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Estimation of Brexit Economic Effect on Intra-European Trade in the GTAP CGE Model

This research provides estimation of Brexit economic effects on trade and the overall economy of the UK by means of the GTAP model. The used methodology of both theoretical and empirical model implementation is founded on approved scientific practices and theories and is well-acclaimed in the academic community. The simulation of two scenarios for the studied policy of the UK exiting the European Union is provided: "Hard Brexit" as a no-deal development of the current political situation between the studied regions and "Soft Brexit" as the Free Trade Agreement between the UK and the EU. The shocks for the model are constructed based on combination of two different approaches, which supports the novelty of the research: trade weighted most-favored nation rates of tariffs varying in time and ad-valorem equivalents of the European single-market effect derived from the structural gravity equation. Evidence of trade creation has not been founded by the simulation, although the problem of trade diversion has been outlined in the model. Possible offset strategies for both regions have been traced, which can be used as recommendation for further trade policy regulation. The main outcome of the research has proved the disproportionality of the impact between the EU and the UK and supported the hypothesis with both internal and external trade and economic effects consideration.

Key words: *United Kingdom, European Union, Brexit, foreign trade, GTAP.*

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Introduction

The referendum on European membership of 23 June 2016 and the triggered Article 50 by UK Prime Minister Theresa May on 29 March 2017 can lead to the United Kingdom leaving the European Union in 2019, which will have a prominent and complex effect on the economy of the UK and world trade. After accession to the European Economic Community (EEC) in 1973, close economic relations have developed between the UK and other European countries inside the Union. A substantial increase in GDP per capita of the United Kingdom (UK) followed

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the European membership, as well as further development of trade activity [25]. Leaving the EU will inevitably mean a crucial change in the whole external and internal economic system of the UK, international trade and possible total renegotiation of all agreements with all of European partners. The terms of this substantial policy change have still not been defined, as there is no definite decision on a new trade agreement and the forthcoming new mode of economic and trade cooperation between the UK and the European countries.

Quantification and estimation of possible overall Brexit outcome for intra-European and world trade present a challenging target because of different related effects of such a decision, which should be taken into account when estimating Brexit in computable general equilibrium models, as well as changing nature of the studied process. Among most important aspects the following can be listed: reduction in investment flows and activity, new migration policy effect on labor market, decrease in the government savings, decline in FDI, changes in households consumption, trade losses from exiting the Single Market and losing preferential access, increasing trade costs and new tariffs, costs of complying with new standards, decreased spill-over and compound effects and the list goes on. First of all, such research sets a significant requirement on data, which should be comprehensive enough to provide information about not only internal economy of the United Kingdom, but also other countries and trade, finance and migration global flows. From modeling viewpoint, it requires prior estimation of shocks from different origins in order to implement them in the model basing the forecasting environment on additional degrees of uncertainty. And for ensuring practical application of the model it is needed to study several scenarios of final agreements between the UK and European countries, because of the moving target ambiguity.

The novelty of the research is of high importance, as the studied event is still developing, and it requires all attention and possible estimations for better policy implementation and adaptation process with minimum additional losses. Nowadays, the future of the EU and the UK still remains to be vague, as Brexit presents itself as rather threatening manifestation of protectionist backlash. Thus, any estimation of coming effects from this policy change is very useful, because it can be employed if not as quantitative to the most scrupulosity valuation, but at least as a proper recognition of the nature and origins of the repercussions. This work combines two different approaches of shock construction taken from scientific papers in order to come up with the most accurate policy representation in terms of trade regulation.

The main hypothesis of the research is that Brexit is likely to be transferred to the UK and the EU disproportionally with the largest losses for the former and being less threatening for the latter. Although, for the world economy and trade6 as well as the studied internal economies it is going to develop as rather a negative event of long-run decline and structural setback. The main purpose of the research is to provide quantitative estimation of Brexit effect for international trade and internal economies of the studied regions and to analyze all the nature and consequences of the studied event with a limitation of the chosen methodology possibilities.

The economic effect of Brexit was previously prognosed in recent studies, and different approaches were used to provide estimation of this substantive policy change for the UK. The applied scope of the research includes, but not limited by, deep data-intensive econometric assay, evaluation and comparison of existing results, theoretic foundation and models, ex ante simulation of policy options and analysis of the structure of policy regimes. It is important to mention several of the studies, which are relevant to the topic. To estimate integration of the United Kingdom into regional and global value chains and potential effect of leaving the EU, there has been conducted an input-output tables estimation with the sectoral World Input Output Database (WIOD), which was able to look into the economic sectoral linkages and assess the impact on the unemployment, productivity and production [35]. Large-scale macroeconomic models and general equilibrium models (such as NiGEM, COSMO and METRO) have been also applied to study the global and regional economic consequences of Brexit on other countries or on particular sectors. Recent studies incorporate different scenarios for Brexit using various estimations on non-tariff measures, including structural gravity and border effects construction, projecting various forms of the final agreement as well as additionally simulating a potential change in agreements with other important trade partners, such as the US or single European countries [14, p. R49].

The literature paper by Ciuriak et. al., 2017, looks at four alternative simulations of the trade related impacts of the UK's exit from the EU [8]. The research contrasts two basic scenarios of the policy: "Brexit", which re-sets the UK's relationship with the rest of the EU to the WTO-rules most favored nation basis (MFN), versus a situation, under which the UK preserves integration with the rest of the EU at the level similar to that of the European Free Trade Association, henceforth called the "Brefta". In their model, "Brexit" scenario is characterized by introduction of the WTO based tariffs, which will be applied by both regions, while "Brefta" will introduce zero tariffs and new non-tariff measures (NTM), such as Rules of origin (RoO), resulting in new trade costs and administrative costs. Another simulation from the paper assumed a possible preferential trade agreement (PTA) between the regions. However, in this case the elasticities will have to be modified from constant elasticity of substitution to constant ratio elasticity of substitution, homothetic in order to capture the effect of home bias towards the European goods. The scenario simulates the implications of the UK securing an FTA with the United States (US). Estimation of new NTMs used in the simulation relies on comprehensive calculation of the ad valorem equivalents (AVE) between the UK and the EU under the "soft" Brexit scenario, which are constructed using additional administrative costs that stem from a total border effect as an AVE on imports of 2.31% for the goods, largely agriculture and manufacturing sectors [Ibid]. Under "Hard Brexit" scenario they build up weighted average protection levels to create GTAP-level aggregation of implied MFN tariffs from 2010 to 2013 between both regions, which are used as tariff shocks to simulate the impact of leaving the EU. In their results, the GTAP model has predicted a long-term fall in the range of 1% to 2.8% from "soft" to "hard" Brexit scenarios with a possible increase of 0.75% GDP from unilateral liberalization.

In other study Valverde et al., 2018, build a CGE model for estimation of the impact on GDP, welfare, wages and capital originating from economic effects of the UK's exit [29]. They fixed capital and land as sector specific leaving labor totally mobile, so in such a manner effects on production are fully derived from changes in labor demand. The design of their model made use of the GTAP, with which they have also simulated four scenarios, namely "zero tariffs", "very soft", "soft" and "hard" Brexit. In the same way as Ciuriak et al., 2017, under "zero tariffs" they assume that the UK and the EU will continue to enjoy a FTA. Meanwhile, under the "very soft" and the "soft" Brexit it is considered that both regions' tariffs will remain at zero, and there will be applied increased non-tariff barriers (NTBs) between the UK and the EU by 10% and 25% respectively [Ibid]. The "hard" Brexit case has been divided into two subsets: one in which they increase import tariffs between the UK and the EU to the MFN level and the second, where they assume a 50% rise in bilateral NTBs. To simulate the rents and inefficiencies attributed to the NTBs, they rely on estimates of ECORYS, 2009, which has quantified the AVEs of NTBs. The results of their simulations have captured a relatively lesser negative impact on the UK comparing to other previous studies. Trade restrictions are expected to generate a welfare reduction between -0.38% and -1.94% for the UK contrasted with -0.03% and -0.14% for the EU.

"New quantitative CGE models", which derive simplified model features of CGE with theory of choice, are also employed for Brexit estimation, as in a recent study of Felbermayer et al. [15, pp. 2-4]. In the same way, Dhingra and his colleagues [10] compare results from the GTAP model with the quantitative model of Eaton-Kortum (as presented by Costinot and Rodriguez-Clare, 2014 [3]), which can be characterized by use of perfect competition and gravity trade determinants. They look into the cost of the UK leaving the EU with simulation of three scenarios. At the first step, their research focuses on the "soft" Brexit case, which prognoses the UK joining the European Economic Area (EEA) with a permission to remain a part of the single market with zero tariffs and no new barriers to services and goods trade between the two regions. However, not being part of the Customs Union will result in necessity to satisfy Rules of Origin (RoO) requirements, which nevertheless will lead to increased trade costs [10, p. 3]. Another scenario of the research represents a bilateral trade agreement between the two regions. A free trade agreement will remove all tariffs on commodities trade, but it will not facilitate free movement of labor. Along with this, it will lead to higher NTBs due to introduction of new border measures. Lastly, the "hard" Brexit in this paper is modeled through an imposition of the WTO's MFN tariffs between the two regions. Their findings show that if the UK remains in the single market, Brexit will reduce living standards and consequently welfare by 1.3%, meanwhile under the "hard" Brexit with regional trade under the WTO MFN terms the loss doubles to 2.7% [10, p. 5].

In addition, there has been implementation of different panel data gravity studies on trade and welfare effects of Brexit, such as in Oberhofer and Pfaffermayr, 2018.

In light of the use of the CGE model, it is evident that it provides both benefits and limitations to the extent of economic assessment that can be modelled. Nevertheless, from the above literature review one can draw the conclusion that the CGE approach offers an elaborated assessment of the Brexit impact for both micro and macroeconomic determinants, which can be used for purposes of this research. The ability to adequately capture such a wide array of variables across economies is realized by its multi-region and multisector model database, which includes both input and output information from national accounts and detailed foreign trade data from different regions [29]. A CGE model computes long run effects of changes in tariffs and other trade barriers, which is an essential requirement for this kind of analysis. Unlike other models such as the partial equilibrium model, which only computes effects on the assumption that the economy at large does not change, the CGE can account for changes seen in various Brexit scenarios [28, p. 64].

As it will be seen in results of the "soft" and "hard" Brexit simulations of this study, the CGE model also captures inter-sectoral linkage effects. Another very useful feature of the CGE model, which should not be neglected, is the opportunity to predict how the economy actually works and its ability to capture ripple effects of policy changes on the economy as a whole.

The research is structured in the following form: in the first part of the study the description and review of the chosen methodology is provided with construction of the implemented shocks to the model. In the second part the interpretation of the simulation is divided into three sub-chapters: global effects on trade, internal effects for the main regions and labor effects for the UK. In the second part recommendations for further trade regulation is provided as well. And the study finishes with conclusion on the final check of the main hypothesis.

METHODOLOGY

Model specification

In this study, simulation results with the GTAP model under two scenarios are presented: so-named "Hard Brexit" and "Soft Brexit". The standard uncondensed GTAP Model is used for the study. It is a multi-region, multisector, computable general equilibrium model with intermediate linkages from input-out tables, perfect competition and constant returns to scale. The basic closure of the model is conducted on the basis of investment-savings equilibrium. Trade is modelled on Armington structure with iceberg trade costs (a certain amount of goods is lost in shipment; thus, producers need to provide larger goods volume to cover trade costs) [27]. Elasticities are taken from theoretical literature.

Thus, there is a representative consumer, who demands three composite goods: Government, Private goods and Savings with Cobb-Douglas substitution elastici-

ty (spending shares are fixed) [21]. Tax revenues are included in the consumer income, as government revenues are consolidated with private expenditure. Private spending is modelled with non-homothetic preferences, constant distance elasticities: budget shares change with income, which makes possible income elasticities different from 1 and allows for changing average and marginal budget shares with a country's growth. However, demand for government goods is modelled with Cobb-Douglas preferences. Savings have the static utility function: they are homothetic goods in each country, and savings are collected by a global unified agent, which channels them to investment equalizing rates of return.

For the production side, the following assumption is implemented in the GTAP model: there is no scope of substitution between the categories of value added and intermediates inputs and between different intermediates (the Leontief production function [33, p. 104]). Price of intermediates does not affect choice between production factors. The preferences for factors inputs bundles are set by CES functions. Firms are perfectly competitive. Savings equalize investment, and they are collected in the model by a global bank. Then global savings are allocated across countries to buy investment goods in different countries in order to equalize rates of return. The trade balance in the model is varying on four other fixed equations: savings=investment and taxes (defined by tax base and fixed tax rates) = government expenditure (defined as a fixed share of household income with Cobb-Douglas specification). There are four types of goods: private goods, government goods, investment goods and intermediate goods. For each type of a good, buyers choose between domestic goods and imported goods basing on Armington structure: domestic and imported goods are distinct with constant substitution elasticity between import and local production. Trade is also modelled with Armington preferences: goods from different exporters are different for consumers and, because of love of variety between goods from different countries, the Armington framework allows for the possibility that each country imports goods from each and every trading partner. Therefore, there are two Armington preferences functions: nested structure of import demand employs two Armington preferences differentiating across imported and domestic goods for one country and across countries. Price index is compounded as weighted average of all prices from different sources. Such typically immobile factors of production, as land and natural resources, are modelled with an elasticity of transformation function. Factors supply being exogeneous in the model is equal to the sum of all factor demands in order to provide for the equilibrium condition.

Additionally, there is a transport sector modelled as transport margin on prices: the difference between fob-values and cif-values is paid for by using so-called margin (or transport) services supplied by the international transport sector with Leontief specification. The demand for international transportation services along any particular route is proportional to the quantity of merchandise shipped.

In equilibrium all markets clear, except supply of savings = global demand for investment in accordance with the Walrasian law. The difference between sav-

ings and investment is calculated to check consistency of the model. In the GTAP model average factor prices across all factors of production (the pfactwld variable) are chosen for numeraire. The system of equations is written in percentage changes and depending on the coding language as for GEMPACK – in linear equations, and for GAMS – in levels. There are different methods of the model solution varying in complexity and utilized steps of linear approximation: The Johansen one-step approach, the n-step Euler approach and the n+1-step Gragg approach. Exogeneous and endogenous variables are set in the model closure.

Elasticities used in the GTAP model are the following: Substitution elasticity between domestic and imported goods (parameter ESUBD, Armington structure) is estimated as change in the ratio of demand in response to the change in ratio of prices and equals 7.77. Substitution elasticity between imported varieties from different sources (parameter ESUBM, Armington structure) is estimated on variation in prices and must be two times as bigger than ESUBD, reflecting easier substitution between imported varieties from different sources than between imported and domestic varieties, which is called nested Armington structure. The elasticity of substitution between intermediates and value added (ESUBT) equals zero by the basic model assumption. The elasticity of substitution between factors of production (ESUBVA) is taken from empirical studies and differs across commodities and sectors. Parameters INCPAR and SUBPAR are the expansion and substitution parameters of the CDE utility function for private expenditure (setting the parameters at 1 and 0 respectively will collapse consumers preference to the Cobb-Douglas form). The constant elasticity of transformation is defined by the parameter ETRE for the different production factors and represents production factors mobility in combination with SLUG indicator, which can be adjusted to different degrees of factors freedom of movement.

The basic GTAP uncondensed model was used without any extensions and with the standard closure choice for the initial static long-run simulation: Savings = Investment. Estimations of parameters, elasticities were not changed as set by the GTAP. The data used for this study is provided by the GTAP for 2011 in the model version 8.0.

The model aggregation for this simulation includes the following 17 regions: the Great Britain, Germany, France, Italy, Spain, the European Union without the mentioned, other European Economic Area countries (such as Switzerland and Norway), Turkey, Eastern Europe with Russia, North Africa with West Asia, Japan, China, other countries of the Trans Pacific Partnership, other Asian countries, other middle income countries, and low income countries.

Brexit shocks

The "Hard Brexit" scenario is modelled as the most extreme future development of the studied policy, when the trade agreement between the UK and the EU is not concluded. If there is no specific bilateral treaty, then trade will be regulated by international agreements signed previously by the parties. Basically, this simula-

tion represents the outcome of leaving the European Union and "single-market unbinding", as the UK will lose all zero tariffs accrued from the Union trade integration and benefits from harmonization of non-tariffs barriers obtained through the single market. The no-deal case is characterised by application of tariffs between the UK and the European countries on the basis of the World Trade Organisation agreements, which sets the tariff rates in compliance with the Most-Favoured Nation principle. It should be mentioned that tariff shocks were constructed as trade-weighted average bound rates for 10-digit goods GTAP classification and, in accordance with Ciuriak's chosen methodology, they differ for the EU and the UK respectively, as regional trade structure needs to be taken into account: the import-export sectors composition is different for each of the studied 2 regions and also varies across years for the countries [8]. Thus, the tariff shock for this scenario should be defined in time and weighted in accordance to the base sector trade data of the UK and the EU provided by the GTAP. The same "halfway house" approach of Ciuriak for the "excessive tariff protection" limiting tariff rates overestimation for several agricultural goods has also been applied for this simulation (i.e. the UK's imports from Ireland in beef and dairy: from 70% to 23% and from 50% to 30% respectively and the UK imports from France in sugar from 63% to 8%). These assumptions provide for the Brexit shock not being excessive on specific sectors.

In addition to tariff changes, the studied policy shock also implies increased non-tariff barriers (NTBs) to trade. First of all, it is important to mention that estimation of NTBs effect is rather a serious challenge, which does not have an apparent solution. Different approaches are used for this purpose, and they differ across studies. For this research the approach of Egger and his colleagues has been chosen [13, pp. 561-563]. They look into the potential trade effect of the Transatlantic Trade and Investment partnership. Thus, the authors use top-down approach of the Preferential Trade Agreements (PTA) depth focusing on the average effect of PTAs in the past. They have estimated NTBs on goods of the TTIP membership using structural gravity regression on bilateral trade flows as function of exporter/importer-country specific fixed effects, a set of bilateral non-policy barriers to trade in goods, the log tariff margin of a country-pair and a dummy variable of PTA depth measures.

Therefore, impact of a Preferential Trade Agreement is conditional on the depth of PTA in non-tariff barriers liberalization and granted preferential tariffs. They use cross-sectional data for the year 2011 (which is the same year, as in this study aggregation); volume of trade is in the form of exponential function of a log-linear index consisting of the five variables, and the model is estimated separately for each sector in order to account for NTBs variability across goods sectors. Non-tariff barriers are controlled for with two dummy-variables: a binary indicator for the effect of the European membership and an integer variable for the depth of PTA. An important note: the former takes into account both legal and institutional liberalization, which reports not only for policy measures. These coefficients are used for estimation of the European integration, and consequently they represent a broader definition of non-tariff barriers on goods. Therefore, they can be used for construction of ad-valorem tariff equivalents of European non-tariff barriers through trade costs, which

is used for simulation of the "Hard Brexit" NTBs shock on goods trade. Because the shock from NTBs is constructed as cost-increasing by the simulation, it should be modelled in a computable general equilibrium model with changes in iceberg trade costs through productivity shifter named in the model as "ams". It is important to mention that even rent-generating NTBs can be also modelled as increasing trade costs, because they can lead to rent-seeking and in such a manner they can make trade more costly. For the "Hard Brexit" scenario the NTBs AVEs estimations were taken without any reductions, because this scenario represents an extreme no-deal case. There is no tariff shock on services by definition and for simulation of NTBs on services the approach of Egger et al. (2015) has been also followed. For this purpose, data of the Services Trade Restrictiveness Index (STRI) provided by the World Bank's has been used and their ad-valorem estimations of services NTBs commitments have been employed both in the TTIP paper and in this study, as this source is the most reliable and updated to this day on the issue [20].

In the same way, the "Soft Brexit" scenario is modelled only with the NTBs European border effect shock without any application of the MFN tariffs. The NTBs effect has been reduced to the half of the estimation, as it is supposed that it will be possible for the countries to preserve some of the single market non-tariff benefits in future agreements. This scenario represents a possible outcome of a free trade agreement, thus the trade between the UK and the EU will be exercised on the conditions of the European Free Trade Association. Nota Bene, application of non-tariff barriers is not an easy process to model, for one reason because the decision has not been taken yet by the parties on these regulations: it is likely that NTBs will remain in the same form after the UK leaving the EU for some time or they will not change substantially. But as the model is static and long-run, it has been decided to implement shocks of NTBs as for the effect of leaving the EU single market for modelling the crush-out scenario and the FTA case, in full force and half reduced respectively for "Hard" and "Soft Brexit". The new border will imply additional costs for trade between the EU and the UK due to introduction of rules of origin, new regulations and requirements, as well as additional administrative costs.

The model was adjusted with different solution methods in order to increase accuracy of the results.

RESULTS INTERPRETATION

Trad effects

The simulation projects that the effect of Brexit is likely to be distributed disproportionally to the UK and the EU, as well as other regions, which can be explained by substantial differences in sizes and trade flows of the main studied regions. As Fig. 1 shows, the change of utility for the representative household in the UK (-3.89%) is going to be much larger than for European countries (-1.57%) in the no-deal scenario. Variable "u" in the model stands for regional per capita house-

hold utility from aggregate household expenditure. It is defined by the sum of the input-neutral shift in utility function, distributional parameters adjusted to the three demand components (savings, government expenditures and private expenditure) and change in per capita income.

The second largest after the UK welfare losses from "Hard Brexit" are going to be incurred by Spain (-0.372,86%), which is almost as big as the utility change for the Rest of the EU region taken collectively (-0.420,457%). An interesting feature of these results is that there are some potential winners in trade from the studied policy: Turkey (+0.143,258%, which is greater than value of the GDP change for the rest of EFTA) and North Africa and West Asia (+0.118,019%) have a positive change, which can be explained with possible trade creation, as the UK and the EU will face the necessity of trade differentiation, and other countries might benefit from more gainful agreements with Britain or increased trade flows with the European Union.

The proportions remain almost the same for "Soft Brexit": -2.33% and -0.87% respectively. As it can be observed for this policy change, Brexit is going to be 2.5 times more costly for the UK as for the EU. Besides, the regions of Turkey, the USA, North Africa and West Asia might experience a slight increase in the welfare, which can be attributed to potential trade substitution of the UK, as Britain is likely to trade more with other trade partners than the EU after Brexit, which holds true also for other regions outside of the EU and other European countries.

This observation is supported by results of the change in real GDP measured by percentage (see Fig. 3). It is important to mention, that taking into account sizes of the two studied economies (the EU and the UK), the negative impact for all European countries taken together might still be rather threatening because of the relation to the percentage change of the base value, which might be reflected in greater changes of real GDP distributed across all European countries. Additionally, it should not be omitted that this simultaneous decline in welfare for European countries can also partly originate from deep interconnections of the region, such as the structure and nature of the European single market, European developed system of added value chains and European economic integration. Thus, the instant short-term effect for a single European country might not be of the same scale and damage as the long-run effect shown in the simulation results.

Identical results can be studied with Equivalent Variation (see Fig. 3), which reflects the change in income expressed in US dollars required to make the representative household equally better off as with the policy shock, which is calculated by determining required change in income at baseline prices to get the same change in utility as with new prices after a policy shock (i.e. by determining the income that would be required to achieve the current actual utility level "u" in a shadow demand system, in which prices are fixed). It can be noticed that the welfare losses for the United Kingdoms are going to be bigger than for the European countries and rather substantial. The striking importance of impact relation to country

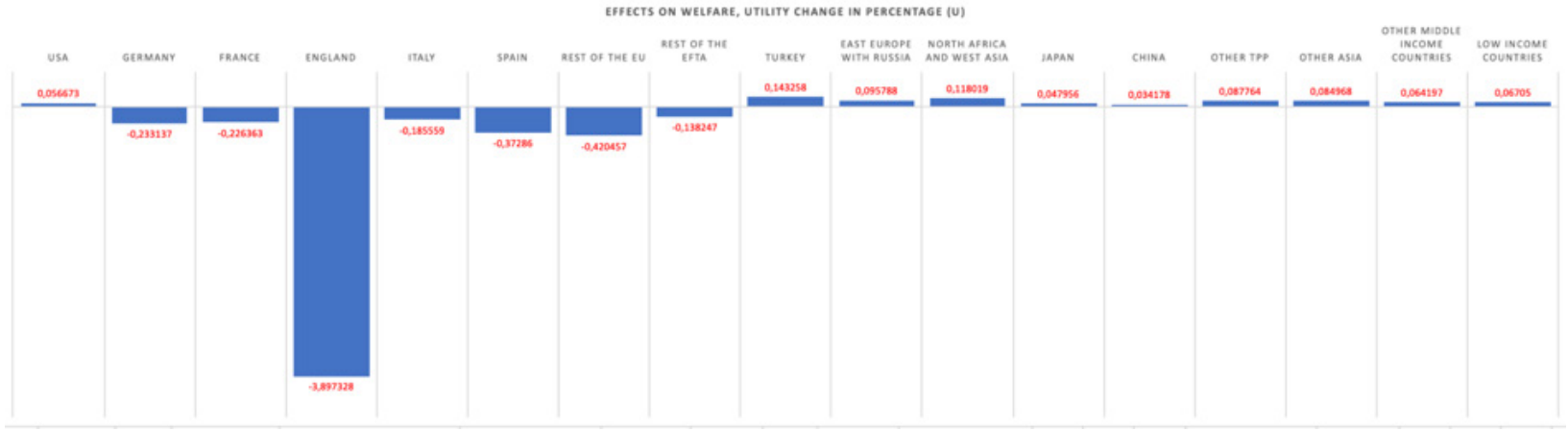

Figure 1. Hard Brexit: Effects on welfare, utility change, % (u).

Source: Author's projections.

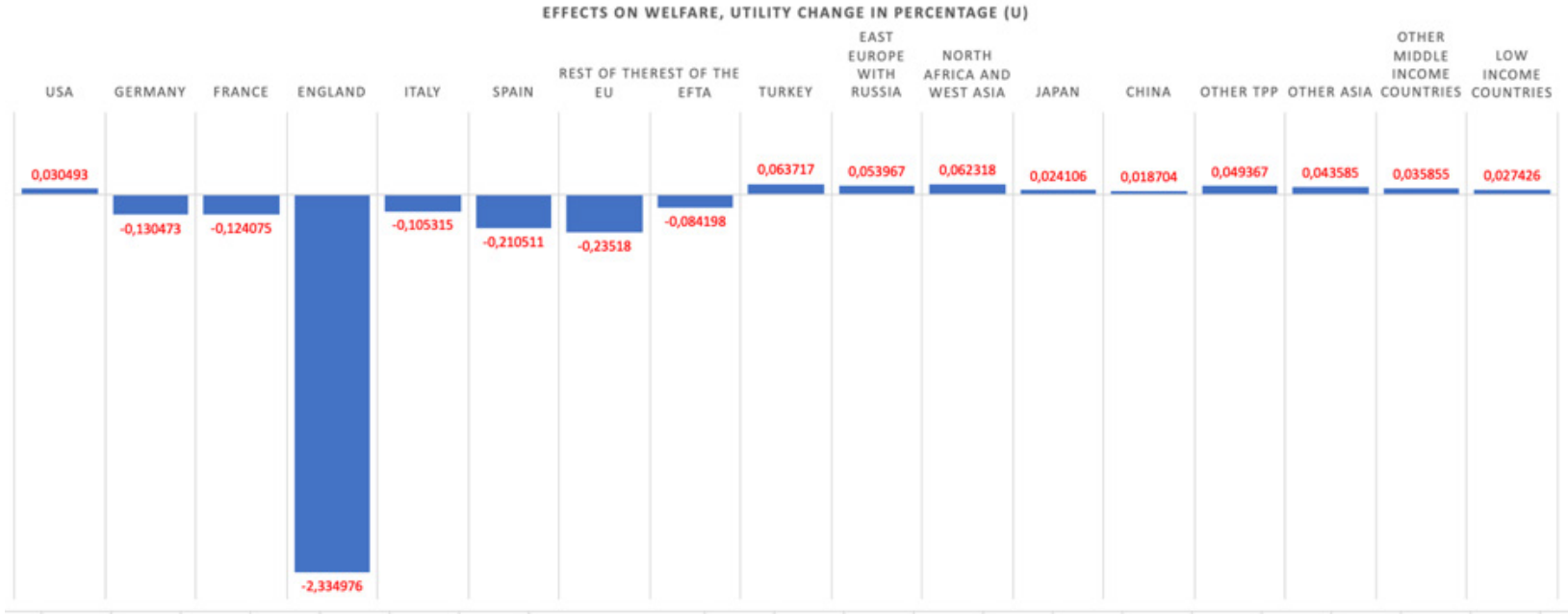

Figure 2. Soft Brexit: Effects on welfare, utility change, % (u)

Source: Author's projections.

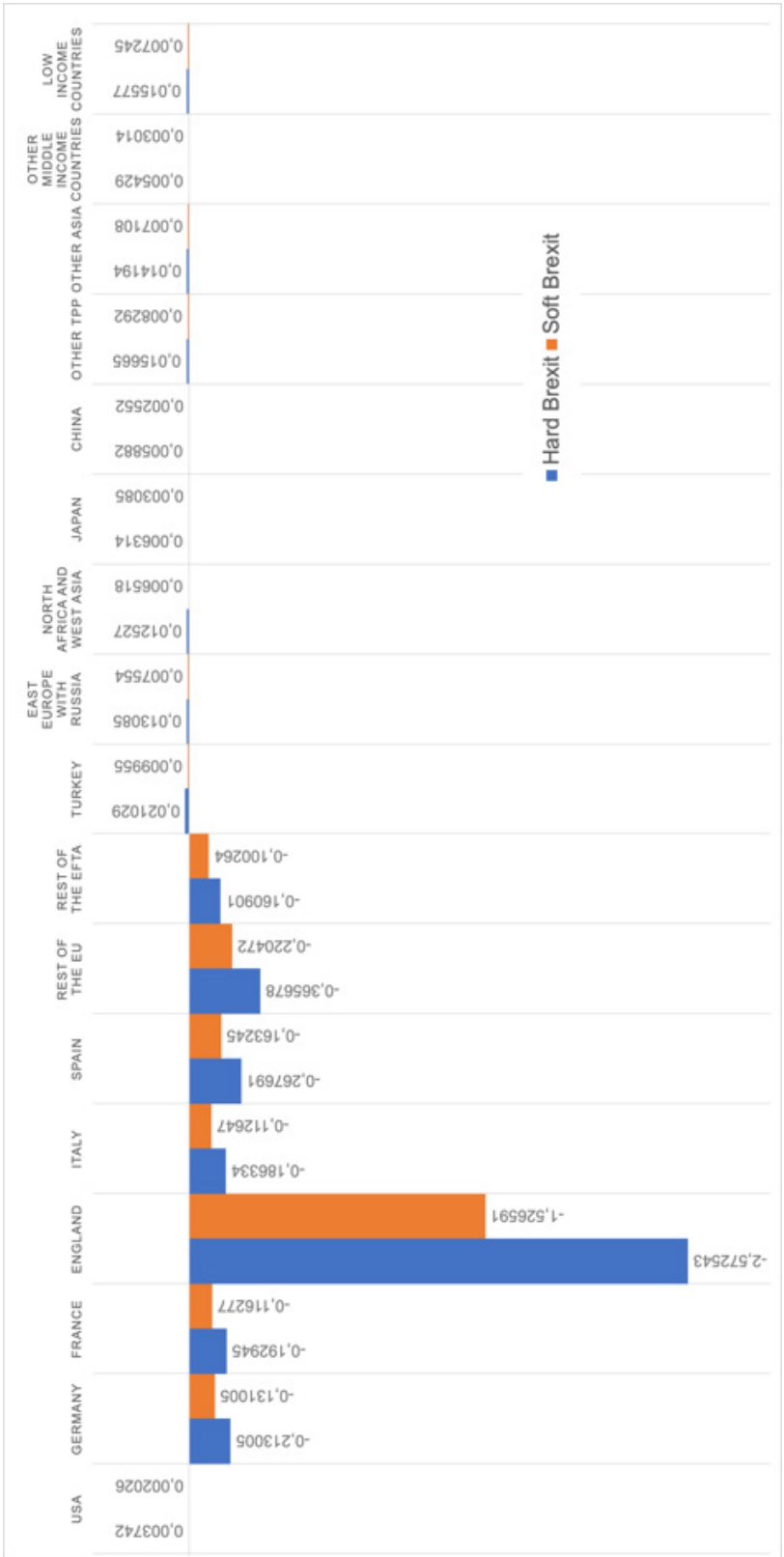

Figure 3. Effects on welfare, qgdp, change in real GDP, %

Source: Author's projections.

size can be observed comparing Fig. 2 and Fig. 4: the positive welfare effect for the United States attributed to the studied policy in real GDP is much less articulated for the relative change than for the absolute equivalent of the Fig. 2. Consequently, the positive effect of Brexit for the USA is bigger than for other regions comparing in absolute values. For instance, the value of positive change for the US is bigger in Equivalent Variation than the value of welfare losses for Germany, which taken into account with the relative change can still indicate that only a small-scale positive welfare gain for America can be expected from Brexit, which is at the same time still greater than gains from Brexit for China.

Comparative analysis of the welfare results for "Hard Brexit" and "Soft Brexit" simulations showcase that more than a half of the policy effect is derived from the "single market unbinding" and application of non-tariff barriers: more than 80% of the impact was caused by the NTMs, while only less than 15% can be attributed to the MFN tariffs (in EV results -88,261 for "Hard" and -52,884 for "Soft Brexit" in millions). It highlights the importance of the single market benefits in terms of non-tariff regulations and its profound effect on the overall trade between European countries. This assumption seems logical, because European tariffs have been measurably decreased since the General Agreement on Tariffs and Trade, all the while non-tariff barriers regulation has become rather advanced and developed in the EU. Additionally, this fact provides ground for the speculation that even in case of "Soft Brexit" the losses for the UK are going to be rather significant and the no-deal case does not differ by the agreement scenario in more than 50% as the main negative effect stems from imposition of the non-tariff barriers. Taken this proportion into account, it should be noticed that even in case of "Soft Brexit" Britain is going to face severe losses for GDP, which can provide a striking example of negative "single market unbinding" and its consequences and also prove the importance and impact of NTB measures. It can be observed that the main negative effect is going to be suffered from the loss of the European single market access, and in both cases the negative welfare effect is going to be serious and substantial.

However, one needs to keep in mind that NTBs do not change instantly and the effect of the single market cannot be reversed in one moment. These obstacles to trade require constitutional changes, legislative changes or technical changes. Additionally, NTBs are not likely to be implemented immediately after Brexit, as they are usually kept by lobbing groups of firms, while at the same time perceived economic benefits lower than costs of changing NTMs. Moreover, the future of the further NTBs regulation between these two regions at this time is not possible to completely foreseen, as following agreements in this field remain to be rather obscure until the 31 December, when the mode of this policy is going to be decided by the UK government.

The decomposition of regional EV is constituted of the allocative effects which are given by various per capita quantity change terms multiplied by initial taxes, terms of trade effects, effects of technical change, and effects of per capita endowment

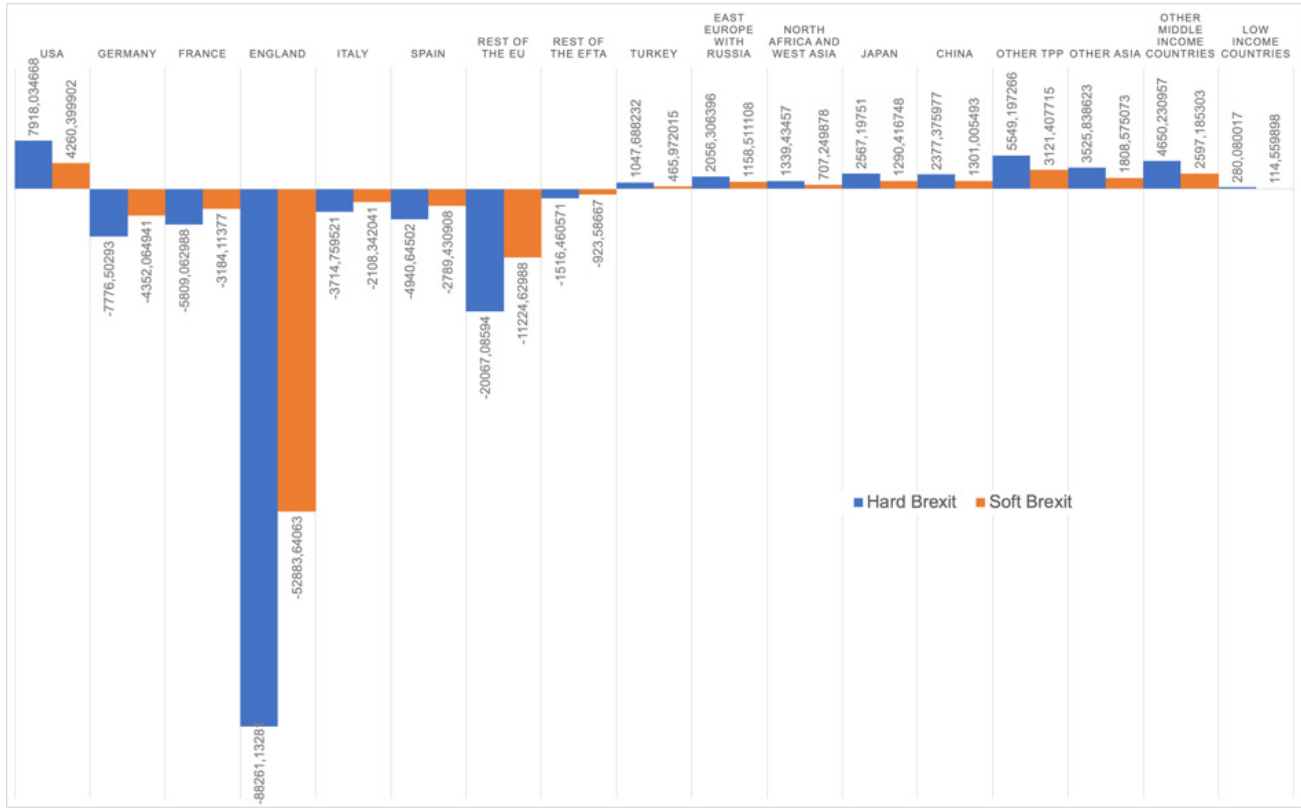

Figure 4. Effects on welfare, EV, Difference in pre- and after shock utility valued at base-year prices measured, million U.S. dollars.

Source: Author's projections.

and population change [24]. It can be noted that positive effect for the rest of the world can be explained with potential trade creation, as the UK and the EU will face the necessity of trade differentiation and other countries might benefit from more advantageous agreements with Britain. However, the studied regions are likely to experience also the problem of trade diversion, which can contribute to the welfare loss. Considering the simulation results, this problem is going to affect at much larger scale world economy than trade creation. Britain will be outside of the European Union, consequently trade flows will be diverted from the UK, because of additional protectionist regulation and the UK being outside of the European single market and customs union. Trade diversion will cause inefficient allocation of resources and increased costs, and in such a way decrease welfare of the regions. This aspect also explains disproportionality in the results, as the UK is going to suffer much more than the EU from Brexit, because Britain is going to become relatively more less attractive export location in terms of trade policy, as other European countries will change its regulation only in respect to the UK, but Britain will have to change its governance in trade with all European countries.

The vast part of negative impacts originates from decreasing technology, which stresses the dominance of NTB's shock impact, as non-tariff barriers have been implemented in the model in form of increased iceberg trade costs with the parameter "ams" incorporated in the production technology. Hence, there is a decline in technology of production, as after the policy is introduced, firms need to produce more goods and services in order to satisfy the same demand, because a bigger part of the total production is lost in export transit. This is the main assumption of the chosen approach for simulation of non-tariff barriers. But technology will be affected only in European countries, as only they are going to change non-tariff barriers regulation because of Brexit. Britain is going to suffer the most damage, because of the compound negative increase in tariff barriers and NTBs from the EU members.

Another important determinant is terms of trade, which is import purchasing power of a country's exports affecting welfare by changing consumption possibilities. In mathematical terms, this variable is defined as export price divided by import price. Derivation of welfare decomposition can be seen in GTAP Technical Papaper №5: "Changes in welfare in the multiregion model are therefore attributed to the interactions between taxes (both pre-existing and newly introduced taxes) and quantity changes taking place over the course of the simulation, as well as the added effect of changes in regional terms of trade and changes in the relative prices of savings and investment" [24]. Because of decreasing trade with the EU and the rise in tariffs and NTBs, the price of English imports increases, and the UK loses purchasing power of its exports, while this setback is reflected in the GDP. Consequently, as terms of trade for Britain are decreasing because of the combined boost from European countries of English import prices, the EU terms of trade improve on the expense of the UK, as European export can buy more import goods from Britain.

To begin with, terms of trade are expressed in the model by the difference between index of prices received for tradeables and index of prices paid for tradeables. However, this determinant for a multi-country model can be estimated with Laspeyres index, as the ration between the Laspeyres price index of exports and the Laspeyres price index of imports, where Laspeyres price index of export is the current value of the base period exports divided by the base period value of the base period exports.. And the opposite holds true: the reversed relation is greater than 1. Therefore, the terms of trade effect is compound from simultaneous application of tariff and non-tariff barriers in all members of the EU against single English export and vice versa. Consequently, for Britain the compound import tariff multiplicator from European prices decreases terms of trade, while for the EU this multiplicator from the product of increased import prices in Europe has multiplicated positive effect. All in all, this fact also explains disparity of the Brexit impact for the UK and the European Union, as terms of trade partly compensate for technology comedown and inefficient allocation of resources in European countries.

Looking into results of "Hard Brexit", the USA has the most positive effect of 4,558.507,324 million U.S. dollars, which is obtained through increase in trade value, as the need for European countries to differentiate trade arises. From the latter only Italy has a positive change (394,346.375 million U.S. dollars) in terms of trade, others vary in the range of 1,000 million. The deterioration in Britain of terms of trade amounts to -23,068.33203 million dollars. Spain has the worst impact on this determinant across all European countries: -842,777.527 million U.S. dollars. All of the effects stem mostly from application of increased tariffs.

From "Soft Brexit" welfare decomposition the following conclusion can be made: the effect of NTBs on terms of trade is rather indirect, whereas in contrast tariffs have immediate impact on price of export/import, and this determinant prevalently depends on trade patterns and particularities. Britain deteriorates by -13822,509766 in terms of trade, which is slightly more than half of the effect for "Hard Brexit". Nevertheless, the same conclusion from the Laspeyres ratio holds true for "Soft Brexit": almost all European countries have positive change, as for this case there is not direct decrease from tariffs.

The rest of the world have an increase in terms of trade, because both the EU and the UK are likely to substitute the missing from increased regulation trade flows and in such a way increase their export value over import value relation. The USA is unsurprisingly the main recipient of the positive change, as this country is one of the main trading partners for every region around the world with unprecedently high overall export value.

Additionally, decrease in efficiency caused by insufficient allocation of resources originates from trade diversion, increased trade costs and a decline in technology. Because of increased export prices and production costs, countries utilize the resources in inefficient way underproducing and shifting trade routes from optimal ones. All of these determinants will negatively affect mostly the economy of Britain,

and only to a lesser extent the European countries. Therefore, the negative impact can be estimated by the difference in income, equivalent variation, which is required to make up for the representative household after the policy shock. Thus, the UK is likely to experience a sharp decline in the welfare, in growth rates, in terms of trade and a drastic negative economic fall, which is going to be also reflected by associated productivity losses. This change is likely to be of structural origin and have long-lasting consequences. It is important to mention that in order to compensate for decreasing trade the UK is likely to use up some of the savings, which is stressed by this model with its closure of balance between investments and savings.

In order to study these effects on trade, it is needed to focus on the impact of terms of trade in relation to the percentage change in the value of merchandise exports ("vxwreg"). These figures provide the results of decreasing terms of trade on the export value. The sharp increase in exports prices contributes to the decline in the welfare and the difference between these two scenarios is substantial for value change of exports: -11.9% for "Hard Brexit" and less than half of it, -5.07%, for "Soft Brexit" correspondingly. The relation of terms of trade to the value of exports is direct, as it can be noticed. The changes reflected in the welfare decomposition are projected on value effects: Spain remains to be relatively the most negatively affected in export across European countries. However, for this case Turkey is going to receive the main gain from Brexit in percentage terms: 0.84% in contrast to the previously studied measures for the USA. Britain is going to experience loss in export value of -72,486.7 million U.S. dollars at world prices for Hard Brexit and -36,974 million for "Soft Brexit", Germany: -1,0468 million U.S. dollars and -5,345 correspondingly, Spain: -3789,5 and -1,879.9. While the USA has an increase in value of 6,530.15 and 3,671.14 million U.S. dollars, which is bigger than losses of all countries in the EU taken separately. Therefore, it can be concluded that in relatively moderate values for the American export this country still can benefit from Brexit. All other regions, among which there is China, are going to gain lesser value of export than the figures above.

Interesting outtakes can be derived when focusing on the effects of terms of trade in relation to the change in the quantity of merchandise exports by regions ("qxwreg"). All European countries are going to face decline in quantity of merchandise traded, although these changes are not directly reflected in the export value, as it can be noticed, because the latter greatly depend on the export structure by commodity and prices. Therefore, even though France faces the greatest losses in quantity, it is still not hurt by Brexit to the same scale in value. Similarly, the USA has a decline in quantity of merchandise, however in value there is a substantial gain in relation to the losses of European countries, which can be explained with this effect generally originating from price changes.

In order to disaggregate export effects by commodities exporter-sector-specific value percentage change is needed (vxwfob). Because the main impact of the policy is going to be incurred by the UK, it is better to begin with this region (see Fig. 6). The general trend from the results can be characterized as greater losses

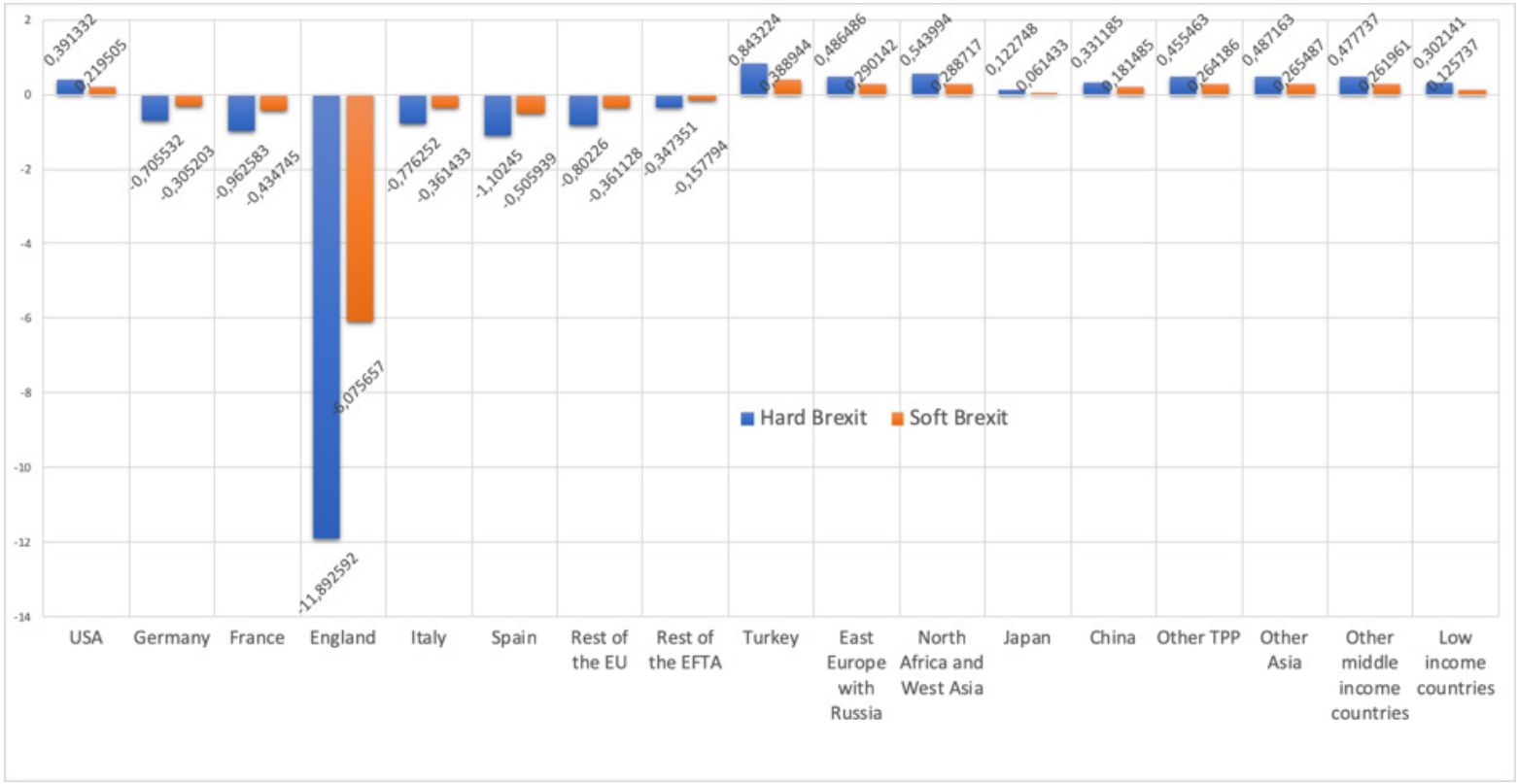

Figure 5A. Value of merchandise exports, by region, % (vxwreg)

Source: Author's projections.

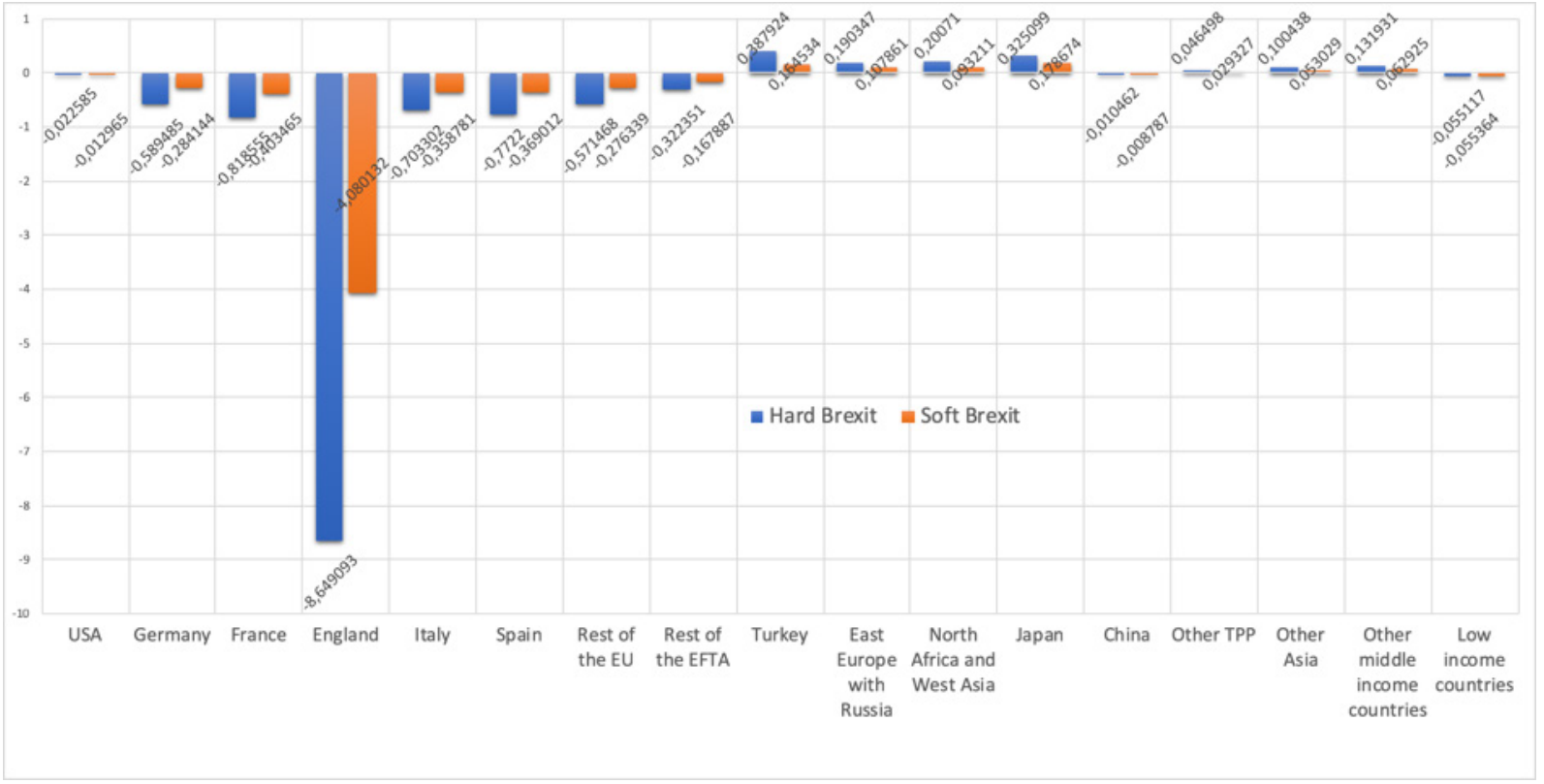

Figure 5B. Volume of merchandise exports, by region, % (qxwreg)

Source: Author's projections.

for both scenarios with some modest increases mostly in services sectors. The main sector at disadvantage is processed foods with -70% for "Hard Brexit" and -43% for "Soft Brexit", because this sector by the shock construction has the most protective MFN tariffs and NTBs. Closely connected to processed foods is primary agriculture, which appears also as rather protected sector in these simulations, and its reduction is of 50% and 22% correspondingly. However, this sector does not have the second place of total losses for "Soft Brexit" simulation, as its ad-valorem equivalent of non-tariff barriers is lower than of metals, fabricated, which is -38% and -29%. Although electrical machinery with a lower AVE is also higher in negative impact (-36% and -23%) for "Soft Brexit" than primary agriculture, which can be explained with the fact that primary agriculture is traditionally supported by subsidies, which helps it to take up some part of the shocks. Primary energy unsurprisingly is not affected by any negative change, because there is no additional protection applied by the simulation both for the EU and the UK. Another important outtake from the results is that beverages and tobacco export is not going to be changed to the same degree as other sectors by Brexit for the UK, which can be explained with consumption demand for this merchandise being inelastic, as these goods are related to dependent usage. Therefore, their export volume is not going to be decreased to the same degree by additional tariffs and NTBs being rather "sticky" even with an increase in prices, as the demand for these goods will stay persistent for some values, which also supports the total value of the trade in this sector. The same can be attributed to petrochemicals, because of these goods being used as fuel, and consequently they are one of the main intermediates for all types of production with additionally lower increased protection, which generates persistent demand for this commodity.

Other machinery sector has the lowest levels of tariff and NTB protection among all commodities, except primary energy, which can signalize that it is possible for Britain to partly offset trade losses with increased export of this goods, especially taking into account that base data in the model indicate that English exports at world prices for this sector is the greatest in value across all of commodity goods. The same conclusion can be attributed to other goods with positive change in export value of 6.6%, because their NTBs regulation for "Soft Brexit" is rather low and relatively lower than tariffs for "Hard Brexit", while their value of trade is moderate, which also makes this sector preferable for trade differentiation and amortization of negative impacts in case of "Soft Brexit".

When looking into effects on services, it can be highlighted that almost for all sectors, except for business and professional services, air transport and other transport, there is an increase in export value. The main explanation for this trend can be provided in the following form: services are not protected by tariffs, as well as their NTBs protection remains to be rather low, which supports their preferability for trade substitution. However, their export is highly dependent on modes of supply and some of services are untradeable being consumed only at local markets. Therefore, this improvement in value does not compensate for the general losses of Brexit, as the main competitive services sector of Britain (business

and professional services with base export value of 88,947 million U.S. dollars) is strongly regulated by NTBs with the highest ad-valorem equivalents across all of services. Other transport and air transport are also under increased protective regulation, which brings negative value changes. The highest increase for services is in the sector of other services, as for this group the data is missing, and for trade and distribution, because the proportion of value-added gain in this sector is the most profitable and the NTBs are low.

Because of the mostly negative change in volume of trade, a sharp decrease in bilateral volume of sales can also be expected. Trade between the UK and the EU is going to fall almost for all goods sectors if "Hard Brexit" takes place. The variable "qxs" stands for regional demand for disaggregated imported commodities by source, and it depends on the productivity shifter (-ams), market clearing conditions (qim(i,s)), elasticity of imports substitution (ESUBM) in relation to world prices and price for aggregate imports (ESUBM*(pms-ams-pim)). These changes should be studied in combination with the base values of bilateral export at world prices (VXWD), as these indicators also represent relative change in percentage. The fall in export volume from the UK to the EU is estimated in the range from -95% in processed foods, -87% in metals, fabricated, -70% in motor vehicles, -69% in electrical machinery, - 68% in primary agriculture to -25% in petrochemicals and -5% in construction. As it can be noticed, goods are affected to a much larger scale in comparison to services, because the former falls under tariffs. For services there is only decrease in construction, transport (except for maritime transport) of approximately -40% for each category and business and professional services of -43%. With a closer look into results of the "Hard Brexit" simulation, it can be noticed that Britain is likely to substitute some of the trade losses with the help of these sectors, which are increasing in sales for all regions despite the studied policy: primary energy and other machinery. Primary energy is not increasing to a large degree though: only approximately 8-9% going up, while other machinery ranges from 4% for the EU to 31% for other regions. These sectors are not declining because, firstly, they are much less regulated than other sectors by tariffs and non-tariff barriers of Brexit, and secondly, they are prevalently auxiliary sectors, thus they contribute to domestic production of regions and their external demand is more stable. Another plausible explanation can be that these sectors produce intermediates, which are highly needed at local markets and domestic prices for the UK, as Brexit is going to disrupt previously set up value-added regional chains, which means that increased quantities of these goods can be expected for new trade in intermediates. Although it should be noticed that these sectors do not increase to a greater extent than the losses from Brexit, which can indicate that they will not become another line of English export specialization only merely trying to compensate for the losses of the studied policy.

Another important observation is that there is an increase in all sectors of bilateral trade with the USA, which can support the assumption that English trade might be more inclined to shift from European trade flows towards America and other destinations. However, the same holds true for Turkey, as well as for all regions

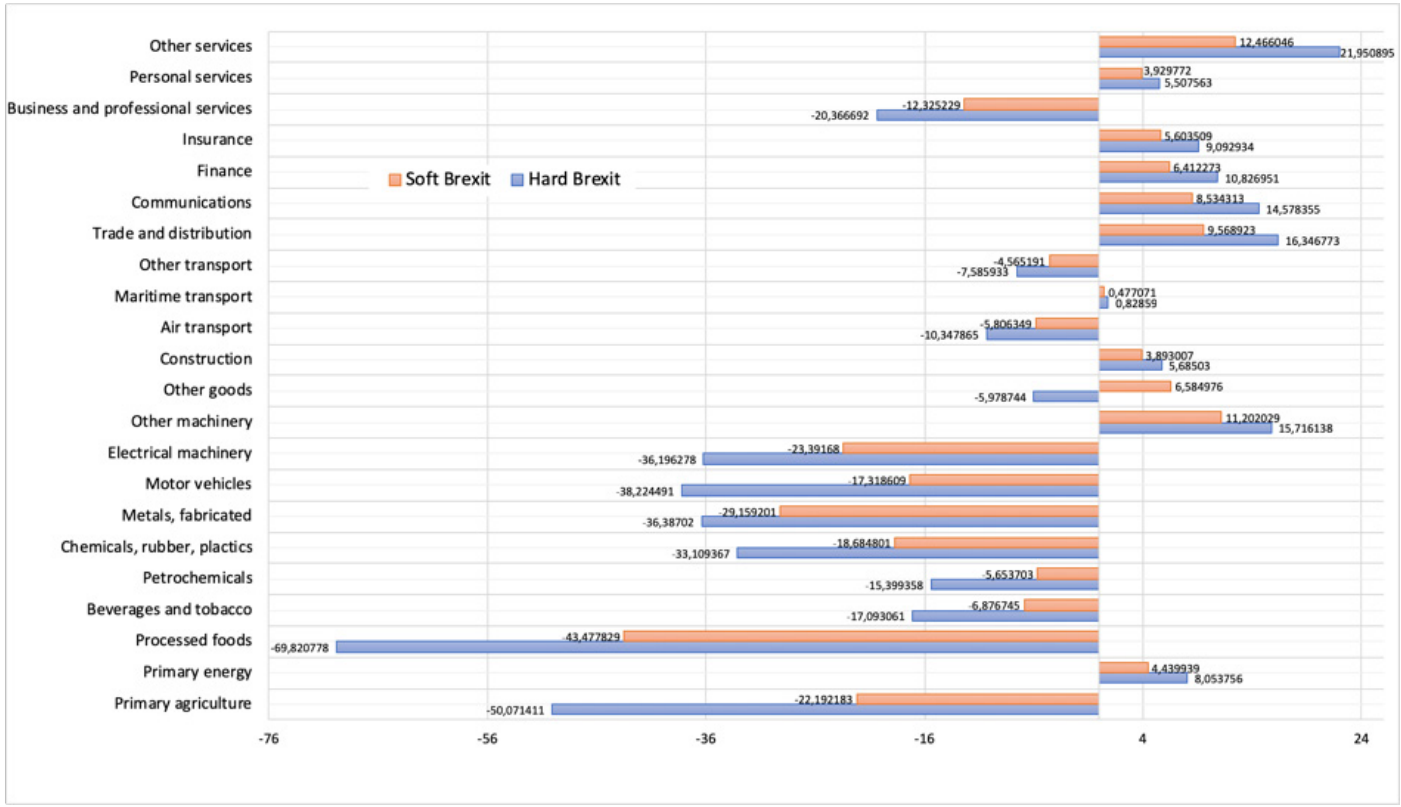

Figure 6. Exporter-sector-specific value of merchandise exports, %, Britain (vxwfob)

Source: Author's projections.

outside the EU in almost the same values, which taking into account the size and intensity of American export and import, generally outlines the trend for trade substitution without any special regional vector. Additionally, more than the half of the sectors are increasing in correspondence to the decreased trade flows. The most increased volume of exports ranging from 2% to 31% is in the following sectors: electrical machinery, primary agriculture, processed foods, other machinery, electrical machinery, other goods and almost all services. Even though all other sectors are largely damaged in export to the same scale as goods, it makes it possible for Britain to partly offset losses of "Hard Brexit" through increased trade in this area, taken into account low ad-valorem equivalents of services in relation to tariffs on goods. Furthermore, almost all service sectors are going to increase in export to the EU, except for air and other transport, construction, business and professional services. Among them the latter is one of the top traded services sectors of the UK, which explains the high level of non-tariff barriers.

One limitation to this research is that it is hard to ascertain from the results, whether there is trade creation by "Hard Brexit", as the substituted trade to other regions does not obviously create additional trade flows. And the future of new trade agreements remains to be unknown, because such international decisions depend not only on economic reasons, but they are also greatly influenced by political and social matters. By the results it is visible, that there is a necessity to compensate for Brexit losses. And the example of "Hard Brexit" simulation provides two possible ways of trade substitution for the UK: 1) sectoral trade substitution, as the UK can potentially increase trade in services in case of "Hard Brexit", because they are regulated to a lesser extent by the studied policy and 2) regional trade substitution: Britain can compensate for the damage to its exports in volume by diversification of their trade structure and trading with other than the EU partners.

By simulation of "Hard Brexit", import volume change to the UK proves the assumption that production of axillary sectors is increasing in Britain, because of a decrease in imports of these goods. The decline in import from the EU to Britain is almost of the same reciprocal scale as the fall in export from the UK to the European countries. However, for the European Union quantities of all sectors are decreasing in exports to the UK, although the European countries are not going to suffer from the same compound effect of simultaneously applied additional obstacles to trade, as it is the case for the UK, because for them only import from Britain is restricted. Furthermore, the EU have better opportunities to cope with Brexit negative changes, which is indicated by lesser welfare loses, because it is possible for them not only to trade more with other regions and in other sectors, but also differentiate and increase the "internal" trade with other European countries. Additionally, low export losses at the global scale for the EU can be explained with the fact that it can be easier for European countries to substitute and differentiate trade inside the European Union and outside with other countries than for the UK, as European trade destinations, agreements and flows are already set up and they don't require additional institutional, legislative and economic regulation after Brexit, therefore, they will not induce additional costs.

This is supported with the observation that there is a modest increase for the EU in exports with all regions except the UK, despite a very limited number of some regional exceptions.

However, for services there is one service sector which is generally decreased for all European countries almost for all destinations, which is finance. To provide an explanation for this change, export of finance services is generally depended on the overall political and economic world situation, as finance is highly influenced by expectations of all agents and prices for these services can change abruptly with any disruptive events. Therefore, it can be wisely and necessary to limit the export of this sector in times of such a global and controversial process as exit of the UK from the EU, because the prices of these services are likely to be unstable during and after Brexit. All other effects to the volume of European export are mostly positive, and in case of the negative ones they are much of a lesser extent of the studied changes, and they mainly depend on regional export structure and peculiarities. The import of all other than the axillary goods sectors to the UK is increasing from all countries other than the EU, because of the increased English import demand, as import from European countries falls, and thus the UK needs additional volumes of imported goods and intermediates in order to satisfy growth of local industries and support the welfare of consumers, as one of the most increased sector in import is processed foods, which has approximately quantity of 100% change from all non-European regions.

However, this situation is not the same with services: construction, trade and distribution, communication, finance, personal services, insurance and other services are declining in imports to the UK. The reason behind this change is the same as with auxiliary sectors: increased English export of these sectors reduces the imports by protectionist policy in order to obtain competitive advantage at global markets. This is supported with the fact that in all of these sectors there is an increase of export from the UK. While on the contrary, import of reduced sectors by additional obstacles to trade (such as business and professional services, transport, etc.) is increasing. Therefore, there is an interesting outtake from "Hard Brexit" simulation that this policy can develop English specialization in finance at the expense of other regions, as this sector is less regulated than the other, and this is proven by corresponding increase in English export to the decrease in global export of these services.

When looking into export changes for the UK under "Soft Brexit", the character of the effects generally remains the same but of lesser extent, which was previously studied with overall dissimilarities of export volume impact by region. However, additionally to the previously increasing sectors in export from Britain there is the sector of other goods, which also shows the same upward trend for all regions. It can be possible for this sector to expand in export because of the tariff staying the same. Therefore, expansion of consumer goods manufacturing is possibly a logical extension of Brexit protectionist policy, because these goods have the smallest AVEs among all goods sectors, except for primary energy and other machinery. The same

corresponding situation with the negative addition of other goods is with changes to import volume destined for the UK. Export from European countries also differs with "Hard Brexit" simulation only in decreased values, but there is no any change of trends, which is not very surprising as the impact of non-tariff barriers is already included in the "Soft Brexit" simulation with halved estimations of AVEs.

To sum up the analysis of export and import changes for "Hard Brexit", this policy change might be beneficial for English specialization in services to some extent and new trade relations of the studied regions, and also Brexit can stimulate trade flows in different direction from the EU. But even these positive effects of no-deal case are highly unlikely to compensate for negative welfare effects in the UK and the global problem of trade diversion.

Conclusion

To sum up the results of the research, it can be concluded that the main hypothesis of the work has been proved: the effects of Brexit on trade and economy are going to be distributed disproportionally to the UK and the EU, and also inside the UK, as they depend on the structure of the internal and external economy systems and also on world trade patterns. Brexit is going to negatively affect the UK at a much larger scale than the EU, which supports the assumption of a greater importance of trade disproportionality. The loss in welfare and income from increased trade costs and inefficient resources allocation is significant for the UK and is not likely to be compensated in a short/medium run perspective, as it has structural nature and its repercussions are going to incur long-lasting negative effects. Not only will Brexit change the export/import structure of the UK, but it is likely to also change the world trade, as the studied countries will have to offset the losses with trade differentiation and new trade policies.

One of the main results of the research illustrated that both Hard Brexit and Soft Brexit will be seriously damaging for economy, as their impacts does not differ from each other by more than a half. Through this outcome of the carried-out simulation the importance of non-tariff barriers in respect to tariffs has been again proven. Almost for all cases the differences between two scenarios were in the scale, although for some aspects Hard Brexit has been discovered to have some different from "Soft Brexit" reactions. And these dissimilarities mostly indicate the different nature of these two factors of the studied policy and their effects: tariffs and non-tariff barriers.

Overall, the effect of Brexit has proved the intuition that Britain will have to substitute the lost trade with other partners increasing protectionists measures towards the EU and additionally liberalising trade in other directions. However, the UK will also likely not only to change its trade patterns, but also to modify its import-export structure, as under Brexit this country will have to shift trade specialization from its comparative advantage to less regulated sectors, increasing the losses of inefficient

allocation, loss in world and national welfare and trade distortion. Although, some sectors might benefit from this policy change – mostly agricultural ones, which typically benefit from government regulation. But even for such a protected and subsidised sector as agriculture, which is relatively small in the UK, the protectionist gain is not going to compensate for the national losses. It can be also mentioned that trade in manufacture and intermediates between the UK and other trade partners is likely to decrease because of the structural change in economy of Britain.

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Анненков Г.[1]

Оценка экономического эффекта Брексита для торговых потоков между Великобританией и Европейским союзом с помощью вычислимой модели общего равновесия GTAP

В исследовании дается оценка экономических эффектов Брексита для внешней торговли и экономики Великобритании в целом с применением модели проекта GTAP. Приводится анализ двух сценариев выхода Великобритании из ЕС: «жесткий Брексит», т.е. выход «без сделки», и «мягкий Брексит», т.е. выход с заключением соглашения о свободной торговле между Великобританией и ЕС. Модель не позволила обнаружить эффект создания торговли. Напротив, присутствует эффект отклонения торговли. В рамках исследования выявлено, что влияние Брексита на Великобританию и на ЕС не является пропорциональным, а также подтвердилась гипотеза о влиянии Брексита на внешнюю торговлю и экономику Великобритании в целом.

Ключевые слова: *Соединенное Королевство, Европейский союз, Брексит, внешняя торговля, GTAP.*

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