MODELLING THE ECONOMIC EFFECTS OF TRADE POLICIES

A Submission to the Treasury and International Trade Committees inquiry into implications of the UK's approach to international trade

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NIESR Policy Paper. 007

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Date: 11 July 2018

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This paper was first published in July 2018

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Abstract

- Computable General Equilibrium (CGE) trade models are helpful and widely used laboratories to study the economic effects of changes in trade policy and in particular different Brexit scenarios.

- Both the calibration of the structural parameters of the model (e.g. trade elasticity) and the quantification of future trade tariffs and non-tariff costs are of the first order importance for any counterfactual evaluation.

- Any counterfactual scenario of Brexit evaluated in a CGE framework should be assessed against credibility and limitations of its assumptions, and calibration of its crucial parameters. Extreme assumptions often lead to extreme results.

- There are many channels not included in CGE models and which are very likely to impact the UK economy after Brexit (foreign direct investment, additional productivity channels, the role of global value chains, etc.).

Acknowledgements

Any views expressed here are solely those of the authors and cannot be taken to represent those of the National Institute of Economic and Social Research (NIESR) or Economic Centre of Statistical Excellence (ESCoE). This paper should therefore not be reported as representing the views of the NIESR or ESCoE. The author thanks Jagjit Chadha, Giordano Mion, David Nguyen and Sergio Salis for helpful comments and conversations.

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1. Introduction

1.1 The aim of this note is to provide a reference point for comparing the various approaches to modelling the economic impact of the United Kingdom (UK) leaving the European Union (EU), and explain their mechanics in non-technical way. We will contrast the main differences in these approaches and stress their similarities. Additionally, we will briefly discuss the important areas beyond the scope of these models.

1.2 A standard economic assessment of any policy change or a counterfactual scenario involves thinking of the two types of effects: direct and indirect. The direct effects encompass usually all of the changes related to the first-order relationships between the studied variables. The indirect effects typically relate to all of the possible changes induced by the policy change within a complex and inter-related economic setting.

1.3 As an example we could think of the effects of simple bilateral trade liberalization. When goods tariffs fall between any two countries, an expected direct effect is an increase in trade volumes between the two parties. However, given the inter-related nature of the economy, one could hypothesise about the whole range of the indirect effects a tariff reduction could induce: greater competition among trading firms and potential productivity gains, impact on the trade volumes vis-à-vis other trading partners, wage effects in the sectors affected by tariff reductions and so on, as well as the overall changes to tax revenue as output, consumption and firm profits change.

1.4 The standard economic approach to measure the impact of a counterfactual scenario that would account for direct and indirect effects is the general equilibrium modelling. General equilibrium models aim at explaining *simultaneously* supply, demand, and factor prices in a whole economy populated by many interacting markets (in contrast to a partial equilibrium theory, which seeks to explain the mechanisms of individual markets, considered in isolation). In economics, the general equilibrium modelling principle can be translated into various classes of models.

1.5 Trade economists typically use computational general equilibrium (CGE) models of trade as a toy lab to study counterfactual trade policy scenarios. Various CGE modelling approaches would differ in the assumptions specifying the production structure, consumer preferences, and market designs. However, the execution of the counterfactual scenarios is always implemented through the following three steps:

(1) exact specification of consumer preferences and utility function, production technologies and trade costs around the world;

(2) estimation or calibration[1] of the structural parameters governing the system specified in (1); and

(3) counterfactual simulation of an alternative trade policy scenario, taking (1) and (2) as given.

[1] Economists refer to estimation of parameters if the deep structural coefficients of the model are baked up by micro-level data analysis. Calibration refers to a case in which an educated guess on the parameter value is made and later on the model accuracy is validated by contrasting model’s output against the real data.

1.6 The first widely used CGE framework was the Global Trade Analysis Project (GTAP) model[2]. GTAP framework was founded in 1994 and since then the model has been substantially developed in order to encompass more aspects of the economy. In brief, GTAP is a multi-region, multi-sector, CGE model relying on the assumption of perfect competition and constant returns to scale. Over the years GTAP modelling faced criticism related to its lack of analytical transparency, excessive complexity and unclear exposition of the economic mechanisms at play (e.g. Kehoe *et al.*, 2017; p.26).

1.7 This critique contributed to the development of a new class of CGE models based on the quantitative Ricardian model of comparative advantage as presented in the seminal work by Eaton and Kortum, 2002 (EK 2002). This wide class of so called 'new trade models' relies on a common set of assumptions on preferences, single factor of production, linear costs of production and perfect or monopolistic competition, which are usually employed for the sake of tractability. For instance, within the demand system (Constant Elasticity of Substitution, *i.e.* CES demand) of EK 2002 the individual income level does not affect the expenditure share spent on a given good[3]. In addition to micro-level assumptions, the new Ricardian framework assumes the macro-level restriction of balanced trade (within country total imports equal the total exports)[4]. Despite the balanced trade being a standard equilibrium condition in the static models (as EK 2002), in reality we observe countries running export surpluses and deficits. In practice, the models which assume balanced trade abstract from questions related to trade imbalances and by construction disregard any feedback loops from current account imbalance to the real economy[5]. As Allen *et al.*, 2014 (p.5) put it: "*This empirical discrepancy is an inherent limitation arising from the use of a static model to explain an empirical phenomenon with dynamic aspects. However, given both its ubiquity in the literature and the necessarily ad hoc nature of any alternative assumption (e.g. exogenously trade deficits), balanced trade seems the natural assumption on which to focus.*"

1.8 Although the simplicity of new Ricardian models partially stems from relatively strong assumptions on the preferences and production functional forms, the recent literature shows that its main takeaways remain unchanged even after relaxing the most stringent assumptions. Adao *et al.*, 2015 show that the main findings of the new Ricardian models are not reliant on the CES demand and aggregation structure. They demonstrate that if a given trade model can be expressed in a form of *exchange economies*[6] then the shape of these countries' reduced factor demand, which itself does not require imposing strong functional-form assumptions, is sufficient for addressing many counterfactual questions.

[2] For the full exposition of the GTAP modelling methodology and its history see Corong *et al.,* 2017.
[3] Formally, this result stems from the assumption of homothetic preferences, taking a form of Constant Elasticity of Substitution (CES) preferences in EK 2002. The validity of this assumption can be questioned as there is vast evidence that income elasticity of demand varies across goods.
[4] In addition to the Constant Elasticity of Substitution (CES) aggregator in the production side; this leads to the conveniently simple expression of the aggregate profits being a constant share of the aggregate revenues.
[5] See Dekle *et al.*, 2007 for a new Ricardian quantitative model with incorporated trade imbalances used to quantify the changes in relative wages, real wages, the manufacturing share of GDP and bilateral trade flows required for worldwide balancing in trade.
[6] The authors define *the reduced exchange economies* as a theoretical framework in which countries simply trade factor services (Adao *et al.*, 2015; p. 8-10).

On a related note, Fieler, 2011 relaxes the homothetic preferences assumption. She finds that accounting for differences in preferences related to country income per capita levels significantly improves the explanatory power of the EK 2002 framework and allows for a better replication of low levels of trade among poor countries and high levels of trade among the rich ones.

1.9 The main difference between GTAP and the new Ricardian modelling relates to the parsimony in the model parameters governing the welfare effects. Different versions of GTAP models require estimation of as many as 13,000 structural parameters[7], whereas in the new Ricardian framework the aggregate welfare effects of any changes in trade costs boil down to only two sufficient statistics: the share of traded goods in the total domestic expenditure and the elasticity of bilateral trade flows to trade costs or, in short, trade elasticity (Adao *et al.*, 2015 and Arkolakis *et al.,* 2012).

1.10 Apart from welfare analysis, the class of new trade models developed in the spirit of EK 2002 provide also the theoretical underpinnings of so-called structural gravity equations.

1.11 Gravity equations in trade, which relate bilateral trade volumes between any two countries to their size (GDP), mutual distance and bilateral trade costs, have been a surprisingly stable empirical regularity, immune to changes in country samples and estimation methodologies. Tinbergen (1962) first related countries' bilateral trade volumes as *"proportional to the gross national products of those countries and inversely proportional to the distance between them*". His early approach to gravity estimation did not account for the general equilibrium effects of bilateral trade, *e.g.* the fact that changes in trade between any two partners may also have an impact on other trading partners and vice-versa (these are so-called multilateral resistance terms). Any reduced-form estimation that does not account for the multilateral resistance is necessarily biased. On the empirical side, in their seminal work Anderson and van Wincoop, 2003 derived a simplified theoretical formulation of gravity equation[8] and developed a modern econometric toolkit for gravity estimation accounting for the general equilibrium effects (*i.e.:* accounting for the multilateral resistance terms).

The steady state solutions in the class of the new Ricardian models, which have a fully specified both demand and production side (as opposed to Anderson and van Wincoop, 2003) generate log-linear relationships between bilateral trade flows and trade costs measures, *i.e.:* the structural[9] the gravity equations.

[7] See Hertel *et al.*, 2012.
[8] They rely on CES structure in the demand and assume that all goods are differentiated by place of origin. Further, they assume that each region is specialized in the production of only one good and that supply of each good is fixed.
[9] Structural gravity, i.e.: gravity equation derived from a fully specified model, as opposed to the reduced-form general gravity, i.e.: ad-hoc econometric specification of gravity equation but accounting for the multilateral resistance terms.

2. Trade elasticity

2.1 The trade elasticity parameter, *i.e.*: the elasticity of bilateral trade flows to changes in trade costs is crucial for the welfare analysis in the new trade models. Given its importance in the modern CGE models, it is worth to take a step back and understand its role.

2.2 The new Ricardian models[10] relate trade elasticity to the distribution of firm productivity in the economy, a supply-side characteristic. This parameter can be interpreted as a measure of comparative advantage. The older class of models (Armington, 1969 and Krugman, 1980) link trade elasticity to the degree of substitution between different product varieties, a demand-side feature. Despite those conceptual differences in micro-foundations, trade elasticities are sufficient to summarize the fundamental welfare-related outcomes in all of these classes of models and produce a similar structural gravity equation (Arkolakis *et al*., 2011).

2.3 Within the workhorse model of EK 2002 if in a country firm productivity distribution is more dispersed[11] (that is – the trade elasticity is low) a change in trade costs will not alter the share of traded goods in a substantial way. Conversely, if the productivity distribution is more concentrated (trade elasticity is high) then a small increase in trade costs will trigger a large adjustment in the share of imported goods. The reason is that producers are more likely to change their suppliers from overseas to domestic ones as goods are more substitutable.

2.4 The aggregate output (the sum of home production and exports) in a given country relies on trade elasticity in a non-trivial way. On the one hand, as trade elasticity parameter is originally a production technology parameter – countries with more efficient technology will produce more, *ceteris paribus*. On the other hand, trade elasticity will affect the strength of the reaction of exports to changes in foreign demand. High trade elasticity will translate into amplified reactions of trade flows in response to a change in trade costs.

2.5 Trade economists often refer to changes in trade flows occurring at the intensive or extensive margin. Extensive margin represents a change in the number of traded products or trading firms, whereas the intensive margin describes the intensification in the sales volumes (with no effect on the numbers of products or firms). It is worth noting that in the new Ricardian class of models the adjustment in the share of goods traded takes place solely at the extensive margin; that means if the aggregate output increases, it is due to the new product varieties being introduced.

2.6 There is a large body of literature discussing the challenges and issues in the estimation of trade elasticity (see Head and Mayer, 2014). Caliendo and Parro, 2015 developed a multi-sector and multi-country version of EK 2002, whose sector-specific trade elasticity estimates serve as the state-of-the-art reference[12].

[10] This holds true also for the firm-based models in the spirit of Melitz, 2003.
[11] To be precise, it is not only the higher dispersion, but an increased variability of productivity draws around a smaller mode as this parameter affects both first and second moment of the productivity distribution.
[12] The cross-sectoral variation in trade elasticity is large: estimates range from 51.08 for Coke, Refined Petroleum and Nuclear Fuel to 0.37 for Transport Equipment.

3. Brexit analysis and trade costs

3.1 There are a number of studies which analyse Brexit scenarios within the framework of CGE models. Within a general equilibrium setup a natural metric to assess the overall long term impact of Brexit on the UK economy is the percentage point change in welfare; welfare being the measure of the long-term changes in the aggregate real consumption[13].

3.2 Crucially, the trade-related economic impact of Brexit relies on the estimates and assumptions about how Brexit will alter both the tariff and non-tariff costs. Tariff costs describe the official UK-EU goods trade costs, which are currently zero under Single Market. It is usually assumed that under a 'hard' Brexit goods tariffs will increase to WTO's most-favoured nation tariffs (MFN) whereas under the 'soft' Brexit the UK would remain in the Single Market and there would be maintained the current *status quo* of no tariffs. Non-tariff costs relate to regulatory barriers, border checks, transaction costs for goods and services, *etc*. Typically those costs are thought of being greater than standard tariff barriers but are much more difficult to measure.

3.3 Any final Brexit scenario estimates in a CGE trade model are strongly affected not only by trade elasticity parametrization, but also by the parametrization of trade costs split between tariff and non-tariff barriers. The MFN tariff barriers are usually calculated from the WTO MFN tariff database[14] and they are aggregated from product tariff lines to sector level weighted averages with the weights based on product-level trade volumes. As already mentioned, the estimation of non-tariff barriers is much more challenging. Some of Brexit studies[15] rely on comprehensive estimates of tariff equivalents of non-tariff barriers between the US and the EU as reported in Berden *et al*., 2009, 2013 whose estimates are based on a large scale business surveys. Some other studies of Brexit[16] refer to post-Brexit non-tariff costs as to all of the costs arising due to the new EU-UK border. This approach requires quantifying the border waiting time costs, costs of day in transit as well as the costs of additional administrative burden (*e.g.* rules of origin) which apply to the extra-EU trade. Quantification of those costs is clearly explained in Ciuriak et al., 2015 (p.34), albeit is does not directly rely on non-tariff estimates from the data.

3.3 In Table 1 below we concisely present the main assumptions and findings of the Brexit studies and we briefly discuss them in the following paragraphs.

3.4 Dhingra *et al.*, 2017 developed a new Ricardian model in the spirit of EK 2002 at the country- and sector-level, which suggested that Brexit will translate into a long-term loss in the aggregate real consumption of 1.3% or 2.7% (for 'soft' and 'hard' Brexit, respectively).

[13] There are a couple of studies that additionally provide the direct long-term output effects, which we will discuss further in this paragraph. However, often in the Brexit debate welfare effects and GDP effects are used interchangeably which is a convenient, but not a methodologically correct statement.
[14] Alternative source for product-level MNF tariffs is the International Trade Centre's (ITC) Market Access Map database.
[15] For example Dhingra *et al.,* 2017, 2018.
[16] Ciuriak et al., 2015.

3.5 Ciuriak *et al*., 2015 used a GTAP model to predict a long-term fall in the range of 1% to 2.8% from 'soft' and 'hard' Brexit scenario and an increase of 0.75% GDP from unilateral liberalization[17].

3.6 Mayer *et al.,* 2018 developed a new Ricardian framework with an intention to study the trade-related welfare gains that each country member has reaped from the European Union. They first estimated structural gravity equations in order to derive the size of trade frictions within and outside the EU, and trade effects of the Single Market. Next, they directly fed those results into a new Ricardian framework in order to assess counterfactual scenarios[18]. They concluded that Brexit will trigger a welfare loss of 0.8 or 2.9% ('soft' and 'hard' Brexit scenario, respectively). Interestingly, they found that "*Brexit also imposes losses to other members of the European Union, but these are generally one order of magnitude lower than for the UK. GDP decreases by 0.2% to 0.6% for the average EU country. With its close geographic and historical linkages with the UK, Ireland stands as an exception with losses comparable to UK ones"* (p. 30).

3.7 Minford, 2018 is the only study that relies on CGE modelling (GTAP) and reports positive (and strikingly large) long-term effects of Brexit, of the magnitude of 4% of GDP. They focus is only on the unilateral tariff liberalization scenario (estimated to be 0.75% GDP gain in Ciuriak *et al.,* 2015 and 1.1% to 2.3% welfare loss in Dhingra *et al*., 2017). It is the nature of the assumptions that make Minford's 2018 estimate different from the other Brexit analyses.

3.8 Minford, 2018 shares the assumption on goods tariff change with the other studies: moving to WTO's MFN's tariff will, in isolation, have a detrimental effect on UK GDP (p.3). However, in contrast to the other studies, Minford, 2018 assumes that post-Brexit UK will face no border check costs (p.4) and that Brexit will not result in any additional non-tariff barriers between UK and EU, *e.g.* there will be no costs from EU regulatory compliance for UK exporters (p.4; in Dhingra *et al*., 2017 they increase from 2.8% to 8.3%; Ciuriak *et al.,* 2015 model them as a tariff-equivalent of at least 2.3% to 3.3%). Any other losses originating in EU exit are assumed away (barriers to FDI, gains from a faster price fall within Single Market*, etc.*).

[17] 0.75% GDP gain from unilateral liberalization in Ciuriak *et al.,* 2015 stems from setting the import tariff reductions to zero and elimination of non-tariff barriers in form of rules of origin from all of the existing FTAs. They estimate tariff-equivalent of this reduction to be 4 per cent.

[18] See Mayer *et al.*, 2018, p. 18 for a full exposition of the methodology.

Table 1. Main assumptions and findings of Brexit analyses in CGE trade models.

Brexit study (method)	'Hard' Brexit assumptions		'Soft' Brexit assumptions		Fiscal Savings	Other Assumptions	Long-term impact	
	Tariff	**Non-tariff**	**Tariff**	**Non-tariff**			**'Hard' Brexit**	**'Soft' Brexit**
1. Dhingra *et al.*, 2017 **(new Ricardian model)**	MFN tariffs (p. 41)	+ 8.31 % (p. 15-16)	Status quo	+2.77 % (p. 15-16)	+17% of fiscal contribution to the EU (p.17)	Loss from long-term differences between intra-EU and extra-EU non-tariff trade costs[19].	*metric: change in real consumption (welfare)* **- 2.7 %**	**-1.3 %**
2. Ciuriak *et al.*, 2015 **(GTAP model)**	MFN tariffs (p. 31-33)	+ 3.26 % (p. 35) + extra NTM on goods (p.36)	Status quo	+ 2.31% (p. 35)	Not included	Increase in barriers to FDI under soft Brexit (p.9-10).	*metric: change in GDP* **-2.76 %**	**-1.03 %**
3. Mayer *et al.*, 2017 **(new Ricardian model)**	No explicit assumption of the non-tariff and tariff costs. Methodology based on structural gravity estimation fed into a new Ricardian framework. For full exposition see p. 17-18.				Not included		*metric: change in real consumption (welfare)* **-2.4 % / -2.9 %** [20]	**-0.8 % / -1 %** [21]
4. Minford*, 2018 **(GTAP model)**	***) Please note that this study is considering only a unilateral liberalisation scenario**							
	MFN tariffs (after Ciuriak et al., 2015)	0 - 0.1% (p.4-5)	MFN tariffs (after Ciuriak et al., 2015)	0 - 0.1% (p.4-5)	Not included	+20% of tariff-equivalent gain from reduction in EU-related regulation (p.8).	*metric: change in GDP* **+ 4 %**	

[19] Dhingra *et al.,* 2017 rely on the observation that non-tariff barriers continue to fall faster in internal EU trade compared to other trade. This assumption is based on the research into the functioning of the Single Market (Ilzkovitz *et al.*, 2007). It is documented that intra-EU barriers are falling faster than those outside the Single Market. Méjean and Schwellnus, 2009 find this rate to be approximately 40% faster than between other OECD countries. Dhingra *et al.*, 2017 assume that intra-EU barriers will fall 40% or 20% faster than in the rest of the world ('hard' and 'soft' scenario, respectively).

[13,14] Greater magnitude estimates refer to the model variant accounting for the trade in intermediate goods.

3.9 Kara *et al.*, 2018, building on the analysis by Ebell, Hurst and Warren, 2016 analyse the long-term effect of Brexit in a fully developed general equilibrium macroeconomic model NiGEM. NiGEM is not a trade CGE; it is multi-country economic forecasting model, capturing a rich structure of macro-level dependencies within and across countries. 2016 NIESR estimates of Brexit costs which did not include productivity channel suggested a long term GDP loss of between 1.8% and 3.2% of GDP (for 'soft' and 'hard' Brexit scenarios, respectively; Ebell, Hust and Warren, 2016, p. 134). Kara *et al.,* 2018 fed the model with the Brexit-related shocks as identified in the literature (trade, FDI, migration, productivity, EU budget contributions) and found a 7.2% GDP Brexit-related loss in the long term.

4. The channels relating Brexit to long-term welfare effect

4.1 The main mechanism behind the new Ricardian models is as follows: Brexit is treated as a shock that increases the trade costs between the UE and the UK[22]. An increase in trade costs triggers a fall in British exports to the EU, followed by a fall in British imports. The real consumption is defined as the expenditure divided by a price index in the economy[23] and country's total expenditure coincides with the labour share of income. EK 2002 model in question abstracts from migration flows, the labour supply is fixed and thus after reduction in trade flows, wages fall in adjustment to a new equilibrium. After an increase in the trade costs, both the total expenditure will fall (due to falling wages) and the price index will increase (as the price of imports will rise). Both of those effects result in a fall in the real consumption. Furthermore, the severity of the welfare impact due to increase in the trade costs will also depend on the trade elasticity as a sector with a higher elasticity will experience a greater reduction in trade flows, all other things equal.

4.2 As already mentioned, the exact magnitude of any long-term welfare costs of Brexit critically relies on the definition of the Brexit scenario and the calibrated increase in the post-Brexit trade costs. In addition, the baseline framework of this class of models does not account for the additional channels, often highly relevant for the magnitude of the aggregate country-level effects. Those channels span from the role of inter-sectoral linkages and global value chains participation, foreign direct investment, productivity gains and technology diffusion thanks to trade to the role of uncertainty for firm decision. We will briefly discuss here the most relevant research developments in this area.

5. Which channels are *not* there?

- Role of global value chains

5.1 Although informative, the CGE modelling based on EK 2002 model abstracts from the role of the supply chains and, hence, it cannot fully assess the Brexit-related consequences of their disruption. Britain is highly involved in vast international supply chains and production networks, with the case of the automobile industry as a leading example. Felbermayr *et al.*, 2018 is one of the first attempts to incorporate the international aspect of the inter-sectoral demand and supply relationships. They relied on the international input-output tables that are the matrices of inter-industrial flows of goods and services within and across countries, which they incorporated into a quantitative new Ricardian framework for the Brexit analysis. They applied improved trade elasticity estimation techniques and embedded a set of international input-output linkages into the model. They predict

[22] The models are flexible enough to accommodate an asymmetrical impact on the bilateral trade costs.
[23] Price index in the new Ricardian framework is a geometric average of the delivered prices of all goods (both domestically produced and imported) in the economy.

Brexit will lead to a welfare loss for the UK, yet suggesting heterogeneity in the magnitude of the effects conditional on the Brexit scenario and member country. For example, they find that *"[…] percentage losses of real consumption from a hard Brexit are actually larger in Ireland and Luxembourg than in the UK, where the 90% confidence interval is [-3.79%,-2.52%]. […] Finally, the global Britain scenario results in losses contained in the 90% interval [-2.89%,-1.49%] for Britain, but leads to somewhat larger losses in the EU countries relative to the hard Brexit scenario."* (p.3).

5.2 Vandenbussche *et al.*, 2018 developed a quantitative model with a Cobb-Douglas-CES structure both in production consumption, which also incorporates a rich set of inter-sectoral linkages. This framework allows them to depart from the new Ricardian feature that every input is sourced from only one particular country (as in Dhingra *et al.,* 2017). They found that Brexit will cause a fall in value added production between 1.21% and 4.47% of GDP, translated to job losses of 139,860 and 526,830 jobs (in 'soft' and 'hard' scenario, respectively). Unfortunately, this effect is not directly comparable to Dhingra *et al.,* 2017 whose main metric is the change in the aggregate real consumption.

5.3 On a related note, global value chains are also documented to promote knowledge spillovers and technology transfer, *e.g*. Javorcik and Poelhekke, 2017 found that a disinvestment by a multinational company results in a permanent 0.4pp fall in the output and 0.04pp fall in the productivity of the disinvested plants. Piermartini and Rubínová, 2014 found that the elasticity of home country patenting with respect to foreign R&D is increasing with the strength of supply links. A potential Brexit-related disruption of production networks is also likely to harm UK technology and knowledge diffusion within and across firms.

- Productivity, product variety and mark-ups

5.4 Lower trade barriers benefit consumers directly *via* consumption goods prices. However, quoted prices are not a simple derivative of import tariffs. The prices a British firm charges depend on the inputs it uses, firm efficiency in turning those inputs into final products, the quality of the final product and the charged mark-up. All those characteristics are also margins of adjustment to changes in trade costs. Seminal work by Melitz, 2003 highlighted the importance of trade barriers for firm entry and exit, and for the aggregate productivity. Subsequent contributions, both theoretical and empirical, draw attention to the firm-level mark-ups, their dispersion and reaction to trade costs. In a structurally estimated general equilibrium framework Behrens *et al.* 2014 quantify the importance of firm selection and competition for the aggregate productivity effects and welfare changes. Trade liberalization is found to be welfare improving as the least productive firms exit the market and the most productive survivors quote lower markups. It is highly likely that Brexit-related increase in trade costs will distort UK firm entry and exit patterns, and undermine aggregate productivity.

5.5 On a related note, Kara *et al.*, 2018 within NiGEM framework model explicitly the impact of productivity loss, treating it as a technology (total factor productivity) shock. On par with reduction in trade volumes, it is found to be the largest contributor to the long-term 7.2% GDP Brexit-related loss.

- Foreign Direct Investment

5.6 The new Ricardian framework does not allow for explicit modelling of the impact of Brexit on the foreign direct investment flows (FDI). Ciuriak et al., 2015 in their GTAP model allow the FDI flows respond to changes in restrictions on FDI (increasing after Brexit) yet their contribution to Brexit loss is moderate (0.08% contribution to the overall effect, p.14). However, there is a large body of empirical evidence suggesting positive and economically meaningful effects of EU membership on FDI inflows (see Dhingra *et al.,* 2017). Kara *et al.,* 2018 relying on Ramasamy and Yeund, 2010 and the literature surveyed in Dhingra *et al.,* 2017 analyse the long-term impact of a 24% reduction in FDI on the UK economy. They find that Brexit-related direct effect of the reduction in FDI on economic output is small (approx. 0.3pp) but negative. It is worth to note that in the most recent OECD report on the FDI patterns in the advanced economies suggests that in 2017 the FDI inflows to the OECD had fallen by 37% as compared to 2016 and that this decline is largely driven by the decreases in the UK and the US (OECD, 2018).

- Aggregate effects vs. spatial distribution of impact

5.7 All CGE models of Brexit impact report aggregate welfare effects. An aggregate statistics is very informative in many respects but one wants to gauge the anti-globalization sentiment rising across Europe and the US, the concentration and spatial distribution of economic impact (locally and regionally) should also be taken into account. The study by Dhingra *et al.*, 2017 published in the National Institute Economic Review, takes a first step in this direction: the UK-wide Brexit impact from a general equilibrium model is translated to the effects at the level of Local Authorities. They disaggregated the nation-wide welfare losses as predicted by Dhingra *et al.,* 2017 into regional effects by exploiting the sectoral employment composition in Local Authorities: *"Local Authorities in the South of England, and those in urban areas, are predicted to be harder hit by Brexit under both [hard and soft] scenarios. […] this pattern is explained by the fact that those areas are specialised by sectors that are predicted to be badly hit by Brexit."* (p. R35).

Even with this evidence at hand, it is clear that there is a need for more research into the regional and local effects of Brexit, as well as for a clear outline for the long-term growth agenda and reforms at the regional level (see Chadha, 2016).

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