

# Defying Gravity:



A critique of estimates of the economic impact of Brexit

Graham Gudgin, Ken Coutts  
Centre for Business Research, University of Cambridge

Neil Gibson, Jordan Buchanan  
Ulster University Economic Policy Centre



---

# Defying Gravity:

## A critique of estimates of the economic impact of Brexit

Graham Gudgin, Ken Coutts  
Centre for Business Research, University of Cambridge

Neil Gibson, Jordan Buchanan  
Ulster University Economic Policy Centre



---

**Policy Exchange** is the UK's leading think tank. We are an educational charity whose mission is to develop and promote new policy ideas that will deliver better public services, a stronger society and a more dynamic economy. Registered charity no: 1096300.

Policy Exchange is committed to an evidence-based approach to policy development. We work in partnership with academics and other experts and commission major studies involving thorough empirical research of alternative policy outcomes. We believe that the policy experience of other countries offers important lessons for government in the UK. We also believe that government has much to learn from business and the voluntary sector.

### **Trustees**

Diana Berry, Candida Gertler, Greta Jones, Edward Lee, Charlotte Metcalf, Krishna Rao, Andrew Roberts, George Robinson, Robert Rosenkranz, Peter Wall.

---

# Abstract

The predictions of the Treasury, OECD and IMF for the long-term impact of Brexit remain influential. They provide an important context for the Brexit negotiations and underpin the belief of Scottish and Irish nationalists that Brexit strengthens their case for independence or Irish unity. Because these predictions have received limited scrutiny, they are examined in detail in this report.

The bases of the predictions are similar for each of the three organisations. In each case estimates are made of the impact of Brexit on trade and on foreign direct investment. This is followed by an estimate of the knock-on effect on productivity. The OECD and IMF also include an assessment of the impact of lower migration. The aggregate impact of these factors is then fed into a macro-economic model to obtain forecasts for GDP and unemployment.

Much of the final impact depends on the estimate for trade which, in each case, is assessed using a ‘gravity model’. Because gravity models are inaccessible to the general public, they are explained here in comprehensible terms. In addition the Treasury’s gravity model results are replicated and examined in detail. Our conclusion is that different versions of the model give a range of results. Most importantly the trade impacts reported by the Treasury and OECD are an average for all EU countries. We find that the specific impact for the UK is much smaller. The implication is that these official predictions of the impact of Brexit are overly pessimistic.

A technical version of this report can be obtained at [www.cbr.cam.ac.uk/publications/working-papers/2017](http://www.cbr.cam.ac.uk/publications/working-papers/2017)

## JEL Classification

C54 E24 E44 H24

**Keywords:** Brexit; Gravity Model; H M Treasury; IMF;  
Trade: macroeconomic forecasts; OECD

© Policy Exchange 2017

Published by  
Policy Exchange, 8 - 10 Great George Street, Westminster, London SW1P 3AE  
[www.policyexchange.org.uk](http://www.policyexchange.org.uk)

ISBN: 978-1-910812-30-3  
Printed by Heron Dawson and Sawyer

---

# Acknowledgements

We are grateful for insights gained in discussion with Garry Young and Patrick Schneider and of the Bank of England. Neither they nor the Bank of England are responsible for the views expressed in this paper.

---

# Contents

Abstract	2
Acknowledgements	3
Overview of the Treasury, OECD and IMF Reports on Brexit	5
Gravity Models	5
Foreign Direct Investment and Productivity	8
OECD Estimates of the Economic Impact of Brexit	9
IMF Estimates of the Economic Impact of Brexit	11
Conclusions	12
The Gravity Model in More Detail	13
The Gravity Model Approach	14
The Treasury's Gravity Model Results	18
New Gravity Model estimates of the Impact of Brexit	18
Impact of EU Membership on the UK Alone	20
Estimates based on Trade with a Subset of Countries	20
Estimates Without Fixed Effects	23
Trade Diversion	24
Service sector trade	25
Conclusion on Gravity Models	25
Annex A. Predictions of the Economic Impact of Brexit	26

---

# Overview of the Treasury, OECD and IMF Reports on Brexit

The Treasury, IMF and the OECD made important predictions about the impact of Brexit on the UK economy in reports published during the referendum campaign. Their pessimistic short-term forecasts have, thus far, been proved largely wrong, but their long-term predictions that Brexit will be economically damaging remain important and are still widely believed. The expectation was that GDP would be 2.5-9.5% lower if the UK defaulted to WTO rules on leaving the UK in 2019<sup>1</sup>. Nor did the prospect of a free-trade agreement between the UK and EU make the predicted outcome much more favourable. These predictions will colour the Brexit negotiations on both sides, and already underpin the belief of Scottish and Irish nationalists that Brexit strengthens their case for leaving the UK.

There has been only limited academic scrutiny of these long-term predictions, and the complexity of the methods used means that the general public has not been in a position to evaluate the work. We are re-examining the Treasury estimates in detail because others have not done so, and will also comment on those of the OECD and IMF. Where forecasters other than the Treasury, OECD and IMF estimated the impact of Brexit, they generally used similar methods or assumptions. The majority of professional economists supported the view that Brexit would have a negative long-term impact on the UK economy<sup>2</sup> and have not debated or re-examined the methods used by the Treasury. The Treasury described their gravity model work as ‘best-practice’ and the specialists in this area appear to have accepted this without further inquiry.

Each of these three official assessments adopts a similar approach. They firstly estimate how much extra trade in goods and services occurs between countries which are members of the EU Single Market compared with countries that are not members, and then assume that most of this extra trade will be lost on leaving the EU. Secondly, they do the same for foreign direct investment (FDI). Thirdly, they estimate by how much productivity will fall as consequence of lower trade and FDI. Fourthly, these estimates are entered into a macro-economic forecasting model to generate post-Brexit forecasts for GDP.

## Gravity Models

The assessments of the overall economic impact of Brexit made by all three organisations are largely dependent on their estimates of the putative losses of trade due to leaving the EU. The key statistical method used in all of the reports to calculate the trade losses is the so-called ‘gravity model’. Gravity models for trade are analogous to Newton’s theory of physical gravity in which the attraction of planetary bodies is directly proportional to their size and inversely proportional to their distance apart. The gravity model of trade says that the volume of trade between two countries is

<sup>1</sup> Forecasts of a reduced level of GDP in the UK by 2030 were summarised by the Institute for Fiscal Studies in May 2016<sup>1</sup> and are reproduced in annex A.

<sup>2</sup> An Ipsos-Mori poll found that 72% of economists expected a negative impact on UK economic growth over 10-20 years. An even higher proportion (88%) expected a negative impact on growth over a 5-year horizon. Paul Johnson of the Institute for Fiscal Studies said that “it no doubt reflects the level of agreement among economists about the benefits of free trade and costs of uncertainty for economic growth”. Guardian Newspaper 28th May 2016. The poll received replies from over 600 members of the Royal Economic Society and the Society of Business Economists.

directly proportional to the sizes of their economies and inversely proportional to the distance between them. Other factors such as common language and colonial history, membership of free-trade associations or currency unions, the presence of contiguous boundaries or lack of intervening countries (as with Australia and New Zealand) are also influential and can be introduced into gravity model equations.

The importance of gravity models for the Brexit debate is that they provide the most commonly used statistical means of assessing how much extra trade occurs between members of free-trade associations or monetary unions. This article focuses on the gravity model work in the Treasury report, which is the most extensive and important of the three. We also outline the similarities and differences between the three reports.

This Policy Exchange report outlines what gravity models are and describes the results of research replicating the Treasury's gravity model analysis. This includes the same range of countries as in the Treasury analysis and a similar time period, including over half a million trade observations in all<sup>3</sup>. The gravity model is then examined in detail to assess the robustness of the conclusions drawn by the Treasury, OECD and IMF.

Using the available data, the Treasury gravity model identifies how much extra trade occurs between EU members allowing for the size of their economies, their distance apart and other relevant factors<sup>4</sup>. This is done by predicting the level of trade between any trade partners on the basis of their size, distance apart, etc., and then observing whether trade between EU members is greater or less than would be predicted by the basic gravity equation. It is important to recognise that this estimate of extra trade is an average for EU economies. Nowhere does the Treasury attempt to measure the impact of EU membership specifically on UK trade. Indeed, there is relatively little within the Treasury report about trends in UK trade with the EU, and virtually no mention of the fact that the share of UK exports going to the EU has been falling quite rapidly since the Eurozone was formed in 1999.

The Treasury estimated that trade in goods with EU partners is 115% higher than it would be if the UK had not joined the EU. The estimate for the gain in services trade is smaller at 25%. This gives an average of a 78% gain for all trade with the EU compared with a situation in which the UK is completely outside the Single Market and reliant on WTO rules. Reversing this gives a smaller percentage loss (because the denominator is now larger) of 43%. The loss to all trade (EU and non-EU) due to reverting to WTO rules is estimated by the Treasury to be 24%. A negotiated free-trade agreement is little better, involving an 18% loss of trade.

The Treasury also uses its gravity model to estimate that there has been no significant diversion of trade from non-EU markets and hence that leaving the EU will involve few gains in goods trade to off-set the estimated goods losses in trade with the EU. It would be clearly wrong to say that no trade relationships were damaged by the UK joining the EU, as the case of New Zealand shows, but this issue is left for another day.

We can broadly reproduce the Treasury estimates for trade in goods, but we have not attempted to do so for services where we accept the Treasury estimate. The average increase in goods trade due to EU membership, estimated in our case from data for 1950-2015, is close to the Treasury's estimate of 115%. However, - this is an average across all 28 EU members. The UK does not fit this pattern and our estimate for the gain in UK exports to the EU is much lower.

<sup>3</sup> This article develops and improves on a working paper by the same authors published in January 2017 which used the gravity model approach but with a much smaller range of countries and a restricted time period than the vast dataset used by the Treasury<sup>3</sup>. [www.cbr.cam.ac.uk/publications/working-papers/2016A](http://www.cbr.cam.ac.uk/publications/working-papers/2016A). Technical version of this Policy Exchange report is available at [www.cbr.cam.ac.uk/publications/working-papers/2017](http://www.cbr.cam.ac.uk/publications/working-papers/2017).

<sup>4</sup> The Treasury gravity model is estimated using trade data for 120 countries extended over the period from 1948 to 2013 for goods trade alone. For services trade the period is much shorter. Many countries did not exist in the early years, and others lacked reliable trade data. Some countries have only existed since the 1990s and others have had data problems up until recent years. Hence a lot of trade data is missing at least for part of the period.

This is not, however, the end of the story. The inclusion in the Treasury gravity model of a large number of small emerging economies, often with minimal trade flows, influences the underlying gravity relationship between trade and GDP, distance etc. It thus influences the measurement of the EU effect, which is the average difference between observed trade and the trade predicted on the basis of the underlying gravity model. To remove these small trade flows, which are of little relevance to UK trade, we estimated an alternative gravity equation based on data for the 60 largest UK export partners. These 60 countries account for close to 100% of UK exports and include all 28 EU members. The result is that the measured impact of EU membership on average for all EU countries falls from 115% to 90%. More importantly, the measured effect for the UK alone falls to 23%.

The estimates of the EU effect on goods exports also tend to be lower if the analysis is undertaken for shorter and more recent periods. This is partly because there are fewer new EU members in the later periods. If we use a version of the gravity model that allows us to compare with all EU countries throughout the period<sup>5</sup> we find that the EU trade effect remains large on average across all EU members. The same version of the gravity model shows that the effect of EU membership solely on UK exports to the EU remains in the low range of 20-25% throughout the period. We know that the EU has been an export market of declining importance since the Eurozone was formed, and EU economic growth has been slower than in alternative markets. Although the impact of the EU Single Market per se may have remained static through the years, the slow growth of the Eurozone compared with non-EU markets means that the EU diminishes as market for UK exports. The declining importance of the EU for UK exports is likely to continue. A prediction by Oxford Economics is that the share of UK exports going to the EU will continue to fall. By 2030 Oxford Economics forecasts that even in the absence of Brexit the EU share of UK exports would have fallen to the level predicted by the Treasury as a result of Brexit<sup>6</sup>.

If we accept the Treasury's estimate for service sector trade, then the analysis based on the top 60 export partners would result in an estimate of the positive impact of EU membership on trade with EU members of 24%. If we were to also accept the Treasury view that the estimated trade gain will be almost fully lost after leaving the EU, then the loss would be 20% of exports to the EU, and around 8% of all (EU and non-EU) exports. If we also take into account that the Sterling exchange rate has depreciated by some 12%, and will help exports, then the overall loss to exports could be quite small. This will be especially so if the Treasury is wrong about the ability of UK exporters to seek out alternative markets to the EU. Our own estimates suggest that displacement of non-EU trade may have occurred for EU members, and hence leaving the EU may similarly result in some substitution for lost EU trade.

Alternative methods of obtaining the underlying gravity equation also generate different estimates. The Treasury themselves noted a wide range of estimates in their review of the academic literature on gravity models<sup>7</sup>. Our conclusion is that the gravity model approach lacks the degree of precision needed to make a definitive estimate of the impact of EU membership on trade. Having said this, all samples and approaches suggest a positive and relatively large average impact across EU member states in aggregate. It is most important to examine whether the impact on UK exports to the EU is similarly affected by EU membership. Our

5 In technical terms this involves a gravity model without country fixed effects. In our case we use a poisson maximum-likelihood estimator and multilateral trade resistance terms.

6 Slater A (2016) Will Brexit Speed a Seismic Shift in UK Trade Patterns? Oxford Economics Research Briefing. Global 7 Sept. 2016

7 HM Treasury Analysis. The Long-term economic impact of EU Membership and the Alternatives. April 2016 Table A.5. Cmnd 9250. It was also noted in an earlier Treasury paper that the UK trade gained much less from EU membership than other member states, but this conclusion was not mentioned in the Treasury Report published during the Referendum. This earlier paper can be found at [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/220968/foi\\_eumembership\\_trade.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220968/foi_eumembership_trade.pdf)

work suggests that the impact on the UK is substantially smaller than for the average of the other member states. Our preferred estimate based on the range of gravity model results would be that leaving the EU might reduce UK goods exports to the EU by around 20% other things being equal. However, the post-referendum depreciation in Sterling should substantially reduce this loss.

A useful study from the ESRI in Dublin has undertaken a more direct targeted study of the potential impact of WTO tariffs on UK exports to the EU<sup>8</sup>. This estimates that the imposition of WTO tariffs by the EU would reduce UK exports to the EU by 22%, and hence reduce total UK exports by 10%. The average tariff is only around 4% but 15% of UK exports to the EU would face tariffs of over 10% and some export lines, those facing very high tariffs (mainly in food products), would cease altogether.

If the UK is outside the EU's customs union there will be an additional administrative cost for border controls, but at least initially little in the way of non-tariff (regulatory) barriers. The ESRI estimate of a 10% loss in total UK exports would in practice be reduced due to the depreciation in sterling since June 2016. This depreciation would fully offset the impact of new WTO tariffs for around 90% of exported products. Most firms would be able to maintain their pre-referendum export prices within the EU despite the imposition of tariffs. Some exports of clothing and agri-food products would have to increase their prices and would thus sell less within the EU or in some cases sell nothing at all.

An assumption that most of the estimated trade gain from EU membership could be reversed when the UK leaves the EU is not, in our view, correct<sup>9</sup>. It is the imposition of tariffs and administrative costs (offset by any depreciation in sterling) that will reduce export flows. The gains due to regulatory convergence over the long period of UK membership of the EU will not be reversed, or will be reversed only in part, because UK firms are by now fully compliant with these regulations. There may of course be a regulatory drift over the post-Brexit period, but this will be a matter for UK firms and the UK authorities.

## Foreign Direct Investment and Productivity

We take less notice of the Treasury estimates of the impact of Brexit on FDI and on productivity. The Treasury again use a gravity model to assess the extent to which EU membership increases the flow of foreign direct investment between country pairs. The data covers 40 countries over the period 2000-14 and the estimate is that if the UK left the EU to rely on WTO rules, FDI would fall by 22%. Although the Treasury do not say so, the data is in the form of financial flows. It is thus dominated by financing flows for mergers and acquisitions rather than physical investment projects such as new green-field sites or extensions to existing sites. The Treasury do admit that the data is troublesome due to profit shifting for tax reasons. In fact, the data can be very difficult, with annual FDI inflows into Luxemburg in recent years averaging 320% of GDP and flows into Ireland and the Netherlands averaging 25% of GDP. Our own estimates for the UK are that under a quarter of FDI flows measured in money terms relate to new physical investment projects<sup>10</sup>. The issue then is: even if EU membership increases FDI flows in money it is difficult to assess what impact this will have on an individual economy.

The impact of new physical investment is likely to be very different from the impact of acquisitions or profit-shifting. While some firms have been attracted to

8 Lawless M and Morgenroth E L W (2016) The Product and Sector level Impact of a Hard Brexit across the EU. ESRI Working Paper 550. Dublin Nov. 2016

9 The Treasury report modified this assumption when they input the trade loss assumptions into NIESR's NIGEM macro-economic model. In this case they halve the potential impact of trade losses by 2020 for their lower scenarios to allow for a low level of non-tariff barriers, but retain the full impact for their severe scenario.

10 We have used data from FDI Intelligence, an FT subsidiary, on employment in FDI projects to estimate the money value of physical projects. The Treasury do undertake some sensitivity analysis but in our view this will not solve the problem. Fournier (2015) includes an estimate that two-thirds of FDI flows across OECD member states are via mergers and acquisitions (para21).

invest physically in the UK because of access to the wider EU, it is unclear how much of this will be lost even outside the Single Market, especially if a free-trade agreement is negotiated. Plans to reduce corporation tax to 17% by 2017, together with a competitive value for Sterling, are countervailing factors not considered by the Treasury. The Treasury estimate that Brexit will reduce FDI flows to the UK is thus not in our view reliable since we do not know how much of this relates to physical investment and because no estimate is made of the importance of countervailing factors. Some loss may occur but in our view it is likely to be small.

The knock-on effects of any loss of trade and FDI on productivity in the UK are also unclear. If the losses to trade and FDI are as small as we estimate, the productivity losses would also be concomitantly smaller. We do not regard the Treasury's evidence for links between trade and productivity as reliable since much of it is based on the opening up to trade of emerging economies and is of limited relevance to the UK. For example, in citing of Canada as an exemplar of the economic gains from joining a free-trade area (NAFTA) is not correct. While some manufacturing firms in Canada became more efficient as result of greater competition from US firms, as the Treasury report noted, per capita GDP as a whole in Canada declined sharply after joining the FTA and did not recover its position relative to the USA for 20 years.

Finally, the Treasury insert their estimates into the NiGem model of the National Institute of Economic and Social Research (NIESR) to obtain a forecast for GDP and unemployment. The resulting estimate is that GDP would be 7.5% lower in 2030 under WTO rules than if the UK had remained within the EU, and 6.2% lower with a free-trade agreement. Using our more Keynesian model, based on past trends and relationships, suggests only a minor loss to GDP by 2030 with much of this due to reduced post-Brexit migration flows. Per capita GDP is predicted to be higher by 2030 as a result of Brexit, as lower GDP is shared among a smaller population. The important factors in reaching this assessment are the lower exchange rate, and the assumption that interest rates will be lower than would otherwise have been the case. Austerity in public spending will also be tempered as a result of Brexit.

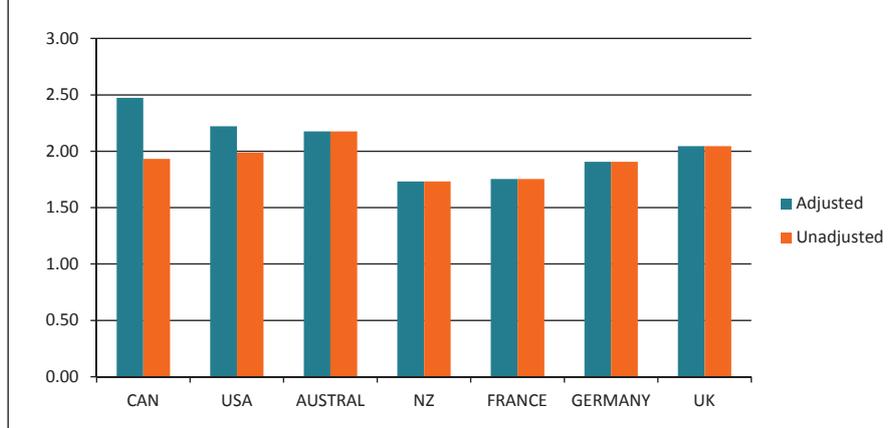
## OECD Estimates of the Economic Impact of Brexit

Like the Treasury, the OECD anticipates major negative consequences for the UK economy due to Brexit, and uses gravity models to estimate the impact on trade. The OECD foresees<sup>11</sup> 'a major negative shock to the UK economy...imposing a persistent and rising cost on the economy...by 2020 the UK economy would be 3% smaller than otherwise...by 2030 in a central scenario GDP would be 5% lower than otherwise with the cost of Brexit equivalent to £3200 per household in today's prices'.

The OECD's short-term forecast of lower growth, based on depressed confidence, has not thus far materialised. The longer-term forecast, which is a little less pessimistic than that of the Treasury, depends on a range of factors, including lower migration which the Treasury did not consider. The OECD regard EU membership as having been beneficial for the UK economy, with economic growth since joining in 1973 being faster than in other English-speaking countries. This conclusion was based on OECD data on per capita real GDP at purchasing power parity. Chart 1 below reproduces the figures but with data from the US Conference Board which includes adjustments to US and Canadian data to allow for rapidly falling IT prices. This shows UK growth to be generally a little slower than other

11 OECD. The Economic Consequences of Brexit. A Taxing Decision. Economic Policy paper no. 16 April 2016.

**Chart 1 Annual average growth in per capita Real GDP 1973-2016**



major English speaking countries, except New Zealand whose economy was significantly disadvantaged by the UK’s membership of the EU. The UK economy has outpaced major EU economies since 1973, but this is unlikely to have been due to the UK’s membership of the EU. Growth in per capita GDP did not accelerate in the UK after joining the EEC in 1973. Instead, growth slowed sharply in France, Germany and other EU6 nations. This occurred mainly because these countries had converged quickly on US productivity levels, after a long post-war catch-up, and they could not sustain their earlier rapid growth. The adoption of the Euro since 1999 has further slower growth within the Eurozone. In these circumstances, it is not possible to draw conclusions from these figures about the benefits of EU membership of the EU. More revealing is the fact that per capita GDP in the UK (measured at purchasing power parity) has remained close to 70% of the US level throughout the post-war period irrespective of being in or out of the EU<sup>12</sup>.

The OECD’s assessment of the economic impact of Brexit parallels the Treasury in starting with trade and FDI and then estimating the consequent impact on productivity. An additional factor in the OECD analysis is to take account of restrictions in migration leading, in its view, to lower investment in R&D and reduced managerial quality. Like the Treasury, the OECD uses a gravity model to calculate the impacts on trade and FDI.

The OECD estimated that ‘trade openness’ will decline by 10-20% as a result of Brexit<sup>13</sup>. This is said to be based on an OECD gravity model paper<sup>14</sup> but it is difficult to see how this paper supports these figures. The gravity model analysis covers only OECD members over a short time period of 1990-2012. The results are confusing and contradictory with some equations showing no rise in intra-EU exports as a result of EU membership. Other equations show a large increase (72%) in exports to other EU members. An average of zero and 72% would give 36% increase in exports due to EU membership. Reversing this gives a decline of  $(36/136=)$  25% for exports to the EU or 11% for total exports, so it remains unclear why the OECD report adopts a range of 10-20%. The figure of 72% seems to us to be more plausible, but this is an average across all 28 EU members and there is no attempt to examine whether this applies specifically to the UK.

12 The OECD also over-eggs the importance of the EU to UK trade in a chart with the title ‘Market Shares have been stable’ even the chart clearly shows a steady decline in the share of UK exports going to the EU27. OECD op. cit. Figure 8. The IMF does something similar in paragraph 16 of its Brexit Report (IMF Country Report 16/169 June 2016).

13 OECD (2016) op. cit. Box 4. Trade openness is measured as the ratio of exports and imports to GDP.

14 Fournier J, Doms A, Gorin Y, Guillet X, and Morchoisne (2014) Implicit Regulatory Barriers in the EU Single Market. New Empirical Evidence from Gravity Models. OECD Economics Department Working Papers no. 1181

The OECD estimates that FDI flows would fall by 10-45% if the UK left the EU and reverted to WTO rules. Once again FDI is defined to include mergers and acquisitions and hence its impact on an economy like the UK is ambiguous. The OECD estimate that reduced FDI flows would lead to reductions in R&D spending by companies and would also reduce the quality of management. The latter conclusion is based on a useful study of world management practices which concludes that between a quarter to a third of productivity differences<sup>15</sup> can be ascribed to management practices. However, this relationship is weak for developed nations and it is unclear how changes in FDI would impact on management practices in the UK.

The OECD converts these predicted impacts into a forecast for productivity. As with the Treasury analysis, the forecast depends on the magnitude of the gravity model-based estimates for trade and FDI. Productivity is finally multiplied by population (and hence employment) forecasts to obtain GDP, with population assumed to be lower due to an 86,000 reduction in annual migration. GDP is forecast to be 5% lower by 2030. Since UK population is also assumed to be lower due to reduced migration, per capita GDP declines by less and is calculated to be 3% lower than it otherwise would have been by 2030<sup>16</sup>. We conclude that this relatively small reduction in per capita GDP is based on uncertain analyses. It is not sensible, in our view, to place much weight on the conclusion and certainly not on its precision. Once again uncertainty surrounding the gravity model analysis lies at the heart of this scepticism.

## IMF Estimates of the Economic Impact of Brexit

The IMF published its Brexit report in June 2016 shortly before the referendum<sup>17</sup>. The logic of the report was similar to that of the OECD, with sections on trade, FDI, productivity and migration. Most of the report consisted of a selective literature review. The IMF had much less of its own research to use than the OECD, but unsurprisingly had more to say on the financial sector.

The main contribution of its own research to the IMF report was a gravity model. Unlike any other Brexit report, the IMF pointed out that the impacts of EU membership on trade measured by most gravity models were averages across all EU member states. In an attempt to isolate the impact on the UK alone, the IMF conducted a gravity analysis with data confined to UK trade partners, over the short time-period of 2004-14.<sup>18</sup> In this case the measured impact of EU membership is simply the average difference between UK exports to EU members compared with UK exports to non-EU countries, after allowing for the size and distance away of partner economies. The IMF estimates are that EU membership raises exports by 103% and services by 84%.

We have replicated this analysis with our IMF trade data for goods (the IMF paradoxically use UK data from ONS) and get lower estimates for the impact of EU membership. Depending on the exact approach used, we estimate an impact of either 36% or 70%<sup>19</sup>. The methods used by the IMF are not directly comparable with the Treasury and the comparison with our own analysis suggests that a wide range of estimates are possible depending on data sources and on the precise methods used. However, as expected, all of the estimates show a significantly positive impact of EU membership on trade.

The IMF also estimate that higher levels of trade lead to higher levels of FDI. An increase in of 1% in the ratio of trade to GDP, in their view, leads to a small increase in the stock of FDI (2% of GDP). While it is plausible that increasing

15 After allowing for differences in capital endowments

16 This reduces the growth rate for per capita GDP by 0.2% per annum over the period 2016-30.

17 IMF (2016) United Kingdom. Selected Issues. IMF Country Report no.16/169

18 The shortness of the period made it more appropriate to use an analysis without fixed effects (see next chapter).

19 In technical terms the 70% estimates was derived from a least squares gravity equation with time fixed effects estimated over the period 1995-2015. The 36% estimate was derived from a pseudo-poisson analysis with multi-lateral resistance terms fitted over the period 2004-14 and with the home GDP term constrained to equal unity.

trade with the EU may have led to rise in FDI from the EU in the early years of UK membership it is less plausible that it has done so subsequently. Since the ratio of UK trade with the EU to UK GDP has been broadly flat for two decades, the level of EU-owned investment due to trade can also be expected to have been flat. Again, the measure of FDI is financial, and only a minority of this is in the form of physical investment.

The IMF's conclusion on Brexit was that *'increased uncertainty and risk-aversion in the short to medium term would result in a material hit to incomes. The net long-run economic effects of leaving would also likely be negative and substantial, though there is significant uncertainty about the precise magnitude. Reduced trade access would likely lead to lower output and investment. . . . . The direct effects would be felt in loss of income from reduced trade access, extending to potential productivity losses, and would be magnified if exit from the EU were accompanied by restrictions on migration'*

The IMF was rather more tentative in its conclusions than the Treasury but clearly expected a negative outcome on both GDP and per capita GDP.

## Conclusions

Our conclusion is that the Treasury estimates of the impact of Brexit are just one set among a range of potential alternative estimates depending on which samples of countries or time periods are used and which statistical approaches. Most of these alternative approaches generate smaller estimates than those of the Treasury, OECD or IMF. There is an important issue about whether the Treasury estimates relating to the average benefit to trade due to EU memberships applies to the UK where the EU has been declining in importance as a market for UK exports. Our alternative versions of the gravity model lead us to expect that the impact of Brexit on GDP, although negative, will be small. In addition, if migration is substantially lower, the impact on per capita GDP could actually be higher by 2030.

A small economic impact of Brexit is in line with our intuition that the small average external tariff of the EU, together with the fact that most UK firms are already compliant with EU regulations, will mean that the impact will be limited. This is not to say that Brexit will not be disruptive. New border controls will be in place with a need for more paperwork and with potential delays to trade. Nor is it to suggest that lower migration will not pose serious problems for particular sectors in which low-wage migrant labour is an important part of the business model. These issues were not, however, part of the Treasury's core argument and have not been dealt with here.

---

# The Gravity Model in More Detail

The Treasury approach to estimating the impact of Brexit on the UK economy involved four stages:

- estimation of the impact of EU membership for UK trade in goods, and separately for services, with the assumption that these gains could be largely reversed on leaving the UK
- estimation of the impact of EU membership on financial flows of Foreign Direct Investment (FDI) into the UK
- calculation of loss of productivity due to losses of trade and FDI
- generation of estimates of the impact of EU membership on future GDP, incomes and unemployment

The Treasury's estimates of these impacts are summarised in the Box below.

## Summary of Treasury Estimates of 2030 Impacts of Brexit with WTO Rules

### Trade

- 76% gain in trade with EU due to membership of EU assumed to be largely reversible, giving a loss of trade with EU of 43%.
- No trade diversion i.e. no gain of trade with 3rd parties after leaving the EU
- Giving a **total loss of trade (to EU and non-EU destinations) of 24%**

### FDI

- **Loss of 22% of FDI** (measured in money)

### Productivity

- Productivity (per capita GDP) impact due to loss of trade at 25% of trade loss.
- Extra small productivity loss of 4% of FDI loss

### GDP

- **Overall loss of GDP is 7.5% after 15 years** for reversion to WTO rules

A large part of the overall economic impact of Brexit comes from the loss of productivity, and much of this stems from the loss of openness to trade. Hence, we focus on the Treasury's measurement of the trade impact and in particular, on the gravity model methodology used to make this measurement. This is a highly technical matter, and the aim here is to de-mystify the approach by giving as full an account as possible but without mathematics or technical terms.

## The Gravity Model Approach

The most common approach to estimating the impact of free trade areas, customs unions or monetary unions, over the last decade, has been “gravity” modelling. The Treasury report describes this as ‘best practice and uses this approach to derive its own estimate of the UK gain in trade in goods and services from membership of the EU. The topic is complex and few professional economists understand it, or had even heard of it before it came to the fore in the Brexit debate.

The basic gravity model equation of the type used by the Treasury is:

$$\text{Trade} = \text{GDP times POP divided by DIST..... (1)}^{20}$$

Where:

**Trade** is the volume of trade in current prices between a pair of countries<sup>21</sup>

**GDP** is the product of the GDPs of the two countries adjusted for inflation

**POP** is the product of the populations of the two countries

**DIST** is the distance between the two countries

The Treasury adds population to the simplest gravity model in order to take account of differences between countries in productivity and general affluence<sup>22</sup>. A range of other influences can be added including membership of free-trade areas or monetary unions, common languages or history, contiguous borders etc.

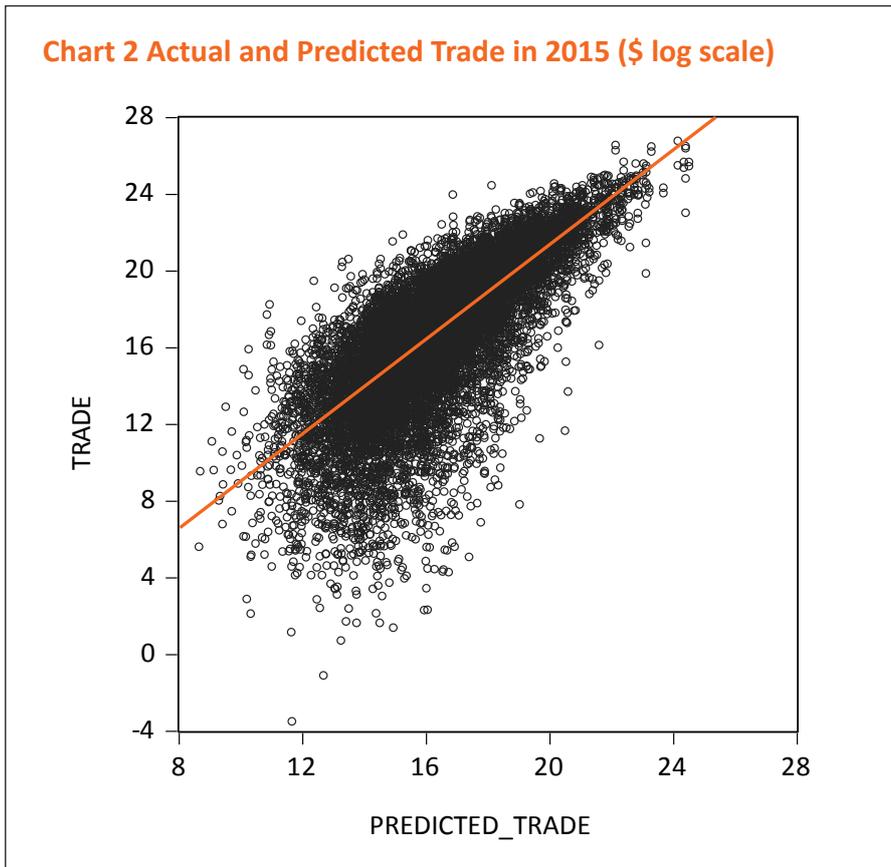
To use the gravity equation it is necessary to estimate the precise relationship between trade and the influences on the right hand side of equation 1. This is done by examining data over a number of countries and over a period of time. Generally, the number of countries is very large. The Treasury used around 115 countries and 65 years covering virtually the entire post-war period from 1948 to 2013. In equation 1, above each of the three variables on the right hand side are implicitly multiplied by one, but this might not be precisely what the data tells us. Each of the three variables may be increased by a number different from one, although in practice these numbers are usually close to one. This indicates that the amount of trade rises in close to direct proportion to GDP and close to inversely with the distance apart of the pair of countries<sup>23</sup>.

20 In practice the right hand side has also to be multiplied by a scaling constant since each of the variables is measured in different units.

21 The trade data used by the Treasury and in our own work is from the IMF in current prices. Some allowance needs to be made for inflation in prices in order to measure the *volume* of trade. This is done by the Treasury and by ourselves through including a time variable in the equation. This allows for the effect of inflation and for other factors such as global recessions and changes in global tariff levels. Some studies deflate the trade data directly using the US consumer price index but this is less satisfactory.

22 In the equation an estimate of the impact of population is obtained along with the level of GDP and hence measures the impact of per capita GDP on top of the influence of GDP per se.

23 In practice the three variables are raised to powers rather than multiplied by numbers. This allows equation to be expressed in logarithms with the three variables added together rather than multiplied. This logged form is convenient for estimating the coefficients on each of the right-hand side or ‘independent’ variables in a so-called ‘regression’ equation.



The situation may be appreciated more easily from chart 2 which shows the data for 2015 from nearly 13,000 pairs of countries for illustrative purposes. The chart includes the exports of approximately 115 countries with each of the other 114 countries<sup>24</sup>. The 'predicted trade' on the horizontal axis is the right hand side of equation 1, i.e. it is calculated as the product of the GDP of each of the trade partners divided by their distance apart<sup>25</sup>. The best-fit line shown in chart 1 indicates that the amount of trade increases on average directly with GDP and inversely with distance in a ratio of close to one for one. This applies only to the average, however, and it is obvious from chart 2 that there is a lot of variation around the line. Some country pairs above the line are doing more trade with each other than predicted from their GDP and the geographical distance between them, and others less. It is also apparent that there is more variability in trade for small countries with low GDP<sup>26</sup>.

This variability about the line is caused by a wide range of factors. For instance, countries within free-trade associations or currency unions tend to do more trade with each other than would be predicted by a simple gravity equation. Similarly, a common language or linked colonial history, or a common border all tend to lead to more trade than predicted. Intervening voids such as between Australia and New Zealand also lead to more trade than one would expect given the distances involved, and more trade than for countries at similar distances apart which have intervening countries providing opportunities to trade.

Chart 2 shows the data only for 2015. A similar chart can be drawn for every other year and the Treasury data stretched from 1948 to 2013. This generates a

24 The figure is approximate because some trade data is missing from some countries.

25 In this chart we are assuming that the coefficients on GDP and distance are exactly unity, but more realistic assumptions make little difference to the chart.

26 In principle the variability could also come from distance but in practice it comes mainly from GDP.

vast amount of data. The trade for 115 countries with each of the other 114 for 65 years would for instance involve 850,000 observations. In practice, the number is nearer half a million because some countries did not exist in the early part of the period or did not provide trade data for any or all of their trade partners.

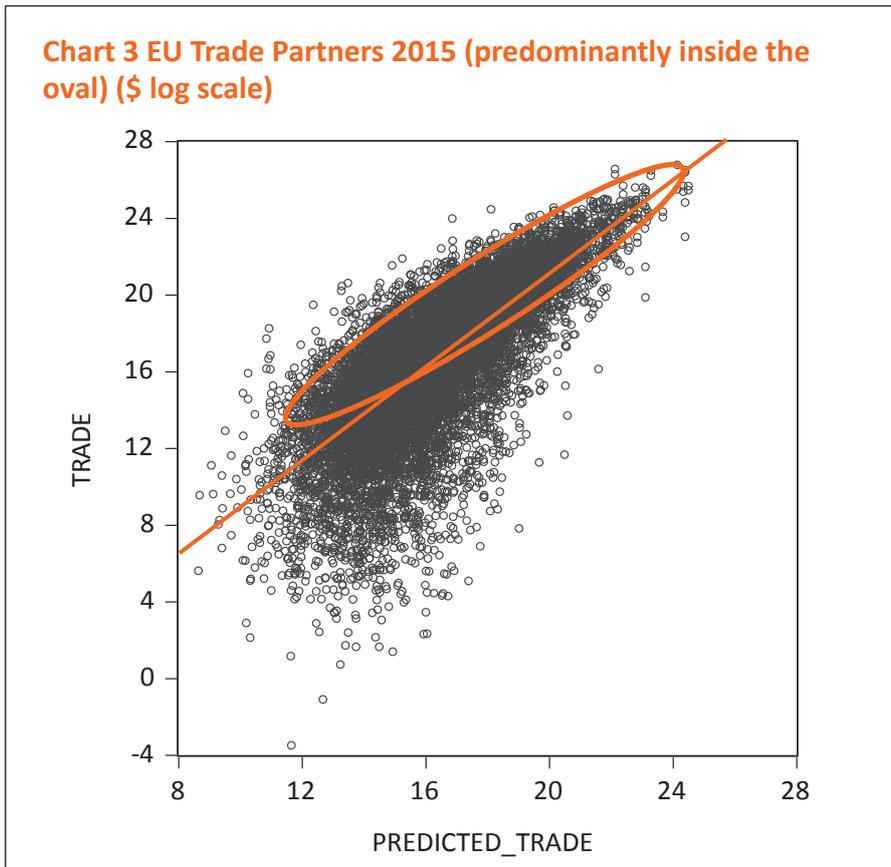
Interest centres on whether the volume of trade between members of the EU is greater than between non-members, after allowing for GDP, distance etc. In other words, the question is being asked ‘does the EU promote trade between its members *all other things being equal*’. The role of the gravity equation is to hold all other things equal. It is equivalent to experiments in science, agriculture or social science in which impacts of ‘treatments’ are measured in controlled experiments. The impact of a reading scheme in schools might, for instance, be measured by dividing a class of children into two groups and introducing a new reading scheme to only one of the groups. The impact of the scheme upon reading attainment can be observed in a ‘before and after’ contrast among pupils in the group selected to join the new scheme. Alternatively, the impact can be measured as the difference between the two groups, after the scheme is introduced. Best of all is to combine the two approaches in a so-called ‘difference in difference’ approach. This allows for changes in attainment within the selected group but also allows for the fact that other changes are going on, including the aging of the children. These other factors affect the non-selected group also, which is why they remain relevant as a control group<sup>27</sup>.

Because it is difficult to observe controlled experiments with trade data, some other way has to be found to measure the impact of ‘treatments’ such as EU membership. This can be achieved by introducing a variable into the gravity equation which identifies the EU members. This is done by adding a variable that takes the value ‘1’ when both trade partners are members of the EU and ‘0’ when they are not. Such binary variables are usually referred to as ‘dummy variables’.

A gravity equation with a dummy variable for EU membership will generate an estimate of the additional volume of trade between EU members over and above that predicted for non-EU members, allowing for GDP, distance, etc. Chart 3 shows the location of EU trade-pairs, and as can be seen these are mostly above the average line for all countries’ trade. The average distance above the line of these EU trade-pairs provides a simple measure of the impact of EU membership on trade between EU members. In practice, it is also necessary to allow for the influence of other factors which affect the level of trade in addition to GDP and distance as we noted above. Just as it was necessary to allow for differences in attainment levels between pupils in the education example, it is necessary to allow for as many of the influences on trade as possible. One approach is to add more dummy variables to capture the influence of common languages, currencies, borders colonial history as well as membership of FTA areas.

---

<sup>27</sup> We are grateful to Patrick Schneider of the Bank of England for this analogy.



'Best practice' in gravity model work holds that this is not enough. Instead it necessary to calculate a constant for each pair of trading countries to measure the average impact of all of the influences on trade which are fixed over time. These 'fixed effects' would include such things as distance and common language but will also include other things whether directly observable or not. This is done through calculating an average difference between actual trade and that predicted by a basic gravity equation with only time-varying factors such as GDP or population as explanatory variables. These 'fixed effects' are an average over time, i.e. usually over the whole post-war period. They measure the impact of all factors which are constant over time, including distance, common language, contiguous borders etc., but also a whole host of unidentified factors. Adding fixed effects means that the single scaling constant in equation 1 above is replaced by a large set of constants, one for each pair of trade partners.

The inclusion of fixed effects also helps with determining a direction of causation. It is possible that countries form a free-trade area like the EU not only in order to trade more among themselves, but also because they already trade a lot among themselves. The fixed effects will pick up the level of trade before the FTA is formed and can be taken into account in assessing the impact of the FTA per se. This helps to avoid what might otherwise be an overestimation of the impact of an FTA like the EU.

This 'best practice' approach tends to give different results from an approach in which these constant factors are included individually. As a result, different approaches result in differing estimates of the advantage of EU membership to

the UK. This is an important issue for policy-makers. If there is no consensus on the size of the EU membership effect, then it is difficult to predict the impact of a policy such as leaving the EU and reverting to WTO rules.

### The Treasury’s Gravity Model Results

The Treasury’s gravity model work estimates that EU membership increases goods trade between its members by 115% and services trade by 24% giving an average for both goods and services of 76%<sup>28</sup>. The Treasury report assumes that these benefits to trade from EU membership could be largely lost when the UK leaves the EU. A fully symmetric loss of the 76% gain would imply a loss of  $(76/176=)$  43% trade in goods and services with the EU. This translates into a loss of total (i.e. EU and non-EU) trade of 24%.

The Treasury estimates are not notably out of line with recent academic estimates of the impact of trade of EU membership. These are all based on a similar gravity model approach. The Treasury table A5, reproduced below, shows a selection of estimates from major studies. While the Treasury’s estimate that EU membership increases trade by 76% is within the range of estimates, it is striking that the range is wide. However, all of the estimates are positive and the lowest in this list suggests an increase of 31%. A more recent study by Glick (2016) interestingly estimates separate impact for old (pre-2000) and new (post-2000) EU members<sup>29</sup>. Glick estimated a 68% increase in trade for older members to almost 300% for new (largely post-Soviet Eastern European) members.

**Table A.5: External and HM Treasury estimate of EU and FTA membership effects**

	EU membership effect	FTA membership effect
HM Treasury	68% / 76% / 85%	14% / 17% / 21%
OECD (2015)	60%	N/A
Baier, Bergstrand et al (2008)	92%	58%
Hufbauer and Schott (2007)	31%	27%
Carrere (2006)	104%	N/A
Eicher and Henn (2011)	37%	Insignificant
Eicher et al (2012)	51%	N/A

*\*The range of impacts for the HM Treasury results is based on using a +/- 1 standard error range*

28 H. M. Government (2016) H. M. Treasury Analysis: the Long-term Economic Impact of EU Membership and the Alternatives, April 2016. Cmnd. 9250. Table A4

29 Glick R (2016) Currency Unions and Regional Trade Agreements. EMU and EU Effects on Trade. Federal Reserve Bank of San Francisco. Working Paper 2016-27.

30 Like the Treasury, our trade data comes from the IMF’s Direction of Trade (DoT) statistics on trade in goods, with data on real GDP (at purchasing power parity) and population taken from the Conference Board.

31 These are country and time fixed effects. We also use an alternative approach with fixed effects for comparison. One slight difference is the Treasury equations are fitted from 1948-2013, where-as ours are from 1950-2015. This should have little impact on the results. We also add equations without country fixed effects for comparison.

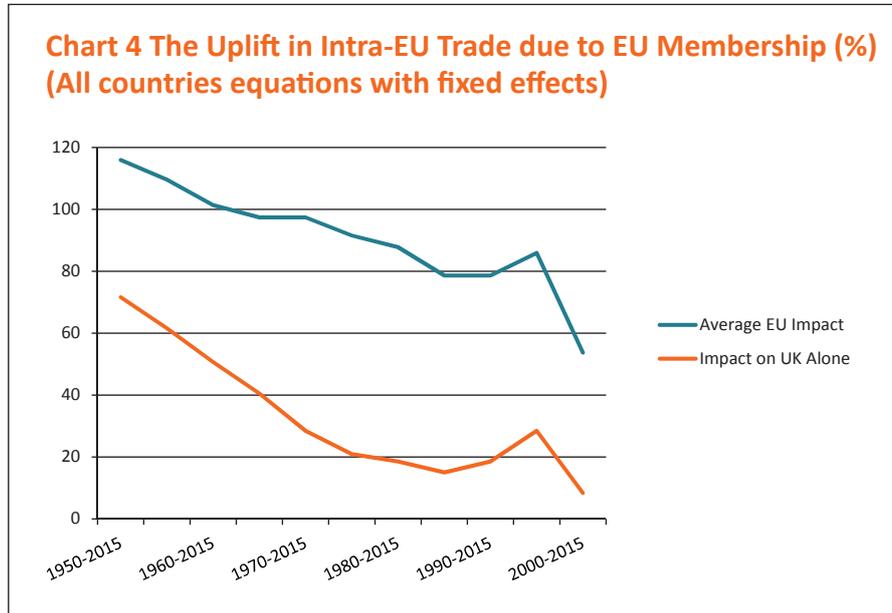
### New Gravity Model estimates of the Impact of Brexit

Because the Treasury’s estimates of the impact of Brexit seem high, and the methods used are opaque to most policy makers and to the general public, we have constructed a database and attempted to replicate the gravity model analyses of the Treasury, OECD and IMF for trade in goods<sup>30</sup>. Our initial gravity model equations take the same form as those in the Treasury report, including the use of fixed effects<sup>31</sup>. Importantly, we are able to closely reproduce the Treasury estimate of an uplift of 115% on trade between EU members relative to what is predicted by an underlying gravity equation. The measure of trade used by the Treasury

was an average of exports and imports, whereas our measure was exports. This might make a small difference to results but is unlikely to be substantial. More importantly, we notice that this equation tends to over-predict the level of UK exports to EU countries, which the Treasury report did not comment upon. We return to this important issue below.

We have also estimated gravity model equations for more recent periods than the long 1948-2013 period in the Treasury report. The Treasury's full-period equation for 1948-2013 estimates the average gain to intra-EU trade among all EU members since the foundation of the EU in 1958. Shorter periods capture the impact on trade for those countries which join the EU during the period. The full post-war period is long and it may be that the advantage of EU membership has changed over time. One obvious reason is that international tariff barriers have declined over time. The various multilateral trade agreements under the General Agreement on Trade and Tariffs (GATT) and the World Trade Organisation (WTO) have reduced international tariffs and non-tariff barriers. The difference in tariff barriers between the EU and the rest of world is now smaller than it was in the 1950s and 1960s. Gravity models may allow for this change over time, along with average global price inflation, and factors such as world recessions, but this is unclear.

Gravity model estimates of the average trade advantage due to EU membership (the 'EU effect') diminish over time, as shown in the upper line in chart 4. The implication is the EU effect is lower for those EU members which joined the EU later in the post-war period. For instance, the impact measured in the 1995-2015



period includes only the uplift in trade for the Eastern European countries, Malta and Cyprus which joined the EU in 2004, plus Romania and Bulgaria (2007) and Croatia (2007)<sup>32</sup>. There is some rise in the measured impact in the 1995-2015 period which may reflect the influence of the setting-up of the Single Market under the Maastricht Treaty of 1992. The sharp fall in the following periods is unexpected since the impact on Eastern European trade is likely to be large, and is estimated as large by Reuven Glick of the Federal Reserve Board of San Francisco<sup>33</sup>. One factor may be the role of the Euro in slowing economic growth and hence demand for imports within and outside the Eurozone, but it not obvious to us that a gravity model is able to identify growth effects like this.

### Impact of EU Membership on the UK Alone

As the IMF point out for gravity models<sup>34</sup>: ‘the estimated coefficients are therefore in a broad sense, averages across all EU economies’. This raises the question of whether they can be assumed to apply to the UK’. The IMF test this issue by an estimated a gravity model without country fixed effects for UK trade data alone for the short period 2004-2014. They calculate that EU membership doubled UK goods trade with EU partners and hence confirm the Treasury’s estimate. However, the IMF equation has the disadvantage that without country fixed effects it is not directly comparable with the Treasury’s equation or with many other estimates.

We have approached the issue of a UK-specific impact of EU membership in a different way which allows us to maintain comparability by continuing to use a fixed-effects approach. Instead of a UK-only data set, we maintain the full dataset of 120 countries and estimate the average impact on trade for all 28 EU members in the same way as above. The degree of under-prediction for the UK alone is measured by including a new dummy variable which measures the average deviation of actual UK exports from that predicted by the equation. This variable indicates that UK exports to EU countries are around 30% lower than the average level of intra-EU exports for all EU members.

To calculate the impact of EU membership specifically on the UK we subtract this value from the calculated average value for EU membership across all EU members. The resulting values are shown in the ‘impact on UK alone’ in chart 4. The impact on UK goods exports obtained from an equation estimated over the whole period, 1950-2015 is 70% rather than the 115% in the Treasury report. Once again this estimate is smaller in equations estimated over shorter, more recent, periods, and declines to around 10% in equations fitted from 2000-2015.

### Estimates based on Trade with a Subset of Countries

In a gravity equation estimated with data on the trade of 120 countries with each other (around 14,000 trade-pairs), over a 65 year period, a significant number of the trade flows are miniscule. Each trade observation counts as one data point whether it be trade between Azerbaijan and Angola, or between the USA and China. This can be seen for 2015 on Chart 2 above where there is a scatter of very low trade observations in the lower left quadrant of the chart. This is even more obvious if we were to include all observations since 1950. The inclusion of these countries affects the underlying gravity equation, and hence also the EU impact measure which is just an average deviation from the underlying relationship.

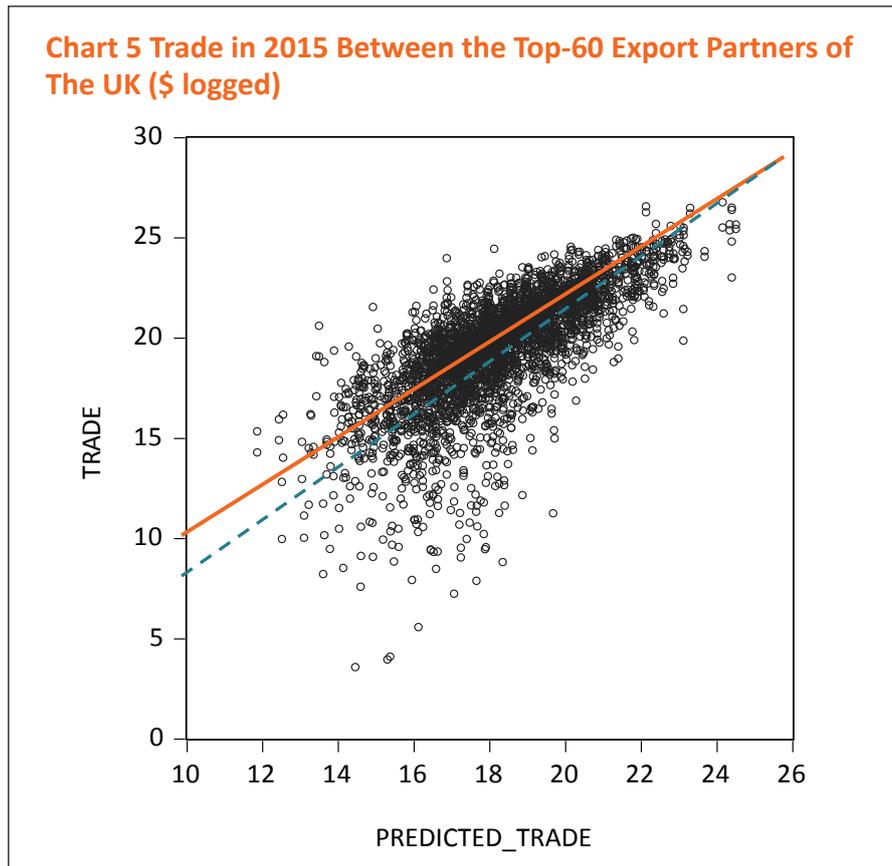
To avoid the influence of countries with small trade flows of little relevance to the UK, we have repeated the analysis restricting the data to only the UK’s top 60 export

32 Because there are fewer observations in each successive time period, the statistical precision with which the EU effect is measured tends decline over time. However each of the values on chart 3 is statistically significantly different both from zero and also from the value estimated for the 1950-2015 period.

33 Glick R (2016) Op Cit.

34 IMF United Kingdom: Selected Issues June 1st.2016. Box 1 p39.

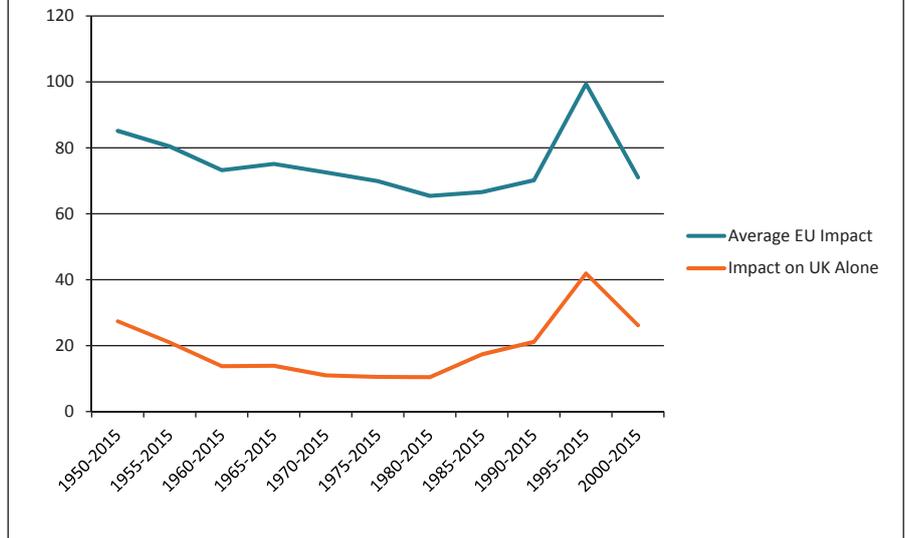
markets (illustrated in chart 5). This accounts for close to 100% of all UK exports and includes all 28 EU member states. There are 3500 trade-pairs in this dataset compared with 13,100 in the full dataset, but this is the set of countries of most relevance to the UK's trade. The solid red line on chart 5 is the best-fit line through this data. For comparison, we have also included a dashed blue line which represents the best-fit line through all of the data for the full 120 countries. The dashed line starts from a lower level and rises more steeply than the solid line because there are fewer small-trade outliers than in the full sample. This reduces the estimate for the impact of EU membership.



If we were to also remove all of the cases on Chart 5 with annual trade of less than one million dollars, the new best-fit line would start at an even higher point and then rise even more slowly. This would further reduce the average deviation of the intra-EU trade from the best-fit line and hence reduce the estimate of the impact of EU membership.

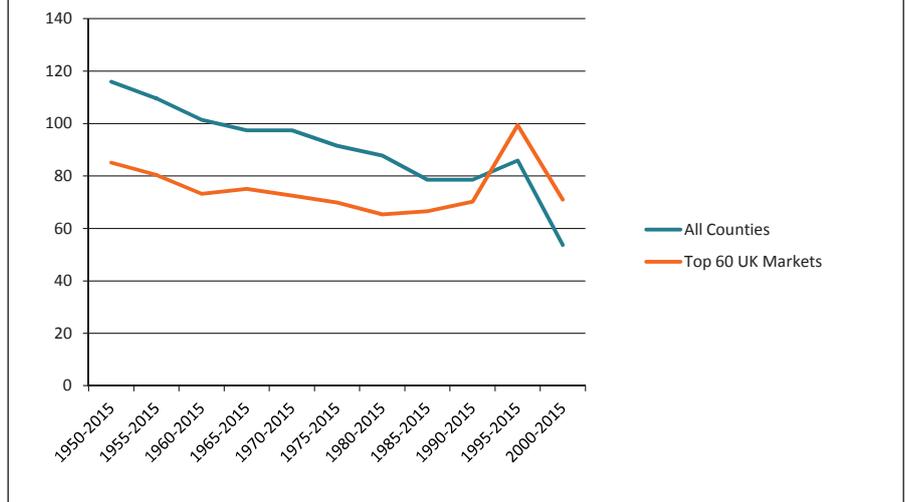
The average impact of EU membership on intra-EU trade, estimated from this 'Top 60' sample, is shown in chart 6. A comparison of chart 6 with chart 4 shows that the average EU impact is a little lower than obtained using the full sample of countries, at around 80-90% for the longest time period. The impact for the UK alone is much smaller over the whole period than when measured with the full set of countries. Equations estimated over periods since 1970, or more recent periods, however, result in an estimate for the UK alone generally in a range of 10-30%. This is not dissimilar from the range obtained using the full 120-country dataset shown in chart 4 above.

**Chart 6 The Percentage Uplift in Intra-EU Trade due to EU Membership estimated from the Top 60 markets for UK exports**



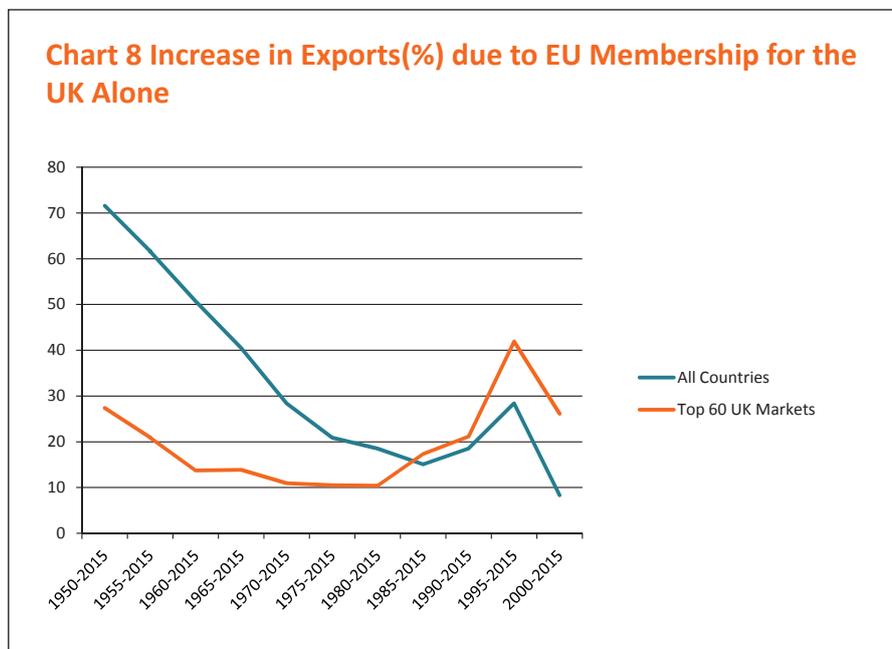
The average impact on the EU28 countries is shown for both dataset subsets in Chart 7. Estimates based on the full set of countries generate the highest estimates of the impact of EU membership.

**Chart 7 Average Percentage Increase in Trade due to EU Membership.**



Estimates based on the Top 60 UK trade partners are 20% smaller at the start of the period, but are more constant over the different time periods. They also show the largest increase in impact after the Single Market is formed in 1992, followed by a sharp decline.

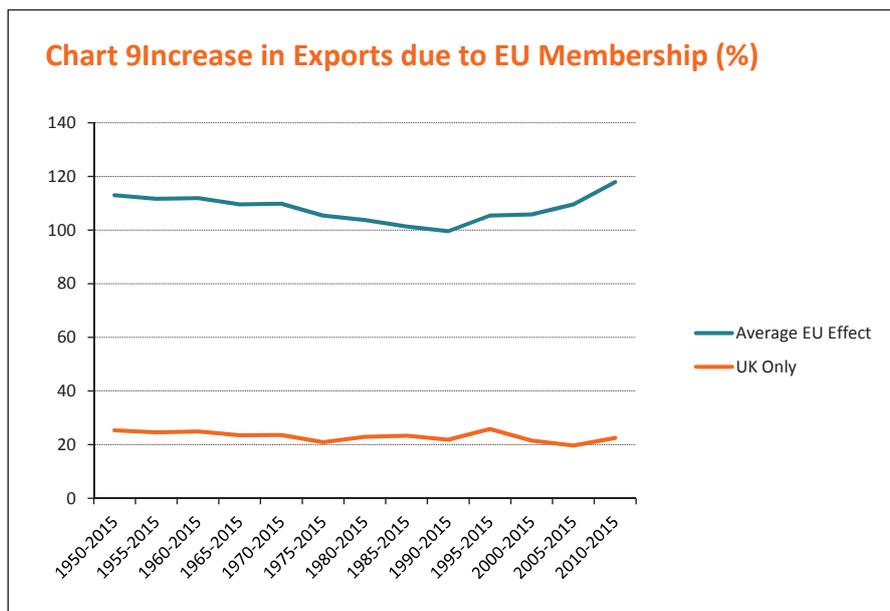
The range of estimates for the UK alone, are shown in chart 8 for both the full set of countries and for the Top 60 dataset. Since the Top 60 dataset is most relevant to the UK and includes a wider range of trade between non-UK countries than the smaller samples, we give this more prominence. These ‘Top 60’ estimates are also the most consistent over time, and again show the largest increase after the Single Market is formed. The uplift from EU membership for UK exports varies between 10-40% and averages around 20%. This is much lower than the estimated impact on exports for all EU members. A full reversal of this level of EU impact would give a reduction in exports of 16% (i.e. 20/120) and a range of 9-29%. This is lower than the estimated impact on exports for all EU members, and much lower than the Treasury estimate of a 115% uplift.



### Estimates Without Fixed Effects

As a final demonstration of the variability of estimates of trade impacts obtained using gravity models, we examine gravity equations without fixed effects<sup>35</sup>. In this case the fixed effects for individual countries are replaced by a range of dummy variables for distance, contiguity of borders, common languages, membership of free-trade areas and separately for membership of the EU. This approach is commonly used to deal with the problem of low trade volumes among small economies and the presence of large numbers of zero entries for trade.

<sup>35</sup> These equations follow accepted best practice in estimating these equations with pseudo-poisson estimators and including variables for multi-lateral resistance.



Note: these results were generated from gravity equations estimates without fixed effects on a datasets including all 120 countries.

The impact of EU membership is shown in chart 9 for both the aggregate of EU members and for the UK alone.<sup>36</sup> In this version of the gravity model the impact of EU membership is for all member states in each period and not solely for the new joiners in the period. The average impact of EU membership across all members tends to decline for later periods but only up to the 1990-2015 period. For data covering more recent time periods the estimated impact rises, reflecting the impact of the Maastricht Treaty and the accession of East European countries from 2004. The results accord with the intuition that the impact of EU membership on East European member’s trade with the UK has been large.

The impact of EU membership solely on UK goods exports to the EU is stable but much lower, in the range of 20-25%. This is not dissimilar to the (wider) range shown for fixed effects equations in chart 8. In both cases the estimates are very much lower than the 115% figure in the Treasury report. Reversing a 20% increase in exports would lead to a 16% loss of exports to the EU. In the Treasury’s case a reversal of the 115% increase would result in a loss of trade with EU of 45%. Our estimate of the loss is thus under half of that of the Treasury.

### Trade Diversion

A separate important issue in measuring the impact of EU membership on trade concerns trade diversion. It is possible that membership of the EU increases trade with other EU members at the expense of trade with non-members. To measure this, a dummy variable is added into the gravity equation to identify pairs of countries in which one trade partner is an EU member and the other is not. Using this approach the Treasury reports no significant effect, i.e. there was no evidence that increased trade with other EU members was associated with diminished trade flows with non-members. ‘Putting these estimates into our own macro-economic

36 In this case the estimates in each year refer to the UK relative to all EU members and not only the new members in each period.

model leads us to conclude that the long-term impact of Brexit on GDP and employment is likely to be small. Since migration is also likely to be lower after 2019 the impact on per capita GDP is judged likely to be mildly positive.’

Following a similar approach we get mixed results. Using a conventional gravity equation with country and time fixed effects, the results suggest a win-win situation in which trade with non-members is actually higher once countries become members of the EU. The impact is also higher for newer members of the EU. In contrast, equations without country fixed effects, but including a range of dummy variables for common languages, contiguous borders etc., show a significant trade diversion. Moreover, the degree of diversion increases over time<sup>37</sup>. Hence we conclude that we have not found it possible to use gravity models to generate a clear answer on the question of whether trade diversion takes place. Nor have we been able to replicate the Treasury analysis leading to a conclusion of no trade diversion. This may be because the Treasury’s trade variable was an average of exports and imports whereas we just used exports.

### Service sector trade

The Treasury report used a similar gravity model approach to estimate the impact of EU membership on trade in services. The data includes a large range of countries over the period 1981-2009. Once again the method found a positive impact of EU membership, albeit smaller than for goods, and again no evidence of trade diversion. The increase in intra-EU trade due to membership of the EU was 24%. We have not re-created the data and equations for services trade and use the Treasury estimate to calculate the impact of EU membership on the aggregate trade in goods and services.

### Conclusion on Gravity Models

We conclude that gravity models generate estimates of the impact of EU membership on trade which are variable and much care is needed to provide useful guidance on Brexit policy. All of our estimates are much lower than that of the Treasury. This is mainly because we have calculated an estimated impact for UK exports alone, instead of the Treasury’s average impact across all 28 EU member states. An additional factor is that some versions of the gravity model give estimates based on data for more recent periods than the Treasury’s entire post-war period tend to give lower estimates of the boost to trade from membership of the EU. Our preferred estimate is that leaving the EU and adopting WTO rules for trade in goods would lead to a decline in UK exports to the EU of around 20%.

Our estimates of the impact on the UK alone are close to the impact of WTO tariffs given in the ESRI study. The ESRI calculated that trade in goods might fall by 22% if the UK adopted WTO rules. Estimates obtained using the gravity model implicitly also include the impact of higher administrative costs for borders and the impact of regulatory differences. The former will be relevant outside the EU customs unions, but the latter should be largely absent at least in the early years. The ESRI’s estimate of the impact solely of tariffs, may thus be nearer to the true impact than any estimate based on a gravity model. However, neither the gravity model nor the ESRI’s more direct approach take into account the post-referendum depreciation of sterling. This depreciation has been large enough to offset the impact of higher tariffs in around 90% of commodities.

37 This contrast in results is the same irrespective of whether the database includes the full set of countries or just the top 60 UK export markets.

# Annex A. Predictions of the Economic Impact of Brexit

**Table A1 IFS Summary of Assessments of 2030 Economic Impact of Brexit**

Organisation	Scenario	Estimate (% GDP)	Range	Impacts modelled
CEP (2016a)	Dynamic EEA/FTA	- 7.9	(- 6.3 to - 9.5)	Budget, trade, productivity
	Static EEA	- 1.3	N/A	Trade only
	Static WTO	- 2.6	N/A	Trade only
HM Treasury	EEA	- 3.8	(- 3.4 to - 4.3)	Budget, trade, FDI, productivity
	FTA	- 6.2	(- 4.6 to - 7.8)	
	WTO	- 7.5	(- 5.4 to - 9.5)	
OECD	WTO/FTA	- 5.1	(- 2.7 to - 7.7)	Budget, trade, FDI, productivity, migration, regulation
NIESR	EEA	- 1.8	(- 1.5 to - 2.1)	Budget, trade, FDI
	FTA	- 2.1	(- 1.9 to - 2.3)	
	WTO	- 3.2	(- 2.7 to - 3.7)	
	WTO+	- 7.8	N/A	Adds productivity
PwC/CBI	FTA	- 1.2	N/A	Budget, trade, FDI, regulation
	WTO	- 3.5		
Oxford Economics	FTA <sup>a</sup>	- 2.0	(- 0.1 to - 3.9)	Budget, trade, FDI, migration, regulation
Open Europe	FTA	- 0.8 to + 0.6	(- 2.2 to 1.6)	Budget, trade, migration, regulation
Economists for Brexit	WTO	+ 4.0	N/A	Budget, trade <sup>b</sup>

<sup>a</sup> FTA with moderate policy scenario used as central estimate; range includes 'liberal customs union' (-0.1) to 'populist MFN scenario' (-3.9).

<sup>b</sup> Regulation impacts assessed separately.

Note: Estimates are for impact on GDP in 2030.

Source: Estimates from organisations above. Authors' assessment of impacts modelled.

Source: Institute of Fiscal Studies (2016) Brexit and the UK's Public Finances. Table 3.1 Page 18.

Although the short-term predictions of the Treasury, OECD and IMF have thus far proved wide of the mark, their pessimistic forecasts for the long-term impact of Brexit remain influential. These provide an important context for the Brexit negotiations and underpin the belief of Scottish and Irish nationalists that Brexit strengthens their case for independence or Irish unity. These long-term predictions are examined in detail in this report and judged to be overly pessimistic. The forecasts for GDP are based in each case on predictions for the impact of Brexit on trade and on foreign direct investment. These predictions are, in turn., obtained using a statistical technique called 'gravity modelling'. Our view is that the technique has been poorly applied especially by the Treasury. The Treasury estimate the benefit to trade from EU membership and assume that most of this benefit will be lost on leaving the EU. However, they calculate an average benefit for all EU member states and fail to look specifically at the UK experience., even though they had done so in previous unpublished work. This is unfortunate since the evidence is that the UK exports to the EU have benefitted much less from EU membership than has been the case for other EU members. The consequence is that the UK has less to lose from leaving the UK than calculated by the Treasury. Our estimate is that the UK might lose 20% of its exports to the EU after 2019 if it fails to negotiate a free-trade agreement with the UK and reverts to WTO rules for trade. This is less than half the impact estimated by the Treasury and is lower than estimated by the OECD or IMF. The impact of lower trade and FDI is also likely to be offset for a number of years through a lower exchange rate. Our estimate is that GDP will be only slightly lower by 2025 than would otherwise be the case in the absence of Brexit, but per capita GDP may well be a little higher if, as we assume ,migration will be lower after Brexit.

£10.00  
ISBN: 978-1-910812-30-3

Policy Exchange  
8 - 10 Great George Street  
Westminster  
London SW1P 3AE

[www.policyexchange.org.uk](http://www.policyexchange.org.uk)