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A Simple Model of Brexit under Oligopoly*

December 2017

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Abstract

The welfare effects of Brexit on the UK, the EU27 and the rest of the world are analysed in a model of international trade under oligopoly. A hard Brexit where the UK trades according to WTO rules is shown to decrease total UK welfare, to have an ambiguous effect on total EU27 welfare, and to increase total welfare in the rest of the world. Unilateral free trade for the UK is shown to decrease total UK welfare, to increase total EU27 welfare, and to increase total welfare in the rest of the world. A free trade agreement with the rest of the world rather than the EU27 will be beneficial, *ceteris paribus*, if the rest of the world market is larger than the EU27 market; if the rest of the world tariff is larger than the EU27 tariff; and if firms in the rest of the world have higher costs than EU27 firms. It will not be beneficial if trade between the UK and the rest of the world is more costly than trade between the UK and the EU27 as is likely to be the case since the EU27 is close to the UK.

JEL Classification: F12; F13; L13

Keywords: Brexit; Oligopoly; International Trade; Tariffs; EU

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1. Introduction

On the 23rd June 2016, a majority (51.9%) of voters in the United Kingdom (UK) unexpectedly voted to leave the European Union (EU) in a referendum, and on the 29th March 2017 the UK Government formally notified the European Council of its intention to leave the EU in accordance with Article 50 of the Treaty of the European Union (Lisbon Treaty) in two years. The UK Government is currently negotiating with the European commission the terms for the UK withdrawal and future relations with the EU. On the 15th December 2017, the European Council confirmed that sufficient progress had been made in the first phase of negotiations, including a financial settlement, to allow progress to the second phase of negotiations that would cover the future trade relations between the UK and the EU27 (the member states of the EU except for the UK) as well as many other issues. The joint report on progress during the first phase of negotiations includes the caveat *‘that nothing is agreed until everything is agreed’* so the final outcome of the negotiations is far from clear. The default option if the negotiations breakdown, and one favoured by some supporters of Brexit, is a hard Brexit where the UK does not obtain a free trade agreement with the EU27 and instead trades according to World Trade Organisation (WTO) rules or pursues a policy of unilateral free trade.

Previous studies of the welfare effects of Brexit, reviewed by Sampson (2017), have either run simulations using a computable general equilibrium trade model or used reduced-form evidence.¹ The simulation approach employed by Dhingra et al. (2017) uses a multisector version of the Eaton and Kortum (2002) model with 31 industries and 35 countries. They estimate that UK welfare (consumption per capita) would be reduced by 1.3% in the optimistic case when the UK remains in the Single Market, and by 2.7% with a hard Brexit when the UK trades according to WTO rules. The reduced-form approach uses the gravity equation to

¹ For other studies, see the references in Sampson (2017) as well as Ries et al. (2017) that applies game theory to Brexit negotiations and Vandebussche, Connell, and Simons (2017) that looks at the effect of Brexit on jobs.

estimate the effect of EU membership on trade and then uses this result together with estimated trade elasticities to calculate the welfare effects of Brexit. The reduced-form approach of Dhingra et al. (2017) gives estimates of the UK welfare loss (income per capita) from Brexit between 6.3% and 9.4%. The estimates using the reduced-form approach give significantly higher estimates of the welfare loss from Brexit, and this probably because they capture channels that are not considered in simulation approach such as through technological change. This paper will consider an alternative approach to the welfare analysis of Brexit using an oligopoly model of trade, and making only qualitative predictions rather than quantitative predictions about the welfare effects of Brexit.

The oligopoly approach to international trade of Brander (1981) started as an explanation for intra-industry trade in identical products between similar countries that could not be explained by traditional comparative advantage models. Brander and Krugman (1983) analysed the welfare effects of multilateral free trade under Cournot oligopoly and Collie (1996) analysed the welfare effects of unilateral free trade under Cournot oligopoly whereas Clarke and Collie (2003) consider the welfare effects of unilateral and multilateral free trade under Bertrand oligopoly with differentiated products. There is an extensive literature on trade policy under oligopoly that was surveyed by Brander (1995) and is often labelled as strategic trade policy due to the profit-shifting motive for trade policy identified by Brander and Spencer (1984) in the case of tariffs and Brander and Spencer (1985) in the case of export subsidies. Dixit (1984) considered the optimal combination of production subsidies and import tariffs, and Collie (1991) analysed countervailing duties as a response to export subsidies. Recent developments in the literature on oligopoly and trade are surveyed by Leahy and Neary (2011) and a recent application to trade agreements is provided by Bagwell and Staiger (2012).

Since intra-industry trade is particularly important for international trade between the similar countries that make up the EU, oligopoly models of international trade seem to be more

appropriate than comparative advantage models that cannot explain intra-industry trade between similar countries. Also, comparative advantage models assume perfect competition whereas most industries are far from perfectly competitive and it would be appropriate to model such industries as oligopolies. Under oligopoly, since price is greater than marginal cost, firms make positive profits and profits from exports are a source of welfare for a country that is not present under perfect competition. Therefore, this paper will analyse Brexit using an oligopoly model rather than perfectly competitive models or the reduced-form gravity equations used by other studies of Brexit.

Section two presents a Cournot oligopoly model of the world economy consisting of the UK, the EU27 and the rest of the world (RoW). A hard Brexit where the UK does not have a trade agreement with the EU27 but trades according to WTO rules is analysed in section three. Section four analyses unilateral free trade where the UK does not have a trade agreement with the EU27 but pursues a policy of unilateral free trade. The desirability of replacing membership of the EU with a free trade agreement with the RoW is considered in section five. The conclusions are presented in section six.

2. The Model

The world economy in this model consists of a number of identical countries: the UK, the EU27 (EU countries excluding the UK), and the rest of the world (RoW). The number of countries in the UK is equal to one and is denoted by $m_U = 1$; the number of countries in the EU27 (excluding the UK) will be denoted by $m_E \geq 2$; and the number of countries in the RoW will be denoted by $m_R \geq 2$. There are two goods X and Y with good X produced by an oligopolistic industry and the numeraire good Y produced using constant returns to scale technology by a perfectly competitive industry. In the oligopolistic industry, the product is assumed to be homogenous, and the markets are assumed to be segmented. There are n firms

in the oligopolistic industry in each country, all of which are assumed to have constant marginal cost. The oligopolistic firms in the UK have marginal cost c_U , while the firms in the EU27 have marginal cost c_E , and the firms in the RoW world have marginal cost c_R . For the oligopolistic good, there is also a transport cost k on exports from the RoW to the UK and the EU27, and on exports from the UK and the EU27 to the RoW, but there is no transport cost on goods traded between the UK and the EU27 since they are close neighbours.² The tariff on imports of the oligopolistic good imposed by the UK is t_{UE} on imports from the EU27 and t_{UR} on imports from the RoW. That imposed by the EU27 is t_{EU} on imports from the UK and t_{ER} on imports from the RoW, while that imposed by the RoW (for simplicity, assumed to be a single free trade area) is t_{RU} on imports from the UK and t_{RE} on imports from the EU27. As is standard in the analysis of trade policy or taxation, there are no tariffs or taxes imposed on the numeraire good.

In each country, preferences of the representative consumer are assumed to be given by the quasi-linear linear utility function:

$$u = \alpha x - \frac{\beta}{2} x^2 + y \quad \alpha > \text{Max}\{c_U, c_E, c_R\}, \beta > 0 \quad (1)$$

where x is consumption of the oligopolistic good and y is consumption of the numeraire good by the representative consumer. Utility maximisation yields the inverse demand function for the oligopolistic good: $P(x) = \alpha - \beta x$, where P is the price of the oligopolistic good. Aggregating the demand functions over all the countries in the EU27 and over all the countries

² According to Hummels and Schaur (2013), each day in transit is equivalent to an *ad valorem* tariff of 0.6-2.1%, and the most time sensitive trade involves parts and components. Rail transportation from China to the UK takes 18 days, which is 30 days less than maritime transportation and at one-fifth the cost of air transportation; see: <https://www.ft.com/content/ed033dae-6c69-11e7-b9c7-15af748b60d0>.

in the RoW, yields the inverse demand function in the markets of the UK, the EU27, and the RoW:

$$P_Z = \alpha - \beta_Z X_Z \quad \beta_Z = \frac{\beta}{m_Z} \quad Z = U, E, R \quad (2)$$

where P_Z is the price and X_Z is consumption in the market $Z = U, E, R$. Since preferences are quasi-linear, consumer surplus is a valid measure of welfare and is given by:

$$CS_Z = \int_0^{X_Z} (\alpha - \beta_Z X) dX = \frac{\beta_Z}{2} X_Z^2 \quad Z = U, E, R \quad (3)$$

Since markets are assumed to be segmented and marginal cost is assumed to be constant, each market can be analysed independently starting with the UK market. The profits in the UK market of the firms from the UK, the EU27 and the RoW are:

$$\begin{aligned} \pi_{UU}^i &= (P_U - c_U) x_{UU}^i & i = 1, \dots, n \\ \pi_{EU}^i &= (P_U - c_E - t_{UE}) x_{EU}^i & i = 1, \dots, m_E n \\ \pi_{RU}^i &= (P_U - c_R - k - t_{UR}) x_{RU}^i & i = 1, \dots, m_R n \end{aligned} \quad (4)$$

where π_{ZU}^i is the profits and x_{ZU}^i is the output of the i th firm from $Z = U, E, R$ in the UK market. Assuming an interior solution where all firms supply the UK market, it is straightforward to solve for the Cournot-Nash equilibrium outputs sold in the UK market by firms from the UK, the EU27 and the RoW, respectively:

$$\begin{aligned} x_{UU} &= \frac{1}{M\beta} \left[\alpha - M_U c_U + m_E n (c_E + t_{UE}) + m_R n (c_R + t_{UR} + k) \right] \\ x_{EU} &= \frac{1}{M\beta} \left[\alpha + n c_U - M_E (c_E + t_{UE}) + m_R n (c_R + t_{UR} + k) \right] \\ x_{RU} &= \frac{1}{M\beta} \left[\alpha + n c_U + m_E n (c_E + t_{UE}) - M_R (c_R + t_{UR} + k) \right] \end{aligned} \quad (5)$$

Where $M \equiv (1 + m_E + m_R)n + 1$ is the total number of firms in the world plus one; while $M_U \equiv M - n > 0$, $M_E \equiv M - m_E n > 0$, and $M_R \equiv M - m_R n > 0$. The total output sold in the UK market by the UK industry is $X_{UU} = nx_{UU}$, by the EU27 industry is $X_{EU} = m_E nx_{EU}$, and by the RoW industry is $X_{RU} = m_R nx_{RU}$. From (5), it can be seen that the EU27 and RoW firms will supply the UK market provided that the tariffs and the transport cost are not prohibitive, and it will be assumed throughout the paper that:

$$\begin{aligned} t_{UE} < \bar{t}_{UE} &\equiv \frac{\alpha + nc_U - M_E c_E + m_R n(c_R + t_{UR} + k)}{M_E} \\ t_{UR} + k < \bar{t}_{UR} &\equiv \frac{\alpha + nc_U + m_E n(c_E + t_{UE}) - M_R c_R}{M_R} \end{aligned} \quad (6)$$

The market price in the UK market is obtained by substituting the total consumption in the UK market, $X_U = X_{UU} + X_{EU} + X_{RU}$ into the inverse demand function, which yields:

$$P_U = \frac{1}{M} \left[\alpha + n(c_U + m_E(c_E + t_{UE}) + m_R(c_R + k + t_{UR})) \right] \quad (7)$$

The market price (and aggregate output) is a function of the aggregate marginal cost of the firms in the market as the Cournot oligopoly model is an aggregative game when marginal costs is constant.³ Aggregate Cournot-Nash equilibrium profits from sales in the UK market of the firms from the UK, the EU27 and the RoW, respectively, are:

$$\begin{aligned} \Pi_{UU} &= n(P_U - c_U)x_{UU} = n\beta(x_{UU})^2 \\ \Pi_{EU} &= m_E n(P_U - c_E - t_{UE})x_{EU} = m_E n\beta(x_{EU})^2 \\ \Pi_{RU} &= m_R n(P_U - c_R - k - t_{UR})x_{RU} = m_R n\beta(x_{RU})^2 \end{aligned} \quad (8)$$

³ The Cournot oligopoly model being an aggregative game does not depend upon the assumption of linear demand, but requires the assumptions of constant marginal cost and homogeneous products; see Bergstrom and Varian (1985) and Corchón (2001).

Similarly, in the EU27 market, the profits of the firms from the UK, the EU27 and the RoW are:

$$\begin{aligned}
\pi_{UE}^i &= (p_E - c_U - t_{EU})x_{UE}^i & i = 1, \dots, n \\
\pi_{EE}^i &= (p_E - c_E)x_{EE}^i & i = 1, \dots, m_E n \\
\pi_{RE}^i &= (p_E - c_R - k - t_{ER})x_{RE}^i & i = 1, \dots, m_R n
\end{aligned} \tag{9}$$

where π_{ZE}^i is the profits and x_{ZE}^i is the output of the i th firm from $Z = U, E, R$ in the EU27 market. Assuming an interior solution where all firms supply the EU27 market, it is straightforward to solve for the Cournot-Nash equilibrium yields the output sold in the EU27 market by each firm from the UK, the EU27 and the RoW, respectively:

$$\begin{aligned}
x_{UE} &= \frac{1}{M\beta_E} \left[\alpha - M_U(c_U + t_{EU}) + m_E n c_E + m_R n (c_R + t_{ER} + k) \right] \\
x_{EE} &= \frac{1}{M\beta_E} \left[\alpha + n(c_U + t_{EU}) - M_E c_E + m_R n (c_R + t_{ER} + k) \right] \\
x_{RE} &= \frac{1}{M\beta_E} \left[\alpha + n(c_U + t_{EU}) + m_E n c_E - M_R (c_R + t_{ER} + k) \right]
\end{aligned} \tag{10}$$

The total output sold in the EU27 market by the UK industry is $X_{UE} = nx_{UE}$, by the EU27 industry is $X_{EE} = m_E nx_{EE}$, and by the RoW industry is $X_{RE} = m_R nx_{RE}$. The market price in the EU27 market is obtained by substituting the total consumption in the EU27 market, $X_E = X_{UE} + X_{EE} + X_{RE}$ into the inverse demand function, which yields:

$$P_E = \frac{1}{M} \left[\alpha + n((c_U + t_{EU}) + m_E c_E + m_R (c_R + k + t_{ER})) \right] \tag{11}$$

Aggregate Cournot-Nash equilibrium profits in the EU27 market of the firms from the UK, the EU27 and the RoW, respectively, are:

$$\begin{aligned}
\Pi_{UE} &= n(p_E - c_U - t_{EU})x_{UE} = n\beta_E x_{UE}^2 \\
\Pi_{EE} &= m_E n(p_E - c_E)x_{EE} = m_E n\beta_E x_{EE}^2 \\
\Pi_{RE} &= m_R n(p_E - c_R - k - t_{ER})x_{RE} = m_R n\beta_E x_{RE}^2
\end{aligned} \tag{12}$$

Similarly, in the RoW market, the profits of the firms from the UK, the EU27 and the RoW are:

$$\begin{aligned}
\pi_{UR}^i &= (p_R - c_U - k - t_{RU})x_{UR}^i \quad i = 1, \dots, n \\
\pi_{ER}^i &= (p_R - c_E - k - t_{RE})x_{ER}^i \quad i = 1, \dots, m_E n \\
\pi_{RR}^i &= (p_R - c_R)x_{RR}^i \quad i = 1, \dots, m_R n
\end{aligned} \tag{13}$$

where π_{ZR}^i is the profits and x_{ZR}^i is the output of the i th firm from $Z = U, E, R$ in the RoW market. Assuming an interior solution where all firms supply the EU27 market, solving for the Cournot-Nash equilibrium yields the output in the RoW market of each firm from the UK, the EU27 and the RoW, respectively:

$$\begin{aligned}
x_{UR} &= \frac{1}{M\beta_R} \left[\alpha - M_U(c_U + k + t_{RU}) + m_E n(c_E + k + t_{RE}) + m_R n c_R \right] \\
x_{ER} &= \frac{1}{M\beta_R} \left[\alpha + n(c_U + k + t_{RU}) - M_E(c_E + k + t_{RE}) + m_R n c_R \right] \\
x_{RR} &= \frac{1}{M\beta_R} \left[\alpha + n(c_U + k + t_{RU}) + m_E n(c_E + k + t_{RE}) - M_R c_R \right]
\end{aligned} \tag{14}$$

The total output sold in the RoW market by the UK industry is $X_{UR} = nx_{UR}$, by the EU27 industry is $X_{ER} = m_E n x_{ER}$, and by the RoW industry is $X_{RR} = m_R n x_{RR}$. Aggregate Cournot-Nash equilibrium profits in the RoW market of the firms from the UK, the EU27 and the RoW, respectively, are:

$$\begin{aligned}
\Pi_{UR} &= n(p_E - c_U - k - t_{RU})x_{UR} = n\beta_R x_{UR}^2 \\
\Pi_{ER} &= m_E n(p_E - c_E - k - t_{RE})x_{ER} = m_E n\beta_R x_{ER}^2 \\
\Pi_{RR} &= m_R n(p_E - c_R)x_{RR} = m_R n\beta_R x_{RR}^2
\end{aligned} \tag{15}$$

When looking at welfare, the UK, the EU27 and the RoW will each be aggregated and treated as single entity. To aid the analysis, for each entity, total welfare will be split into domestic welfare and aggregate profits from exports of domestic firms. Domestic welfare of the UK, the EU27 and the RoW, is given by the sum of consumer surplus (3), the profits of the domestic firms in the domestic market, and tariff revenue, respectively:

$$\begin{aligned}
V_U &= \frac{\beta}{2} X_U^2 + \Pi_{UU} + t_{UE} X_{EU} + t_{UR} X_{RU} \\
V_E &= \frac{\beta_E}{2} X_E^2 + \Pi_{EE} + t_{EU} X_{UE} + t_{ER} X_{RE} \\
V_R &= \frac{\beta_R}{2} X_R^2 + \Pi_{RR} + t_{RU} X_{UR} + t_{RE} X_{ER}
\end{aligned} \tag{16}$$

The welfare obtained from exporting is given by the aggregate profits from exports of firms from the UK, the EU27 and the RoW are, respectively:

$$\Pi_U = \Pi_{UE} + \Pi_{UR}, \quad \Pi_E = \Pi_{EU} + \Pi_{ER}, \quad \Pi_R = \Pi_{RU} + \Pi_{RE} \tag{17}$$

Total welfare of the UK, the EU27 and the RoW is given by the sum of domestic welfare (16) and aggregate profits from exporting of domestic firms (17), which is:

$$W_Z = V_Z + \Pi_Z \quad Z = U, E, R \tag{18}$$

Before Brexit, when the UK is a member of the EU, it is in a customs union with the EU27 and there is free trade within the customs union, $t_{UE} = t_{EU} = 0$, while there is a common external tariff t_E on imports from the RoW so $t_{UR} = t_{ER} = t_E$. The RoW imposes its most-favoured-nation (MFN) tariff t_R on imports from the UK and the EU27 so $t_{RU} = t_{RE} = t_R$. Substituting these import tariffs into the equations above would give the equilibrium outputs, price and profits in the three markets and substituting these into (16), (17), and (18) would give domestic welfare denoted by V_Z^{eu} ; the aggregate profits of firms from exports denoted by Π_Z^{eu} ; and total welfare denoted by W_Z^{eu} for $Z = U, E, R$. Since these expressions are rather messy

they are not presented in the paper. These will provide the benchmarks for welfare comparisons of the Brexit options considered in later sections.

3. Hard Brexit: WTO Rules/No Deal Brexit

After withdrawal from the EU, one option for the UK either by design or by accident is a hard Brexit where the UK does not have a free trade agreement with the EU27 (or the RoW) but trades according to WTO rules. Assuming that the UK inherits the WTO commitments in the EU schedule of concessions regarding MFN tariffs then the UK bound tariff on imports of the oligopolistic product would be equal to the common external tariff of the EU, t_E .⁴ Assuming that the UK sets its tariff equal to the bound tariff, then UK exports to the EU27 would have to pay the EU27 common external tariff t_E so $t_{EU} = t_E$ and imports from the EU27 would have to pay the UK bound tariff $t_{UE} = t_E$. Imports from the RoW to the UK would face the same tariff as before Brexit when the UK was a member of the EU so the tariff would be $t_{UR} = t_E$. Therefore, a hard Brexit can be modelled as an increase in the UK tariff on imports from the EU27, t_{UE} , from zero to the UK bound tariff (inherited from the EU), t_E , and an increase in the EU27 tariff on imports from the UK, t_{EU} , from zero to the EU27 common external tariff, t_E .

To obtain the effect of a hard Brexit on the market (consumer) price in the UK and the EU27 markets, differentiate the UK market price (7) with respect to the UK tariff on imports from the EU27, t_{UE} , and the EU27 market price (11) with respect to the EU27 tariff on imports from the UK which yields:

⁴ For a review of the issues involved in the negotiating the UK's trade arrangements after Brexit, see: Holmes, Rollo, and Winters (2016).

$$\frac{\partial P_U}{\partial t_{UE}} = \frac{m_E n}{M} \in (0,1) \quad > \quad \frac{\partial P_E}{\partial t_{EU}} = \frac{n}{M} \in (0,1) \quad (19)$$

Since the number of countries in the EU27 is greater than one, $m_E > 1$ the market (consumer) price will increase by more in the UK than in the EU27, because the UK tariff is imposed on a larger number of firms (the $m_E n$ firms in the EU27) than the EU27 tariff (the n firms in the UK). Hence, a hard Brexit will impact consumers in the UK more than consumers in the EU27, which shows that the impact of a hard Brexit does not affect symmetrically the UK and the EU27.

A hard Brexit will increase the market price and reduce consumer surplus in the UK, but the UK will gain tariff revenue on imports from the EU27 and the profits of UK firms will increase in the UK market. The effect on domestic UK welfare of the UK imposing the tariff on imports from the EU27 is obtained by differentiating (16) with respect to the UK tariff on imports from the EU27, t_{UE} , which yields:

$$\frac{\partial V_U}{\partial t_{UE}} = (P_E - c_E) \frac{\partial X_{UU}}{\partial t_{UE}} + X_{EU} \left(1 - \frac{\partial P_U}{\partial t_{UE}} \right) - X_{RU} \frac{\partial P_U}{\partial t_{UE}} + t_{UE} \frac{\partial X_{EU}}{\partial t_{UE}} + t_E \frac{\partial X_{RU}}{\partial t_{UE}} \quad (20)$$

The first term is the profit-shifting effect, which is positive; the second term is the terms of trade effect on imports from the EU27, which is positive; the third term is the terms of trade effect on imports from the RoW, which is negative; the fourth term is the tariff revenue effect on imports from the EU27, which is negative; and the fifth effect is the tariff revenue effect on imports from the RoW, $t_{UR} = t_E$, which is positive. The overall effect on welfare is ambiguous, but it is quite possible that the effect may be positive (if the first two terms and the final term dominate the other two effects) and then imposing the tariff on imports from the EU27 may increase domestic welfare as with a rent-extracting tariff in Brander and Spencer (1984).

A hard Brexit will also affect UK exports to the EU27 market. To obtain the effect of a hard Brexit on the profits of the UK industry from exporting, differentiate aggregate profits from exports (17) with respect to the EU27 tariff on imports from the UK, which yields:

$$\frac{\partial \Pi_U}{\partial t_{EU}} = \frac{\partial \Pi_{UE}}{\partial t_{EU}} = 2n\beta_E X_{UE} \frac{\partial X_{UE}}{\partial t_{EU}} = -2 \left(1 - \frac{n}{M}\right) X_{UE} < 0 \quad (21)$$

Since markets are segmented and marginal cost is constant, the increase in the EU27 tariff does not affect UK exports to the RoW, but it does reduce UK exports to the EU27 and reduces the profit-margin on those exports. Hence, the EU27 tariff reduces the profits earned by UK firms from exporting to the EU27. In fact, since $2(1 - n/M) \in (8/5, 2)$, the reduction in profits from exports to the EU27 for UK firms is greater than the amount of the tariff even though part of the tariff is borne by EU27 consumers. The amount of tariff revenue paid by UK firms exporting to the EU27 is often regarded as an upper bound on the loss from a tariff on UK exports, which is the case under perfect competition, but is not the case under oligopoly where the lower bound is 1.6 times and the upper bound is twice the amount of the tariff revenue.⁵ The reason that the burden of the EU27 tariff on the profits of firms is larger than the amount of tariff revenue under oligopoly is that the tariff on UK exports gives EU firms and RoW firms, which are not subject to the tariff increase, a competitive advantage. A hard Brexit does not stop the UK exporting to the EU27 market, but the EU27 tariff leads to a decrease in exports and a reduction in the profitability of exporting.

Since the effect on total UK welfare is ambiguous, some further assumptions are required to obtain some clear-cut results. An obvious assumption is to impose symmetry so

⁵ Under perfect competition, if the profit function of UK firms is $\Pi_{UE}(P_E - t_{EU})$ then Hotelling's lemma implies that $\partial \Pi_{UE} / \partial t_{EU} = -X_{UE}$ if the market price in the EU27 does not change (the worst outcome for the profits of UK firms) and $\partial \Pi_{UE} / \partial t_{EU} = 0$ if the market price in the EU27 increases by the full amount of the tariff (the best outcome for the profits of UK firms). This is the negative terms of trade effect of the EU27 tariff on UK exports to the EU27.

that the number of countries in the EU27 and the RoW is equal so $m_E = m_R = m \geq 2$, and that all the firms have the same marginal cost so $c_U = c_E = c_R = c$ and the transport cost is equal to zero, $k = 0$. Then, the change in UK domestic welfare from a hard Brexit where the UK exits the EU and trades according to WTO rules is $\Delta V_U^{wto} = V_U^{wto} - V_U^{eu}$, which can be shown to be:

$$\Delta V_U^{wto} = \frac{mnt_E}{2\beta M^2} \left[2(2n+1)(\alpha - c) + (4n^2m^2 + (4n^2 + n)m - 2(n+1)^2)t_E \right] > 0 \quad (22)$$

A hard Brexit will increase domestic welfare in the UK due to the terms of trade effect and the profit-shifting effect of the UK tariff, but the EU tariff will decrease aggregate profits from exports for the UK. Then, the change in total UK welfare from a hard Brexit where the UK exits the EU and trades according to WTO rules is $\Delta W_U^{wto} = W_U^{wto} - W_U^{eu}$, which can be shown to be:

$$\Delta W_U^{wto} = \frac{mnt_E}{2\beta M^2} \left[2((4m-2)n+1)(\alpha - c) - n(4m^2n + (4m-2)n + 5m - 4)t_E \right] \quad (23)$$

When the common external tariff is zero, $t_E = 0$, the change in total welfare is zero, $\Delta W_U^{wto} = 0$, and decreasing in the tariff, $\partial \Delta W_U^{wto} / \partial t_E < 0$ at $t_E = 0$. Also, it can be shown that the change in total welfare is convex in the common external tariff, $\partial^2 \Delta W_U^{wto} / \partial t_E^2 > 0$, and when the tariff is equal to the prohibitive tariff, $t_E = \bar{t}_E = (\alpha - c) / (1 + n + mn)$, the change in total welfare can be shown to be:

$$\Delta W_U^{wto} \Big|_{t_E = \bar{t}_E} = - \frac{mn(\alpha - c)^2}{2\beta M^2(1 + n + mn)^2} \left[(4m^2 - 2)n^2 + 5mn + 2n + 2 \right] < 0 \quad (24)$$

Hence, the change in UK total welfare is negative for any EU common external tariff between zero and the prohibitive tariff, $t_E \in (0, \bar{t}_E]$. In this symmetric case, the overall effect of a hard Brexit where the UK exits the EU and trades according to WTO rules, is unambiguously

negative as the loss of profits for UK firms from exports to the EU27 outweighs the gains from introducing a tariff on imports from the EU27 in the domestic market. Figure 1 shows the changes in domestic welfare, aggregate profits from exports, and total welfare for the UK as a function of the common external tariff of the EU. This leads to the following proposition:

Proposition 1: *In the symmetric case, a hard Brexit increases domestic welfare, decreases aggregate profits from exports, and decreases total welfare in the UK.*

Now consider the effect of a hard Brexit on the EU27 starting with the effect on the profits of EU27 from exporting to the UK. To obtain the effect of a hard Brexit on the profits of the EU27 industry from exporting, differentiate aggregate profits from exports (17) with respect to the UK tariff on imports from the EU27, which yields:

$$\frac{\partial \Pi_E}{\partial t_{UE}} = \frac{\partial \Pi_{EU}}{\partial t_{UE}} = 2m_E n \beta_E x_{EU} \frac{\partial x_{EU}}{\partial t_{UE}} = -2 \left(1 - \frac{m_E n}{M} \right) X_{EU} < 0 \quad (25)$$

Since $2(1 - m_E n / M) \in (0, 2)$, the reduction in profits from exports to the UK for EU27 firms is greater than the amount of the tariff revenue, but smaller than the effect of the EU27 tariff on UK exports to the EU27 in (21), since $2(1 - m_E n / M) < 2(1 - n / M)$.⁶ This is because the number of UK firms exporting to the EU27 and subject to the EU27 tariff is smaller than the number of EU27 firms exporting to the UK and subject to the UK tariff. Therefore, the competitive disadvantage for UK firms is greater as they face a larger number of competitors that are not subject to the tariff increase. Hence, a hard Brexit will impact exporting firms in the UK more than exporting firms in the EU27, which again shows that the impact of a hard Brexit does not affect symmetrically the UK and the EU27. This is true even if one takes

⁶ The effect of the UK tariff on the aggregate profits from exports of EU27 firms will be equal to zero if the number of countries in the EU27 goes to infinity, $m_E \rightarrow \infty$. For $m_E = m_R = 5$ and $n = 3$, these effects on profits are $2(1 - m_E n / M) = 19/17 \approx 1.12$ for the EU27 and $2(1 - n / M) = 31/17 \approx 1.82$ for the UK.

account of the fact that the EU27 has a trade surplus with the UK, a fact that is often used to justify the claim that the EU27 is in a weak bargaining position.⁷

A similar welfare analysis can be undertaken for the EU27 as for the UK, in the symmetric case. Like the UK, the domestic welfare of the EU27 increases as a result of a hard Brexit but profits of EU27 firms from exports to the UK decrease so the overall effect on total EU27 welfare is ambiguous. The change in total EU27 welfare from a hard Brexit where the UK trades according to WTO rules is $\Delta W_E^{wto} = W_E^{wto} - W_E^{eu}$, which can be shown to be:

$$\Delta W_E^{wto} = -\frac{mnt_E}{2\beta M^2} \left[2(2n+1)(\alpha-c) - (2n^2m^2 + 2(n-1)nm + (2n+3)n)t_E \right] \quad (26)$$

When the common external tariff is zero, $t_E = 0$, the change in total welfare is zero, $\Delta W_E^{wto} = 0$, and it is decreasing in the tariff, $\partial \Delta W_E^{wto} / \partial t_E < 0$ at $t_E = 0$. Also, it can be shown that the change in total welfare is convex in the common external tariff, $\partial^2 \Delta W_E^{wto} / \partial t_E^2 > 0$, and when the tariff is equal to the prohibitive tariff, $t_E = \bar{t}_E = (\alpha - c) / (1 + n + mn)$, the change in total welfare can be shown to be:

$$\Delta W_E^{wto} \Big|_{t_E = \bar{t}_E} = \frac{mn \left[2n^2m^2 - 2n(n+2)m - (n^2 + 3n + 2) \right]}{2\beta M^2 (1 + n + mn)^2} \quad (27)$$

The sign of this expression is ambiguous, but it will be positive if the number of countries in the EU27 and the RoW, m , is greater than the critical value, m_{wto}^* :

$$m > m_{wto}^* \equiv \frac{1}{2n} \left[n + 2 + \sqrt{5n^2 + 10n + 8} \right] \quad (28)$$

⁷ In 2016, UK exports to the EU27 were £236 billion and EU27 exports to the UK were £318 billion but, using the figures from the previous footnote, the cost of a 1% tariff on UK exporters would have been £4.3 billion and on EU exporters would have been £3.6 billion.

The critical value, m_{wto}^* , is decreasing in the number of firms in each country, n , from $(3 + \sqrt{23})/2 \approx 3.90$ when $n = 1$ to $(1 + \sqrt{5})/2 \approx 1.62$ as $n \rightarrow \infty$. If $m < m_{wto}^*$ then a hard Brexit will decrease total welfare of the EU27, but if $m > m_{wto}^*$ then a hard Brexit may increase total welfare in the EU27. When $m > m_{wto}^*$, there exists a critical value of the EU common external tariff, t_E^* such that the change in total welfare is negative for $t_E \in [0, t_E^*)$ and positive for $t_E \in (t_E^*, \bar{t}_E]$. The critical value t_E^* can be obtained by setting (26) equal to zero and solving for the critical value of the common external tariff:

$$t_E^* \equiv \frac{2(2n+1)(\alpha - c)}{n(2nm^2 + 2(n-1)m + 2n + 3)} > 0 \quad (29)$$

Therefore, the EU27 may gain from a hard Brexit, which leads to the following proposition:

Proposition 2: *In the symmetric case, if $m < m_{wto}^*$ or if $m > m_{wto}^*$ and $t_E < t_E^*$, then a hard Brexit decreases total welfare in the EU27, but if $m > m_{wto}^*$ and $t_E > t_E^*$ then a hard Brexit increases total welfare in the EU27.*

The reason that the EU27 may gain from a hard Brexit whereas the UK unambiguously loses is that the size of the domestic market relative to the size of the export market. There is an increase in domestic welfare in the UK and the EU27 from imposing tariffs on imports and a decrease in aggregate profits as a result of tariffs imposed on their exports. Since, the domestic market of the EU27 is large relative to its export market where tariffs are imposed (the UK market), the EU27 may gain from a hard Brexit. However, for the UK, the domestic market is small relative to the export market where tariffs are imposed (the EU27 market), the UK unambiguously loses from a hard Brexit. Note that this result contrasts with a common misconception that the EU27 will lose from a hard Brexit since it has a trade surplus with the

UK, and therefore the UK is in a strong bargaining position. Here, under a hard Brexit, the EU27 has a trade surplus with the UK in the oligopolistic good but the UK unambiguously loses from a hard Brexit and the EU27 may gain.⁸

The effect of a hard Brexit where the UK trades according to WTO rules on the RoW welfare will be through its effect on the aggregate profits from exports of firms in the RoW as there will be no effect on domestic welfare in the RoW due to the assumption of segmented markets and constant marginal cost. The effect of a hard Brexit on the aggregate profits from exports of RoW firms can be obtained by differentiating Π_R with respect to the tariff imposed by the UK on imports from the EU27, t_{UE} , and the tariff imposed by the EU27 on imports from the UK, t_{EU} , which yields:

$$\begin{aligned}\frac{\partial \Pi_R}{\partial t_{UE}} &= \frac{\partial \Pi_{RU}}{\partial t_{UE}} = 2m_R n \beta x_{RU} \frac{\partial x_{RU}}{\partial t_{UE}} = \frac{2m_E n}{M} X_{RU} > 0 \\ \frac{\partial \Pi_R}{\partial t_{EU}} &= \frac{\partial \Pi_{RE}}{\partial t_{EU}} = 2m_R n \beta_E x_{RE} \frac{\partial x_{RE}}{\partial t_{EU}} = \frac{2n}{M} X_{RE} > 0\end{aligned}\tag{30}$$

A hard Brexit increases the costs of UK firms exporting to the EU27 market and raises the costs of EU27 firms exporting to the UK, which will benefit firms in the RoW exporting to the UK and the EU27 markets. Therefore, the RoW will unambiguously gain from a hard Brexit where the UK trades according to WTO rules, which leads to the following proposition:

Proposition 3: *A hard Brexit will increase aggregate profits from exports in the RoW and hence total welfare in the RoW.*

Firms in the RoW make higher profits because the costs of their rivals in their export markets (EU27 firms in the UK market and UK firms in the EU27 market) are raised, which

⁸ Under a hard Brexit, the UK has a trade deficit (and the EU27 has a trade surplus) in the oligopolistic good since the value of UK exports is less than the value of imports $(P_E^{wto} - t_E) X_{UE}^{wto} - (P_U^{wto} - t_E) X_{EU}^{wto} < 0$.

will increase both their exports and the profit-margin on their exports.⁹ Hence, there will be an increase in their aggregate profits from exports, and an increase in total RoW welfare.

Figure 2 shows the change in total welfare for the UK, the EU27, the RoW and the World of a hard Brexit where the UK trades according to WTO rules in the symmetric case. In line with the propositions, it can be seen that there is an unambiguous loss for the UK; that there is a loss (gain) for the EU27 if the common external tariff is low (high); that there is an unambiguous gain for the RoW; and that there is an overall loss for the World economy.

This analysis assumes that the trade barriers (apart from the transport cost k) are tariff barriers, but non-tariff barriers are also significant barriers to trade nowadays. Non-tariff barriers can easily be incorporated into the analysis by assuming that a proportion μ of any trade barrier is a tariff barrier and a proportion $1 - \mu$ is a non-tariff barrier.¹⁰ This will alter the domestic welfare of the UK, the EU27 and the RoW in (16), as the non-tariff barriers will not generate any tariff revenue and hence, for example, the tariff revenue of the UK will be $\mu(t_{UE}X_{EU} + t_{UR}X_{RU})$. This will reduce the gains to domestic welfare from the introduction of trade barriers on trade between the UK and the EU27, but will not affect the losses to aggregate profits from exports as in this case it makes no difference if the trade barriers are tariff or non-tariff barriers. Assuming that $\mu = 1/2$ in the symmetric case, figure 3 shows the changes in domestic welfare, aggregate profits from exports and total welfare of a hard Brexit as function of the common external trade barrier of the EU, and it can be seen that the effect on domestic welfare of the UK now may be negative when the trade barrier is low. This is because the introduction of trade barriers that are half tariffs and half non-tariff barriers with a hard Brexit

⁹ This result applies to firms in the RoW that supply the UK and EU27 markets by exporting from their home country. If there were RoW firms in the model that supplied the UK and EU27 markets by undertaking FDI rather than exporting from the RoW then they would be in the same position as UK and EU27 firms, and would lose from a hard Brexit.

¹⁰ A similar approach is used by Collie (2016) in the analysis of the gains from variety in a free-entry Cournot oligopoly model.

raises less tariff revenue than when the trade barriers are purely tariffs. Figure 4 shows the change in total welfare for the UK, the EU27, the RoW, and the World of a hard Brexit. In contrast to figure 2, the effect of a hard Brexit on the EU27 is now unambiguously negative so both the UK and the EU27 lose while the RoW still gains from a hard Brexit.

4. Unilateral Trade Liberalisation

The UK bound tariff after Brexit, which is assumed to be equal to the common external tariff of the EU, is an upper bound on the tariff set by the UK as the applied tariff can be lower than the bound tariff under WTO rules. It has been suggested that the UK could pursue a policy of unilateral free trade after Brexit by unilaterally reducing its applied tariff to zero like Singapore.¹¹ Alternatively, the UK could pursue a policy of unilateral trade liberalisation by reducing its applied tariff to some rate between zero and the bound tariff. With unilateral trade liberalisation, the UK applied tariff is $t_{UE} = t_{UR} = t_U \in [0, t_E]$, the EU27 common external tariff is $t_{EU} = t_{ER} = t_E$, and the RoW tariff is $t_{RU} = t_{RE} = t_R$.¹²

Comparing the price of the oligopolistic good in the UK market under EU membership, hard Brexit, and unilateral free trade it can easily be shown that $P_U^{uni} < P_U^{eu} < P_U^{wto}$. Unilateral free trade leads to a lower price of the oligopolistic good than under a hard Brexit or under EU membership so as one would expect consumers gain, but the effect on domestic firms and government revenue also has to be considered. Starting from a hard Brexit where the UK trades according to WTO rules, unilateral trade liberalisation does not affect the exports of the UK to

¹¹ Although Singapore pursues a policy of unilateral free trade, it is a member of the Association of Southeast Asian Nations (ASEAN) and has regional and/or bilateral free trade agreements agreed or pending with all its major export destination countries (China, Malaysia, Indonesia, Hong Kong and the EU) that account for 53% of its merchandise exports plus agreements with many other countries (eg. Japan, Korea, India, Australia and New Zealand). See: <https://www.iesingapore.gov.sg/Trade-From-Singapore/International-Agreements/free-trade-agreements/Singapore-FTA>.

¹² Note that the most-favoured nation (MFN) principle of the WTO does not allow countries to discriminate between WTO members when setting tariffs. In an oligopoly model of trade, Saggi (2004) shows that the adoption of MFN by countries improves world welfare.

the EU27 or the RoW so it can be analysed by looking solely at the effect on domestic welfare of the UK. The domestic welfare effect of an increase in the UK tariff on imports from EU27 and the RoW can be obtained by differentiating (16) with respect to t_U :

$$\frac{\partial V_U}{\partial t_U} = (P_E - c_E) \frac{\partial X_{UU}}{\partial t_U} + (X_{EU} + X_{RU}) \left(1 - \frac{\partial P_U}{\partial t_U} \right) + t_U \frac{\partial (X_{EU} + X_{RU})}{\partial t_U} \quad (31)$$

The first term is the profit-shifting effect, which is positive since price is above marginal and the tariff increases the output of the UK firms; the second term is the terms of trade effect on imports, $X_{EU} + X_{RU}$, which is positive as the UK market price increases by less than the amount of the tariff; and the third term is the tariff revenue effect, which is negative since the tariff reduces imports. If the tariff is equal to zero then the third term is zero while the first and second terms are both positive so a small tariff will increase the domestic welfare of the UK. The optimal tariff can be obtained by setting (31) equal to zero and solving for the optimal tariff, which yields:

$$t_U^* = \frac{(P_E - c_E) \frac{\partial X_{UU}}{\partial t_U} + (X_{EU} + X_{RU}) \left(1 - \frac{\partial P_U}{\partial t_U} \right)}{\frac{\partial (X_{EU} + X_{RU})}{\partial t_U}} > 0 \quad (32)$$

The optimal tariff for the UK is positive due to the profit-shifting effect and the terms of trade effect as in Brander and Spencer (1984). Therefore, unilateral free trade is not the optimal policy for the UK as reducing the tariff below the optimal tariff will reduce UK domestic welfare.¹³ This is the rationale for countries to engage in multilateral trade liberalisation through free trade agreements or the GATT/WTO negotiating rounds rather than

¹³ In Dhingra et al. (2017), the optimal uniform tariff is 15% while the average tariff is about 3%, but unilateral trade liberalisation increases UK welfare by 0.3% compared to a hard Brexit. Presumably, the explanation is that the current tariff structure (EU common external tariffs) has tariffs that are too high on some products.

pursuing unilateral trade liberalisation. Under Cournot oligopoly, Collie (1996) shows that there may be losses from unilateral free trade and that multilateral trade liberalisation is more likely to lead to gains for all countries. The point that unilateral trade liberalisation may reduce welfare does not rely on the assumption of imperfect competition as a large perfectly competitive country will also have a positive optimum tariff as a result of the terms of trade argument for protection and unilateral free trade will not be optimal in this case.¹⁴

In the symmetric case, the change in UK domestic welfare as a result of moving from EU membership to unilateral free trade, $t_U = 0$, is $\Delta V_U^{uni} = V_U^{uni} - V_U^{eu}$, which can be shown to be;

$$\Delta V_U^{uni} = \frac{-mnt_E}{2\beta M^2} \left[2(2n+1)(\alpha - c) - (4m^2n^2 + 4mn^2 + 2n^2 + 5mn + 4n + 2)t_E \right] \quad (33)$$

When the common external tariff is zero, $t_E = 0$, the change in domestic welfare is zero and it is decreasing in the tariff, $\partial \Delta V_U^{uni} / \partial t_E < 0$, at $t_E = 0$. Also, it can be shown that the change in domestic welfare is convex in the tariff, $\partial^2 \Delta V_U^{uni} / \partial t_E^2 > 0$, and when the tariff is equal to the prohibitive tariff, $t_E = \bar{t}_E$, it can be shown to be equal to:

$$\Delta V_U^{uni} \Big|_{t_E = \bar{t}_E} = \frac{mn^2(\alpha - c)^2}{2\beta M^2(1 + n + mn)^2} [4m^2n + 3m - 2n - 2] > 0 \quad (34)$$

Since the change in domestic welfare is initially negative and then positive at the prohibitive tariff, there must be a critical value of the tariff that can be obtained by setting (33) and solving for the critical value of the tariff:

¹⁴ Supporters of unilateral free trade after Brexit may argue that all markets are perfectly competitive and that the UK is a small country and therefore that its optimum tariff is zero, but this ignores the evidence from Broda, Limão, and Weinstein (2008, p.2063): ‘many economists simply assumed that most countries are small, i.e., do not have market power in trade. One of the contributions of this work is to demonstrate that this assumption is not correct. This is likely to have important implications in areas like computable general equilibrium modeling where small country assumptions are often the rule.’

$$\tilde{t}_E^{uni} = \frac{2(2n+1)(\alpha-c)}{4m^2n^2 + 4mn^2 + 2n^2 + 5mn + 4n + 2} > 0 \quad (35)$$

Therefore, the change in domestic welfare is negative for $t_E \in (0, \tilde{t}_E^{uni})$ and positive for $t_E \in (\tilde{t}_E^{uni}, \bar{t}_E]$, whereas the change in domestic welfare was always positive for a hard Brexit so unilateral free trade may be a worse policy than a hard Brexit. The effect of unilateral free trade on the aggregate profits from exports of the UK firms is the same as in the case of a hard Brexit as the UK firms will face the EU27 tariff on their exports to the EU27.

The change in total UK welfare as a result of moving from EU membership to unilateral free trade is the sum of the change in domestic welfare and the change in aggregate profits from exports, and is given by $\Delta W_U^{uni} = W_U^{uni} - W_U^{eu}$, which can be shown to be:

$$\begin{aligned} \Delta W_U^{uni} = & \frac{mnt_E}{2\beta M^2} \left[2(4mn + 2n + 3)(\alpha - c) \right. \\ & \left. - (4m^2n^2 + 4mn^2 + 2n^2 + 9mn + 4n + 4)t_E \right] \end{aligned} \quad (36)$$

When the common external tariff is equal to zero, $t_E = 0$, the change in total welfare is zero and it is decreasing in the tariff, $\partial \Delta W_U^{uni} / \partial t_E < 0$. Also, it can be shown that the change in welfare is everywhere convex in the tariff, $\partial^2 \Delta W_U^{uni} / \partial t_E^2 > 0$, and that it is negative at the prohibitive tariff, $\Delta W_U^{uni} < 0$ when $t_E = \bar{t}_E$. Therefore, the change in total UK welfare as a result of moving from EU membership to unilateral free trade is always negative. Figure 5 shows the changes in domestic welfare, aggregate profits from exports, and total welfare for the UK as a function of the common external tariff of the EU for unilateral free trade. This leads to the following proposition:

Proposition 4: *In the symmetric case, unilateral free trade decreases (increases) UK domestic welfare if $t_E < (>) \tilde{t}_E^{uni}$, decreases the aggregate profits from exports of UK firms, and decreases total UK welfare.*

For the EU27 and the RoW, compared to hard Brexit, the only difference with unilateral free trade is that EU27 and RoW firms will not pay a tariff on their exports to the UK. Firms from the EU27 (RoW) will see a reduction in the tariff on their exports and on the exports of their RoW (EU27) competitors. Compared to a hard Brexit, the effect of a change in the UK tariff on the aggregate profits of firms from the EU27 and the RoW can be obtained by setting $t_{UE} = t_{UR} = t_U$ in (5) and (8) then differentiating (17) with respect to t_U , which yields:

$$\frac{\partial \Pi_{ZU}}{\partial t_U} = 2\beta X_{ZU} \frac{\partial x_{ZU}}{\partial t_U} < 0 \quad Z = E, R \quad (37)$$

This is unambiguously negative so a reduction in the UK tariff will increase the aggregate profits from exports of firms from the EU27 and the RoW. Hence, since the RoW firms unambiguously gained from hard Brexit, it will undoubtedly be the case that they gain from unilateral free trade compared to when the UK was a member of the EU. Neither a hard Brexit or unilateral free trade by the UK has an effect on domestic welfare in the RoW hence, since aggregate profits from exports increase for firms in the RoW, total welfare will increase in the RoW. This leads to the following proposition:

Proposition 5: *Unilateral free trade increases the aggregate profits from exports for the RoW firms and hence total RoW welfare.*

However, the effect of a hard Brexit on the EU27 was ambiguous so it not clear whether the EU27 will gain from unilateral free trade compared to when the UK was a member of the EU. In the symmetric case, the change in total EU27 welfare $\Delta W_E^{uni} = W_E^{uni} - W_E^{eu}$ can be shown to be:

$$\Delta W_E^{umi} = \frac{mnt_E}{2\beta M^2} \left[2(\alpha - c) + (2m^2n^2 + 2mn^2 - 2mn - n - 2)t_E \right] \quad (38)$$

When the common external tariff is equal to zero, $t_E = 0$, the change in total welfare is zero and it is increasing in the tariff, $\partial \Delta W_E^{umi} / \partial t_E > 0$. Also, the change in total welfare is convex in the tariff and when the tariff is equal to the prohibitive tariff, $t_E = \bar{t}_E$, the change in total welfare can be shown to be positive. Therefore, the change in EU27 total welfare as a result of unilateral free trade is positive for any tariff, $t_E \in (0, \bar{t}_E]$. This leads to the following proposition:

Proposition 6: *In the symmetric case, unilateral free trade increases the total EU27 welfare.*

Figure 6 shows the change in total welfare for the UK, the EU27, the RoW and the World of unilateral free trade where the UK reduces its tariff to zero in the symmetric case. It can be seen that there is an unambiguous loss for the UK; that there is an unambiguous gain for the EU27; that there is an unambiguous gain for the RoW; and that there is an overall loss for the World economy. The only qualitative difference compared to a hard Brexit is that the EU27 always gains so once again this option does not give the UK a strong bargaining position in negotiations with the EU27.

As in the previous section, non-tariff barriers to trade can easily be incorporated into the analysis. Assuming that $\mu = 1/2$ in the symmetric case, figure 7 shows the changes in domestic welfare, aggregate profits from exports, and total welfare for the UK as a function of the common external trade barrier of the EU for unilateral free trade. In comparison to figure 5, there is an unambiguous increase in domestic welfare, since eliminating trade barriers involves a smaller loss of tariff revenue when the trade barriers are half tariffs and half non-tariff barriers, but there is still an unambiguous decrease in total welfare from unilateral free

trade. Figure 8 shows the change in total welfare for the UK, the EU27, the RoW and the World of unilateral free trade in the symmetric case. In contrast to figure 6, there is an unambiguous loss for the EU27 so the UK and the EU27 lose while the RoW gains from unilateral free trade.

While a unilateral reduction in all tariffs to zero may not be desirable in this model, in practice, there is scope after Brexit for the UK to reduce protection in the case of heavily-protected sectors such as agricultural products protected by high tariffs and tariff-rate quotas; industries protected by anti-dumping duties; and the car industry where the tariff of 10% is high compared to other manufacturing industries.¹⁵

5. Free Trade with the Rest of the World

An alternative to a hard Brexit or unilateral free trade is for the UK to negotiate trade agreements with other countries such as the USA, Japan, Canada, South Korea, Mexico, India, China, etc. The EU already has free trade agreements with Japan, Canada, South Korea, Mexico, etc. so negotiating free trade agreements with these countries would merely replace the EU free trade agreement with a UK free trade agreement. Therefore, the UK would have to negotiate a large number of free trade agreements to replicate membership of the EU, and mainly with countries that are not close neighbours. This raises the question of what makes a desirable free trade agreement for the UK in comparison to membership of the EU.

In this simple model, this option can be modelled as the UK swapping from having a free trade agreement with the EU27 (EU membership), $t_{UE} = t_{EU} = 0$, to having a free trade agreement with the RoW, $t_{UR} = t_{RU} = 0$. Since there would be no incentive for other countries to form a free trade area with the UK if it pursued a policy of unilateral free trade, the UK tariff

¹⁵ Messerlin (2001) measured the cost of protection in the EU for 22 highly protected sectors and not all of these sectors have been liberalised in the meantime. High levels of protection are often the result of contingent protection such as anti-dumping duties or countervailing duties, where the policy of the UK after Brexit is unclear, but where there would be scope for a more liberal trade policy.

on imports from the EU27 will be assumed to be the bound MFN tariff inherited from the EU, $t_{UE} = t_E$.¹⁶ By comparing welfare from a free trade area with the RoW with welfare from a free trade area with the EU27 (EU membership), the factors that would make such a swap beneficial can be ascertained. To make such comparisons tractable, they will be undertaken in by looking at differences in one factor (size differences, tariffs, cost differences and transport cost) at a time while keeping all the other parameters as in the symmetric case. The change in welfare from such a swap is $\Delta W_U^{fta} = W_U^{fta} - W_U^{eu}$. Firstly, consider the effects of differences in the size of the EU27 and the RoW measured by the number of identical countries in each market, m_E and m_R respectively. Setting the costs of all firms equal, $c_U = c_E = c_R = c$; the tariffs all equal, $t_E = t_R = t > 0$; and the transport cost equal to zero, $k = 0$; the change in welfare from a free trade area with the RoW is:

$$\Delta W_U^{fta} = \frac{nt(m_R - m_E)}{2\beta M^2} \left[2(2(m_E + m_R - 1)n + 1)(\alpha - c) - (2(m_E + m_R + 1)(m_E + m_R - 1)n + 3(m_E + m_R) - 4)t \right] \quad (39)$$

Since the term in square brackets can be shown to be positive, *ceteris paribus*, a free trade agreement with the RoW will be beneficial for the UK if the RoW market is larger than the EU27 market, $m_R > m_E$, as one would expect. As the EU has free trade agreements with the European Free Trade Association (EFTA), Canada, South Korea, Turkey and Mexico, and has recently reached an agreement in principle with Japan, EU membership allows free trade with a market much larger than the EU27 market.¹⁷ Therefore, the UK would need to negotiate free trade agreements with a large number of countries in order to be better off than as a member

¹⁶ In practice, free trade agreements are about a lot more than tariffs as can be seen by Singapore negotiating many free trade agreements despite pursuing a policy of unilateral free trade.

¹⁷ In the case of Turkey there is an EU-Turkey customs union. The European Free Trade Association (EFTA) consists of Switzerland, Norway, Iceland and Liechtenstein. The EFTA countries apart from Switzerland are part of the European Economic Area (EEA).

of the EU or as a party to a free trade agreement with the EU. Of course, the UK can negotiate free trade agreements with some of the countries that have free trade agreements with the EU.

Secondly, consider the effects of differences in the tariffs of the EU27 and the RoW, t_E and t_R respectively, on the desirability of a free trade agreement with the RoW. Setting the costs of EU27 and RoW firms equal, $c_E = c_R = c$; the transport cost equal to zero, $k = 0$; and the sizes of the EU27 and the RoW markets equal, $m_E = m_R = m$; the change in welfare from a free trade agreement with the RoW is:

$$\Delta W_U^{fta} = \frac{mn(2mn+1)(t_R-t_E)}{\beta M^2} [2\alpha - 2(2mn+1)c_U + 4mnc - t_E - t_R] \quad (40)$$

Since the term in square brackets is positive if UK exports to the EU27 and the RoW are positive, *ceteris paribus*, a free trade area with the RoW is beneficial if the RoW tariff is higher than the EU27 tariff, $t_R > t_E$. This is a fairly obvious, but somewhat paradoxical point. The benefits of entering a free trade agreement are increasing in the tariff avoided so there is more to be gained from a free trade agreement with a protectionist bloc than with a free trading bloc.

Thirdly, consider the effects of the transport cost on the desirability of a free trade agreement with the RoW. Recall that the transport cost k is incurred on trade between the UK/EU27 and the RoW whereas there is no transport cost on trade between the UK and EU27. Setting the costs of the EU27 and the RoW firms equal, $c_E = c_R = c$; the sizes of the EU27 and the RoW markets equal, $m_E = m_R = m$; and the EU27 and RoW tariffs equal, $t_E = t_R = t > 0$; the change in welfare from a free trade agreement with the RoW is:

$$\Delta W_U^{fta} = -\frac{mntk}{\beta M^2} [4m^2n^2 - 4mn^2 + 4mn - n^2 - 2n + 1] \quad (41)$$

Since the term in square brackets is positive, *ceteris paribus*, a free trade agreement with the RoW will not be beneficial if the transport cost is positive, $k > 0$. As a result of the transport cost, the price-cost margin of UK firms in the RoW market with a free trade agreement will be lower than their price-cost margin in the EU27 market when the UK is a member of the EU. Therefore, UK firms gain more from the competitive advantage, relative to RoW firms, from being a member of the EU than they gain from the competitive advantage, relative to EU firms, from being in a free trade agreement with the RoW. Free trade agreements with distant countries that involve a significant transport cost will be less beneficial, *ceteris paribus*, than a free trade agreement with the EU27.

Fourthly, consider the effects of differences in costs between EU27 firms and RoW firms on the desirability of a free trade agreement with the RoW. Setting the sizes of the two markets equal, $m_E = m_R = m$; all the tariffs equal, $t_E = t_R = t$; and setting the transport cost equal to zero, $k = 0$; the change in welfare from a free trade agreement with the RoW is:

$$\Delta W_U^{fa} = \frac{mnt}{\beta}(c_R - c_E) \quad (42)$$

This is positive if the firms in the RoW have higher marginal costs than firms in the EU27. The reason is that if the EU firms have a cost advantage over RoW firms then they will export more to the UK when the UK has a free trade agreement with the RoW than RoW firms will export to the UK when the UK has a free trade agreement with the EU27. Therefore, the UK will receive more tariff revenue when it has a free trade agreement with the RoW than when it has a free trade agreement with the EU. Note that whether the UK has a free trade agreement with the RoW or the EU27 does not affect the aggregate profits of UK firms from exporting as the game is aggregative.¹⁸ Similarly, it does not affect the output of UK firms or

¹⁸ Since marginal cost is constant, the Cournot oligopoly model is an example of an aggregative game where aggregate output only depends upon the sum of marginal costs, see Bergstrom and Varian (1985).

the market price in the UK domestic market, and the only difference is the tariff revenue. It is perhaps counterintuitive that a free trade agreement with the country that has the high cost firms would be beneficial. These results lead to the following proposition:

Proposition 7: *A free trade agreement with the RoW will be beneficial, ceteris paribus, if: (i) the RoW market is larger than the EU27 market, $m_R > m_E$; (ii) the RoW tariff is higher than the EU tariff, $t_R > t_E$; (iii) firms in the RoW have higher costs than firms in the EU27, $c_R > c_E$; but will not be beneficial, ceteris paribus, if the transport cost is positive, $k > 0$.*

Supporters of a hard Brexit often argue that the EU is protectionist and inefficient so they presumably believe that the EU27 has higher tariffs than the RoW, $t_E > t_R$, and that EU27 firms have higher costs than RoW firms, $c_E > c_R$, and hence they argue that the UK should enter into a free trade agreement with countries in the RoW rather than the EU27. However, the results in proposition 7 imply that in this case the UK should enter into a free trade agreement with the EU27. Similarly, the fact that the EU27 market is large (as it has free trade agreements with Canada, South Korea, Mexico, etc) and it is close to the UK (so low transport costs) imply that the UK should ideally enter into a free trade agreement with the EU27. Of course, the UK negotiating a free trade agreement with both the EU27 and the RoW would be the best outcome for the UK, which is the *have your cake and eat it* solution so beloved by Boris Johnson.

6. Conclusions

This paper has analysed various options for Brexit in an oligopoly model that provides an alternative perspective to perfectly competitive models and monopolistically competitive models that have so far been used to analyse Brexit. In oligopoly models, firms make pure profits and these profits contribute to the welfare of a country. In comparison to other models,

this increases the costs from a hard Brexit that sees tariffs imposed on the UK's exports to the EU27, and increases the benefits from free trade agreements that eliminate tariffs on UK exports.

Under a hard Brexit, the UK exits the EU and trades according to WTO rules with the UK imposing tariffs on EU27 exports to the UK and the EU27 imposing tariffs on UK exports to the EU27. The welfare effect on the UK was unambiguously negative as the gains from introducing a tariff in the domestic market were outweighed by the loss of profits from exports to the EU27. The welfare effect on the EU27 was ambiguous and it was possible that the EU27 may gain from a hard Brexit if the gain from a tariff in the domestic market outweighed the loss of profits from exports to the UK. The welfare effect on the RoW was unambiguously positive as firms in the RoW gained a competitive advantage in the UK market where the costs of their EU27 competitors increased and in the EU27 market where the costs of their UK competitors increased. With non-tariff barriers, it was shown that the UK and the EU27 would both lose from a hard Brexit.

Under unilateral free trade, after Brexit the UK eliminates its tariff on imports but the EU27 still imposes a tariff on UK exports to the EU27 market. The welfare effect on the UK was shown to be unambiguously negative while the welfare effects on the EU27 and the RoW were unambiguously positive. Since the optimum tariff of the UK is positive under imperfect competition (or in the case of a large country), unilateral trade liberalisation will decrease UK welfare and this is the reason that countries pursue multilateral free trade rather than unilateral free trade. With non-tariff barriers, it was shown that the UK and the EU27 would both lose from unilateral free trade.

It has been shown that it is quite possible that the EU27 gains while the UK loses from a hard Brexit (or from unilateral free trade). This suggests that the bargaining position of the UK is not as strong as suggested by some commentators who propose that the UK should walk

away from the negotiations. The reason that a hard Brexit may have an asymmetric impact on the UK and the EU27 is the small size of the UK relative to the EU27. It was shown that the tariff imposed by the UK on imports from the EU27 would have a larger effect on the market price in the UK market than the tariff imposed by the EU27 on imports from the UK would have on the market price in the EU27. Similarly, it was shown that the EU27 tariff imposed on UK exports to the EU27 would have a larger (negative) effect on the profits of UK firms than the UK tariff imposed on EU27 exports to the UK would have on the profits of EU27 firms.

A possible advantage of Brexit is that the UK can pursue its own trade policy and negotiate free trade agreements with other countries such as the USA, China and India. It was shown that replacing EU membership with a free trade agreement with the RoW would be beneficial, *ceteris paribus*, if the RoW market was larger than the EU market; if the RoW tariff was higher than the EU tariff; if the RoW firms had higher costs than EU firms; and would not be beneficial if there was a significant transport cost on trade between the RoW and the UK/EU27. This shows that the greatest benefits from a free trade agreement come from getting tariff-free access to a large protected market, which is just how many supporters of a hard Brexit would describe the EU!

This simple model has employed the homogeneous product Cournot oligopoly model with linear demands and constant marginal costs. There are a number of possible extensions that can be envisioned but all would make the model much less tractable and one would probably have to resort to calibration to get any results. One extension would be to consider more general demand functions and/or differentiated products. Differentiated products would give individual firms more market power and introduce the possibility of gains from variety as in Krugman (1979). Another possibility would be to assume Bertrand competition between firms rather than Cournot competition, which would change the nature of competition between the firms. A further possibility, would be to allow the market structure to be endogenous by

allowing free entry and exit as in Venables (1985), but then firms would make zero profits in equilibrium. Ideally, one would like to be able to model oligopoly in a general equilibrium setting with many industries as in Neary (2016), but such models are still in their infancy.

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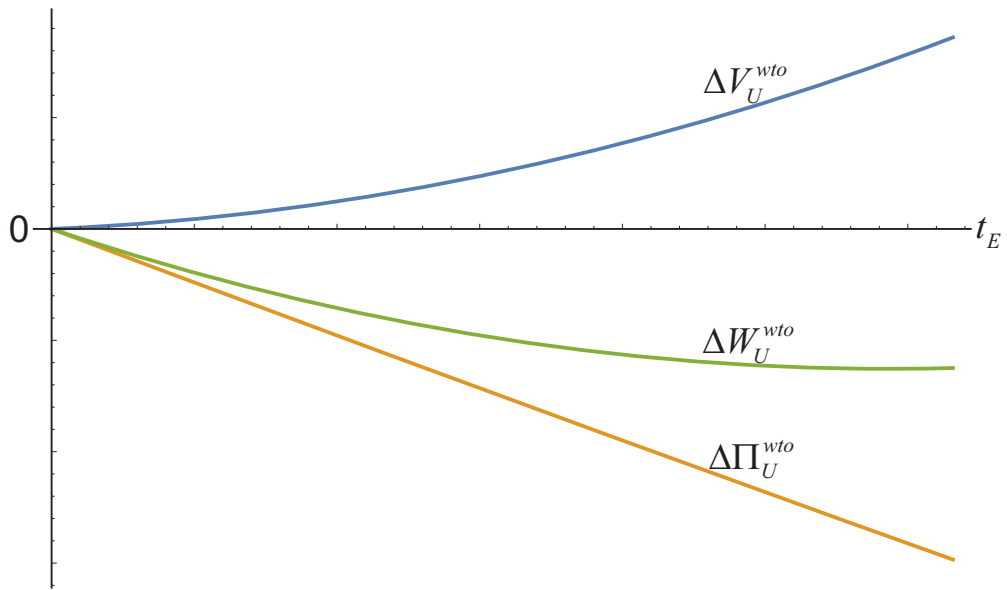


Figure 1: Effects of WTO Rules on UK Welfare

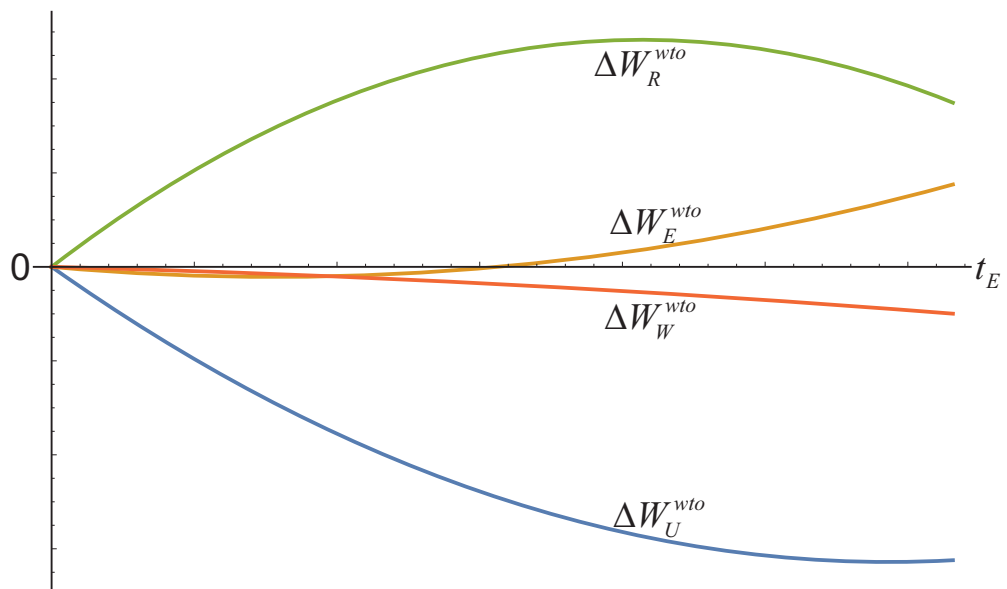


Figure 2: Welfare Effects of WTO Rules on the UK, the EU27, the RoW and the World

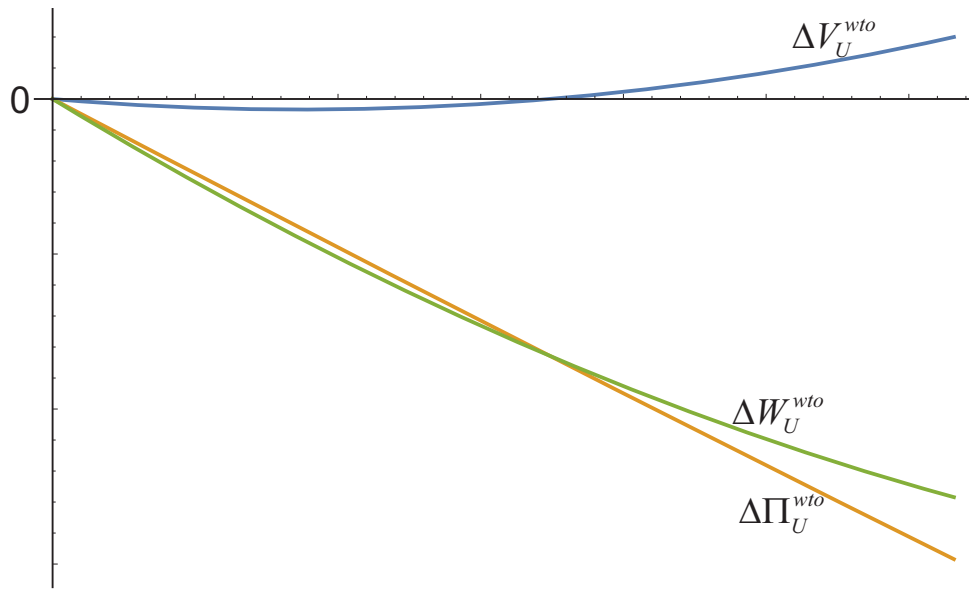


Figure 3: Effects of WTO Rules on UK Welfare with Non-Tariff Barriers

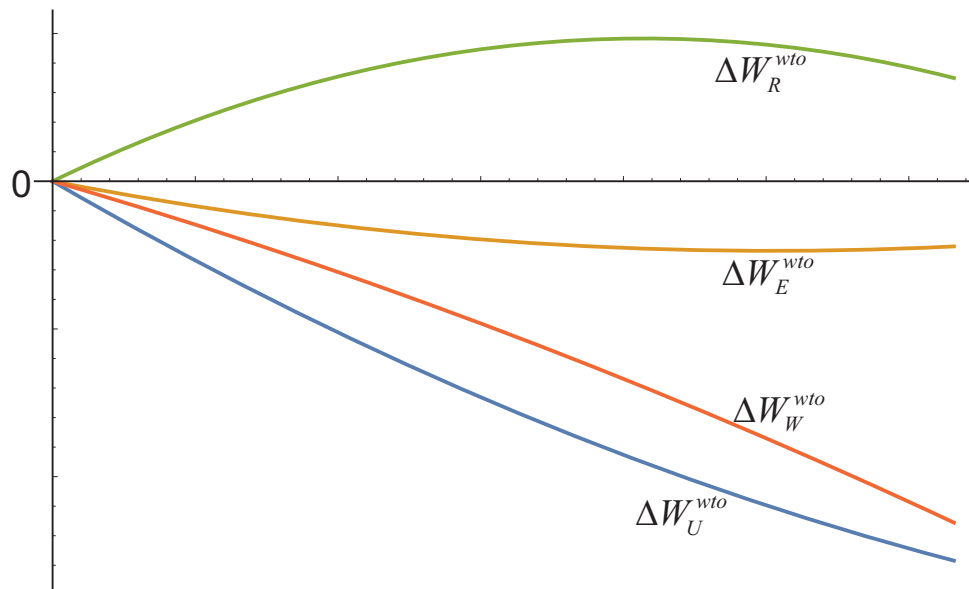


Figure 4: Welfare Effects of WTO Rules on the UK, the EU27, the RoW and the World Non-Tariff Barriers

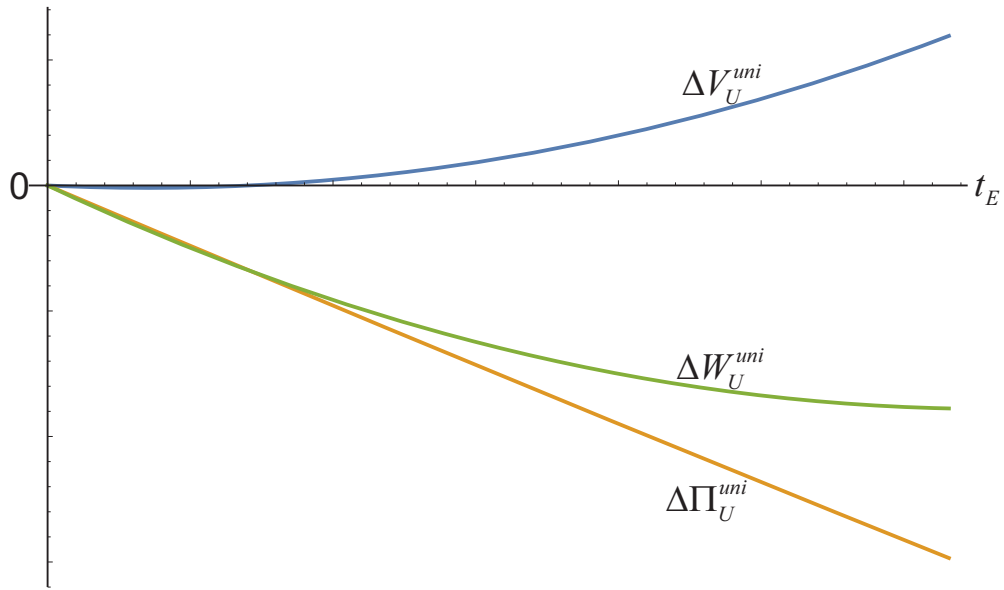


Figure 5: Effects of Unilateral Free Trade on UK Welfare

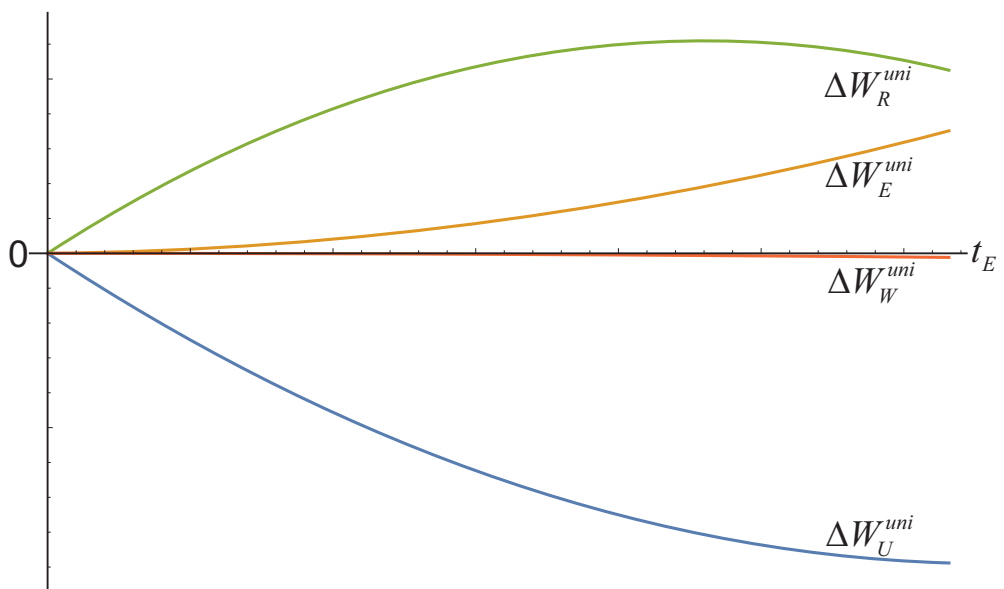


Figure 6: Welfare Effects of Unilateral Free Trade on the UK, the EU27, the RoW and the World

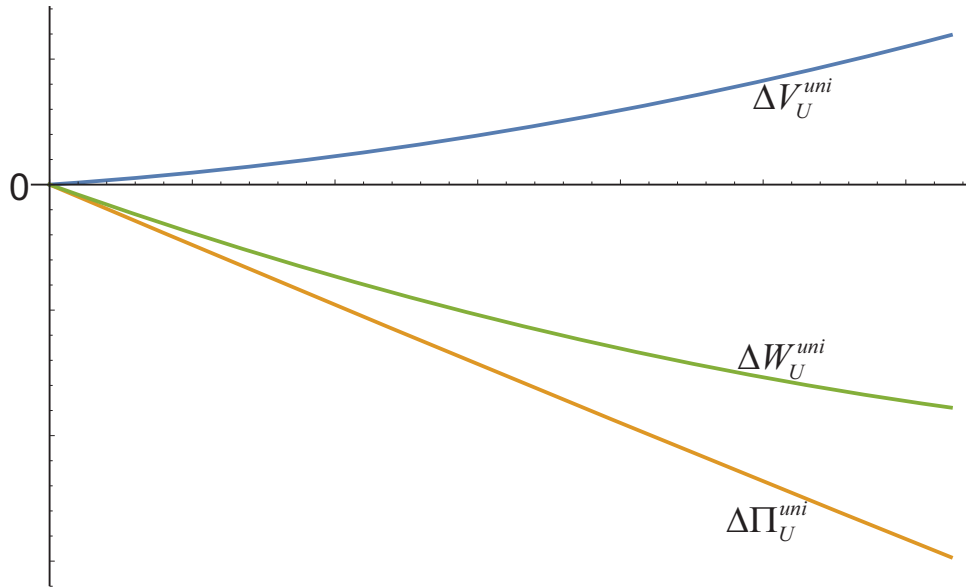


Figure 7: Effects of Unilateral Free Trade on UK Welfare with Non-Tariff Barriers

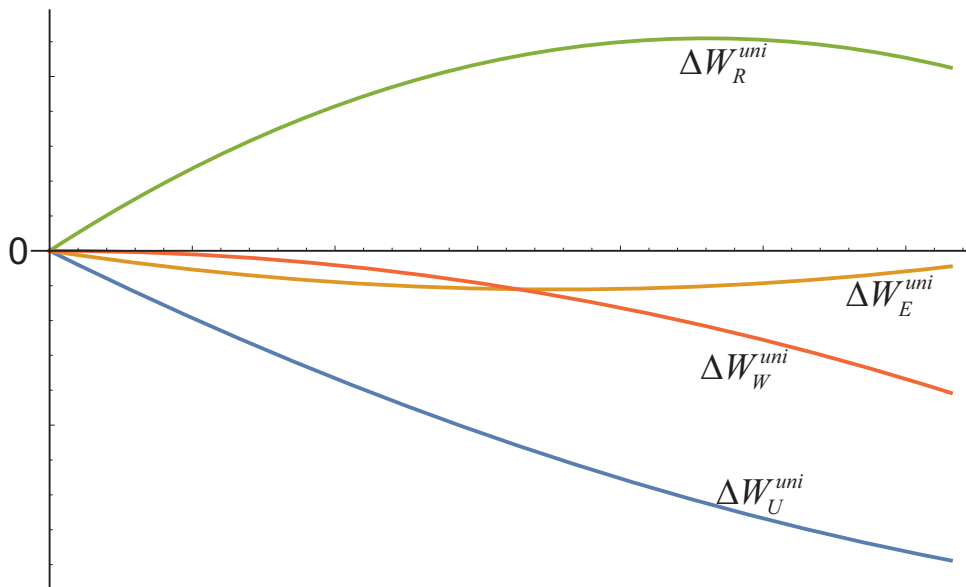


Figure 8: Welfare Effects of Unilateral Free Trade on the UK, the EU27, the RoW and the World with Non-Tariff Barriers