Department for
International Trade

Analysis

Services trade modelling

DIT Analysis Working Paper – Benjamin Fraser, Analysis Group

August 2021

This DIT Analysis Working Paper sets out research and analysis relating to one of the Department's policy areas. This paper is intended to promote knowledge sharing and foster discussion regarding analytical methods, ideas and practices.

Abstract

This paper sets out a gravity modelling methodology for estimating the effect of restrictions to trade in services and simulating their trade impact. We build on existing work by using new OECD data on services trade restrictiveness in free trade agreements (FTAs).

Introduction and background

Services are a vital part of the UK economy, making up 80% of economic activity and 35% of total UK trade. As compared to manufacturing, however, trade in services has been the focus of relatively fewer quantitative economic analyses. This stems, at least in part, from a focus on tariffs. As compared to non-tariff barriers, tariffs are more straightforwardly operationalisable in a trade model but do not apply to services.

A core question within the Department for International Trade's (DIT's) 2020 to 2021 Areas of Research Interest is 'how can we best evaluate the barriers to trade in services and their impact on trade flows?'. This question is crucial to all stages of the FTA policy process. Its answer should inform the UK's FTA negotiating priorities with partner countries and form the basis of discussion within those negotiations. It should also facilitate public understanding of the benefits of specific services provisions once agreement is reached.

This paper sets out a 2 stage services gravity modelling methodology, comprising econometric estimation followed by theory-consistent partial equilibrium simulation, to begin to answer this question. The work uses methods increasingly popular in the gravity modelling literature to simulate the trade impact of specific policy changes, as proxied by the OECD's Services Trade Restrictiveness Index (STRI).

This model represents a complement to computable general equilibrium (CGE) modelling. CGE remains the standard approach used by DIT to evaluate the likely impacts of FTAs across the economy. Whereas CGE is best suited to analysing the impacts of whole agreements, partial equilibrium models — like the one set out here — can offer additional insight at the more granular provision-by-provision level.

The rest of the paper is organised as follows. First, we review the theoretical foundations and rationale for estimation of the structural gravity model. Then, we review the literature on barriers to trade in services, focusing in particular on existing gravity work using the STRI. After that, we introduce the data, estimation strategy, and simulation framework used in our model. A section on results and discussion follows, ahead of a conclusion.

The Gravity Model: foundations

Arkolakis, Costinot, and Rodriguez-Clare (2012) show that the same gravity equation can be established from a broad range of available micro-foundations satisfying standard assumptions. These include:

- Armington (1969), under which goods are differentiated by country of origin
- the supply-side Ricardian framework of Eaton and Kortum (2002)
- Krugman's (1980) model incorporating monopolistic competition

- certain variants of the Melitz (2003) heterogenous firms model, for example those set out by Chaney (2008) and Helpman, Melitz, and Rubinstein (2007)

The exposition here follows Anderson and Van Wincoop (2003) in using the Armington model as its basis for simplicity.

Suppose that within a given sector, goods and services vary only according to the country in which they were produced. Consumers globally have identical, homothetic preferences which can be approximated with the following CES form:

$$U = \left(\sum_i \beta_i^{(1-\sigma)/\sigma} c_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}$$

Where C_{ij} denotes consumption of goods from i in country j and $\sigma > 1$ is the elasticity of substitution for all goods in the sector. Consumers maximise utility subject to $\sum_i p_{ij} c_{ij} = y_j$, where p_{ij} and y_j represent the price of country i goods to consumers in j and nominal per capita income in j respectively.

Costs follow the Samuelson (1954) 'iceberg' heuristic, under which cross-border trade makes a proportion of the shipped goods 'melt' in transit; costs affect volumes rather than prices. This usefully allows us to look at (variable) trade costs as an ad-valorem equivalent (AVE). Letting $t_{ij} \geq 1$ be an AVE trade cost factor between i and j and p_i the supply price from the exporter, then $p_{ij} = p_i t_{ij}$. Exporters incur these trade costs and pass them on to the importer. Let total income in i therefore be $y_i = \sum_j x_{ij} := \sum_j p_{ij} c_{ij} = \sum_j (p_i + (t_{ij} - 1)) c_{ij}$.

Taking the first order conditions of the utility function subject to the budget constraint yields the following demand for i goods from j consumers:

$$x_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j} \right)^{(1-\sigma)} E_j$$

Where the importer consumer price index is:

$$P_j = \left[\sum_i (\beta_i p_i t_{ij})^{1-\sigma} \right]^{1/(1-\sigma)}$$

Imposing a market-clearing condition in equilibrium further implies that:

$$y_i = \sum_j x_{ij} = (\beta_i p_i)^{1-\sigma} \sum (t_{ij}/P_j)^{1-\sigma} E_j \,, \quad \forall i$$

Now, define world (sectoral) income as $y^W := \sum_i y_i$ and country expenditure shares as $S_j := \frac{E_j}{y^W}$. This yields the gravity equation:

$$x_{ij} = \frac{y_i E_j}{y^W}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma}$$

Where the following term transmits the effect of an increase in the level of import restrictiveness for non-j services importers that stimulates exports from i to j:

$$\Pi_i := \left(\sum_j S_j \left(t_{ij}/P_j\right)^{1-\sigma}\right)^{1/(1-\sigma)}$$

Using the equilibrium scaled prices, we can furthermore note that:

$$P_j = \left[\sum_i \left(\beta_i p_i t_{ij}\right)^{1-\sigma}\right]^{1/(1-\sigma)} = \left(\sum_i S_i \left(t_{ij}/\Pi_i\right)^{1-\sigma}\right)^{1/(1-\sigma)}$$

In other words, the levels of each Π_i and P_j – known in the literature as "multilateral resistance terms" (MRTs) – can be solved simultaneously, with solutions in terms of the elasticity of substitution, iceberg trade costs, and national incomes. These MRTs contain important information about the general equilibrium effects of bilateral changes to trade policy. They capture the remoteness of trading partners, relative to their remoteness from the rest of the world. This ensures that changes to the bilateral terms of trade between two partners have an effect on all countries in the model. Yotov and others (2016) offer an extensive treatment of the theoretical general equilibrium properties of the MRTs and their sectoral separability.

The Gravity Model: estimation

Recall the theoretical gravity equation:

$$x_{ij} = \frac{y_i E_j}{y^W}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma}$$

This can be subsequently log-linearised and transformed slightly to yield an estimatable model:

$$ln(x_{ij}) = (1-\sigma)ln(t_{ij}) - ln(y^W) + ln(y_i) + (\sigma-1)ln(\Pi_i) + ln(E_j) + (\sigma-1)ln(P_j)$$

Importantly, however, the variables Π_i, P_j, and t_{ij} are unobserved. Most modern pieces of gravity work use fixed effects to proxy for these (Yotov and others 2016). In a panel setting, importer-year fixed effects control for all importer-specific characteristics, while exporter-year fixed effects control for all exporter-specific characteristics. This includes the expenditure and output terms respectively, as well as each multilateral resistance. Pair fixed effects are increasingly used to proxy for t_{ij}, particularly given their potential to mitigate against the potential endogeneity of trade policy (Baier and Bergstrand 2007). However, pair effects absorb all time-invariant bilateral trade cost determinants. This means they are not suitable in applications seeking to identify the effect of variables with limited or no time variation. A typical log-linear gravity specification in such a case is as follows:

$$ln(x_{ij}) = \boldsymbol{X_{ij,t}\beta} + \pi_{i,t} + \chi_{j,t} + ln(\epsilon_{ij,t})$$

Where:

- $\boldsymbol{X_{ij,t}\beta}$ represents the effect of a vector of bilateral trade cost determinants, proxying for t_{ij}
- $\pi_{i,t}$ represents an exporter-year fixed effect
- $\chi_{j,t}$ represents an importer-year fixed effect.

Finally, Santos Silva and Tenreyro (2006) show that heteroscedasticity can bias OLS estimates of the log-linearised form above, due to the need to take logs of the error term[1]. It also requires the dropping of zeroes, which are relatively common in trade data. Instead, the gravity literature uses Poisson Pseudo Maximum Likelihood as the estimator of choice. This necessitates the following exponential mean model for estimation:

$$x_{ij} = exp(\boldsymbol{X_{ij,t}\beta} + \pi_{i,t} + \chi_{j,t})(\epsilon_{ij,t})$$

Literature review on the STRI and Gravity Modelling

The OECD STRI sets out a series of sector-specific potential restrictions to services imports for each of 48 countries and weights them according to expert judgements. This leads to a final country-sector score on a 0 to 1 scale, where 0 represents complete openness and 1 represents a completely closed services regime. The index covers countries and sectors representing over 80% of global trade in services at an unparalleled level of granularity. It therefore represents a highly useful quantitative proxy for services restrictiveness in empirical analysis.

Though services feature less prominently in the gravity literature than goods, several authors have already made significant contributions to the quantitative literature on the trade effects of services restrictiveness.

Nordas and Rouzet (2017) produced the first published analysis of the trade impact of the STRI. This used a Poisson Pseudo Maximum Likelihood (PPML) gravity model to recover sectoral estimates of the semi-elasticity of trade flows to the STRI. It found support for the hypothesis that greater restrictiveness (a higher STRI) is associated with less trade. It also, however, found the potentially counterintuitive result that exporter restrictiveness generally appeared more trade-inhibiting than importer restrictiveness.

A key limitation of this analysis was in the fixed effects structure used. Only the published MFN version of the STRI was incorporated, which meant that theory-consistent importer-year and exporter-year fixed effects were collinear with the importer and exporter STRIs respectively. In other words, the authors were unable to adequately control for the multilateral resistance terms

[1] The expectation of the logarithm of a variable is a function of that variable's variance. Under heteroscedacity, this implies by definition that the regressors are correlated with the logged error and therefore endogenous.

while identifying an STRI effect, leading to potential omitted variable bias. Domestic trade data was also not used. As Yotov (2021) points out, this is a departure from the gravity model set out by theory and is likely to bias results. Finally, while a panel of 2009 to 2013 data was used, the STRI was entered as a static variable without a time-varying dimension, meaning some useful longitudinal variation was not captured.

Ciuriak and Lysenko (2019) attempt to overcome the fixed effects issue identified above by pooling across several sectors and including importer-year and exporter-year fixed effects. By pooling like this, the STRI variable is no longer collinear with the fixed effects. However, as the authors note, this specification omits the effect of sectoral heterogeneity – the inclusion of additional sector fixed effects would again lead to collinearity. Furthermore, a theory-consistent fixed effects structure in a pooled setting would actually include fixed effects at the importer/exporter-sector-year level (rather than additively). Borchert and others (2020) find that atheoretical fixed effects structures like this lead to statistically different results from theory-consistent ones in gravity estimations.

The authors do make an important contribution to the literature by quantifying the effects of binding commitments in services trade. One function of services agreements is to reduce ‘water’, or the extent to which countries have the policy space under their General Agreement on Trade in Services (GATS) WTO commitments to become more restrictive[2]. This represents a source of uncertainty for firms associated with future market access, which could act as a risk premium on top of applied trade costs. Ciuriak and Lysenko (2019) operationalise bilateral water as the difference between the STRI-equivalent of the level of openness to which an importer is committed and the applied STRI. For bilateral pairs operating under WTO terms, the OECD has published STRI equivalents for commitments in the form of the GATS Trade Restrictiveness Index (GTRI). For bilateral pairs operating under preferential terms from FTAs, the authors had to hard code the contents of commitments in a range of agreements into the STRI format. Their pooled gravity results suggest that changes to applied restrictiveness had approximately 2.4 times the trade effect of equivalent bindings.

Lamprecht and Miroudot (2018) use an alternative gravity methodology. It comprises a bespoke bilateral non-STRI coding of the extent to which binding commitments are made in GATS and FTAs and find results of a comparable magnitude. They find that trade increases by 8% when moving from average GATS to average FTA commitments. Ciuriak and Lysenko (2019) find that the reduction in uncertainty associated with moving from GATS to FTA commitments typically leads to a 4.7% increase in services trade.

Shepherd and Hoekman (2020) make a novel machine learning contribution to the issue of extending the STRI to developing countries. They also identify an STRI effect in the presence of theory-consistent fixed effects, albeit at the cross-sectional level. The authors use a methodology proposed by Heid and others (2017) in order to get around the collinearity of the MFN STRI with the fixed effects. By incorporating domestic trade data, they can construct a dummy variable for international trade observations and interact it with the STRI. This produces sufficient variation along the dimension of the fixed effects for an effect to be identifiable. Furthermore, the authors introduce a novel methodology for at least partially controlling for preferential terms: they interact an FTA variable with the STRI to this end.

Benz and Jaax (2020) similarly use the Heid and others (2017) interaction in order to identify an STRI effect in the presence of theory-consistent fixed effects. They also use their gravity results to construct ad valorem equivalent inputs into a CGE model – facilitating simulation results for trade

[2] In other words, water represents the difference between the regime to which a country is committed and the one it actually applies.

flow effects of measures. As the most recent empirical OECD work using the STRI, this is rightly regarded as the most advanced piece of STRI gravity work to date[3].

Our work seeks to build upon this work and go further in several core areas. One such area is in the bilateral specification of the STRI for country pairs. Incorporating the STRI on an MFN[4] basis alongside some form of FTA dummy variable inadequately captures the variation arising from preferential services relationships. Interestingly, Benz and Jaax (2020) find negative coefficients for RTAs in 4 of 5 sectors in their core specification, with 2 of these being statistically significant. This result is unexpected and difficult to explain without reference to specification error.

One potential source of this apparent downward bias in FTA effects is country heterogeneity in the border barrier effect. We seek to mitigate against this by allowing the border coefficient to vary by importer and find wide country heterogeneity. A secondary source of this result, however, may be that the FTA dummy is inadequately able to capture the effects of preferential terms on trade. Using Benz and Rozensteine's (2021) recent work on coding RTAs into the STRI framework, we go the furthest of any paper yet in producing theory-consistent STRI gravity estimates that incorporate preferential trading relationships.

Review of the STRI Gravity literature

Paper	Theory-consistent FEs	Intranational trade data	Bilateralised STRI	Measures water	Panel data, including time-varying STRI	Country specific border coefficient	Simulation
Nordas and Rouzet (2017)	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Ciuriak and Lysenko (2019)	**X**	**X**	✓	✓	**X**	**X**	**X**
Shepherd and Hoekman (2020)	✓	✓	**X**	**X**	**X**	**X**	**X**
Benz and Jaax (2020)	✓	✓	**EEA Only (Robustness Check)**	**X**	**(Robustness Check)**	**X**	**CGE**
Fraser (2021)	✓	✓	✓	✓	✓	✓	**Bespoke**

[3] Khachaturian and Oliver (2021) follow a similar approach but break the STRI down by modes of supply and find heterogenous effects on cross-border trade in services across measures corresponding to different modes.

[4] Benz and Jaax (2020) also incorporate the intra-EEA STRI in robustness checks

Data and concordance

For our analysis, the standard gravity covariates are taken from the Dynamic Gravity Dataset (Gurevich and Herman 2018).

We use Borchert and others' (2020) International Trade and Production Database for Estimation (ITPD-E) as the source of our trade data for 3 primary reasons. First, it provides extensive coverage of sectoral cross-border trade in services data. When compared to alternative datasets, we found it had the most extensive cross-sectional coverage for our sample. Second, it contains data on domestic consumption of domestic production – which is required to produce both theory-consistent estimates and theory-consistent simulations. This also forms an important role in the identification procedure for certain country-specific variables in rigourously-specified gravity models (Heid and others 2017). Third, ITPD-E differs from most international trade in services datasets by containing only observed values reported by statistical agencies, rather than constructed data. The use of statistically constructed data in estimations should be avoided, given that it is likely to bias estimates through overfitting.

Where trade observations are missing, zeroes are assigned in the downloadable version of ITPD-E. However, given that it is possible that data could be missing even where true values are large, we exclude these assigned zeroes from the dataset we use. Given that our estimator attaches less weight to smaller observations, this has a very limited effect on estimates.

We extend ITPD-E by filling in missing domestic consumption of domestic production (DCDP) data for several countries. Consistent with the initial construction of ITPD-E, we calculate DCDP as the difference between production and exports. The production data we use is sourced from OECD STAN, OECD supply-use tables, and the Asian Development Bank's supply-use tables. Export data from within ITPD-E is used.

Given the policy-facing nature of the model discussed here, sectoral data granularity is desirable. ITPD-E, however, does not contain optimally granular sectors – particularly with respect to 'other business services', which comprises all of ISIC sections M and N. Data limitations mean that granularity beyond this level is unrealistic from any comprehensive services dataset for gravity. In particular, reliable production data is needed for calculating domestic consumption of domestic production. However, this data is not generally available at an international level in a more disaggregated form than is used in ITPD-E. We prioritise the 3 advantages identified above over sectoral granularity.

In cases where multiple STRI sectors map to given ITPD-E sectors, a two-step simple average procedure is used. STRI sectors judged to be smaller sub-sectors are grouped and averaged together, before this average is treated as a single sector in the overall sector average. For example, courier services are weighted by 5% in the index for transport, whereas maritime transport is weighted by 25%. This procedure is by no means exact and reflects the fact that there is no single appropriate trade weighting system across countries in the absence of sub-sectoral data. The STRI sectors which have been aggregated are listed below:

- rail freight and road freight transport are averaged together to make a composite freight transport sub-sector. Logistics cargo handling, logistics storage and warehouse, logistics freight forwarding, logistics customs brokerage, and courier services are averaged together to make a composite logistics sector. These composite logistics and freight transport sub-sectors are averaged with air and maritime transport to produce a final STRI score for the transport ITPD-E sector
- the construction STRI sector maps directly to the construction ITPD-E sector
- the insurance STRI is mapped to the insurance and pension services ITPD-E sector

- the commercial banking STRI is mapped to the financial services ITPD-E sector
- the broadcasting, motion pictures, and sound recording STRI sectors are averaged to form a composite audio-visual sub-sector. This is then averaged with the telecoms and computer services STRIs to cover the telecommunications, computer, and information services ITPD-E sector
- architecture and engineering are averaged together to form a composite sub-sector. This is then averaged with accounting and legal services to form an STRI for the other business services ITPD-E sector
- the distribution STRI maps directly to the trade-related services ITPD-E sector

Estimates were not particularly sensitive to the weighting procedure used.

There are three years of overlap between the STRI (2014-20) and the trade data (2000-2016). In order to take advantage of all available time variation in the STRI, we use it as a time-varying variable across the 3 available panel years of overlap. This contrasts with just applying it statically to additional years in the trade data.

The core STRI is only published on a Most Favoured Nation (MFN) basis – it does not take the preferential terms from FTAs into account. Existing STRI gravity work has therefore been forced to either incompletely capture preferential effects through an FTA dummy variable or hard code a selection of FTAs into the STRI framework. Our work incorporates new official OECD codings of recent services FTAs from Benz and Rozensteine (2021), which cover 93% of the preferential services trade flows in our final dataset[5]. This allows us to more fully capture the variation in trade flows associated with given bilateral levels of restrictiveness.

Following a methodology proposed by Heid and others (2017), some pieces of gravity work interact an MFN STRI variable with an international trade dummy variable for identification purposes. This effectively imposes an assumption that the STRI does not reflect restrictions on domestic service providers serving the domestic market. Given that our work uses a bilateralised STRI, such an interaction is not required for identification. However, an STRI still needs to be assigned to domestic trade observations. Instead of assigning a value of zero, we use the summed scores from the 'Barriers to Competition' and 'Regulatory Transparency' STRI categories. We do so on the basis that this is a good proxy for the non-discriminatory portion of the STRI in each sector. Using this subset of the STRI leads to lower scores for intranational trade observations, consistent with the expectation that domestic trade costs are lower than international trade costs.

As discussed already, the OECD also produce a GTRI, which codes a country's GATS commitments into the STRI format[6]. The work on coding the services provisions of FTAs also covers the extent to which commitments bind – analogous to a post-FTA GTRI. Following work previously done by Ciuriak and Lysenko (2019), we use the GTRI data to operationalise water and estimate its trade-inhibiting effect in our model.

---

[5] We use the OECD data for all covered FTAs in the sample. An FTA is considered to be in the sample for a given year if it was in force for the majority of that year. USMCA has been additionally included as a proxy for NAFTA. The existing intra-EEA STRI is used for country pairs it covers during our panel. This includes the UK, which was an EU member at the time.

[6] The GTRI was first produced by the OECD in 2015, with a methodology available at https://www.oecd-ilibrary.org/trade/water-in-the-gats_5jrs6k35nnf1-en. The OECD have generously provided DIT with a new unpublished GTRI, updated for the 2020 STRI sectors and weightings.
The OECD do not code a GTRI for the Air Transport sector, on the basis that countries take out minimal commitments in this sector in GATS and FTAs. For the purpose of our analysis, we set Air Transport GTRI scores to the maximum level of restrictiveness possible in the index (1)

Specification

In line with best practice, we estimate a PPML gravity model at the sectoral level with country-year fixed effects[7]. Our core specification is as follows:

$$x_{ij} = exp\big(\beta_1 log\big(DIST_{ij}\big) + \beta_2 CNTG_{ij} + \beta_3 CLN_{\ ij} + \beta_4 LANG_{ij} + \beta_5 STRI_{ij,t} + \beta_6 WATER_{ij,t} + \beta_7 INTER \times IMPORTER_j + \pi_{i,t} + \chi_{j,t}\big)\big(\epsilon_{ij,t}\big)$$

Where:

- x_{ij} denotes exports
- $DIST_{ij}$ is bilateral distance
- $CNTG_{ij}$ is a dummy for contiguity
- CLN_{ij} is a dummy for a past colonial relationship
- $LANG_{ij}$ is a dummy for common language
- $STRI_{ij,t}$ is our bilateralised version of the STRI
- $WATER_{ij,t}$ is the difference between applied and bound commitments
- $INTER$ is a dummy for international trade observations
- $IMPORTER_j$ is an importer indicator variable
- $\pi_{i,t}$ is an exporter-year fixed effect
- $\chi_{j,t}$ is an importer-year fixed effect

The chosen gravity covariates are the same as those found in Khachaturian and Oliver (2021), with the exception of the omission of EEA and services FTA variables. We omit these here because, unlike in that work, we specify bilateralised STRI and water variables. These should together pick up the trade-promoting effects of the applied liberalisation and uncertainty reduction associated with FTAs.

Yotov and others (2016) recommend the use of country-pair fixed effects in panel gravity models. They can account for the potential endogeneity of trade policy[8] and all time-invariant gravity covariates. In our context, however, country-pair fixed effects are not possible to include because of limited time variation in the STRI over the course of our panel. The dimension along which the pair effects control is the dimension in which most of the STRI variation is present. As such, we follow the existing STRI gravity literature in using the standard gravity covariates rather than country-pair fixed effects.

The effect of the STRI on trade may vary by country pair. Due to a lack of degrees of freedom, however, we cannot estimate country- or pair-specific STRI coefficients. As such, β_5 should be interpreted as the average effect of the STRI across countries.

---

[7] We use the excellent R package *fixest* for our estimations

[8] For example, that countries may be more likely to sign up to FTAs and liberalise their trade with countries with whom they trade a lot already.

Services can be delivered through different modes of supply[9], with certain restrictions potentially affecting some modes but not others. Indeed, if modes are substitutes, a given restriction to one mode of supply may increase trade through another mode. Services trade data is generally published on a cross-border basis, i.e. aggregating modes 1, 2, and 4 and excluding mode 3. Our core model uses cross-border trade in services data. It also uses the STRI as a single index, which may mask within-index heterogeneity related to modes of supply.

Simulation framework

Our estimation stage gives us the elasticity of trade to changes in the STRI in the form of $\hat{\beta}_5$. Directly applying this estimated coefficient to counterfactual STRI shocks is not, however, a theoretically sound way of calculating counterfactual trade impacts. The MRTs link the trade costs of all bilateral pairs in a system of simultaneous equations and therefore transmit any shocks across all pairs. To put it less mechanically, global relative prices are what matters for trade. In effect, direct coefficient application necessitates an assumption that the trade costs for the bilateral pair of interest have only a negligible effect on global prices. For larger economies, this will not be the case.

We account for these equilibrium changes across the system using a simulation framework. It is possible to use a nonlinear solver to solve the described system of simultaneous equations (Herman 2021), although this can be computationally demanding. We broadly follow the simulation method set out by Yotov and others (2016)[10]. They show that equivalent results to explicitly solving out the system can be obtained using an iterative procedure.

First, we estimate our baseline sectoral gravity model as above. We then use fitted values from this model to construct baseline indices for each country – output, expenditure, exports, and both sets of MRTs. Following the literature, a reference country with good data but which is remote from the counterfactual of interest is used to normalise our estimates of the MRTs (Yotov and others 2016).

This involves estimation of the bilateral trade costs vector and means that our baseline values will not necessarily represent an exact match to the data. Yotov and others (2016) alternatively suggest exact calibration of the trade cost vector to the data by also including the error term in the trade costs vector[11]. This method would also lead to results matching the ‘exact hat’ methods employed by Baier, Yotov, and Zylkin (2019) in the Stata package ‘ge_gravity’.

The data requirement for an exact match to the data is high: it necessitates a fully balanced dataset without any missing trade flows among country pairs in the model. Using our approach with fitted values, the requirement is simply that the relevant fixed effects are identifiable and there are no missing values for the regressors. Given the extremely good fit of the gravity model, there is little divergence between our fitted values and reported trade flows. Furthermore, we ensure final reported results are consistent with observed data by applying the percentage export change results to ONS data when reporting values in GBP.

The next stage in the model involves adjusting the trade cost vector for the counterfactual scenario. Generally, this comprises reducing the STRI for a given country pair by an amount equivalent to a potential FTA liberalisation of interest.

Intermediate ‘conditional general equilibrium’ changes to the indices of interest are found by constraining the trade cost vector to the baseline estimated coefficients and counterfactual data.

---

[9] GATS definitions are generally used. Mode 1: remote delivery. Mode 2: consumption abroad. Mode 3: commercial presence. Mode 4: movement of natural persons.

[10] We also drew inspiration from Vargas’ (2021) implementation of Yotov’s procedure in R

[11] This is sometimes referred to as “estibration”

We then re-run the PPML model to allow the fixed effects to adjust. This yields predicted changes to trade, with initial third country effects, but importantly holds output and expenditure constant.

The final 'full endowment general equilibrium' changes are found by allowing output and expenditure to endogenously adjust. To do this, we must assume a value for the elasticity of substitution, σ. Interpreting this parameter as the elasticity of substitution between home and foreign goods, the framework in effect becomes an Armington partial equilibrium model. We close the model by assuming a constant trade imbalance ratio. From here, an iterative procedure is used until convergence as trade and the MRTs adjust and feed back into each other. Final indexes are constructed and compared to the baseline to yield results in percentage changes.

It is important to note that this simulation does not take supply linkages into account. It is agnostic to the fact that sectors may serve as inputs into others, inasmuch as a shock to one sector will not impact trade in another. Likewise, cross-modal effects are absent in these simulations. As described above, our model uses cross-border trade in services data, which aggregates modes 1, 2, and 4 and excludes mode 3.

The simulation stage also necessitates the treatment of all trade costs as variable, despite the fact that fixed costs associated with establishment and regulatory compliance are also common in services trade.

Estimation results and discussion

Table 1 sets out regression results from our core specification, incorporating both the STRI and a water variable. As described above, these can be interpreted as partial equilibrium effects of the variable of interest on bilateral trade. For all variables entered in levels (that is, everything except distance), interpretation of a coefficient β and an STRI change $\Delta STRI$ should be of the form "bilateral exports rise $100(exp(\beta \times \Delta STRI) - 1)\%$ before accounting for third country effects".

Table 1: Regression output from core specification

	Transport	Construction	Insurance	Financial Services	Other Business Services	Telecoms	Distribution
log distance	-0.672***	-1.054***	-0.354**	-0.605***	-0.626***	-0.560***	-0.602***
	(0.064)	(0.129)	(0.144)	(0.101)	(0.083)	(0.056)	(0.179)
contiguity	0.291***	0.254	0.340	-0.017	-0.069	0.178	0.162
	(0.110)	(0.193)	(0.232)	(0.180)	(0.126)	(0.122)	(0.191)
colony ever	0.294**	-0.005	-0.193	-0.016	-0.201	-0.465***	-0.369
	(0.115)	(0.300)	(0.223)	(0.171)	(0.190)	(0.163)	(0.256)
common language	0.149	0.383*	0.239	0.568***	0.207	0.208	0.274*
	(0.101)	(0.210)	(0.282)	(0.142)	(0.151)	(0.141)	(0.151)
STRI	-2.611**	-4.656	-5.341***	-2.341	-4.398***	-1.167**	-8.138***
	(1.149)	(2.930)	(2.014)	(1.458)	(1.217)	(0.578)	(2.955)
water	0.397	-0.055	-2.810	-1.798	-1.558*	0.866	-1.338
	(0.457)	(1.712)	(1.847)	(2.416)	(0.847)	(0.630)	(3.570)
obs	4653	3614	3806	4083	4555	4752	3177
Std. Errors	Pair	Pair	Pair	Pair	Pair	Pair	Pair

* p < 0.1, ** p < 0.05, *** p < 0.01

In line with the existing literature, all STRI coefficients are negative and of a sensible magnitude. For example, assuming an illustrative STRI liberalisation of -0.01, our transport STRI coefficient implies a partial trade rise of 2.65% in response. Performing the same calculation with the transport coefficient from Benz and Jaax (2020) implies a partial trade rise of 3.61%.

Clustering by country-pair, 3 of our sectoral STRI coefficient estimates are significant at the 1% level, 2 are significant at the 5% level, and 2 are statistically insignificant. The insignificant STRI estimates, for construction and financial services, still have relatively low associated p values of 0.112 and 0.108 respectively, however.

With respect to the water variable, results are more mixed. The prior, from Ciuriak and Lysenko (2019), is that we expect the effect of binding commitments to be around half of that of the equivalent applied STRI changes. Handley and Limao (2017) similarly find that reductions in uncertainty about future tariffs have approximately half the impact of applied changes to tariffs in goods trade. Our results estimate a negative water coefficient in 5 of 7 sectors, although the magnitude of these estimates is generally less than half of that of the sector's STRI coefficient estimate. The exception here is in financial services, where the water coefficient is over 75% the size of the STRI coefficient.

The water estimates are associated with a considerable amount of noise, with statistical significance only established in other business services. This reflects results found in an earlier working version of the Ciuriak paper, which offered a sectoral breakdown of results and failed to establish significance in a majority of sectors (Ciuriak 2016). These mixed results should not be seen as evidence to reject the hypothesis that water has an effect – rather it simply represents inconclusive evidence surrounding water's impact.

In this paper, we do not provide specific examples of simulations due to their country-specific nature.

Conclusion

This paper has sought to contribute to a growing literature that uses the STRI in a structural gravity model to evaluate the impact of barriers to services trade. We use new OECD data to capture additional variation from FTAs and find largely significant effects of a similar magnitude to those in the existing literature. We also show how a gravity simulation framework can be used to produce country-specific trade flow impacts of given STRI measures.

Future work could look to lengthen the panel used as more data becomes available, which may improve the quality of estimates and facilitate the use of pair fixed effects. It could also explore the heterogeneity of STRI and water effects, both within the index and across countries. The simulation framework could likewise be extended to incorporate fixed costs and supply linkages.

Bibliography

Anderson and Van Wincoop "Gravity With Gravitas: A Solution to the Border Puzzle". AER 93: 170-192.

Armington. "A Theory of Demand for Products Distinguished by Place of Production". IMF Staff Papers 1969.

Arkolakis, Costinot, and Rodriguez-Clare. "New Trade Models, Same Old Gains?". American Economic Review 2012, 102(1): 94–130.

Baier and Bergstrand "Do free trade agreements actually increase members' international trade?". 2007 Journal of International Economics, Volume 71, Issue 1: 72-95.

Borchert, Larch, Shikher, and Yotov "Disaggregated gravity: Benchmark estimates and stylized facts from a new database." Rev Int Econ. 2021; 00: 1– 24

Ciuriak, Dadkhah, and Lysenko "The Effect of Binding Commitments on Services Trade". 2019 World Trade Review, 19(3), 365-378.

Eaton and Kortum. "Technology, Geography, and Trade". 2002 Econometrica, 70: 1741-1779.

Khachaturian and Oliver "The Role of Mode Switching in Services Trade" 2021 USITC Staff Working Papers

Krugman. "Scale Economies, Product Differentiation, and the Pattern of Trade" 1980 Volume 70 Number 5: 950-959.

Melitz “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity”. 2003 Econometrica, 71: 1695-1725.

Nordås and Rouzet “The Impact of Services Trade Restrictiveness on Trade Flows.” 2017 World Econ, 40: 1155-1183

Samuelson “The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments”. 1954 The Economic Journal, Volume 64, Issue 254: 264–289.

Santos Silva and Tenreyro “The Log of Gravity”. 2006. Federal Reserve Bank of Boston Working Paper No. 03-01

Yotov and Piermartini “The Advanced Guide to Trade Policy Analysis: The Structural Gravity Model” Chapter 1. 2016 WTO Press

Yotov “The Variation of Gravity within Countries (or 15 Reasons Why Gravity Should Be Estimated with Domestic Trade Flows)” 2021. CESifo Working Paper No. 9057.

The UK's Department for International Trade (DIT) helps businesses export, drives inward and outward investment, negotiates market access and trade deals, and champions free trade.

Legal disclaimer

Whereas every effort has been made to ensure that the information in this document is accurate the Department for International Trade does not accept liability for any errors, omissions or misleading statements, and no warranty is given or responsibility accepted as to the standing of any individual, firm, company or other organisation mentioned.

Copyright

This document is also available on our website at gov.uk/dit

Any enquiries regarding this publication should be sent to us at

enquiries@trade.gov.uk.

Published 2021 by Department for International Trade