Joseph Rowntree Foundation

The Impact of Brexit on Poverty in the UK

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Cambridge Econometrics
Cambridge, UK

sh@camecon.com
www.camecon.com

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Executive Summary

The UK is planned to leave the EU on 29th March 2019 and, with six months of negotiations left, the coming weeks are crucial to securing the best possible deal for the UK.

Whilst many studies that have assessed the potential economic impacts of alternative Brexit scenarios, previous studies have primarily focused on economy-wide impacts of changes in trade relationships with Europe. There has been limited analysis of the potential impacts on low-income groups specifically.

In light of this, Cambridge Econometrics was commissioned by the Joseph Rowntree Foundation to assess the medium-term (2030) impact of alternative post-Brexit trade scenarios on prices, employment, wages and tax revenues. The analysis presented in this report represents an independent contribution to the debate. It explores the potential impacts on low-income households from a politically-neutral perspective.

A series of scenarios was constructed to reflect alternative possible trading relationships with Europe, ranging from a 'Norway' scenario where the UK remains in the European Economic Area (EEA), to a 'No Deal' scenario, where the UK-EU trading relationship reverts to WTO rules. The scenarios are comprehensive in the sense that they reflect the full economic impacts of Brexit, taking account of the impact of changes in migration and investment, as well as changes in trade patterns. In the central scenarios, we assume that there is no change to import or export tariffs for trade with countries outside of the EU. Any FTAs negotiated between the EU and partner countries in the rest of the world before Brexit are assumed to be automatically carried over to the UK post-Brexit.

To model the impact of the alternative post-Brexit scenarios on low-income groups, we use E3ME[1], a global macroeconomic model that captures bilateral trade relationships between the UK, each EU Member State and key global trading partners. E3ME includes a series of econometric equations to estimate the behaviour of firms and households in response to economic drivers and applies an input-output framework to model industry interdependencies.

Results from modelling potential Brexit economic impacts are subject to a high degree of uncertainty, reflecting the lack of historical precedence of such an event. Whilst there is readily available data on some of the important factors involved – such as the size of current and potential future tariffs – there is much less certainty over other important factors such as foreign direct investment, migration, and non-tariff barriers.

In addition to data limitations, different modelling approaches in existing studies have found a wide range of results for the potential impact of Brexit. The modelling approach which underpins this analysis finds more moderate impacts of Brexit on the economy compared to other similar studies. The analysis is based on a conservative assumption that there is an orderly exit

[1] More information about the model is available from www.e3me.com.

from the EU and we do take account of increased business uncertainty or potential exchange rate shocks.

The results from our analysis show that:

Prices will rise, due to higher costs of trade with the EU

- When the UK leaves the EU, if no free trade agreement is in place, higher tariff and non-tariff barriers could drive a 3% increase in average consumer prices.
- If a free trade agreement between the UK and the EU is negotiated, consumer prices would still be likely to increase due to increased trade friction costs, but to a lesser extent (around 0.7%-2.8%, depending on the level of regulatory alignment).
- These price effects compare to an estimated 2% increase in consumer prices due to the depreciation of the pound in the period immediately following the referendum result[2].
- The average estimated impact on prices for low-income households in the 'No deal' scenario is equivalent to a £480 increase in the cost living.

Impacts on employment are dependent on the extent to which the UK workforce can be up-skilled

- In the scenarios where the UK leaves the Single Market, we assume that net migration into the UK will fall from the current 245,000 per annum to 165,000 per annum, due to tighter immigration controls. By 2030, this corresponds to a 930,000 (1.3%) reduction in the size of the population relative to a no-Brexit baseline.
- The size of the working-age population falls to a larger extent in percentage terms, by nearly 2% by 2030 (790,000 people), due to the relatively high share of the migrant population that is of working age.
- Studies have suggested that high net migration into the UK did not significantly increase the rate of unemployment and so we assume that lower net migration will not reduce it. The rate of unemployment is already low, and those in unemployment are unlikely to have similar characteristics to the migrants that no longer come to the UK. Consequently, the reduction in the working age population relative to the baseline will lead to a corresponding reduction in the productive capacity of the economy, leading to a fall in output and employment as firms scale back production in the UK.
- In the No Deal scenario, there are 850,000 fewer jobs than the baseline in 2030 and the employment rate is 0.5 pp lower, as there is a smaller migrant workforce, reduced consumer spending and higher labour costs, due to reduced levels of productivity and reduced economies of scale.

There is a fall in real wages for low-pay workers due to an increase in the prices

- In all of the Brexit scenarios, real wages for low-pay workers are depressed due to increases in prices and reduced levels of productivity, due to skills shortages and lower industry investment.
- There are some wage-bargaining effects and so the scale of reduction in real wages is not as great as the scale of increase in the price level. Real wages are 1% lower than the baseline in 2030 in a scenario where no deal is agreed with the EU.

[2] Levell, P. (2018), 'The Customs Union, tariff reductions and consumer prices' *IFS Briefing Note BN225*

1 Introduction

1.1 Background

According to the 'Poverty in the UK 2017' report[3], over recent decades, there has been strong progress towards reducing poverty and inequality in the UK, particularly among pensioners and families with children. However, this trend has begun to reverse. In 2015/16, 22% of the UK population (14 million people) were living in poverty, compared to 20% of people in 2004[4]. This increase in poverty in the UK is due, in part, to increases in housing costs and a real-term fall in the value of benefits and tax credits.

It is still unclear what eventual deal will be agreed with the EU but the impacts of the referendum result are already being felt by low-income groups. In the 24-hour period following the announcement of the outcome of referendum, sterling depreciated sharply, falling by over 10% in one day. The pound weakened further to a low of £1=$1.2 in January 2017, reflecting a large increase in uncertainty and reduced business confidence. As a consequence of the referendum-induced exchange rate shock, prices are already estimated to be 2% higher[5] than they otherwise would have been if UK voted to remain.

This study is an independent assessment of the impact of alternative Brexit scenarios on low-income groups in the UK. We consider the combined impacts of changes in the UK's trading relationship with the EU, changes in patterns of migration and changes in foreign direct investment on prices, wages and employment for low-income groups.

Definitions

The impact of Brexit on prices and living costs is assessed at the household level. For the purposes of this study, 'low-income households' are defined as households in the bottom fifth of the income distribution, where income is adjusted for housing costs and household size.

The labour market results focus on the impacts for low-paid workers, defined as people who are in employment and earning less than 60% of median incomes (in the no-Brexit baseline).

1.2 Structure of the report

The remainder of this report is structured as follows:

- Chapter 2 describes our modelling approach and provides information about the E3ME model, which was used for the scenario analysis
- Chapter 3 describes the key features of each scenario and the assumptions that they are based upon
- Chapter 4 presents results for the impact of each of the Brexit scenarios on prices, employment and real wages
- Chapter 5 provides a comparison of our results to other studies
- Chapter 6 concludes

[3] JRF (2017), 'UK Poverty 2017'

[4] JRF (2017), 'UK Poverty 2017'

[5] Levell, P. (2018), 'The Customs Union, tariff reductions and consumer prices' *IFS Briefing Note BN225*

2 Modelling approach

To model the impact of Brexit on low-income workers, we use a scenario-based approach and application of the macroeconomic model, E3ME. Estimates from the literature are used to inform our assumptions about the impact of alternative trading relationships on tariffs, non-tariff barriers, investment and migration. These assumptions are input to E3ME, to assess the wider impacts on low-income groups.

In addition to the macroeconomic modelling in E3ME, detailed labour market analysis is undertaken off model, to translate the sectoral labour market results into impacts for low-income workers.

2.1 Macroeconomic modelling using E3ME

To model the impact of alternative Brexit scenarios on prices, employment and wages, we use the macro-econometric model, E3ME, which has been extensively applied for modelling trade and other policy scenarios across the European Union, most recently in a project for the Greater London Authority to model the economic impacts of a hard Brexit on London and UK[6].

E3ME includes a series of econometric equations to estimate the behaviour of households and businesses in response to an economic shock and applies an input-output framework to model industry interdependencies

The key features that distinguish the E3ME model are:

- its global geographical coverage, capturing bilateral trade relationships, while still allowing analysis at a national level for the UK[7]
- its detailed sectoral disaggregation (GVA and employment are modelled for 70 separate sectors in the UK, consistent with SIC07)
- its econometric specification which provides a strong empirical grounding instead of relying on assumptions about the functioning of the economy, such as perfect competition and optimal behaviour (for example, no involuntary unemployment), which are common to other (CGE) modelling approaches

In E3ME, the determination of output comes from a post-Keynesian framework. The model is demand-driven and it is not assumed that prices always adjust to clear markets. More information about the model is available from www.e3me.com.

Whilst E3ME can provides a range of output indicators, the purpose of this study is to focus, specifically, on low-income groups and so results are provided for:

- impacts on employment and wages by sector (so that sectors that employ a higher proportion of low-paid workers can be distinguished)

[6] Cambridge Econometrics (2018), 'Preparing for Brexit'. Available online at: https://www.london.gov.uk/sites/default/files/preparing_for_brexit_final_report.pdf

[7] The geographical scope of E3ME allows us to capture bilateral trade relationships between the UK and 58 partner countries/regions (including every EU Member State).

- impacts on prices by consumption category (so that the products that are more important for spending by low-income households can be distinguished)

The labour market

Treatment of the labour market is an area that distinguishes E3ME from other macroeconomic models. E3ME includes econometric equation sets for employment, average working hours, wage rates and participation rates. The first three of these are disaggregated by economic sector while participation rates are disaggregated by gender and five-year age band.

Prices

Input-output tables are used to model the impact of price shocks in industry supply chains. Empirically-estimated price equations are used to determine the degree of cost pass-through, which is dependent on the competitiveness of each sector.

2.2 What is not captured by the scenarios modelled in E3ME

The scenarios that have been modelled are comprehensive in the sense that they reflect the trade, migration and investment effects associated with a representative range of possible Brexit deals, but there are some aspects of the Brexit scenarios that are not fully captured within our modelling framework.

The housing market

We do not model the impacts of Brexit on the housing market and the consequential impact on the cost of housing or rents. It could be argued that reduced migration into the UK would reduce pressure on the housing market, due to a reduction in demand. However, findings from the literature on this topic are inconclusive, with studies by Sá (2014) and Braakmann (2016), counterintuitively, finding that increased in-migration to a local area led to reduction in house prices[8]. Furthermore, a study by Belfield et al. (2015) shows that the drivers of house price inflation are complex, with the most important factors including real income growth, the availability of mortgage credit and demographic structure (i.e. the size of households). Further studies have suggested that house prices are most affected by interest rates and government policies (such as the 'Help to Buy' scheme). We do not assume a link between immigration and house prices, due to the limited evidence of this relationship.

Investment

Our estimates of the impact of Brexit on investment are based on assumed changes in foreign direct investment due to reduced access to EU markets. We regard these assumptions as conservative, in that they do not capture any potential falls in investment that could occur if there is increased uncertainty and reduced business confidence.

Skills shortages

E3ME does not capture the supply of skills in the migrant workforce vs the native workforce. We assume that the skills of British non-economically active working-age people are not a perfect substitute for the skills of the migrant workforce and therefore, reductions in the working-age migrant population create capacity constraints, leading to reductions in output, rather than pulling people out of economic inactivity. This assumption is supported by a large body of literature that shows the impact of migration on unemployment is insignificant.[9]

[8] As these studies were focusing on a local level, this effect is likely to be partly explained by a concurrent out-migration of British households from those areas with increasing in-migration.

[9] For example, see: Wadsworth et al, 2016, 'Brexit and the Impact of Immigration on the UK'

3 Scenarios

3.1 Overview of the scenarios

We use a scenario-based approach to model outcomes for low-income workers in the UK under a range of possible future trading relationships with the EU, ranging from a Norway scenario where the UK remains in the European Economic Area (EEA), to a No Deal scenario, where the UK-EU trading relationship reverts to WTO rules. Results are generally reported for 2030 as comparisons with a no-Brexit baseline.

The key features of each scenario are summarised in Table 3.1 below and a more detailed description of each scenario is provided in Annex A.

Table 3.1 Key features of each scenario

Scenario	Summary
S1 – Baseline	The UK remains in the EU.
S2 - Norway	The UK remains in the European Economic Area (EEA) and the 'four freedoms'[10] of the single market are preserved. There is no change in the level of migration compared to in the baseline. There are no tariffs to trade with the EU (with the exception of food and agriculture imports, where a low tariff rate is applied).
S3 - Turkey[11]	The UK remains in the Customs Union, but not in the EEA. There are no tariffs on trade between the UK and other EU countries and the EU customs duty is applied to trade with non-EU countries. There is a reduction in migration and an increase in trade friction costs.
S4 - Ukraine	The UK joins the Deep and Comprehensive Free Trade Area (DCFTA). There are no tariffs for trade with the EU (except for food and agriculture). There is a reduction in migration and an increase in trade friction costs.
S5 - Canada	The UK negotiates a Free Trade Agreement (FTA) with the EU. There is a reduction in migration and high trade friction costs.
S6 - No Deal	Trade between the UK and the EU reverts to WTO rules with MFN tariffs. There is a reduction in migration and high trade friction costs.

In the central variants of each scenario it is assumed that there is no change to import or export tariffs for trade with countries outside of the EU. Any FTAs negotiated between the EU and partner countries in the rest of the world before Brexit are assumed to be automatically carried over to the UK post-Brexit.

[10] Freedom of movement in labour, capital, goods and services.

[11] This illustrative scenario assumes that the UK remains in the complete customs union. The scenario does not fully reflect Turkey's relationship with the EU, as Turkey is only in a partial customs union with the EU and does face some tariffs on agriculture, for example.

3.2 Key sensitivities that were tested

To gauge the potential benefit of abolishing all import tariffs[12] for all the scenarios with independent trade policy we carry out a sensitivity test in which the UK also implements unilateral trade liberalisation. In this sensitivity, we also assume FTAs are reached with the US and China, leading to a reduction in prices of exports to these countries.

In the No Deal scenario, we test a more pessimistic variant where we assume that EU-negotiated deals with third countries[13] are not carried over and the trade relationship between the UK and these countries reverts to WTO rules.

3.3 Overview of our assumptions

The key exogenous model inputs to each scenario include:

- tariff and non-tariff barriers for trade with the EU
- tariff and non-tariff barriers for trade with the rest of the world
- net immigration into the UK from the EU
- investment
- agricultural subsidies

Food costs account for around 15% of total spending by low-income households. Given the impact of the Common Agricultural Policy (CAP) on food prices (which is of particular relevance for low-income groups) and agricultural output, we have also made assumptions about what agricultural policy might look like in the various Brexit scenarios. Although the UK is likely also to withdraw from other EU policies when it leaves the EU, these were considered to have less impact on low income groups[14] and so were not included in the scope of the analysis.

3.4 Tariffs for trade with the EU

The tariffs applied in the No Deal scenario are based on the assumption that trade between the UK and EU reverts to the WTO Most Favoured Nation (MFN) tariffs. Dhingra et al (2017)[15] have calculated average trade-weighted MFN tariffs at a broad sector level that is consistent with the sector classification used in E3ME. These tariffs are used as assumptions in the No Deal scenario, as shown in Figure 3.1.

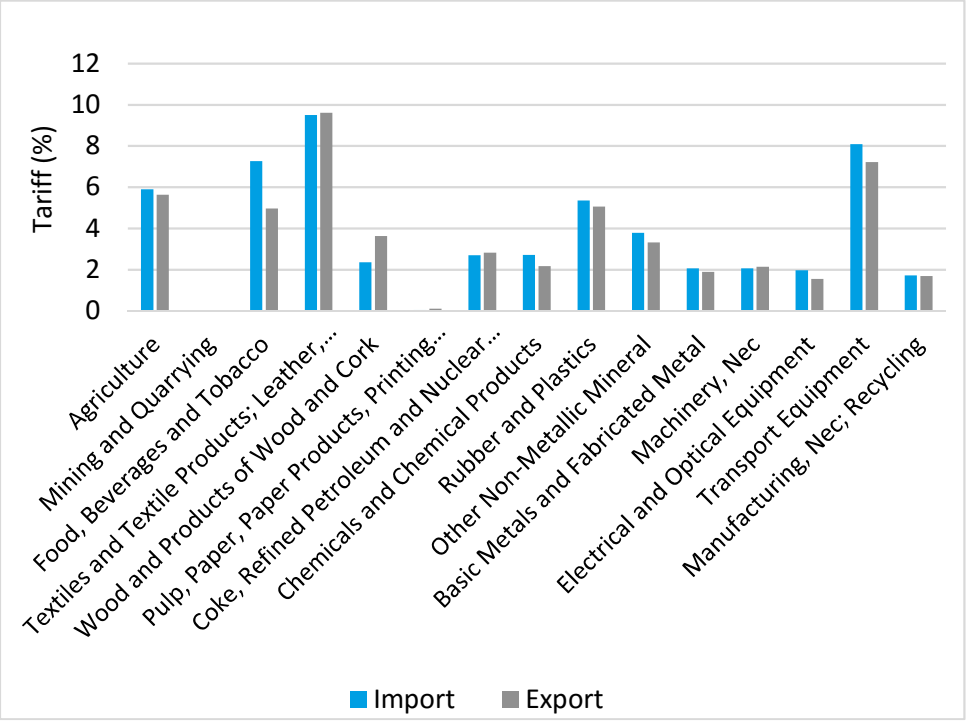
[12] Minford et al (2016) argue that a Brexit scenario with unilateral trade liberalisation would lead to a net increase in GDP, compared to a baseline where the UK remains in the EU.

[13] The EFTA includes Iceland, Norway and Switzerland. In addition, the EU has FTAs with Mexico, Colombia, Canada, South Korea, Singapore, Ukraine and Turkey. Trade with these countries accounts for around 10% of total UK trade.

[14] One such policy is the EU ETS. Retraction from the EU ETS could affect the price of electricity (which is another important component of expenditure for low-income groups), but the UK already has a more stringent carbon pricing policy for the power sector than that which is applied at EU level, opting to impose a carbon-price floor on electricity generators. Therefore, even if the UK left the EU ETS, this is unlikely to have a large impact on UK electricity costs.

[15] Dhingra et al (2017), 'The Costs and Benefits of Leaving the EU: Trade Effects'.

Figure 3.1 Tariffs applied to trade in goods between the UK and EU in the No Deal scenario (presented as a percentage change in prices of trade with the EU)



Source: Dhingra et al (2017), 'The Costs and Benefits of Leaving the EU: Trade Effects'.

In all scenarios except for the 'No Deal' scenario, we assume that the UK and the EU reach a free trade agreement, with no tariffs applied to the trade in goods between the two regions. The only exception to this is in the food and agriculture sectors where, in line with current EU trade policy with the respective nations, there are some tariffs applied, despite FTAs in place for trade of all other goods. We assume tariffs on food and agricultural products are one third of the MFN tariff rate in the Norway scenario, and two thirds of MFN tariff rate in the Ukraine and Canada scenarios.

3.5 Non-tariff barriers to trade with the EU

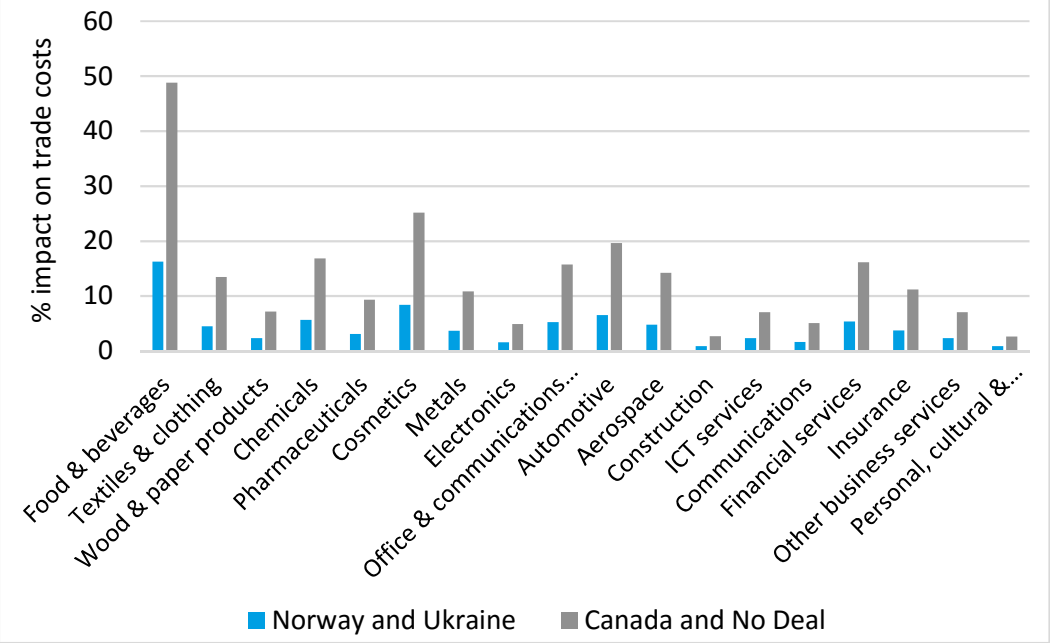
In all scenarios except for the no-Brexit baseline, there is an increase in non-tariff barriers to reflect factors such as rules of origin checks, border controls and regulatory divergence. These non-tariff barriers increase the cost of trade with the EU and are therefore an important assumption and key driver of the price effects in the modelled scenarios.

The literature on the impact of non-tariff barriers on trade costs is limited. Cadot and Gourdon (2015) find that, across the product lines they considered, non-tariff measures increased trade costs by an average of 8.8 percentage points, but that trade agreements with deep-integration clauses, recognition and harmonization of standards can substantially reduce these costs. Our assumptions for EU-UK non-tariff barriers are taken from Dhingra et al (2017), and Ries et al (2017) where it is assumed that, under a FTA with the EU, EU-UK non-tariff barriers would rise to one quarter of the EU-US non-tariff barriers. If no deal was agreed and EU-UK trade took place under WTO rules, the increase in non-tariff barriers is assumed to be three quarters of EU-US non-tariff barriers. The assumptions in these studies, in turn, rely on estimates

of the scale of EU-US non-tariff barriers from Berden et al (2009)[16]. Ries et al (2017)[17] use bilateral trade data to show that one-quarter vs three-quarter assumption proves to be a good approximation of the non-tariff barrier costs between the EU and trade partners.

The immediate non-tariff barriers that are applied in each scenario are shown in Figure 3.2.

Figure 3.2 Immediate non-tariff barriers applied in each scenario (presented as a percentage change in prices of imports from the EU)



Source: CE calculations based on Dhingra et al (2017) and Berden et al (2009).

In Ries et al (2017), as well as an immediate increase in non-tariff barriers (reflecting increased trade friction and border controls), there is assumed to be a gradual increase in non-tariff barriers over time to reflect growing regulatory divergence. We use a similar approach to take account of this effect[18]:

- in the Norway, Turkey and Ukraine scenarios, we apply a 0.06% pa increase in non-tariff barriers for trade in goods and services over the period to 2030
- in the Canada and No Deal scenarios, we apply a 0.08% pa increase in non-tariff barriers for trade in goods and services over the period to 2030

[16] Berden K. G., Francois J., Thelle M., Wymenga P. and S. Tamminen (2009). Non-Tariff Measures in EU-US Trade and Investment – An Economic Analysis (Annexes). See http://trade.ec.europa.eu/doclib/docs/2009/december/tradoc_145614.pdf

[17] Ries et al (2017), 'Alternate forms of Brexit and their implications for the United Kingdom, the European Union and the United States'

[18] The estimates for the impact of regulatory divergence (0.06%pa and 0.08% pa depending on the closeness of the trading relationship between the UK and the EU) are based on the parameters from an econometric estimation by Ries et al (2017), which reflects how non-tariff costs evolve within the EU or an FTA compared to under WTO rules.

3.6 Independent trade policy

In addition to the assumptions for tariff and non-tariff barriers to trade between the UK and the EU, in the Norway, Ukraine, Canada and No Deal scenarios the UK is assumed to have an independent trade policy with other nations. There is considerable uncertainty about whether new preferential trade agreements could be negotiated with other nations in the medium term. We test a trade liberalisation sensitivity in which the UK eliminates all import tariffs and negotiates free trade deals with the US and China.

Around 10% of UK trade is with countries that have an EU Free Trade Agreement[19]. In our central scenario, we assume that these FTAs are carried over to the UK. We also test a more pessimistic case on the No Deal scenario, in which we assume that these trade agreements are not automatically inherited by the UK when it leaves the EU and that trade between these countries and the UK instead reverts to WTO rules.

3.7 Agricultural subsidies

The Government has historically been a strong critic of the Common Agricultural Policy (CAP) and in all the scenarios (apart from the baseline) we assume that the UK will leave the CAP. To model the impacts of leaving the CAP we take account of:

- changes to the structure of tariffs on agricultural products (including a reduction in extra-EU tariffs in the Norway, Ukraine, Canada and No Deal scenarios)
- changes to the level of support available to farmers

The Government has committed to maintaining direct payments until the end of this Parliament (expected to be to 2022) and has indicated that it is unlikely to move to a new system of farm support before 2025. It has indicated that, after a transition period, direct payments will be replaced with a system of public money for public goods.[20]

We therefore keep the level of support available to farmers fixed in *nominal* terms over the period to 2025 to represent the Government's current position[21].

Our assumptions about agricultural policy post-2025 are based on scenarios drawn from NFU (2016)[22] and AHDB (2017)[23]. We assume no change to the Pillar II (rural development) payments, but a gradual reduction in Pillar I payments, reaching a 5% reduction by 2030 (roughly equivalent to a €600m reduction annually compared to the baseline).

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[19] According to the 2017 edition of the ONS Pink Book, around 5% of UK trade was with the EFTA countries (Iceland, Norway and Switzerland) and another 5% of trade was with other countries with which the EU has a FTA (Mexico, Colombia, Canada, South Korea, Singapore, Ukraine and Turkey).

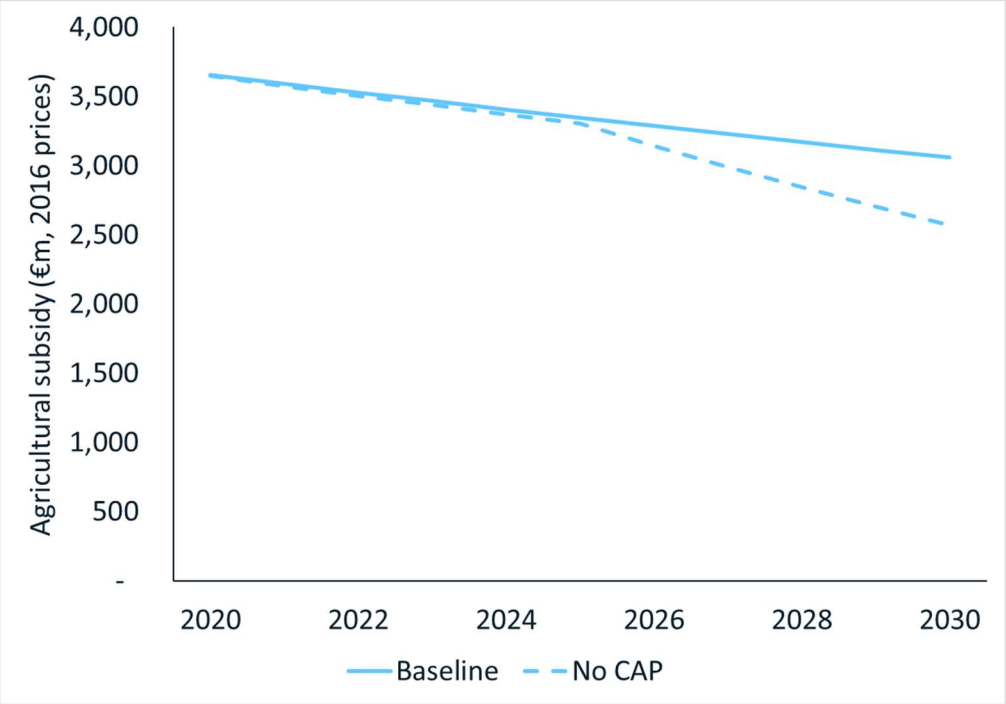
[20] House of Commons Library (2018), 'Brexit: UK agriculture policy' http://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-8218

[21] Note that, even in the Baseline where the UK stays in the EU, Pillar I and Pillar II payments are expected to fall in *real* terms, see: https://ec.europa.eu/agriculture/sites/agriculture/files/cap-funding/budget/mff-2014-2020/mff-figures-and-cap_en.pdf

[22] NFU (2016), Implications of a UK exit from the EU for British agriculture - Study for the National Farmers' Union

[23] AHDB (2017), Brexit Scenarios: an impact assessment

Figure 3.3 The assumed scale of reduction in agricultural subsidies in the baseline scenario and Brexit scenarios



3.8 Investment

There has been limited discussion in the literature directly addressing the potential impact of Brexit on investment. Most of the discussion has centred on the impacts on inward foreign direct investment (FDI) and finds that it would be lower in any scenario compared to the baseline of the UK remaining in the EU. Ebell and Warren (2016) is the only study that explored *quantitatively* different scenarios with respect to all business investment (but their result is still derived from an FDI impact). Based on the results of the Ebell and Warren study, we assume that investment in 2030 is lower than the baseline by 1.5% in the Norway scenario, by 2.6% in the Turkey and Ukraine scenarios, and by 3.5% in the Canada and No Deal scenarios.

Note that the scale of the reduction in investment is considered to be a conservative assumption, as it does not capture potential falls in investment due to increased uncertainty and reduced business confidence.

3.9 Migration

Assumptions about migration in each scenario

Our migration assumptions are based on ONS population projections.

In the baseline and Norway scenarios, there is free movement of labour and we assume annual net international migration of 245,000 per year. This figure is similar to recent migration figures (net migration to the UK was 246,000 in 2016-2017).

In the other Brexit scenarios, where it is assumed that there are tighter immigration controls, net migration is assumed to fall to 165,000 per year from

2021 (in line with the 'principal' ONS scenario)[24]. As a result, the UK population is around 900,000 lower by 2030 in the Brexit scenarios compared to the baseline and Norway scenarios. We use recent data on the shares of migrants by age group to infer the impact on the working-age population.

Impacts on wages

To capture the effect of lower immigration on wages for low-skilled workers in the Ukraine, Turkey, Canada and No Deal scenarios (where freedom of movement is restricted), we combine estimates of the impacts of migration on wages from Nickell and Saleheen (2015)[25] with our assumptions about the level of immigration in each scenario.

3.10 Other assumptions

Government spending

We assume no change in government spending between scenarios. Despite higher government revenues from import tariffs in the No Deal scenario, income tax receipts and VAT revenues fall considerably due to reductions in economic activity and a smaller population. In aggregate, tax receipts from VAT, income tax, social security payments and import tariffs are £13bn (2.3%) lower in the No Deal scenario than in the baseline. This figure does not take account of the loss of cohesion funding from EU or the change in net contributions to the EU budget[26].

Exchange rates

We do not assume any change in the sterling exchange rate in the Brexit scenarios. We therefore implicitly assume that the financial sector has already factored in the economic consequences of the Brexit deal that is ultimately negotiated, when trading in currency markets. It is noted that, if there were a disorderly Brexit, there could be an exchange rate shock that would put further upward pressure on consumer prices.

[24] The principal scenario reflects the latest projections from the ONS, taking into account the impact of Brexit. See: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections

[25] Nickell and Saleheen (2015) 'The impact of immigration on occupational wages: evidence from Britain'.

[26] Analysis by the ONS, shows that the UK's net contribution to the EU budget was £8.1bn in 2016. See: ONS (2017), 'The UK contribution to the EU budget'. Available online at: https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/articles/theukcontributiontotheeubudget/2017-10-31

4 Model results

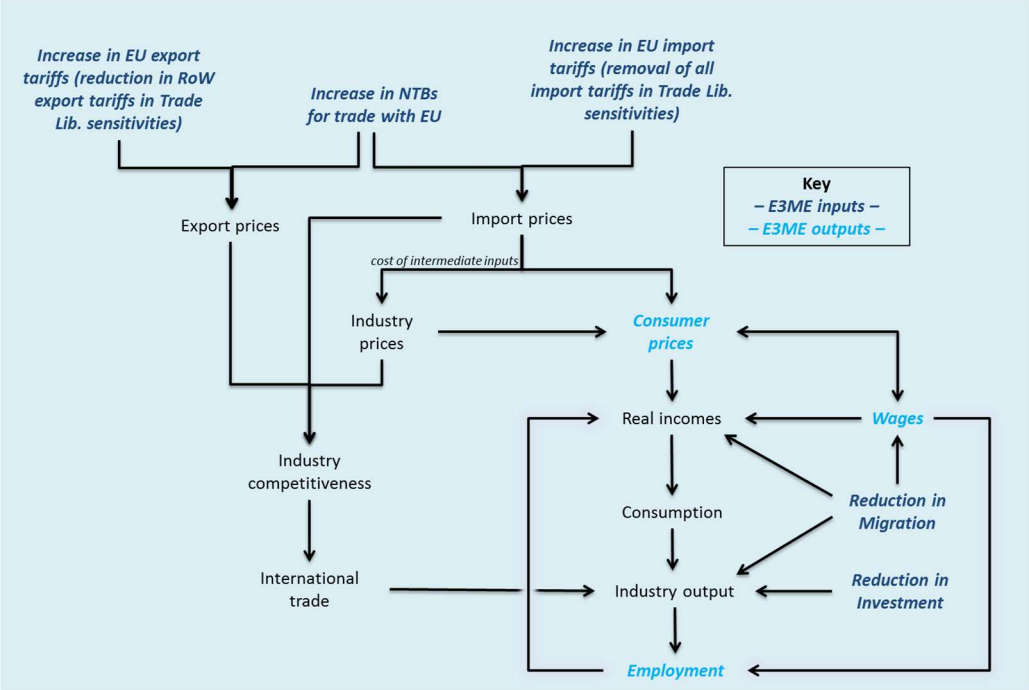
4.1 Feedbacks and interactions captured in E3ME

As described in the previous chapter, the net the socio-economic impact of each Brexit scenario, as modelled in E3ME, is determined by four key drivers:

- changes to export prices (reflecting the change to tariff and non-tariff barriers on exports)
- changes to import prices (reflecting the change to tariff and non-tariff barriers on imports)
- changes to investment (reflecting reduced foreign direct investment, as firms based in the UK have reduced access to EU markets)
- changes to migration (reflecting restrictions to the freedom of movement of people)

Figure 4.1 below shows how these drivers interact with other variables in the model to ultimately affect prices, wages and employment. The interactions and feedbacks between these variables in E3ME are described in more detail below.

Figure 4.1 Key interactions and feedbacks in E3ME



Export prices

An increase in export tariffs (in the No Deal scenario) and an increase in non-tariff barriers (in all of the Brexit scenarios) reduces the competitiveness of UK industry, leading to a reduction in exports and a reduction in industry output, particularly in the most price-competitive sectors. In the trade liberalisation sensitivities, a reduction in export tariffs for trade with the US and China leads to an increase in trade with these countries.

Import prices

An increase in import tariffs (in the No Deal scenario) and non-tariffs barriers (in all of the Brexit scenarios) drives an increase in import prices, which has a

direct impact on industry competitiveness, with some manufacturing sectors benefitting from the more protectionist measures. However, the longer-term effect includes the impact of higher prices of imports on the costs of intermediate inputs in industry supply chains, ultimately leading to increases in industry prices. The extent of this increase is dependent on the estimated cost pass-through rates in each sector and the import-intensity of each sector's supply chain. The higher industry prices drive an increase in prices for consumers, although the impact on consumer prices is dampened by the role that (non ad valorem) taxes and retail and distribution margins play.

Higher consumer prices lead to a reduction in real incomes and consumption, with this reduction in demand eventually driving a reduction in industry output and employment.

Investment

Reduced investment in the Brexit scenarios reflects a relocation of manufacturing activities to outside of the UK, where there is more unrestricted access to EU markets. The reduced investment leads to a reduction in industry output and employment, as the productive capacity of the economy is reduced.

Migration

The impacts of migration on output in the economy depends on the extent to which non-economically active people are willing, capable and suitably qualified to fill the jobs that the migrant workforce would otherwise fill. This potential substitution effect (where economically inactive British workers take jobs that would otherwise be filled by migrants) is not included in our central scenario assumptions. One of the reasons for assuming no substitution effect is that the unemployment rate in the UK is already low (4.2% in May 2018), so many of those left in unemployment are likely to be those that are hardest to place in jobs. It is likely that, in many cases, the skill set of unemployed or inactive British workers are not a suitable substitute for the migrant workforce. Furthermore, migrants are twice as geographically-mobile as British workers and tend to enter tight labour markets

Therefore, by design, we assume that the productive capacity of the workforce falls in line with the reduction in the size of the working age population due to reduced immigration. We do not assume that the reduction in immigration creates job vacancies that are then filled by the otherwise unemployed or inactive workforce. This assumption is consistent with the finding that high net immigration in the past two decades did not lead to any significant increase in unemployment[27].

The impacts of migration on nominal wages are taken from a study by Nickell and Saleheen (2015)[28], which shows that the reduced migration is likely to have a small positive impact on wages in most occupations. The increase in prices also leads to a positive impact on nominal wages, due to wage bargaining effects.

The net impact on *real* wages depends on the scale of the increase in nominal wages relative to the scale of the increase in prices. Real incomes are also affected by changes in the employment rate.

[27] See: Lemos and Portes (2008), Jean and Jimenez (2010), Lucchino, Rosazza-Bondibene and Portes (2012)

[28] Nickell and Saleheen (2015) 'The impact of immigration on occupational wages: evidence from Britain'

4.2 Impacts on consumer prices

The impacts on consumer prices (by category) are determined by:

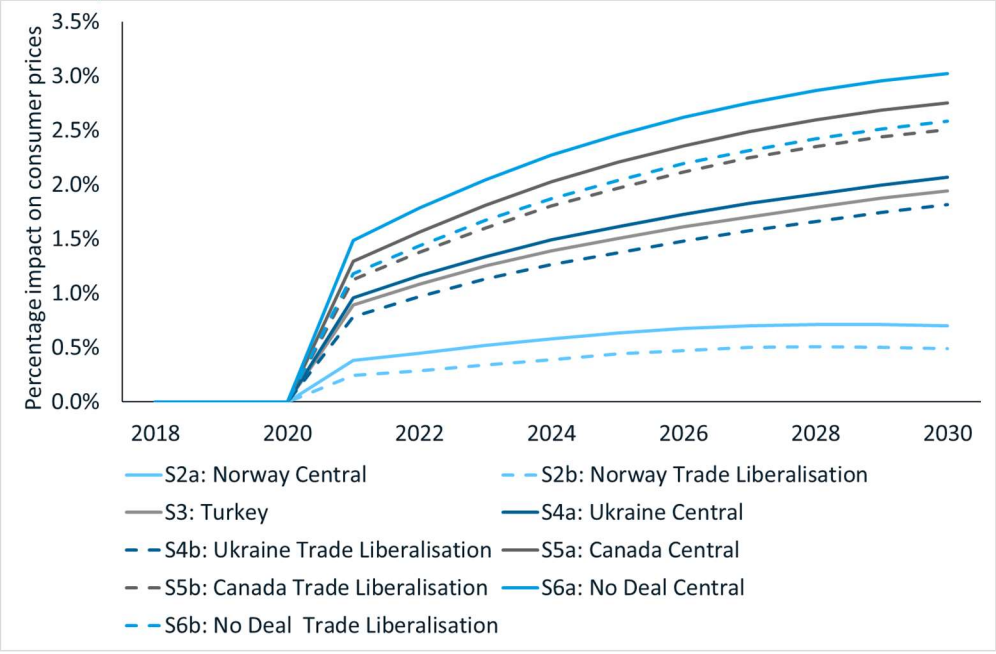
- the scale of the increase in the level of tariff and non-tariff barriers (which are equivalised to price effects)
- the share of imports relative to domestic production in domestic consumption
- the import intensity in each sector's supply chain
- cost pass-through rates in each sector
- the influence of import prices on domestic prices in each sector
- the level of tax and retail and distribution margins for each consumer good

Our results show that consumer prices increase by up to 3% in the No Deal scenario as a result of the increase in tariff and non-tariff barriers.

Some studies[29] have argued that the effect of Brexit on prices could be reduced by the implementation of unilateral trade liberalisation. Our analysis shows that this policy would have a limited impact on prices, as a large part of the price impacts are driven by non-tariff barriers and trade frictions (such as border controls and regulatory divergence). In the trade liberalisation sensitivity that was tested on the No Deal scenario, there is still an increase of around 2.5% in the consumer price level due to non-tariff barriers.

In the other scenarios we assume that FTAs are agreed with the EU and so, in the central scenarios, the increase in prices in these cases primarily reflects the impact of non-tariff barriers.

Figure 4.2 Impacts of selected scenarios on consumer prices (% difference from baseline)



Source: E3ME

The price impacts are largest for food, where prices in the No Deal scenario increase by over 8%, due to high tariffs for trade with the EU (due to the

[29] Economists for Brexit (2016), 'The Economy After Brexit'

Common Agricultural Policy) and high non-tariff barriers for trade with the EU (reflecting the cost of divergence in food standards).

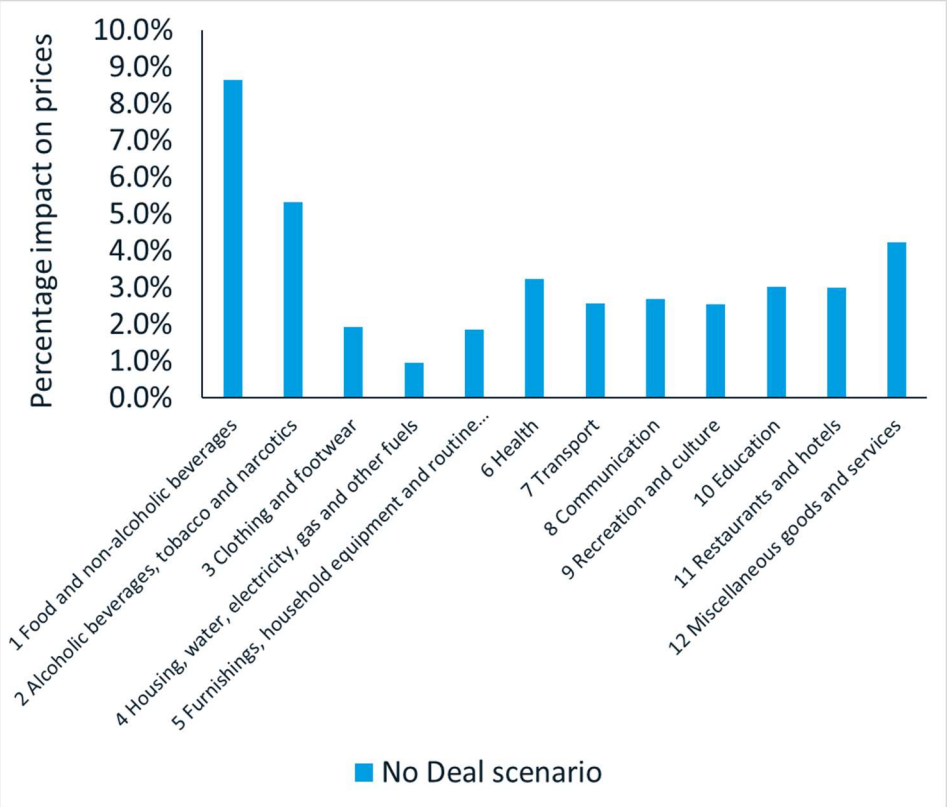
Prices of clothing and footwear increase by around 2% in the No Deal scenario. Even though a high share of clothing and textiles are imported, the overall impact on prices of clothing and footwear are dampened by high retail margins (which are assumed not to rise).

Housing and fuel costs are an important component of expenditure for low income groups (accounting for a quarter of total spending for the bottom income decile). These items are less affected by the changes in trade costs: prices of these commodities increase only by around 1% in the No Deal scenario[30].

In the No Deal scenario, there is a 6.8% increase in the price of vehicles, due to the high share of vehicle imports and the relatively high MFN tariff rate applied. The overall impact on transport prices faced by consumers is much lower, however, as transport services are not a traded sector and so are less affected by the increase in trade costs.

Modest increases in the prices of services are driven by increased costs of intermediate inputs in their supply chains.

Figure 4.3 Impacts on consumer prices by category in the No Deal scenario in 2030 (% difference from baseline)



Source: E3ME

[30] We do not model the impacts of Brexit on the housing market and the consequential impact on the cost of rent as a number of studies show that interest rates are a more important driver of house prices than supply and demand interactions.

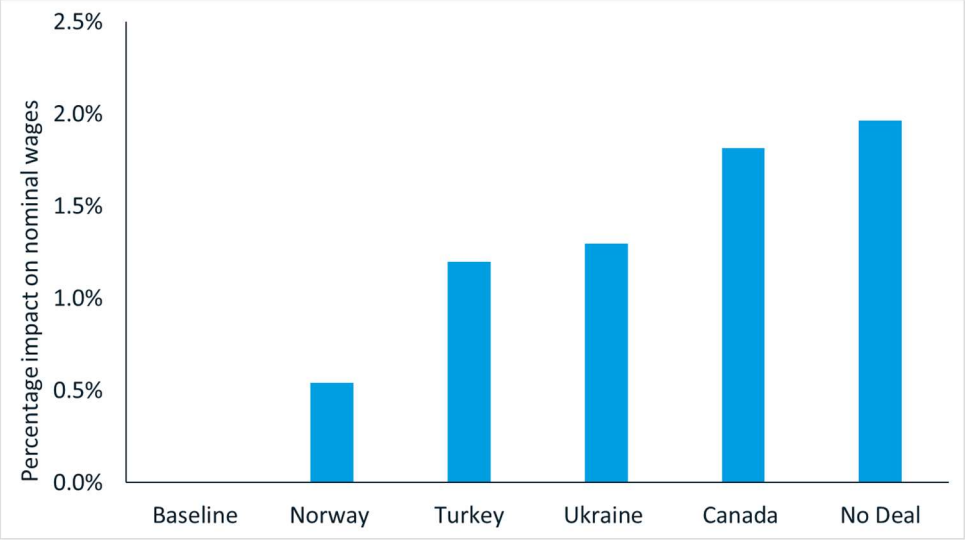
4.3 Impacts on wages

The key drivers of the impacts of Brexit on wages are: (i) migration effects and (ii) price effects.

Our assumption for the impact of migration on nominal wages is based on Nickell and Saleheen (2015)[31], who estimate the impact of changes in the share of migrants on wages at an occupational level. For most of the low-wage occupations there is a small negative relationship between migration and wages. As a result, the reduction in migration, when taken in isolation, has a small positive impact on nominal wages (of around 0.2%).

In addition to the migration impacts, the wage equations in E3ME also capture the effect of wage bargaining effects (as prices rise, workers demand higher pay) and this further pushes up nominal wages in the Brexit scenarios (as shown in Figure 4.4 below).

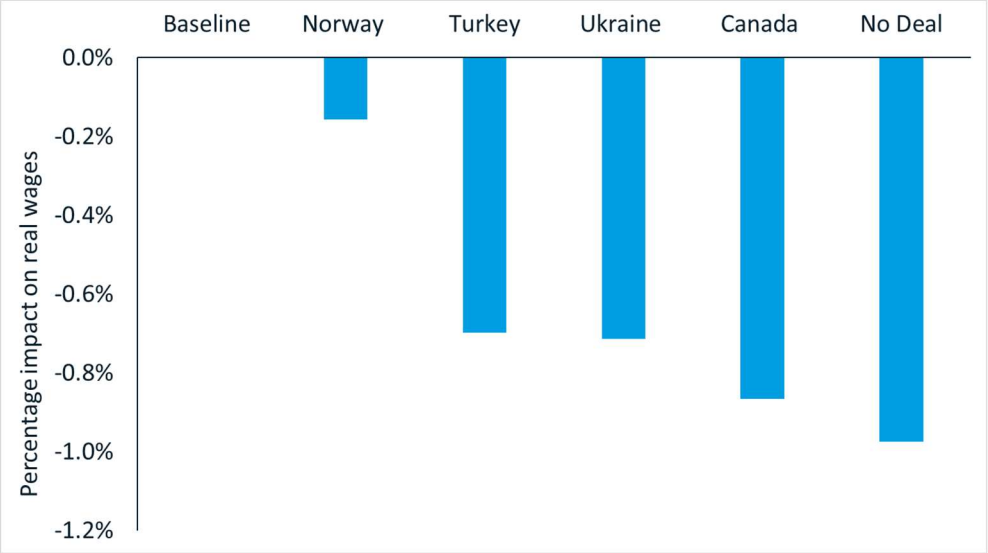
Figure 4.4 Impact on nominal wages in each scenario by 2030 (% difference from baseline)



Over the period we are considering, however, the migration and wage bargaining effects are not large enough to counter the overall increase in the price level and so there is a reduction in real wages in the Brexit scenarios, as shown in Figure 4.5 below. By 2030, real wages are estimated to be 0.2% lower than baseline in the Norway scenario and 1.0% lower than baseline in the No Deal scenario. Real wages in the (low-paid) caring and elementary occupations fall by slightly less, in percentage terms, than the UK average. Real wages in these occupations are around 0.6% lower by 2030 in the No Deal scenario (as shown in Figure 4.6).

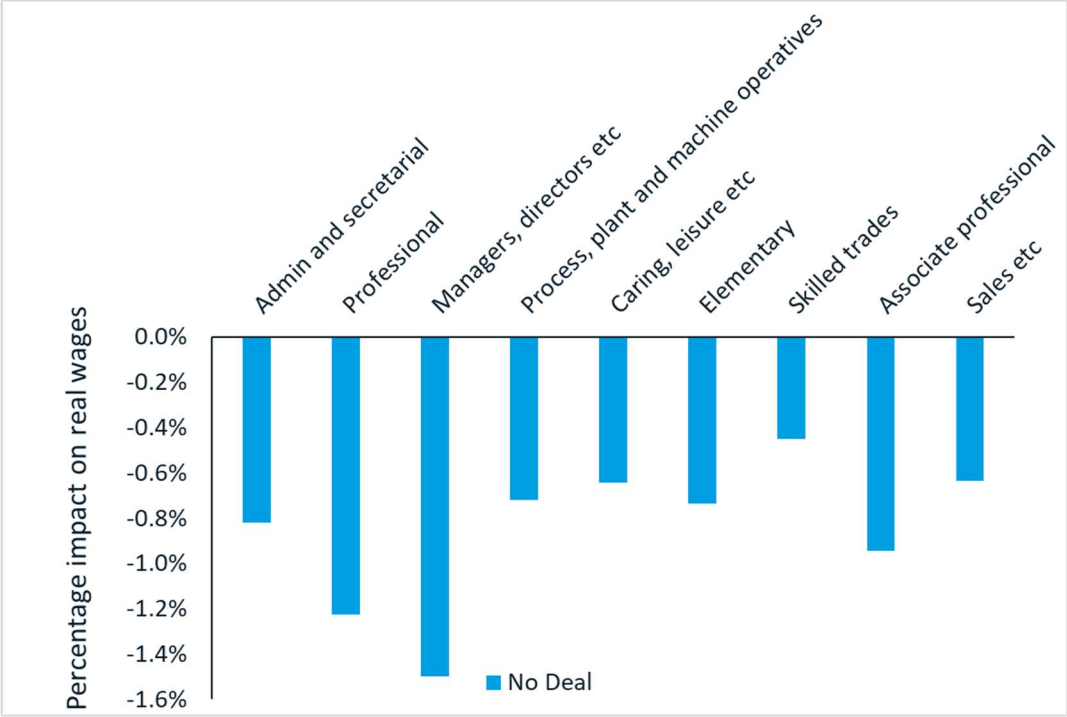
[31] Nickell and Saleheen (2015) 'The impact of immigration on occupational wages: evidence from Britain'

Figure 4.5 Impact on real wages in 2030 (% difference from baseline)



Source: E3ME

Figure 4.6 Impact on real wages by occupation in the No Deal scenario in 2030 (% difference from baseline)



Source: E3ME

4.4 Impacts on employment

The E3ME results show an overall reduction in employment in the Brexit scenarios. This is predominantly due to a reduction in labour supply because of reduced immigration but reductions in gross output, driven by lower investment and exports, are also contributing factors. The percentage reduction in employment is spread fairly evenly across occupational groups, which each see a 2.5-3% reduction in employment by 2030 in the No Deal scenario (equivalent to around 850,000 jobs in total).

When considering impacts on those living in the UK, the employment rate is a more useful measure. Our modelling is consistent with the findings of several studies[32] that high net migration into the UK did not significantly increase the rate of unemployment and so, in our central scenarios, we assume that lower net migration will not reduce it. It is plausible that a sudden tightening in migration policy would lead to certain skill shortages if the UK working-age population are not readily substitutable for working-age migrants in the UK. However, the impact of migration policy due to particular skill attributes of migrants is out of scope for this analysis.

In addition to the scaling-back of UK production in response to shortages of migrant labour and reduced exports in the Brexit scenarios, reduced levels of investment adversely affect labour productivity which raises unit labour costs. These effects, in combination, lead to an employment rate that is 0.5 pp lower than the baseline by 2030.

4.5 Impacts on low-paid workers

To assess the impact of Brexit on in-work poverty, we calculate the proportion of workers that earn below a certain pay threshold. The low-pay threshold is defined as the proportion of the workforce earning less than 60% of median (baseline) income, which is equivalent to £14,790 in 2030 (in 2017 prices).

Our results show a small increase in the proportion of the workforce on low-pay following Brexit. Using the definition above, in the No Deal scenario the share of low-pay workers increases by 0.6 pp, 0.4 pp and 0.5 pp, respectively in the 'Caring', 'Administrative' and 'Elementary' occupations.

4.6 Decomposition analysis

A decomposition analysis[33] was performed on the No Deal scenario to distinguish the impact of each of the key drivers of the result. Net impacts on prices, employment and wages are decomposed into the respective effects of changes in (i) trade (ii) migration and (iii) investment.

Prices

As shown in Figure 4.7, in the No Deal scenario, the impacts on prices are primarily driven by *trade* effects (which include the effect of higher import tariffs and price-equivalised non-tariff barriers on imports). The results suggest that non-tariff barriers (such as border controls, rules of origin checks, pre-shipment inspections) are a more important driver of the overall increase in price, as EU tariffs are comparatively low. The assumption about non-tariff barriers is therefore crucial to determining the scale of the price effects.

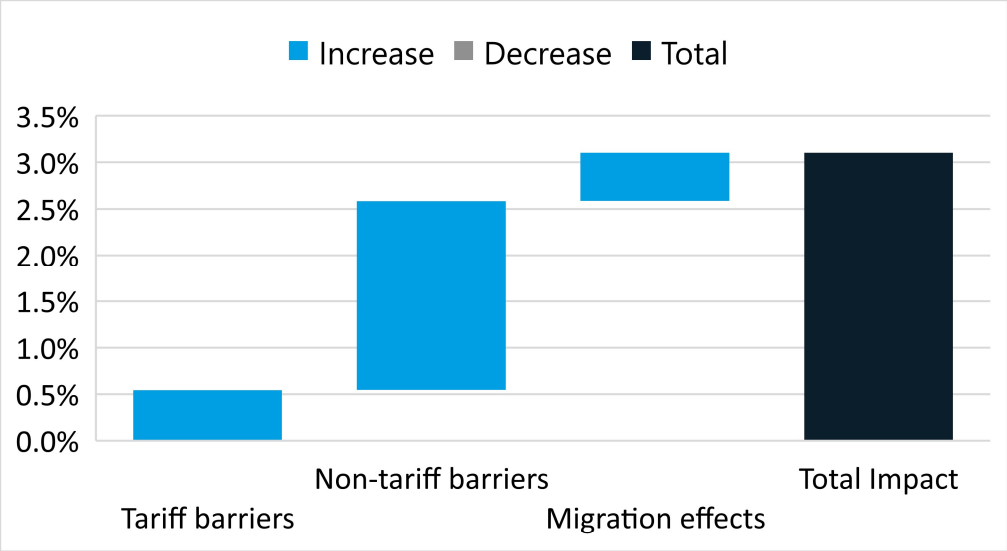
Reduced *migration* also has a small positive impact on prices, due to a reduction in labour productivity as a result of reduced economies of scale and skills shortages.

[32] See: Lemos and Portes (2008), Jean and Jimenez (2010), Lucchino, Rosazza-Bondibene and Portes (2012)

[33] The decomposition analysis is carried out by carrying out separate runs of the model introducing each of the relevant assumptions separately.

Lower *investment* is expected to increase prices in the long run, through its impact on industry productivity. However, the model also picks up an offsetting quality effect (reduced investment reduces the quality of output and therefore reduces prices). Over the period to 2030, the E3ME results suggest that the effect of reduced investment on prices is negligible, even in the No Deal scenario, although the quality of goods manufactured in the UK could be adversely affected.

Figure 4.7 Decomposition of price effects in the No Deal scenario (2030)

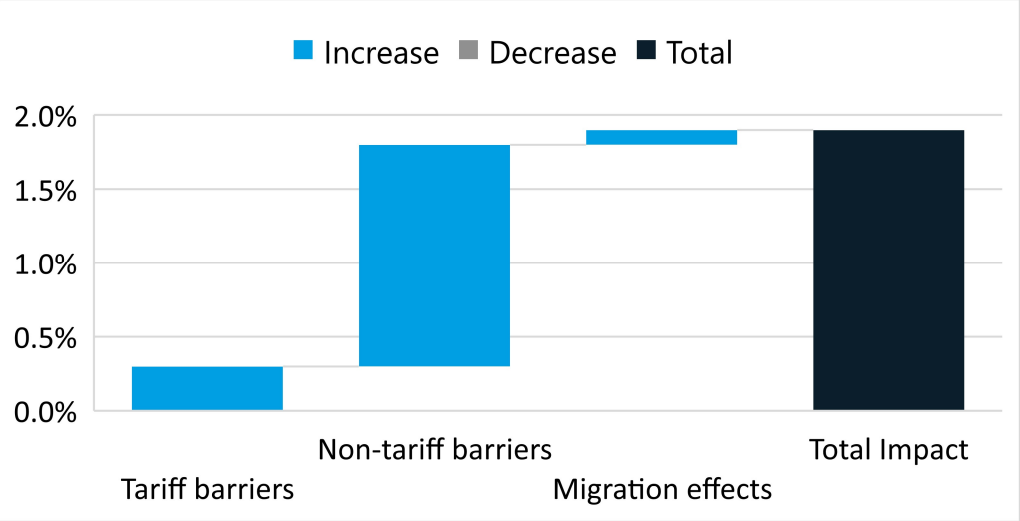


Source: E3ME

Wages

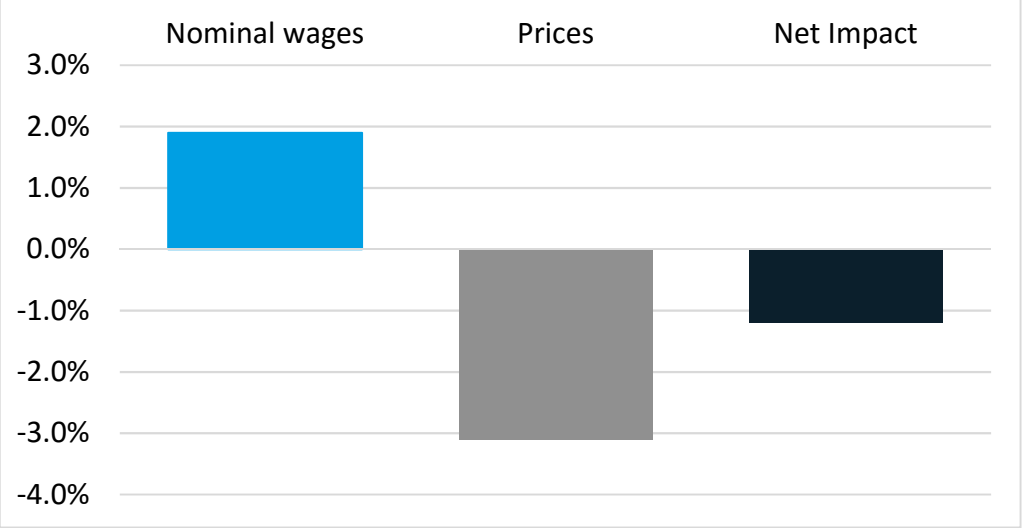
Trade and *migration* effects are also the key drivers of the increase in nominal wages in the No Deal scenario, due to wage-bargaining effects. The reduced migration also has a small positive impact on nominal wages, following the findings from Nickell and Saleheen (2015). However, the overall impact on real wages is negative, as the increase in prices that outweighs the increase in nominal wages (see Figure 4.9).

Figure 4.8 Decomposition of nominal wage effects in the No Deal scenario (2030)



Source: E3ME

Figure 4.9 Decomposition of real wage effects in the No Deal scenario (2030)

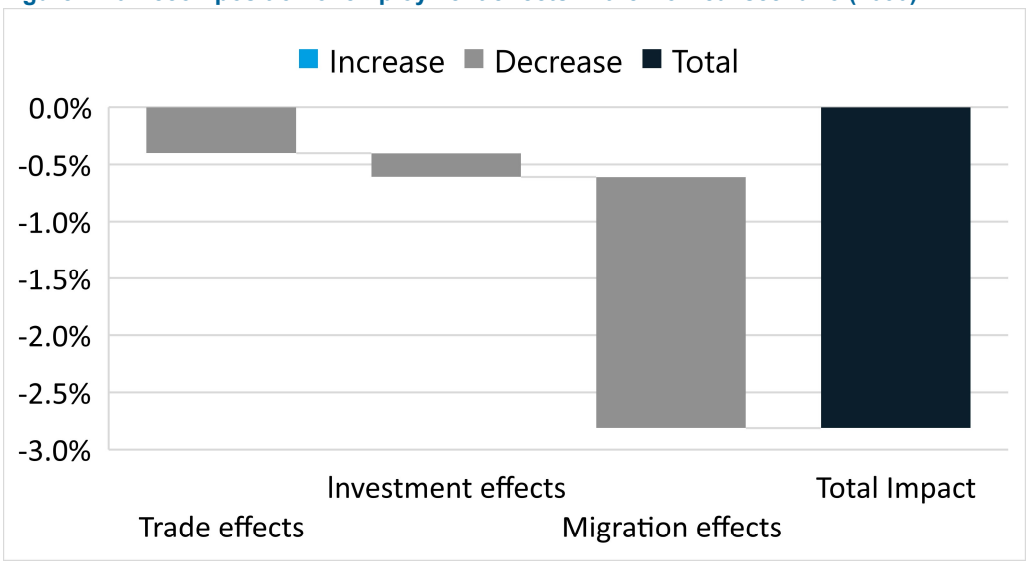


Source: E3ME

Employment

As shown in Figure 4.10, the impact of the No Deal scenario on employment is predominantly driven by the reduction in *migration*, which reduces the size of the workforce and the productive capacity of the UK economy. By assumption, the change in migration does not affect the employment rate for workers in the UK. However, there are small reductions in the employment rate in the No Deal scenario due to *trade* effects (as UK competitiveness and industry output is harmed by the export tariffs imposed in this scenario) and *investment* effects (which reduce the productive efficiency of the economy and reduce output in the long-run).

Figure 4.10 Decomposition of employment effects in the No Deal scenario (2030)



Source: E3ME

5 Comparison with other studies

5.1 Comparison of GDP impacts

Whilst the focus of this study is on impacts of Brexit on low income groups, most other studies of Brexit impacts focus on GDP outcomes. Table 5.1 presents a comparison of the GDP impacts of the scenarios in this report with those of other studies. GDP per capita is perhaps a more appropriate measure to assess the impact of Brexit, given the effect of changes in immigration on the size of the population[34] but, for the purposes of comparison, GDP is instead used, as it is not always clear how the size of the population is affected in the various Brexit scenarios referenced in the literature.

Table 5.1 Comparison with GDP results in the literature (percentage difference from No Brexit baseline)

Study	EEA Scenario	Free Trade Area	WTO Rules
This study	**-0.3**	**-1.7 to -1.9**	**-2.0**
Cambridge Econometrics (GLA)[35]	-1.0	-1.6	-3.0
CPB[36]		-2.0 to -5.9	-2.7 to -8.7
HM Government[37]	-6.2 to -7.5	-4.6 to -7.8	-5.4 to -9.5
IMF[38]	-1.5		-4.5
NIESR[39]	-1.5 to -2.1	-1.9 to -2.3	--2.7 to -3.7
OECD[40]		-2.7 to -7.7	
PWC[41]		-1.2	-3.5
RaboBank[42]	-8.4 to -11	-11.3 to -13.7	-18 to -18.5
RAND[43]			-4.9

Source: Based on the table presented in Cambridge Econometrics (2018), 'Preparing for Brexit'

[34] See Coutts, Gudgin and Buchanan (2018), 'How the Economics Profession got it wrong on Brexit'

[35] Cambridge Econometrics (2018), 'Preparing for Brexit'.

[36] CPB (2016), Brexit Costs for the Netherlands Arise from Reduced Trade. CPB Policy Brief 2016/07

[37] HM Government (2016) 'HM Treasury analysis: the long-term economic impact of EU membership and the alternatives'.

[38] IMF (2016) 'United Kingdom – Selected Issues', IMF Country Report No. 16/169, June 2016

[39] Ebell, M. and J. Warren (2016), The Long-Term Economic Impact of Leaving the EU. *National Institute Economic Review, No. 236*

[40] OECD (2016), The Economic Consequences of Brexit – A Taxing Decision. *OECD Economic Policy Papers.* Note that it is not entirely clear what the OECD assumptions are regarding the Brexit deal that is negotiated, hence it is assumed to fall somewhere in the FTA/WTO models, as also reported in NIESR (2016)

[41] PwC (2016), Leaving the EU: Implications for the UK economy. March 2016.

[42] RaboBank (2017), Assessing the economic impact of Brexit: background report.

[43] RAND (2017), After Brexit. Alternative forms of Brexit and their implications for the United Kingdom, the European Union and the United States. Only 10-year cumulative effects are reported, whereas most other studies tend to use 2030 as the comparison period. Other scenarios are difficult to assess as they are reported as relative to the WTO scenario.

It is immediately evident from the table above that there is a considerable range in the estimates of the economic (GDP) impacts of Brexit.

The E3ME results are at the lower end of the scale when compared to the impacts reported in other Brexit studies and are most similar to those obtained using CBR's UKMOD, which is also a macro-econometric model.

The study by Cambridge Econometrics for the GLA is the only other study that applied the same E3ME model to assess the impacts of Brexit. The scale of the GDP impact in the No Deal scenario is not quite as large as in the equivalent scenario from the GLA study. The present study has smaller impacts because it only includes assumed changes to investment that relate to the possible impact of Brexit on foreign direct investment, whereas the GLA study included estimates of the potential impact of Brexit uncertainties on investment through its impact on business confidence.

The difference in the GDP results obtained using E3ME compared with those using most other models in the studies in Table 5.1 mostly reflect differences in the treatment of international trade and productivity.

E3ME uses trends in historical bilateral trade data to estimate the impact on trade in the UK due to higher trade costs (e.g. due to tariff and non-tariff barriers). Most of the other studies use a gravity approach, where trade between two economies is dependent upon the size of the economies, geographical distance and other costs/barriers to trade between the two. Our approach (based on bilateral trade data for the UK and its main trading partners), typically finds that a given increase in trade costs will result in a less than proportional reduction in trade i.e. a 1% increase in export prices results in less than 1% fall in exports. By comparison, the trade elasticities used in gravity models are typically much larger (and can imply that a 1% increase in trade costs leads to a 5-10% reduction in trade, for example).

Furthermore, many other studies assume that reduced trade with the EU will harm productivity. The evidence of this is inconclusive, with recent evidence suggesting that there is no such link for advanced open economies, such as the UK[44]. We apply a conservative assumption and do not assume any direct hit on productivity from the reduced trade under a Brexit scenario.

It is noted that we implicitly assume a smooth Brexit transition. Our estimates do not take account of the effect of increased uncertainty and reduced business confidence in the case of a more disorderly exit from the EU. For example, we assume a reduction in UK investment due to reduced access to EU markets but assume no further hit to investment from increased business uncertainty. Furthermore, we assume no shock to exchange rates. In practice, if there is a disorderly exit from the EU, there could be a further devaluation of the pound and increased uncertainty could affect business confidence and investment, leading to a more severe GDP impact.

5.2 Comparison of price impacts

The impact of Brexit on prices has been quantified in the following studies:

- Resolution foundation (2017), 'Changing Lanes'

[44]

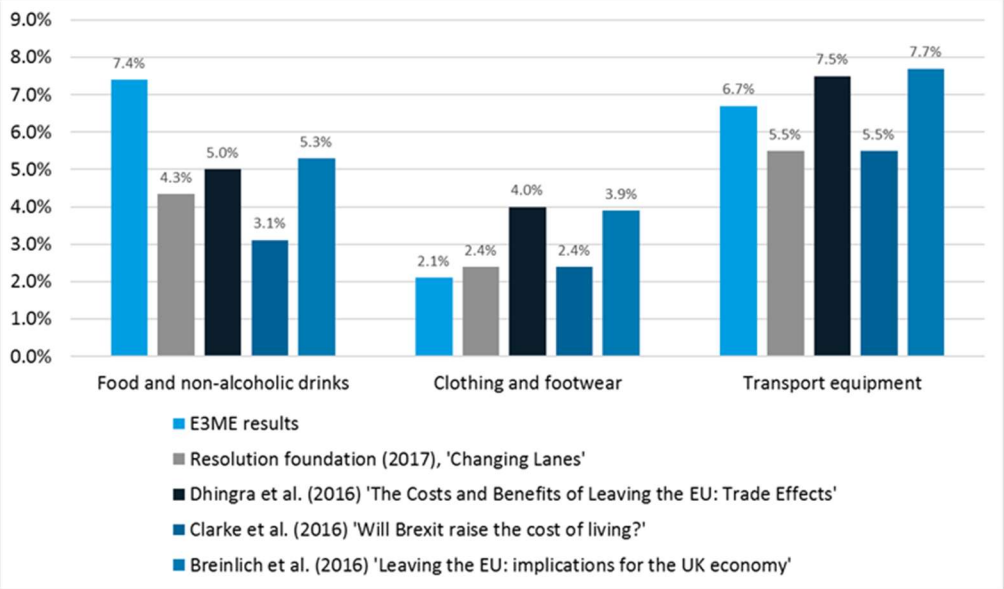
- Dhingra et al. (2016), 'The Costs and Benefits of Leaving the EU: Trade Effects'
- Clarke et al. (2016), 'Will Brexit raise the cost of living?'
- Breinlich et al. (2016), 'Leaving the EU: implications for the UK economy'
- Levell, P. (2018), ‘The Customs Union, tariff reductions and consumer prices’

Figure 5.1 shows a comparison of E3ME results for the price impacts of a No Deal Brexit (where trade with the EU reverts to WTO rules) with key literature. The E3ME results show that a No Deal Brexit scenario would lead to a 7.4% impact on food prices; a 2.1% impact on prices for clothing; and a 6.7% impact on prices of transport equipment. The E3ME results for food prices are slightly higher than in other literature, whereas the impacts on the prices for clothing are slightly lower.

The key reasons for differences in the estimated price impact across studies are due to:

- differences in assumptions about the effect of non-tariff barriers on prices
- differences in assumptions about the degree of import dependency in the supply chain for consumer goods and services
- differences in assumed cost pass-through rates – in E3ME, these are based on the results of econometrically-estimated equations

Figure 5.1 Comparison of price results in the literature for a No Deal scenario (% difference from baseline)



Note: In the Resolution Foundation and Clarke et al studies, an overall impact on food prices was not provided, so this has been calculated by CE, based on the reported price impacts for individual food products and the relative share of expenditure that those food items accounted for in 2017; E3ME results for ‘Transport Equipment; are based on prices of motor vehicles.

6 Conclusions

This study has sought to explore the potential impacts of Brexit for low-income households from a politically-neutral perspective across several archetypal trade arrangements between the UK and EU. Focussing on the largest impacts – in the 'No deal scenario' – the results from E3ME show the following:

- When the UK leaves the EU, higher tariff and non-tariff barriers will drive a 3% increase in the level of average consumer prices years by 2030.
- The estimated average impact on prices for low-income households is equivalent to a £480 increase in the cost living.
- By 2030, real wages for those employed in low-skilled occupations will be around 1% lower than in the baseline.
- The employment rate is estimated to reduce slightly – by 0.5% – due to lower competitiveness, output, and investment for UK business.
- UK GDP would fall by 2.0%, but GDP per capita would fall by less (0.7%) given that the reduction in migration leads to a lower population
- Government tax revenues[45] would fall by 2.3%.

[45] Total tax receipts from VAT, income tax, import tariffs, social security payments and national insurance

Appendices

Appendix A Scenario assumptions

Table A.0.1 Key features of each scenario

Scenario	Tariff assumptions (Central Scenario)	Tariff assumptions (Sensitivity)	Non-tariff barriers (NTB) apply for trade with the EU?	Agricultural subsidy	Migration	Investment
1-Baseline	No change	-	No change	CAP	Net annual migration: 245,000	Baseline
2-Norway	No tariffs for trade with EU (except food and agriculture)	0% import tariffs for trade with EU and RoW; FTAs with US and China	1/4 of US-EU non-tariff barriers	Subsidy maintained in nominal terms to 2025; 5% reduction over period to 2030	Net annual migration: 245,000	1.5% reduction in investment by 2030 relative to baseline
3-Turkey	No tariffs for trade with EU (inside customs union)	-	1/2 of US-EU non-tariff barriers	Subsidy maintained in nominal terms to 2025; 5% reduction over period to 2030	Net annual migration: 165,000	2.6% reduction in investment by 2030 relative to baseline
4-Ukraine	No tariffs for trade with EU (except food and agriculture)	0% import tariffs for trade with EU and RoW; FTAs with US and China	1/2 of US-EU non-tariff barriers	Subsidy maintained in nominal terms to 2025; 5% reduction over period to 2030	Net annual migration: 165,000	2.6% reduction in investment by 2030 relative to baseline
5-Canada	No tariffs for trade with EU (except food and agriculture)	0% import tariffs for trade with EU and RoW; FTAs with US and China	3/4 of US-EU non-tariff barriers	Subsidy maintained in nominal terms to 2025; 5% reduction over period to 2030	Net annual migration: 165,000	3.5% reduction in investment by 2030 relative to baseline
6- No deal	MFN tariffs for trade with EU	0% import tariffs for trade with EU and RoW; FTAs with US and China	3/4 of US-EU non-tariff barriers	Subsidy maintained in nominal terms to 2025; 5% reduction over period to 2030	Net annual migration: 165,000	3.5% reduction in investment by 2030 relative to baseline

Appendix B Technical description of E3ME

6.1 Overview

E3ME is a computer-based model of the world's economic and energy systems and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used in Europe and beyond for policy assessment, for forecasting and for research purposes. The global version of E3ME provides:

- better geographical coverage
- better feedbacks between individual European countries and other world economies
- better treatment of international trade with bilateral trade between regions
- new technology diffusion sub-modules

This model description provides a short summary of the E3ME model. For further details, please read the full model manual available online from www.e3me.com.

6.2 Applications of E3ME

Scenario-based analysis

Although E3ME can be used for forecasting, the model is more commonly used for evaluating the impacts of an input shock through a scenario-based analysis. The shock may be either a change in policy, a change in economic assumptions or another change to a model variable. The analysis can be either forward looking (ex-ante) or evaluating previous developments in an ex-post manner. Scenarios may be used either to assess policy, or to assess sensitivities to key inputs (e.g. international energy prices).

For ex-ante analysis a baseline forecast up to 2050 is required; E3ME is usually calibrated to match a set of projections that are published by the European Commission and the International Energy Agency but alternative projections may be used. The scenarios represent alternative versions of the future based on a different set of inputs. By comparing the outcomes to the baseline (usually in percentage terms), the effects of the change in inputs can be determined.

Price or tax scenarios

Model-based scenario analyses often focus on changes in price because this is easy to quantify and represent in the model structure. Examples include:

- changes in tax rates including direct, indirect, border, energy and environment taxes
- changes in international energy prices

Regulatory impacts

All of the price changes above can be represented in E3ME's framework reasonably well, given the level of disaggregation available. However, it is also possible to assess the effects of regulation, albeit with an assumption about effectiveness and cost. For example, an increase in vehicle fuel-efficiency standards could be assessed in the model with an assumption about how efficient vehicles become, and the cost of these measures. This would be entered into the model as a higher price for cars and a reduction in fuel

consumption (all other things being equal). E3ME could then be used to determine:

- secondary effects, for example on fuel suppliers
- rebound effects[46]
- overall macroeconomic impacts

6.3 Comparison with CGE models and econometric specification

E3ME is often compared to Computable General Equilibrium (CGE) models. In many ways the modelling approaches are similar; they are used to answer similar questions and use similar inputs and outputs. However, underlying this there are important theoretical differences between the modelling approaches.

In a typical CGE framework, optimal behaviour is assumed, output is determined by supply-side constraints and prices adjust fully so that all the available capacity is used. In E3ME the determination of output comes from a post-Keynesian framework and it is possible to have spare capacity. The model is more demand-driven and it is not assumed that prices always adjust to market clearing levels.

The differences have important practical implications, as they mean that in E3ME regulation and other policy may lead to increases in output if they are able to draw upon spare economic capacity. This is described in more detail in the model manual.

The econometric specification of E3ME gives the model a strong empirical grounding. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend. The dynamic specification is important when considering short and medium-term analysis (e.g. up to 2020) and rebound effects[47], which are included as standard in the model's results.

Key strengths of E3ME

In summary the key strengths of E3ME are:

- the close integration of the economy, energy systems and the environment, with two-way linkages between each component
- the detailed sectoral disaggregation in the model's classifications, allowing for the analysis of similarly detailed scenarios
- its global coverage, while still allowing for analysis at the national level for large economies
- the econometric approach, which provides a strong empirical basis for the model and means it is not reliant on some of the restrictive assumptions common to CGE models

[46] In the example, the higher fuel efficiency effectively reduces the cost of motoring. In the long-run this is likely to lead to an increase in demand, meaning some of the initial savings are lost. Barker et al (2009) demonstrate that this can be as high as 50% of the original reduction.
[47] Where an initial increase in efficiency reduces demand, but this is negated in the long run as greater efficiency lowers the relative cost and increases consumption. See Barker et al (2009).

- the econometric specification of the model, making it suitable for short and medium-term assessment, as well as longer-term trends

Limitations of the approach

As with all modelling approaches, E3ME is a simplification of reality and is based on a series of assumptions. Compared to other macroeconomic modelling approaches, the assumptions are relatively non-restrictive as most relationships are determined by the historical data in the model database. This does, however, present its own limitations, for which the model user must be aware:

- The quality of the data used in the modelling is very important. Substantial resources are put into maintaining the E3ME database and filling out gaps in the data. However, particularly in developing countries, there is some uncertainty in results due to the data used.
- Econometric approaches are also sometimes criticised for using the past to explain future trends. In cases where there is large-scale policy change, the 'Lucas Critique' that suggests behaviour might change is also applicable. There is no solution to this argument using any modelling approach (as no one can predict the future) but we must always be aware of the uncertainty in the model results.

The other main limitation to the E3ME approach relates to the dimensions of the model. In general, it is very difficult to go into a level of detail beyond that offered by the model classifications. This means that sub-national analysis is difficult[48] and sub-sectoral analysis is also difficult. Similarly, although usually less relevant, attempting to assess impacts on a monthly or quarterly basis would not be possible.

6.4 E3ME basic structure and data

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

E3ME's historical database covers the period 1970-2014 and the model projects forward annually to 2050. The main data sources for European countries are Eurostat and the IEA, supplemented by the OECD's STAN database and other sources where appropriate. For regions outside Europe, additional sources for data include the UN, OECD, World Bank, IMF, ILO and national statistics. Gaps in the data are estimated using customised software algorithms.

The main dimensions of the model

The main dimensions of E3ME are:

- 59 countries – all major world economies, the EU28 and candidate countries plus other countries' economies grouped

[48] If relevant, it may be possible to apply our E3-India or E3-US (currently under development) models to give state-level analysis.

- 44 or 70 (Europe) industry sectors, based on standard international classifications
- 28 or 43 (Europe) categories of household expenditure
- 22 different users of 12 different fuel types
- 14 types of air-borne emission (where data are available) including the 6 GHG's monitored under the Kyoto Protocol

The countries and sectors covered by the model are listed at the end of this document.

Standard outputs from the model

As a general model of the economy, based on the full structure of the national accounts, E3ME is capable of producing a broad range of economic indicators. In addition there is range of energy and environment indicators. The following list provides a summary of the most common model outputs:

- GDP and the aggregate components of GDP (household expenditure, investment, government expenditure and international trade)
- sectoral output and GVA, prices, trade and competitiveness effects
- international trade by sector, origin and destination
- consumer prices and expenditures
- sectoral employment, unemployment, sectoral wage rates and labour supply
- energy demand, by sector and by fuel, energy prices
- CO_2 emissions by sector and by fuel
- other air-borne emissions
- material demands

This list is by no means exhaustive and the delivered outputs often depend on the requirements of the specific application. In addition to the sectoral dimension mentioned in the list, all indicators are produced at the national and regional level and annually over the period up to 2050.

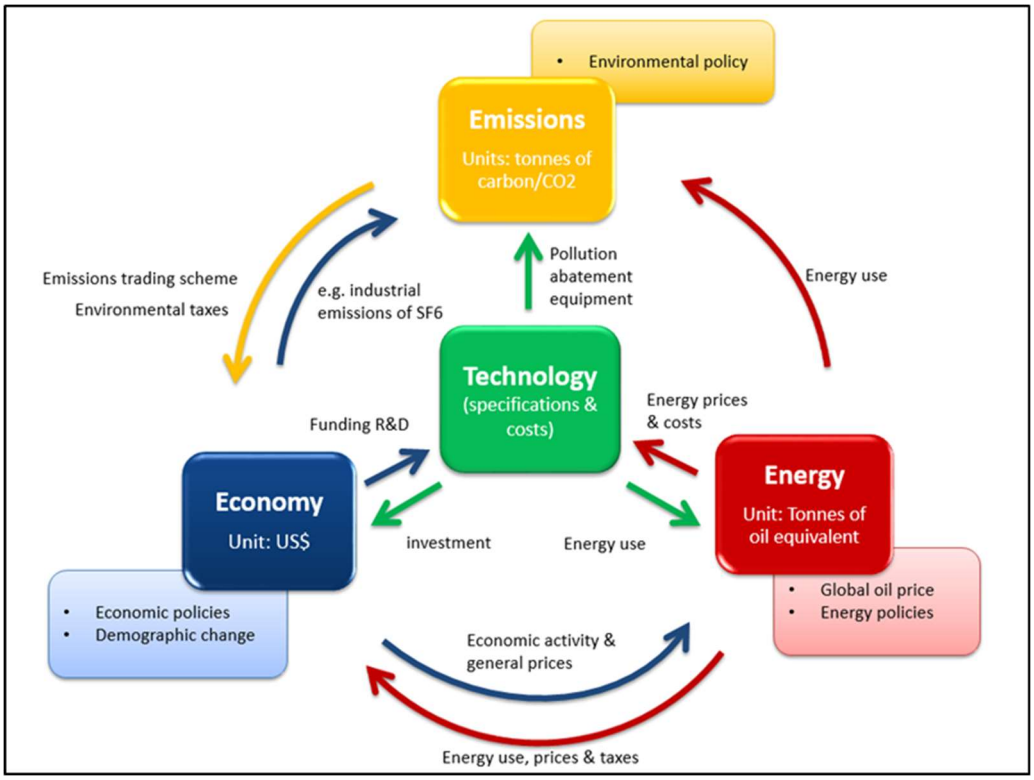
6.5 E3ME as an E3 model

The E3 interactions

Figure B.1 shows how the three components (modules) of the model - energy, environment and economy - fit together. Each component is shown in its own box. Each data set has been constructed by statistical offices to conform with accounting conventions. Exogenous factors coming from outside the modelling framework are shown on the outside edge of the chart as inputs into each component. For each region's economy the exogenous factors are economic policies (including tax rates, growth in government expenditures, interest rates and exchange rates). For the energy system, the outside factors are the world oil prices and energy policy (including regulation of the energy industries). For the environment component, exogenous factors include policies such as reduction in SO2 emissions by means of end-of-pipe filters from large combustion plants. The linkages between the components of the model are shown explicitly by the arrows that indicate which values are transmitted between components.

The economy module provides measures of economic activity and general price levels to the energy module; the energy module provides measures of emissions of the main air pollutants to the environment module, which in turn can give measures of damage to health and buildings. The energy module provides detailed price levels for energy carriers distinguished in the economy module and the overall price of energy as well as energy use in the economy.

Figure B.0.1 E3 linkages in the E3ME model



Treatment of international trade

An important part of the modelling concerns international trade. E3ME solves for detailed bilateral trade between regions (similar to a two-tier Armington model). Trade is modelled in three stages:

- econometric estimation of regions' sectoral import demand
- econometric estimation of regions' bilateral imports from each partner
- forming exports from other regions' import demands

Trade volumes are determined by a combination of economic activity indicators, relative prices and technology.

The labour market

Treatment of the labour market is an area that distinguishes E3ME from other macroeconomic models. E3ME includes econometric equation sets for employment, average working hours, wage rates and participation rates. The first three of these are disaggregated by economic sector while participation rates are disaggregated by gender and five-year age band.

The labour force is determined by multiplying labour market participation rates by population. Unemployment (including both voluntary and involuntary unemployment) is determined by taking the difference between the labour force and employment. This is typically a key variable of interest for policy makers.

The role of technology

Technological progress plays an important role in the E3ME model, affecting all three E's: economy, energy and environment. The model's endogenous technical progress indicators (TPIs), a function of R&D and gross investment, appear in nine of E3ME's econometric equation sets including trade, the labour market and prices. Investment and R&D in new technologies also appears in the E3ME's energy and material demand equations to capture energy/resource savings technologies as well as pollution abatement equipment. In addition, E3ME also captures low carbon technologies in the power sector through the FTT power sector model.[49]

6.6 Main dimensions of the E3ME model

	Regions	Industries (Europe)	Industries (non-Europe)
1	Belgium	Crops, animals, etc	Agriculture etc
2	Denmark	Forestry & logging	Coal
3	Germany	Fishing	Oil & Gas etc
4	Greece	Coal	Other Mining
5	Spain	Oil and Gas	Food, Drink & Tobacco
6	France	Other mining	Textiles, Clothing & Leather
7	Ireland	Food, drink & tobacco	Wood & Paper
8	Italy	Textiles & leather	Printing & Publishing
9	Luxembourg	Wood & wood prods	Manufactured Fuels
10	Netherlands	Paper & paper prods	Pharmaceuticals
11	Austria	Printing & reproduction	Other chemicals
12	Portugal	Coke & ref petroleum	Rubber & Plastics
13	Finland	Other chemicals	Non-Metallic Minerals
14	Sweden	Pharmaceuticals	Basic Metals
15	UK	Rubber & plastic products	Metal Goods
16	Czech Rep.	Non-metallic mineral prods	Mechanical Engineering
17	Estonia	Basic metals	Electronics
18	Cyprus	Fabricated metal prods	Electrical Engineering
19	Latvia	Computers etc	Motor Vehicles
20	Lithuania	Electrical equipment	Other Transport Equipment
21	Hungary	Other machinery/equipment	Other Manufacturing
22	Malta	Motor vehicles	Electricity
23	Poland	Other transport equip	Gas Supply
24	Slovenia	Furniture; other manufacture	Water Supply
25	Slovakia	Machinery repair/installation	Construction
26	Bulgaria	Electricity	Distribution
27	Romania	Gas, steam & air cond.	Retailing
28	Norway	Water, treatment & supply	Hotels & Catering
29	Switzerland	Sewerage & waste	Land Transport etc
30	Iceland	Construction	Water Transport
31	Croatia	Wholesale & retail MV	Air Transport
32	Turkey	Wholesale excl MV	Communications
33	Macedonia	Retail excl MV	Banking & Finance
34	USA	Land transport, pipelines	Insurance

[49] See Mercure (2012).

35	Japan	Water transport	Computing Services
36	Canada	Air transport	Professional Services
37	Australia	Warehousing	Other Business Services
38	New Zealand	Postal & courier activities	Public Administration
39	Russian Fed.	Accommodation & food serv	Education
40	Rest of Annex I	Publishing activities	Health & Social Work
41	China	Motion pic, video, television	Miscellaneous Services
42	India	Telecommunications	Unallocated
43	Mexico	Computer programming etc.	
44	Brazil	Financial services	
45	Argentina	Insurance	
46	Colombia	Aux to financial services	
47	Rest Latin Am.	Real estate	
48	Korea	Imputed rents	
49	Taiwan	Legal, account, consult	
50	Indonesia	Architectural & engineering	
51	Rest of ASEAN	R&D	
52	Rest of OPEC	Advertising	
53	Rest of world	Other professional	
54	Ukraine	Rental & leasing	
55	Saudi Arabia	Employment activities	
56	Nigeria	Travel agency	
57	South Africa	Security & investigation, etc	
58	Rest of Africa	Public admin & defence	
59	Africa OPEC	Education	
60		Human health activities	
61		Residential care	
62		Creative, arts, recreational	
63		Sports activities	
64		Membership orgs	
65		Repair comp. & pers. goods	
66		Other personal serv.	
67		Hholds as employers	
68		Extraterritorial orgs	
69		Unallocated/Dwellings	

Source(s): Cambridge Econometrics.

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