

LONG-RUN GROWTH PROSPECTS FOR THE UK'S REGIONS

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Abstract

The UK faces a number of economic challenges in the short- to medium-term. Renegotiation of trading arrangements with the European Union is the most prominent of these. We build on existing macroeconomic analysis of these challenges by projecting the effects on the UK's regions. The forecasts are generated by combining a global macroeconometric model and a regional computable general equilibrium of the UK. The macroeconomic forecasts show a national average annual GDP growth rate of 1.71% to 2044. When the macroeconomic forecasts are applied across regions growth rates range from 1.64% for Cambridge to 2.17% for Pembrokeshire. Despite such wide variation the standard deviation is low at 0.07% and the coefficient of variation is 0.04%. The country results favour Scotland, which grows at annual rate of 1.78%, whereas Wales is the slowest growing of the countries at 1.70%. Consistent with the macroeconomic analysis international trade is the most important contributor to the regional variation in growth rates.

Keywords: computable general equilibrium, economic growth, trade shocks, regional analysis.

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1. Introduction

The United Kingdom (UK) faces a number of economic challenges in the short- to medium-term. The most prominent of these, given the vote to leave the EU in the referendum of 2016, is the state of future trading arrangements with the European Union (EU) and with other countries. The UK has originally given notice that it would withdraw from the EU in March 2019; this has now been extended to October 2019. The uncertainty around how the future economic and legal relationship with the EU will affect UK trade with the EU has significant potential for economic disruption, as roughly half of all UK trade occurs with EU members. A second important medium-term challenge is the slowdown in productivity growth in the UK over the last two decades and the associated low overall labour productivity growth relative to other high-income countries. A third important challenge is the persistent and significant government budget deficit and corresponding accumulation of government debt that now stands at over 80% of GDP.

These challenges have been analysed by the UK government and others as regards their aggregate effects on the UK economy but there has been little research focussing on how these challenges will affect different regions of the UK. This work focusses on this issue by projecting growth outcomes for UK regions out to 2044. The forecasts are generated by combining two sophisticated analytical frameworks: a global macroeconomic model and a regional computable general equilibrium (CGE) of the UK.

At the macro level we apply NiGEM (National institute's Global Econometric model). NiGEM is a large model of the world economy, which is used for forecasting and scenario analysis. It encompasses discrete models for most OECD economies and regional blocks for the remaining countries in Asia, America, Africa, the Middle East and Europe. The regional sub-models that make up NiGEM depend on both theory and data. There is a common (estimated and calibrated) underlying structure across all economies. The model's long-run equilibrium properties are neoclassical. That is, output is tied down in the long-run by factor inputs and technical progress interacting through production functions. In contrast, the short-term dynamic properties and underlying estimated properties are consistent with data. The model can treat agents as forward looking, as holding rational expectations or applying adaptive learning. The model is flexible in the treatment of different policy environments.

NiGEM is applied to generate a forecast of the UK economy out to 2044. The forecast encompasses all known future changes in economic variables for the UK and other major economies. The forecast also encompasses judgements on the future effects of Brexit and other economic challenges. The forecasts provide a detailed picture of all important macroeconomic

variables on a quarterly basis. These outcomes are converted to annual changes and subsequently applied to a regional model of the UK.

The UK regional model is a dynamic CGE model with long-run properties similar to NiGEM. The short-run behaviour is mainly characterised by the movement from an initial steady-state that is consistent with the latest input-output data, and national and regional accounts. Over time the model slowly moves from the initial steady-state along a balanced growth path to a new steady-state. The model represents 29 industries, 109 regions, 44 investment inputs for each industry, a central and local government sector with detailed government expenditure and revenue accounts. Exports and imports are specified by EU and non-EU destinations and sources. It also includes a detailed representation of the current and capital accounts, accumulation of foreign assets, foreign liabilities, and government debt.

NiGEM and UK-SCGE belong to different classes of model. NiGEM is multi-country macroeconomic macro model whereas UK-SCGE is multi-region, multi-sector CGE model of a single country. Both models are dynamic but their periodicity varies; NiGEM is a quarterly model whereas UK-SCGE is, like most dynamic CGE models, an annual model. The nature of the dynamics also varies. The dynamics of NiGEM are driven by lagged error correction around trend growth rates determined by econometric estimation. The dynamics of UK-SCGE are purely deterministic and are mostly driven by the behaviour of stock-flow relationships. Of these, the capital stock is most important and those for financial assets less so. Applying a forecast from NiGEM to UK-SCGE thus poses challenges in reconciling modelled behaviour that diverges.

The NiGEM results are applied as annual inputs to the regional model. The inputs include the expenditure- and income-side components of GDP, labour productivity, price deflators (import, exports and consumer goods) and the exchange rate. This ensures that at the macro level the two models are consistent in their representation of the path of the aggregate economy. Using the macro inputs from NiGEM, the regional model generates a rich pattern of effects for 109 regions. The effects provide an internally consistent story of changes in regional output. These changes are decomposed to explain how regions are affected differentially by the various long-run trends in the UK economy that are projected by the macro model. Further, the regional results also provide a ranking of growth prospects across the UK regions. This ranking can provide policy makers with a view on where economic policy changes might be focussed to reduce the largest disparities in regional outcomes.

2. The NiGEM model

The NiGEM¹ model represents the world economy. It contains XX countries or regional groupings. Most OECD countries are modelled individually. There is a common underlying structure across all economies. The structure is estimated and calibrated. The model's long-run is neoclassical. Expectations can be characterised as forward looking, rational or adaptive learning. The country models have a comprehensive representation of the demand and supply side, and asset structures. Most behavioural equations are estimated in error-correction form.

Expenditure-side GDP is defined as the familiar national accounts identity $GDP = C + I + G + X - M$. In the short- to medium-run the model is Keynesian and GDP is demand driven. In the long-run GDP is supply-side driven and related to potential output (Y^P)

$$Y_t^P = \gamma \left\{ \left[\beta K_t^{-\rho} + (1-\beta) L_t^{-\rho} \right]^{-1/\rho} \right\}^{(1-\alpha)} M_t^\alpha. \quad (1)$$

Thus, production is represented by CES technology applying capital (K) and effective labour (L) where $\sigma = 1/(1+\rho)$ is the elasticity of substitution between labour and capital. The capital-labour composite is combined with oil (M) by a Cobb-Douglas production function with α as the share parameter for oil. The elasticity of substitution between the labour-capital composite and oil is one. Effective labour equals actual labour (N) adjusted for labour productivity (LP) and the speed of adjustment per period towards the long-run (λ): $Ne^{\lambda LP}$.

The first-order condition for labour defines labour demand as

$$\ln(L_t/Q_t) = \vartheta - \sigma \ln(W_t/P_t) - (1-\sigma)\lambda LP, \quad (2)$$

where Q_t is total primary factor usage, and P_t is the primary factor price index, being a CES aggregate of the rental price of capital R_t and the effective wage rate W_t/P_t .

The first-order condition for capital defines the equilibrium capital-output ratio (K_t/Q_t) as a function of the effective user cost of capital $U_t = (R_t/P_t)$:

$$\ln(K_t/Q_t) = \eta - \sigma \ln U_t. \quad (3)$$

The user cost of capital incorporates corporate taxes, depreciation and risk premia. It is a weighted average of the cost of equity finance and the long real interest rate. The supply of capital evolves as

$$K_t = (1-\delta)K_{t-1} + I_t, \quad (4)$$

¹ National institute's Global Econometric model.

where δ is geometric rate of depreciation. As full capacity utilisation is not assumed, business investment is determined by the relationship between actual and equilibrium capital stocks, which is of error correction form.

Unit total cost is a function of the prices of labour, capital and oil. The wage rate is a function of unit total cost and the unemployment rate, which acts as a proxy for bargaining power for workers. Short-term wage dynamics depend on a weighted average of expected and current inflation.

Capacity utilisation (Y/Y^P) drives producer prices so that full capacity utilisation is achieved over time. Consumer prices are a mark-up on unit total costs and import prices, adjusted for the indirect tax rate.

Consumption follows a dynamic adjustment path around real household disposable income ($RHDI$) and the sum of real housing wealth (RHW) and real financial wealth (RFW):

$$\ln C = \phi + \beta \ln RHDI + (1 - \beta) \ln (RFW + RHW). \quad (5)$$

Each country has a stock of foreign assets and liabilities. These are linked to the stock of domestic financial assets and the stock of domestic private sector and public sector liabilities. A proportion of government debt is owned abroad, as are proportions of the national stock of equities and the stock of banking assets. Some national financial wealth is held in foreign equities and bonds as well as banks. Income flows from asset stocks are allocated in relation to ownership, and hence net property income from abroad depends on income receipts and payments on bonds, equity holdings and bank. Once model and judgement based forecasts for asset prices, exchange rates and interest rates have been made the forecast for wealth follows automatically. The wealth and accumulation system allows for flows of saving into wealth and for revaluations of existing stocks of assets in line with their prices determined as above. When foreign equity and bond prices change, domestically held assets change in value.

The government sector is represented as raising direct and indirect taxes, undertaking consumption spending and making interest payments. A tax rule is imposed that ensures long-run solvency. Government consumption and investment have an exogenous component and an endogenous component. The endogenous component is linked to Y^P . The exogenous component dominates.

Exports are a function of external market size (S) and relative export prices (PX/APX)

$$X = \mu + S + \kappa (PX/APX). \quad (6)$$

where PX represents export prices and APX is the weighted average of competitor export prices. Imports are a function of total final expenditure (TFE) and relative import prices (CP/APM)

$$M = \psi + \nu TFE + \omega(CP/APM), \quad (7)$$

where CP represents consumer prices and APM is the weighted-average of export prices in import source countries.

Long-term interest rates (i_t^L) are related to expected future short-term interest rates (i_t)

$$1 + i_t^L = \prod_{t=1}^T (1 + i_{t+j}). \quad (8)$$

Equity prices (EQP) reflect the net present discounted value of expected profits (PR), including an equity risk premium (RP)

$$EQP_t = \frac{EQP_{t+1}}{1 + i_t} + PR_t(1 + RP_t). \quad (9)$$

Exchange rates (ER) are forward-looking and reflect an uncovered interest parity condition:

$$ER_t = ER_{t+1} + \left(\frac{1 + i_t^*}{1 + i_t} \right) (1 + RP_t), \quad (10)$$

where i_t^* is the short-term interest rate abroad.

Short-term interest rates are determined by monetary policy rules. The standard treatment is to target a combination of inflation and a nominal aggregate:

$$i_t = \nu(\inf_t - \text{inf}t_t) + (1 - \nu)(GDPN_t - GDPNT_t), \quad (11)$$

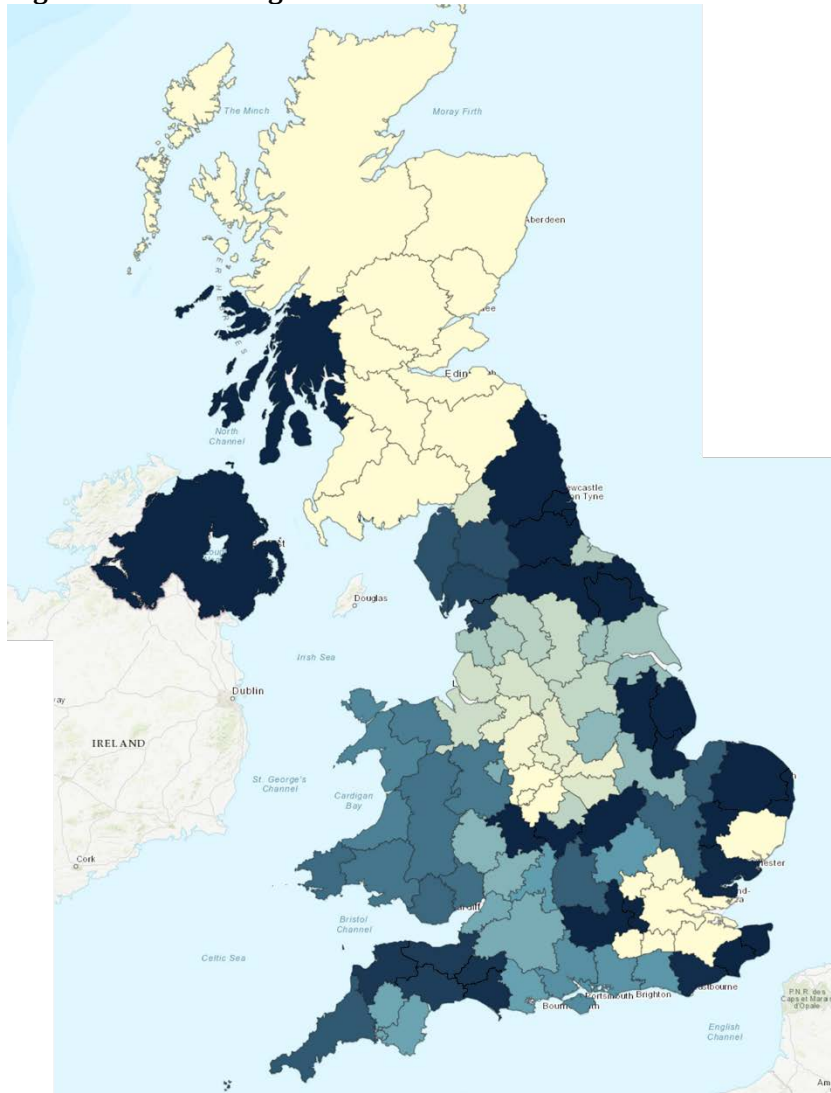
where $\inf_t$ and $\text{inf}t_t$ are actual and target inflation rate, and $GDPN_t$ and $GDPNT_t$ are actual and target nominal GDP.

3. The regional model

UK-SCGE is a spatial computable general equilibrium (CGE) model of the United Kingdom that we apply to determine how the NiGEM forecast is distributed across the UK. The model represents 109 regions of the UK – 86 in England, 9 in Scotland, 13 in Wales and Northern Ireland – as separate economies linked by inter-regional trade flows.² Figure 1 shows a geographic breakdown of the regions.

² The regions are listed in the Appendix.

Figure 1. The 109 regions in UK-SCGE



UK-SCGE is a dynamic model. The baseline simulation is designed to move the economy from an initial steady-state along a balanced growth path to a new steady-state. The policy simulation quantifies deviations of variables from their baseline values caused by the policy shock modelled. The differences in the values of variables in the baseline and policy simulations quantifies the effects of moving the variables of interest away from their baseline values.

UK-SCGE distinguishes 105 sectors and commodities, based on the 2013 input-output (IO) tables published by the ONS (Office of National Statistics, 2016). Primary factors are distinguished by 105 types of capital (one type per industry), 9 occupations and 2 types of land. The national IO table is disaggregated into regional IO tables using a combination of industry shares in employment or labour hours and commodity-specific consumption shares to split industries, investment and government and private consumption across regions.

A representative firm in each sector produces a single commodity. Commodities are distinguished between those destined for export markets and those destined for domestic sales. Some commodities produced for use in the domestic market are further divided into a margin and non-margin component. The margin component of a commodity is used to facilitate the movement and sale of both imported and domestic commodities within the UK, and of the exported commodities to the point of exportation. Margin commodities include such activities as the various modes of transportation, wholesale and retail trade and insurance. The non-margin component is used as a direct input into industry activity, investment and government or private consumption across all regions.

Production technology is represented by nested CES and CRESH functions (Hanoch, 1971) allowing a high degree of flexibility in the parameterisation of substitution and technology parameters. The supply of labour within each region is determined by a labour-leisure trade-off that allows workers in each occupation to respond to changes in after-tax wage rates thus determining the hours of work they offer to the labour market. The overall supply of labour is normalised on working-age population, which typically moves with population.

Household consumption decisions are determined by a linear expenditure system (Stone, 1954) that distinguishes between subsistence (necessity) and discretionary (luxury) consumption.

UK-SCGE has detailed central and local government fiscal accounts, including the accumulation of public assets and liabilities. On the revenue side, detailed modelling of all direct and indirect taxes and income from government enterprises is included. On the expenditure side, government consumption, investment and payments of various types of transfers (such as pensions and unemployment benefits) are modelled.

Investment behaviour is industry specific and is positively related to the rate of return on capital. This rate takes into account company taxation.

Foreign asset and liability accumulation are modelled for each region, as are the cross-border income flows they generate and that contribute to the evolution of the current account. Along with other foreign income flows like labour payments and unrequited transfers, UK-SCGE takes account of primary and secondary income flows in the UK's current account; these are particularly important for the UK as they typically comprise the significant share of the balance on the current account.

3.1 Production technology

Within each region, a representative firm in each sector produces a single commodity.³ Two broad categories of inputs are recognised: intermediate inputs and primary factors. Representative firms choose inputs of primary factors and intermediate inputs to minimise costs subject to a given production technology and given factor and commodity prices. Primary factors include two types of land, nine types of labour (occupations)⁴ and physical capital. Intermediate inputs consist of up to 105 domestically produced goods and services, each with a foreign substitute. Demands for primary factors and intermediate inputs are modelled using nested production functions. The nested production functions have three tiers.

At the top level, industry i 's activity Q_i^{ACT} is determined as a Leontief combination of the intermediate input composite $Q_{\bullet i}^{INT}$ and the primary factor composite $Q_{\bullet i}^{FAC}$:

$$Q_i^{ACT} = \min \left[\frac{Q_{\bullet i}^{INT}}{A_{\bullet i}^{INT}}, \frac{Q_{\bullet i}^{FAC}}{A_{\bullet i}^{FAC}} \right] \quad (12)$$

where the A variables represent unit input requirements.

At the second level of the production nest firms choose the optimal mix of the c individual intermediate inputs Q_{ci}^{INT} using CRESH (constant ratios of elasticities of substitution, homothetic):

$$\sum_c \left[\frac{Q_{ci}^{INT}}{Q_i^{ACT} A_{ci}^{INT}} \right]^{h_c} \frac{X_c}{h_c} = \alpha, \quad 0 < h_{c+f} < 1, X_c > 0, \sum_c X_c = 1, \alpha > 0, \quad (13)$$

where X_c , h_c and α are parameters and the A variables represent unit input requirements. The CRESH formulation is due to Hanoch (1974) and it relaxes the assumption implied by CES functions that the elasticity of substitution between all pairs of inputs must be the same. Thus, the elasticity of substitution between inputs i and j is $\sigma_i \sigma_j / \sum_{k=1}^{105} S_k \sigma_k$ where $\sigma_i = 1/(1-h_i)$ is the CRESH parameter associated with input i and S_k is the input cost share of input k . In the special case when all σ_i have the same value, the CRESH system is equivalent to CES and all substitution elasticities are equal.

At the second level of the production nest, firms also choose the optimal mix of the f individual primary factors Q_{fi}^{FAC} using CES production technologies:

³ All the variables in this section have a region subscript but it has been dropped to reduce notational clutter, that is, the equations in this section are replicated in all regions of UK-SCGE.

⁴ The occupational classification corresponds to 1-digit occupations in ONS (2010).

$$Q_{\cdot i}^{FAC} = \left[\sum_f \chi_f \left(\frac{Q_{fi}^{FAC}}{A_{fi}^{FAC}} \right)^{-\rho} \right]^{-1/\rho}, \quad 0 < \chi_f < 1, \sum_f \chi_f = 1, \rho \geq -1, \rho \neq 0. \quad (14)$$

where χ_f and ρ are parameters and the A variables represent unit input requirements. The CES elasticity of substitution is $\sigma = 1/(1 + \rho)$.

At the third level of the production nest, the composition of each commodity, land and labour are determined, by firms minimising costs subject to the constraints that:

- (i) Each commodity is a CES composite of a domestic and imported variety;
- (ii) Land is a CES composite of primary-production land and non-primary production land;
and
- (iii) Labour is a CES composite of nine skill types (that is, broad occupational categories).

3.2 Zero-pure profits and market-clearing conditions

Within each region, all firms are assumed to operate in competitive markets and thus take their output prices as given. Consistent with this, we impose a zero-pure-profits condition that equates revenues with costs and determines each industry's activity level or output:

$$P_{ir}^{OUT} Q_{ir}^{ACT} = \sum_{c \in COM} P_{cir}^{INT} Q_{cir}^{INT} + \sum_{f \in FAC} P_{fir}^{FAC} Q_{fir}^{FAC}. \quad (15)$$

In (15) the left-hand side is revenue for the i -th industry in region r ; the right-hand side is the sum of intermediate input and primary factor costs for the i -th industry in region r .

Output prices of domestically produced commodities are determined by a market-clearing condition that equates the quantity of each commodity supplied to a region with the total quantity of the commodity demanded by all users within the region. The same type of market clearing condition applies to the imported varieties of each commodity by region of use. The market clearing condition is expressed as:

$$Q_{csd}^{USE} = \sum_{u \in USR} Q_{csud}^{USE}, \quad (16)$$

where Q_{csud}^{USE} is the quantity of commodity c from source s used by user u in region d and Q_{csd}^{USE} is the quantity of commodity c from source s supplied to region d . Q_{csd}^{USE} is a CES composite, across all supplying regions r , of Q_{csrd}^{DEL} , the supply of commodity c from source s produced or landed in region r and delivered to region d .

Note that there is a market-clearing conditions for margins that requires

$$\sum_{p \in REG} Q_{mrpd}^{SUPMAR} = \sum_{\substack{c \in COM \\ s \in SRC}} Q_{csmrd}^{MAR}, \quad m \in MAR, r, d, p \in REG, \quad (17)$$

where Q_{mrdp}^{SUPMAR} is the supply of margin m produced in region p and used to facilitate the trade in goods and services from region r to region d , and Q_{csmrd}^{MAR} is the quantity of margin m used to facilitate the trade in commodity c from source s to destination d .

5. Regional growth prospects

Here we describe the macroeconomic forecasts over the medium term. We then describe the regional outcomes for UK conditional on these forecasts.

5.1 The macroeconomic picture

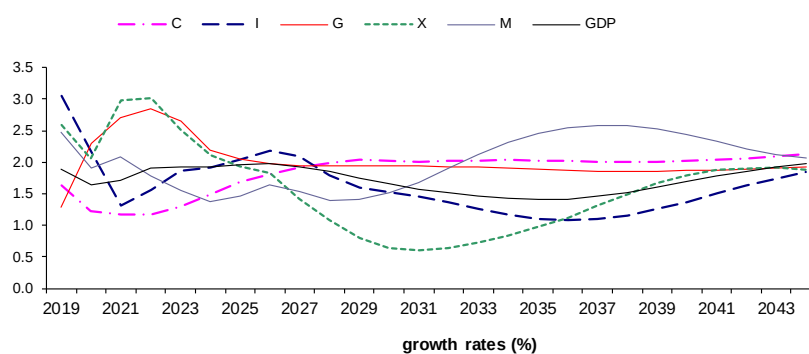
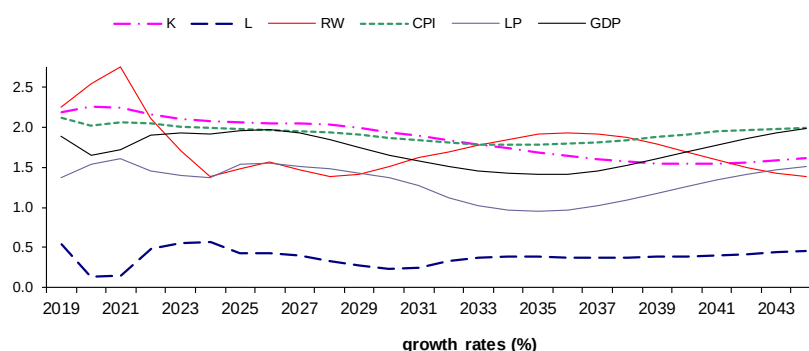
The macro forecast is discussed in Hantzsche *et al.* (2018) and is identified as the main forecast for the UK. It is conditional on a ‘soft’ Brexit. There is much uncertainty around these forecasts due to the unresolved nature of the future relationship between the UK and the EU. Under this forecast the UK government is able comply with the fiscal mandate but it is not able to achieve its medium-term objective to balance the budget unless it chooses to tax more. The details of the forecast appear in Table 1. Figures 1 and 2 present the time path of the forecast variables.

The forecast for GDP growth is at 1.4% for 2018 and 1.9% in 2019. The forecast allows the achievement of near-term fiscal targets (i.e., a cyclically adjusted deficit of less than 2% by 2020-21) (fiscal mandate) and a falling debt-to-GDP ratio over the same period (supplementary target). Inflation is forecast to fall from an average of 2.7% in 2017 to 2.5% in 2018 and to 2.1% in 2019, and then 2% thereafter. That return to the target represents a shift in the balance between the inflationary effects of the recent currency depreciation and oil and commodity prices and domestic factors, such as higher wage inflation.

Table 1. Macro forecasts (average annual growth rates)

	2019-2020	2021-2030	2031-2040	2040-44
Household consumption	1.42	1.66	2.02	2.08
Investment	2.62	1.79	1.23	1.68
Government consumption	1.79	2.22	1.89	1.90
Exports	2.33	1.83	1.12	1.89
Imports	2.19	1.58	2.31	2.19
GDP	1.77	1.86	1.51	1.89
Capital	2.23	2.07	1.68	1.58
Labour hours	0.34	0.39	0.36	0.43
Labour productivity	1.45	1.47	1.08	1.43
Employment	0.37	0.39	0.37	0.44
Labour supply	0.48	0.48	0.45	0.44
Population	0.60	0.46	0.33	0.29
Real wage	2.39	1.68	1.81	1.47
GDP deflator	2.62	2.03	2.35	2.09
CPI	2.07	1.97	1.82	1.97
Export price index	2.61	2.16	2.08	2.07
Import price index	1.49	2.35	0.64	1.64
PSBR (% of GDP)	-0.029	-0.026	-0.020	-0.017
Current account (% of GDP)	-0.031	-0.019	-0.025	-0.019

Note: All figures are percentage changes unless otherwise stated. PSBR = Public Sector Borrowing Requirement.

Figure 1. Expenditure components**Figure 2. Income components**

Public sector net borrowing in 2017–18 was £39.8 billion due to lower central government spending and less net borrowing by local authorities. A borrowing requirement of 1.9% of GDP is the lowest level of borrowing since 2001-02. This can in part be explained by

better-than-expected employment and unemployment outturns, which increase the tax base and reduce social security payments. The forecast assumes that total managed expenditure as a share of GDP will remain between 38% and 39% over the forecast horizon. This aligns it closely with its long-run average of 39%. Maintaining current spending levels relative to GDP also means that the public deficit will remain elevated for longer. Net borrowing as a share of GDP settles at 2%. Public sector net debt as a share of GDP starts to fall from 2018-19 onwards reaching 80% within the next three years.

The fiscal forecast faces a number of other risks. If population ageing was faster than is currently expected, spending requirements would be higher. External shocks due to global trade tensions would affect spending requirements and the revenue base, and may increase borrowing costs if risk premia rose. Higher than forecast productivity growth would improve the long-term fiscal outlook. The UK unemployment rate is the lowest seen in decades and output per worker remains low, both of which suggest the economy is operating close to capacity. But growth is forecast to slow over the next two years and the unemployment rate is forecast to rise to around 4.5% in the medium term. The slowdown in growth to 2020 reflects the exit from the EU and is mainly due to a fall in business investment. Private and government consumption growth also slows. Although trade barriers are expected to rise, the UK economy is expected to see a rise in net exports in the short-run due to a depreciation in the effective exchange rate. Higher net exports is mainly due to higher import costs. Thus, net trade makes a positive contribution to real GDP growth from 2019 to 2026 but not thereafter.

The assumptions on the path of economywide productivity growth are independent of Brexit. The forecast reflects 10 years of low productivity performance and hourly productivity growth is assumed to be just under 1.5% per annum. Labour productivity continues to recover very gradually some of the losses made since the financial crisis but given the lack of clarity about future trading relationships with the EU, the outlook remains uncertain in the short and medium term. On an annual basis, labour productivity growth of 1.5% is observed in 2018, which is 1 percentage point greater than the post-GFC average. The forecast reflects an expectation for the rise in labour productivity growth to continue based on soft Brexit assumptions. The expected rise in business investment and therefore the growth rate of the capital stock will support productivity growth. The annual growth rate of output per hour is forecast to stabilise at around 1.5% in the medium term.

Despite the unemployment rate being at the lowest level since the early 1970s wage growth has been low. Recent rises in public sector pay and the National Living Wage relative to productivity growth may lead to greater inflationary pressure. The forecast reflects higher

wage growth and a rising unemployment rate. There are also downside risks to wage growth: Bell and Blanchflower (2018) argue supply capacity is being underestimated in the labour market as the standard measure of unemployment does not adjust for workers, part-time and full-time, that would prefer to work longer hours.

Net migration was 270,000 in the year to March 2018. Ninety thousand were from the EU, which is lowest level since 2012. The fall in EU net migration is likely due to the currency depreciation and strong economic growth in other European economies. Uncertainty regarding future access to the UK labour market may also be important. The forecast assumes that the UK population grows according to principal projections provided by the Office for National Statistics. These imply a fall in net migration to around 200,000 people per year in the medium term.

Household saving as a share of GDP has been falling since 2016. This has allowed consumer expenditure to remain higher than otherwise. The forecast assumes that the household saving rate will begin to rise over the medium term towards the long-run average. Household investment as a share of GDP has risen from 3.2% in 2009 to 4.3% in 2017, which is similar to the pre-crisis high of 4.5% in 2006–07. As housing demand is still growing strongly, the forecast predicts household investment to increase to reach 5% of GDP in 2022. Household saving and investment imply that in 2017 households required 1.2% of GDP in funding from the rest of the economy. The household sector has not been a net borrower since 1987. The forecast assumes households to return to a near-balanced net position in the medium term.

Corporate saving increased 9.5% of GDP 2017 from 7.5% in 2016 due to higher corporate profits in manufacturing, oil and natural gas extraction. The forecast assumes corporate saving to GDP to remain around 9% in the medium term. The corporate investment ratio was steady at around 10.5% of GDP in 2017. The forecast reflects the expectation that corporate investment will remain at about 10% of GDP in the medium term, and thus the corporate sector will require about 1% of GDP of net financing from the rest of the economy over the same time horizon.

The government sector stopped dis-saving in 2016 due to fiscal consolidation. The forecast reflects the expectation that saving will be steady at about 1–2% of GDP from 2018 to 2022 due to a slower pace of fiscal consolidation from 2019. Government investment was stable in 2017 at 2.5% of GDP and the forecast assumes this will be maintained over the forecast horizon. As a result of constant saving and investment, the government is expected to remain in a net borrowing position of 1% of GDP until 2022.

To finance the triple deficit of the household, corporate and government sectors, the domestic economy borrowed 3.7% of GDP in 2017 from the rest of the world, the lowest ratio since 2012. The current account balance is forecast to stabilise at around 2.5% of GDP in 2022.

5.2 The regional picture

Applying the macro forecast to UK-SCGE allows us to generate long-run results for the 109 regions as presented in table 2, column 5. Aggregating these results to the four countries indicates the degree of divergence across broad parts of the UK. Figure 3 shows that country output growth diverges little across the forecast horizon. The only noticeable feature is the country growth rates is that Scotland grows noticeably faster over the periods 2020-2024 and 2033-2041. In terms of average annual growth, Scotland leads with 1.78%, followed England and Northern Ireland at 1.71% and 1.72, and then Wales at 1.70%. These growth rates translate into cumulative changes of 55.7% (England), 55.2% (Wales), 58.4% (Scotland) and 56.10% (Northern Ireland).

There are four major drivers of GDP growth in the NiGEM forecast: labour productivity, housing investment, business investment and export prices. Figure 4 presents the GDP outcomes when we apply each of these drivers individually. This gives an indication of the importance of each driver to the overall GDP outcome. Labour productivity is the most important driver of GDP growth over the forecast horizon. The other drivers are much less important; of these, housing investment and export prices are the most important. Business investment makes the smallest contribution of the four drivers, and in the second half of the horizon makes almost no contribution to GDP.

The weak contribution of business investment to GDP growth reflects the slow growth in business investment relative to GDP growth over the forecast horizon: see figure 1. Business investment averages 1.43% growth compared with 1.71% for GDP. By contrast, housing investment is the second most important contributor to GDP growth: it averages 2.52%. Growth in total investment (business, private and government) averages 1.62% over the forecast horizon. The weak contribution of business investment to GDP growth reflects the longer run effects of Brexit where risk premia are expected to be higher than otherwise.

Figure 3. Country GDP

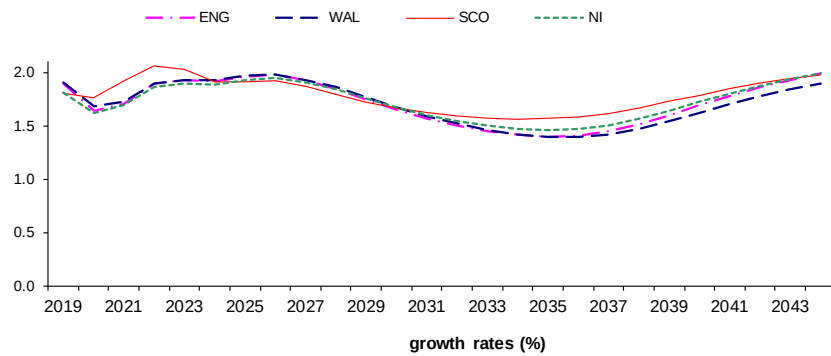
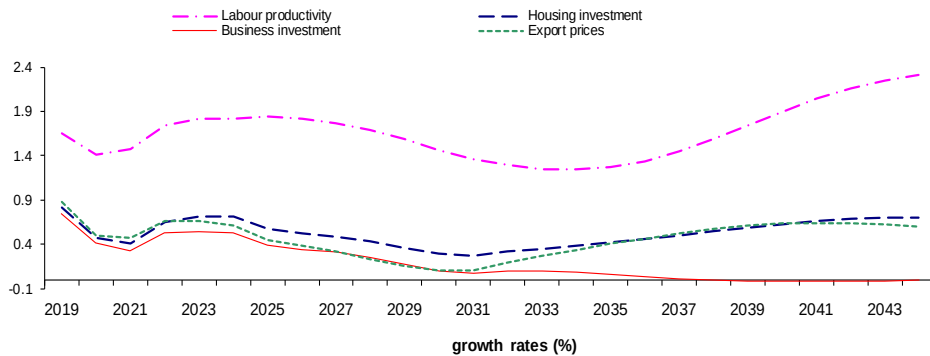


Figure 4. Decomposition of GDP



Relative export prices make a strong positive contribution over the first and last third of the forecast horizon. These movements reflect movements in the exchange rate and import prices in export destinations. Initially, higher export prices reflect the expected depreciation of the exchange rate due to the uncertainties related to Brexit. The depreciation dissipates by 2025, after which the movements in export prices mainly reflect price movements in export destinations.

Table 2. Regional GDP outcomes: decomposition (average annual growth rates)

	(1) Labour productivity	(2) Housing investment	(3) Business investment	(4) Export price	(5) Total
<i>National</i>	1.66	0.53	0.20	0.47	1.72
Dudley1	1.59	0.57	0.31	0.52	1.76
Birmingham2	1.64	0.51	0.18	0.44	1.73
CanockCha3	1.63	0.61	0.30	0.55	1.77
Babergh4	1.69	0.32	0.20	0.42	1.75
Aberdeen5	2.12	1.05	0.68	1.12	1.80
ScottishB6	1.61	0.51	0.18	0.41	1.68
DumfriGal7	1.62	0.44	0.25	0.43	1.69
Angus8	1.62	0.48	0.17	0.43	1.68
Fife9	1.66	0.46	0.20	0.45	1.68
EileanSia10	1.70	0.60	0.21	0.52	1.68
PerthKinr11	1.63	0.53	0.15	0.43	1.68
Clackmann12	1.84	0.67	0.30	0.63	1.73
EastLothi13	1.76	0.50	0.14	0.48	1.69
EastDunba14	1.64	0.50	0.10	0.41	1.66
EastAyrsh15	1.60	0.49	0.25	0.43	1.68
London16	1.68	0.50	0.08	0.34	1.69
Southendo17	1.60	0.50	0.12	0.38	1.72
Medway18	1.65	0.60	0.19	0.47	1.74
MoleVall19	1.80	0.53	0.12	0.46	1.69
Guildford20	1.67	0.35	-0.04	0.30	1.66
Dacorum21	1.66	0.47	0.02	0.35	1.70
EastHertf22	1.65	0.52	0.13	0.43	1.72
StokeonTr23	1.58	0.59	0.30	0.55	1.78
Charnwood24	1.67	0.45	0.19	0.45	1.70
EastStaff25	1.56	0.65	0.28	0.48	1.75
CheshireE26	1.74	0.40	0.10	0.42	1.71
Derby27	1.64	0.49	0.22	0.47	1.74
Leicester28	1.62	0.52	0.21	0.44	1.71
Carlisle29	1.59	0.66	0.30	0.51	1.75
Mancheste30	1.65	0.53	0.21	0.47	1.71
Halton31	1.64	0.53	0.24	0.50	1.75
CheshireW32	1.64	0.48	0.28	0.68	1.90
Barnsley33	1.62	0.51	0.20	0.44	1.70
Doncaster34	1.59	0.54	0.26	0.49	1.71
Coventry35	1.64	0.47	0.17	0.46	1.74
Bradford36	1.66	0.55	0.29	0.50	1.74
Hartlepoo37	1.68	0.69	0.37	0.67	1.82
Blackburn38	1.65	0.49	0.29	0.50	1.73
Blackpool39	1.63	0.59	0.29	0.55	1.75
EastRidin40	1.63	0.60	0.32	0.55	1.76
York41	1.61	0.54	0.21	0.46	1.68
NorthEast42	1.71	0.38	0.31	0.57	1.89
NorthLinc43	1.59	0.40	0.26	0.89	2.11
Rutland44	1.64	0.49	0.21	0.44	1.68
Nottingha45	1.58	0.50	0.21	0.44	1.70
Herefords46	1.60	0.61	0.27	0.50	1.75
Cheltenha47	1.67	0.48	0.17	0.45	1.72
Telfordan48	1.68	0.56	0.26	0.53	1.75
BathandNo49	1.63	0.54	0.17	0.45	1.73
Bristol50	1.69	0.52	0.14	0.44	1.70
Plymouth51	1.55	0.51	0.26	0.45	1.69
Torbay52	1.54	0.62	0.28	0.50	1.71
Bournemou53	1.63	0.55	0.21	0.44	1.72
Swindon54	1.73	0.52	0.17	0.48	1.72
Bedford55	1.66	0.43	0.11	0.40	1.70

Table 1. Regional GDP outcomes: decomposition (average annual growth rates) (cont)

	(1) Labour productivity	(2) Housing investment	(3) Business investment	(4) Export price	(5) Total
Brightona56	1.71	0.54	0.17	0.47	1.73
Portsmouth57	1.63	0.49	0.17	0.42	1.72
Southampton58	1.68	0.39	0.09	0.41	1.73
Isle of Wight59	1.56	0.47	0.21	0.40	1.73
Isle of Angle60	1.77	0.38	0.41	0.56	1.80
Gwynedd61	1.65	0.99	0.77	0.93	1.75
Ceredigion62	1.66	0.90	0.69	0.86	1.74
Conwy63	1.63	1.01	0.79	0.95	1.76
Shropshire64	1.58	0.70	0.29	0.56	1.78
Carmarthen65	1.69	0.86	0.67	0.85	1.77
Powys66	1.67	0.87	0.68	0.84	1.75
Blaenau Gwent67	1.73	0.80	0.60	0.79	1.76
Pembrokeshire68	1.66	0.51	0.44	0.99	2.17
Bridgend69	1.76	0.80	0.60	0.80	1.75
Cambridge70	1.62	0.35	0.03	0.31	1.64
Cherwell71	1.66	0.43	0.01	0.36	1.68
Kings Lynn72	1.55	0.65	0.30	0.48	1.75
Cornwall73	1.53	0.63	0.32	0.51	1.71
Isles of Scilly74	1.62	0.64	0.23	0.50	1.86
Allerdale75	1.65	0.53	0.30	0.72	1.91
Eden76	1.63	0.56	0.34	0.53	1.69
Barrow-in-Furness77	1.62	0.30	0.23	0.36	1.66
South Lakes78	1.65	0.57	0.29	0.51	1.71
Lancaster79	1.70	0.68	0.41	0.68	1.73
East Devon80	1.57	0.65	0.22	0.48	1.73
Sedgemoor81	1.57	0.54	0.26	0.46	1.68
North Devon82	1.64	0.58	0.26	0.50	1.72
South Somerset83	1.63	0.49	0.23	0.46	1.73
West Dorset84	1.56	0.57	0.25	0.46	1.70
Eastbourne85	1.56	0.53	0.18	0.40	1.72
Braintree86	1.62	0.59	0.21	0.47	1.75
Malvern Hills87	1.61	0.63	0.22	0.49	1.77
Ashford88	1.57	0.48	0.18	0.40	1.69
Canterbury89	1.63	0.32	0.20	0.42	1.76
Lincoln90	1.61	0.55	0.28	0.50	1.71
Boston91	1.59	0.46	0.30	0.45	1.67
East Lindsey92	1.52	0.53	0.36	0.51	1.69
Breckland93	1.66	0.51	0.23	0.46	1.69
Forest Heath94	1.65	0.50	0.17	0.45	1.70
Great Yarmouth95	1.63	0.47	0.26	0.46	1.68
Corby96	1.61	0.50	0.20	0.44	1.72
Hambleton97	1.65	0.60	0.30	0.54	1.71
Ryedale98	1.69	0.51	0.18	0.48	1.72
Scarborough99	1.58	0.63	0.39	0.58	1.72
Argyll and Bute100	1.68	0.58	0.20	0.50	1.71
County Durham101	1.61	0.65	0.38	0.59	1.77
Gateshead102	1.62	0.54	0.24	0.49	1.73
Inverclyde103	1.63	0.53	0.21	0.46	1.73
Hillingdon104	1.67	0.40	0.07	0.38	1.70
Stratford105	1.73	0.59	0.22	0.60	1.85
Sunderland106	1.69	0.61	0.34	0.61	1.81
Bracknell107	1.71	0.40	0.02	0.39	1.69
Northumbria108	1.59	0.69	0.41	0.60	1.75
North Ireland109	1.65	0.54	0.27	0.52	1.73

5.3 The fastest and slowest growing regions

In a model with a 109 regions there is a major challenge to understand what determines the differences in growth rates across regions. Careful inspection of table reveals that the fastest growing region is Pembrokeshire (south-west Wales) with average growth of 2.17% and the slowest growing region is Cambridge (east England) with average growth of 1.64%. We can present a decomposition of the four major drivers of GDP growth (similar to figure 4) for all regions. This is done in figure 5. Due to the clustering of growth rates it is difficult to discern strong patterns in figure 5. One discernable pattern is that labour productivity is the largest contributor to GDP growth for all regions; other patterns are less clear.

To aid in revealing more patterns requires that the results are filtered to some extent. In figure 6 we present the results for the five fastest and five slowest growing regions. The five fastest growing regions are Pembrokeshire (south-west Wales) 2.17%, North Lincolnshire (east England) 2.11%, Allerdale (north-west England) 1.91%, Cheshire (north-west England) 1.90%, North East Lincolnshire (east England) 1.86%, Boston (east England) 1.67%, East Dunbartonshire (west central Scotland) 1.66%, Guildford (south England) 1.66%, Barrow-in-Furness (north-west England) 1.66%, and Cambridge (east England) 1.64%.

Figure 6 confirms that although the average growth rate between five fastest and five slowest growing regions varies from 2.17% to 1.64%, labour productivity makes an almost identical contribution to GDP growth for each of these regions. While housing investment is a much less important contributor than labour productivity, nevertheless its contribution is also very even across these 10 regions. The largest variation in GDP contributions is seen for business investment and export prices.

The contribution of export prices reflects the importance of international trade in each regional economy. Pembrokeshire and North Lincolnshire have very high trade shares in GDP (ranging from 70% to 150%) whereas Guildford, Barrow-in-Furness and Cambridge have much lower trade shares (ranging from 7% to 30%). Thus, Pembrokeshire and North Lincolnshire benefit strongly from export prices whereas Guildford, Barrow-in-Furness and Cambridge do not.

Figure 5. Decomposition of GDP: all regions

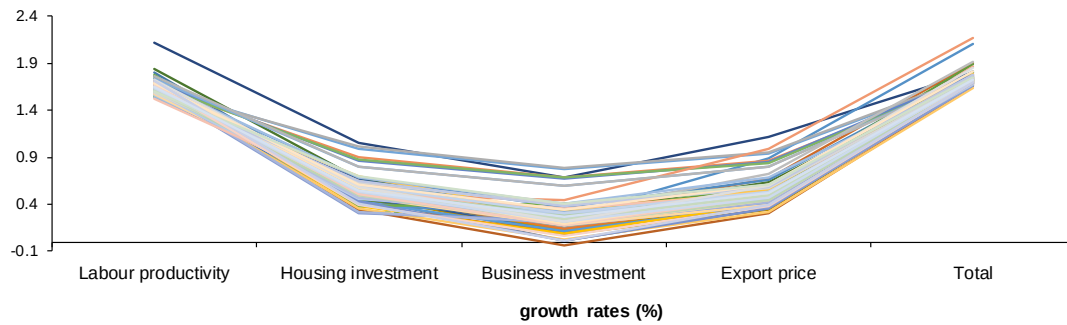
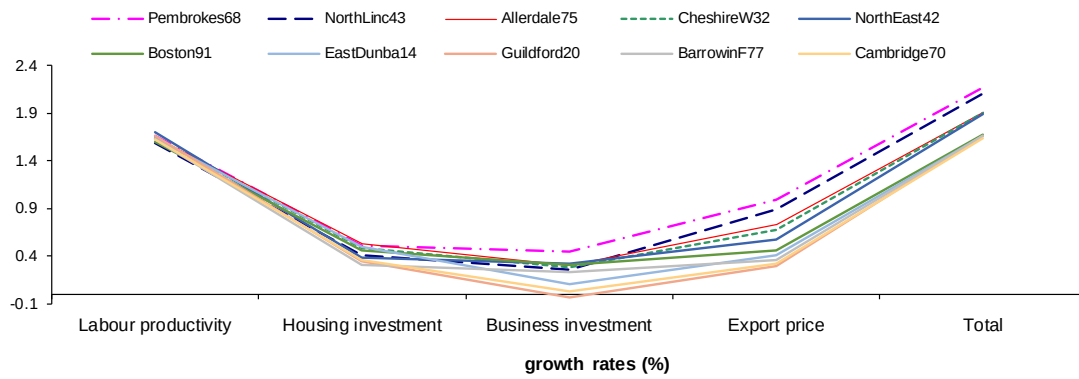


Figure 6. Decomposition of GDP: 5 fastest and 5 slowest growing regions



Housing investment makes a similar contribution to GDP for the five fastest and five slowest growing regions. By contrast, the contribution of business investment varies significantly between these two groups of regions. Nationally, housing and business investment comprise 3% and 17% of GDP. All other things being equal, a given growth rate in housing investment will be much less important in determining output growth for a region than a given growth rate in business investment. Thus, we observe that variations in the importance of business investment in a region reflect differences in growth rates across these two groups of regions. That is, the fastest growing regions have business investment shares less than average and the slowest growing regions have business investment shares above average.

6. Conclusion

The UK faces a number of economic challenges in the short- to medium-term. Renegotiation of trading arrangements with the European Union is the most prominent of these. A second important medium-term challenge is the slowdown in productivity growth in the UK

over the last two decades and the associated low overall labour productivity growth relative to other high-income countries. A third important challenge is the persistent and significant government budget deficit and corresponding accumulation of government debt.

These challenges have been analysed using the NiGEM model: a macroeconomic framework that is internally consistent, robust and built on micro-theoretic foundations (Hantzsche *et al.*, 2018). NiGEM is a multi-country macroeconometric model of the global economy that is data driven in the short to medium term and neoclassical in the long term. We build on existing macroeconomic analysis of these challenges by projecting the effects on the UK's regions. The forecasts are generated by combining NiGEM with UK-SCGE, a regional computable general equilibrium of the UK.

The UK regional model is a dynamic CGE model with long-run properties similar to NiGEM. Short-run behaviour is mainly characterised by the movement from an initial steady-state that is consistent with the latest input-output data, and national and regional accounts. Over time the model slowly moves from the initial steady-state along a balanced growth path to a new steady-state. The model represents 29 industries and 109 regions. Like NiGEM, UK-SCGE includes a government sector with expenditure and revenue accounts, a representation of the current and capital accounts, accumulation of foreign assets, foreign liabilities, and government debt.

The NiGEM results are applied as annual inputs to the regional model. The inputs include expenditure-side components of GDP, labour supply, employment, labour hours, labour productivity, and consumer prices. This ensures that at the macro level the two models are consistent in their representation of the path of the aggregate economy. Using the macro inputs from NiGEM, the regional model generates a rich pattern of effects for 109 regions. These changes are decomposed to explain how regions are affected differentially by the various long-run trends in the UK economy that are projected by the macro model. Further, the regional results also provide a ranking of growth prospects across the UK regions. This ranking can provide policy makers with a view on where economic policy changes might be focussed to reduce the largest disparities in regional outcomes.

The macroeconomic forecasts show a national average annual GDP growth rate of 1.71% over the period 2019-2044. When the macroeconomic forecasts are applied across regions growth rates range from 1.64% for Cambridge to 2.17% for Pembrokeshire. Despite wide variation at the extremes the standard deviation is low at 0.07% and the coefficient of variation is 0.04%. The country results favour Scotland, which grows at annual rate of 1.78%, whereas Wales is the slowest growing of the countries at 1.70%.

Decomposing the forecasts we find that labour productivity is the most important contributor to the overall growth rate. Housing investment and export prices are the next most important contributors to the overall growth rate. Business investment makes the smallest contribution to the overall growth rate. While labour productivity is the most important contributor to the overall growth rate, it has a rather even effect on regional growth rates reflecting the even importance of labour shares in GDP across regions. There is much greater variation in the importance of exports in GDP. Thus, we find that movements in export prices cause the largest variations in regional growth rates.

Combining macro inputs from NiGEM with UK-SCGE generates a rich pattern of effects for 109 regions. The effects provide an internally consistent story of changes in regional output. The regional results also provide a ranking of growth prospects across the UK regions. This ranking can provide policy makers with a view on where economic policy changes might be focussed to reduce the largest disparities in regional outcomes. Our results suggest that policies focussed on improving productivity in regions with low growth prospects would reduce some of the unevenness in expected growth outcomes.

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Appendix: Implementing NiGEM forecasts in UK-SCGE

In applying NiGEM forecasts to UK-SCGE, it is necessary to accommodate the NiGEM outcomes within the theory of UK-SCGE if the relevant variable is endogenously determined. This describes the situation for most variables to which exogenous forecasts are applied.

Household consumption.

To impose a path of household consumption we set as endogenous the current account to GDP ratio path rather than imposing a path on it. This will mean that the household saving rate will adjust to allow household consumption to follow the path forecast by NiGEM.

Housing and business investment.

Sectoral investment is a function of the rate of return in UK-SCGE. To impose a path on housing investment we endogenise the intercept term for dwelling investment. To impose a path on business investment we endogenise the intercept term for non-dwelling investment.

Government investment and consumption.

Government investment and consumption are typically exogenous variables in UK-SCGE. Therefore we are able to directly apply NiGEM forecast for these variables.

Exports.

We apply a path on exports by endogenising the world export prices.

GDP.

To impose a path on GDP we endogenise output per worker.

Population and labour supply.

Population is an exogenous variable in UK-SCGE. Therefore we are able to directly apply NiGEM forecast for population. Labour supply is typically determined by a labour supply function. To impose a path on labour supply we endogenise the intercept term.

Employment and labour hours.

Employment is typically determined by the interaction of labour demand and supply given an exogenous unemployment rate in UK-SCGE. To impose a path on employment we endogenise the unemployment rate. In UK-SCGE labour hours are a function of hours per worker and the number of workers (employment). To impose a path on labour hours we endogenise hours per worker, exogenise labour hours.

Consumer prices.

The consumer price index (CPI) is usually endogenous in the baseline of UK-SCGE. We make it exogenous and impose the NiGEM forecast and we make the exchange rate endogenous.

Government budget.

In the baseline the ratio of the central government budget to GDP is typically exogenous and reduced by 2% per annum to ensure that government debt as share of GDP stabilises by the terminal year. The personal income tax rate adjusts to allow the path in budget balance to be achieved. Here we adjust the exogenous path in government to ensure it arrives in the terminal year consistent with the value observed in the NiGEM forecast.