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The Benefits of Intellectual Property Rights in EU Free Trade Agreements

METHODOLOGICAL ANNEXES

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ANNEX I: SELECTION OF IP-INTENSIVE SECTORS

The choice of sectors that classify as Intellectual Property (IP) intensive is necessary for analysing IP-intensive exports and imports of the study. Not all sectors are intense in the use of patents, trademarks, and copyrights (amongst others) and so a careful selection is necessary. This selection of sectors should be done on the basis of reliable and different sets of data.

In doing so, we have used three sets of data from which we have computed IP-intensities. The first data set is from the EUIPO (EUIPO, 2019) which provide measures of intensity in the use of patents, trademarks and designs (as well as copyrights, geographical indicators and PVRs) compared to labour (i.e. employment) for the EU. The list of sectors by NACE 2-digit categories that are ranked from most to least IP-intensive sectors is given in Table A1 in the annex and is based on patents.

Second, a next data set is from the EU Joint Research Centre that includes information on R&D expenditures for the years 2017/2018 per sector for a sample of 2500 companies in the EU. As well, addition data on net sales and employment are given for each firm. From this data, we have computed two measures of IP-intensity, namely R&D expenditure over net sales and over employment. Combining the results of the two indicators gives a ranking from most to least IP-intensive sector at NACE 2-digit sector level as provided in Table A2 in the annex.

Third, and last, additional data from Eurostat has been examined as a final robustness check. This source provides data on the business R&D expenditure for the majority of EU members (including the bigger states such as France and Germany), as well as data on turnover and employment for the year 2017. From there, we again have computed two measures of IP-intensity: one of R&D expenditure over turnover, and one over employment. Combining the two indicators gives a ranking from most to least IP-intensive sector at NACE 2-digit sector level in Table A3 in the annex.

When combining the three rankings, normalizing the measures and check for consistency of sectors in each of the rankings, we come to the conclusion that the final list of sectors that are classified as IP-intensive are: *(1)* Pharmaceuticals; *(2)* Scientific R&D; *(3)* Computer electronics; *(4)* Motor vehicles; *(5)* Chemicals; *(6)* Machinery; *(7)* Electrical equipment; *(8)* Other transport equipment; *(9)* Other manufacturing; *(10)* Information services; *(11)* Telecoms; and *(12)* Architectural & Engineering services. These sectors are marked in blue in each of the tables in the Annex.[1]

[1] Note that for computing all three ranking tables, considerable effort is being put into making the sectors (and firms) consistent across each other with the NACE 2-digit classification schedule. That has not been an easy task because of overlapping sectoral definitions and lack of availability of data in various cases.

As one can see, the 12 IP-intensive sectors appear in most cases in the top half of the rankings in each table. There are, however, some exceptions. For instance, Architectural and Engineering services does not rank as very IP-intensive using EUIPO data. However, one should note that the IP-intensities from EUIPO in the table are based on patent over employment, and therefore design, copyrights and trademarks are left out. Moreover, when looking at the Top 3 sector intensities for other types of IP such as trademarks and designs given by the EUIPO, sector would otherwise classify as IP-intensive are Pharmaceuticals, Machinery, Scientific R&D, Electrical equipment and Other manufacturing. All these industries appear in our selection above and so therefore are in line with our list.[2]

There is one other exception in our final list of selected IP-sectors, namely the Food industry. This sector does appear in some instance as rather IP-intensive when using data for trademarks and to some extent patens. However, the sector ranks low in the list of intensities using the data form Joint Research Centre (Table A3) and does not appear in the data from Eurostat (Table A3). Therefore, this sector is omitted. Note furthermore that one could argue that this sector has a relatively high level of geographical indicators (GI). But, when looking at EUIPO's list of GI-intensive sectors, almost all sectors classified as GI-intensive are part of the Beverages industry (NACE 2-digit 11) and not in the Food industry (NACE 2-digit 10).

Last, the sectors that are categorized as copyright-intensive according to the EUIPO data are not based on any scoring but are directly listed. Most of these sectors fall into the NACE Section J of Information and Communication services. Two 2-digit sectors that fall into this Section J are covered by our list of IP-intensive sectors above, namely Information services and Telecom.

A further remark is that although the intensity numbers for each dataset differs per source (i.e. EUIPO, Joint Research Centre and Eurostat), once we perform rough correlations a consistent pattern arises. For instance, Figure A1 in the annex shows the correlation between the Joint Research Centre data (using their preferred option of net sales) and the EUIPO data (which is only given in employment). One can see that the correlation is strong which after performing simple regression analysis is significant at the 5 percent level with an R2 of 0.34. The correlations between the Joint Research Centre data (using their preferred option of net sales) and the Eurostat data (which is given in turnover) is even stronger, namely with a significance at the 1 percent level and an R2 of 0.62.

[2] Of further note, the sector Metals also appears in the Top 3 sectors for design intensity. However, given that this sector does not appear in any of the three tables below as highly ranked, and in fact have a pretty low scoring, we omit this sector and therefore do not classify Metals as an IP-intensive sector.

Moreover, one can see that in both figures, the sectors which are ranked as most IP-intensive on either scale are place in the upper corner at the right-side. These sectors, which are circled are therefore the ones that are also selected in our list of most IP-intensive sectors above. It is reassuring to see that in both cases and even when using alternative intensity indicators that we have developed; the same set of sectors appear as most IP-intensive.

Finally, the final report also consists of a gravity model analysis for which trade potentials in IP-intensive sectors for each country as well as the impact of FTA with IPR provisions will be computed. The gravity equation is performed using a specific data set from the OECD that follows similar NACE classification but at a less disaggregated level. In particular, the data for this part of our analysis is the trade data that forms part of the underlying structure of the OECD TiVA database and is therefore less specific in its sectoral classification. However, the list of sectors we select above as most IP-intensive are largely covered by the OECD data set and so a gravity analysis can be performed. The most IP-intensive sectors from our list above and which appear in the gravity sectoral classification are marked in blue in Table A4 in the annex.

TABLE A1: RANKING IP-INTENSIVE SECTOR USING EUIPO DATA

NACE 2-digit code	Rank	NACE sector description
21	1	Manufacture of basic pharmaceutical products and pharmaceutical preparations
72	2	Scientific research and development
26	3	Manufacture of computer, electronic and optical products
28	4	Manufacture of machinery and equipment n.e.c.
20	5	Manufacture of chemicals and chemical products
27	6	Manufacture of electrical equipment
30	7	Manufacture of other transport equipment
9	8	Mining support service activities
29	9	Manufacture of motor vehicles, trailers and semi-trailers
61	10	Telecommunications
23	11	Manufacture of other non-metallic mineral products
10	12	Manufacture of food products
24	13	Manufacture of basic metals
6	14	Extraction of crude petroleum and natural gas
32	15	Other manufacturing
74	16	Other professional, scientific
45	17	Wholesale and retail trade and repair of motor vehicles and motorcycles
25	18	Manufacture of fabricated metal products, except machinery and equipment
22	19	Manufacture of rubber and plastic products
12	20	Manufacture of tobacco products
46	21	Wholesale trade, except of motor vehicles and motorcycles
13	22	Manufacture of textiles
58	23	Publishing activities
71	24	Architectural and engineering activities; technical testing and analysis
17	25	Manufacture of paper and paper products
47	26	Retail trade, except of motor vehicles and motorcycles
8	27	Other mining and quarrying
35	28	Electricity, gas, steam and air conditioning supply
33	29	Repair and installation of machinery and equipment
7	30	Mining of metal ores
16	31	Manufacture of wood and of products of wood and cork, except furniture
Absent		
63		Information services

TABLE A2: RANKING IP-INTENSIVE SECTOR USING JOINT RESEARCH CENTRE DATA (SCOREBOARD)

NACE 2-digit code	Rank	NACE sector description
21	1	Manufacture of basic pharmaceutical products and pharmaceutical preparations
63	2	Information service activities
26	3	Manufacture of computer, electronic and optical products
32	4	Other manufacturing
66	5	Activities auxiliary to financial services and insurance activities
27	6	Manufacture of electrical equipment
29	7	Manufacture of motor vehicles, trailers and semi-trailers
64	8	Financial service activities, except insurance and pension funding
82	9	Office administrative, office support and other business support activities
71	10	Architectural and engineering activities; technical testing and analysis
18	11	Printing and reproduction of recorded media
60	12	Programming and broadcasting activities
58	13	Publishing activities
28	14	Manufacture of machinery and equipment n.e.c.
20	15	Manufacture of chemicals and chemical products
41	16	Construction of buildings
61	17	Telecommunications
68	18	Real estate activities
79	19	Travel agency, tour operator reservation service and related activities
14	20	Manufacture of wearing apparel
35	21	Electricity, gas, steam and air conditioning supply
19	22	Manufacture of coke and refined petroleum products
12	23	Manufacture of tobacco products
43	24	Specialised construction activities
10	25	Manufacture of food products
45	26	Wholesale and retail trade and repair of motor vehicles and motorcycles
65	27	Insurance, reinsurance and pension funding, except compulsory social security
11	28	Manufacture of beverages
24	29	Manufacture of basic metals
25	30	Manufacture of fabricated metal products, except machinery and equipment
5	31	Mining of coal and lignite
36	32	Water collection, treatment and supply
52	33	Warehousing and support activities for transportation
49	34	Land transport and transport via pipelines
51	35	Air Transport
50	36	Water transport
6	37	Extraction of crude petroleum and natural gas
47	38	Retail trade, except of motor vehicles and motorcycles

Absent		
30		Manufacture of other transport equipment
10		Manufacture of food products

TABLE A3: RANKING IP-INTENSIVE SECTOR USING EUROSTAT DATA

NACE 2-digit code	Rank	NACE sector description
72	1	Scientific research and development
26	2	Manufacture of computer, electronic and optical products
21	3	Manufacture of basic pharmaceutical products and pharmaceutical preparations
29	4	Manufacture of motor vehicles, trailers and semi-trailers
71	5	Architectural and engineering activities; technical testing and analysis
27	6	Manufacture of electrical equipment
28	7	Manufacture of machinery and equipment n.e.c.
30	8	Manufacture of other transport equipment
32	9	Other manufacturing
20	10	Manufacture of chemicals and chemical products
22	11	Manufacture of rubber and plastic products
33	12	Repair and installation of machinery and equipment
25	13	Manufacture of fabricated metal products, except machinery and equipment
23	14	Manufacture of other non-metallic mineral products
24	15	Manufacture of basic metals
31	16	Manufacture of furniture
19	17	Manufacture of coke and refined petroleum products
68	18	Real estate activities

Absent		
63		Information services
61		Telecommunications
10		Manufacture of food products

FIGURE A1: R&D EXPENSES OVER NET SALES (JOINT RESEARCH CENTRE) VERSUS PATENT IN EMPLOYMENT (EUIPO)

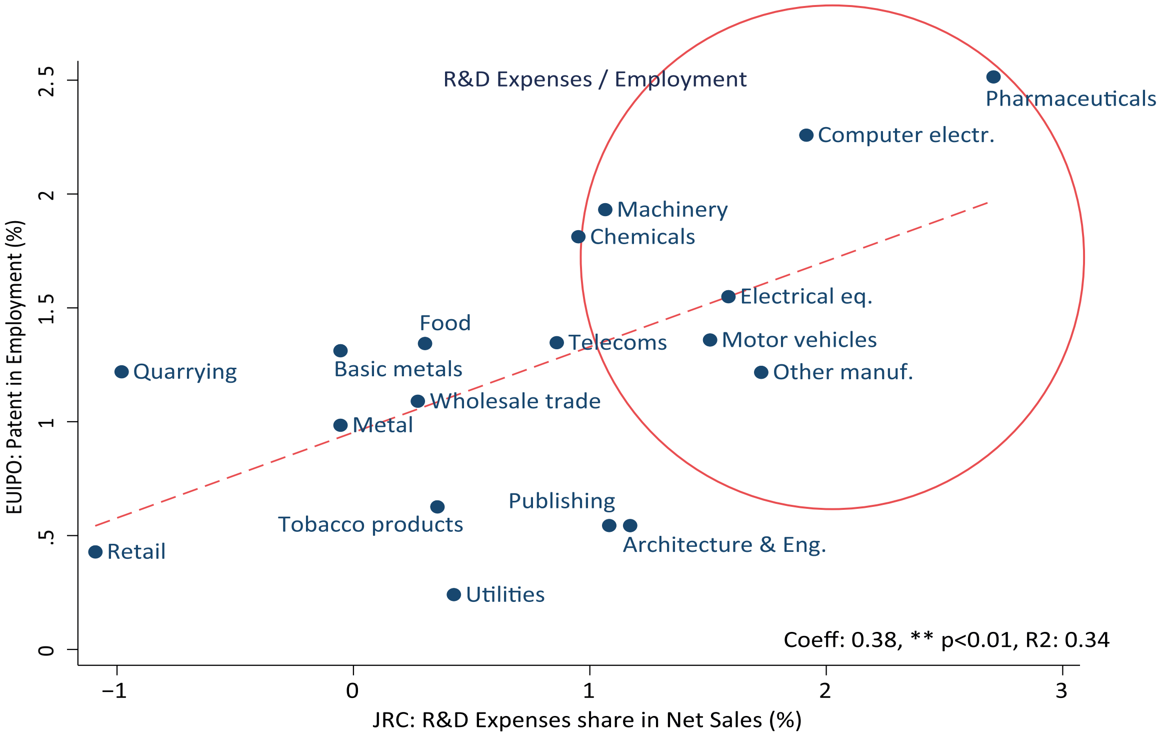


FIGURE A1: R&D EXPENSES OVER NET SALES (JOINT RESEARCH CENTRE) VERSUS R&D EXPENDITURE OVER TURNOVER (EUROSTAT)

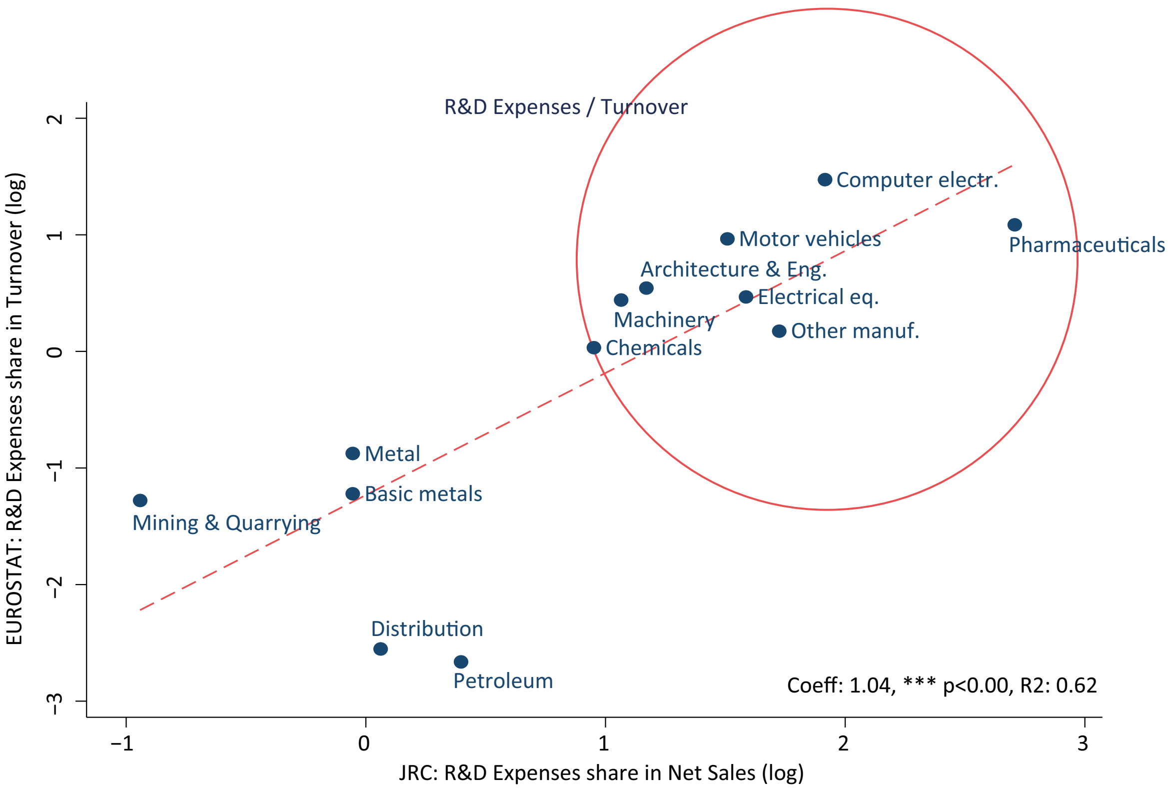


TABLE A4: SELECTION OF IP-INTENSIVE SECTORS FOR THE GRAVITY ANALYSIS (DOES NOT FOLLOWS ANY RANKING)

TiVA code	Sector description
D05T06	Mining and extraction of energy producing products
D07T08	Mining and quarrying of non-energy producing products
D09	Mining support service activities
D10T12	Food products, beverages and tobacco
D13T15	Textiles, wearing apparel, leather and related products
D16	Wood and products of wood and cork
D17T18	Paper products and printing
D19	Coke and refined petroleum products
D20T21	Chemicals and pharmaceutical products
D22	Rubber and plastic products
D23	Other non-metallic mineral products
D24	Basic metals
D25	Fabricated metal products
D26	Computer, electronic and optical products
D27	Electrical equipment
D28	Machinery and equipment, nec
D29	Motor vehicles, trailers and semi-trailers
D30	Other transport equipment
D31T33	Other manufacturing; repair and installation of machinery and equipment
D35T39	Electricity, gas, water supply, sewerage, waste and remediation services
D41T43	Construction
D45T47	Wholesale and retail trade; repair of motor vehicles
D49T53	Transportation and storage
D55T56	Accommodation and food services
D58T60	Publishing, audio-visual and broadcasting activities
D61	Telecommunications
D62T63	IT and other information services
D64T66	Financial and insurance activities
D68	Real estate activities
D69T82	Other business sector services
D84	Public admin. and defence; compulsory social security
D85	Education
D86T88	Human health and social work
D90T96	Arts, entertainment, recreation and other service activities
D97T98	Private households with employed persons

ANNEX II: OVERVIEW ON TECHNICAL ASPECTS OF THE CGE MODEL

2.1 Overview of the Economic Modelling

Our quantitative strategy to estimate the economic effects of the FTA involves the use of a computable general equilibrium (CGE). This model, in turn, is calibrated using the GTAP database,[3] and an integrated assessment that builds on an econometric estimation of trade elasticities that determine the trade volume effects of the trade cost reductions in FTAs. In particular, we measure three different types of trade costs: tariff-rate quotas (TRQs), preferential tariffs and non-tariff measures (NTMs). The resulting structurally estimated general equilibrium model (SEGE model) ensures consistency between the empirically-based estimates of the effects of trade agreements, and the subsequent modelling of those agreements.

2.2 The CGE Model of Global Production and Trade

We employ a computable general equilibrium (CGE) model with multiple countries, multiple sectors, intermediate linkages and multiple factors of production, as developed in Bekkers and Francois (2018) and Bekkers et al. (2018). Trade is modelled as in Eaton and Kortum (2002) with the remaining structure of the model largely following the standard GTAP model (Corong et al. 2017). The main difference from GTAP is the incorporation of the Eaton and Kortum demand structure, where we derive the gravity equation for our structural estimation of the trade elasticities and changes in trade costs, as discussed above, from this same model. The model set-up and calibration combine features of the older computable general equilibrium (CGE) models (cf. Dixon and Jorgenson, 2013), with the micro-foundations of the more recent quantitative trade models (see Costinot and Rodríguez-Clare, 2014, for an overview). This means that analytically we model trade linkages with the improved micro-founded Eaton and Kortum (2002) structure, while at the same time we have structurally estimated the trade parameters and relevant trade cost changes employing a gravity model derived from the same structural general equilibrium model. Thus, we employ a state-of-the-art CGE model that deals with recent academic criticism of standard CGE models – i.e. that models should be micro-founded based on recent trade theory and the main parameters of the model should be structurally estimated using the same underlying data (cf. Costinot and Rodríguez-Clare, 2014; Bekkers, Francois, and Rojas-Romagosa 2018).

Model simulations are based on a multi-region, multi-sector model of the world economy. Sectors are linked through intermediate input coefficients (based on national input-output

[3] Version 10 with base year 2014. See Aguiar et al. (2019).

and social accounting data) as well as competition in primary factor markets. On the policy side, it offers the option to implement tariff reductions, export tax and subsidy reduction, trade quota expansion, input subsidies, output subsidies, and reductions in NTM related trade costs. International trade costs include shipping and logistic services (the source of FOB-CIF margins) but can also be modelled as Samuelson-type deadweight (iceberg) trade costs. These deadweight costs can be used to capture higher costs when producing for export markets due to regulatory barriers or NTBs that raise costs.

In the model, there is a single representative composite household in each region, with expenditures allocated over personal consumption and savings. The composite household owns endowments of the factors of production and receives income by selling these factors to firms. It also receives income from tariff revenue and rents accruing from import/export quota licenses. Part of the income is distributed as subsidy payments to some sectors, primarily in agriculture.

The initial condition of any CGE model is that supply and demand are in balance at some equilibrium set of prices and quantities where workers are satisfied with their wages and employment, consumers are satisfied with their basket of goods, producers are satisfied with their input and output quantities and savings are fully expended on investments. Adjustment to a new equilibrium, governed by behavioural equations and parameters in the model, are largely driven by price equations that link all economic activity in the market. For any perturbation to the initial equilibrium, all endogenous variables (i.e. prices and quantities) adjust simultaneously until the economy reaches a new equilibrium. Constraints on the adjustment to a new equilibrium include a suit of accounting relationships that dictate that in aggregate, the supply of goods equals the demand for goods, total exports equal total imports, all (available) workers and capital stock is employed, and global savings equals global investment. Economic behaviour drives the adjustment of quantities and prices given that consumers maximise utility given the price of goods and consumers' budget constraints, and producers minimise costs, given input prices, the level of output and production technology.

In the structural general equilibrium model, the "whole" economy for the relevant aggregation of economic agents is specified as a set of simultaneous equations. This means that the entire economy is classified into production and consumption sectors. These sectors are then modelled collectively. Production sectors are explicitly linked together in value-added chains from primary goods, through higher stages of processing, to the final assembly of consumption goods for households and governments. These links span borders as well as industries. The link between sectors is both direct, such as the input of steel into the production of transport equipment, and also indirect, as with the link between chemicals and agriculture through the production of fertilizers and pesticides. Sectors are also linked through their competition for resources in primary factor markets (capital, labour, and land). The general conceptual structure of a regional economy in our structural general equilibrium model is detailed in Figure A1 and Figure A2.

FIGURE A1: PRODUCTION STRUCTURE IN THE CGE MODEL

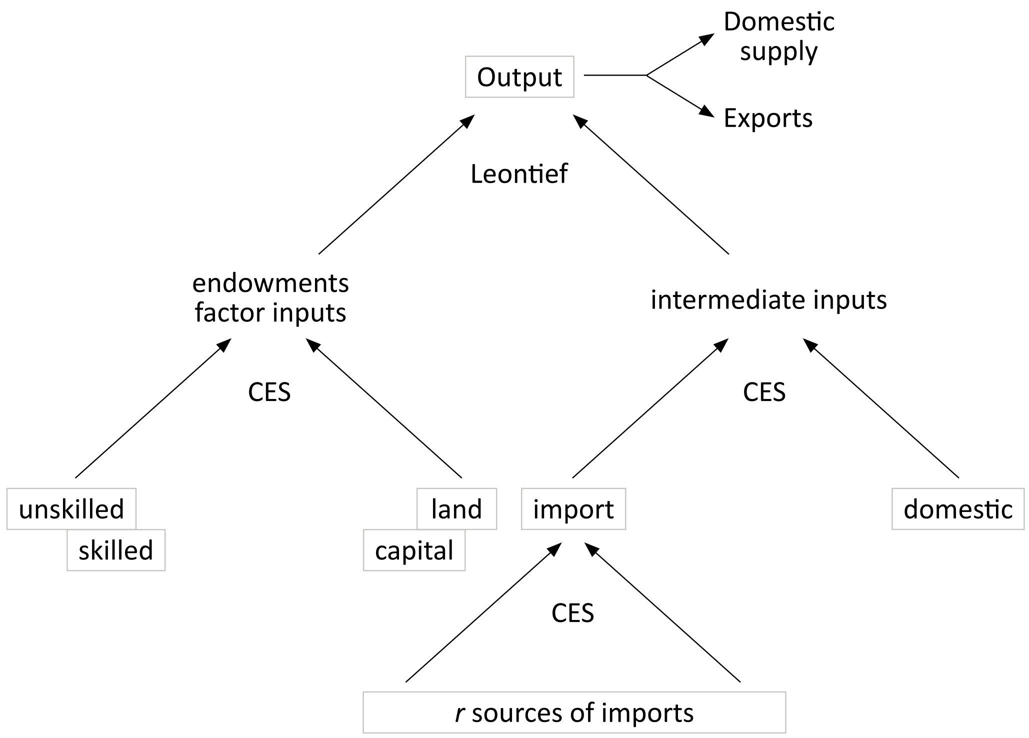
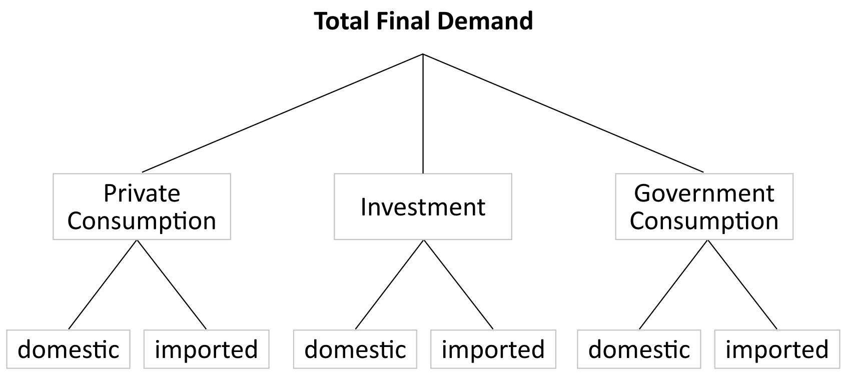


FIGURE A2: CONSUMPTION STRUCTURE IN THE CGE MODEL



On the production side, firms produce output, employing land, labour, capital, and natural resources and combine these with intermediate inputs, within each region/country. In technical terms, we model a combination of value added and intermediate inputs, where intermediates (both imported and domestic) are combined in fixed proportions along with value added (known as a Leontief function). Value added itself (e.g. labour and capital) involves what is known as a CES functional form. Firm output is then purchased by consumers, government, the investment sector, and by other firms, and detailed in Figure A2. Firm output can be and is also sold for export. In the model, arable land is only employed in the agricultural sectors, while capital and labour (both skilled and unskilled) are mobile between all production sectors. While capital is assumed to be fully mobile within regions, land, labour and natural resources are not.

In the experiments themselves, we follow the literature and employ recursive dynamics to link changes in investment expenditure to changes in capital stocks. This involves a fixed savings rate, with changes in savings following from changes in income levels. This change is then transmitted into investment and hence into changes in capital stocks (see Francois, McDonald, and Nordstrom, 1996; as well as Bekkers, et al., 2018; for technical discussions). In reporting, we focus on the reference year of 2040, where we incorporate dynamic effects linking savings, investment, and capital stocks.

For the purpose of defining the scenarios, trading costs are modelled as in ECORYS (2009), CEPR (2012), and Egger, et al. (2015), meaning iceberg trade cost reductions. In the case of goods, benchmark values for trade cost reductions are based on gravity-based estimates of the trade cost from ECORYS (2009), except where estimates are unavailable. Where unavailable from the ECORYS/CEPR studies, we use estimates from Egger et al. (2015), where services estimates are initially taken from Jafari and Tarr (2015). To fit our global data to the theoretical model, following Egger and Nigai (2015) and Bekkers and Francois (2018), total trade costs and technology parameters are fit from actual import shares (calibration), imposing an exact fit. Changes in trade costs (the structural general equilibrium experiments themselves) are based on assumed 50% and 20% reductions in actionable trade costs, as discussed in the main text.

Taxes are included at several levels in the modelling. Production taxes are placed on intermediate or primary inputs, or on output. Tariffs are levied at the border. Additional internal taxes are placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where relevant (as indicated by social accounting data) taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

On the production side, in all sectors, firms employ domestic production factors (capital, labour and land) and intermediate inputs from domestic and foreign sources to produce outputs in the most cost-efficient way that technology allow. Perfect competition is assumed in all sectors, but products from different regions are assumed to be imperfect substitutes.

In the standard GTAP model, tariffs and tariff revenues are explicit in the GTAP database, and therefore in the core model. However, NTMs affecting goods and services trade, as well as cost savings linked to trade facilitation, are not explicit in the database and hence a technical coefficient must be introduced to capture these effects. For this, we instead model NTMs as a mix of dead weight or iceberg costs, and rents generated by these NTMs. In formal terms, dead-weights costs capture the impact of non-tariff measures on the price of imports from a particular exporter due to destination-specific changes in costs for production and delivery.

2.3 Underlying Data

The model employs version 10 of the GTAP database, which is benchmarked to the year 2014 (Aguiar et al. 2019). The GTAP database is a global multi-regional input-output (GMRIO) database that has extensive and comprehensive economic data for 141 countries/regions and 67 production sectors. This database provides disaggregated data for sectoral production, consumption, taxes and subsidies, trade, government finances, labour variables for different skill levels, and data on other production factors. This database is then projected to fit more recent economic data for the year 2040, using real macroeconomic data from the IMF and trade data from the UN and Eurostat

Tariffs reflect the most recent applied rates, as incorporated in the GTAP database, as of 2014. We update these data for recently implemented FTAs. This include the Comprehensive Economic and Trade Agreement (CETA) between the EU and Canada, the EU-Japan Economic Partnership Agreement, and the EU-South Korea FTA. We then define our scenario (the extension of IP provisions in FTAs) with respect to our 2018 database and simulate the changes expected from our policy experiment. The economic effects of the FTA are the quantified differences between the "baseline" equilibrium (before the policy change) and the "scenario" equilibrium after the policy change.

2.4 Calculation of the trade cost changes associated with extending IP provisions in PTAs

2.4.1 Structural Gravity Estimates Trade Cost Reductions and Trade Elasticities

Trading cost reduction associated with NTMs (in this case reduced NTMs related to improved IP provisions) are modelled by extension of the gravity modelling in ECORYS (2009), CEPR (2012), and Egger et al. (2015), meaning iceberg trade cost reductions. In the case of both goods and services, benchmark values for trade costs and for cost reductions are based on gravity-based estimates of the trade cost reductions realized when modern IP provisions/chapters are included in PTAs. Our gravity model data includes a version of the DESTA database indicators of PTA depth (Dür et al. 2014). Algebraically, our estimator is a two-stage Poisson, where the first stage is used to control for endogeneity of PTAs, as developed in Egger et al. (2015). Actual trade elasticity estimates are based on the data used in our computable model (the most recent are GTAP10, benchmarked to 2014), aggregated to high-IP intensive and low-IP intensive sectors. (See Table 1 for the classification.) We use tariff data to estimate trade price elasticities for goods. Technically, the gravity model of trade can be generalized for a broad class of trade models as follows (see Head and Mayer, 2015):

$$v_{k,i,j} = A_{l,i}B_{k,i,j}C_{k,j}D_{k,j} \quad (1)$$

where $v_{k,i,j}$ is the value of trade in sector *k* originating in source country *i* and sold to destination country *j*. The terms $A_{k,i}$, $B_{k,i,j}$, $C_{k,j}$ and $D_{k,j}$ are source country, pairwise, and destination country determinants of trade flows. Frequently, the source and destination county effects are controlled for with importer and exporter fixed effects, with emphasis then placed on the pairwise role of factors like distance, tariffs, and trade agreements. We distinguish between terms $C_{k,j}$ and $D_{k,j}$ because it is sometimes useful to separate destination demand effects from other destination related variables. Table 2 below maps the general equation (1) to specific standard empirical trade models.

TABLE A1: CLASSIFICATION OF GOODS AS IP INTENSIVE

List of goods sectors assessed as intensive in IP	
Overall IP-intensive	
Sector description	**TiVA ISIC code**
Chemicals and pharmaceutical products	D20T21
Computer, electronic and optical products	D26
Electrical equipment	D27
Machinery and equipment, nec	D28
Motor vehicles, trailers and semi-trailers	D29
Other transport equipment	D30
Other manufacturing; repair and installation of mach. and eq.	D31T33

TABLE A2: PAIRWISE GRAVITY SPECIFICATIONS IN STANDARD EMPIRICAL MODELS

	B_{ij}
Armington	services $(\tau_{ij}S_{ij})^{1-\sigma}$ goods $(T_{m,ij}T_{x,ij}\tau_{ij}S_{ij})^{1-\sigma}$
Krugman-Ethier	services $(\tau_{ij}S_{ij})^{1-\sigma}$ goods $(T_{m,ij}T_{x,ij}\tau_{ij}S_{ij})^{1-\sigma}$
Melitz	services $(\tau_{ij}S_{ij})^{-\theta} f_{ij}^{1-\frac{\theta}{(\sigma-1)}}$ goods $(\tau_{ij}T_{x,ij}S_{ij})^{-\theta} f_{ij}^{1-\frac{\theta}{(\sigma-1)}} T_{m,ij}^{1-\sigma\frac{\theta}{(\sigma-1)}}$
Eaton-Kortum	services $(\tau_{ij}S_{ij})^{1-\sigma}$ goods $(T_{m,ij}T_{x,ij}\tau_{ij}S_{ij})^{1-\sigma}$
$T_{m,ij}$	bilateral import tariff multiplier $T_{m,ij} = (1 + t_{m,ij})$ where $t_{m,ij}$ is the import tax rate
$T_{x,ij}$	bilateral export tax multiplier $T_{x,ij} = (1 + t_{x,ij})$ where $t_{x,ij}$ is the export tax rate
S_{ij}	bilateral distance cost multiplier $S_{ij} = (1 + s_{ij})$ where s_{ij} is the shipping rate
σ	elasticity of substitution in demand
f_{ij}	firm fixed cost parameter entering j from i in Melitz model
τ_{ij}	actual iceberg costs between i and j
θ	Pareto shape parameter in Melitz model

Note that with an assumption of granularity, meaning $\theta = (\sigma - 1)$, the tariff elasticity and iceberg (NTM) elasticities in Melitz collapse to the otherwise common parameterization of the Armington, Krugman-Ethier, and Eaton-Kortum models.

In computable models such as the GTAP model and recent structural gravity models, a version of equation (1) is explicitly incorporated in log or proportional change form:

$$(2) \qquad \widehat{v_{i,s,d}} = \widehat{A_i} + \widehat{B_{ij}} + \widehat{C_j}$$

where $\hat{y} = \frac{dy}{y}$. In estimating trade elasticities and the role of NTBs, we expand the term as follows:

$$(3) \qquad B_{k,ij} = \sum_z \beta_{k,z} x_{k,i,j}$$

where the terms β_k are coefficients to be estimated, and x_{ij} are pairwise explanatory variables.

In formal terms, we follow Santos Silva and Teneyro (2006), and Egger et al. (2011, 2015) in employing a generalized-linear exponential-family model for estimating gravity models. One merit of such models is that, unlike ordinary least squares on the log-transformed model, they obtain consistent parameters in the presence of heteroskedasticity even if it is unknown whether the disturbance term is log-additive or level-additive. Furthermore, in line with Terza (1998, 2009), Greene (2002, 2012), Terza et al. (2008), and Egger et al. (2011, 2015) we apply a control-function approach, which is capable of absorbing the endogeneity problem and obtaining consistent parameter estimates, including the partial treatment effects of interest.

Formally, in estimating equation (1) we represent $v_{k,i,j}$ as the dependent variable and specify it as an exponential function of a linear index of the form:

$$(4) \qquad v_{k,ij} = \exp\left(\sum_z \beta_{k,z} x_{z,k,i,j} + a_{k,i} + c_{k,j} + c(z_{k,ij})\right) u_{k,ij}$$

where $x_{k,z,ij}$ is a vector of observable (log) pairwise trade-cost measures z (such as log distance, tariffs, and others) at industry level, β_k is a conformable parameter vector, $\{a_{k,i}, c_{k,j}\}$ catch-all measures of exporter- and importer-specific factors (estimated as parameters on i-specific and j-specific binary indicator variables, respectively). Moreover,

$$(5) \qquad c(z_{k,ij}) = h_{k,ij} a_h = \left(h_{1,k,ij}, \ldots, h_{Dk,,ij}\right) a_h,$$

is a control function used to control for endogeneity if trade agreement depth, which is derived from the assumption of multivariate normality of the disturbances between the processes of selecting into depth and the stochastic term about $v_{k,i,j}$.

Critically, we also include trade with self (domestic shipments) in our regressions. This allows us to identify home market effects (including various interactions with home trade). Because we work with our structural model data (the GTAP database) we have values for trade with self at the same level of aggregation as trade with other countries. A similar approach is also followed in recent applications based on the WIOD database. Note that because we control for destination and pairwise effects in our regression analysis, the exporter fixed effect terms provide, on the basis of trading partner demand, an estimate of the reduced form supply factors determining demand for products indexed *i,k*.

Comparison of predicted pairwise MFN trade and actual trade from the stage two estimation of equation (4) provides a basis for mapping pairwise trade cost reductions at sector and country level to the various provisions of existing PTAs. In the present context, this means we have a basis for estimating trade cost reductions that follow from inclusion of a standard IP chapter within a PTA.

The result of our gravity estimation exercise is reported in Tables 3, 4, and 5. Table 3 reports the first stage control function estimates (equation 5), while Table 4 reports the second stage PPML estimates for equation (4). Table 5 then shows the estimated reduction in trade costs, worth 2.82 percent of the delivered (c.i.f.) cost of goods trade in IP intensive sectors, when a PTA includes and IP chapter.

Importantly, the trade elasticities, which an important parameter in the model, are estimated econometrically from the same underlying gravity approach. Following Egger and Nigai (2015) and Bekkers et al. (2018), total trade costs and technology parameters are calibrated using actual import shares, imposing an exact fit. Changes in trade costs (the structural general equilibrium experiments themselves) follow from our gravity-based estimates of trade costs as discussed above.

To sum up, the above econometric gravity estimations provide both the trade elasticities – which are a key behavioural component of the CGE model – as well as the AVE reductions in trade costs associated with inclusion of IP provisions in a PTA.

TABLE A3: FIRST STAGE PROBIT FOR PTAS, AND FOR IP PROVISIONS IN PTAS

Stage 1 PTA probits and conditional IP provisions probit				
	PTA depth 1	PTA depth 2	PTA depth 3	IP provisions
log of surface disance	-0.958	-0.704	-0.969	0.313
	(0.036)***	(0.030)***	(0.047)***	(0.116)***
log of combined economic mass	0.004	0.004	0.062	0.025
	(0.010)	(0.007)	(0.010)***	(0.027)
common border	-0.733	0.125	0.11	0.419
	(0.119)***	(0.108)	(0.230)	(0.367)
Supply chain overlap index	0.637	1.525	-5.829	-4.033
	(0.265)**	(0.250)***	(0.626)***	(1.435)***
common ethnic language	0.292	-0.422	0.363	0.737
	(0.117)**	(0.101)***	(0.205)*	(0.421)*
common official language	0.141	0.493	-0.269	-0.528
	(0.116)	(0.100)***	(0.214)	(0.448)
common colony	-0.101	0.159	-0.653	0.881
	(0.078)	(0.094)*	(0.239)***	(0.758)
colonian relationship	1.248	-0.028	-0.728	-0.346
	(0.249)***	(0.141)	(0.230)***	(0.632)
Polity similartiy index	-0.057	0.111	0.013	-0.142
	(0.016)***	(0.013)***	(0.027)	(0.067)**
Supply chain overlap index and mfn tariff interaction	-1.425	0.498	7.578	12.817
	(1.036)	(0.763)	(1.832)***	(3.818)***
pairwise avrage MFN tariff	6.005	-2.84	-34.012	-59.655
	(3.990)	(3.228)	(8.309)***	(17.892)***
Pairwise OECD dummy	-1.399	-2.667	-1.504	-4.451
	(0.453)***	(0.107)***	(0.175)***	(0.498)***
N	18,906	18,906	18,906	2,693
PseudoR2	0.5765	0.4875	0.7951	0.8488

* p<0.1; ** p<0.05; *** p<0.01

TABLE A4: SECOND STAGE PPML REGRESSIONS

Second stage PPML regression, bilateral goods trade 2014									
	all goods trade			IP intensive goods trade			low tech goods trade		
	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9
Intra-EU trade dummy	1.093	1.207	1.225	1.184	1.314	1.289	0.858	0.876	0.9
	(0.105)***	(0.098)***	(0.092)***	(0.148)***	(0.148)***	(0.141)***	(0.105)***	(0.102)***	(0.092)***
log of surface distance	-0.35	-0.349	-0.344	-0.356	-0.356	-0.348	-0.419	-0.419	-0.415
	(0.022)***	(0.021)***	(0.019)***	(0.039)***	(0.038)***	(0.036)***	(0.019)***	(0.019)***	(0.017)***
log of internal (home) size	-0.364	-0.362	-0.36	-0.418	-0.416	-0.414	-0.355	-0.355	-0.353
	(0.045)***	(0.047)***	(0.048)***	(0.025)***	(0.027)***	(0.026)***	(0.047)***	(0.047)***	(0.048)***
Polity similartiy index	0.037	0.036	0.037	0.039	0.038	0.039	0.04	0.04	0.041
	(0.006)***	(0.006)***	(0.006)***	(0.009)***	(0.009)***	(0.009)***	(0.008)***	(0.008)***	(0.008)***
Supply chain overlap index	3.332	3.34	3.346	5.274	5.286	5.293	2.474	2.475	2.478
	(0.279)***	(0.275)***	(0.271)***	(0.893)***	(0.886)***	(0.883)***	(0.234)***	(0.235)***	(0.233)***
common colony	0.322	0.324	0.327	0.258	0.26	0.265	0.372	0.372	0.374
	(0.217)	(0.218)	(0.216)	(0.268)	(0.270)	(0.266)	(0.183)**	(0.183)**	(0.183)**
common ethnic language	0.33	0.325	0.32	0.364	0.358	0.355	0.332	0.331	0.325
	(0.195)*	(0.190)*	(0.190)*	(0.166)**	(0.159)**	(0.162)**	(0.159)**	(0.158)**	(0.155)**
common official language	-0.216	-0.213	-0.198	-0.115	-0.109	-0.093	-0.303	-0.302	-0.289
	(0.285)	(0.286)	(0.286)	(0.248)	(0.246)	(0.244)	(0.245)	(0.245)	(0.244)
common border	0.686	0.68	0.685	0.743	0.735	0.745	0.598	0.597	0.6
	(0.112)***	(0.110)***	(0.112)***	(0.133)***	(0.129)***	(0.138)***	(0.119)***	(0.119)***	(0.119)***
colonian relationship	0.313	0.316	0.317	0.161	0.166	0.165	0.357	0.358	0.359
	(0.042)***	(0.044)***	(0.043)***	(0.064)**	(0.065)**	(0.065)**	(0.036)***	(0.036)***	(0.036)***
home (own) trade	8.122	8.082	8.168	8.171	8.096	8.215	7.615	7.608	7.672
	(0.747)***	(0.774)***	(0.726)***	(0.918)***	(0.965)***	(0.933)***	(0.613)***	(0.616)***	(0.587)***
home intercated with per capita income	-0.401	-0.4	-0.404	-0.444	-0.441	-0.446	-0.415	-0.415	-0.417
	(0.020)***	(0.021)***	(0.020)***	(0.055)***	(0.056)***	(0.058)***	(0.011)***	(0.011)***	(0.012)***
home poliy index interaction	0.012	0.012	0.013	0.049	0.05	0.051	0.022	0.022	0.023
	(0.009)	(0.009)	(0.009)	(0.012)***	(0.011)***	(0.012)***	(0.009)**	(0.009)**	(0.009)**
home EUN member interactin	0.656	0.653	0.654	0.227	0.224	0.23	0.703	0.702	0.702
	(0.199)***	(0.198)***	(0.198)***	(0.131)*	(0.129)*	(0.133)*	(0.177)***	(0.177)***	(0.176)***
Tariff elasticity	-5.302	-5.313	-5.292	-6.955	-7.028	-7.054	-6.752	-6.753	-6.74
	(0.935)***	(0.944)***	(0.943)***	(1.207)***	(1.240)***	(1.330)***	(0.543)***	(0.544)***	(0.544)***
PTA1, depth index = 1	0.573	0.558	0.579	0.562	0.534	0.553	0.32	0.318	0.333
	(0.172)***	(0.175)***	(0.168)***	(0.271)**	(0.285)*	(0.281)**	(0.131)**	(0.131)**	(0.129)***
PTA2, depth index = 2	0.479	0.405	0.339	0.302	0.208	0.158	0.35	0.339	0.282
	(0.041)***	(0.044)***	(0.029)***	(0.125)**	(0.124)*	(0.118)	(0.052)***	(0.053)***	(0.048)***
PTA2, depth index = 3	0.272	0.154	0.149	0.181	0.046	0.09	0.244	0.225	0.21
	(0.056)***	(0.061)**	(0.061)**	(0.154)	(0.159)	(0.140)	(0.052)***	(0.055)***	(0.061)***
Rules of origin control	3.346	3.201	3.278	1.018	0.819	0.909	4.459	4.441	4.509
	(0.425)***	(0.361)***	(0.409)***	(2.092)	(2.120)	(2.110)	(0.708)***	(0.696)***	(0.754)***
Rules of origin control PTA3 interaction	-2.724	-2.493	-2.512	1.688	2.485	3.203	-2.295	-2.258	-2.37
	(1.451)*	(1.497)*	(1.564)	(1.452)	(1.446)*	(1.452)**	(1.759)	(1.779)	(1.842)
PTA includes intellectual property provisions		0.15	0.183		0.18	0.196		0.026	0.055
		(0.034)***	(0.044)***		(0.034)***	(0.031)***		(0.026)	(0.040)

	all goods trade			IP intensive goods trade			low tech goods trade		
	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9
N	19,044	19,044	19,044	19,044	19,044	19,044	19044	19044	19044
PseudoR2	0.9988	0.9988	0.9988	0.9968	0.9968	0.9968	0.999	0.999	0.999
controls Chi2	2.39E+02	2.49E+02	2.39E+02	8.28E+01	4.87E+01	2.28E+01	216.465	218.3562	243.0704
control function P-value	0	0	0	0	0	0.0001	0	0	0
AIC	427.792	427.367	426.075	229.904	229.598	228.555	810.236	810.213	808.736
BIC	7,876,000	7,867,917	7,843,314	4,129,540	4,123,720	4,103,848	15,100,000	15,100,000	15,100,000
model	CF1	CF1	CF2	CF1	CF1	CF2	CF1	CF1	CF2

* p<0.1; ** p<0.05; *** p<0.01
CF1: control function for endogeneity of PTA depth
CF2: control function for endogeneity of PTA depth and inclusion of IP provisions in PTA.

TABLE A2.5: ESTIMATED TRADE COST REDUCTIONS

Trade volume effects, high tech goods	
	coeff
PTA includes intellectual property provisions	0.196
Price elasticity	-7.054
NTM cost reduction, AVE equivalent	2.82%

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