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Brexit – an economy-wide Impact Assessment looking into trade, immigration, and Foreign Direct Investment

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Paper to be presented at 20th Annual Conference on Global Economic Analysis

"'Global Economic Analysis in the 21st Century: Challenges and Opportunities"'

West Lafayette, Indiana, USA, June 7-9 2017

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Abstract

We provide an impact assessment of Brexit along three dimensions: EU market access considering tariffs and non-tariff barriers, impacts of less EU citizen working in the UK and reductions in Foreign Direct Investment. Using a Computable General Equilibrium model integrating the Melitz (2003) framework, we consider capital accumulation and feedback of population size on tax income and demand for public services. In our worst-case scenario with all dimensions considered simultaneously, welfare losses per UK citizen amount to around 1.300 USD, exceeding result of other studies which we link to comprehensive scenario design and applying the Melitz model for manufacturing sectors.

Keywords: Brexit, Computable General Equilibrium Modeling, Modern trade theory

JEL classification: C68, C63

1 Background

After decades of enlarging the EU and deepening market integration between EU members, the Brexit vote marked a potential turning point with a majority of those taking part in the referendum opting to leave the EU. Potential reasons are manifold: skepticism about benefits from globalization, of which EU integration has been one central part for EU member countries, the feel of overregulation by and of losing control to a bureaucratic central in Brussels and discontent about how first the financial and now the migration crises had been jointly handled by the EU countries and the EU institutions. Potentially, domestic UK policy issues might have played their role as well such as worries about income distributions between regions and household groups in a largely de-industrialized UK with growing differences between the hinterland and the city.

The Brexit will most likely affect trade between the UK and EU as EU Membership has significantly reduced trade cost among members not only by eliminating tariffs. Removal of border controls and role of origin checks and minimizing cross-country differences in regulations as non-tariff measures was at least equally important. Today, the EU is the UK's dominant export market with 45% and 38% shares in merchandise and services, respectively (Busch and Matthes, 2016). The European Single Market also significantly reduced barriers against foreign supplier of services as part of FDI. EU members can establish greenfield investment, acquire local companies or expand existing establishments in the UK. After the USA and China, the UK is the third major recipient of FDI worldwide with half of its FDI stemming from other EU members. Although the UK is an attractive FDI location due to good governance, flexible labor markets and a highly educated workforce irrespective, the Brexit could significantly reduce FDI for at least two reasons (Centre for Economic Performance, 2016). First, the UK provides an attractive point-of-access for multinationals to the European Single Market at low trade costs, a benefit which might be lost depending on future trade arrangements between the EU and the UK. Second, Brexit will increase the cost of multinationals operating also in other EU members, for instance to relocate staff between the UK and other member.

Additionally, EU membership encompasses free movement of natural persons. Restricting immigration from other EU members was a main argument of the leave campaign. Currently, 35% of all immigrants living in the UK stem from other EU countries. Their number increased

from 0.9 to 3.3 million from 1995 and 2015 (Centre for Economic Performance, 2016) with a significant share attributed to the EU accession of eight East European countries in 2004. Of the 3.3 million EU immigrants living in the UK, 2.2 of the around 2.5 million in working age (16-64) are in work (Centre for Economic Performance, 2016). UK offers currently only a restricted number of working visa to non-EU nationals, an instrument which could be expanded to all or some EU countries after the Brexit. However, that would require a future EU-UK trade agreement with less concession compared to Norway or Switzerland both to which EU immigration is unrestricted.

Quantitative assessments of consequences of a Brexit were already presented before the actual vote (see Busch and Matthes, 2016; for a review). These studies looked into issues such as immigration, capital movements, tariff and non-tariff measures, but not consistently and simultaneously. Booth et al. (2015), Ottaviano et al. (2014) and Aichele and Felbermay (2015), among others, looked into the impacts of restoration of tariff and non-tariff measures between the UK and the EU, using either CGE or gravity type models. Other studies attempted to analyze impact of changes in immigration and FDI, but ignored trade relations at sectorial levels, either using CGEs which do not consider trade in detail (PwC, 2016) or using other type of models (Oxford Economics, 2016). They only depicted aggregate export levels neglecting consequences of sectoral specialization in trade (Busch and Matthes (2016). Further, Hosoe (2016) criticized that exiting studies might underestimate impacts from re-introducing tariffs and NTMs as they neglect modern trade theory. Therefore, he employed a Melitz (2003) type of CGE model and found as expected more profound impacts of restoring bi-lateral MFN tariffs.

Hence, we still see sufficient scope for a coherent and simultaneous assessment of different aspects of the Brexit and thus want to complement to existing literature in three dimensions. Firstly, when looking at EU market access, we take besides tariffs also Non-Tariff Barriers (NTBs) in both goods and services into account while considering monopolistic competition in a Melitz 2003 framework. Secondly, we link labor immigration, population size and demand for public services with the question of how to finance the government budget. And finally, we analyze the role of FDI. The impacts of these aspects are analyzed both independently and jointly in a Computable General Equilibrium (CGE) model which provides a stringent and coherent framework for economy-wide assessments.

Our paper is organized as follows. In the next section, we provide a brief overview on existing quantitative, economy-wide analysis of a Brexit. In section two, we discuss our scenario layout and our methodological choices along three dimensions: access to EU markets, reduced migration from the EU to the UK or even sending EU citizens home, and finally, from reduced FDI. That leads to the result section which presents the quantitative findings from our CGE analysis where we analyze impacts of potential Brexit consequences on EU market access, labor markets and FDI. Finally, we conclude and summarize.

2 Existing quantitative analysis on the Brexit

As touched upon briefly above, several studies already appraise ex-ante impacts of a Brexit, differing in terms of both methodology and scenario design. CGE and the so-called new quantitative models (NQTMs) based on gravity theory are the more frequently used approaches in quantifying the Brexit consequences, used to simulate impacts of a quite large menu of possible scenarios with regard to the Brexit. Given the uncertainty associated with the future of EU-UK relationships, the studies evaluate restrictions to one or more of the so-called four freedoms of the European internal market, i.e. free movement of goods, services, persons and capital. In that regard, several possibilities are considered in the studies by the House of Commons Foreign Affairs Committee (2013), Booth et al. (2015) and Busch and Matthes (2016). Their scenarios range from a full-fledged comprehensive free trade agreement with the EU covering all four freedoms of the European internal market ("Norwegian option") to a fall-back to MFN rates under default WTO rules ("WTO option") with no further concessions with regard to the four freedoms. In between these two more extreme scenarios, a wide range of other possibilities are assessed. Some often discussed variants are the "Switzerland option" where the UK relation with the EU is regulated by wide ranging free trade agreement, but without fully free movement of labour and capital, and the "Turkey option" where the UK and the EU form solely a customs union.

Given that the EU and the UK would not have to choose exactly one of these particular options, several intermediate possibilities are considered in some studies as well. Furthermore, possible scenarios not only touch upon the EU-UK trade links, but also upon the UK trade relationships with third countries, either already in an FTA with the EU or not. The EU has currently FTAs with 55 other countries which the UK might need to renegotiate after a Brexit (Booth et al., 2015). Furthermore, potential UK trade deals with the US and Canada are discussed in literature

(see UK Treasury 2016a). Some studies also evaluate the impact of a large-scale deregulation that the UK might pursue at home (Booth et al., 2015), or estimate the outcome of UK national policies replacing EU policies such as the EU Common Agricultural Policy (CAP) (see Harvey and Hubbard, 2016 for a review of those studies).

As survived by Busch and Matthes (2016) and Harvey and Hubbard (2016), the majority of the studies suggested that the cost of Brexit might not be great and there could be even a modest benefit in the long run under certain assumptions. For example, using a Dynamic version of the GTAP model, Booth et al. (2015) analysed a scenario close to the so-called "WTO option", however with all other FTAs with third countries remaining in place. They found that as a result of the bi-lateral imposition of MFN tariffs and non-tariff barriers and under the assumption that the UK will save from its EU budget contribution (0.5% of GDP), the UK's GDP will decrease by -2.2% in 2030. Further, they found that under a scenario where UK manages to enter comprehensive FTAs with the EU and the rest of the world, whilst pursuing a large-scale deregulation at home and saving its full contribution to the EU budget, the country's GDP even increases by +1.6%. Boulanger and Philippidis (2015) applied a world trade CGE model, and simulated the welfare impact of a free tariff trade agreement between the EU and the UK under the assumption of nationalization of the UK's payments to the EU. Their results suggest that Brexit could contribute to a moderate +0.6% increase in per capita GDP. However, a further +2% increase in iceberg cost associated with the loss of UK access to the single market almost cancels out the benefit of the EU budget saving, and simulation of +5% increase in iceberg cost reduces GDP by -0.7%. Ottaviano et al. (2014), using an NQTM, estimated a reduction in GDP (-1.1%) when the UK and the EU could agree on the continued elimination of all tariffs and a modest decrease in NTBs, and a loss of GDP (–3.1%) when MFN tariffs prevail and EU succeeds on further reduction of -40% for NTBs in its internal market faster compared to other regions in next 10 years. Similarly, Aichele and Felbermayr (2015) employed an NQTM and found that under UK's soft exit where trade is hampered by some nontariff barriers, but not by tariffs, GDP lowers by -0.6 % in 2030. However, under a deep exit with tariffs and higher non-tariff barriers in the UK-EU bilateral link, GDP goes drops between -1.5% to -2.8%. Finally, under isolation of the UK, where the UK also loses privileges from all the FTAs that the EU currently has with third countries, GDP declines between -1.6% to -3%. CEPR (2013), using a CGE model, also found small changes in GDP when they simulated the WTO and TTIP options. All these studies only focused on tariff and non-tariff factors of trade while not explicitly taken

into account other dimensions such as control on immigration and restrictions on capital movement.

Only few studies extended their coverage to immigration and FDI issues. Booth et al. (2015), using a macroeconomic single country dynamic CGE model estimated a short term and long term loss of GDP (-3.1% and -1.2%) in a scenario that makes UK largely integrated with the EU and a loss of GDP (-5.5% and -3.5%) in a scenario where MFN rates are applied. In both scenarios, the decline in GDP is mainly associated with the imposition of restrictions on immigration (-0.7% and -1.4% reduction in labor supply), and on capital, through higher capital cost for UK companies in the short run. Oxford Economics (2016) employed the so-called "Oxford Economics' Global Economic Model" and found that real GDP is only -0.1% lower in 2030 in the best-case scenario (it closely resembles EU membership) while in the worst scenario (no FTA with the EU, no deregulations at home, and adoption of immigration control measures), GDP is -3.9% lower in 2030.

The UK Treasury (2016a), using a gravity model, estimated the impact of Brexit on trade and FDI flows, and translated the estimated the impacts of changes in trade and FDI on productivity. Subsequently, the changes in trade, FDI and productivity were introduced in a global macroeconomic model to predict the impact on the UK's GDP. The analysis suggests that Brexit would lead to a long-run reduction in GDP of -7.5% under the WTO option, -6.2% under the so-called Canada option, and -3.8% under the Norway option. In a similar study conducted by UK Treasury (2016b), using econometric estimates combined with a macroeconomic model, the impact of uncertainty, financial market volatility and less trade and investment openness is projected under two scenarios, namely "shock" and "severe shock". In the "shock" scenario, the UK negotiates bilateral trade agreements while uncertainty reaches a level just below the 1990s recession and financial volatility increases in the same magnitude as an increase in uncertainty. As a result, the UK's GDP decreases by -3.6%. In the "severe shock" scenario, the rise in both uncertainty and financial market volatility is around 50% larger than in the "shock" scenario, while trade ios depicted by the WTO option, which leads to a GDP decrease by -6%. Portes and Forte (2016), utilizing estimated findings from other studies, forecasted that a "middle range" Brexit, where EU net immigration to the UK falls by as much as 91,000 a year, would cut the growth of GDP by -0.6 and -2.7% in 2020 and 2030, respectively. But in the more extreme scenario of a hard Brexit where EU immigration was cut by 150,000 a year, the UK's GDP is

expected to decrease by -0.8% and -4.4% in 2020 and 2030, respectively. However, these studies consider rather overall aggregate export and import relationships and related trade barriers (Busch and Matthes, 2016) and not sectorial trade specializations as key elements in trade focused CGE models.

Hosoe (2016) provided another explanation of potentially underestimated Brexit impacts by comparing results of different Brexit scenarios in a CGE structure that follows either Melitz 2003 or the more standard Armington assumption for manufacturing sectors. His paper suggests that small changes in simulated impacts on core economic variables vanish once elements of modern trade theory such as fixed costs, exit and entry of heterogeneous firms and love of variety are considered. He finds that under models based on the Armington structure, re-establishing trade barriers would benefit or only marginally harm the UK while models based on the Melitz framework show significant welfare losses to the UK due to firm exits and loss of varieties.

In overall, we conclude from existing literature that there is a gap in impact assessments of the Brexit with regard to a simultaneous and consistent analysis taking into account all four freedoms linked to the EU market access, while considering modern trade theory as introduced in Melitz (2003).

3 Methodology

3.1 Overview on modelling framework

We use in here a variant of the flexible and modular CGE model by Britz and Van der Mensbrugghe 2016 in which we incorporate a module based on Melitz (2003). It considers firm heterogeneity, firm entry and exits in the industry as a whole and on specific trade links, and love of variety by the different agents, resulting in monopolistic competition. That module is applied for all manufacturing sectors. Our approach is motivated by literature which shows the importance of considering firm heterogeneity in manufacturing sectors, for instance, see Luckstead and Devadoss (2016), Balistreri et al. (2011) and Akgul et al. (2016). Sectors with perfect competition are depicted as in the GTAP Standard model (Hertel, 1997), a comparative static, global Computable General Equilibrium (CGE) model based on the Walrasian general equilibrium structure. It assumes cost minimizing behavior under constant returns to scale (CRS) production technologies along with utility maximizing consumers in competitive

markets. However, distribution of output to the domestic market and exports for competitive sector is depicted in our configuration as sluggish based on Constant Elasticity of Transformation (CET) function with two nests complementing the Armington specification.

We set up the model such that income distribution does not follow the GTAP Standard model with its regional household concept. Rather, a representative private household and a government account are modelled separately. The single virtual representative household in each region owns the production factors and receives factor returns net of factor taxes paid by firms on which the household pays additionally direct taxes. That net income is distributed to savings and final demand based on fixed value shares, i.e. a CD-utility function. The government collects all tax income which is used to finance government consumption which we fix in real terms to a scenario specific level. As motivated below, we also fix the government deficit (= savings) in real terms and adjust direct taxes to close the account. Considering income generation and distribution for these accounts separately allows for more detail in scenario design and result analysis. The sum of regional savings, i.e. the savings of the private household and the government budget surplus or deficit, plus foreign savings determine gross investments.

As in the GTAP standard model, the private household's demands for Armington commodities are derived from a non-homothetic Constant Difference Elasticity (CDE) implicit expenditure function, while government and saving demands for Armington commodities are driven by a constant elasticity of substitution function. The Armington demand for each agent and commodity is defined as a CES composite of domestic and import demand. The import demand composition from bi-lateral trade flows is depicted by a second CES nest which is not agent specific. On the supply side, production is defined as the Leontief aggregate of value added and intermediate inputs bundles; the value added composition is based on a CES aggregate of primary factors while the composition of intermediate demand is based on fixed physical input coefficients. An exemption provides the agricultural and food processing sector where we consider substitution between feed inputs for the former and agricultural inputs for the latter.

As for the final demand agents, each sector features its own Armington nest to determine the composition of intermediate input demand for each commodity from domestic product and imports. However, the import composition is identical across sectors and final demand, as mentioned above. For the monopolistic sectors and related commodities which consider love of varieties by the consumers, we, however, use a single nest.

We configure the model such that it depicts sluggish mobility of factors between agricultural- and non-agricultural sector following Keeney and Hertel (2005). Inside these sector aggregates, newly formed capital, skilled and unskilled labor are fully mobile, land is sluggish and vintage capital and natural resources are sector specific and immobile. Besides new capital which is investment driven (see section 3.3 below for more detail), the other primary factors are depicted by fixed stocks. Details of the model which can also provide an exact replica of GTAP Standard model, however, coded in GAMS in levels, can be found in Van der Mensbrugghe and Britz (2015). Note that the GTAP Standard model as coded in GEMPACK presents a mix of equations in levels and in linearized relative differences instead, as detailed in Hertel (1997).

3.2 Labor force and population

A key concern during the Brexit vote was the impact of labor immigration into the UK with regard to crowding out domestic labor and straining public services (Harvey and Hubbard 2016; Centre for Economic Performance, 2016). The UK government, different for instance from Germany, granted unlimited access to its labor market to the new Member States immediately. Besides an already strong inflow from well-educated EU citizens especially into the service sector before the EU's east enlargement, that led to a total of around 2.2 Mio EU people working in the UK.

Clearly, we cannot model in detail these more immediate concerns of UK citizens such as longer waiting time to access public services or job displacement. The statement of the exchequer (Dustmann and Frattini, 2014) was however quite clear by showing that the EU migrants provide a net contribution to the government budget. We make a relatively simple assumption with regard to labor markets: both unskilled and skilled labor are assumed fully mobile and fully employed. We assume that a Brexit would imply a reduction in the UK workforce which would also mean less population. Outcomes for an alternative closure with a fixed wage rate for unskilled labor and endogenous (un)employment for the worse case scenarios are briefly discussed below.

Current estimates show around 2.2 Mio EU migrants working the EU, out of a total working population of around 31 Mio. Further, statistics show that 1.2 million UK citizens live in other EU countries. Assuming that each worker has 0.2 dependents somewhat suggests that 1 million UK citizens work in the other EU countries. Hence, one would expect that after repatriating the UK workers from the other EU countries to the UK, and further assuming that at least certain

number of workers (0.1 Mio) will stay there after Brexit due to the issues relevant to the social insurance and etc. we assumed in our pessimistic scenario a net reduction of -1.1 Mio of the UK's workforce and of its population by -1.1 Mio times 1.2. It should be noted that our study ignores the impact of repatriating EU migrants due to its small share on total EU population and workforce.

We assume that a reduced population would also demand less government services. However, the reduction is certainly not fully proportional, the costs for defense, to give a striking example, are most probably not affected at all if population changes, the same might hold more or less for the costs of central and local governments and many other areas of administration. We, therefore, reduce government demand only by 25% of the relative change in population and fix it in real terms. Assuming that it won't be easier for the UK to finance a potential deficit in public budgets after the Brexit, we fix government savings. Thus, in order to close the budget, direct taxes are endogenously adjusted which is the least distortive way of introducing new taxes.

The main interrelated impacts in our CGE framework of reduced migrations are threefold: (1) the production possibility of the economy as a whole reduces as the labor stock is reduced, (2) domestic demand shrinks as less consumers live in the UK and (3) tax income reduces as well. What we cannot model is the claim of the exchequer that the migrant households lead to a net contribution to the government account as we do not consider different household types. If that claim would be true, it would most probably reinforce the negative consequences discussed below as UK households would contribute in average less to the government budget.

3.3 Accounting for changes in capital accumulation

The standard case in comparative-static CGEs is that savings determine the investment demand, but that the capital stock is fixed and thus not linked to changes in investment. Recursive-dynamic model provides that link by updating the capital stock, considering depreciation of the existing capital stock and adding gross investments from the last solution period. We introduce that mechanism here in a comparative-static framework, additionally differentiating between existing (vintage) capital and new one as e.g. also found in ENVISAGE (van der Mensbrugghe 2008). Specifically, we define a stock of old capital which is derived from initial stock, yearly depreciation and the simulation length, in our experiments chosen as five years. As physical depreciation is around 4%, that implies that about 20% of the capital is depreciated after 5 years.

We consider that vintage capital is completely immobile, i.e. sector specific. The endogenous gross investments form the new capital which is assumed fully mobile. That transparent and relative simple mechanism hence endogenizes the capital stock and thus allows accounting for capital accumulation in a comparative static setting.

That mechanism matters for our analysis especially with regard to two analysed effects. Firstly, when labour force and population shrink and the lost access to the EU market lowers GDP, the regional savings in the UK will drop which implies also lower investment. That implies a reduced capital stock compared to the BAU scenario. Secondly, reduced foreign savings would imply less FDI and hence again lead to a reduced capital stock in the UK. As a consequence, the production possibility of the economy and hence output will reduce.

3.3 Modelling impacts on trade

As generally done in global CGE analysis, we depict bi-lateral trade flows and related tariff barriers. Generally, products are differentiated by origin according to the Armington assumption. However, we model manufacturing sectors following Melitz 2003, i.e. under firm heterogeneity in monopolistic competition based on increasing returns-to-scale linked to fixed costs and considering product differentiation based on love for varieties. This amplifies the impact of lost EU market access compared of using the Armington assumption in combination with competitive markets (see also Hosoe 2016).

A challenge remains the assumptions both with regard to changes in tariffs and NTBs after a Brexit. We assume that the UK will not enter into the free trade agreement with the EU, but that EU trade agreement with third countries will remain in place for the UK. In practice, there is no strong reason for third countries to terminate their free trade agreement with the UK if the tariff rates and other benefits from agreement remain untouched (Booth et al 2015). Accordingly, our worst case scenario assumes that both the UK and EU impose bi-laterally most favoured nation (MFN) tariffs. While all studies discussed above more or less suggest that tariffs barriers have no significant impact post-Brexit, regulatory divergences could emerge over time between the EU and the UK. Different proxies for restoration on non-tariff barriers in goods are assumed in the literature. While some studies used some share of tariff equivalent estimates of current US – EU non-tariff barriers as a proxy (Ottaviano et al. 2014, for example), other studies increased bilateral trade costs by some assumed percentage (Boulanger and Philippidis, 2015, for instance) to reflect costs associated with re-introducing custom procedures and role of origin

after Brexit. Interestingly, a review of literature on non-tariff measures reveals that Egger (2015) calculated ad valorem cost saving equivalents (AVE) of being part of the European Union for different economic sectors based on a gravity model (see table 1). Further information can be found in table 3 in the annex.

Table 1: AVEs (%) of NTBs in goods and services sectors

Goods		**Services**	
	Intra-EU AVEs saving		AVEs of current policies
Average	12.9	Average	12.8
Primary agriculture	25.2	Air	25.0
Primary energy	0.0	Maritime	1.7
Processed foods	48.4	Other transport	29.7
Beverages and tobacco	41.8	Banking	1.5
Petrochemicals	7.9	Insurance	6.6
Chemicals. Pharmaceuticals	20.6	Communication	1.1
Metals, fabricated metals	38.5	Distribution	1.4
Motor vehicles	19.5	Professional and business services	35.4
Electrical machinery	1.4		
Other machinery	1.6		
Other manufactures	5.7		

Source: Egger (2015)

Additionally, it is expected that increases in non-tariff barriers after a Brexit could be even more relevant for cross border supply of services as WTO-rules for merchandise trade are more liberal than the GATS-rules for services. Here, we also follow Egger et al. (2015) as presented in table 1 who do not estimate the NTMs for services themselves but rather work with estimates

of trade restrictions in services from the World Bank (Borchert et al., 2014), and AVEs for trade barriers in services based on World Bank data (Jafari & Tarr, 2015), and assessments of GATS bindings and how these compare to PTA services commitments from the WTO (Roy, 2013). The figures in table 1 are AVEs on cross-border trade in services (combination of Mode 1 and 3 restrictions in services supply). Note that, intra-EU market access for services is much more liberal than the multilateral service trade regime relevant for third countries (Busch et al. 2016). Thus, a Brexit could (re)introduce NTBs in service sectors with considerable impact on trade compared to the almost free access under EU membership. Appendix 1 provides the concordance of sectors for which we have estimates of AVEs with GTAP. In this study we assumed that half of the AVE of NTMs in goods and services currently estimated between the EU and non-EU Member countries will be reintroduced.

The impact of losing access to the EU market means less effective demand such that output adjusts by contracting. The impact is quite different in the competitive (Armington) and monopolistic (Melitz) setting. In the former where only variable costs exist under constant returns-to-scale, less production frees resources. That drives down prices for primary factors and consequently also intermediates and implies that UK sectors become more competitive both in the home market and abroad such that stronger trade diversion effects can be expected. In the monopolistic setting following Melitz, these consequences are potentially overshadowed by impacts of fixed costs at industry level. Exporting less to the EU combined will a smaller home market due to less population in the Melitz model implies that fix costs of production and trade will have to be distributed to a lower output quantity, driving per unit costs up. There will, however, be some costs savings as the least competitive firms will exit the industry first. But generally, in the Melitz model, the negative consequences from a less freer trade environment will be larger. The higher fixed cost also imply that the first order positive effect of reduced primary factor and intermediate costs with regard to finding new consumers in other countries will be smaller.

4 Results

We first look at the insulated impact of any of three analysed dimensions (trade, labour and population, FDI). As shown in table 2, losing the free of tariff access to the EU god market would have the smallest impact with around -120 USD per capita. However, when market access for goods is further restricted with a middle increase in NTMs on the top of tariff

restorations, the welfare loss amounts to almost -370 USD per capita. Assuming that Brexit also implies less FDI, here considered by the UK being forced to reduce the trade balance deficit by a quarter, provokes equally a considerable welfare impact (- 233 USD per capita). Perhaps astonishing, the highest welfare losses are found when considering solely the impact of reduced labor force and population with around -650 USD per capita. GDP shrinks (-3.08%) by somewhat more than the reduction in population (-2.16%), which mostly reflects the feedback from population size on savings and thus capital stock. But furthermore, with indirect tax income dropping by -2.8%, direct taxes need to be increased by about +6% to offset the loss of tax basis (less consumption to tax due to a lower population, less labor and capital) under the assumption that the budget deficit will not increase further. The higher direct taxes in combination reduce the purchasing power of the private households.

The combination of all three potential consequences of Brexit leads to simulated yearly welfare losses of -1.300 USD per capita. The impact on real GDP is with -4.6% quite strong, however, considering that the UK population would shrink by about -2.16% compared to the baseline dampens the impact along with a slight reduction in the consumer price index of -2.7% relative to the factor price index used as the regional numeraire.

Table 2: Simulated key results

	MFN Tariffs		MFN Tariffs & NTMs restoration		Reduced Immigration		Reduced FDI		Comprehensive scenario	
	EU27	UK	EU27	UK	EU27	UK	EU27	UK	EU27	UK
Welfare (USD, per cap.)	5	-120	-39	-437	6	-649	-2	-233	-37	-1302
Real GDP (%)	0.02	-0.29	-0.14	-1.08	0.02	-3.08	-0.01	-0.56	-0.13	-4.64
Price index (%)	0.02	0.35	0.26	1.83	-0.02	0.41	0.00	0.18	0.24	2.46
Direct taxes (%)	-0.24	-0.40	-0.99	-4.49	0.00	5.92	0.02	0.23	-0.95	1.82
Tax income (%)	0.10	0.38	0.52	3.97	0.01	-2.77	-0.01	-0.23	0.51	0.94
Population (%)						-2.16				-2.16

In the comprehensive scenario, total output of the UK economy decreases by about -3.36%. That reduction is mainly attributed to the contraction in “Business services nec” (-3.3%), “Motor vehicles and parts” (-21.3%), “construction” (5.3%), “trade” (-3.9%), “chemical, rubber and plastic prods”(-11.9%), and “metal” (-64.2%). These sectors jointly account for 82% of the overall reduction in UK’s output. Other services sectors together contribute with almost 11% to the reduction in total UK’s output. .

Imports of the UK drop by around -12.7% as tension on the trade balance from less foreign savings and following the reduction in population and per capita purchasing power. As to be expected, imports from the EU are affected most with a reduction of around -26%. Exports to the EU drop by about 27% and increase slightly to other countries, mostly around +1%.

The welfare impact on the countries which form the now smaller EU is ambiguous, but negligible small with between -2.5 USD and +3 USD on per capita. The United States are simulated to win about 27 USD per capita from the changes in re-allocation of global foreign savings, driven by our scenario assumptions.

We also looked into an alternative closure for the unskilled labor market where we assumed a fixed price instead of a fixed labor stock. Interestingly, the impact on welfare is even stronger: as the wage rate cannot fall, the reduced demand and lower capital stock drive the demand for unskilled labor down by -9%, i.e. far beyond the reduction exogenously imposed in the scenarios above.

5 Summary and Conclusion

We quantified impacts of the Brexit along three dimensions: access to EU markets, reduced EU labor immigration and thus population size and foreign direct investment (FDI) in a Computable General Equilibrium model with monopolistic competition based on the Melitz 2003 Model in manufacturing sectors. We find quite strong yearly welfare losses of around -1.300 USD per capita under the worst case scenario where the UK would face (1) EU MFN tariffs and some restoration of NTBs, (2) 1.1 Mio less net labor immigration from the EU with related consequences on population size and (3) would need to reduce its trade balance in the medium term by a quarter under reduced FDI. About 2/3 of the impact are due to the consequences of a reduced labor force and thus population: with a shrinking tax base (less domestic consumption, lower labor force, reduced capital stock with decreased regional savings), but little reduction in overall government demand, taxes need to be increased. Furthermore, under the monopolistic competition model, a smaller home market and less exports to the EU implies that industry fix costs are distributed to lower overall output such that per unit production costs increase. We find welfare losses mostly exceeding those from previous studies which we attribute to a more comprehensive scenario design and considering monopolistic competition. Potential improvements are more evidence based assumption with regard to the impact of the Brexit on

FDI, on the number of skilled and non-skilled immigrants, and, not at least, on restoration of non-tariff measures.

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6 Appendix

Table 3. Concordance of sectors for which we have estimates of AVEs with GTAP

		GTAP sectors	Sectors	Industry structure
1	PDR	Paddy rice	Agr forestry fisheries	PC
2	WHT	Wheat	Agr forestry fisheries	PC
3	GRO	Cereal grains nec	Agr forestry fisheries	PC
4	V_F	Vegetables, fruit, nuts	Agr forestry fisheries	PC
5	OSD	Oil seeds	Agr forestry fisheries	PC
6	C_B	Sugar cane, sugar beet	Agr forestry fisheries	PC
7	PFB	Plant-based fibers	Agr forestry fisheries	P C
8	OCR	Crops nec	Agr forestry fisheries	PC
9	CTL	Bovine cattle, sheep and goats, horses	Agr forestry fisheries	PC
10	OAP	Animal products nec	Agr forestry fisheries	PC
11	RMK	Raw milk	Agr forestry fisheries	PC
12	WOL	Wool, silk-worm cocoons	Agr forestry fisheries	PC
13	FRS	Forestry	Agr forestry fisheries	PC
14	FSH	Fishing	Agr forestry fisheries	PC
15	COA	Coal	Primary Energy	PC
16	OIL	Oil	Primary Energy	PC
17	GAS	Gas	Primary Energy	PC
18	OMN	Minerals nec	Primary Energy	PC
19	CMT	Bovine meat products	Processed foods	FH
20	OMT	Meat products nec	Processed foods	FH
21	VOL	Vegetable oils and fats	Processed foods	FH
22	MIL	Dairy products	Processed foods	FH
23	PCR	Processed rice	Processed foods	FH
24	SGR	Sugar	Processed foods	FH
25	OFD	Food products nec	Processed foods	FH
26	B_T	Beverages and tobacco products	Beverages and tobacco products	FH
27	TEX	Textiles	Other manufactures	FH
28	WAP	Wearing apparel	Other manufactures	FH
29	LEA	Leather products	Other manufactures	FH
30	LUM	Wood products	Other manufactures	FH
31	PPP	Paper products, publishing	Other manufactures	FH
32	P_C	Petroleum, coal products	Petrochemicals	FH
33	CRP	Chemical, rubber, plastic products	Chemical and Pharmacuticals	FH
34	NMM	Mineral products nec	Other manufactures	FH
35	I_S	Ferrous metals	metals, fabricated metals	FH
36	NFM	Metals nec	metals, fabricated	FH

			metals	
37	FMP	Metal products	metals, fabricated metals	FH
38	MVH		motor vehices	FH
39	OTN	Transport equipment nec	other machinary	FH
40	ELE	Electronic equipment	electrical machinary	FH
41	OME	Machinery and equipment nec	other machinary	FH
42	OMF	Manufactures nec	Other manufactures	FH
43	ELY	Electricity	Public services	PC
44	GDT	Gas manufacture, distribution	Public services	PC
45	WTR	Water	Public services	PC
46	CNS	Construction	Construction	PC
47	TRD	Trade	Distribution	PC
48	OTP	Transport nec	other transport	PC
49	WTP	Water transport	Maritime	PC
50	ATP	Air transport	Air transport	PC
51	CMN	Communication	Communications	PC
52	OFI	Financial services nec	Bank	PC
53	ISR	Insurance	Insurance	PC
54	OBS	Business services nec	Business Services	PC
55	ROS	Recreational and other services	Personal and Recreational services	PC
56	OSG	Public Administration, Defense, Education, Health	Public services	PC
57	DWE	Dwellings	Public services	PC

Notes: FH: Firm heterogeneity, PC: Perfect Competition (Armington).