixth into a fall in Cospania's imports from third countries.

Impact of using different versions of PETRA: Armington

Whilst the overall pattern and distribution of impacts across sectors remains similar when the same scenario is run using the Armington version of PETRA, the impacts tend to be smaller. This is particularly noticeable for the sectors experiencing the more extreme impacts, especially Meats and to a lesser extent Vehicles, in this scenario. The differences occur for all the key variables - bilateral trade, prices, domestic consumption and domestic production.

Table 3: Comparison of impacts for selected sectors

Sector	% Change Production		% Change Consumption		% Change Exports	% Change Exports
	Arcady	Cospania	Arcady	Cospania	Arcady to Cospania	Cospania to Arcady
Meats – Arm	2.0	- 2.0	0	1.5	376	- 3
Meats – IC	4.1	- 4.8	0	2.8	770	0
Vehicles – Arm	- 0.28	0.15	0.33	0	12	94
Vehicles – IC	- 0.42	0.20	0.39	0	24	121

Chemicals – Arm	0.023	0.20	0.03	0.05	31.4	30
Chemicals – IC	0.023	0.28	0.03	0.06	46.5	44.3
Precious metals – Arm	1.5	- 0.07	0.001	0.19	31	17.5
Precious metals – IC	2.2	- 0.16	0.001	0.24	45.1	25.3

Whilst the difference is noticeable in the most extreme cases, in general there is a very similar pattern of impacts across sectors between the results from these two different versions of PETRA.

The correlation between the two sets of results for changes in production, consumption and bilateral trade whether measured in percentage changes or in values over all 122 sectors ranges between 0.972 and 0.999.

Only in a few sectors (1010, 2620, 2670 & 3212) are there any differences in the signs of the impacts for one of the measures and these typically involve a very small negative change when running one version of the model whilst the other suggests no change or a very small positive change. The differences in values are a few thousands of pounds, which means the results are effectively the same given the margins of error in these simulations.

The larger impacts observed when running the imperfect competition version of PETRA are not unexpected. One possible explanation would be economies of scale. If these exist, they would be expected to increase the impact of liberalisation as increased production would lead to lower costs and this improved competitiveness would lead to a further increase in sales and vice versa when production declines. However, although the Imperfect Competition version of PETRA has an option to include economies of scale, for simplicity these have been excluded in these simulations.

Instead, these differences reflect the nature of the different supply/demand equilibrium conditions in the Imperfect Competition version of the model, which incorporates a mark-up and can place a different weight on the elasticities than the Armington version of the model. In the Imperfect Competition version of PETRA the relative importance of the different elasticities depends on a variety's market share rather than being fixed.

For many manufacturing sectors an assumption of imperfect competition may be more appropriate, but there will be other sectors, especially relatively homogeneous commodities, where the Armington version of the model may be a more reliable guide. Hence, it is important to consider the characteristics of a sector, before deciding which model to use.

Impact of using different versions of PETRA: Imperfect Competition with intermediates

In the Intermediates (supply chain) version of PETRA, the model slightly relaxes its assumption that all sectors and markets are solved independently. In this version of the model, the impact of tariff changes on imported intermediate inputs used to manufacture products is allowed to feed into their cost of production and hence into the simulation results. This tends to magnify the impact of liberalisation, especially of key imported inputs. Cheaper imported inputs reduce the costs of goods and hence lead to greater impacts - falls in price

and increases in demand and consumption. It can also lead to more complex results including potential changes to third countries domestic markets.

For example, when cheaper inputs reduce the cost of producing a product, this will:

1. Make domestic firms more competitive in their home market (so limiting any fall in production due to increased competition from imports) as well as in third markets (so potentially increasing exports to third country markets).

2. Potentially lead to a change in the domestic market of the partner country even if the partner country doesn't liberalise (as it will benefit from the lower cost/price of its imports of the cheaper product).

3. However, the impact of such supply chain effects is often quite limited in practice for many sectors. Partially this reflects the fact that many do not rely on imported inputs. But is also due to the weights that are used to incorporate changes in the price of imported inputs into the calculation of marginal cost remain fixed.

Whilst this version of the model can potentially generate different and larger impacts, in these simulations it still yields very similar results in order of magnitude and dispersion to the standard Imperfect Competition version of PETRA. Mainly this is because the way the data has been constructed in this example, imported intermediates are not a significant element in the cost of products and there are only limited cuts in the tariffs on these intermediate inputs. The largest differences are for manufactured products which use more imported intermediates, but even then, the difference is typically less than 0.1 of a percentage point.

Table 4 Comparison of Impacts for Selected Sectors

Sector	% Change Production		% Change Consumption		% Change Bilateral Exports	
	Arcady	Cospania	Arcady	Cospania	Arcady to Cospania	Cospania to Arcady
Meats IC - Int	4.08	-4.79	0.002	2.79	771.8	0.06
Meats IC	4.07	-4.83	0.000	2.79	772.1	0.00
Chemicals IC - Int	0.05	0.34	0.04	0.06	46.6	44.4
Chemicals IC	0.02	0.28	0.03	0.06	46.5	44.3
Vehicles IC – Int	-0.38	0.22	0.40	0.00	24.1	120.8
Vehicles IC	-0.42	0.20	0.39	0.00	24.0	120.8

The results generated by running the Intermediates version of PETRA have a high correlation to the results from running the standard Imperfect Competition version for changes in Production, Consumption and Bilateral Trade whether measured in percentage changes or in values over all 122 sectors, which ranges between 0.994 and 1.

Results using PE-D model

The PE-D model has a similar basis to the Imperfect Competition version of PETRA, centred around a constant elasticity of substitution (CES) structure. However it has a slightly different

demand function and rather than modelling supply assumes that it adjusts to match the changes in demand. Consequently except for the sectors, such as Meats (ISIC 1010), where the conditions for a large impact exist (ie large change in tariffs, significant historical trade and responsive demand) it generates very similar results to the IC version of PETRA, when using the same data. In particular, the trade results are very similar and whilst there are some differences for consumption and production, they are of broadly similar magnitude (the one exception Meats (ISIC 1010) is detailed below).

For example, as Chart (14) below shows, in this set of simulations, the results for Production for virtually all sectors in Arcady are very close. Only 8/122 sectors have a difference of ±£1m or more. And of these eight only one, the Meats sector (ISIC 1010), was just greater than £5m. But even for Meats the two models produce very similar results for changes in bilateral trade.

Chart 14: Number of sectors grouped by difference between PETRA and PE-D changes in production for Arcady

Arcady: Virtually all sectors see similar changes in PE-D as in PETRA :
Number of sectors by size of difference between production changes

> £1m

< - £1m

-£1m < Change < £1m

Chart shows virtually all sectors see similar changes in PE-D as in Petra.

In only one sector, Meats (ISIC 1010), are there some significant differences between the models results for the change in Cospania's consumption which feeds through into its production and its imports from the rest of the world. Here PE-D suggests there will be less of an increase in Cospania's consumption which translates into a greater fall in its production and decline in its imports from third countries. Even in this case, the changes in bilateral trade produced by the two models are very similar.

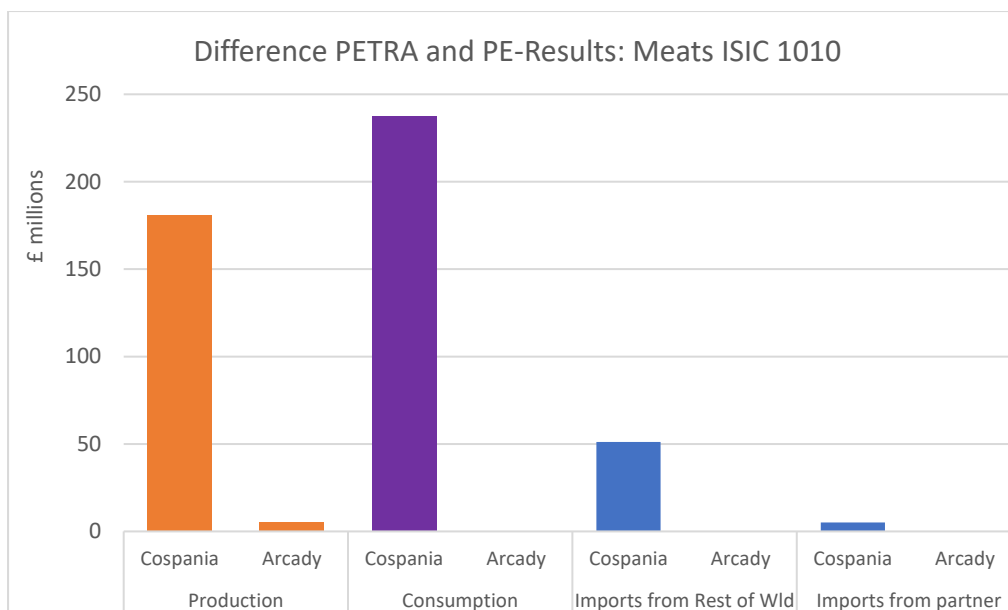Chart 15: Difference between PETRA and PE-D results for Meats

Chart shows the difference between PETRA and PE-Results: Meats ISIC 1010

The main points that emerge from this comparison are:

1. In these simulations for most sectors the changes in the value of bilateral trade data in PE-D are often identical to PETRAs and for the few sectors where they differ are within 0.5% of PETRAs.

2. There are some differences between the two models results for imports from third countries. This illustrates the impact of using different country groupings in the two models. When running PE-D, most third countries were amalgamated into one group. Whilst in the PETRA simulation fifteen different countries, including most major sources of Arcady's and Cospania's imports, are separately identified in the dataset. As Arcady's and Cospania's tariffs and imports from these countries vary, when they are amalgamated into one group the impact on the group of a change in relative prices will differ from the impact on the individual countries. The differences are not typically large, but this shows that the results can be sensitive to the choice of countries included in the simulation.

3. Consumption is sometimes higher and sometimes lower when running PE-D than PETRA. This results from the specification of the demand side in PETRA where the balance between the substitution and income elasticities of demand varies from sector to sector depending on a variety's market share in the sector. In a sector where a variety dominates elasticity is more influenced by the income elasticity of demand, whereas in sectors where a variety has a low market share it is more dependent on the substitution elasticity. For all sectors apart from Meats these differences are not large, with the only sizable gap being in the sector where there is the greatest change in tariffs – Cospania's imports of Meats (ISIC 1010).

4. Production also varies between the two models. Mainly this reflects the differences in their projections of consumption. It could also be affected by the more complex supply side in PETRA, but the assumptions made for this set of simulations (notably highly elastic supply, so that there is not a significant constraint on changes in

production and no economies of scale) means this doesn't have a significant impact. So, as with consumption, most of the differences are minor.

PE-D with a Small shares adjustment (SSA)

In addition, there are some differences caused when the PE-D model's Small Shares Adjustment (SSA) is activated. This is a feature of the PE-D that adjusts the potential impact in sectors where there was minimal historical trade due to restrictive barriers. As models will tend to underestimate the potential growth in such sectors if barriers are relaxed, the SSA estimates a proxy for historical trade based on the exporter's share of global trade and uses this instead of the actual historical value.

The SSA adjustment for this scenario occurs for:

- 22 (out of 122) sectors for Cospania's imports from Arcady,
- 9 (out of 122 sectors) for Arcady's imports from Cospania.

In these simulations the adjustment only leads to a small change in the value of trade. This is because when the SSA is activated the exporting country does not have a large share of global exports.

Chart 16 below demonstrates the sensitivity of the PE-D results to the SSA for the sector where it has the biggest effect, ISIC 2910, Vehicles. It increases the value of Cospania's imports of Vehicles from Arcady from a minimal amount to almost £7.5m. This is still very low compared to Cospania's consumption, but distinct from zero. This limited increase in values reflects Arcady's small share of global exports of Vehicles, which is less than 0.1%. If this was higher, the SSA would have a greater impact.

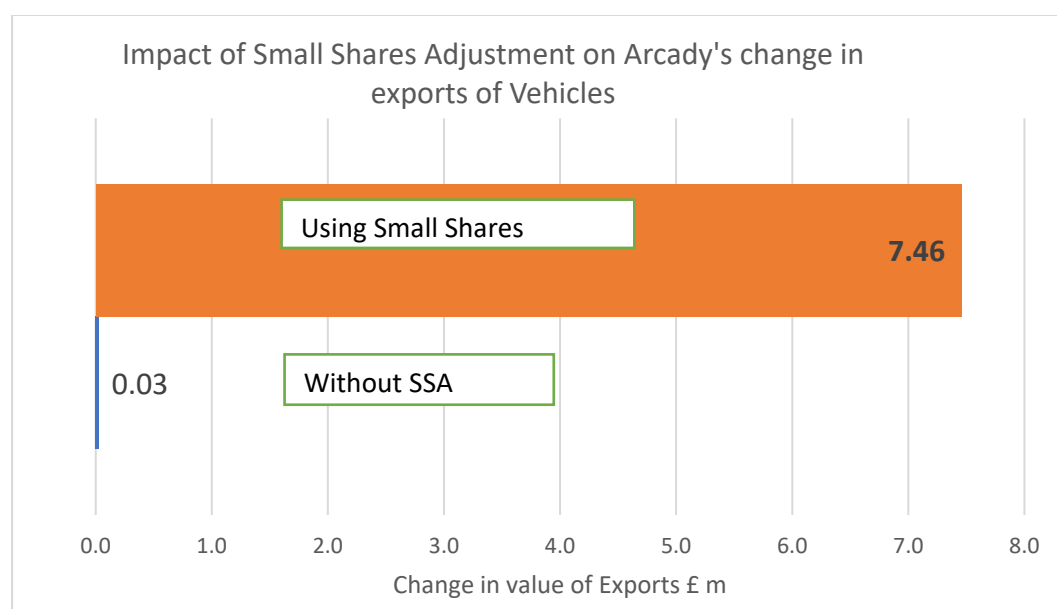Chart 16: Impact of PE-D model's small shares adjustment

Chart shows the impact of PE-D model's small shares adjustment.

Example of Using the PE–D Model with More Granular Data

It is possible to run both PETRA and the PE-D models at a more granular level than ISIC4. In practice the limited availability of more granular data, especially production data for most countries, means that this will not always be practical particularly for PETRA which will typically need such data for a wider range of countries.

More granular simulations can be informative, especially when there is variation across the products within an ISIC4 sector, whether this is in level of liberalisation due to different tariff rates or impact of non-tariff measures such as rules of origin or regulation or if countries specialisation varies significantly across products. In such cases using the average values for an ISIC sector can disguise how impacts can vary for different products.

The following example shows the results of running PE–D for the HS6 lines within the Vehicles, ISIC 2910, sector using the base elasticity assumptions. Significantly different tariffs for the HS6 lines within the ISIC4 sector were used to make the differences between products more distinct.

As Table 5 demonstrates, impacts can vary over HS6 lines within an ISIC4 sector. Here the overall impact (from summing the impact over all the HS6 lines) on Arcady is similar (marginally lower) than when running the simulations at ISIC4 level.

Table 5: Total Impact on Arcady Vehicles sector, changes in £ millions

	DCDP	Imports from RoW	Imports from Cospania	Consumption
SUM HS6 lines	-31	-33	102	38
ISIC 2910	-38	-29	104	38

In this case, the impact (summed over all HS6 products compared to the impact for the ISIC4 sector) on Arcady's DCDP and its imports from third countries differs from its impact on its bilateral imports from Cospania. This is because Arcady doesn't import all HS6 products from Cospania. So there isn't any impact on the consumption, DCDP or imports from third countries on such lines from this scenario of bilateral liberalisation, whilst when the simulation is run for the whole ISIC4 sector there is as they are affected by the average rate for the entire sector.

The percentage impacts on the various HS6 lines can vary considerably. Whilst the average of all HS products is similar to that for the Vehicles sector as a whole there is considerable variation for individual lines. For example, the percentage growth in Arcady's imports from Cospania for selected products are:

Table 6: Impact on Arcady's imports of vehicles by HS6 line

Product/Sector	% Growth Arcady's Imports from Cospania
Vehicles, ISIC 2910	121 %

Average (trade wgtd) of HS6 lines within ISIC 2910	118 %
840734 Petrol engines	85 %
840820 Diesel engines	30 %
870322 Petrol cars 1-1.5 litres	181 %
870323 Petrol cars 1.5-3 litres	178 %
870324 Petrol cars > 3 litres	173 %
870332 Diesel cars 1.5-2.5 litres	65 %
870333 Diesel cars > 2.5 litres	77 %

Chart 17: Comparing changes in Arcady's imports of vehicles to its historic tariff levels by HS6 line
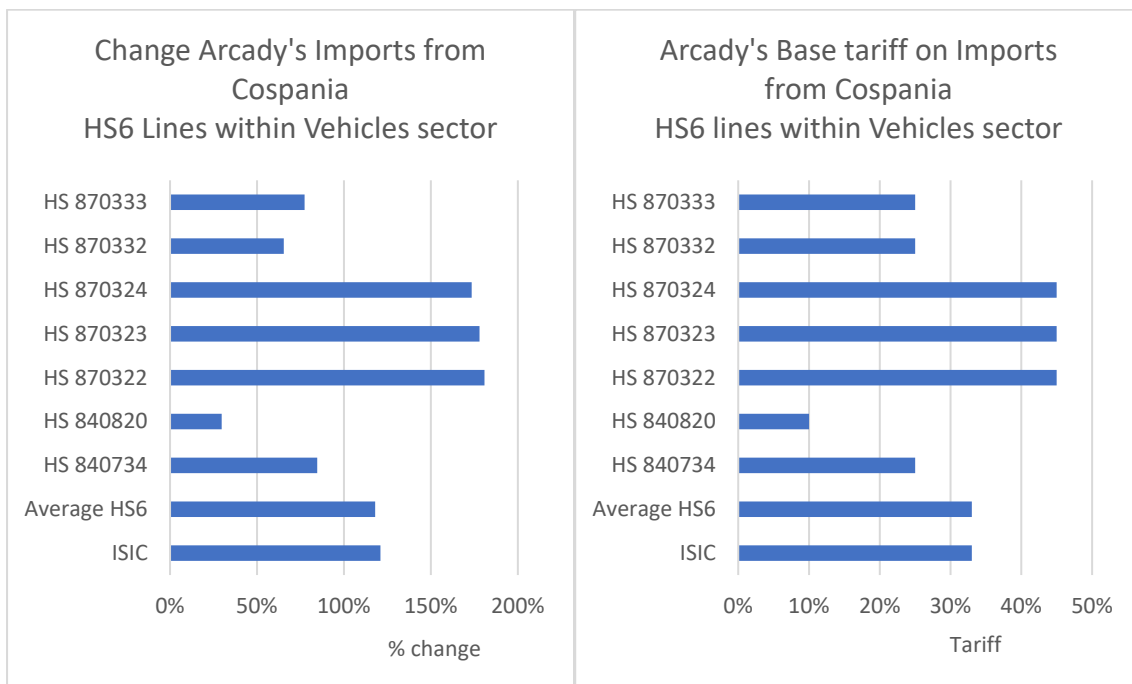

Chart compares changes in Arcady's imports of vehicles to its historic tariff levels by HS6 line.

As Chart (17) shows the driver of the changes for HS6 level products are the assumed base levels for Arcady's tariffs – lower on engines than on cars (eg 10% rather than 25% for diesel engines v diesel cars) and lower on diesel than petrol engines cars (25% v 45%), so that the liberalisation has a significantly greater impact on the latter than on the former.

The impact of the SSA option can vary. Typically, as in this case for Cospania's imports from Arcady there is less of an impact as it is only applied to some HS6 products within the ISIC4 sector rather than the entire sector. The SSA is only applied for 4 of the HS6 lines within ISIC 2910 for Cospania – 840734 (petrol engines < 1 litre), 870321 (petrol engineed cars with engines <1 litre), 870322 (petrol engineed cars, with engines of 1-1.5 litres) and 870600 (chassis with engines for vehicles). The increase in Cospania's imports from Arcady of these 4 HS6 products due to the SSA is £3.4m rather than the £7.5m increase that was estimated by applying the SSA to the full ISIC 2910 sector.

Sensitivity tests

The results are sensitive to the inputs used, especially the Armington elasticities. Charts (18 and 19) on the next page show the impact on trade of an extreme case, varying the Armington elasticity for the Vehicles (ISIC 2910) sector.

This sector has been chosen as it also illustrates the importance of the interaction between the elasticities used and the size of the tariff changes and the level of historical trade. Even large changes in elasticities don't have much impact if historical trade is minimal – see the modest changes in the value of Arcady's exports to Cospania. But when combined with even moderate historical trade and a large change in tariffs then varying the elasticities can generate large shifts in the value of trade as shown in the changes in Cospania's exports to Arcady.

In the earlier scenarios it was assumed that the vehicles sector had a relatively low standard Armington elasticity of 3, reflecting its differentiated products. These charts show the impact of using alternative elasticity estimates:

- Using an econometrically estimated value which almost triples the central elasticity from 3 to 8.7, ie moving to a very homogeneous product where consumers are likely to switch in response to a change in relative prices.
- Allowing the elasticity to vary around this central estimate to capture the range of elasticities which may[9] occur. In this case the range is from 6.9 (low) to 10.6 (high), around the central alternative estimate of 8.7. Note even this low alternative elasticity is far higher than the standard elasticity used in the earlier simulations.

These interact with the following tariff changes:

- 8% percentage point reduction in Cospania's tariffs on its imports from Arcady;
- 33% percentage point reduction in Arcady's tariffs on its imports from Cospania.

And the following base levels of exports:

- £ 0.03m Arcady to Cospania,
- £ 86.3m Cospania to Arcady.

Chart 18: Sensitivity to Armington elasticity of Cospania's vehicle exports to Arcady

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[9] The 95% confidence limit, ie there is a 95% change that the estimated elasticity lies between the low and high values used here.

Sensitivity of change in Cospania's vehicles exports to Arcady to Elasticity

Results highly sensitive to elasticity used (Standard, Alternative (alt) estimates - central, low and high)

Sensitivity increases as elasticities increase
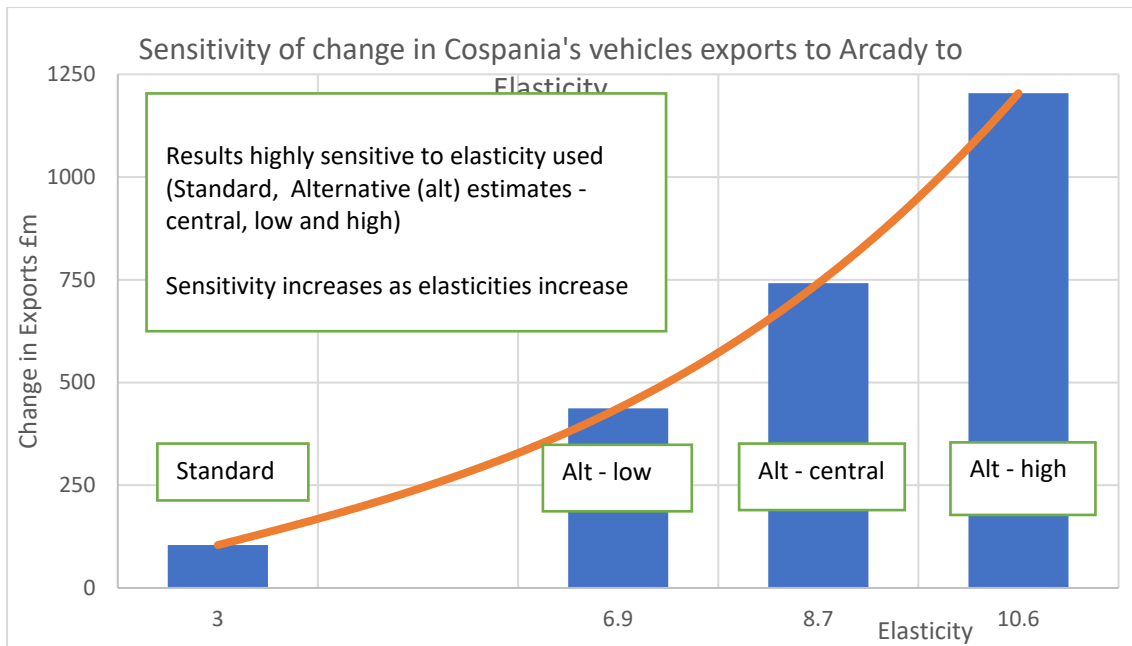
Standard | Alt - low | Alt - central | Alt - high

Chart shows how sensitive the change in Cospania's vehicle exports to Arcady are to the elasticity assumption.

As can be seen the value of Cospania's exports to Arcady rise seven-fold (the increase goes from just over £100m to £740m) when the elasticity is almost tripled from 3 to 8.7.

There is also a very large range of potential impacts between the Low and High estimated elasticities. Using the Low elasticity, Cospania's exports to Arcady rise by £440m, using the High elasticity by £1200m, compared to £740m under the Central elasticity case. So there is a 270% difference between the impacts under the Low and High elasticities.

Chart 19: Sensitivity of Armington elasticity of Arcady's exports of vehicles to Cospania

Sensitivity of change in Arcady's exports to Cospania to Elasticity

Results in percentage terms still very sensitive to elasticities used

But little change in **values** because of Arcady's low market share in Cospania

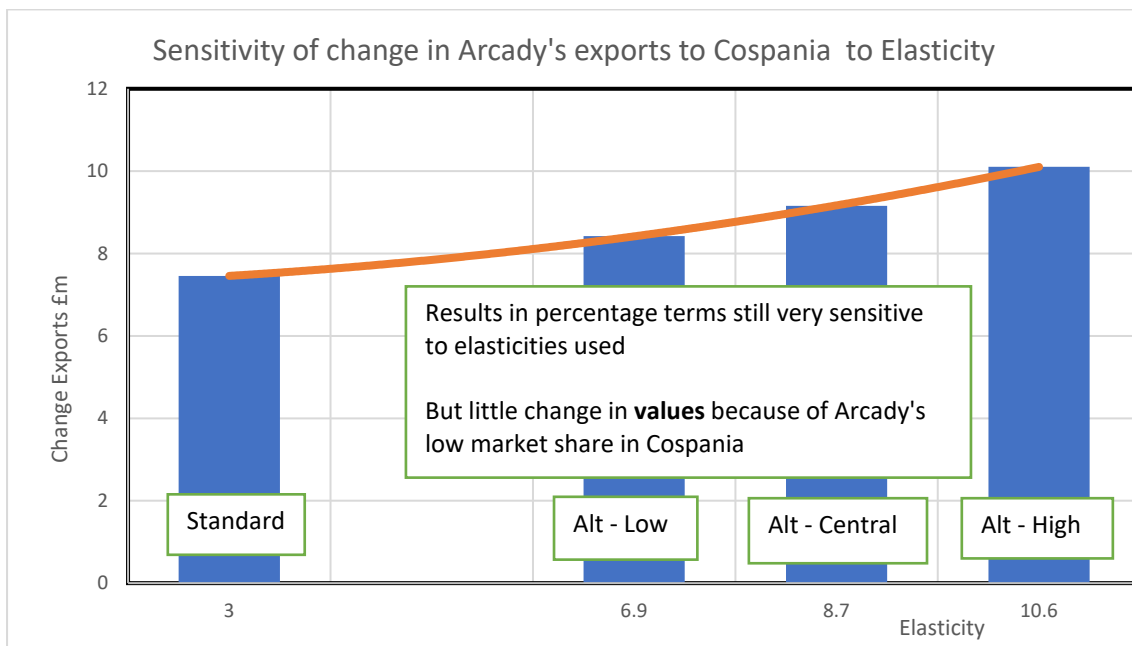Standard | Alt - Low | Alt - Central | Alt - High

Chart shows how sensitive the change in Arcady's vehicle exports to Cospania are to the elasticity assumption.

By contrast, whilst the value of Arcady's exports to Cospania still increases, the change in values is very limited. Partially this is because the tariff change is only a quarter of the size (an 8 percentage point fall in Cospania's tariffs on its imports from Arcady compared to a 33 percentage point fall in Arcady's tariffs on its imports from Cospania), but it is mainly because the scale of historical trade is so limited. Even with the SSA active, the increase in the value of Arcady's exports to Cospania of Vehicles is only £1.5m higher when the high alternative elasticity is used instead of the standard elasticity of 3.

This can be seen more readily by comparing the percentage change in exports for both cases.

The percentage increase in Cospania's exports to Arcady range from:

- 120% using the standard base elasticity of 3.
- 510% using the Low alternative estimated PE-D elasticity of 6.9.
- 860% using the Central alternative estimated PE-D elasticity of 8.7.
- 1400% using the High alternative estimated PE-D elasticity of 10.6.

The percentage increases in Arcady's exports to Cospania are:

- 68004% using the standard base elasticity of 3.
- 7700% using the Low alternative estimated PE-D elasticity of 6.9.
- 8300% using the Central alternative estimated PE-D elasticity of 8.7.
- 9200% using the High alternative estimated PE-D elasticity of 10.6.

Comparison with CGE

These PE models are intended to complement HMG's other trade models, in particular the Computable General Equilibrium (CGE) models.

The advantage of PE models is that they can simulate the direct impact of trade policies on individual products or sectors of interest that may be obscured within the broader sectors commonly used when running CGE models. This can be particularly useful if there are product specific issues that need to be modelled, for example as highlighted earlier in the granularity section (pp 28-30), if there are significant differences in tariff or NTM barriers for particular products within a broader sector.

There can be considerable differences between the results generated by PE and CGE models. CGE models capture the full effects of trade policies and hence provide a better guide to their total, long term impact. For example, if prices change in one sector, the CGE model captures the behavioural responses and resulting reallocation of factors (land, labour and capital) across the entire economy, including firms in other sectors, households, and government, not just in the initial sector. CGE models also capture diversion of exports to third countries. As these effects can be significant PE and CGE models should not be

expected to generate the same results. Indeed, they may not even necessarily suggest that sectors respond in similar ways to specified trade policies if the indirect effects outweigh the direct impacts.

Conclusion

This paper presents the results from simulating a notional FTA using various DBT PE models to illustrate the range of outputs and insights that such models can provide. It shows:

- The importance of considering a range of factors, especially the pattern of historic trade and specialisation and the responsiveness of demand as well as the degree of proposed liberalisation when assessing possible impacts.
- That estimated impacts can vary significantly depending on the value of key inputs, especially elasticities, suggesting that it can be useful to consider the range of potential impacts under different assumptions.
- That whilst the net impact from liberalisation is generally positive there can be some groups who don't benefit, so it can be useful to consider the impact on different groups (such as different sectors and producers/consumers in the various countries) when considering potential impacts.
- Whilst with these simulations the results were not particularly sensitive to the choice of DBT PE model used, it is important to select a model that will capture the critical elements of the question being considered. For example, if concerned about prospects for sectors with minimal historical trade then can run a model with a small shares adjustment; if concerned about the impact on specific products the need to run simulations at an appropriately granular level; or if concerned about potential displacement to third countries consider alternative models (such as gravity of CGE) that capture such general equilibrium effects.
- The importance of being aware of the limitations of any model used. For example, PE models only capture the direct impact, so if want to consider the overall impact of a trade policy need to consider other models that include general equilibrium effects. And the importance of using robust data, as the results of any model will only be as good as the inputs it uses.