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The long-term macroeconomic effects of lower migration to the UK

Katerina Lisenkova and Miguel Sanchez-Martinez

Abstract

This paper looks at the possible scenarios of migration policy should the UK leave the EU. The paper uses an OLG model which brings together labour market, fiscal and other macroeconomic effects in one framework. It also adds a dynamic perspective, differentiates between natives and different categories of immigrants and captures age and qualification compositional effects.

The paper compares the two migration scenarios: Leave and Remain. By 2065, in the Leave scenario, aggregate GDP and GDP per person are 9% and 1% respectively lower compared to Remain scenario. Reduced migration after leaving the EU has a negative impact on the public finances, because of higher dependency ratio. This requires an increase in taxation of about £400 per person (2014 pounds) in 2065. The results are sensitive to the assumptions that change productivity of the labour force and dependency ratio.

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1. Introduction

Between 1990 and 2015 the number of international migrants worldwide has increased from 153 to 244 million (United Nations, 2015). During the same period the net migration in the UK has increased from under 50K to over 300K per year (Figure 1). The proportion of immigrants[1] among people of working age has increased from 8% in 1995 to 17% in 2014 (Wadsworth, 2015). This development has brought migration to the front pages of newspapers and made it a central political issue. Migration within the European Union (EU) has become an especially hotly debated issue due to the influx of immigrants from Eastern Europe, after the recent wave of EU enlargements, and higher inflow from Southern Europe during the Euro crisis. Free movement of people within the EU is one of the fundamental issues during the referendum for the UK membership in the EU. Control over immigration from the EU countries is one of the main arguments for the Leave campaign. This paper looks at the possible scenarios of migration policy in case UK leaves the EU and evaluates their macroeconomic consequences using an overlapping generations general equilibrium (OLG) model.

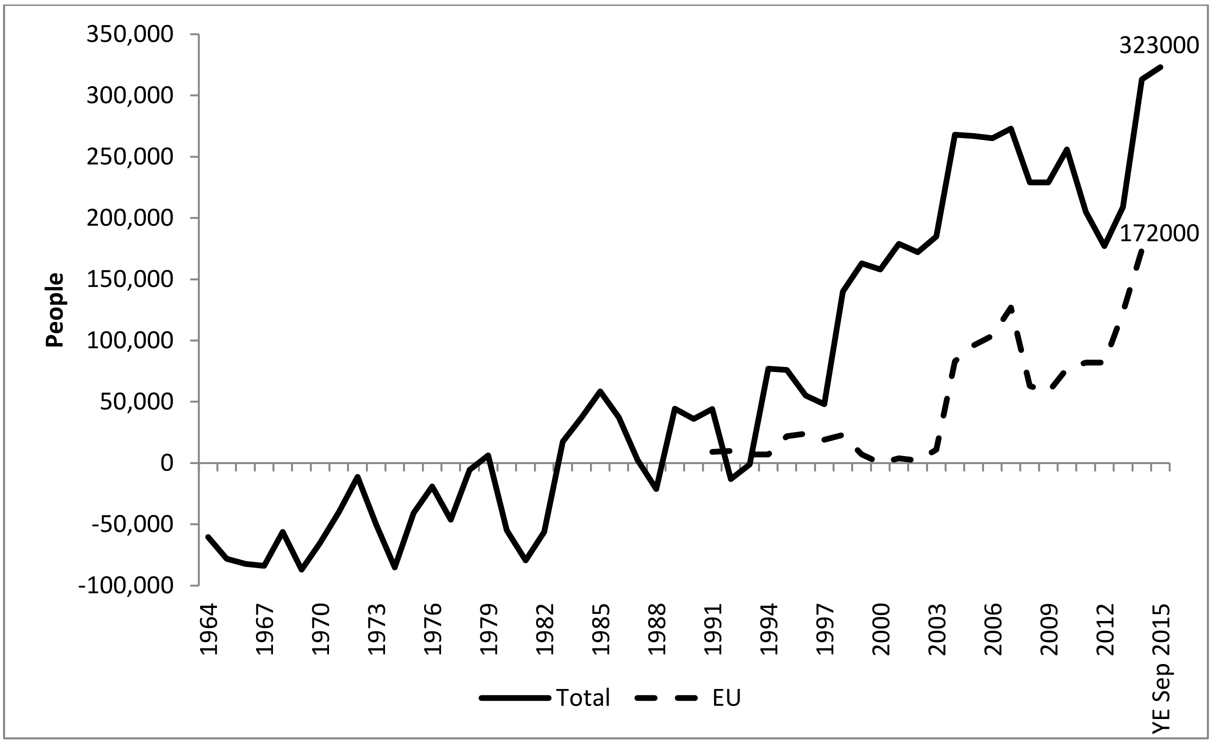
There is a large and growing body of literature on the impact of migration on the UK's economy. The two areas that attract the most attention are effects on the labour market and public finances. The consensus among the researchers studying the impact of migration on the labour market seems to be that immigrants do not have strong effect on labour market outcomes of native workers. Lemos and Portes (2008) studied the labour market impact of A8 immigration[2] to the UK and did not detect any significant effects on native's wages or unemployment. Manacorda et al. (2012) attempted to resolve the observed insensitivity of natives' wages to immigration by arguing that UK native and foreign-born workers may be imperfect substitutes. After estimating the elasticity of substitution between workers of different origins, they concluded that immigration mainly reduces the wages of immigrants, with little impact on those of natives. Nickell and Saleheen (2008, 2015) found that the immigrant-native ratio has a significant but small negative impact on the average occupational wage rates in the region, for both native and foreign workers. They also find that the biggest (but still small) effect is in the semi/unskilled services sector.

[1] In this paper we the term “immigrant” to define people who were born abroad.

[2] A8 countries include: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia

Wadsworth (2015) showed that there is no effect of an increase in immigration on the unemployment rate of natives, even in the low-skilled segment of the labour market.

Figure 1. Net migration to the UK



Source: ONS long-term international migration series

On the fiscal implications of immigration in the UK, Sriskandarajah et al. (2005) provided evidence showing that the net fiscal contribution of immigrants is positive. Moreover, their analysis also suggests that the relative net fiscal contribution of foreigners is greater than that of the UK-born. Similarly, Gott and Johnson (2002) also found that the fiscal impact of the immigrant population is positive overall, although they warned that it is likely that this result masks the different performance of subsections of this population. Dustmann et al. (2010) estimated the fiscal impact of A8 immigrants in the UK. They found that these immigrants have a positive net contribution to public finances. In the most comprehensive study on the fiscal effect of immigrants, Dustmann and Fratinni (2013) computed the net fiscal contribution of the different population groups for each year between 1995 and 2011. They found that the contribution of recent immigrants (i.e. those who arrived after 1999) has been consistently positive. Recent EEA immigrants contributed 34% more to the fiscal system than they took out, and recent immigrants from non-EEA countries contributed about 2% more than they took out.

The other major strand of literature on the economic impact of immigration to the UK is based on the use of macroeconomic models, which are especially suitable for investigating the possible consequences of migration. These approaches generally employ agent-based macroeconomic models which are calibrated to the UK. There has been a particular interest in analysing the macroeconomic impacts of A8 immigrants to the UK, after the EU enlargement in May 2004. Barrell et al. (2007) used the structural macroeconometric model *NiGEM* and estimated that, even though the overall isolated impact is likely to be small from an aggregate perspective, migration from these countries resulted in higher GDP and lower unemployment and inflation. In the same vein, Iakova (2007) employed the IMF's dynamic general equilibrium model with demographic features and finitely-lived individuals, *Multimod,* to explore the effects of Eastern European immigration to the UK. The results from her simulations point to positive effects of this migration on economic growth, capital accumulation, consumption and public finances. Based on an assumed path of migration flows, Bass and Brucker (2011) employed a static CGE model with imperfect labour markets and drew the conclusion that the EU enlargement contributed to the increase in GDP per person in the UK at the expense of slower gains in wage. The Office for Budget Responsibility (2013) estimated long-term fiscal effects of migration in the UK in a partial equilibrium framework. Their report found that their fiscal projections are sensitive to the migration assumption and higher levels of net migration tend to result in a healthier fiscal situation.

This paper adds to existing research by employing a dynamic overlapping generations computable general equilibrium model (OLG-CGE), which is widely acknowledged as the best tool for the modelling of issues associated with demographic change. Among the advantages of an OLG-CGE framework is its age-disaggregated nature, which makes it possible to study age-specific behaviour and the impact of changes in the population age structure on the economy. The model is in the Auerbach and Kotlikoff (1987) tradition and introduces age-specific mortality following Borsch-Supan et al. (2006). There are several studies that model migration in an OLG-CGE framework (Storesletten, 2000; Fehr et al., 2004; Chojnicki et al., 2011).

The model allows us to bring together labour market, fiscal and other macroeconomic effects in one framework. It also adds a dynamic perspective, differentiates between natives and different categories of immigrants and captures age and qualification compositional effects. These features make this paper the most comprehensive analysis of the effects of immigration on the UK economy to date. The EU immigrants benefit the UK economy for two main reasons – they are on average much younger, contributing to lower dependency ratio, and are more highly qualified than the general population.

The rest of the paper is organised as follows: Section 2 presents a brief model description. Section 3 describes the data and calibration procedure. The results of the simulations and sensitivity analysis are presented in sections 4 and 5 respectively. Section 6 concludes.

1. The model description

The model is designed to analyse the long-term economic implications of demographic change in the UK. It is a closed economy model with only one channel of cross-border interaction via international migration. An exogenous demographic process is superimposed on the model and provides the shock or driving force behind the simulation results.

The population is divided into 21 generations or age groups (i.e., 0-4, 5-9, 10-14, 15-19, …, 100-104). The demographic variables, time-variable fertility and time/age-variable net migration and conditional survival rates are calibrated based on exogenous population projections. Population is divided into several groups by origin. Age-specific net migration rates are disaggregated by origin, including the UK-born population.

A perfectly competitive, profit-maximising representative firm hires labour and rents physical capital to produce a single good using a Cobb-Douglas technology. There are three types of labour by skill-level/qualification. Native and foreign-born workers of the same skill-level are perfect substitutes. A firm transforms its demand for total labour into skill-specific labour demand using a constant-elasticity-of-substitution (CES) function. Labour income depends on the individual's age-specific productivity, which is assumed to be reflected in age-earnings profiles that are disaggregated by qualification and origin.

The household sector in the model is disaggregated by age (21 generations), qualification (3 qualifications) and origin (5 groups). Household behaviour in every qualification-origin group is captured by 21 representative households that interact in an Allais-Samuelson overlapping generations structure representing each of the age groups. Individuals enter the labour market at the age of 20, start collecting public pension at the state pension age (SPA), and die at the latest by age 104. Childhood generations are fully dependent on their parents and play no active role in the model. However, they do influence public expenditure. Adult generations optimise their consumption-saving patterns over time by maximising a CES type inter-temporal utility function, subject to the lifetime budget constraint. On top of the usual time discount factor, future consumption is also discounted at the unconditional survival rate, which is the probability of survival up to a certain age. There are no bequests and a perfect annuity market, as described theoretically by Yaari (1965) and implemented in an OLG context by Boersch-Supan et al. (2006).

We assume that the new migrants have no assets when they come to the UK. Intuitively, this assumption might seem important as it influences the equilibrium capital-labour ratio. In practice, it plays a minor role because the majority of migrants belong to young age groups that own a low level of assets[3].

Representatives of different origin groups have different age-specific employment rates, age-productivity profiles and age-qualification distributions. They also have different probabilities of receiving various benefits from the government. Such detailed differentiation allows us to capture multidimensional effects of migration on the labour market, aggregate demand and the public finances.

The law of motion for the capital stock takes into account depreciation and investment. Financial capital is undifferentiated from physical capital, implying that the interest rate parity holds.

The government budget constraint includes spending on healthcare, education, pensions, welfare and other expenditures. Healthcare and education spending is projected using age-specific profiles, which are indexed to wages in the proportion that labour cost represents in

[3] Chojnicki et al. (2011) comes to the same conclusion.

the total budget. Welfare spending is disaggregated by category of benefits. Each type of benefits has its own age profile for each qualification-origin group. Benefits are indexed to wages. The pension program is part of the overall government budget. State pension age changes in accordance with the current plans to increase state pension age. Pension benefits can be indexed according to different rules. Other government spending is assumed to be age-independent. The model imposes the condition that the government budget is balanced and the effective labour income tax rate is adjusted every period to satisfy this condition. A more detailed description of the model is provided in Appendix B.

2. Data and model calibration

The model is calibrated using 2014 data for the UK where available. The data for the demographic baseline shock is taken from the 2014-based principal population projections produced by the Office for National Statistics (ONS). Population projections are used for the calibration of the fertility, survival and net migration rates used in the model. The net migration is disaggregated by origin. In this version of the model we differentiate 4 origins: UK, EU15[4], New EU[5], non-EU. To divide the total net migration flows into these four groups, we use the most recent data available from the ONS on long-term migration by origin. We assume that total future UK net migration will be -70,000 a year. This is the average level over the past 35 years. The rest of the net migration is apportioned between the other three groups according to the recently observed trends: EU15 23%, New EU 32% and non-EU 45%. The age decomposition of migrants in each origin group follows the data on broad age groups of migrants by citizenship from the International Passenger Survey (IPS). We also assume that foreign net migration above the age of 69 is equal to zero, which is confirmed by the IPS data. The data shows that migrants tend to be much younger, on average, than the native population. In recent years, according to the IPS, the share of the EU migrants below the age of 25 was about 68%. In general population this group comprises only 30%.

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[4] Includes the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain and Sweden

[5] Includes the following countries: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia, Bulgaria, Romania and Croatia

The data on public finances and GDP components are taken from the ONS and HM Treasury. The effective labour income, consumption and capital tax rates are calculated from the corresponding government revenue categories and calibrated tax bases. Data on total amount of pensions are taken from the Department for Work and Pensions (DWP). Based on this information, the effective pension contribution rate and the average size of pension benefits can be calculated. The average pension per person is obtained by dividing the total amount of pension benefits by the total number of people of pension age. Pension age in the model is calculated as a weighted average of male and female SPA according to current plans. To reflect the triple lock[6] guarantee, real pensions are assumed to grow at 0.5% per year – 2.5% less 2% inflation target. However during the periods of low inflation and slow earnings growth real pensions can grow much faster. We check the sensitivity of our results to this assumption.

Labour market characteristics and benefits are estimated from the micro data. The data set includes all households present in the latest wave of the Annual Population Survey (APS) running from July 2014 to June 2015. For the majority of estimations, individuals younger than 20 and older than 69 years of age are excluded[7]. The final sample consists of about 174,000 observations. All estimated parameters are disaggregated by origin, qualification and age, and feed into the model as parameters. In this sample, 83% of population aged 20-69 are UK-born, 5% are EU-born and 11% non-EU born.

We differentiate three levels of qualification: low, medium and high. The allocation to these categories is based on age at which a person left education. Those individuals who were in full-time education up to 17 years of age are considered to be low qualified, those who were in education until between 17 and 21 years of age are medium qualified and those who left education after 21 years of age are highly qualified.

Three labour market characteristics are derived from the data: employment rates, qualification distribution and productivity profiles. All of these are broken down by

[6] Triple lock *introduced* in April 2011 guarantees that pension benefits will grow in the future by the highest of inflation, earnings growth or 2.5%.

[7] Except some benefits, e.g. pension credit.

qualification, origin and age.[8] As an illustration of the heterogeneity in the qualification distribution and labour market outcomes across origins, Table 1 shows the difference between the four groups when it comes to qualification distribution and their respective employment rates.

Table 1. UK Labour market characteristics by origin

	Origin			
	UK	EU15	New EU	non-EU
Employment rate*	77%	79%	82%	68%
High qualification	25%	51%	38%	49%
Medium qualification	29%	29%	51%	30%
Low qualification	46%	19%	11%	21%

* Here defined as the number of people employed in each origin group divided by the working age population in the same group.

Source: own calculations based on APS and DWP data

As apparent from these data, the skill composition of the foreign-born work force is in sharp contrast with that of natives; the majority of the foreigners belong to the two highest qualification groups, whereas the distribution for natives is skewed towards low-skilled. In the EU15 and non-EU groups about 50% of people have high qualification, in the New EU group 50% have medium qualification, while in the UK group 46% have low qualification. This is partially explained by different age composition: younger cohorts tend to have higher educational attainment, and younger immigrants tend to be more educated compared with an average UK-born person. The employment rate is the highest for the New EU group and the lowest for the non-EU group, with the UK and EU15 groups showing similar levels.

The skill distribution of the immigrants attracted to the UK is also in stark contrast with that of many other developed countries. For example, Chojnicki et al. (2011) analyse the US experience and show that after 1965 the average skill level of immigrants has been much lower than that of natives[9]. They show that if the skill distribution of immigrants converged toward that of natives, this would have an additional significant positive effect on natives' welfare.

[8] All estimated profiles are smoothed out along the age dimension using a Gaussian-type smoother.

[9] However, it is not possible to compare their data with ours as they use a different definition of skill levels.

We use average weekly wage as a proxy for productivity level. We calculate it by multiplying average hourly pay and average weekly number of hours: both of these variables are directly available in the APS. We observe that the UK and EU15 groups have similar levels of pay, with the other two groups being paid less in all qualification and age groups. There is also a very large pay gap for the New EU migrants in the high qualification group which suggests downgrading – working at a position which requires lower qualification than one has.

Table 2. Average weekly pay, £

	Qualification		
	High	Medium	Low
UK	612	440	377
EU15K	678	456	363
New EU	377	309	308
non-EU	588	388	298

Source: own calculations based on APS

We estimate welfare spending for different qualification, origin and age groups by combining APS data with information available from the DWP. To our knowledge this is the most extensive welfare analysis in the context of migration debate performed to date. For other example see Dustmann and Fratinni (2013).

In benefit estimations we differentiate one more origin category. We divide the non-EU group into those in employment and those out of employment. We do this only for the non-EU group because they have a lower employment rate than other origin groups.

We estimate average weekly amounts received by an average representative in each qualification, origin and age cell[10] for tax credit (working and child tax credit), child benefit, housing benefit and "other" benefits. "Other" benefits include the most important benefits in terms of their proportion out of total welfare budget: carer's allowance, disability living

[10] This is not the same as the average amount of benefit claimed (including only people who claim benefits) but an average amount of benefits received by a representative of each qualification, age and origin cell (including all people in this cell).

allowance, employment and support allowance, incapacity and severe disablement allowances, income support, jobseeker's allowance and pension credit.

Average amounts for tax credits and child benefit are imputed from the APS data. Tax credit is broken down into working tax credit and child tax credit. Only individuals who report receiving it and satisfy the qualifying conditions are considered. The amount imputed to each individual consists of a basic element plus additional elements that depend mainly on individual and household earnings thresholds, the number of children in the household, whether there are couple or lone parents, the number of hours worked during the week and disability status[11]. Child benefit amounts are more straightforward: parents receive £ 20.50 weekly for the first child and £13.55 for each additional child[12][13].

For all other benefits we combine information from the APS and DWP. We take average weekly benefits by age group from the Work and Pensions Longitudinal Study (WPLS) based on 100% of claimants.[14] Unfortunately, the tabulation tool available online does not provide information by origin of claimants or their qualification. To get around this limitation we use data from the APS, which has information on whether a respondent is claiming a certain benefit but not the amount. The average weekly values by age (from the WPLS) are multiplied by the share of claimants in each age, origin and qualification cell for each benefit estimated from the APS survey data. What we get as a result is the average weekly value of each benefit received by an average individual in each age, origin and qualification cell. The implicit assumption here is that the average claimed amount is the same across qualification and origin groups.

We adjusted all estimated and imputed benefits profiles to ensure that the total value of benefit corresponds to the actual welfare budget. Table 3 summarises estimated benefits

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[11] The specific weekly amounts for each particular combination of circumstances, prevailing in the 2014-15 fiscal year, can be found at: https://www.gov.uk/government/publications/tax-and-tax-credit-rates-and-thresholds-for-2015-16/tax-and-tax-credit-rates-and-thresholds-for-2015-16#working-and-child-credit-tax-rates-and-thresholdss

[12] Child benefit is assumed to accrue to the household representative even if it is paid to someone else within the same household.

[13] See https://www.gov.uk/government/publications/tax-and-tax-credit-rates-and-thresholds-for-2015-16/tax-and-tax-credit-rates-and-thresholds-for-2015-16#child-benefit-and-guardians-allowance for details.

[14] The tabulation tool for this data set is available online at http://tabulation-tool.dwp.gov.uk/100pc/tabtool.html. Access to the complete data set is restricted due to data sensitivity.

showing weighted average amount of benefits by qualification and origin. Average benefits are higher for groups with lower incomes (i.e. New EU and non-EU), and for lower qualifications. It is interesting that although New EU and Non-EU employed groups receive higher levels of benefits than UK-born in each qualification group, on average they receive a lower level of benefits (the last column). This is because they have higher average qualification than the UK-born group. For a detailed breakdown of main benefits see the Appendix A.

Table 3. Average annual benefits, £

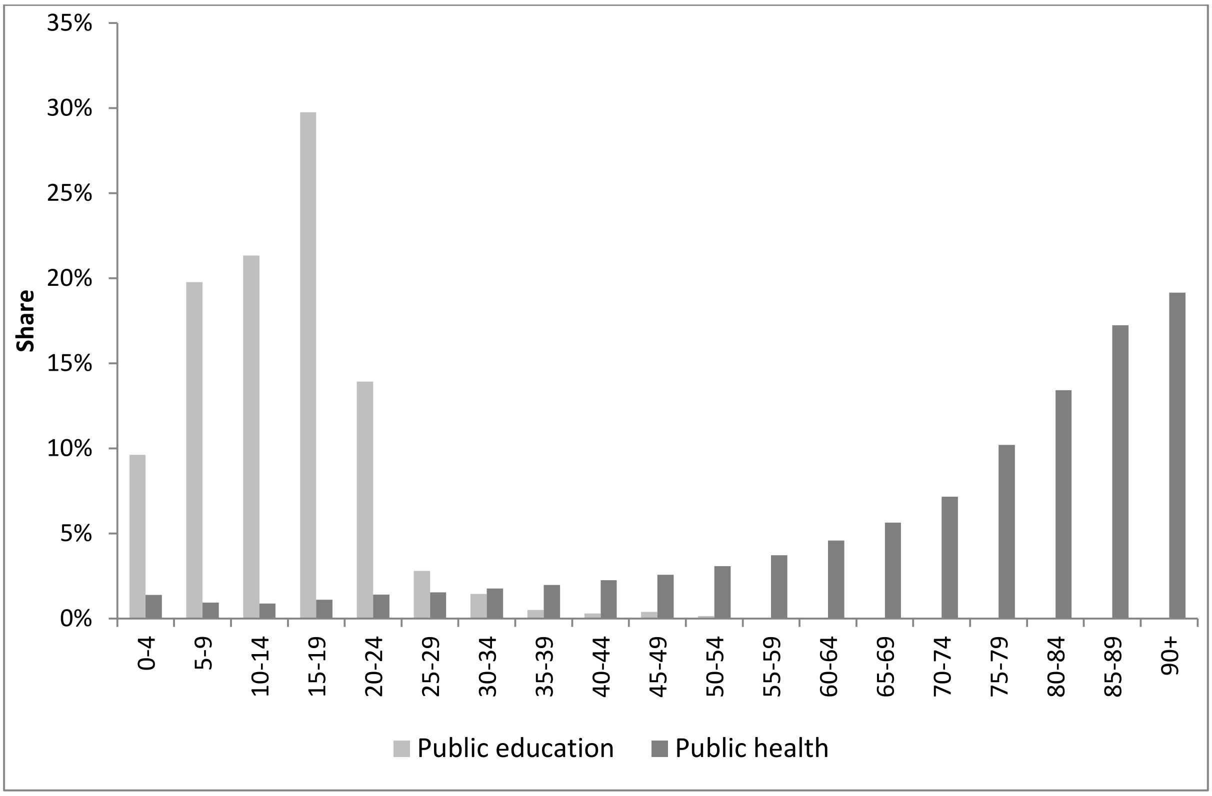
	Qualification			
	High	Medium	Low	**Total**
UK	1,034	2,229	3,326	**2,509**
EU15	730	2,095	3,466	**1,726**
New EU	1,501	2,372	3,451	**2,168**
Non-EU employed	1,225	2,409	3,300	**1,957**
Non-EU not employed	2,759	4,843	5,265	**4,135**

Source: own calculations based on APS and DWP data

The estimates of the age structure of government spending on health care and education are taken from the UK National Transfer Accounts for 2007 as constructed by McCarthy and Sefton (2010). Figure 2 shows these age profiles. For each category numbers add up to 100%. The majority of education spending occurs between the ages 5-9 and 20-24. Health spending grows slowly until the age of 55-59 when it starts increasing much faster and accelerates after age 75-79. Healthcare and education profiles are indexed to wages in the proportion that labour cost represents in the total spending – 83% for education and 41% for health care.

We assume that labour characteristics as well as demand for public services and access to benefits of different population groups will stay the same throughout the simulation period. We also assume that there is exogenous total factor productivity growth of 0.43% - i.e. the average value over the past 30 years (ONS, 2015). These are simplifying assumptions; however, we prefer this solution considering the uncertainty of the future development of these parameters. Also, because our goal is to isolate the effect of demographic shock we abstract from other changes in the parameters of the model that do not interact with it.

Figure 2. Age profile of healthcare and education spending per person, 2007

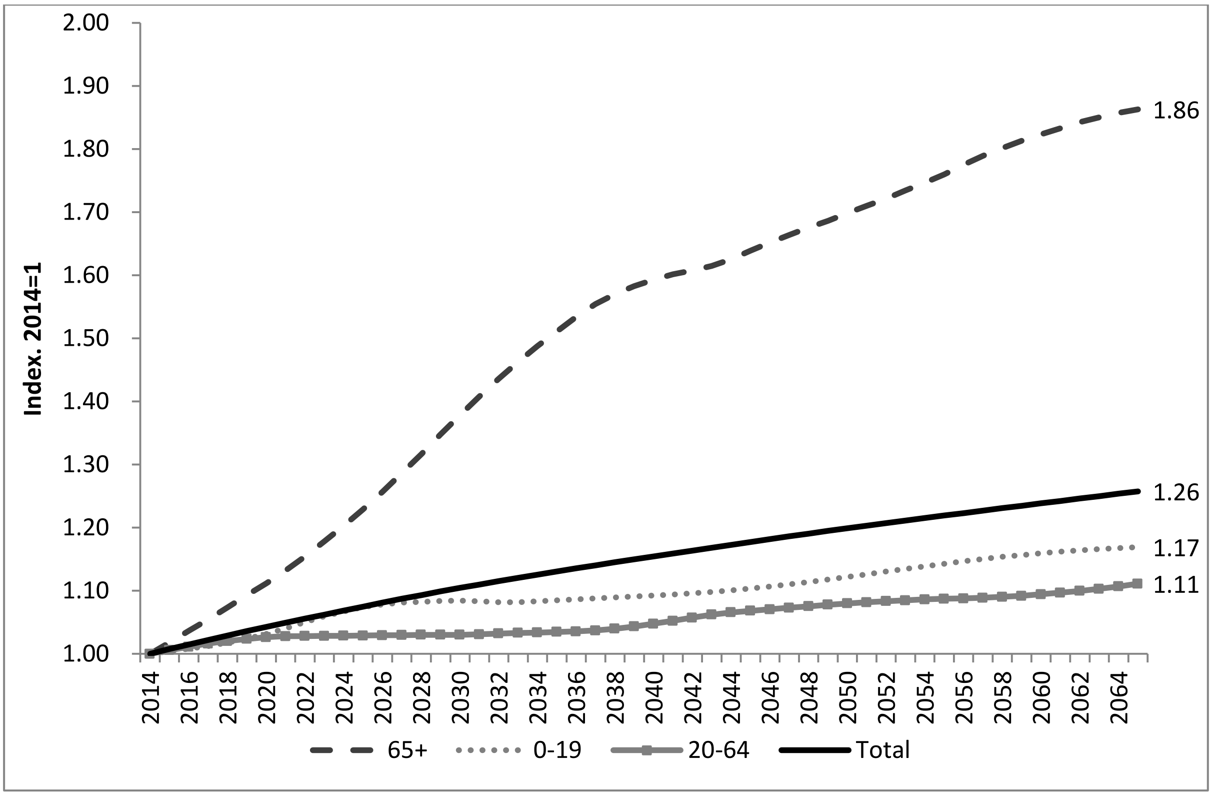


Source: McCarthy and Sefton (2010)

4. Simulations and Results

To construct the baseline "Remain" scenario, we use the 2014-based ONS principal population projections. Figure 3 shows the change in different age groups over the next five decades according to these projections. The fastest predicted growth is for the age group 65+ – in 2065 it is expected to increase by over 85% when compared to 2014 figures. The number of children (0-19) and working age adults (20-64) are also expected to rise, but at a much slower pace – there will be 17% and 11% more people in these age groups respectively in 2065 compared to 2014. Total population is predicted to increase by over 25% during this time.

Figure 3. Change in population age groups, 2014-based ONS principal projections. 2014=1



Source: 2014-based ONS principal population projections for the UK

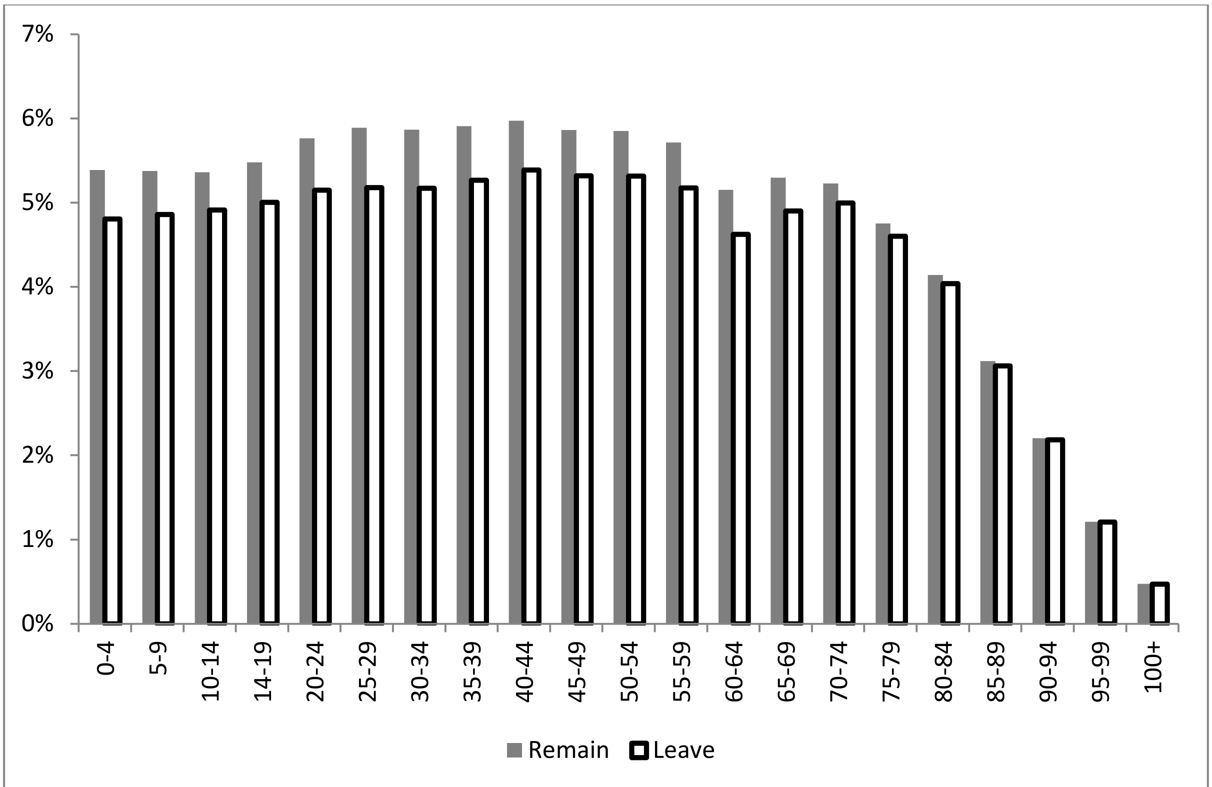
As a counterfactual we create a “Leave” migration scenario. The Leave scenario assumes that net migration from the EU15 and New EU countries would decline by two thirds and net migration from other origins will stay the same as in Remain scenario. This assumption is inspired by the Migration Watch UK (2016) analysis, which suggests that EU net migration would average about one third of the latest net migration figure should the UK leave the EU. We apply their suggested proportion of the net migration reduction to the ONS principal net migration assumption. This would result in the overall long-term assumption for net migration to decline from 185K per year in the Remain scenario to 92K per year. Table 4 summarises long term net migration assumptions by origin.

Table 4. Long-term net migration assumptions by origin, thousands per year

	Scenario	
	Remain	Leave
UK	-70	-70
EU15	59	20
New EU	82	27
Non EU	114	114
Total	**185**	**92**

Figure 4 shows the age structure of the UK population in 2065 according to the two scenarios. All bars add up to 100% for the Remain scenario. This means that for the Leave scenario we can see the change in both population size and structure. In the Leave scenario total population is about 8.4% smaller than in the Remain scenario. Most of the reduction is concentrated in the working age groups, while effect on the retired population is minimal. This is because of the age difference between migrants and the general population.

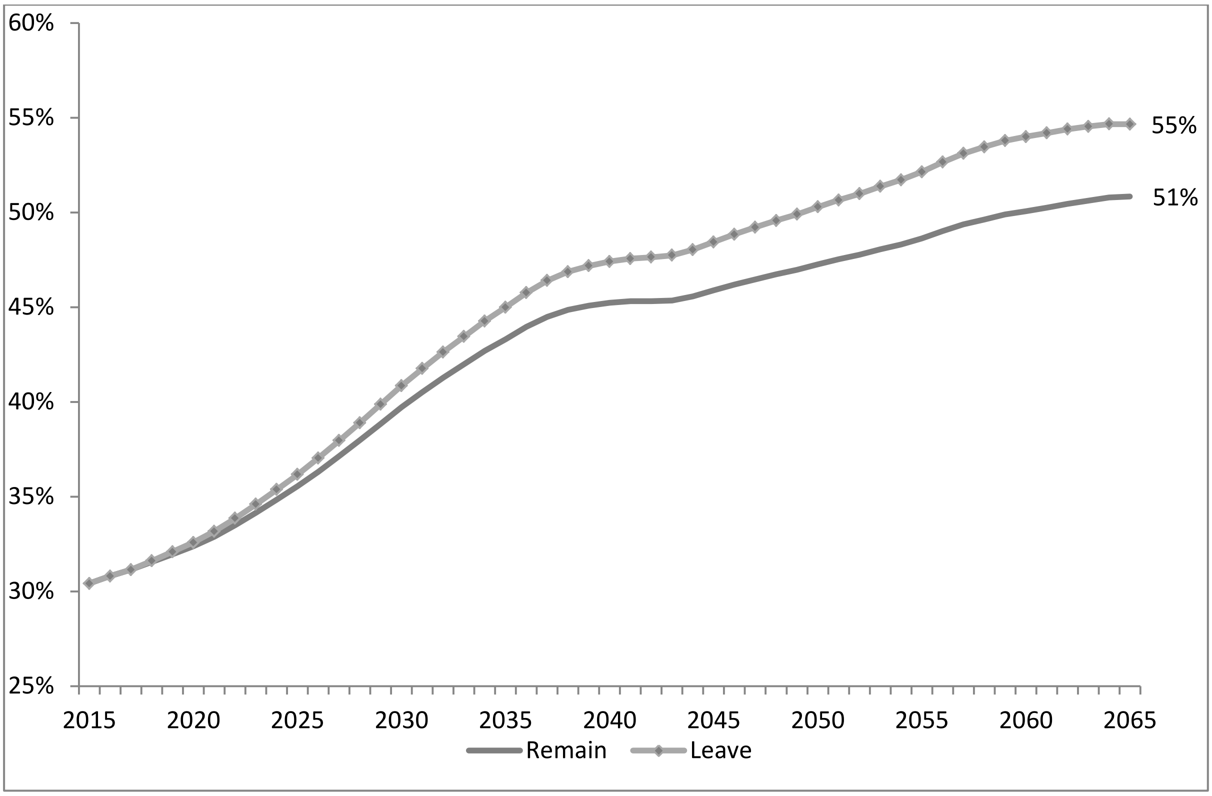
Figure 4. Population age structure in 2065



Source: own population projections

An alternative way of summarising the difference in the age structure between the two scenarios is using old-age dependency ratio. Figure 5 shows the ratio of the population aged 65+ to the population aged 20-64. The old-age dependency increases substantially in both scenarios. But in the Leave scenario it is 4 percentage points higher in 2065 compared with the Remain scenario.

Figure 5. Old-age dependency ratio



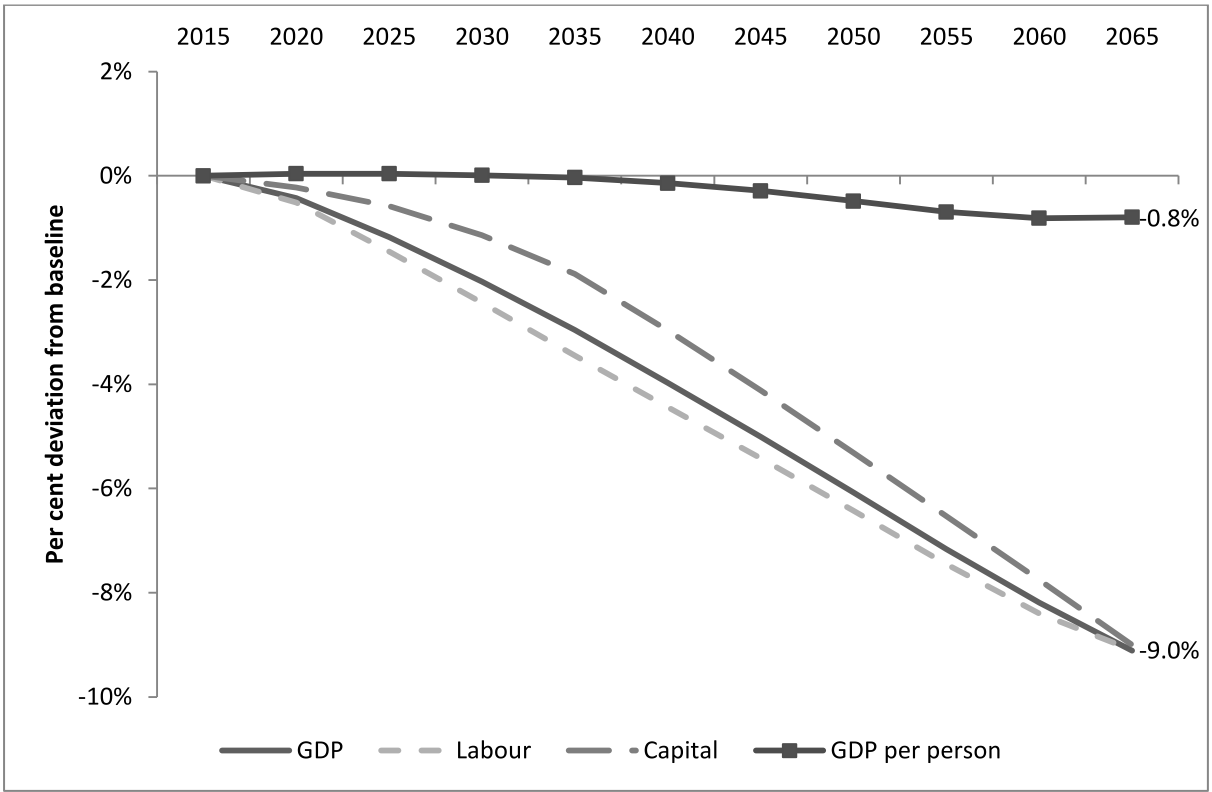
Source: own population projections

The results presented next show the percentage difference between the Leave and Remain scenarios unless otherwise specified.[15] Figure 6 depicts the difference in factors of production and GDP between the two scenarios. In the Leave scenario, by 2065 the productivity adjusted level of labour supply (i.e. taking into account employment rates, productivity profiles and qualification distributions) is about 9% lower than in the Remain scenario. The same is true regarding the level of GDP and the capital stock. GDP per person

[15] This paper only looks at the effects of reduced immigration in case the UK lives the EU. For all other macroeconomic effects associated with leaving the EU see Ebell and Warren (2016)

falls to a much lower extent as less net migration means lower population. Nevertheless, GDP per person is 0.8% lower in the Leave scenario.

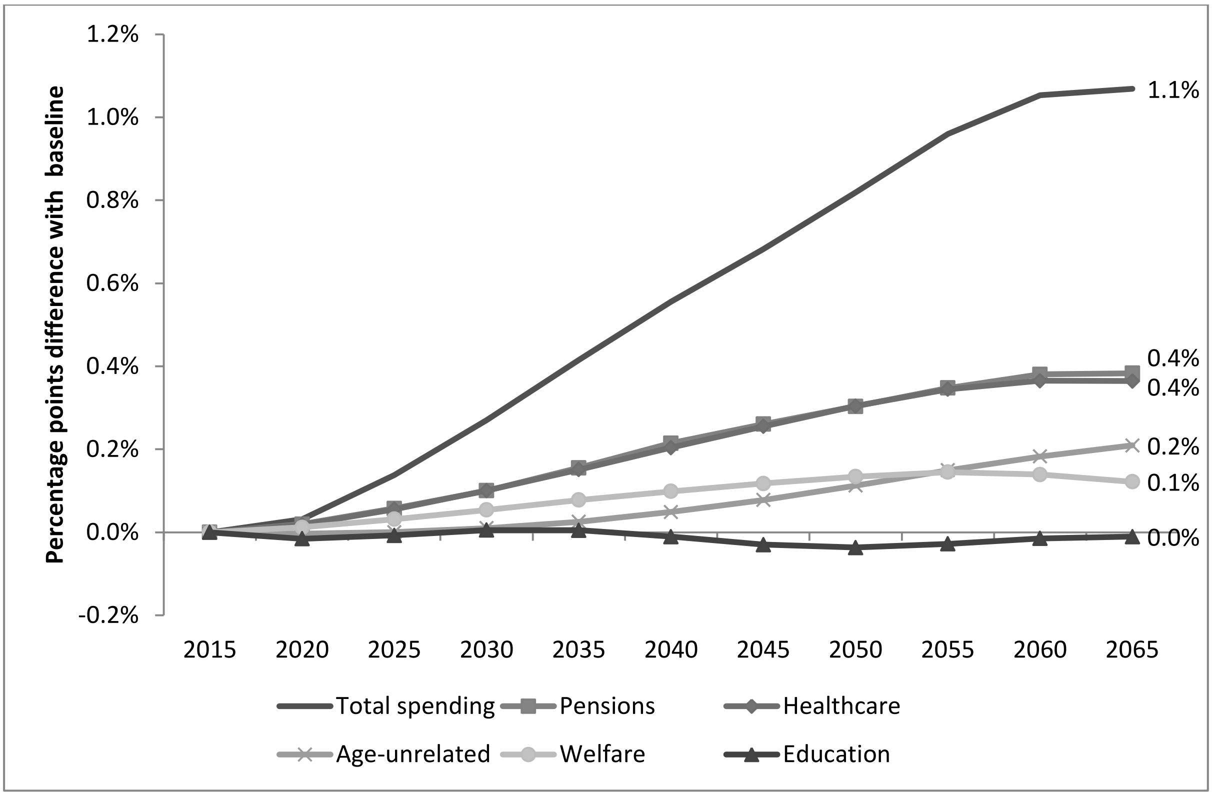
Figure 6. GDP and factors of production



Source: simulation results

Given our assumption that different categories of government expenditures depend on the size of the relevant population groups, government spending is lower in the Leave scenario relative to the Remain scenario simply because there are fewer people. However, when expressed as a share of GDP, government expenditures increase. Figure 7 shows the trajectories of change for different categories of government spending as a percentage points difference between the two scenarios. The categories that are most affected are pensions and healthcare expenditures. This is due to the fact that both of these categories of spending are concentrated in the older age groups; immigrants, being generally younger than natives, help to alleviate this burden. The total level of government spending is about 1.1 percentage points of GDP higher in the Leave scenario by 2065.

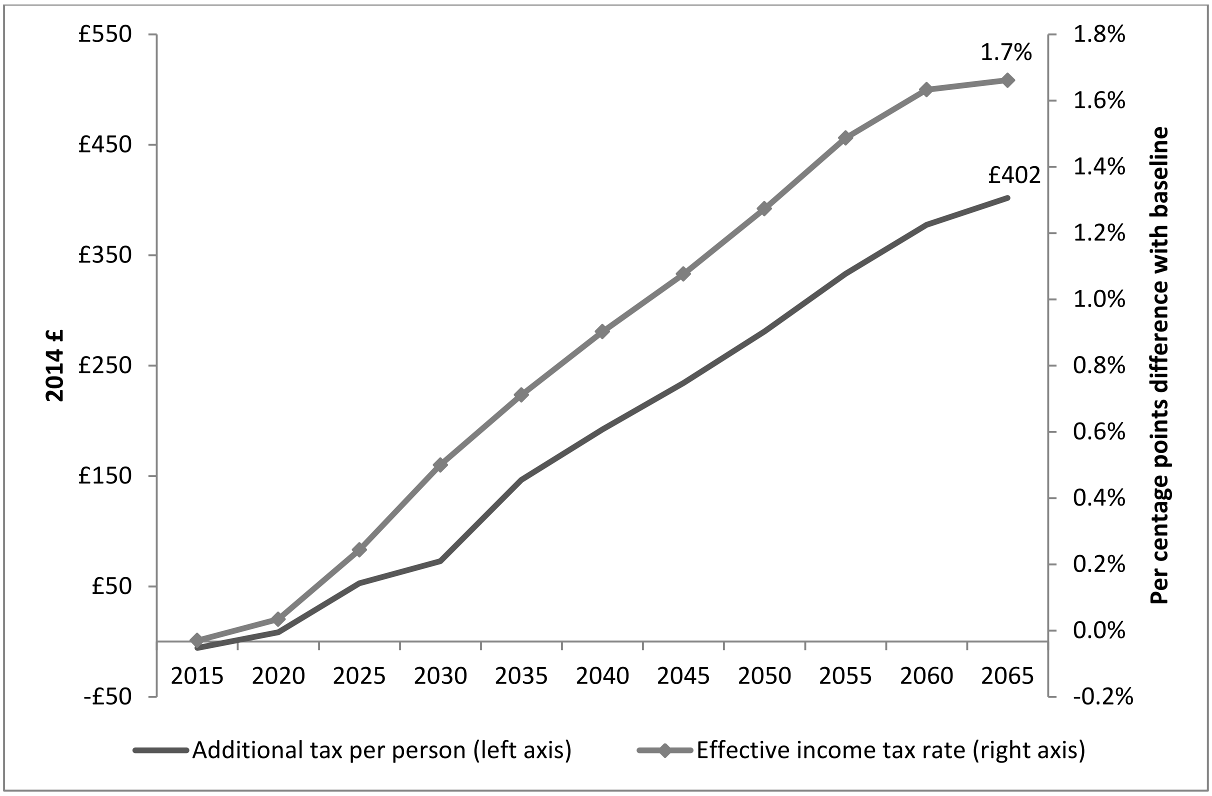
Figure 7. Government spending as a share of GDP



Source: simulation results

Because of the additional strain that a faster ageing population puts on government finances, and given the balanced budget assumption throughout the simulations, the level of taxation is higher in the Leave scenario. The instrument that is used for endogenous adjustment of taxation level is the effective rate of income tax. Figure 8 shows additional taxes per person, in 2014 pounds and percentage points difference, in effective rate of income tax in the Leave scenario relative to the Remain scenario. The level of increased taxation depends on the relative size of total government expenditure and revenue. On the revenue side, the labour income tax base suffers erosion in the Leave scenario. Aggregate consumption is also reduced in the Leave scenario, which results in relatively weaker consumption tax revenues. At the same time, government expenditures on, for example, healthcare and pensions, decrease significantly less than revenues. Thus, taxation needs to be higher with lower migration in order to compensate for the increase in the old-age dependency ratio.

Figure 8. Additional taxation

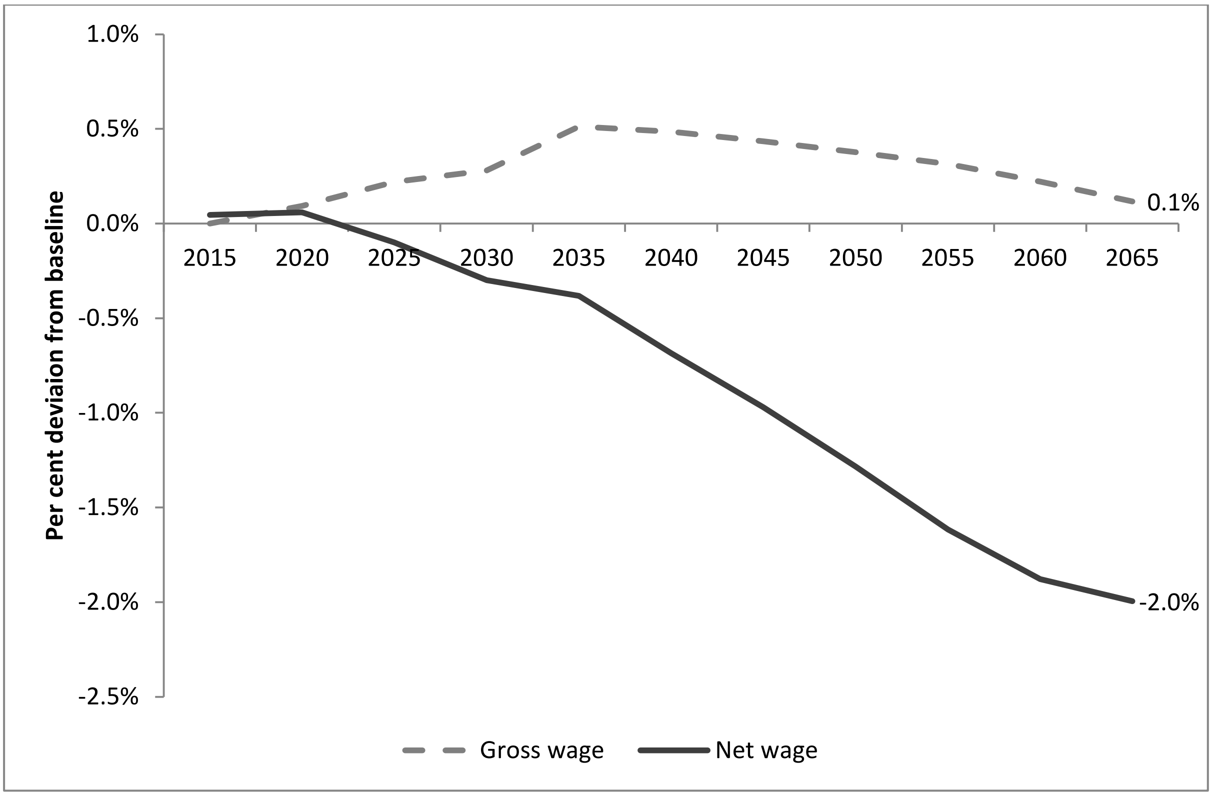


Source: simulation results

Figure 9 depicts the path followed by the average wage index as well as the net average wage. The equilibrium gross wage composite becomes slightly higher after the migration shock, due to the reduction in overall labour supply, which leads to a higher capital-labour ratio. But this effect does not persist for long; as the capital-labour ratio adjusts, the positive gross wage differential disappears by the end of the simulation period.

On the other hand, the evolution of net wage captures the difference between the gross wage and income tax payments. As is apparent, the increase in the effective income tax rate offsets the initial increase in the gross wage once the migration shock takes place, thereby causing a reduction in the net wage and hence a reduction in households' disposable income.

Figure 9. Wage



Source: simulation results

5. Sensitivity analysis

The results presented above are sensitive to some key assumptions. In this section we will demonstrate several of them. We will look at four additional scenarios:

1. Non-EU migration –net migration for EU15 and New EU countries will decline by two thirds, net migration from non-EU countries will increase to compensate half of this decline and net migration of UK-born people will stay the same as in the Remain scenario. This will result in the overall long-term assumption for net migration to decline from 185K per year in the Remain scenario to 138K per year.
2. UK migration –net migration for EU15, New EU and UK-born will decline by two thirds and net migration from non-EU countries will stay the same as in the Remain scenario. This will result in the overall long-term assumption for net migration to

decline from 185K per year in the Remain scenario to 138K per year. This scenario illustrates the situation when UK migrants face symmetrical restrictions from the EU countries.

3. EU migrants qualification – the same number and origin composition of migrants as in the Leave scenario, but all new migrants from EU15 and New EU countries have high qualification. This scenario illustrates the situation when a points-based system is used to select only the immigrants with high qualification.

The scenarios presented cover a range of possible options and show that the results are sensitive to the assumptions that change the productivity of the labour force (3 EU migrants qualification scenario) and dependency ratio (1 Non-EU migration and 2 UK migration scenarios). Although the effect on GDP is substantial in all scenarios, GDP per person reaction is modest, because lower migration results in lower population. Fiscal effects are more pronounced because of the changes in dependency ratio. Government spending as a share of GDP is higher by between 0.4 and 1.1 percentage points. This leads to higher taxes – by between £225 and £402 (2014 £) – and lower net wage – by between 0.6% and 2.0%.

The Non-EU migration (1) and UK migration (2) scenarios have almost the same level of net migration (rounded in Table 5). But the results are different due to the higher employment rates of the UK nationals. The UK migration (2) scenario is the only one that has positive (although small) effect on GDP per person compared with the Remain scenario. This is because UK-born migrants have higher qualification than the UK-born population on average, are at least as productive as the EU15 migrants and more productive than New EU migrants. Comparing the scenarios with higher net migration (1 and 2) and the EU migrant qualification (3) scenario demonstrates that "quantity" or migrants has stronger effect than "quality" of migrants.

Table 5. Comparison of scenarios

	Migration assumptions					Simulation results vs Remain scenario in 2065				
	UK-born net migration, K per year	EU15 net migration, K per year	New EU net migration, K per year	Non-EU net migration, K per year	Total net migration, K per year	GDP, % dif	GDP per person, % dif	Gov't spending % of GDP, pp dif	Additional tax per person, 2014 £	Net wage, % dif
Leave	-70	20	27	114	92	-9.1%	-0.8%	1.1%	£402	-2.0%
1 Non-EU migration	-70	20	27	162	138	-4.9%	-0.7%	0.7%	£237	-1.3%
2 UK migration	-23	20	27	114	138	-4.1%	0.3%	0.4%	£225	-0.6%
3 EU migrants qualification	-70	20	27	114	92	-8.6%	-0.2%	0.8%	£344	-1.6%
Remain	-70	59	82	114	185					

6. Conclusions

In this paper we employed an OLG-CGE model for the UK to illustrate the long-term macroeconomic effects of reduced migration as a result of UK leaving the EU. In our analysis, we compare the Leave scenario with a Remain scenario which is built in line with the 2014-based principal ONS population projections.

First, we find that the significant reduction in net migration has negative effects on the economy. By 2065, in the Leave scenario, aggregate GDP and GDP per person are 9% and 1% respectively lower compared to the Remain scenario. Second, reduced migration after leaving the EU has a significant negative impact on the public finances, owing to the shift in the demographic structure following the migration shock. The level of total government spending expressed as a share of GDP increases by 1.1 percentage points in 2065. This, in turn, requires an increase in the effective labour income tax rate for the government to balance its budget in every period. By 2065, the required increase is about 1.7 percentage points, which is equal to £402 (2014 pounds) per person. Third, the effect of the higher labour income tax rate is felt at the household level, with average households' net income worsening despite the initial increase in gross wages due to lower labour supply. By 2065, the net wage is 2% lower in the Leave scenario. The results are sensitive to the assumptions which change productivity of the labour force and dependency ratio.

As with any modelling exercise, a number of caveats are in order. From a purely technical point of view, our estimates provide, if anything, a lower bound of the potential effects of this policy. First, the model does not take into account potential positive productivity effects from higher levels of immigration. Two such potential effects that attracted attention recently are the effects on total factor productivity growth (e.g. Rolf et al., 2013) and the effects stemming from the imperfect substitution between natives and immigrants (Manacorda et al., 2012). Second, we use a closed economy model, which in the case of the low migration scenario results in a lower capital-labour ratio and lower returns on capital during the transition period. If we employed an open economy model with perfect capital mobility instead, downward pressure on interest rates would lead to capital outflow and thus stronger negative effects of reduced migration. Third, we do not take into account the potential transmission of the education levels within households (i.e. high-skilled parents tend to have high-skilled offspring). Nevertheless, due to the higher average skill level of immigrants, the presence of this effect would make our results stronger. Fifth, we assume that immigrants have the same access to public services as natives. However, recent evidence indicates that migrants might have lower demand for public services (e.g. Georges et al. 2011). Taking this into account would reinforce our conclusion regarding the negative impact of reduced immigration on public finances.

At the same time, while we take into account the direct impact of migration on population and hence on public expenditure, including capital spending, we do not capture the negative externalities resulting from, for instance, congestion. Finally, these simulations do not take into account the potential social impacts of higher immigration. This is a hotly debated area which, even though it should be considered when formulating migration policy, lies outside the scope of this paper.

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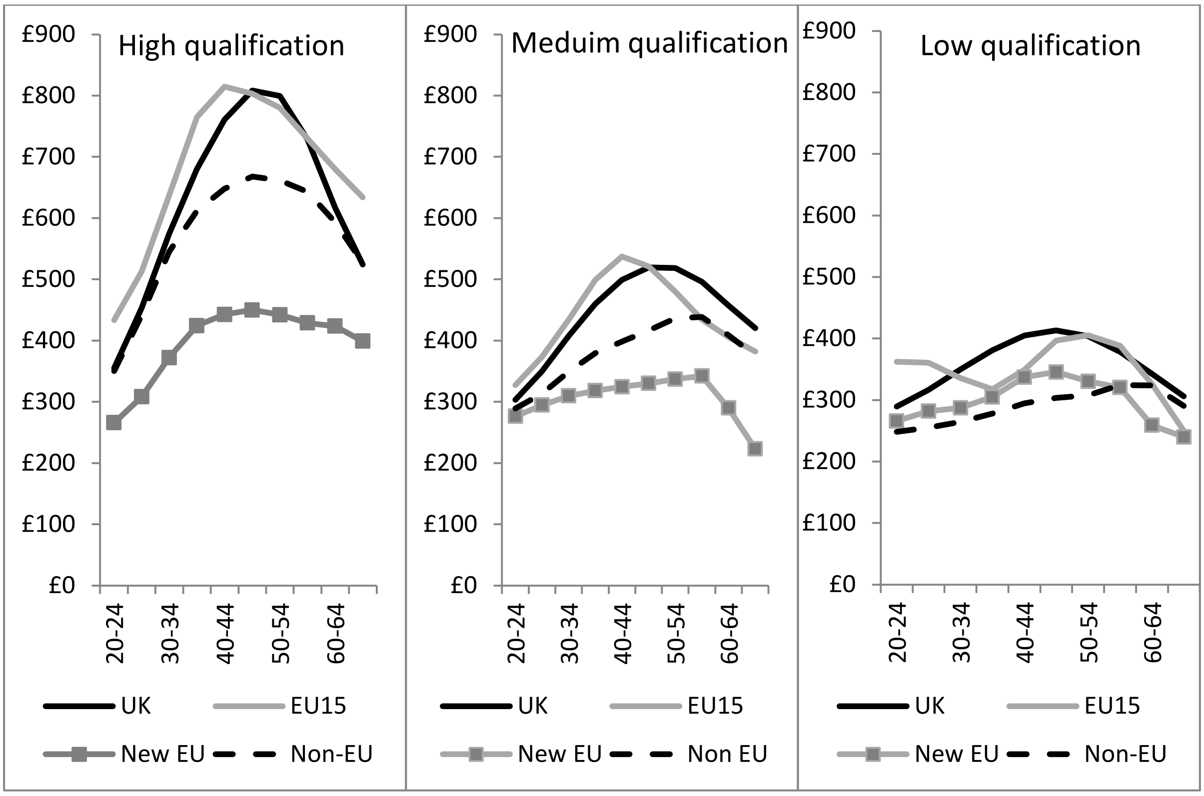
Appendix A

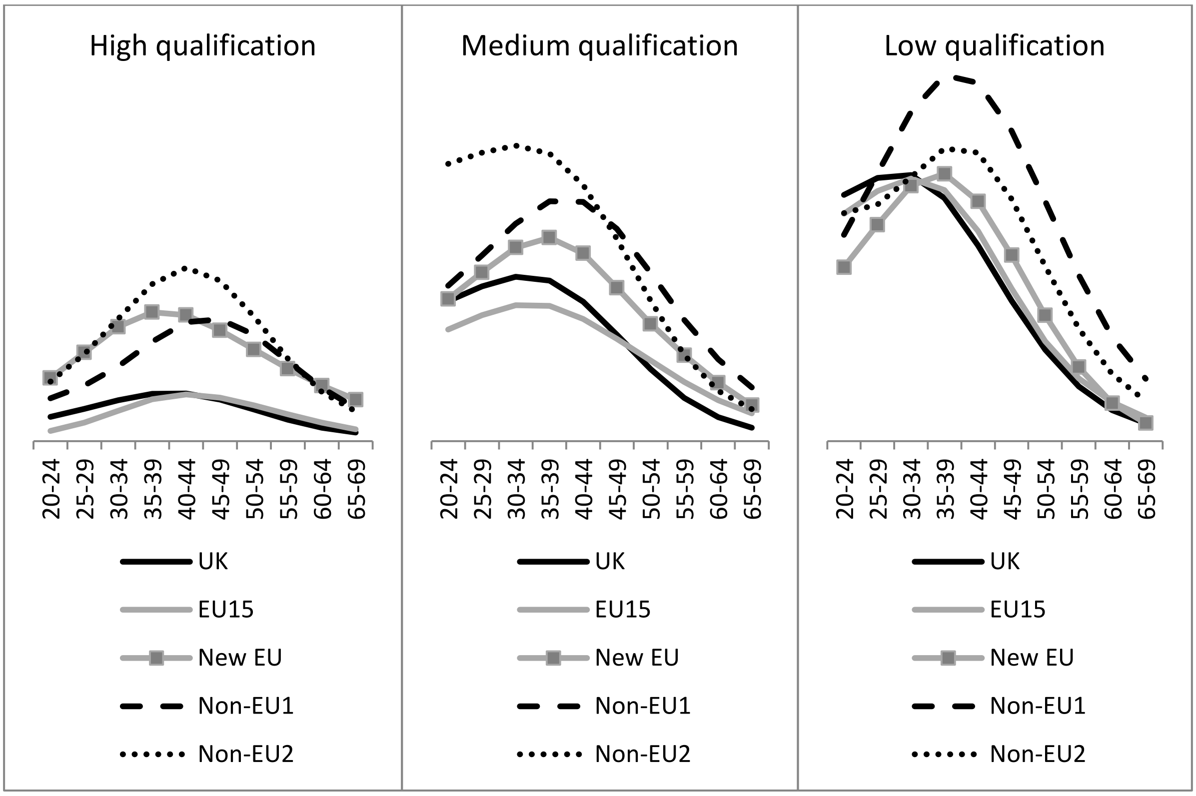
Average weekly earnings profiles



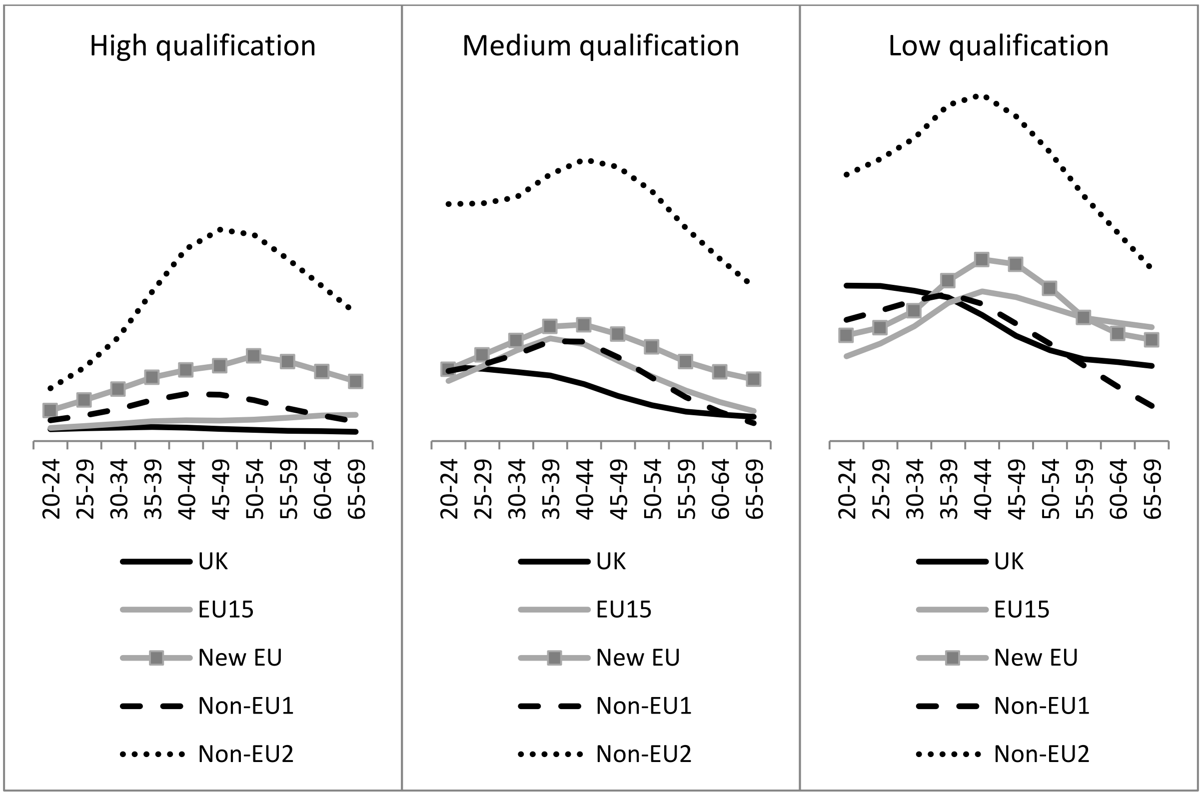
Relative size of average amount of benefits received by a representative of each qualification and origin group[16] by age.

[16] Non-EU1 is non- EU employed and non-EU2 is non-EU not employed

Tax credit profile



Housing benefit profile



Appendix B

1. Demographic Structure

The population is divided into 21 generations or age groups (i.e., 0-4, 5-9, 10-14, 15-19, …, 100-104). Demographic variables, fertility, mortality and net-migration rates are assumed to be exogenous. This is a simplifying assumption given that such variables are likely endogenous and affected by, for example, changes in economic growth. Every cohort is described by two indices. The first is *t*, which denotes time. The second is *g*, which denotes a specific generation or age group.

The size of the cohort belonging to generation *g+k* in any period *t* is given by the following two laws of motion:

(1)
$$Pop_{t,g+k} = \begin{cases} Pop_{t-1,g+k+5}\, fr_{t-1} & for \quad k=0 \\ Pop_{t-1,g+k-1}\left(sr_{t-1,g+k-1} + mr_{t-1,g+k-1}\right) & for \quad k \in [1,20] \end{cases}$$

The first equation simply implies that the number of children born at time *t* (age group *g+k = g*, i.e. age group 0-4) is equal to the size of the first adult age group (*g+k+5=g+5*, i.e. age group 20-24) at time *t-1* multiplied by the "fertility rate", *fr*, in that period. If every couple has two children on average, the fertility rate is approximately equal to 1 and the size of the youngest generation *g* at time *t* is approximately equal to the size of the first adult generation *g+5* one year before. A period in the model corresponds to five years and a unit increment in the index *k* represents both the next period, *t+k,* and, for an individual, and a shift to the next age group, *g+k*.

The second law of motion gives the size at time *t* of any age group, *g+k,* beyond the first generation, as the size of this generation a year ago times the sum of the age specific conditional survival rate, *sr,* and the net migration rate, *mr,* at time *t-1.* In this model the fertility rates vary across time, while the survival and net migration rates vary across time and age. For the final generation (i.e., the age group 100-104 (*k*=20)), the conditional survival rate is zero. This means that everyone belonging to the oldest age group in any period dies with certainty at the end of the period.

We disaggregate age-specific net migration rates by origin. Aggregate net migration rates, *mr*, are a sum of net migration rates by origin.

Time variable fertility and time/age-variable net migration and conditional survival rates are calibrated based on exogenous population projections. This permits a precise modelling of the demographic scenario of any configuration within the model. This feature of the model makes it ideal for studying the overall impact of demographic change on the economy.

2. Production

At any time *t*, a representative firm hires labour and rents physical capital to produce a single good using a Cobb-Douglas technology. The production function thus reads:

(2) $$Y_t = AK_t^{\alpha} L_t^{1-\alpha}$$

where Y denotes output, *K* is physical capital L denotes effective units of labour, *A* is a scaling factor and α represents the share of physical capital in output. The market in which the representative firm operates is assumed to be perfectly competitive. Factor demands thus follow from the solution to the recursive profit maximization problem:

(3) $$re_t = \alpha A \left(\frac{K_t}{L_t} \right)^{\alpha-1}$$

(4) $$w_t = (1-\alpha) A \left(\frac{K_t}{L_t} \right)^{\alpha}$$

where re and w denote, respectively, the rental rate of capital and the wage rate.

We assume that there are three types of labour that can be employed by the firm, which are indexed as *qual = 1, 2 and 3*. These types are defined in terms of skill-level/qualification: "high-skilled workers" (*qual=1),* "medium-skilled workers" (*qual=2)* and "low-skilled workers" (*qual=3)*. Native and foreign-born workers of the same skill-level are perfect substitutes. A firm transforms its demand for total labour, *L,* into a skill-specific labour demand, L_{qual}, based on the following constant-elasticity-of-substitution (CES) function:

(5) $$L_{qual,t} = \varsigma_{qual}\left(\frac{w_t}{w_{qual,t}}\right)^{\sigma^L} L_t$$

where w_{qual} denotes the wage rate for a specific qualification, ς_{qual} is the share of each qualification in total labour input and σ^L represents the elasticity of substitution between qualifications. The relationship between the composite wage rate of the firm's aggregate labour input, w, and the skill-specific market wages, w_{qual}, is given by:

(6) $$w_t^{1-\sigma^L} = \sum_{qual} \varsigma_{qual} w_{qual,t}^{1-\sigma^L}$$

3. Household sector

The household sector in the model is disaggregated by age (21 generations), qualification (3 qualifications) and origin (native- or foreign-born). Household behaviour in every qualification/origin group is captured by 21 representative households that interact in an Allais-Samuelson overlapping generations structure representing each of the age groups. Individuals enter the labour market at the age of 20, retire at age 65, and die at the latest by age 104. Younger generations (i.e. 0-4, 5-9, 10-14 and 15-19) are fully dependent on their parents and play no active role in the model. However, they do influence the public expenditure. An exogenous age/time-variable survival rate determines life expectancy.

Adult generations (i.e. age groups 20-24, 25-29, …, 100-104) optimise their consumption-saving patterns over time. The household's optimization problem consists of choosing a profile of consumption over the life cycle that maximizes a CES type inter-temporal utility function, subject to the lifetime budget constraint. In particular, the inter-temporal preferences of an individual born at time *t* are given by:

(7) $$U_{qual,nat} = \frac{1}{1-\theta}\sum_{k=4}^{20}\left\{\left[\frac{1}{1+\rho}\right]^k \Pi_{m=0}^{k} sr_{t+m,g+m}\left((C_{qual,nat,t+k,g+k})^{1-\theta}\right)\right\} \qquad 0 < \theta < 1$$

where C denotes consumption, ρ is the pure rate of time preference and θ represents the inverse of the constant inter-temporal elasticity of substitution. Future consumption is also discounted at the unconditional survival rate, $\Pi_k sr_{t+k,g+k}$, which is the probability of survival up to the age *g+k* and period *t+k.* It is the product of the age/time-variable conditional survival rate, $sr_{t+k,g+k}$, between periods *t+k* and *t+k+1* and ages *g+k* and *g+k+1*.

The household is not altruistic, i.e. it does not leave intentional bequests to children. However, it leaves unintentional bequests due to unknown life duration. The unintentional bequests are distributed through a perfect annuity market, as described theoretically by Yaari (1965) and implemented in an OLG context by Boersch-Supan et al (2006).

Given the assumption of a perfect annuity market, the household's dynamic budget constraint takes the following form:

(8)
$$HA_{qual,nat,t+1,g+1} = \frac{1}{sr_{t.g}} \times \left[Y^{L}_{qual,nat,t,g} \left(1 - \tau^{L}_{t} - Ctr_{t}\right) + Pens_{t,g} + TRF_{nat,t,g} + \left(1 + Ri_{t}\right) HA_{qual,nat,t,g} - C_{qual,nat,t,g} \right]$$

where *HA* is the level of household assets, *Ri* is the rate of return on physical assets, τ^K is the effective tax rate on capital, τ^L the effective tax rate on labour, *Ctr* is the contribution rate to the public pension system, Y^L is the labour income, *Pens* is the level of pension benefits and *TRF* is public transfers other than pensions. The intuition behind the term *1/sr* is that the assets of those who die during period *t* are distributed equally between their surviving peers. Therefore, if the survival rate at time *t* in age group *g* is less than one, then at time *t+1* everyone in their group has more assets. That is, they all receive an unintentional bequest through the perfect annuity market.

Labour income is defined as:

(9)
$$Y^{L}_{qual,nat,t,g} = w_{qual,t} EP_{qual,nat,g} LS_{qual,nat,g}$$

where *LS* is the exogenously given supply of labour differentiated by qualification and origin. It is assumed that labour income depends on the individual's age-specific productivity. In turn, it is assumed that these age-specific productivity differences are captured in age-earnings profiles that are also disaggregated by qualification and origin.

Differentiating the household utility function, subject to its lifetime budget constraint, with respect to consumption yields the following first-order condition for consumption, commonly known as Euler equation:

(10) $$C_{qual,nat,t+1,g+1} = \left[\frac{[1+Ri_{t+1}]}{(1+\rho\ )} \right]^{\frac{1}{\theta}} C_{qual,nat,t,g}$$

It is important to note that, since survival probabilities are present in both the utility function and the budget constraint, they cancel each other out and are not present in the Euler equation.

4. Modelling migration

We differentiate households by origin along many dimensions. The origin groups have different age-specific employment rates, age-productivity profiles and age-qualification distributions. They also have different probabilities of receiving various benefits. Such detailed differentiation allows us to capture multidimensional influences of migration on the labour market, aggregate demand and public finances.

5. Investment and Asset Returns

The law of motion for the capital stock, *Kstock*, takes into account depreciation:

(11) $$Kstock_{t+1} = Inv_t + (1-\delta)Kstock_t$$

where *Inv* represents investment, δ is the depreciation rate of capital.

Capital markets are assumed to be fully integrated. This implies that financial capital is undifferentiated from physical capital, so that the interest rate parity holds:

(12) $$1 + Ri_t = re_t + (1-\delta)$$

where *Ri* and *re* denote the net and gross rates of return to physical capital, respectively.

6. Government Sector

The Government's budget constraint reads:

(13) $$\begin{aligned} &\sum_{qual,nat,g} Pop_{qual,nat,t,g} \left\{ \left(\tau_t^L + Ctr_t\right)\left(w_{qual,t} EP_{qual,nat,t,g} LS_{qual,nat,t,g}\right) + \tau^C C_{qual,nat,t,g} \right\} \\ &= Gov_t + GovH_{t,g} + GovE_{t,g} + \sum_{qual,nat,g} Pop_{qual,nat,t,g} \left(TRF_{nat,t,g} + Pens_{t,g}\right) \end{aligned}$$

where τ^C is the effective tax rate on consumption, Gov is age-independent public consumption, $GovH$ denotes government expenditure on health and $GovE$ denotes government expenditure on education. The left-hand side of the constraint contains the government revenues, grouping together all tax revenues from different sources. The right-hand side of the equation represents different categories of government expenditure including origin-dependent transfers to households and pension benefits. Note that the pension program is a part of the overall government budget.

The government budget constraint includes spending on healthcare, education, pensions, welfare and other expenditures. Healthcare and education spending is projected using age-specific profiles, which are indexed to wages in the proportion that labour cost represents in the total budget. Welfare spending is disaggregated by category of benefits. Each type of benefits has its own age profile for each qualification-origin group. Benefits are indexed to wages. The pension program is part of the overall government budget. State pension age changes in accordance with the current plans to increase state pension age. Pension benefits can be indexed according to different rules. Other government spending is assumed to be age-independent.

In the simulations presented in this paper we use the wage tax rate, τ_t^L, as the only endogenous policy variable that adjusts in every period to achieve a balanced government budget. The choice to focus on the wage tax rate as the main fiscal instrument is justified, among other reasons, by the fact that it does not generate efficiency distortions, given the absence of an endogenous labour-leisure decision.

7. Market and Aggregation Equilibrium Conditions

Perfect competition is assumed in all markets. The equilibrium condition in the goods market requires that the UK's output be equal to aggregate absorption, which is the sum of aggregate consumption, investment and government spending:

(14) $$Y_t = \sum_g Pop_{t,g} C_{t,g} + Inv_t + Gov_t + GovH_t + GovE_t$$

Labour market clearing requires that the demand for labour of a specific qualification level be equal to the supply of this qualification:

(15) $$L_{qual,t} = \sum_{nat,g} Pop_{qual,nat,t,g} LS_{qual,nat,g} EP_{qual,nat,g}$$

Similarly, the units of capital accumulated up to period *t* must equal the units of capital demanded by the representative firm in that period:

(16) $$Kstock_t = K_t$$

In the same vein, equilibrium in the financial market requires total stock of private wealth accumulated at the end of period *t* to be equal to the value of the total stock of capital and government debt accumulated at the end of period *t*:

(17) $$\sum_{g} Pop_{qual,nat,t,g} HA_{qual,nat,t,g} = Kstock_t$$