The Impact of Trade and Labour Immigration Policies on the UK Economy

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Abstract.
This paper investigates the effects of the interaction between trade and labour immigration policies. We apply a computable general equilibrium (CGE) model, specifically designed to count for imperfect native-migrant substitution across sectors and to allow for imperfect labour mobility between agriculture and the rest of the economy. The CGE model is employed to analyse the effects of trade policy combined with a series of labour immigration restrictions on the UK economy. Our findings show that no change to the current immigration policy, with a modest reduction of labour force, would lead substantial gains in terms of GDP and welfare with respect to the most rigid immigration scenario in UK.

Keywords: computable general equilibrium; immigration; labour market; trade.

JEL Classification: C68; E24; F16; J61; Q11.

1. Introduction

Agriculture contributes to a small part of the world GDP and yet it has a special status in most developed economies for two reasons. First, it is protected from international competitions either directly, with tariffs, or indirectly, with non-tariff barriers and subsidies. Second, it heavily draws from immigrant workers as a source of cheap unskilled labour. Countries continuously face trade-offs when they set their policies in the way that their trade partners are often their immigration partners. The Brexit negotiations are a typical example. As for the rest of the EU, the United Kingdom benefited of free movement of people and access to the single market when the Maastricht treaty became in effect in 1993. During the first decade, immigration increased modestly in the UK following the trend started after WWII (Migration Watch UK, 2014). It was after the EU enlargement to Eastern and Central European countries in 2004 that migrant labour increased substantially in the UK[1]. This was due to the favourable cross-country wage differentials that attracted an increasing number of *unskilled* labourers from the new member states (NMS). After the Brexit referendum in June 2016 this trend partially slowed down, but the presence of unskilled workers from NMS is still dominant in the British agriculture (OFS, 2018a)[2]. Despite this, the UK is preparing to leave the EU with departure date temporarily scheduled for the end of October 2019 plus a possible transition period (UK Parliament, 2019). Whenever this will happen, the UK will need to have put in place new trade and immigration policies necessary to deliver the novel relationship with the EU. A complete understanding of the effect of these combinations is therefore impossible without understanding how trade and immigration policies interact within the UK economy.

Previous studies mainly focused on the trade side. For instance, Boulanger and Philippidis (2015) employed a computational general equilibrium (CGE) model to assess the effect of different trade scenarios on the UK economy. Similarly, Davis et al. (2018) employed a partial equilibrium

[1] The share of the UK population born abroad increased by only 3% between 1971 and 2001 (Dustmann, Frattini, and Preston 2012; Migration Watch UK 2014). In contrast, the share of population born abroad increased by 6% between 2004 and 2016 (Office of National Statistics 2018a, 2018b).

[2] In 2018, the percentage of foreign workers represented 17% of the British labour force, but 37% and 54% of the unskilled labour force in horticulture and other crops (UK Data Service, 2019).

model to study the effect of different trade options on the UK agriculture. More recent studies from the Bank of England (2018), the UK Government (2018a) and Hubbard et al. (2019) extended their CGE analysis to include immigration, but without modelling specifically the labour market.

In reality, the process of relocating labour can be slow because skills are not perfectly transferable across sectors and retraining takes time and money (Campo, Forte, and Portes, 2018; Mountford and Wadsworth, 2018). In other words, workers specialize in occupations where they have a comparative advantage (Lee and Wolpin, 2006). Similarly, natives and migrants have different skill sets and immigration encourages workers to specialize where they have a lower opportunity cost (Peri and Sparber, 2009). Besides, although farm and non-farm wages have moved together, there is a substantial evidence that wage differential persists in developed economies (Kilkenny, 1993). Moreover, if labour would be perfectly mobile we should not observe low unemployment rate, high number of vacancies, and wage differentials across agriculture and non-agriculture (Office of National Statistics, 2018b).

In this paper, we present a CGE model specifically designed to count for imperfect native-migrant substitution across sectors and to allow for imperfect labour mobility between agriculture and the rest of the economy. The model is then employed to analyse the effect of trade and immigration options on the UK economy. Section 2 introduces the model and data calibration, Section 3 describes the scenarios, Section 4 shows the results, while the conclusions are drawn in Section 5.

2. Model and data calibration

To assess the systemic, general equilibrium effects of immigration policy, we use a multi-country world computable general equilibrium (CGE) model, that is the global trade and migration model (GMig2), developed by Walmsley *et al*. (2005; 2007), in the version modified by Aguiar and Walmsley (2013), and subsequently extended by ourselves introducing the distribution of migration flows amongst sectors, segmented factor markets and agricultural specificity.

The GMig2 model includes bilateral labour flows amongst countries in the original GTAP model (Hertel, 1997), which is a comparative static, multi-commodity and multi-region CGE model with the assumptions of perfect competition, market equilibrium and open economy. As the mathematical structure of the GTAP model is very complex including a large number of equations, that would become too much long to discuss here, this section aims to provide a concise description of the original GTAP model and its refinements for the aims of this paper.

2.1 Consumption

On the consumption side, the economy is modeled by a representative household in each region *r*, whose Cobb-Douglas utility function allocates expenditures between private consumption (C), government consumption (G) and savings expenditure (S) as follows:

$$U_r = C_r^{\alpha_{C,r}} G_r^{\alpha_{G,r}} S_r^{\alpha_{S,r}} \tag{1}$$

with $\alpha_{C,r}$, $\alpha_{G,r}$ and $\alpha_{S,r}$ income shares and $\alpha_{C,r} + \alpha_{G,r} + \alpha_{S,r} = 1$.

The constrained optimizing behavior of the household in region *r* for private consumption is represented by a non-homothetic Constant Difference of Elasticity (CDE) expenditure function for the set of goods and services. A Cobb-Douglas sub-utility function is employed for government spending. In this case the expenditure shares are constant across all commodities. Private and government consumption are split in a series of alternative composite Armington aggregates (Armington, 1969).

2.2 Production

On the production side, the producers receive payments for selling consumption goods to the private households and the government, intermediate inputs to other producers and investment goods to the savings sector. Under the zero profit assumption, these revenues must be precisely exhausted on expenditures for intermediate inputs and primary factors of production. The nested production

technology exhibits constant returns to scale and every sector produces a single output. The technology is simplified by employing the Constant Elasticity of Substitution (CES) functional form (Figure 1):

$$y_{i,r} = \left(\sum_{j=1}^{n} \theta_j x_{j,r}^{1-\frac{1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad (2)$$

where, in region r, $y_{i,r}$ is the production of the good i, $x_{j,r}$ is the input j, θ_j is a non-negative parameter, with $\sum_{j=1}^{n} \theta_j = 1$, and σ is the elasticity of substitution.

Both intermediate and final products from different regions are considered to be imperfectly substitutable with each other (Armington, 1969). All factor inputs (land, labour, capital, natural resources) are assumed to be fully employed. Capital and labour are perfectly mobile across sectors land and natural resources are sluggish to adjust.

[FIGURE 1 HERE]

2.3 Segmented factor markets

Following the GTAP-AGR model developed by Keeney and Hertel (2005) we have integrated a module for segmenting the market for mobile factors in the agricultural and non-agricultural sectors (Figure 2). The separation of agricultural and non-agricultural markets leads to separate market clearing conditions and different factor prices in the two markets. The segmented factor markets module links to the rest of the model through endowment prices (pf) and the factor market clearing condition. The endowment price is defined as the market price for the factor endowment plus any taxes on factor use. As there are two markets for factors in the segmented market (agriculture and non-agriculture), the endowment price is defined as the agriculture market price plus taxes in the agricultural market, and as the non-agriculture market price plus taxes for the non-agricultural market. The market price for each factor (pm) is therefore a weighted average of the agricultural market price (pmagr) and the non-agricultural market price (pmnagr).

[FIGURE 2 HERE]

The market supply of each factor is therefore equal to the demand for each factor across all industries within each market. The total supply of each factor is the sum of the supply of each factor in the agricultural and non-agricultural factor markets. Although there are two distinct markets for mobile factors in the segmented factor markets module, labour and capital can still move between the two markets. The movement of factors between agricultural and non-agricultural markets is determined by either changes in relative prices and an elasticity of transformation (CET function).

2.4 Agricultural specifity

We have introduced agricultural specifity in the production function as in the GTAP-AGR model (Keeney and Hertel, 2005). Output is produced using a constant elasticity of substitution (CES) production function combining two inputs, which are themselves composite inputs (Figure 3). The first of these is a purchased input aggregate. The second composite input is a farm-owned value-added aggregate. The individual inputs in each of these groups are assumed to be separable from one another. The purchased input and farm-owned aggregates are themselves each a CES function of individual farm inputs, the latter corresponding to the value-added aggregation function in the standard GTAP model.

[FIGURE 3 HERE]

Another important aspect of the farm and food marketing system relates to the crop-livestock interactions generated by the use of feedstuffs in livestock production. We capture the average degree of feedstuff substitution by a constant elasticity of substitution among crop and food products used in livestock production following Rae and Hertel (2000). The demand for feedstuffs is treated as a further CES nest below the purchased inputs aggregate. Figure 4 shows livestock feedstuffs substitution.

[FIGURE 4 HERE]

2.5 Savings and investment

Savings are exhausted on investment and capital markets are assumed to be in equilibrium only at the global level. If savings exceed investments for one country, then it has a trade surplus; otherwise, it has a trade deficit. A hypothetical world bank collects savings from all regions and allocates investments so as to achieve equality of changes in expected future rates of return:

$$\Delta\eta_r = \Delta\eta \tag{3}$$

where $\Delta\eta_r$ and $\Delta\eta$ are the percentage change, respectively, in region's rate of return and global rate of return.

2.6 Taxation

Every economy includes government interventions. Private households and the government not only spend their available income on consumption goods, but also pay taxes to the regional household. In the case of the government, taxes consist of consumption taxes on commodities. In the case of private household, taxes consist of consumption taxes and income tax net of subsidies. The accounting relationships of these two agents therefore include taxes as additional expenditures. This is captured by the distinction between market prices and agent's prices inclusive of tax. Also firms have to pay taxes to the regional household. These value flows represent taxes on intermediate inputs and production taxes net of subsidies. Trade generated tax revenues and subsidy expenditures are computed in a manner analogous to the ones which are being raised by policy instruments used in the domestic market. The only difference is that now the tax or subsidy rates are defined as the ratio of market prices to world prices. If there is an import tax (subsidy), the market price is higher (lower) than the world price, so that the power of the ad valorem tax is greater (smaller) than one. In the case of an export tax (subsidy), the market price lies below (above) the world price and the power of the ad valorem tax is smaller (greater) than one. All taxes levied in the economy always accrue to the regional household.

2.7 Bilateral migration flows

The GMig2 model, developed by Walmsley *et al*. (2005; 2007), is a bilateral global migration model based on the GTAP model. The GMig2 model explicitly tracks the bilateral movement of skilled and unskilled workers from the home to the host region, where the home region is defined as the permanent residence of the worker; the host region is the region in which the person resides or works.

The labour force of skill *i*, located in region *r* ($LF_{i,r}$), and available to firms for production, is the sum across home regions (*c*) of all workers located in the host region *r*:

$$LF_{i,r} = \sum_c LF_{i,c,r} \tag{4}$$

Similarly, for population we have:

$$POP_r = \sum_c POP_{c,r} \tag{5}$$

An increase in the number of migrant workers from region *c* to region *r* reduces the number of workers in the labour supplying regions and increases the labour force of the labour importing region. The population would change in similar ways.

The migrant workers are assumed to gain a portion of the difference between their nominal wages at home and the nominal wages in the host region, reflecting the fact that their productivities have also changed. Thus, the initial wages of the migrant workers from the home region *c* to the host region *r* are defined as follows:

$$W_{i,r,c} = W_{i,r,r} + \beta\left(W_{i,c,c} - W_{i,r,r}\right) \tag{6}$$

Any changes in the labour force are allocated across sectors so as to equalize the percentage change in the wage earned by all workers (domestic and foreign).

The income of permanent residents depends on the change in income from non-labour and labour endowments (FY), plus remittances (RM) received from migrant workers abroad and the tax revenue (T), less depreciation (D), as follows:

$$\Delta Y_{r,r} = \sum_{f \in NLAB} \Delta \mathrm{FY}_{f,r,r} + \sum_{l \in LAB} \Delta \mathrm{FY}_{l,r,r} - \Delta D_r + \Delta T_r + \sum_{c \in REG} \Delta \mathrm{RM}_{r,c} \tag{7}$$

The income of existing migrants depends on the income from their endowment of labour (FY^{E}_{l}), less remittances (RM^{E}) sent home as follows:

$$\Delta Y^{E}_{r,c} = \sum_{l \in LAB} \Delta FY^{E}_{l.r,c} - \Delta RM_{r,c} \quad (8)$$

The change in real income of new migrants equals the final income obtained in their new country of residence from their endowment of labour (FY^{N}_{l}) less remittances sent home (RM^{N}) and the initial labour income they received before they migrated (IFY^{N}). Following Timmer and van der Mensbrugghe (2006), the final income is discounted by PPP in their new residence relative to the PPP in their home country so that the final income is converted back to equivalent income in the home country. It follows that the change in the income of new migrants is:

$$\Delta RY^{N}_{r,c} = \frac{PPP(c)}{PPP(r)} \left[\sum_{l \in LAB} \Delta FY^{N}_{l.r,c} - \mathrm{RM}^{N}_{r,c} \right] - \sum_{l \in LAB} IFY^{N}_{l.r,r} \quad (9)$$

The change in real income of return migrants equals the final income obtained in their home country from their endowment of labour (FY^{R}_{l}), less the initial labour income they received from their host country, prior to returning home (IFY^{R}) less initial remittances (IRM^{R}). In this case the initial income is discounted by PPP in their host country and any change is prices in the home country are applied to obtain the change in real income at the home country's market exchange rate. Thus, we have that the change in the income of return migrants is given by

$$\Delta RY^{N}_{r,c} = \sum_{l \in LAB} \Delta FY^{N}_{l.r,c} - \frac{PPP(c)}{PPP(r)} \left[\sum_{l \in LAB} IFY^{N}_{l.r,c} - IRM^{R}_{r,c} \right] \quad (10)$$

The flows of remittances from the host country back to the home country are assumed to be a constant proportion of income. Remittances reduce the income of the migrants and increase the incomes of permanent residents back home. Remittance flows also affect a county's balance of payments, that becomes:

$$Y = C + I + G + X - M + NREM = C + S + G \quad (11)$$

Furthermore, Figure 5 shows that to produce final output (qo), firms need domestic (qfd) and imported (qfm) intermediate inputs as well as value added (qva). Within the value added tree, unskilled labour has been differentiated between domestic and foreign.

[FIGURE 5 HERE]

Finally, we have modified the GMig2 modelling the distribution of labour force and the migration flows, both differentiated by skill type, amongst sectors and regions.

2.8 Data calibration

In the CGE models, a set of equations translates the structure of an economy and describes the behaviour of all agents and the equilibrium conditions of all markets. A calibration procedure fixes the parameters for the model's equations (called benchmark equilibrium) and, then the model can be solved for an alternative equilibrium associated with any changed policy regime. A comparison between the alternative and the benchmark equilibrium makes it possible to assess effects on allocation and income distribution.

The GMig2 model is calibrated using the GTAP data base, version 9, which contains macroeconomic data for the year 2007. We use an aggregation of 8 countries and 39 sectors (Table 1 and 2 in Appendix). It is a cross-section data of international trade flows and national input-output tables. All the information in the data base is reported in values converted to US dollars. The behavioural parameters utilized in the GTAP model are described in Dimaran (2006). There are four sets of behavioural parameters in GTAP data base: (i) elasticities of substitution, in both consumption and production; (ii) transformation elasticities, that determine the degree of mobility of primary factors across sectors; (iii) the flexibilities of regional investment allocation; (iv) consumer demand elasticities.

Furthermore, we use the native-migrant elasticity of substitution by industry in UK following Ottaviano and Peri (2012), to allow for sectorial differentiation. The estimated elasticities are reported in Table 3 of the Appendix.

3. Design of Simulation Exercises

To model the impact of Brexit on the UK economy, we combined a trade scenario with a series of immigration scenarios. Specifically, we run the trade scenario and assess its costs on the UK economy. Then, we take the results of the trade scenario as the new baseline status and we run an immigration scenario, that represents the change of immigration policy given those trade conditions. It is useful to separate the effect of immigration from trade. Overall, for each combination of trade and immigration scenario, the cumulative effect on the UK economy is given by the summation of the trade impact and the immigration impact (see UK Government 2018a for a similar design of the simulation exercises).

3.1 Trade scenario

In this study, we employed the No Deal trade scenario (No Deal), that represents the case of the UK crashing out of the EU single market without any trade agreement. The UK-EU trade will be regulated under the WTO Most Favoured Nation tariffs (MFN). In March 2019, the UK Government published the full list of these tariffs (UK Government, 2019). With respect to the outflow trade, the UK exports to the EU will be subject to the full MFN tariffs. In contrast, the UK imports from the EU will be subject to a reduced version of the MFN tariffs. Notice that the only sectors affected by the reduced tariffs are in the food processing industry. For instance, the tariffs for the UK imports of beef will be 53% of the full MFN tariffs. Similarly, the tariff on the poultry meat is 13% of the full MFN tariffs. Overall, this implies that

- the tariffs on the UK exports to EU will increase from zero to the full MFN rates;
- the tariffs on the UK imports from the EU will increase from zero to the reduced MFN rates.

Note that since under the WTO regulation the UK cannot discriminate amongst trade partners, this implies that the tariffs on the UK imports from the Rest of the World (ROW) will decrease from the full MFN rate to the reduced MFN rate. Thus, in general the effect of the No Deal shock on the

domestic production and prices is unknown in advance since it will be driven by the tariff differentials with EU (positive) and ROW (negative).

Trade shocks were implemented via ad-valorem equivalent (AVE) tariffs as in the standard GTAP. AVE tariffs are provided by International Trade Centre (2019) and are inclusive of non-tariffs barriers and tariffs rate quotas already existing (RTQs). Table 4 of the Appendix reports AVE Tariffs on UK trade for No Deal Scenario. To include the new RTQs that would be set under the No Deal scenario (UK Government, 2019b) we followed the methodology implemented by the International Trade Centre (2019)[3]. Two additional aggregation were implemented to reconcile the trade shocks with the industrial classification employed in GTAP. First, the UK Government (2019) provided two hundred and seventy-seven MFN tariff rates according to their eight digit product code. These tariff rates are classified in twenty-six macro sectors and consequently the first aggregation was to calculate the average AVE for each one of these twenty-six sectors. The shares of trade volumes, imports or exports according to the case, were employed to calculate the average AVE (HM Revenue & Customs, 2019). Then, the AVE of these twenty-six sectors were mapped into the corresponding GTAP sectors according to their volume shares. For instance, the macro-sector aluminium has an average AVE equal to 7.5%. In GTAP, aluminium is part of the metal sector and the AVE was multiplied by the share of trade volume of aluminium within the metal sector (again, differentiating imports from exports according to the case).

Finally, to complete the trade shock, we followed Philippidis (2019) including an increase of trade costs in the UK because of the No Deal. These costs represents the so called behind the border costs being different from the border costs already included as NTB in the AVE. To do so, we assumed a 4% increase of the trade costs of all for crops, 8% for livestock, and 2% for the rest of the economy.

[33] New RTQs under No Deal scenario would be in bovine meat, fish, poultry meat, rice, sheep meat, sugar, and swine meat (pork). Apart from sheep meat, the amount of imports of all these sectors (last three years average) exceed the quota and out of quotas rates were applied everywhere. For the sheep meat, the quota and the amount of imports are quite close, and the arithmetic average between the in quota rate (0%) and out of quota rate was applied.

3.2 Immigration scenarios

Regarding the immigration scenarios, we assumed three policy alternatives: Zero EEA immigration (ZeroEEA), Zero Unskilled EEA immigration (ZeroUnskEEA), e No Change. We focused on the EEA countries since under the European Economic Agreement, free movement of people is conferred, along with the EU citizens, to the EEA nationals (EEA 2018)[4]. As a starting point, we updated the UK labour force to the 2018 level as reported by the Quarterly Labour Force Survey (UK Data Service, 2019). For every region of origin of a worker, we mapped the four-digits standard industrial classification of the UK industries into the GTAP version 9 sectors. This database also includes 140 countries that were aggregated into 8 regions depending of if they are net labour importer or exporter[5]. To remove seasonal effects that can affect substantially the estimates of the labour force in minor sectors, we averaged over the four quarters of 2018[6].

The calculation of the immigration shocks is from the UK Government (2018a) and is based on the estimates of the predicted net EEA immigration until 2030 in a series of steps. First, the relationship between the inflow of EEA workers and macroeconomic predictors such as the differentials of GDP, unemployment rate, and age profile between UK and EEA countries were econometrically estimated. Second, the predictions of these macroeconomic variables (International Monetary Fund, 2018) were used to project the EEA migration inflow over time (UK Government 2018a). Third, due to the lack of data, the outflow of EEA workers was estimated through the data provided by the Office of National Statistics on the long-term EEA immigrants by year of arrival between 2005 and 2016 (2017). Based on this, it is estimated that 40 per cent of EEA inflows leave the UK within 9 years (see UK Government 2018a for details). The difference between inflow and outflow of workers provided an estimate of the net EEA flow in UK until 2030 and was used to

[4] The EEA includes the EU member states, the European Free Trade Association States (EFTA) and Switzerland. The EFTA includes Iceland, Liechtenstein, and Norway (EEA 2018).
[5] Labour importing regions are UK, EU1, EFTA, ROI, and UC (USA plus Canada). Labour exporting regions are EU2, Mexico (resto of NAFTA), and ROW. EU1 includes the EU15 countries without UK and ROI. EU2 includes the EU countries after the 2004 enlargement. See Table 2 of the Appendix for details.
[6] The skill distribution across regions and industries was based on the National Qualification Framework by assuming level 4 and above as skilled and unskilled the rest (UK Data Service, 2019).

calculate the immigration shocks[7]. Specifically, ZeroEEA scenario represents the most rigid immigration option by assuming zero EEA net migrants. This would imply a reduction of labour force in UK equal to 2.1%. In contrast, No Change assumes that there are no modifications to the current immigration policy. This would imply a modest reduction of labour force (-0.2%) to reflect the trend started after the Brexit referendum that has already witnessed a reduction of the number of EEA migrant workers in the UK[8]. Finally, under the ZeroUNskEEA scenario the reduction of the EEA immigration would affect only unskilled workers (-1.1% labour force). This option was included to reflect immigration options addressed to decrease only the number of this type of workers (UK Government, 2018b; Migration Advisory Committee, 2018a)[9]. In all the immigration scenario, it is assumed that the shocks to the labour force are proportional across sectors, skill type, and EEA region.

4. Results

In this section we present the simulation results of the trade and immigration scenarios on the UK economy. We begin with the analysis of the effects generated by the trade scenario, followed by the policy implications of the immigration scenarios.

The trade shocks of the no deal scenario can generate conflicting impacts for UK prices and output. If on the one hand, the EU imposed trade costs discourage demand for UK exports, decreasing UK production and market prices; on the other hand, trade protection on imports in UK increases production and domestic market prices. The net market effects of these individual shocks depends on the purchase share of EU imports in the UK and the UK sales share of EU exports in each sector, as well as on the primary factor reallocations between expanding and contracting sectors. Table 1 reports the sectoral effects in terms of quantity and price. For the agricultural sectors, we find, on average,

[7] The domestic labour force and immigration from the rest of the world and were assumed constant through all the simulation exercises.
[8] This was mostly due to the depreciation of the British currency with respect to the Euro and the climate of uncertainty initiated with the Brexit process (Born et al., 2019)
[9] The White Paper on Immigration (UK Government, 2018b) considered the threshold of £30,000 annual gross salary to discriminate between skilled and unskilled EEA workers. This follows the final recommendations provides by the Migration Advisory Committee (2018a).

that the change in imports is positive and the change in exports is negative, the domestic sales of agricultural goods increase; these changes yield, as total effect, a decrease in the production of agricultural goods. For the non-agricultural sectors, on average, we have negative effects for imports and exports, whereas the effect on domestic sales is positive; the production of these goods will decrease. Overall, an increase (decrease) in production implies a decrease (increase) in the corresponding market price. Furthermore, there is a redistribution of labour and capital between agricultural and non-agricultural sectors. The demand of labour decreases; whereas, the demand of capital decreases in the agricultural sectors, but it slightly increases in the non-agricultural sectors (Table 1 and 2). The real wages and the capital rental prices falls in both segmented market (Table 2).

[Table 1 here]

[Table 2 here]

The sectoral impacts, above discussed, imply the macroeconomic effects reported in table 3. The decrease in the capital rental price leads to a quite considerable decrease in investment; the excess of exports with respect to imports yields substantial trade gains; we have also negative effects on real GDP and welfare. The impacts on welfare are due mainly to the increase of the so called behind the border costs in the UK (almost 90%); the remaining contributions to welfare change are due to allocative efficiency (11%) and terms of trade (5%).

[Table 3 here]

Table 4 shows the macroeconomic effects of the immigration scenarios. As a result of restricted immigration policy in the UK, the direct effect of the decrease of labour supply is the

increase in the real wages, that would lead to a decline in production and, hence, loss in real GDP. The decline in production lowers demand for all endowments. The lower rate of return also leads to a decrease in investment. The immigration scenarios reduces remittances flowing back to the EEA countries. Therefore, the UK current account increases yielding opposite effects on welfare. Overall, the macroeconomic results suggest that a combination of the trade scenario with no change to the immigration policy would lead to the lowest reduction in GDP and welfare for the UK.

[Table 4 here]

Table 5 shows the sectoral effects in terms of output and market prices. According to the Rybczynski Theorem, if the level of an endowment decreases, the industry that uses it intensively would decrease production, and the industry, which uses it less intensively, would increase its production. From Table 5, we find that almost all of the sectors are heavily affected by the restricted immigration policy with a decrease in production, that would yield an increase in market price.

[Table 5 here]

Table 6 reports the effects on the segmented factor markets (labour and capital). The reduction in labour supply is more substantial for skilled workers in the zero EEA immigration scenario and for the non-agricultural sectors. The decrease in unskilled labour supply is almost equal in the ZeroEEA and ZeroUnskEEA scenarios, but slightly different amongst sectors. The decrease of labour supply yields the increase in the real wages and the re-adjustment of the firms involves substituting labour for other endowments, such as capital and, in the ZeroUnskEEA scenario, skilled labour. However, the extent of substitution is limited and, hence, the general decline in production prevails and the capital rental prices fall as well as the real wages of the skilled workers in ZeroUnskEEA scenario.

[Table 6 here]

5. Conclusions

Agriculture is protected from international competitions either directly, with tariffs, or indirectly, with non-tariff barriers and subsidies. It also heavily draws from immigrant workers as a source of cheap unskilled labour. Countries continuously face trade-offs between trade and immigration policies. The Brexit negotiations in the UK are a typical example.

In this context we have applied a multi-country CGE model for understanding the interactions between trade and immigration policies in the UK economy. We have integrated the global trade and migration model (GMig2) introducing the distribution of migration flows amongst sectors, segmented factor markets and agricultural specificity. In this study, we combined a trade scenario (no deal) a series of three immigration scenarios (ZeroEEA, ZeroUnskEEA and no change). Our findings show that a combination of the trade scenario with no change to the immigration policy would lead to the lowest reduction in GDP and welfare for the UK.

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Appendix

Table 1A. Sectoral Aggregation

Table 2A. Regional Aggregation and Labour Migration

Table 3A. Native-Migrant Elasticity of Substitution by Industry in UK

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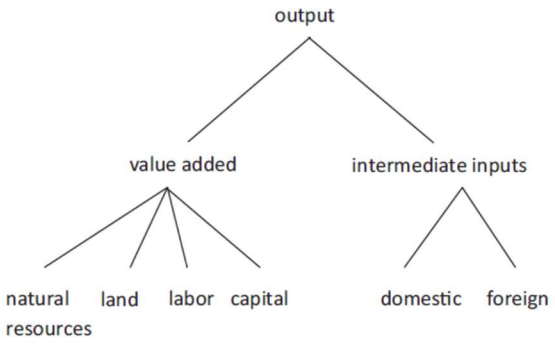

Figure 1. Production structure in the original GTAP model (Hertel, 1997)

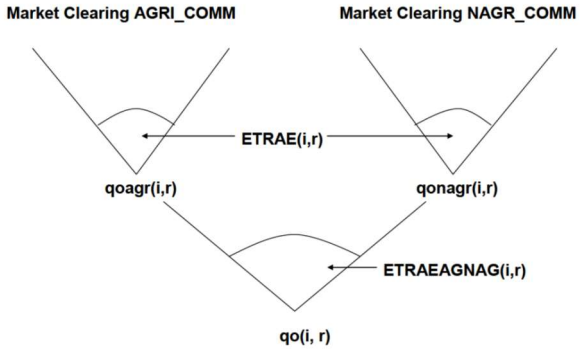

Figure 2. GTAP-AGR Factor market segmentation (Keeney and Hertel, 2005)

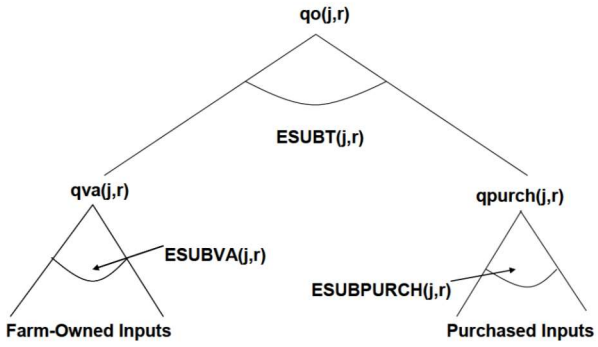

Figure 3. GTAP-AGR Agricultural production technology (Keeney and Hertel, 2005)

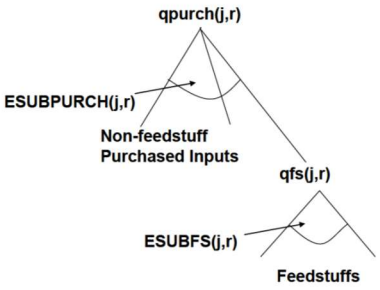

Figure 4. GTAP-AGR Livestock feedstuffs substitution (Keeney and Hertel, 2005)

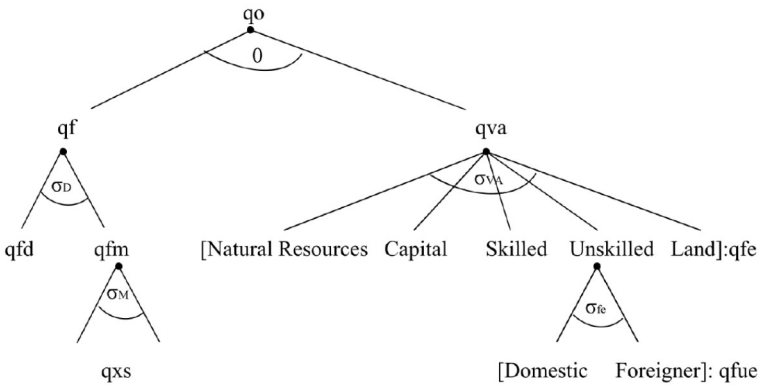

Figure 5. Production structure in the GMig2 model (Walmesley *et al*., 2007)

Table 1. Sectoral effects of the trade scenarios (% change w.r.t. baseline)

Sector	Imports	Exports	Domestic sales	Output	Market price	Unskilled Labour demand	Skilled Labour demand	Capital demand
pdr	-1.66	-49.37	2.97	-13.96	-0.82	-0.14	-0.17	-0.01
wht	29.11	37.22	-3.54	1.33	-0.76	-0.13	-0.15	-0.01
gro	-0.62	-12.94	0.49	-1.58	-0.91	-0.12	-0.15	-0.01
v_f	1.22	-8.00	7.27	4.39	-0.31	-0.12	-0.14	-0.01
osd	10.89	-16.88	16.09	9.46	0.02	-0.11	-0.13	0.00
c_b	-2.71	1.92	-7.17	-7.12	-1.01	-0.14	-0.16	-0.03
pfb	-0.96	1.58	5.02	3.40	-0.56	-0.08	-0.10	0.00
ocr	-1.52	-32.79	7.15	1.05	-0.31	-0.14	-0.16	-0.02
ctl	-14.44	-7.58	-8.06	-8.04	-1.14	-0.15	-0.17	-0.03
oap	1.97	-4.99	1.96	1.09	-0.87	-0.13	-0.15	-0.02
rmk	-18.41	6.44	-2.41	-2.41	-0.88	-0.14	-0.16	-0.03
wol	3.55	-30.23	64.87	-24.77	-1.22	-0.13	-0.16	0.00
frs	-1.38	0.22	1.33	1.26	-0.11	-0.12	-0.13	-0.10
fsh	1.86	0.16	0.16	0.16	-0.15	-0.04	-0.05	-0.01
OthPrimary	-1.66	-4.49	3.92	0.76	0.50	0.00	-0.01	0.03
cmt	12.32	-69.61	-6.94	-16.27	-0.78	-0.15	-0.19	0.00
omt	-9.01	-24.73	6.04	1.75	-0.41	-0.15	-0.19	0.00
vol	0.64	71.09	2.35	23.59	1.28	-0.12	-0.16	0.02
mil	-9.37	-41.37	0.66	-3.09	-0.40	-0.15	-0.19	0.00
pcr	1.08	-58.88	-1.24	-5.52	0.97	-0.14	-0.18	0.01
sgr	-4.22	-33.09	4.25	-8.34	-0.88	-0.14	-0.18	0.01
ofd	-4.15	3.22	0.45	0.76	-0.40	-0.13	-0.17	0.01
b_t	-1.75	-1.29	-0.17	-0.43	-0.29	-0.13	-0.17	0.01
texwap	-3.09	-13.29	3.20	-1.09	-0.35	-0.18	-0.23	-0.01
woodpap	-3.67	2.86	1.82	1.95	-0.51	-0.17	-0.21	0.00
pchemineral	-3.15	-3.99	1.66	-0.50	0.43	-0.12	-0.16	0.05
metals	-1.60	-1.32	1.66	0.61	0.22	-0.19	-0.23	-0.02
autos	-11.11	-22.19	7.01	-7.87	1.00	-0.15	-0.19	0.02
othmnfcs	-4.42	0.53	2.09	1.41	-0.05	-0.20	-0.25	-0.03
Electronics	-2.79	-0.31	3.87	1.68	0.07	-0.20	-0.24	-0.03
hhutilities	-4.48	5.19	-0.26	-0.23	-0.90	-0.23	-0.28	-0.05
Construction	-5.98	1.84	-3.32	-3.27	-0.45	-0.29	-0.34	-0.10
Trade	-3.57	3.23	-0.22	-0.11	-0.85	-0.17	-0.23	0.06
Transport	-1.41	0.14	0.57	0.45	-0.04	-0.14	-0.20	0.08
Comm	-2.45	2.70	0.78	0.96	-0.77	-0.16	-0.21	0.00
FinanceInsur	-1.86	1.86	0.63	0.98	-0.54	-0.15	-0.20	0.04
Busservices	-2.98	2.98	0.34	0.80	-0.84	-0.17	-0.22	0.01
Otherservice	-3.13	3.22	0.27	0.53	-0.87	-0.16	-0.21	0.00
PublidAdm	-3.59	2.91	-0.23	-0.17	-0.76	-0.13	-0.18	0.04

Table 2. Effects in the segmented factor markets of the trade scenario (% change .w.r.t baseline)

		Input	Market Price
Agricultural sectors	Unskilled labour	-0.37	-2.08
	Skilled labour	-0.48	-2.13
	Capital	-0.19	-1.62
Non-Agricultural sectors	Unskilled labour	0.01	-1.33
	Skilled labour	0.00	-1.18
	Capital	0.00	-1.24

Table 3. Macroeconomic effects of the trade scenario

Variable Description	change .w.r.t baseline
Real GDP (%)	-0.81
Real wage of unskilled labour (%)	-1.34
Real wage of skilled labour (%)	-1.18
Capital rental price (%)	-1.24
Investment (%)	-4.54
Remittances from the UK to EEA and EFTA (%)	-1.2
Trade balance (Mln US$)	16284
Welfare (Mln US$)	-19821

Table 4. Macroeconomic effects of the immigration scenarios (change w.r.t. trade scenario)

Variable Description	ZeroEEA	ZeroUnskEEA	No change
Real GDP (%)	-1.25	-0.42	-0.12
Real wage of unskilled labour (%)	0.58	1.09	0.05
Real wage of skilled labour (%)	1.00	-0.23	0.09
Capital rental price (%)	-0.86	-0.26	-0.08
Investment (%)	-2.73	-0.93	-0.26
Remittances from the UK to EEA and EFTA (%)	-27.81	-8.76	-2.61
Trade balance (Mln US$)	5492	2170	514
Welfare (Mln US$)	-24566	-8529	-2324

Table 5. Sectoral effects of the immigrations scenarios (% change w.r.t. trade scenario)

Sector	Output			Market price		
	ZeroEEA	ZeroUnsk EEA	No change	ZeroEEA	ZeroUnsk EEA	No change
pdr	-1.16	-0.67	-0.11	0.07	0.09	0.01
wht	-1.05	-0.57	-0.10	0.11	0.13	0.01
gro	-1.02	-0.47	-0.10	0.11	0.13	0.01
v_f	-0.95	-0.64	-0.09	0.04	0.12	0.00
osd	-0.87	-0.54	-0.08	0.08	0.12	0.01
c_b	-1.18	-0.54	-0.11	0.06	0.13	0.01
pfb	-0.67	-0.67	-0.06	0.04	0.15	0.00
ocr	-1.13	-0.62	-0.11	0.05	0.09	0.01
ctl	-1.23	-0.57	-0.12	0.05	0.13	0.00
oap	-1.07	-0.56	-0.10	0.04	0.15	0.00
rmk	-1.13	-0.46	-0.11	0.03	0.15	0.00
wol	-1.08	-0.95	-0.10	0.08	0.07	0.01
frs	-1.04	-0.45	-0.10	-0.39	-0.03	-0.04
fsh	-0.10	-0.06	-0.01	-0.41	-0.15	-0.04
OthPrimary	0.15	0.05	0.01	-0.16	-0.06	-0.02
cmt	-1.16	-0.54	-0.11	0.09	0.09	0.01
omt	-1.15	-0.62	-0.11	0.08	0.09	0.01
vol	-0.74	-0.43	-0.07	0.05	0.06	0.01
mil	-1.14	-0.47	-0.11	0.10	0.07	0.01
pcr	-1.11	-0.50	-0.11	0.03	0.01	0.00
sgr	-1.20	-0.54	-0.11	0.19	0.10	0.02
ofd	-1.09	-0.41	-0.10	0.15	0.05	0.01
b_t	-0.86	-0.32	-0.08	0.06	0.02	0.01
texwap	-1.80	-0.61	-0.17	0.27	0.08	0.03
woodpap	-1.47	-0.49	-0.14	0.21	0.07	0.02
pchemineral	-0.97	-0.33	-0.09	0.09	0.03	0.01
metals	-1.91	-0.63	-0.18	0.19	0.06	0.02
autos	-1.49	-0.49	-0.14	0.20	0.06	0.02
othmnfcs	-1.87	-0.61	-0.18	0.20	0.06	0.02
Electronics	-1.65	-0.53	-0.16	0.13	0.04	0.01
hhutilities	-0.69	-0.25	-0.07	-0.54	-0.17	-0.05
Construction	-2.27	-0.78	-0.21	0.05	0.11	0.00
Trade	-1.17	-0.47	-0.11	0.18	0.15	0.02
Transport	-0.99	-0.37	-0.09	0.14	0.08	0.01
Comm	-1.11	-0.40	-0.11	0.08	0.09	0.01
FinanceInsur	-1.10	-0.29	-0.10	0.21	0.03	0.02
Busservices	-1.33	-0.35	-0.13	0.23	-0.02	0.02
Otherservice	-1.13	-0.54	-0.11	0.10	0.19	0.01
PublidAdm	-1.42	-0.43	-0.13	0.43	0.09	0.04

Table 6. Effects in the segmented factor markets of the immigration scenarios (% change w.r.t. trade scenario)

		Input			Market Price		
		ZeroEEA	ZeroUnsk EEA	No Change	Zero EEA	ZeroUnsk EEA	No Change
Agricultural sectors	Unskilled labour	-1.38	-1.17	-0.13	-1.74	-1.75	-0.17
	Skilled labour	-1.62	-0.34	-0.15	-2.18	0.00	-0.21
	Capital	-0.20	-0.14	-0.02	0.00	0.00	0.00
Non-Agricultural sectors	Unskilled labour	-1.74	-1.75	-0.17	0.56	1.08	0.05
	Skilled labour	-2.18	0.00	-0.21	0.99	-0.23	0.09
	Capital	0.00	0.00	0.00	-0.86	-0.26	-0.08

Appendix

Table 1A. Sectoral aggregation

1	pdr	Paddy rice
2	wht	Wheat
3	gro	Cereal grains nec
4	v_f	Vegetables, fruit, nuts
5	osd	Oil seeds
6	c_b	Sugar cane, sugar beet
7	pfb	Plant-based fibers
8	ocr	Crops nec
9	ctl	Cattle,sheep,goats,horses
10	oap	Animal products nec
11	rmk	Raw milk
12	wol	Wool, silk-worm cocoons
13	frs	Forestry
14	fsh	Fishing
15	OthPrimary	other primary resources: coal,
16	cmt	Meat: cattle,sheep,goats,horse
17	omt	Meat products nec
18	vol	Vegetable oils and fats
19	mil	Dairy products
20	pcr	Processed rice
21	sgr	Sugar
22	ofd	Food products nec
23	b_t	Beverages and tobacco products
24	texwap	textiles, wearing apparel, lea
25	woodpap	wood products
26	pchemineral	chemical, rubber, plastic prod
27	metals	ferrous and metalproducts
28	autos	motor vehicles and parts
29	othmnfcs	other manufacturing: transport
30	Electronics	electronics equipment
31	hhutilities	electricity, gas, water utilit
32	Construction	construction
33	Trade	trade
34	Transport	water, air, and other transpor
35	Comm	communications
36	FinanceInsur	finance and insurance services
37	Busservices	business services
38	Otherservice	recreational and other service
39	PublidAdm	public administration, defence

Table 2A. Regional Aggregation and Labour Migration

Region	*Countries*	*Migratory Flow*
UK	United Kingdom	Labour Importing
EU1	Austria, Belgium, Cyrus, Denmark, Finland, France, Germany, Greece, Italy, Luxemburg, Malta, Netherlands, Portugal, Spain, Sweden, Switzerland, Norway, and Rest of EFTA	Labour Importing
EU2	Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bulgaria, Croatia, and Romania	Labour Exporting
EFTA	Iceland, Liechtenstein, Norway and Switzerland	Labour Importing
ROI	Republic of Ireland	Labour Importing
UC	USA & Canada	Labour Importing
NAFTA	Mexico and Rest of Nafta	Labour Exporting
ROW	Rest of the World	Labour Exporting

Table 3A. Native-Migrant Elasticity of Substitution by Industry in UK

GTAP Sector	Elasticity[a]	Office of National Statistics[b]
Agriculture: Crops	3.59	Agri-Food
Agriculture: Livestock	3.59	Agri-Food
Agriculture: Meat	3.59	Agri-Food
Agriculture: Milk	3.59	Agri-Food
Forestry	3.59	Agri-Food
Fishery	3.59	Agri-Food
Raw Minerals & Oil	10.89	Other Sectors
Food & Beverage: Meat	3.59	Agri-Food
Food & Beverage: Vegetables	3.59	Agri-Food
Food & Beverage: Dairy	3.59	Agri-Food
Other Food & Beverage	3.59	Agri-Food
Food & Beverage: Drinks	3.59	Agri-Food
Textile	10.89	Other Manufacturing
Wood & Paper	10.89	Other Manufacturing
Chemical Products	10.89	Other Manufacturing
Metal Products	10.89	Other Manufacturing
Automobile Industry	10.89	Other Manufacturing
Transport Equipment	10.89	Other Manufacturing
Electronics	10.89	Other Manufacturing
Utilities	10.89	Other Manufacturing
Construction	7.59	Construction
Trade	8.47	Wholesale & Retail
Transport	5.39	Transport
Communication	8.24	Other Sectors
Finance & Insurance	Perfect	Finance & Insurance
Business Services	Perfect	Professional Services
Other Services	8.23	Other Sectors
Public Administration	12.15	Public Administration

[a]: Authors' calculation based on Institute for Social and Economic Research (2017).
[b]: Migration Advisory Committee (2018b).
The estimates from Angioloni and Wu (2018) are based on the classification employed by MAC (2018c) that employed the 2 Digit Standard Industrial Classification 2007 (ONS, 2009).
The miscellaneous category "Other Services" includes sectors considered by Migration Advisory Committee (2018b) and not present in the GTAP classification and it was calculated as weighted by the corresponging employment shares.

Table 4A. AVE Tariffs on UK trade for No Deal Scenario

Sector	UK Imports from Everywhere	UK Exports to EU
pdr	0.00	8.97
wht	0.00	10.71
gro	0.00	7.60
v_f	3.11	5.09
osd	0.00	3.96
c_b	0.00	0.00
pfb	0.00	0.71
ocr	0.00	9.78
ctl	0.00	3.00
oap	0.00	5.81
rmk	0.00	0.00
wol	0.00	26.71
frs	0.00	0.00
fsh	0.01	0.00
OthPrimary	0.00	0.00
cmt	18.62	42.60
omt	7.42	19.60
vol	0.97	0.90
mil	2.41	13.48
pcr	9.94	20.83
sgr	12.29	15.51
ofd	1.11	0.28
b_t	1.42	2.15
texwap	2.60	3.74
woodpap	0.00	0.00
pchemineral	1.13	0.56
metals	0.00	0.00
autos	7.70	7.67
othmnfcs	0.03	0.01
Electronics	0.00	0.00
hhutilities	0.00	0.00
Construction	0.00	0.00
Trade	0.00	0.00
Transport	0.00	0.00
Comm	0.00	0.00
FinanceInsur	0.00	0.00
Busservices	0.00	0.00
Otherservice	0.00	0.00
PublidAdm	0.00	0.00

AVE =Ad valorem equivalent. Source: UK Government (2019b); International Trade Centre (2019); HM Revenue & Customs (2019).
See Section 3.1 for the description of the methodology.