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Can Anything Save Britain's Trade after Brexit? Evidence from Structural Gravity

Policy Brief

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Abstract: Gravity models have been ubiquitous in debates over the impacts of the UK's decision to leave the European Union. We estimate a theory-consistent model and use it to conduct counterfactual simulations in general equilibrium. We consider a "Hard Brexit", a "Soft Brexit", then variations on a Soft Brexit where the UK signs trade agreements with (respectively) the USA, all Commonwealth members for which data are available, and the totality of non-EU countries for which data are available. In our sample of 63 exporting and importing countries that account for 93% of world GDP and 92% of world trade, and include all major trading economies, we show that even signing trade agreements with all non-EU countries would only reduce, but not eliminate, the negative trade and welfare consequences of Brexit for the UK. The short answer, then, is no: Britain's trade relations will suffer a severe negative shock from Brexit, and negotiating trade agreements with third countries can only ever reduce, not eliminate, those losses. As a trading power, the UK will be diminished.

JEL Codes: F13; F15.

Keywords: Trade; gravity model; counterfactual simulation; European Union; free trade agreements.

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1 INTRODUCTION

No serious trade economist believes that British trade will not suffer a decline following the country's decision to leave the European Union. While there is extensive debate as to the magnitude of the effect of trade agreements on bilateral trade, there is no disagreement among professionals as to sign: the gravity literature almost always shows that trade agreements boost bilateral trade. As a result, there is little doubt that leaving an agreement, particularly one as deep as the EU, will have a negative impact on Britain's trade. Recent work using structural gravity confirms this intuition: Oberhofer and Pfaffermayr (2017), for example, find that Brexit would reduce UK exports to the EU by between 7.2% and 45.7%, a decline that is only partially offset by increased trade with other countries; as a result, the UK's real income would decline by 1.4% to 5.7%. Dhingra et al. (2016) do not report trade effects, but they estimate that Brexit would reduce UK welfare by between 1.28% and 2.61% on a static basis, or 6.3% to 9.5% after dynamic factors are accounted for. These estimates are broadly in line with HM Government (2016), a widely quoted Treasury study on the effects of Brexit.

Engaging with non-EU countries is an important part of the UK government's post-Brexit trade strategy, in addition to support for the rules-based multilateral system.[1] In loose terms, the idea is that increased trade with other countries, perhaps facilitated by trade agreements, can make up for any trade losses with EU countries due to Brexit. Indeed, the Department for International Trade's 2017 Policy Paper rosily notes that "90% of global economic growth in the next 2 decades will come from outside the EU, so it is likely that a greater proportion of UK trade will continue to be with non-EU countries". As such, the Department has a brief to advance trade relations with the rest of the world, including by assessing the scope for agreements to be concluded in a short time frame with willing partners. The popular press has seized on three main possibilities for how this new engagement could work: a trade agreement with the USA; some form of enhanced trade with the Commonwealth (so called "Empire 2.0"); and unilateral free trade.

This Brief does not aim to assess the political feasibility of these options. We recall, however, that the trade policy environment in the USA is not currently conducive to a deal with the UK, or any other party. There is also little evidence of appetite for any kind of agreement with Commonwealth countries, and indeed some large members, like India, are notoriously skeptical of trade agreements. Unilateral free trade is always an option in theory, but it seems unlikely as a matter of politics given the climate of nationalism surrounding Brexit itself.

Our purpose here is to examine to what extent the UK can trade itself out of Brexit. In other words, is there some kind of trade agreement, or set of trade agreements, that could undo any trade losses due to leaving the EU?

To answer this question, we use the structural gravity model, and make use of recent results in the literature that make it possible to use the same platform for econometric estimation and counterfactual simulation. Using data for 63 countries that account for over 90% of world GDP, we show that there is, in fact, no set of trade agreements that could make up for the losses the UK will see as a result of Brexit. This result holds true even if we assume a "soft" Brexit, where the UK concludes a meaningful free trade agreement with the EU. The logic of gravity asserts itself: distance matters for bilateral trade, and the EU is the UK's closest large market. Increasing trade costs with respect to its immediate

[1] https://www.gov.uk/government/publications/preparing-for-our-future-uk-trade-policy/preparing-for-our-future-uk-trade-policy.

neighbors will have a large and persistent negative impact on UK exports even if it manages to sign trade agreements with other major economies.

The Brief proceeds as follows. Section 2 provides an intuitive discussion of the methodology and data, supplemented by a technical discussion in the Appendix. Section 3 presents results. The final section concludes, and discusses policy implications.

2 METHODOLOGY AND DATA

The gravity model is one of the most successful frameworks in empirical economics. Having initially been posited on an intuitive, basis, it now has a strong theoretical foundation (e.g., Anderson and Van Wincoop, 2003; 2004), and models that take account of that foundation are known as "structural gravity". The key insight of structural gravity is that it is relative trade costs that matter for bilateral trade: in other words, changing trade costs on one bilateral route has a ripple effect to trade flows on all bilateral routes. This is the essence of general equilibrium trade theory. It is typically allowed for by researchers at the estimation stage by including appropriate fixed effects. But in interpreting results and conducting counterfactual simulations, it is frequently ignored. In the Brexit context, the analysis by HM Treasury in fact makes that typical error: the report explicitly states that changes to the membership of a trade agreement affect only the bilateral exports of those countries, and not third countries—as trade economists, we know this to be false. Of course, more sophisticated analyses do fully take account of general equilibrium effects (e.g., Dhingra et al., 2016; and Oberhofer and Pfaffermayr, 2017).

In this Brief, we use the structural gravity framework due to Anderson et al. (2015), known as GE PPML. It combines a flexible estimating platform with a simulation framework that makes it possible to obtain unbiased estimates of key parameters, and then to use properties of the model to perform accurate counterfactual simulations that take full account of the general equilibrium properties suggested by theory. We emphasize that the outputs of this approach are not forecasts, but estimates of how the current world would look if a given policy were to change (leaving the EU), but all other factors were to be kept constant.

The main input for the model is trade data. We source data on total exports of goods and services for 63 exporting and importing countries from the OECD-WTO TiVA dataset. We stress that the data are standard trade data in gross shipments terms, not value added data. We use this data source because it has a balanced trade dataset in which exports and imports are reconciled, and covers services as well as goods. In addition, it contains data on total gross production, which makes it possible to include estimates of self-trade, i.e. goods produced and consumed within a country. Anderson et al. (2015) emphasize that inclusion of self-trade is important for ensuring consistency of the model.

Additional inputs are standard from the gravity model literature. We use Mario Larch's database of regional trade agreements (RTAs), and separately code a variable for EU membership to allow for the fact that the trade effects of the EU may differ from the trade impact of an average trade agreement. Then we control for geographical and historical factors like distance, colonial linkages, contiguity, and a common language.

To obtain an unbiased estimate of the elasticity of bilateral trade with respect to RTA and EU membership, we first run the model as a panel using data for 1995-2010 at five year intervals. We include country pair fixed effects, exporter-time fixed effects, and importer-time fixed effects. The country pair fixed effects limit the impact of simultaneity bias on the parameters of interest. Then in a second stage, we take the latest available data (2011) and re-run the model with the constraint that the EU and RTA coefficients should equal those obtained from the panel estimates, but leaving the other coefficients (geographical and historical linkages) free to vary.

Once the second stage estimates are obtained, we proceed through the following procedure, as set out in Anderson et al. (2015) to obtain full general equilibrium trade and welfare effects:

1. Solve the gravity system using the output from the regressions to provide baseline values of all indices.
2. Define a counterfactual scenario in terms of changes to the EU and RTA variables.
3. Solve the counterfactual model in conditional general equilibrium, i.e. direct and indirect changes in trade flows at constant output and expenditure.
4. Solve the counterfactual model in full general equilibrium, i.e. direct and indirect changes in trade flows with endogenous output and expenditure driven by trade-induced changes in factory-gate prices.

3 RESULTS

The Appendix shows estimation results from the panel model and the 2011 model. Both accord well with previous estimates from the gravity model literature. In particular, we find that RTA membership is associated on average with a 27.8% increase in trade, while EU membership is associated with an 87.8% increase, both before accounting for general equilibrium effects. Both parameters are well within the bounds of what is commonly seen in the literature, and are close to what is reported by HM Treasury (Table A.1).

The first scenario we consider is "Hard Brexit". Under this scenario, the UK leaves the EU and does not sign a replacement free trade agreement with the EU. In addition, it does not execute new free trade agreements to cover countries that currently have agreements with the EU. We report full general equilibrium estimates obtained from structural gravity as set out above.

The second scenario is "Soft Brexit". As in the previous scenario, the UK leaves the EU, but this time it signs a standard free trade agreement with its European partners. However, it does not execute new agreements with third countries to replace those currently in force with the EU.

For the remaining scenarios, we consider whether it is possible for the UK to improve its trade and welfare outcomes from Brexit by signing some combination of free trade agreements. The third scenario is "USA FTA", which is equivalent to Soft Brexit, but the UK signs a trade agreement with the USA. The fourth scenario is "Commonwealth FTA" (commonly known as "Empire 2.0"), which is equivalent to Soft Brexit, but the UK signs a trade agreement with all Commonwealth partners. Finally, we consider an "All FTA" scenario, which is equivalent to Soft Brexit, but the UK signs trade agreements with all non-EU partners in the sample. In stating these scenarios, we make no assumption as to their political attractiveness, or technical feasibility. We are simply examining the claim that the UK can use free trade agreements to overcome any trade and welfare losses that may result from Brexit.

Table 1 presents results. In line with the quasi-totality of analytical work on Brexit, our results show that trade losses for the UK are substantial under a Hard Brexit scenario, and an order of magnitude higher in relative terms than for the EU. Of course, there is substantial variation across EU members in terms of the size of the Brexit effect, ranging from a 4.39% loss of total exports for Ireland, to just a 0.67% loss for Estonia. Despite the large trade reallocations induced by a Hard Brexit, however, our estimated welfare effects are small: 0.11% for the EU and 0.85% for the UK. These numbers are smaller than other estimates (e.g., Dhingra et al., 2016), because they do not take account of input-output linkages among sectors, or dynamic effects. They are comparative static only.

The key insight of our paper is in the remaining columns of Table 1, where we consider alternative scenarios. Naturally, a soft Brexit results in lower trade and welfare impacts for the UK and the EU, but the trade losses are still large for the UK. The next column shows that those losses are reduced, but do not disappear, if the UK enters into a free trade agreement with the USA. Because of the higher trade costs between the UK and the USA relative to the EU, trade flows will necessarily be less intense. This finding also flows from the likelihood that any UK-USA trade deal would likely be a more "average" trade agreement, as compared with the deep integration of the EU. The next scenario, of an FTA with all Commonwealth countries, shows that without a large market like the USA, there is still the prospect of increased trade for the UK, but it does not make up for the loss even under a Soft Brexit scenario. Finally, we consider the extreme case of the UK signing a trade agreement with every non-European country in the sample. This would mean the USA, Japan, Canada, all of the BRIICS countries, and selected other countries in Latin America and Asia. Even under this highly unlikely scenario, the UK's trade is below the no-Brexit baseline, and real GDP is 0.28% lower, or about one-third as large as in the Hard Brexit scenario.

4 Conclusion and Policy Implications

We have applied a rigorous estimation and simulation framework to analyze the UK's trade policy options post-Brexit. In short, they are not good. The idea that the UK can overcome the inevitable losses from distancing itself from its closest large market by signing trade deals with smaller or more distant countries has no empirical basis. Of course, trade deals can help soften the blow of Brexit, but our results show that they can never eliminate it completely. That point is true of a deal with the United States, as it is for any other combination of trade deals permitted by our country sample. Even signing deals with all of the BRIICS countries, for example, which are large and rapidly growing emerging markets, would not make up for the losses of even a Soft Brexit, let alone a hard one.

Assuming that the UK persists with Brexit, in line with the government's pronouncements, it will be important to prepare public opinion for the inevitable: that Britain's prominence as a trading country will be substantially reduced, and that it will suffer real income losses as a result of this policy choice. The question for the British people is not whether there is anything their government can do to prevent these losses, but whether they are prepared to sustain them as the price to pay for some other, largely intangible, benefits.

A secondary point that emerges from our work is that the trade and welfare losses to the EU under Brexit are, unsurprisingly, much smaller in relative terms than those for the UK. As such, there is no particular urgency for the EU to secure a beneficial market access deal post-Brexit; it would be desirable, but it does not have the same urgency as for the UK. The irony that a policy change sold to the British public as strengthening the country's sovereignty in fact durably undercuts its negotiating power with the very bodies it sought to distance itself from should be lost on nobody.

Table 1: Simulation results, by scenario, UK and EU, percentage changes over baseline.

	Hard Brexit			Soft Brexit			USA FTA			Commonwealth FTA			All FTA		
	Exports	Imports	Real GDP	Exports	Imports	Real GDP	Exports	Imports	Real GDP	Exports	Imports	Real GDP	Exports	Imports	Real GDP
EU	-2.48	-2.58	-0.11	-1.67	-1.73	-0.08	-1.67	-1.74	-0.08	-1.68	-1.75	-0.08	-1.76	-1.84	-0.08
UK	-28.58	-26.13	-0.85	-20.03	-18.34	-0.60	-17.43	-15.85	-0.52	-17.58	-16.07	-0.53	-9.22	-8.34	-0.28

Source: Author's calculations.

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Appendix: Technical Details

Structural Gravity Model: GE PPML

Theory-consistent gravity models are well known in the trade literature. Anderson et al. (2015) develop a simple method for conducting theory-consistent policy simulations using the familiar structural gravity model derived from CES preferences across countries for national varieties differentiated by origin (the Armington assumption). The model takes the following form:

$$(1)\ X_{ij} = \left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} Y_i E_j$$

$$(2)\ P_j^{1-\sigma} = \sum_i \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma} Y_i$$

$$(3)\ \Pi_i^{1-\sigma} = \sum_j \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} E_j$$

$$(4)\ p_j = \frac{Y_j^{\frac{1}{1-\sigma}}}{\gamma_j \Pi_j}$$

Where: X is exports in value terms from country i to country j; E is expenditure in country j; Y is production in country i; t captures bilateral trade costs; sigma is the elasticity of substitution across varieties; P is inward multilateral resistance, which captures the dependence of bilateral shipments into j on trade costs across all inward routes; Π is outward multilateral resistance, which captures the dependence of bilateral shipments out of i on trade costs across all outward routes; p is the exporter's supply price of country i; and gamma is a positive distribution parameter of the CES function.

Most commonly, the model represented by (1) through (4) is estimated by fixed effects, which collapses it into the following empirical setup:

$$(5)\ X_{ij} = exp\left(T_{ij}\beta + \pi_i + \chi_j\right)e_{ij}$$

Where: T is a vector of observables capturing different elements of trade costs; π is a set of exporter fixed effects; χ is a set of importer fixed effects; and e is a standard error term.

The model has a number of salient features, which are well known, but which need restating. First, its structure makes clear that the elasticity of trade with respect to particular bilateral trade costs—such as membership of an RTA—specified within t is not an accurate summary of the impact of a change of trade costs on trade. The reason is that the multilateral resistance indices depend on trade costs across all partners, which means that the model takes account of general equilibrium effects. This point is typically recognized at the estimation stage, when fixed effects by exporter and by importer are included to account for multilateral resistance. However, when a counterfactual simulation is conducted, the effects need to be passed through the two price indices, not simply extracted from the relevant regression coefficient. This point is much less commonly appreciated in the literature.

Second, if the model is estimated by PPML with fixed effects as recommended by Santos Silva and Tenreyro (2006), then Fally (2015) shows that the estimated fixed effects correspond exactly to the terms required by the structural model. In other words, if (5) is estimated correctly, then it follows that:

$$(6)\ \widehat{\Pi_i^{1-\sigma}} = E_0 Y_i \exp(-\pi_i)$$

$$(7)\ \widehat{P_j^{1-\sigma}} = \frac{E_j}{E_0} \exp(-\pi_i)$$

Where E0 corresponds to the expenditure of the country corresponding to the omitted fixed effect (typically an importer fixed effect) in the empirical model, and the normalization of the corresponding price terms in the structural model.

Let $\hat{\beta}$ be the PPML estimates of the trade cost parameters in (5). To see the impact of a counterfactual change in trade costs, such as the elimination of an RTA between two trading partners, we can re-estimate (5) imposing $\hat{\beta}$ as a constraint and with counterfactual trade costs T_{ij}^{c}:

$$(8)\ X_{ij} = exp\left(T_{ij}^{c}\hat{\beta} + \pi_i + \chi_j\right)e_{ij}$$

Estimating (8) with PPML and the original trade data means that output and expenditure remain constant, so the PPML fixed effects adjust to take account of changes in multilateral resistance brought about by the change in bilateral trade costs. Once estimates have been obtained, counterfactual values of relevant indices can be calculated, but they are conditional on fixed output and expenditure although they take account of general equilibrium reallocations. In particular, $\widehat{X_{ij}}$ from (8) provide counterfactual values of bilateral trade that are consistent with the general equilibrium restrictions of theory, but which still sum to give observed output and expenditure, consistent with a remarkable property of the PPML estimator (Arvis and Shepherd, 2013; Fally, 2015).

It is possible to push the model further, by allowing counterfactual changes in factory-gate prices to drive changes in output and expenditure, which in turn lead to additional changes in trade flows, until the system converges. Specifically, endogenous responses in output and expenditure are as follows in an endowment economy where trade imbalance ratios $\phi_i = E_i/Y_i$ remain constant:

$$(9)\ Y_i^c = \left(\frac{p_i^c}{p_i}\right) Y_i$$

$$(10)\ E_i^c = \left(\frac{p_i^c}{p_i}\right) E_i$$

Anderson et al. (2015) propose an iterative approach to solving the system. First, use structural gravity to translate changes in output and expenditure into changes in trade flows:

$$(11)\ X_{ij}^c = \frac{\left(t_{ij}^{1-\sigma}\right)^c}{t_{ij}^{1-\sigma}} \frac{Y_i^c E_j^c}{Y_i E_j} \frac{\Pi_i^{1-\sigma} P_j^{1-\sigma}}{(\Pi_i^{1-\sigma})^c \left(P_j^{1-\sigma}\right)^c}$$

Where superscript c indicates counterfactual values obtained from constrained estimation of (8) and calculation of relevant indices. Counterfactual values of output and expenditures come from applying market clearing conditions $p_i = \left(\frac{Y_i}{Y}\right)^{1/1-\sigma} \frac{1}{\gamma_i \Pi_i}$, which makes it possible to translate changes in the fixed effects between (8) and (5) into first order changes in factor-gate prices:

$$(12)\ \frac{p_i^c}{p_i} = \frac{\exp(\widehat{\pi_i^c})}{\exp(\widehat{\pi_i})}$$

Further changes occur in a second order sense, as changes in prices lead to further changes in output and expenditure, which in turn drive changes in trade. By iterating the PPML estimation and calculation of changes until convergence, it is possible to obtain full endowment general equilibrium estimates of trade flows and relevant indices.

To summarize, Anderson et al. (2015) show that starting with the standard structural gravity model, it is possible to design a simple approach for first estimating the model's parameters, and then using the estimated parameters to perform counterfactual simulations in a way that is fully consistent with the general equilibrium implications of gravity theory. The methodology can be broken down as follows:

1. Estimate the model using PPML and fixed effects to obtain estimates of trade costs and trade elasticities for the baseline.
2. Solve the gravity system using the output from step 1 to provide baseline values of all indices.
3. Define a counterfactual scenario in terms of an observable trade cost variable.
4. Solve the counterfactual model in conditional general equilibrium, i.e. direct and indirect changes in trade flows at constant output and expenditure.
5. Solve the counterfactual model in full general equilibrium, i.e. direct and indirect changes in trade flows with endogenous output and expenditure driven by trade-induced changes in factory-gate prices.

Yotov et al. (2017) provide a detailed explanation of the above steps, as well as Stata code for implementing them in a general setting. We adopt their approach and freely adapt their code here. Concretely, we use PPML to estimate (8) on a balanced panel of 63 exporters and importers for the years 1995, 2000, 2005, and 2010. This setup allows us to introduce importer-time, exporter-time, and country-pair fixed effects to account for multilateral resistance, expenditure, output, and pair-varying trade costs. Use of panel data attenuates simultaneity bias and produces credible estimates of the impact of trade agreements on bilateral trade. Given the rigor of the fixed effects setup, we can use a very simple trade costs function with just a dummy variable for RTAs in addition to the fixed effects (suppressed for clarity, but included in all models):

$$T_{ij}\beta = \beta_0 rta_{ij}$$

The coefficient of interest is β_0, which gives the elasticity of bilateral trade flows with respect to membership of a trade agreement. Because of the pair fixed effects, our claim to identification lies on within sample variation in trade agreement membership.

Once we have isolated β_0 from the panel regression, we use data for 2011 only to conduct the counterfactual simulations. The PPML approach requires us to re-estimate the model for a single year, imposing the panel estimate of the RTA coefficient as a constraint, but letting all other parameters vary freely. We include standard gravity controls, and use the methodology described above to run the simulations.

Estimation Results

	(1)	(2)
RTA	0.246 ***	0.246
	(0.090)	
EU	0.630 ***	0.630
	(0.095)	
Log(Distance)		-0.517 ***
		(0.047)
Common Border		0.262
		(0.185)
Colony		0.275 **
		(0.120)
Common Colonizer		0.733 ***
		(0.170)
Common Language		0.379 ***
		(0.126)
International		-4.331 ***
		(0.146)
Observations	15876	3969
R2	1.000	0.999
Pair Fixed Effects	Yes	No
Exporter-Time Fixed Effects	Yes	No
Importer-Time Fixed Effects	Yes	No
Exporter Fixed Effects	No	Yes
Importer Fixed Effects	No	Yes

Source: Author's calculations. Note: Estimation is by PPML in all cases. Robust standard errors corrected for clustering by country pair appear in parentheses below coefficient estimates. Statistical significance is indicated as follows: * (10%), ** (5%), and *** (1%). Statistical significance is suppressed for RTA and EU in column 2 as they are imposed constraints based on results from column 1.

Data and Sources

Variable	Definition	Years	Source
Colony	Dummy variable equal to one for country pairs that were ever in a colonial relationship.	N/A.	CEPII
Common Border	Dummy variable equal to one for countries that share a common land border.	N/A.	CEPII.
Common Colonizer	Dummy variable equal to one for country pairs that were colonized by the same power.	N/A.	CEPII
Common Language	Dummy variable equal to one for countries that have a common official language.	N/A.	CEPII
Exports	Total merchandise exports from country i to country j in time period t.	2011.	OECD-WTO TiVA.
International	Dummy variable equal to one if country i and country j are not the same.		
Log(Distance)	Distance between country i and country j.	N/A.	CEPII.
RTA	Dummy variable equal to one for country pairs that are members of the same regional trade agreement.	1995, 2000, 2005, 2010, and 2011.	Mario Larch.