Evaluating the UK-EU Trade Cooperation Agreement's Impact on Service Trade: A Gravity Model Comparison of Competing Estimation Strategies

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Abstract

This dissertation examines how econometric estimation strategy shapes modelled impacts of higher services trade costs, focusing on the UK–EU Trade and Cooperation Agreement (TCA). I compare two gravity approaches: (i) a non-linear PPML specification with exporter-year and importer-year fixed effects, the Department for Business and Trade's gold-standard; and (ii) a linear three-country estimator (per Caliendo and Parro (CP), 2015) that algebraically eliminates multilateral resistance. Using a harmonised trade dataset panel with gravity controls, I use the OECD's Services Trade Restrictiveness Index (STRI) as a proxy for services trade costs to estimate sectoral trade elasticities. Applying an illustrative 0.15 increase in UK-EU STRI, to mimic the TCA, shows material divergence across sectors. For example, in financial services, PPML implies a ~60% fall in UK exports to the EU, versus ~39% under CP; in other sectors the sign and ranking are consistent, but magnitudes differ substantially in some cases. Re-estimation checks indicate that differences stem mainly from how each method handles time-varying multilateral resistance and unobserved heterogeneity rather than from zero-trade observations. The policy implication is practical: when evidence is used to size market-access negotiations, regulatory reform or export-support, reliance on a single estimator risks over- or under-stating impacts. Modellers should therefore deploy a range of estimation strategies depending on data features and the question at hand, as opposed to using a single approach dogmatically.

AI Statement

I confirm that generative AI was not used in during the research or drafting of this paper.

1. Introduction

The UK is a services-oriented economy where the EU is an integral market

Services trade plays an integral role in UK economy, it accounted for over 4/5 of total UK economic output and employment in 2024 (Brien, 2025). Furthermore, services exports are becoming increasingly valuable with time, overtaking the value of goods exports for the first time in 2020, and remaining ahead ever since; by 2023, UK services exports were 25% higher than goods. Unsurprisingly, the EU is a crucial market for the UK: over 2/5 of all UK exports go the EU and over a half of UK imports come from there as well. Specifically, over 1/3 of UK services exporters are delivered to the EU in (Webb, 2024).

UK-EU barriers to trade are increasing

The UK's trading relationship with the EU has fundamentally changed after leaving the single market and customs union in early 2020. This has material costs for UK firms trading with the EU. The increased regulatory differences have raised costs and administrative burdens for UK exporters, thus reducing trade volumes. For instance, UK firms are finding it more difficult to export to the EU due to more custom checks to consider and learning how to adhere to technical rules of origin requirements (Low & Caswell, 2025). While UK services trade has demonstrated more resilience than goods trade in this period, this does not mean it is unencumbered by increasing trade barriers. For example, services exports to non-EU countries have risen 23% above their 2019 levels, while exports to the EU are 19% above in comparison: this suggests UK exporters are reaching into further markets in response to more barriers faced in EU markets (Ward and Webb, 2025).

Policymakers depend trade models to quantify the impact of increasing trade costs

While there are no tariffs on trade in goods with the EU, subject to certain conditions (such as rules of origin requirements), non-tariff barriers are now higher (Ward and Webb, 2025). As a result, quantifying the impact of non-tariff services trade barriers, such as those captured in the OECD's Services Trade Restrictiveness Index (STRI), is a central concern for UK policymakers, particularly when negotiating future trade deals and trade policies (OECD, 2024). Economists turn to gravity trade models to estimate the effect of changes in trade costs on trade flows. Modelling trade using gravity is among the most popular and successful frameworks in economics, in part, because of predictive power: gravity equations of trade flows consistently deliver a remarkable fit of between 60%-90% with aggregate and sectoral data, for both goods and services (Yotov, 2016).

The trade elasticity is the most important parameter for gravity trade modelling predictions

Gravity trade models contain relatively few parameters (a value that describes a characteristic/property/behaviour of the model that is ascertained using data). The most important being the ‘trade elasticity’ parameter which describes how sensitive trade flows are to changes in trade costs. Therefore, how this parameter is estimated largely dictates what impacts the model predicts (Costinot & Rodríguez-Clare, 2014). Accordingly, small differences in estimated trade elasticities can yield substantially different policy simulations.

Econometrics of modelling trade costs in gravity models

A critical component in gravity modelling is adequately representing trade costs. Trade costs are decomposed into bilateral trade costs (such as tariffs) and multilateral resistance terms (MRTs represent how easy it is for a country to access third country markets to import from, as well as how easy it is for third countries to access said country’s market to export to it). To note, MRTs are unobservable constructs, hence the difficulty in controlling for it. The gold-standard method for controlling for MRTs is using fixed effects, alongside a Poisson Pseudo Maximum Likelihood (PPML) estimator (Silva & Tenreyro, 2006). An alternative approach is to simply eliminate MRT terms algebraically by using appropriate ratios based on the gravity equation. For example, Caliendo and Parro (CP, 2015) estimate developed a ‘three-country’ to algebraically isolate trade elasticities without the explicit use of fixed effects.

Research aims

The aim of this dissertation is to assess whether CP’s (three-country) estimation method, originally designed for goods tariffs, can be reliably applied to services trade, and to understand how it compares to the gold standard (PPML + fixed effects). Beyond technical interest, this has clear policy implications. I contextualise results in the context of the UK leaving the EU single market, using the increased services trade restrictiveness to illustrate the differential effect of estimation strategies, even if the inputs are the same. If elasticities are under- or over-estimated due to modelling choices, then predicted trade gains or losses from deregulation, new trade agreements, or divergence from EU rules may be misleading.

2. Literature Review

Origins of gravity in trade

Tinbergen (1962) modelled trade between two countries by drawing from Newton's Law of Universal Gravitation (equation 1), where bilateral trade is proportional to economic size and inversely proportional to distance (equation 2). This early gravity trade model is empirically robust, describing the stylised facts of trade data generally well. However, it leaves behind substantial unexplained variance caused by omitted variables (figure 1). Afterall, this model is 'atheoretical' in that there are no explanatory economic mechanisms. The shortcoming of this approach is exemplified in practice. Equation 3 is a regression model based on the 'naïve' gravity approach, taking the partial derivative of trade with respect to *third country* trade costs, we are forced to also accept the logical error that trade-costs of third countries do not affect bilateral trade, simply incorrect.

Equation 1 - Gravity equation in physics

$$Force_{ij} = G\frac{Mass_i\, Mass_j}{distance_{ij}^2}$$

Equation 2 - Gravity equation in economics

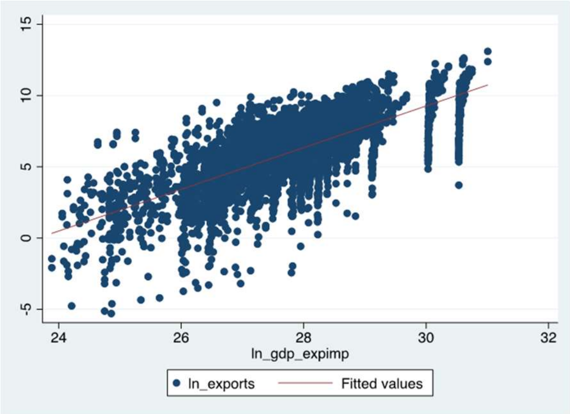
$$Trade_{ij} = \frac{(GDP_i)^a\,(GDP_j)^b}{(distance_{ij}^2)^c}$$

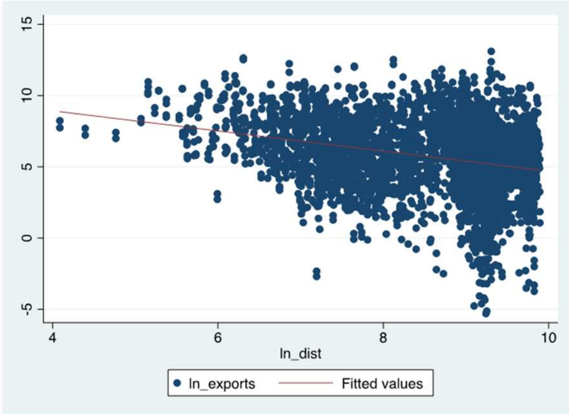
Equation 3 - Proof that an atheoretical gravity equation is insufficient for explaining trade flows

$$log\ (trade_{ij} = b_0 + b_1 log\ (GDP_i) + b_2\, log\big(GDP_j\big) + b_3 log\big(trade\_costs_{ij}\big) + error_{ij}$$

$$\therefore \frac{\partial\ log(trade_{ij})}{\partial\ trade\_costs_{kl}} = 0$$

Figure 1 - Comparing predictions of a naive gravity model to trade observations (Shepherd, 2025)





Structural gravity trade models permit trade policy analysis

Anderson (1979) provided the first *theoretical foundations* for gravity in trade, hence making the model 'structural'. The intuition remains the same, showing that bilateral trade is proportional to economic sizes and inversely proportional to the distance (trade-cost term captures this element and other frictions). The difference is in how the gravity equation is derived. Specifically, Anderson derived trade flows from consumers maximizing consumption utility, subject to a budget constraint, leading to a demand function for goods that incorporates trade costs. This approach grounds the gravity equation in microeconomic theory, linking trade flows to consumer preferences and firm behaviours. Therefore, 'structural' gravity models provide a tractable framework for trade policy analysis as the model identifies specific economic levers, such as trade costs, that policymakers can act upon. This contrasts with the naive gravity equation, which does not provide insights into these economic levers, thereby limiting its usefulness for policy analysis.

Gravity equation isomorphism

There are now several theory-consistent gravity modelling frameworks, each elaborating on varying economic mechanisms (Anderson & van Wincoop, 2003; Eaton-Kortum, 2002; Melitz, 2003; Caliendo and Parro, 2015). Remarkably, despite differing theoretical underpinnings, Arkolakis, Costinot & Rodriguez-Clare (2012) show that the same gravity equation (4) can be established from a broad range structural gravity models (what isomorphism refers to) and that the welfare gains from trade remain relatively unchanged across the models. Across the various gravity trade models, the (unobservable) trade elasticity parameter was identified to be the most important determinant of trade flows and welfare gains.

Equation 4 - 'Universal' gravity equation

$$X_{ij} = GS_i M_j \phi_{ij}$$

Equation 4 shows how bilateral trade (X) generally depends on the capacity of exporter's supply (S), importer demand (M), and multilateral resistance terms (φ). G is a variable that does not depend on the bilateral partner, such as the level of world liberalisation.

Theory vs estimation methods in gravity modelling

Head and Mayer (2014) demonstrated that a range of structural gravity models fit the trade data consistently well, between 60% and 90%, across aggregate, sectoral, goods and services trade, *given adequate estimation methods.* They argued *against* the sole reliance on any one estimation method, but instead on adapting methods to the question and data under examination. Given the isomorphism of gravity equations, it appears that the estimation approach for the trade elasticity parameter is more important for model fidelity than the underlying theory itself.

Estimation of services trade elasticity

Gravity applies to services trade as well as goods trade (Walsh, 2006). However, while goods trade costs are readily apparent (tariffs), for services trade barriers, they need to be quantified somehow. For example, the OECD's Services Trade Restrictiveness Index (STRI) provides a comprehensive measure of the level of restrictions in services trade across various countries, ranging across regulatory transparency, barriers to competition, restrictions on movement of people, etc. (OECD, 2024).

Benz and Jaax (2020) used the STRI to proxy services trade costs within the Anderson and van Wincoop (AvW, 2003) gravity modelling framework to show that services trade barriers discourage services trade just as tariffs hinder goods trade. Through expressing estimated services trade elasticities in tariff equivalent terms, they illustrated that even in liberal countries, and between EU member states, there is a great amount of services trade barriers (equivalent to 30% to 250% in tariff terms, depending on the country and sector). This illustrates the importance of estimating services trade elasticities, particularly for sectoral insight.

In the Department for Business and Trade, Fraser (2021) also implemented STRIs to estimate the effect of restrictions on trade in services. The key difference is that Fraser goes beyond partial equilibrium analysis (i.e., just looking at elasticities) and applies these estimates to simulate the trade impacts of policy changes. This approach provides a more comprehensive understanding of how policy adjustments can influence trade dynamics.

Controlling for multilateral resistance: fixed effects vs algebraic elimination

In gravity trade modelling, the Poisson Pseudo Maximum Likelihood (PPML) estimator is widely regarded as the gold standard. It handles zero-trade flows, accounts for heteroskedasticity, and is well-suited for the multiplicative (nonlinear) structure of trade models (Silva & Tenreyro, 2006). The PPML estimator is used with fixed effects to control for unobservable country-specific factors; the AvW (2003) gravity framework is so successful to this day because it factors in not just bilateral market frictions, but third country market frictions too (multilateral resistance terms) via fixed effects.

In contrast, Caliendo and Parro (CP, 2015) innovated a 'three-country' construct which sets-up ratios based on the structural gravity equation between three countries to isolate a relationship between trade costs and trade flows to algebraically triangulate the trade elasticity parameter. The CP estimation approach is fully elaborated in methods ahead. For now, it is crucial to note that their approach retains the theoretical consistency of traditional gravity estimation methods without the use of fixed effects, when examining goods trade. Yet, I have not come across the application of CP's three country estimation method in services gravity trade modelling.

Applying CP estimation to estimate services trade elasticities

CP's estimation method provides a theoretically consistent method for estimating trade elasticities, initially applied in the context of goods trade using tariff data. Theoretically, there is no reason why it cannot be applied to services trade, given a suitable proxy for services trade costs, such as the OECD's STRI. However, it remains unclear how CP's method compares to PPML-based estimation in the context of services trade, and whether it provides more reliable or robust estimates when dealing with non-tariff barriers. Given these gaps, my dissertation adapts CP's approach to estimate services trade elasticities using the OECD's STRI as a proxy for services trade costs. This adaptation will test whether CP's method remains valid when applied to non-tariff barriers rather than explicit tariff-based trade costs. I will benchmark CP-estimates against PPML-estimates with fixed effects. This comparison will help assess whether CP's method, by eliminating unobservables algebraically rather than relying on fixed effects, offers advantages for estimating services trade elasticities.

3. Methods & Data

Overall strategy: comparing two methods for estimating services trade elasticities with respect to STRIs

This dissertation compares two distinct estimation strategies to analyse how responsive bilateral services trade is to changes in the Services Trade Restrictiveness Index (STRI). Despite differing theoretical underpinnings between Anderson and van Wincoop (AvW, 2003) and Eaton and Kortum (2002) gravity modelling approaches, the trade elasticity parameter in both models is comparable due to the isomorphism of the gravity equation. This allows for a methodological focus on the estimation strategy, rather than theoretical divergence. Thus, the aim is to understand how the contrasting methods of controlling for unobservable heterogeneity, one reliant on fixed effects and the other on an algebraic elimination, affects our understanding of the link between STRI and trade flows.

Estimation Approaches

PPML estimation

Fraser (2021) demonstrates how to estimate the effect of changes in STRIs on bilateral services trade using a PPML estimator with two-way fixed effects (equation 5).

Equation 5 - gravity specification for non-linear trade model using PPML with two-way fixed effects

$$x_{ij} = exp(\mathrm{T}_{it,j} + \pi_{i,t} + \nu_{j,t})(\epsilon_{ij,t})$$

Bilateral trade (x) is modelled multiplicatively in terms bilateral trade cost determinants (T), exporter-year fixed effects (π) and importer-year fixed effects (ν). T includes STRIs and a vector of standard gravity variables including dummies for contiguity, common language, and past colonial relationship. Full specification detailed in Annex 1.

The two-way fixed effects control for country-specific unobservable heterogeneity (MRTs), such as country-specific price indices or macroeconomic shocks. This ensures that the STRI's effect is estimated in relative and bilateral terms. This approach is widely used in the structural gravity literature (Yotov et al., 2016). The objective estimate would be retrieved from the coefficient for T, this would show the services trade (semi) elasticity representing the average percent change in trade associated with a unit change in STRI.

Caliendo and Parro (2015) Estimation

CP proposed an alternative identification strategy to using a non-linear trade model with

PPML and fixed effects. In brief, their 'three-countries' method constructs trade flow ratios between three countries to cancel out unobserved trade cost components (MRTs) algebraically. This method removes the need for fixed effects by exploiting symmetry assumptions in Eaton-Kortum (2002). In detail, the idea is to construct a trade flow ratio among three countries (n, i, h), as highlighted in equation 6 (left-hand side). The numerator shows the cross-product of trade (X) for a sector (j) in one direction between the three countries and the denominator shows the reverse. The right-hand side of equation 6 is the result of expressing each trade flow term using a gravity equation. Due to the ratio-arrangement, all parameters and terms to do with prices cancel out, ending up with an equation isolating the relationship between trade, traded-costs (κ) and trade elasticity (θ). Crucially, the advantage of using equation (6) is that unobservable trade costs cancel out. Subsequently equation 6 is used to estimate responsiveness of trade to tariffs (τ) in a linear model using an OLS estimator [equation 7].

Equation 6 - CP's three country trade flow ratio construct

$$\frac{X_{ni}^{j}X_{ih}^{j}X_{hn}^{j}}{X_{nh}^{j}X_{hi}^{j}X_{in}^{j}} = \left(\frac{\kappa_{ni}^{j}\kappa_{ih}^{j}\kappa_{hn}^{j}}{\kappa_{nh}^{j}\kappa_{hi}^{j}\kappa_{in}^{j}}\right)^{-\theta^{j}}$$

Equation 7 - CP's three country estimation strategy

$$\log\left(\frac{X_{ni}^{j}X_{ih}^{j}X_{hn}^{j}}{X_{nh}^{j}X_{hi}^{j}X_{in}^{j}}\right) = -\theta^{j}\log\left(\frac{\tau_{ni}^{j}\,\tau_{ih}^{j}\tau_{hn}^{j}}{\tau_{nh}^{j}\tau_{hi}^{j}\tau_{in}^{j})}\right) + \epsilon^{j}$$

Using STRIs as a proxy for services trade costs in CP's estimation approach

CP focused on goods trade, I adapt their methods for services trade by simply substituting their use of tariffs with STRIs [equation 8]. As it's a linear model (uses OLS), and both sides are logged, the objective estimate is the θ coefficient which is the services trade elasticity with respect to STRIs, showing the percentage change in trade associated with a 1% change in the STRI.

Equation 8 - specification for linear trade model using CP estimation approach

$$\log\left(\frac{X_{ni}^{j}X_{ih}^{j}X_{hn}^{j}}{X_{nh}^{j}X_{hi}^{j}X_{in}^{j}}\right) = -\theta^{j}\log\left(\frac{STRI_{ni}^{j}\,STRI_{ih}^{j}STRI_{hn}^{j}}{STRI_{nh}^{j}STRI_{hi}^{j}STRI_{in}^{j})}\right) + \epsilon^{j}$$

Comparison and Interpretation

Both methods treat the STRI as a proxy for services trade costs but differ in how they control for MRTs. Therefore, coefficients from either model show the change in services trade associated with a change in STRIs. This means that comparing estimates across the models enables a direct comparison between country-specific fixed effects in a nonlinear trade model (PPML) and linear trade model with which uses algebraic elimination to control for sector-specific unobservable heterogeneity (CP).

Data sources

1) Services Trade Restrictiveness Index (OECD)

The OECD's Services Trade Restrictiveness Index is used to proxy bilateral services trade costs. The STRI quantifies and indexes barriers to services trade by sector and country from a score of 0 to 1. It covers five policy areas: 1) Restrictions on Foreign Entry, 2) Restrictions to the Movement of People, 3) Other Discriminatory Measures, 4) Barriers to Competition and 5) Regulatory Transparency. This data spans from 2014-2023, covering 22 services sectors and represents over 80% of global trade in services. The STRI indicates the regulatory environment for Most Favoured Nation (MFN) and the European Economic Area (EEA). Specifically, the intra-EEA STRI covers the 24 OECD EU member countries. Both MFN and intra-EEA STRIs are used in the dissertation (OECD, 2024).

2) Trade in Value Added (OECD)

OECD's Trade in Value Added (TiVA) spans from 1995-2020, covering 76 economies and 20 services sectors plus a total services aggregate. The OECD performs validation and cross-checking to ensure TiVA's accuracy. This includes comparing TiVA with national accounts and other macroeconomic datasets. Expert review and feedback from national statistical offices help to further refine the dataset (OECD, 2023).

3) Gravity data (CEPII)

The Gravity database gathers a set of variables for estimating gravity equations. Each observation corresponds to a combination of an exporting country, an importing country and a year (i.e. "origin-destination-year"), for which CEPII provide trade flows, as well as geographic, cultural, trade facilitation and macroeconomic variables. The data spans from 1948 to 2019, and includes 252 countries (Conte, Cotterlaz & Mayer, 2023).

Data preparation

Estimating the services trade elasticity with respect to the STRI requires data across gravity, TiVA, STRI for PPML estimation but only the latter two for CP estimation, the reduced data requirements being a part of the appeal for it as an alternative modelling approach.

The detailed steps for data cleaning and preparation are available in a GitHub Repository: rmferdous/dissertation_gravity: Modelling for ECOX6007 Economics Dissertation (2024/2025).

The main challenge was setting up the three-countries method for CP-estimation. I wrote an algorithm to help take bilateral observations, attach an index to identify pairs, then use this sequence to identify all third-country observations to be able to set up the ratios set out by CP. The approaches are set out in the following script: dissertation_gravity/triangular_trade_flows_final.R at main · rmferdous/dissertation_gravity

The data could not be uploaded as the file size exceeds the limit set by GitHub, please contact me on robinferdous1@gmail.com and I can share zip files.

4. Results

CP estimation is viable for estimating services trade elasticities with respect to STRIs
In Table 1, I demonstrate that CP estimation can be used to estimate the elasticity of services trade with respect to changes in the STRI. All CP estimates are negative and statistically significant. This suggests that the CP service trade elasticities align with expectations: as services trade restrictiveness increase, trade decreases.

Table 1 – Sectoral CP estimates services trade elasticities w.r.t. STRIs

sector	estimate	std.error	p.value	bp_stat	bp_value	n
Construction	-3.84	0.28	0.000	1.74	0.187	29398
Land transport and transport via pipelines	-8.38	0.17	0.000	5.25	0.022	115157
Water transport	-6.52	0.15	0.000	0.02	0.889	62316
Air transport	-1.93	0.17	0.000	0.33	0.563	110150
Warehousing & support activities for transportation	-3.85	0.15	0.000	0.04	0.839	104900
Postal and courier activities	-4.33	0.24	0.000	19.89	0.000	53612
Publishing, audiovisual & broadcasting activities	-2.00	0.14	0.000	3.67	0.056	97020
Telecommunications	-2.11	0.21	0.000	35.46	0.000	101123
Computer programming, consultancy & information services activities	-3.58	0.17	0.000	2.29	0.130	86987
Financial & insurance activities	-2.57	0.13	0.000	0.49	0.484	105040
Professional, scientific & technical activities	-0.77	0.08	0.000	21.22	0.000	105725
Total services (incl. construction)	-3.63	0.11	0.000	19.56	0.000	117600

The issue with linear trade models: 5 CP estimates suffer from heteroscedasticity

Statistical significance of CP estimates is valid only insofar as the model does not violate key assumptions such as homoscedasticity. One of the reasons why PPML is the gold standard estimator for trade modelling is because it is non-linear and thus robust to heteroscedasticity, which linear estimators like OLS struggle with. To test for heteroskedasticity, I subjected CP estimates to the Breusch-Pagan (BP) test: if the test has a p-value < 0.05, then the null hypothesis of homoscedasticity is rejected and heteroskedasticity assumed.

Heteroscedasticity is not detected across 7/12 sector estimates (bp-test: $p > 0.05$), highlighted in green in table 1, supporting the validity of standard errors (SE) in those cases, and thus statistical significance.

However, for the remaining 5/12 estimates, heteroskedasticity is present (bp-test, $p < 0.05$). The SEs for these 5 CP estimates are biased, therefore subsequent inferential statistics are unreliable, such as inferring statistical significance using p-values. Therefore, even if the coefficient estimate appears statistically significant, that significance is false as it is an artifact of biased SEs across 5 sectors highlighted in table 1, not a reflection of a true signal.

On converting CP and PPML estimates to trade flows impacts

Estimates discussed represent partial equilibrium (ceteris paribus) effects of STRI changes on bilateral services trade. They give a sense of initial impact effects of trade costs on trade flows, to examine more comprehensive general equilibrium effects, simulation models would be required, outside the scope of this dissertation.

PPML estimates are semi-elasticities showing the percentage change in trade flows for a one-unit change (0.1) in STRI. To find the change in bilateral exports corresponding with 15% increase in restrictiveness, I apply: $100 * (\exp(\beta STRI_{PPML} * \triangle STRI) - 1)$

CP estimates are elasticities showing the percentage change in trade for 1% change STRI. To find the change in bilateral exports corresponding with 15% increase in restrictiveness, I apply: $\beta STRI_{CP} * \triangle STRI$ (%)

The change in STRI I decided to use to illustrate trade impacts was informed by the following. After leaving the Single Market, UK exporters faced an increase in services trade restrictiveness with EU partners. Market access shifted from intra-EEA (access only afforded to EU members) to something closer to most-favoured nation (MFN) status (bare-minimum market access afforded to all). I calculated the average increase in STRIs associated with the UK shifting from intra-EEA to MFN (to proxy for the UK-EU Trade Continuity Agreement). This comes down to an average increase in STRI of 0.15 across all sectors and all EU27 partners, so an approximate 15% rise in trade restrictiveness experienced by UK services exporters. I use this average increase in STRI to demonstrate interpret trade impacts as highlighted in table 2.

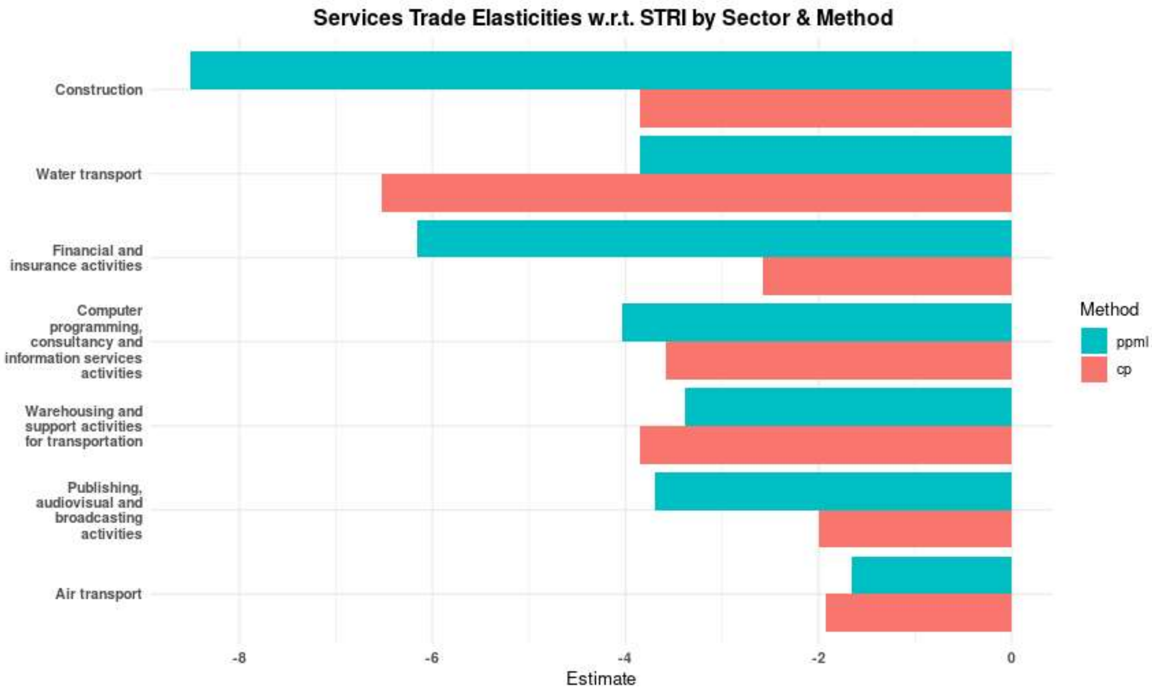
Table 2 - Comparing CP and PPML trade elasticity estimates w.r.t. STRIs

	CP			PPML				
sector	**estimate**	**SE**	**Δtrade**	**estimate**	**SE**	**Δtrade**	diff	bp
Construction	-3.844	0.28	-57.7%	-8.500	0.75	-72.1%	14%	1
Land transport and transport via pipelines	-8.378	0.17	-125.7%	-3.803	0.41	-43.5%	82%	0
Water transport	-6.520	0.15	-97.8%	-3.850	0.85	-43.9%	54%	1
Air transport	-1.932	0.17	-29.0%	-1.664	0.45	-22.1%	7%	1
Warehousing and support activities for transportation	-3.853	0.15	-57.8%	-3.379	0.53	-39.8%	18%	1
Postal and courier activities	-4.325	0.24	-64.9%	-5.526	0.65	-56.3%	9%	0
Publishing, audiovisual and broadcasting activities	-1.999	0.14	-30.0%	-3.696	0.66	-42.6%	13%	1
Telecommunications	-2.108	0.21	-31.6%	-2.758	0.61	-33.9%	2%	0
Computer programming, consultancy and information services activities	-3.575	0.17	-53.6%	-4.030	0.90	-45.4%	8%	1
Financial and insurance activities	-2.571	0.13	-38.6%	-6.155	0.86	-60.3%	22%	1
Professional, scientific and technical activities	-0.766	0.08	-11.5%	-2.344	0.49	-29.6%	18%	0
Total services (incl. construction)	-3.627	0.11	-54.4%	-3.695	0.43	-42.6%	12%	0

Sectoral differences across CP and PPML estimates

In Figure 2, I visualise the 7 homoscedastic CP estimates to PPML counterparts for comparison.

Figure 2 - Comparing CP and PPML estimated services trade elasticity w.r.t. STRIs



Sectors with consistent estimates (low divergence) include: air transport, warehousing & support activities for transportation, and computer programming, consultancy & information. For these services sectors, there is agreement across methods, suggesting a more stable relationship between STRI and trade. Given widespread acceptance of PPML estimation, convergence provides indirect evidence that CP's algebraic elimination is sufficient for controlling for unobservable trade cost components in certain sectors (e.g. multilateral resistance terms, sector-specific shocks, country-level unobserved heterogeneity). For example, in computer programming & consultancy, both methods suggest that a 15% increase in STRI reduces exports by 45–54%, pointing to a consistent, large and elastic effect of services restrictions on services trade.

Sectors with notable divergence include: construction, water transport, financial & insurance, and publishing, audiovisual & broadcasting. In these sectors, the CP and PPML estimates diverge substantially.

On one hand, some CP estimates are smaller than PPML. For example, a 15% increase in STRIs in financial services corresponds to a 39% (CP) or 60% (PPML) reduction in services exports. On the other hand, CP estimates are greater than PPML. For instance, a 15% increase in STRIs in water transport corresponds to a 44% (PPML) or 98% (CP) reduction in services exports. This two-way divergence suggests that differences are not systematic, but likely reflect sector-specific features, such as the nature of trade costs, the degree of policy heterogeneity, or the presence of nonlinearities that the linear CP estimator may miss. 'Nonlinearities' include heteroscedasticity-inducing time-varying unobservables that algebraic differencing cannot eliminate but fixed effects can absorb. In these cases, the flexible fixed effects of PPML could be doing 'more work' to control for country-year specific shocks and variation in services-trade landscape (competitiveness, consumer preferences, or regulatory environment, etc.).

Qualitative interpretation of estimate divergence

In financial services, the larger elasticity estimated via PPML may reflect the influence of high, unobserved regulatory complexity that fixed effects partially absorb. Conversely, the CP estimator, limited by differencing, may understate this effect. Similarly, in audiovisual services, where content quotas and linguistic factors act as informal trade barriers, PPML's ability to capture latent cultural frictions may explain the higher sensitivity. These results underscore that the nature of barriers, whether formal (legal) or informal (social, institutional), can shape model outcomes.

Are CP estimates more precise? Not really

All CP estimates are associated with lower standard errors, suggesting they are more statistically precise (table 2). However, this apparent precision stems from the CP method's stronger identifying assumptions and the absence of fixed effects which leads to over-attribution of variation in trade flows to the STRI variable. By contrast, the PPML framework incorporates fixed effects (representing MRTS and other country-level heterogeneity), yielding more flexible but less precise estimates.

Summary of findings and implications for model choice

Taken together, these results suggest that the CP approach can be a viable method for estimating services trade elasticities with respect to STRIs. The crucial caveat being, where heteroscedasticity is not present. Overall, where estimates converge, we can be more confident in the robustness of the STRI-trade relationship. However, divergence between CP and PPML in other sectors raises questions on what is driving differences in estimates. These differences are not just statistical; they reflect deeper differences in how each estimator treats unobserved heterogeneity and controls for MRTs. This motivates a more nuanced interpretation of service trade elasticities (w.r.t STRIs) across sectors, which I explore further in the discussion.

5. Discussion

Differences in estimates are NOT due to zero trade flows

The two models differ by 2 main aspects: functional form (linear vs non-linear) and how unobserved heterogeneity is controlled for (fixed-effects vs three-country algebraic elimination method). To identify the cause behind the divergence in estimated elasticities, I re-estimated using the PPML estimator but only using positive trade flows (PPML+), aligning the sample with that of the CP model. Recall linear models must drop zero-trade observations as zero cannot be logged, not an issue for nonlinear PPML. Across nearly all sectors, these 'PPML+' estimates remained much closer to the original PPML estimates than to the CP estimates. This suggests that the inclusion of zero trade flows and PPML's multiplicative form are not the main sources of divergence (Annex 1). Therefore, I can conclude that the treatment of unobservable trade costs (MRTs) are the drivers of divergent estimates.

Interpreting the UK-EU TCA through estimated elasticities: methodological choices matter.

This dissertation addresses a technical but policy-critical issue: how do different estimation strategies alter our interpretation of how changes in the UK's trading relationship with the EU affect services exports?

Supposing the two estimation approaches are equally viable, and estimates diverge, how we understand the impacts of trade shocks *and* our responses to them becomes substantially different. *Take the financial services sector*, where the UK is a global leader, under the UK-EU TCA as an example.

Firstly, diverging estimates affect our interpretation on how costly services restrictions are. The Department for Business and Trade uses a PPML estimator with two-way fixed effects to model services trade (Fraser, 2021; DBT, 2022). Given the average impact of the UK-EU TCA is a 15% increase in the STRI, the PPML estimate suggests a 60% reduction in financial services exports. On the other hand, the CP estimate indicates a 39% decline. Due to the 21-percentage point gap predicted impact difference, the scale of policy response required, whether in terms of market access negotiations, domestic regulatory reform, or export support, will differ substantially. In this sense, the choice of estimation method influences how we understand the magnitude of shocks.

Secondly, diverging estimates affect our understanding on plans to mitigate or remedy the impact of trade shocks. Nordas & Rouzet (2017) found that increases in services trade costs directly reduce UK productivity and estimate that halving the regulatory gap with best performers could lower trade costs by 3.5%, thereby unlocking significant trade gains. Yet, illustrated above, lowering the trade cost by a given amount can have differing impacts depending on the model used. Therefore, methodological modelling choices can shape the evidence base for UK trade policy single handedly.

To further contextualise these findings, Mourougane et al. (2021) highlight that, due to the central role of services in the UK economy, including their contribution to global value chains and their role as key inputs to manufacturing, barriers to services trade have consequences not only for trade and employment, but also for long-term productivity and economic resilience. They argue that in a post-crisis environment, maintaining open services markets is essential for recovery. As such, methodological choices in estimating the trade impact of barriers do not merely shift numbers but can meaningfully reshape the policy lens through which the UK navigates its trading relationship with the EU.

Understanding why estimates diverge: the role of fixed effects and what they represent

The CP method removes average country-sector unobservables through algebraic differencing, it does not fully absorb time-varying MRT that affect all sectors within a country differently over time. Two-way fixed effects, on the other hand, capture this latent variation by allowing exporter- and importer-year dummies. This means the PPML framework can better account for temporal shocks such as recessions, regulatory reform waves, or country-specific changes in comparative advantage, which may bias STRI estimates if not properly controlled for.

The results reveal two broad patterns:

- CP estimates < PPML estimates: this could indicate that PPML's fixed effects are capturing time-varying unobservables that CP does not fully control for, implying CP may understate trade responsiveness. Alternatively, PPML estimates might be overstated if subject to incidental parameter bias, where the inclusion of numerous fixed effects in a short panel-data results in inconsistent estimates (Fernández-Val & Weidner, 2016). Additionally, multicollinearity or endogeneity issues may arise if, for example, STRI levels are influenced by prior trade flows.
- CP estimates > PPML estimates: this could mean that CP is attributing too much trade variation to STRI due to omitted variable bias, especially where unobserved sector-specific demand or supply shocks correlate with STRI movements. Alternatively, PPML

may be over-absorbing relevant variation, especially in sectors with limited STRI variation over time, muting the estimated trade response.

From a policy perspective, this matters as PPML's more flexible design tends to yield larger (in absolute terms) semi-elasticities in sectors with complex, asymmetric, or evolving trade barriers, characteristics typical of services trade. While CP offers transparency and low data demands, the findings suggest that omitting rich fixed effects may downplay true trade sensitivities in highly heterogeneous sectors. In short, there is a trade-off: CP offers structural clarity under strong assumptions, while PPML prioritises empirical flexibility, which may be especially valuable when trade costs are proxied, as with STRIs.

Limitations and Scope: STRIs may be a poor proxy for services trade costs

The CP estimation approach was developed for goods trade using tariffs, a direct measure of trade costs. In that context, CP's three-country ratio method algebraically cancels unobserved heterogeneity and yields estimates consistent with structural gravity models (Caliendo and Parro, 2015).

In using STRIs to proxy for services trade costs, I assume that the STRI relates *linearly and stably* to services trade costs: that is, a unit change in STRIs yields a proportionate, consistent change in services trade costs. However, this simplifying assumption may not hold. Blank and Egger (2021) provide evidence of nonlinearity and heterogeneity in the relationship between STRIs and (log) services trade costs. Their analysis suggests that the impact of regulatory restrictiveness varies substantially depending on the level of restrictiveness, the nature of the regulation, and the structure of the sector in question. Crucially, they highlight the importance of fixed costs and uncertainty in services trade, factors that are not well captured by linear models or index-based proxies.

This raises questions about how faithfully STRIs capture the true cost structure faced by firms, especially where entry barriers, compliance ambiguity, or informal frictions play a larger role. If the STRI is only loosely correlated with the underlying services trade cost, this weakens the explanatory power of elasticities estimated using it, whether via PPML or CP. In this context, the PPML estimator with exporter- and importer-year fixed effects is likely better equipped to handle latent, time-varying unobservables, such as evolving institutional quality or policy shocks, than the CP approach, which relies on differencing to eliminate time-invariant country-sector effects. Yet, PPML may also risk over-absorbing meaningful variation if STRI signals are weak or collinear with fixed effects. This reinforces a key theme: when proxies like STRIs are imperfect, estimation choices must be carefully matched to the structure of the data.

Implications for modelling trade policy

These findings underscore the importance of methodological transparency and robustness checks in empirical trade modelling. Since different credible estimators yield diverging services elasticities with respect to STRIs, particularly in sectors like financial services, trade impact assessments and policy responses must be interpreted with due caution. In practice, this means using a range of models, reporting confidence intervals more transparently, and understanding the limits of each estimation approach. For policymakers, this technical nuance translates into real decisions: whether to pursue deeper negotiations, regulatory reform, or export promotion depends on the estimated magnitude of costs, and that hinges on model choice. Ultimately, analysis should complement clear thinking, not substitute for it. Models simplify reality, but the assumptions behind them, especially around estimation strategy, must be understood by decision-makers, not just technicians. Greater transparency around these technical choices can help ensure that policy is not only data-driven, but also judgment-led.

6. Conclusion

This dissertation set out to evaluate how methodological choices in gravity modelling influence our interpretation of trade shocks, with a particular focus on services trade under the UK-EU TCA. The central aim was not only to illustrate partial equilibrium trade effects of the new regulatory divergence, but also to examine the sensitivity of these effects to different estimation strategies. I adapted the structural CP model that algebraically eliminates MRTs, initially designed for goods trade and tariffs, to estimate services trade elasticities using STRIs. I contrast these estimates to the established gold-standard approach: using a PPML estimator in a nonlinear model with high-dimensional fixed effects. By contrasting two estimation approaches, this study provides empirical insights into the magnitude and implications of services trade frictions.

The findings reveal substantial divergence in the estimated elasticities of services trade depending on the estimation method used. This divergence was not primarily due the treatment of zero trade flows, but rather to the treatment of unobserved trade costs. The fixed-effects approach embedded in the PPML estimator appears more sensitive to the presence of bilateral frictions, while the CP method's reliance on theoretically inferred MRTs results in more conservative estimates. This technical distinction has important real-world consequences, particularly when such estimates are used to infer the impact of policy changes such as those introduced by the UK-EU TCA, as well as efforts to alleviate trade barriers.

This matters because services trade, and by extension services trade policy, are increasingly central to the UK economy. Services account for over 80% of the UK's economic output and employment, and a significant share of exports go to the EU. The UK's comparative advantage in sectors such as financial, professional, and IT services makes the accurate measurement of trade costs vital for policy. If two technically credible models produce different estimates, suggesting a 60% versus a 39% decline in financial services exports in response to the same regulatory shock, the scope and nature of any subsequent policy response can differ significantly. This issue is especially salient when evidence feeds directly into high-stakes policy choices, such as decisions on trade negotiation priorities, regulatory alignment strategies, or export promotion efforts.

More broadly, the research highlights how methodological modelling decisions are not merely academic exercises; they structure the evidence base upon which governments rely. The implication is that policy analysts and economists must be transparent about estimation choices and the assumptions they embed. Models are simplifications of reality, and different assumptions yield different results, not all of which are interchangeable. Therefore, using multiple estimation strategies can help construct a more robust range of potential impacts, offering policymakers a clearer sense of the uncertainty surrounding quantitative findings.

At the same time, this dissertation underlines the need for continued refinement of trade modelling techniques, especially in the context of services, where data challenges and conceptual ambiguities persist. Future work could explore improved methods of measuring services trade costs, given the instability in the link between the STRI and services trade costs. There is also room to examine how sector-specific characteristics, such as digital delivery or regulatory intensity, condition the sensitivity of trade to STRI changes.

In sum, this study contributes to a growing body of literature that emphasises the importance of rigorous and transparent methodological choices in applied trade modelling. It reaffirms that how we model trade matters, not just for economists, but for those tasked with shaping the UK's new global trading strategy. While this dissertation does not advocate for one estimation method over another, it underscores the critical importance of recognising the implications of methodological divergence, especially in a policy context as fluid and consequential as post-EU UK trade.

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Appendix

Appendix 1 – full model specification for the two-way fixed effects trade model with PPML estimator

$$x_{ij,t} = \exp(\beta_0 + \beta_1 \ln(DIST_{ij}) + \beta_2 STRI\_INTER_{ij} + \beta_3 INTER_{ij} + \sum_k \lambda_k GRAVITY_{ij} + \pi_{i,t} + \nu_{j,t})(\epsilon_{ij,t})$$

Where:

- $x_{ij,t}$ = exports
- $DIST_{ij}$ = bilateral distance
- $STRI\_INTER_{ij}$ = STRI
- $INTER_{ij}$ = dummy for international trade observations
- $GRAVITY_{ij}$ = vector of standard gravity variables including dummies for contiguity, common language, and past colonial relationship
- $\pi_{i,t}$ = exporter-year fixed effect
- $\nu_{j,t}$ = importer-year fixed effect

Appendix 2 – model outputs when re-estimating with PPML/fixed-effects but removing zero trade flows

	PPML+			
sector	**estimate**	**SE**	**p_value**	**n**
Air transport	-1.66362	0.454279	0.0003	17221
Computer programming, consultancy and information services activities	-3.99744	0.897813	0.0000	16179
Construction	-6.48929	0.779024	0.0000	12117
Financial and insurance activities	-6.15275	0.859653	0.0000	17101
Land transport and transport via pipelines	-3.80176	0.40818	0.0000	17413
Postal and courier activities	-5.39638	0.653549	0.0000	13940
Professional, scientific and technical activities	-2.34426	0.493765	0.0000	17090
Publishing, audiovisual and broadcasting activities	-3.68379	0.655627	0.0000	16715
Telecommunications	-2.75392	0.611608	0.0000	16923
Total services (incl. construction)	-3.69541	0.429872	0.0000	17500
Warehousing and support activities for transportation	-3.37374	0.534303	0.0000	17056
Water transport	-3.84127	0.848465	0.0000	12756