The effects of Brexit on the UK economy

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I was astonished during late 2015 to discover that most economists in the UK favoured staying in the EU on the basis of what appeared to be neo-protectionist arguments derived from recent 'gravity-related' trade thinking. In late additions to the second edition of my book 'Should the UK leave the EU?' (Minford et al, 2015) I pointed out that the gravity modelling was of a partial equilibrium nature and that attempts hitherto made to turn it into general equilibrium were misconceived. It soon became apparent that my professional colleagues were not going to take any notice of these points; and indeed the Treasury economists promptly enlisted help from the LSE's gravity trade group in developing the gravity-based case for retaining existing trade links with the EU regardless of the costs of its well-known protectionism. In the same vein they disregarded the effects of both EU regulation and uncontrolled EU unskilled immigration. Accordingly I felt compelled to enter the EU referendum debate and with the help of friends and colleagues founded Economists for Brexit, which after the referendum was renamed and expanded as Economists for Free Trade; the aim of this group has been to explain the economic arguments for leaving the EU. In this paper I set out these arguments and the modelling and facts from which they are derived. I also relate them to the ongoing debate in the UK media and Parliament.

I begin in section I with an account of my and coauthors' modelling work on trade and my comments on the various rival approaches. I then go on in section II to set out the quantitative analysis we reached on Brexit, using these tools and the policy assumptions from available data; and contrast it with the equivalent work of others. I conclude in a brief section III with our estimates of the net gains or losses from various options that have been the subject of negotiations with the EU.

I. Trade modelling:

Gravity Models

During the referendum debate and since, the Remain side has relied on a 'consensus' of trade economists in favour of the 'gravity model'. The Treasury's case against Brexit was based on this, as has been the work at the London School of Economics (LSE) on which the Treasury relied for much advice (Breinlich et al, 2016).

A gravity model is in principle a full model of the economy open to international trade, investment and borrowing. It (e.g. Costinot and Rodriguez-Clare, 2014) regards trade as an outcrop of internal trade, the only difference being that it crosses borders. Otherwise trade grows naturally due to the specialisation and division of labour within neighbouring markets. Viewed through the lens of the gravity model, a customs union merely makes official what is already a fact of neighbourly inter-trade. Other sorts of trade, with more distant markets, grow analogously but more weakly, the greater the distance; size of distant markets may

make up for their distance to some extent, because they are a 'neighbourhood' that naturally leads to inter-trade. 'Gravity' in trade creation can be thought of as a function of distance and size. In this view of trade, it makes no sense to put obstacles in the way of trade with close neighbours, such as the EU, in the hope of boosting trade with distant markets via new trade agreements that lower trade costs. The disruption from the former will reduce welfare while the gains from the latter will be small, simply because the reduced trade costs will have little effect in switching demand from existing products in the presence of weak and imperfect competition.

Under this model trade is determined largely by the forces of demand, from neighbours wanting imports and from others modified by the factor of distance - due to transport costs and border costs; competition is rather limited, highly `imperfect', and prices are set by producers as a mark-up on costs, so they move rather little. Once demand has determined trade and the production to meet it, foreign direct investment (FDI) and associated innovation follow it, boosting productivity. In short, while supply is important in this gravity approach, supply is largely determined by the forces of demand.

Because it is hard to break into new and distant markets it makes sense in this approach to support existing markets. Hence leaving the EU will damage existing markets' demand, so reducing trade and so reducing supply and productivity via falling FDI and innovation. Reducing trade barriers with the rest of the world will only weakly substitute for this loss of demand by stimulating more demand there.

Even though the EU protects its markets via trade barriers, this on the gravity view is good for the UK because it raises demand for our exports within the EU. Hence this school of thought is in favour of EU protectionism - it could be called `neo-protectionist'. In general, free trade, according to the gravity approach, is something that must be evaluated case by case on the basis of its effects on demand for UK products and so the supply side of the economy.

Proponents of this gravity approach claim that it is supported by the ‘facts’ - consisting of many estimated relationships between exports and the GDP of the demanding countries, adjusted for distance. However, as already explained, we need to allow for a possible problem: that the rival classical model also generates these relationships. Indeed it has routinely been thought by proponents of this rival model that such gravity equations, first estimated by Tinbergen (1962) and well known since, would be implied by the model.

The Classical Model

This classical model was developed by the great trade theorists of the past two centuries - starting with Ricardo (1817) - and pursued in much empirical work based on it. The fact that these ideas come from a long tradition of thinking does not of course mean that they are thereby wrong because ‘old’. We have also witnessed an earlier major reversal of classical thought, the Keynesian Revolution, which has now been largely ditched in favour of a return to classical principles.

The classical model assumes high competition across world markets, with world prices being the same across the world subject to transport costs and trade barriers; there is free entry into all industries so that prices equal average costs. Capital flows freely across borders in the modern world version, but each country has largely fixed supplies of other factors, namely unskilled labour, skilled labour and land. In this model, supply forces such as the supply factors and their productivity determine the size of a country's different sectors. The resulting income is then spent according to home demands and the surplus of supply over demand is then exported, the deficit imported in each sector. The model is silent on the allocation of demand to imports and home goods and on the allocation of exports to different foreign markets. However, it would be normal to add on some such allocative model of demand on top of the basic structure.

Thus, it can be seen that the causal structure of the classical model is quite different from that of gravity thinking. In the classical model supply determines the essential structure of trade; demand adjusts to be consistent with this. In the gravity approach demand determines the structure of trade and in turn forces supply to adjust to this.

How Do Gravity Modellers Implement Their Model?

You might think from this account of the gravity approach that you would expect to see - at the Treasury and at the LSE - a full computable general equilibrium (CGE) model of the UK's economy, trade and foreign investment, complete with final demands, markets for labour and capital, and market-clearing, including balance of payments equilibrium. But this is not what you will find. Instead, there will be some equations for bilateral trade in a lot of different goods with different countries in which GDP at home and in foreign countries figure together with relative prices; then another lot of equations for different countries relating foreign direct investment (FDI) to trade; then yet another lot of equations for UK industries relating productivity to FDI. The 'model' generates results by computing what under the first set of equations a trade regime change would do to trade; then this is 'fed' into the second set of equations relating FDI to total trade; finally the FDI effect is fed into the last set of equations relating FDI to productivity. The resulting estimate of the productivity effect of the trade regime change is then put into a model of the economy. This procedure can be found in the Treasury's long-term assessment of the effects of Brexit (HMTreasury 2016). The LSE pursues a broadly similar methodology.

What we have is one set of empirical associations between trade and trade regimes; another set of associations between trade and FDI; then another set of associations between FDI and productivity. Only at the last stage when all this has been computed from these associations is a model brought in, where productivity is inputted into a standard 'macro' model in which the origins of trade and its interactions around the economy are not included. While all the empirical associations are based on data, they do not tell us what the causal origins of these associations are. There could be reverse causation (FDI could cause trade or productivity cause FDI; trade regimes could have been caused by closer trade), or simultaneous causation by a third factor (better policies could have led simultaneously to more trade, more FDI and more productivity). Association as is well known does not imply causation.

There is therefore a serious question of identification, that is interpretation of what causal processes are driving these associations. One would like the gravity modellers to write out a complete system of causal equations that they believe and set them side by side with a rival system such as the classical model. Then we could check which of these two systems comes closest to implying all these associations we observe - more precisely since this debate is about Brexit, implying the associations we find for specifically UK trade and the UK economy, i.e. the 'UK trade facts'.

But there neither was nor is in existence at the Treasury (see appendices to HM Treasury, 2016) and the LSE (see chapter 2 of Breinlich et al, 2016) any such complete gravity trade model linking all goods, labour, capital and land markets into one (UK) 'economy' linked to the rest of the world. Nor by implication has anyone in either place asked whether such a model would fit the UK trade facts; it simply has not occurred to them to build the model or to ask it this question.

In some such associations, GDP and even prices are substituted out in favour of trade shocks, whether from trade policy or world developments such as globalisation, with which an average 'elasticity' is calculated for trade- this is recommended by Costinot and Rodriguez-Clare (2014) as a shortcut to achieving a general equilibrium model in reduced (i.e. solved-out) form. However, while this would work if the elasticity were the same for all such shocks, we know it cannot be so, from the workings of full theoretical trade models. Each shock will have its own reduced form relationship with the endogenous variables of the model. Hence to treat these as one unique relationship is plainly a mis-specification of the reduced form model for policy use; this is in no sense a proper general equilibrium model or a solution of it.

Gravity and Classical Trade Models – Tests, Checks and Policy Implications To make some progress on these issues, we spent a year doing work of this sort on a gravity model of the UK. We took a full classical trade/economy model and adjusted it for gravity assumptions: first, imperfect competition and second an effect from total trade to productivity (via FDI). What we found is detailed in Minford and Xu (2018).

We found that testing these models against the full array of associations found in the data the gravity model is statistically rejected while the classical model survives the test.

As this is the first time to our knowledge that trade models have been tested in this way, it is of interest to show a few details of how this test was conducted. Formally, it is an indirect inference test in which the facts of UK trade relationships are summarised in some way, the 'auxiliary model', and the trade models to be tested are then simulated repeatedly to create alternative sample histories from each of which these summary facts are extracted. This creates a joint distribution of these facts which can be used to assess the probability of the trade model generating the actually observed facts. If the probability lies in the test's tail (which we set at the usual 5% level), the model is rejected.

A first question concerns the power of this test which we assess by Monte Carlo experiment, hypothetically falsifying to an increasing extent some 'true model' similar to one of our models here. We create many samples from the true model; we then disturb the true parameters by + or - x% alternately and see how many of these samples reject our falsified model. The left hand column of Table 1 shows this x% 'general mis-specification' and the next column the rejection rate. It can be seen that this rejection rate which measures the power of the test rises sharply to virtually 100% once mis-specification reaches only 3%.

Table 9: Power of II Wald test: classical model as true,with w/h, eq1)-4)

Percent Mis-specified	Indirect Inference test
True	5.0
1	40.5
3	99.9
5	100.0
7	100.0
10	100.0
15	100.0
20	100.0

Source: Minford and Xu (2018)

Table 1: Source: Minford and Xu (2018) Table 9

Table 2 shows the Wald test results for the two models. As can be seen, the classical model is not rejected with a 0.09 p-value while the Gravity model is rejected with a 0.035 p-value. The power of the test implies that the Classical Model can be considered as highly accurate.

Table 10: II Wald test results when equations 1)-4) are used, with w/h

	Equations in auxiliary model	P-value
Classical trade model	1),2),3),4)	0.0904
Gravity model	1),2),3),4)	0.0350

ırce: Minford and Xu (2018)

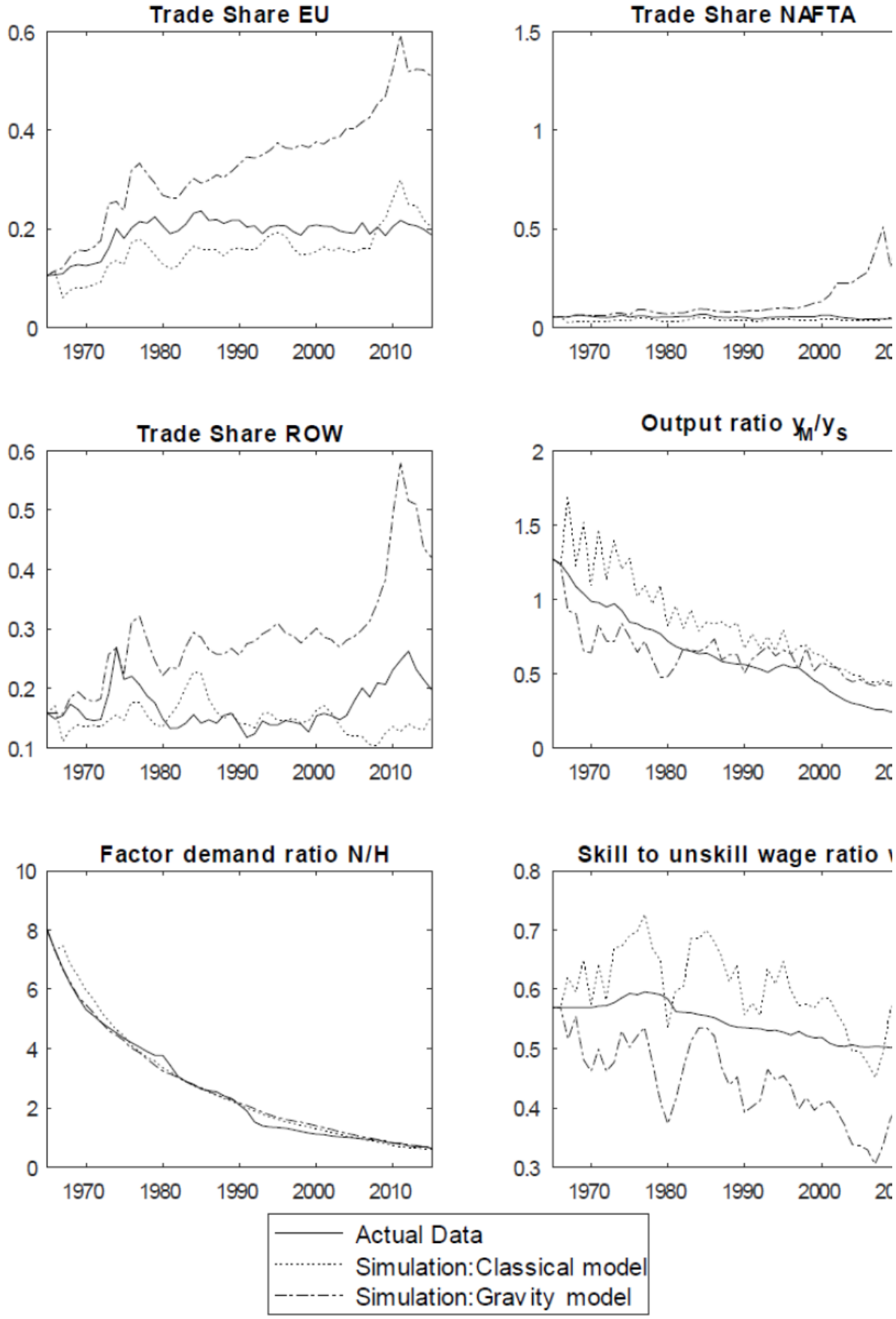
Table 2:Source: Minford and Xu (2018) Table 10

Some idea of just why these results occur due to UK trade facts can be seen from charts of various of these facts versus the average value of the facts simulated by each model, shown as Figure 1 taken from our paper.

Figure 1:Source: Minford and Xu (2018) Figure 2

One can see from these charts that the simulated behaviour of UK trade shares and the skilled wage ratio according to the Gravity model lies well away from the actual behaviour compared with the simulated behaviour from the Classical model. This would tend to push the regression coefficients' distribution further away from the ones found from the actual data.

Figure 2: Actual and average of simulated data



ource: Minford and Xu (2018)

Figure 1: Source Minford and Xu (2018) Figure 2

The policy implications for Brexit of the two models

But a finding we made that is perhaps more important for policy: when we put the assumption of free trade into the gravity model it produces the same answer for the effects on UK welfare and GDP as the classical model.

What this means is had gravity modellers used the true underlying causal model of trade and the economy, together with the full free trade assumptions about policy, to compute the effects of Brexit they would have come to a strongly positive conclusion about post-Brexit economics, as we did. The reason is clear: even in the gravity model general free trade lowers consumer prices and stimulates resource movement to the more productive sectors.

Later modelling developments

The Treasury released no replies to our criticisms of these gravity-equation-based methods; nor indeed did any of the other modellers using similar methods. Rather the contrary; they happily allowed sympathetic outside commentators like the Institute of Fiscal Studies (IFS, 2016) to trumpet abroad the fact that our work was an 'outlier', without drawing attention to the differences of modelling method or of assumptions where the method was similar. In fact there has always been a spread of economists' analyses, giving the lie to the implication that we were the only economists who thought Brexit would or could have a positive trade effect on the economy.

Thus our group were not the only one to find that Brexit would have a positive long term trade effect under favourable policy assumptions. Another was Open Europe (2015) which used the GTAP model from Purdue University, Indiana; this is a well-known internationally developed CGE Model of world trade. It is a model of all countries, grouped into smaller groups, usually around 50, and of all goods and services sectors, usually around 40. Its equations are derived from trade theory, and the equilibrium in each market of supply and demand. Furthermore, as noted by Whyman and Petresku (2017), other studies finding negative Brexit effects used a variety of damaging assumptions that had nothing to do with trade, such as short term uncertainty, migration, and regulation.

However, more significantly, the Treasury and the rest of the UK Civil Service have now collectively abandoned the gravity-equations methods described above and so in terms of method have now joined us in using a general equilibrium model of trade, as evidenced by the Cross-Whitehall (2018) project. Thus had they shared our policy assumptions, they too would have come up with similarly positive assessments of the trade effects.

There is therefore now general agreement between ourselves, Open Europe and the collective UK Civil Service that Brexit must be evaluated by a Computable General Equilibrium model. The Cross-Whitehall Project (Civil Service, 2018) to evaluate Brexit like Open Europe also uses GTAP. This GTAP model has thus replaced the set of correlations (between trade agreements and trade; trade and FDI; FDI and productivity) previously used by the Treasury to produce its pre-referendum report on the long term trade effects of Brexit. What separates us all qualitatively is the assumptions we make as policy inputs into the particular CGE models being used, to which I now turn.

II. The Policy Assumptions made by ourselves and the Cross-Whitehall study; and their implications for UK welfare

The Cross-Whitehall study has made assumptions about 'general free trade via FTAs' that are conservative in the extreme. It has stated that gains from their general FTA assumption are only a 0.5-0.8% rise in UK GDP. From this it would seem that they assume either that EU trade barriers are rather small or that barriers are reduced by rather little. This is puzzling since current EU protection of food and manufactures including non-tariff barriers is authoritatively estimated at 20% (Minford et al, 2015, chapter 4; also for non-tariff barriers Berden et al, 2009). Our assumption of the likely Brexit reduction of protection is deliberately cautious at 10%; it can be thought of as assuming either that only half is abolished or that somehow the EU would itself have abolished half anyway. With this 10% assumption our Cardiff World Trade Model predicts a 4% rise in GDP (Minford et al, 2015, chapter 4). If this 10% is fed into the GTAP model, then UK GDP would rise by 2%, while if all 20% EU protection were abolished it would rise by 4%. Interestingly, a recent study of Australian trade liberalisation over the past thirty years using GTAP (CIE, 2017) finds that its GDP has been increased by 5.4%- a figure rather similar to the gains being discussed for the UK's Brexit liberalisation.

The other key assumption made by the Cross-Whitehall study is that large costs arise at the EU border for UK-EU trade even if we negotiate 'free trade' with the EU. One element of this appears to be related to pure 'border costs'; such things as time to get paperwork agreed before ships are allowed to unload.

However these assumptions have been bypassed by the progress of technology and WTO rules for customs procedures (WTO, 2018c; World Bank, 2016). Computerisation has more or less eliminated border costs among developed countries, since almost all cargoes are cleared before reaching port, with only some 2 per cent or so physically inspected and even this is taking only around a day typically. Prof. Dr. Michael Ambühl (ETH Zürich), who negotiated one of the Swiss-EU bilateral free trade deals, estimated that border costs were as low as 0.1% of the value of trade (Ambühl, 2018, slide 8).

Another assumption in the Cross-Whitehall study appears to be that UK-EU non-tariff protection would spring up after Brexit. The idea seems to be that the EU and maybe the UK too would claim that exporters do not satisfy required product standards; thus non-tariff barriers would sprout on the UK-EU border, regardless of any trade negotiations. However,

current WTO rules (WTO, 2018 a and b) outlaw such behaviour as illegally discriminative, given that existing product standards are already exactly obeyed on both sides.
Thus it is hard to understand the Cross-Whitehall assumptions on EU-UK border costs post-Brexit. Nevertheless, on the basis of these assumptions, the Cross-Whitehall GTAP model calculates large losses in GDP, variously amounting to between 3 and 7%, depending on the 'closeness' of the eventual EU arrangements. On our calculations, these costs are simply not there in the event of a free trade (Canada-plus) agreement with the EU. We also have an assessment (Economists for Free Trade, 2018a) of the 'no deal' case within the Cardiff World Trade Model. In this case again non-tariff barriers and customs hold-ups are illegal but tariffs do apply; in our assessment the tariff element damages the EU but not the UK essentially because given that FTAs have driven UK prices to world prices, tariffs in both directions must be absorbed by EU traders. The Table below summarises how based on available GTAP simulations (Ciuriak et al, 2015 and 2017) we have reconstructed the assumptions made by Whitehall as well as their published impact on GDP according to the GTAP model; it sets them side by side with what the GTAP model would say based on the alternative assumptions we regard as reasonable for UK-EU trade barriers and an assumption for FTAs with the rest of the world that achieve the full abolition of EU protection of food and manufactures.
Table 3: Trade Effects under Brexit Scenarios According To GTAP-type model used by Whitehall

Table: Trade Effects under Brexit Scenarios According To GTAP-type model used by Whitehall

	A: Whitehall Assumptions		**B: Variant Assumptions**	
Trade Barriers expressed as % Tariff Equivalent; Effect on GDP shown as % of GDP in italics				
	Canada+	**WTO**	**Canada+**	**WTO**
Tariffs	-	4.5	-	4.5
Effect on GDP	-	*-1.0*	-	*-1.0*
New Standards	16.2	20.3	-	-
Effect on GDP	*-3.6*	*-4.5*	-	-
New Customs	5.8	5.8	-	-
Effect on GDP	*-1.3*	*-1.3*	-	-
Total Tariff Equivalent (%)	**22.0**	**30.6**	-	**4.5**
Total Effect on GDP (% of GDP)	*-4.9*	*-6.8*	-	*-1.0*
FTAs with rest of world				
Effect on GDP (% of GDP)	*.....+(0.3-)0.6....*		*..... +4.0*.....*	
All Trade Effects on GDP				
(% of GDP)	*-4.3*	*-6.2*	*+4.0*	*+3.0*

*assume all EU protection of food and manufactures (20% average on each) eliminated via FTAs

The Cross-Whitehall study therefore reaches its conclusions that Brexit reduces UK GDP on the basis of untenable assumptions. When reasonable assumptions are substituted for the extent of the trade barriers eliminated against the rest of the world and for the trivial UK-EU border costs, this reduction is turned into a substantial increase on both the GTAP model, and on the Cardiff World Trade Model. What is more this is true even on the Gravity version of that Cardiff model.

The Treasury in its latest Report published nov 28 has not materially changed its overall estimates of the costs to GDP of the different Brexit scenarios; my

critique remains the same; that it is inputting false assumption- see Economists for FreeTrade (2018b).

III. Our estimates of how a full Brexit impacts on the economy

What are then the whole range of economic benefits we estimate from achieving a Clean Brexit - ie, leaving the Single Market and the Customs Union, regaining control over our borders, laws, and regulations, freeing ourselves from the European Court of Justice, and having the freedom to establish our own trading relationship with the rest of the world? Over the past two years, we have reported at length on the long run effects of such a 'Clean Brexit'. Here we briefly recapitulate the arguments and findings from our research.

A Clean Brexit produces long-run gains from four main sources (Minford, 2017):

1. Moving to free trade with non-EU countries that currently face high EU protection in goods trade
2. Substituting UK-based regulation for EU-based Single Market regulation
3. Ending the large subsidy the 'four freedoms' forces the UK to give to EU unskilled immigrants
4. Ending our Budget contribution to the EU

The gains under (1) come about because elimination of the EU's protection lowers consumer prices and increases competition in our home market, so raising productivity across our industries. With the economy at full employment and a flexible exchange rate, any jobs lost in industries where higher productivity releases labour will be offset by extra jobs in other (unprotected) industries where productivity is already high and where demand is projected to expand. For our calculations on our Cardiff World Trade Model (Minford et al, 2015,chapter 4), we assume that protection leading to higher prices of 10% in both food and manufactures is eliminated (as noted above detailed research shows prices inside the EU in both sectors currently are some 20% higher than world market prices). Our estimates are that consumer prices will fall by 8% and GDP will rise by 4%.

For (2), we rely on models of the economy developed by Cardiff researchers (see Minford et al, 2015, chapter 2) that assess the effects of regulation on the economy via their effect in

raising business costs. We estimate that EU regulation has reduced GDP by around 6%; and that probably about a third of this can be reversed giving us a projected gain of 2% of GDP, or a growth rate 0.15% per annum faster over the next 15 years.

For (3), we have examined the costs to the taxpayer of EU unskilled immigrants owing to the entitlement to the full range of tax credits and other benefits, including free education and healthcare (Ashton, MacKinnon and Minford, 2016). A further effect is that wages of UK unskilled workers are depressed; this represents a transfer from unskilled workers to the consumers who use their products. A further relevant distributional element is that the taxpayer burden and wage effect are both highly localised in areas of immigration. From these costs, we find that Brexit would save 0.2% of GDP in taxpayer costs. Furthermore, there would be a particular benefit to UK low-income households of about 15% of their living costs from the combination of ending this unskilled immigrant subsidy and the trade-led reduction in the CPI (MacKinnon, 2018). For (4), we have followed the standard calculations made by the Office of Budget Responsibility and others, arriving at around 0.6% of GDP.

In total these four elements create a rise in GDP in the long term over the next decade and a half of about 7%, which is equivalent to an average rise in the growth rate of around 0.5% per annum.

Conclusions

In this paper I have summarised work my coauthors and I have done on the effects of Brexit on the UK economy, with particular emphasis on the trade effects where controversy has been greatest. I have also reviewed the work on trade done by others and particularly that of the Treasury and the rest of Whitehall who are responsible for official advice to Ministers.

The key point of this review is that this Civil Service work has taken a sharp turn in the past year towards the CGE methods we have been using throughout and has rightly in our view abandoned the original Treasury methodology of gravity-based associations which are incapable of establishing causality. In this methodological sense our work is certainly not, as repeatedly claimed by our opponents, an ‘outlier’ but rather entirely ‘mainstream’. Where the Civil Service continues to differ from us is in their assumptions about the extent to which FTAs with the rest of the world can reduce current EU protection and also about the trade and border barriers that would be created between us and the EU. However these assumptions of theirs are almost impossible to justify, since such barriers would be illegal and the scope for reducing EU protection is very large.

Once one substitutes reasonable assumptions into the type of world trade model used by the Civil Service the trade effects estimated for Brexit become positive and potentially rather large. When one adds these to the less controversial gains from proceeding with UK-created regulation of the economy, the control of unskilled immigration and the ceasing of our payments into the EU budget, the gains to the UK economy suggest that growth could rise by around 0.5% per annum on average for the next decade and a half.

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