Scottish Fiscal Commission

How we forecast the Scottish economy

May 2021

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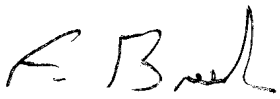
Foreword

As Scotland's independent forecaster, the Commission is committed to openness and transparency in all of our work. We regularly produce reports to inform users of our forecasts about the approaches used to develop them. By being transparent in our forecasting, we aim to help people interested in our forecasts understand how they are constructed and we welcome any feedback to help us improve them.

This report sets out our approach to forecasting Scottish GDP and the other economic determinants which feed into our fiscal forecasts. It also describes the main features of the Commission's new in-house macroeconomic forecasting model.

The report is structured into two parts. The first part is intended for a general audience, so we have endeavoured to capture the most important aspects of the forecasting process, alongside the most important assumptions we have to make during the creation of our economy forecast. The second part is intended for readers who are interested in a detailed technical description of the new in-house macro model. Readers interested in additional information about our work can get in touch with us directly by e-mailing info@fiscalcommission.scot.

Dame Susan Rice DBE



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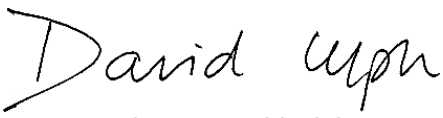

Professor David Ulph

26 May 2021

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Chapter 1
Introduction

1.1 This report describes how we produce our five-year forecasts of the Scottish economy. These include onshore Gross Domestic Product (GDP) growth, employment and earnings which feed into our fiscal forecasts. It also describes the main features of the new in-house macroeconomic forecasting model developed by the Scottish Fiscal Commission – where all data, analysis and judgements are brought together into a coherent forecast.

1.2 The Commission is committed to openness and transparency in all of our work. We regularly publish these reports to inform users about our forecasting methodology and encourage them to provide feedback that can help improve our forecasts. We previously described our economy forecasting approach in two occasional papers published in September 2017 and March 2018.[1]

1.3 Our January 2021 economy forecast was the first to use the Commission's new in-house macroeconomic forecasting model and historical database. Our previous medium-term economic forecasting tool, the Scottish Government Global Economic Model (SGGEM), is developed and customised for Scotland by the National Institute for Economic and Social Research and is owned by the Scottish Government.

1.4 The development of an in-house macroeconomic model was recommended by the 2019 OECD review. The OECD highlighted that "while SGGEM is appropriate for the young age of the Commission, a longer-term solution with full ownership in open-source or at least non-proprietary software should be developed as the Commission matures". [2] Having an in-house model means we can fulfil our legislative requirement of making all methodologies and assumptions available for scrutiny by the Scottish Ministers, Parliament, academic commentators, and the public. To address this transparency issue, when we began our in-house model development in 2018 we chose to build the new model in EViews – a software package which is not free but is widely used and easily accessible.

1.5 Chapter 2 of this paper provides a high-level overview of the current steps in forecasting the Scottish economy as an update of our two previous papers; it also provides a non-technical overview of our new in-house macroeconomic model and a full discussion of the motivations behind it.

1.6 Chapter 3 provides a detailed technical description of the new model and is intended for readers interested in the mechanics of the model and how it was built. Chapter 3 also contains a section focusing on our modelling and forecasting of employment and earnings in the private and public sectors. The labour market is important because the breakdown by private and public sectors was one of the main motivations for the new model, and because of the interconnection of employment and earnings forecasts with income tax. Moreover, given the nature of the model where factors such as interest rates and prices are determined at UK level, the labour market is central to how we model and forecast the Scottish economy.

[1] Scottish Fiscal Commission (2017) Current Approach to Forecasting (link), Scottish Fiscal Commission (2018) Forecasting the long-run potential of the Scottish economy (link)
[2] OECD (2019) OECD Review of the Scottish Fiscal Commission (link)

1.7 We welcome comments on our in-house macroeconomic model or any other material in this report and are grateful to everyone who has already provided feedback throughout the model development phases. A full equation list is provided in Annex A. The EViews code as well as further information about any of our analysis are available on request to interested readers.

Chapter 2
Forecasting Scotland's economy

Overview of forecasting process

2.1 A range of models are adopted to forecast the economy. These include theory-based structural econometric models, empirically-based time series models, and simple trend projection models. Judgment is required in both how the models operate and how the results from different models are used and combined. Ultimately, the forecast is driven by the judgement of the Commissioners, rather than depending mechanically on the output of any one model.

2.2 Short-term forecast techniques attempt to model the economy's response to shocks and short-term volatility, typically driven by the demand side of the economy. This volatility is modelled with empirically-driven time series approaches such as Autoregressive Integrated Moving Average (ARIMA) models, using high-frequency economic data and surveys of the Scottish and UK economies. This approach is appropriate for the first few quarters of the forecast but has a limited time horizon, after which more structural and theoretical models are needed.

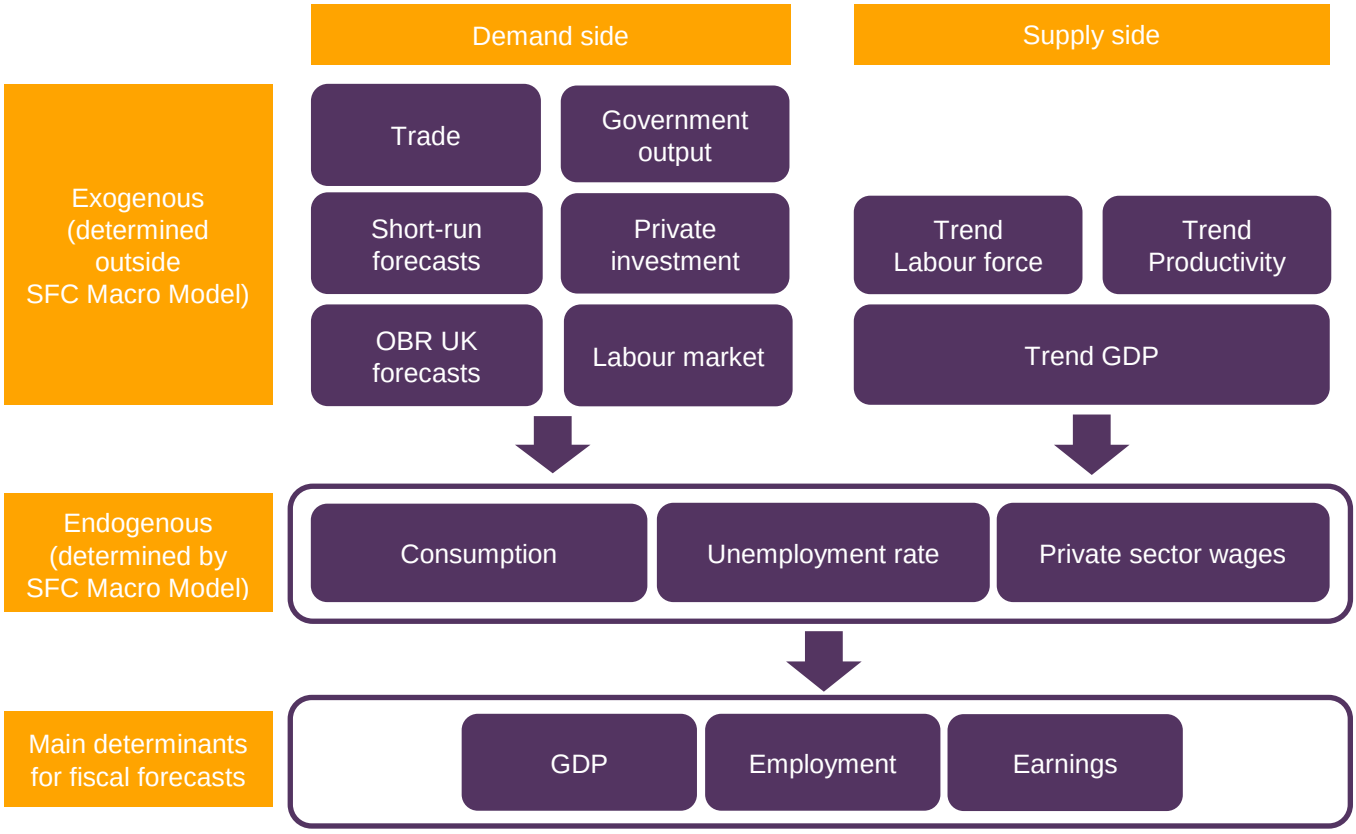
2.3 The long-term outlook is anchored to theoretical supply constraints of the Scottish economy. We combine trend forecasts of population, the labour market and productivity to generate trend GDP, or the maximum amount of goods and services the economy can sustainably produce. This forecast in particular is heavily influenced by the judgement of the Commissioners.

2.4 The final part of the forecast process is to construct a medium-term GDP forecast by connecting aggregate demand forecasts to the long-run supply projections. This is done using our new in-house macro forecasting model. Some components of aggregate demand such as trade and government output are exogenous, that is determined by data and judgement in standalone auxiliary models and imposed on the core model. The pathway of wages, consumption and unemployment are endogenous, determined by the core model aiming to align demand with supply over the forecast horizon as spare capacity gradually returns to zero.

2.5 This approach is similar to that of the Office for Budget Responsibility (OBR), the UK's official independent forecasting organisation. The OBR also starts with an assessment of short-term GDP growth and generally assumes that over the longer term economic output returns to its trend level, in line with OBR's judgements about the economy's underlying growth potential.[3]

[3] OBR economy forecasts in-depth pages: Potential output and the output gap (link), Near-term GDP forecast (link), Medium-term GDP forecast (link).

Figure 2.1: Schematic representation of economy forecasting process



Source: Scottish Fiscal Commission

Short-run forecasts

2.6 Our forecasts are based on publicly available official statistics in accordance with our commitment to openness and transparency. The timeliness of these statistics has improved significantly, but they are required to comply with high professional standards and so are inevitably published with a lag. For example, we now have monthly GDP data for Scotland which are faster than the quarterly releases and available with a lag of around two months. Short-run forecast models are used to predict both the current position of the economy and the outlook for the economy in the near term. We have a suite of models for forecasting GDP in the short run, including ARIMA models and sectoral approaches.

2.7 We analyse timely surveys of the Scottish economy, as well as wider data, to build up a picture of what is happening in Scotland today and the likely pathway in the near future. Statistical models are used to generate short-run forecasts for up to two quarters ahead. For each variable we wish to forecast such as GDP, we run a number of ARIMA models, each with a single predictor variable. We then take an average of the outcomes, assigning greater weight to those models that had greater predictive accuracy historically, to create the short-run forecast.

2.8 Another tool we have is bottom-up industry analysis based on published monthly GDP data. This consists of making judgments about the short-run path of individual sectors and then weighting these together to create a short-run forecast of GDP. We are looking into other possible extensions to our toolkit, including a top-down sectoral breakdown approach.

Trend GDP

2.9 Trend GDP is the maximum amount of goods and services the economy can sustainably produce without inducing inflationary pressure in the economy. In the short term actual output can deviate from trend, but over the longer term it is assumed to be constrained to the supply capacity of the economy.

2.10 One of the main challenges in forecasting trend GDP is that it is not directly observable. Instead, we capture the underlying trends by decomposing output into supply factors. Judgement is inevitably needed to incorporate the best available qualitative and quantitative intelligence into our trend GDP projections. Over our forecast horizon of five years, actual output is anchored to our forecast of trend GDP.

Steps in forecasting trend GDP

2.11 Trend GDP depends primarily on growth in productivity, the amount of goods and services that can be produced for a given amount of labour input. Our forecasts of productivity and the size of the labour force, combined with assumptions about long-run unemployment and average hours worked, produce a forecast of trend GDP.

Figure 2.2: Schematic representation of trend GDP forecast

Source: Scottish Fiscal Commission

2.12 To forecast the size of the labour force, first we forecast the size of Scotland's population making assumptions about migration, fertility and mortality specific to Scotland. Then we apply our forecasts of labour force participation rates by age and gender to create a forecast of trend labour force.[4]

2.13 Once we have a trend labour force forecast, we split this into those in employment and those unemployed. We do this by making an assumption about long-run unemployment, also known as the Non-Accelerating Inflation Rate of Unemployment (NAIRU). Subtracting this from the labour force gives a forecast for the rate of employment at which the economy can sustainably operate without causing inflation to rise. Combining employment with assumptions about average hours worked gives total hours worked.

2.14 Finally we apply our forecast of trend productivity, based on Commissioners' judgement, to total hours worked to create our forecast of trend GDP.

[4] Details of how we forecast labour force participation rates can be found in our previous occasional paper: Scottish Fiscal Commission (2018) Forecasting the long-run potential of the Scottish economy (link).

Other exogenous forecasts

2.15 Some components of aggregate demand and other economic factors are imported into the SFC macro forecasting model as standalone forecasts and are fixed using the assumptions and models described below.

- **OBR UK economy variables**. Economic conditions in the UK are relevant to Scotland and feed into our modelling of the Scottish economy. These include inflation, interest rates, the UK output gap, UK consumer expenditure deflator, and UK implied GDP deflator. For these, we usually rely on official forecasts published by the OBR.

- **Trade**. Trade between Scotland and the rest of the UK is modelled based on growth in demand in both economies – that is, our forecast of Scottish GDP and the OBR's forecast of UK GDP. Trade between Scotland and the rest of the world is based on the OBR's UK trade forecasts, with some adjustment for Scottish circumstances.

- **Government output**. Government spending is a significant component of Scottish GDP. This is split into government consumption on day-to-day spending and government investment in long-term projects such as hospitals and roads. Government output is forecast using spending plans at all three levels of government – local authorities, Scottish Government, and other UK Government departments in Scotland.

- **Private fixed investment**. This is expenditure on fixed capital such as machinery and property. Scottish business investment is grown broadly in line with UK business investment, with Scotland-specific adjustments made as necessary. Housing investment is forecast based on recent growth as well as taking account of any support from government's homes delivery programmes.

- **Labour market**. The labour force is forecast by converging the latest labour force outturn data to the trend labour force forecast described in the previous section on trend GDP. Similarly, the latest hours worked data is converged towards our trend hours worked forecast. Using the SFC macro forecasting model we are now able to split employment and earnings between the public and private sectors.

SFC macro forecasting model

2.16 The new in-house macro forecasting model works in the same way as other classic macroeconomic models and the forecasting methodology is fundamentally unchanged from the model we previously used. The advantage of developing the model in-house is that aspects such as ownership and transparency are more in line with best practice at longer-established Independent Fiscal Institutions.

2.17 The major benefit of the new model is the control and flexibility it allows with regards to timely incorporation of new data and the addition and amendment of equations. This means we are better positioned to respond to the latest developments in the Scottish economy and capture them fully in our forecast. It also means we can tailor the model to our forecasting needs. This includes producing the economic determinants required for our fiscal forecasts, for example separate forecasts of employment and earnings for the private and public sectors to feed into our income tax model.

2.18 The breakdown of employment and earnings forecasts between the private and public sectors is a major innovation of the new model. This allows for more detailed modelling of earnings, and also enables us to better integrate changes in public sector pay policy into our forecasts.

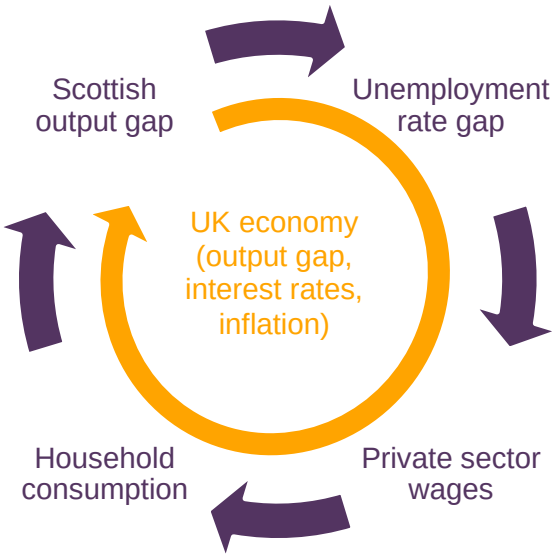
2.19 As with all macroeconomic models, our model is a simplified representation of the economic activity described and recorded in the National Accounts. Our core data are published by the Scottish Government and by the Office for National Statistics (ONS) for the UK, and include: the Quarterly National Accounts for Scotland (QNAS) for GDP and other economy variables; the Labour Force Survey (LFS), Annual Population Survey (APS), Annual Survey of Hours and Earnings (ASHE) and Public Sector Employment (PSE) publication for labour market variables; NRS population and migration estimates. These are all official statistics produced on a consistent basis, according to the National Accounts framework. We also use administrative data from PAYE Real Time Information (RTI), which is more timely than official data, to inform our short-term outlook for earnings and employment.

Overview of new model

2.20 The forecast centres around trend GDP, primarily determined by population growth and productivity. The forecasting process includes three interlinked regions: Scotland; the rest of UK, for which we use OBR UK economy forecasts; and the rest of the world. Actual output can deviate from trend, creating an output gap or spare capacity, which closes via wages, UK prices, and monetary and fiscal responses. An important assumption in our forecast is that the output gap usually closes over the five-year forecast horizon.

2.21 The Scottish economy is a regional economy, with currency and monetary policy set at UK level; fiscal policy is partially devolved but power to run a large and sustained fiscal deficit or surplus is reserved to the UK government. The mechanics leading to the closure of the output gap in Scotland will depend on UK conditions as well as what happens in Scotland, as shown in Figure 2.3.

Figure 2.3: Closure of our model of the Scottish economy



2.22 We expect the pace of closure of the output gap in Scotland to be affected by:

- Scotland's own internal automatic stabilisers. These act on unemployment, wages, internal demand, and competitiveness relative to the rest of the UK – all of which can freely adjust and deviate from UK patterns, feeding back to each other.
- UK conditions. These include the position of the UK relative to its own economic cycle (UK output gap), UK-wide policy responses such as interest rates, and UK prices.
- Scotland's cyclical position compared to the UK as a whole.

2.23 When the Scottish economy is operating above capacity (positive output gap) and unemployment is below trend (negative unemployment rate gap), scarce supply may be expected to lead to higher costs, particularly of labour, in Scotland. Although in the short run this may increase the income of Scottish households, in the long run it will – all else equal – make Scotland less competitive, limiting production and consumption. This will gradually drive the Scottish economy back towards trend.

2.24 At the same time, if the UK is in the same cyclical position as Scotland, and interest rates rise to counterbalance the positive UK output gap, then we can expect the higher interest rates to have a similar, counter-cyclical effect on both the Scottish and UK economies. Investment and consumption will be reduced, unemployment will increase towards trend, which will put downward pressure on wages, and the economy will return to equilibrium. This adjustment process is shown in Figure 2.3.

2.25 In the event that Scotland and UK are in different cyclical positions, then prices and monetary conditions may act pro-cyclically and the Scottish output gap may be more persistent and take longer to close.

2.26 Through this adjustment process, the model determines forecasts of employment, earnings and household consumption. Summing up household consumption with the other components of aggregate demand from the auxiliary models gives our forecast of GDP.

2.27 The new model focuses on private-sector employment and earnings. Public-sector wages and employment are determined in standalone auxiliary models, along with other sources of household income. The labour market modelling and forecasting process is covered in detail in the next chapter.

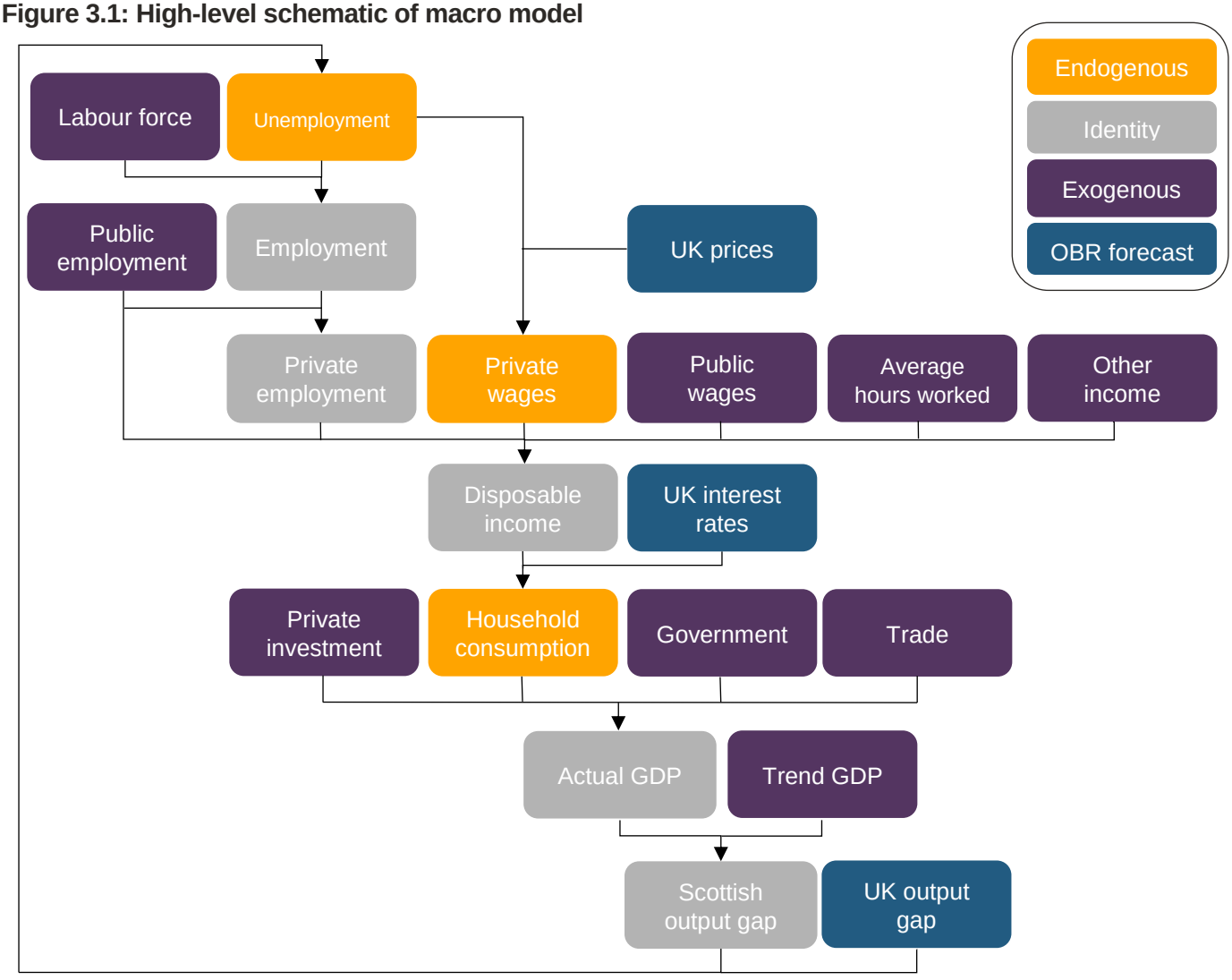
Chapter 3
The SFC macro forecasting model

3.1 This chapter sets out a detailed explanation of the structure and mechanics of our new macroeconomic model and has been written with a technical audience in mind. As such, familiarity with econometric concepts and technical terminology is assumed. Chapter 2 provides a more accessible introduction to our macro model.

Structure of the model

3.2 The equations in the model, as summarised in Annex A, represent a set of relationships between economic variables. Figure 3.1 provides a high-level schematic of our macro model.

Figure 3.1: High-level schematic of macro model



3.3 As shown in Figure 3.1, variables can be classified into three types:

- **Exogenous variables**, as outlined in Chapter 2. These are determined in auxiliary models outside the main macroeconomic model. They currently make up the majority of our model but over time we will aim to move more of these from being forecast off-model to in-model.

- **Endogenous variables**, as explained later in this section. Endogenous variables are determined by the model through behavioural equations which have an error correcting structure. There are currently three of these in the model – the unemployment rate gap, private-sector real hourly wage, and household consumption – but we will aim to add more in future.

- **Variables resulting from identity equations**. These specify the accounting indentities and definitions in the National Accounts.

Endogenous relationships

3.4 Our endogenous relationships are modelled in the form of error correction equations, with the choice of explanatory factors justified by the conventional theoretical and empirical literature and by judgement. We specify our error correction models (ECM) as follows.[5]

$$dlogY = a*(logY(-1) - b*logX(-1)) + c_1*dlogY(-1) + c_2*dlogX(-1) + c_3*dlogX + d_1*dlogZ_1 + d_2*dlogZ_2$$

3.5 An ECM consists of two parts:

- **Long-run, or cointegrated, part**. Variables X and Y have a stable equilibrium relationship, from which they can drift away in the short term ("error"). The ECM "corrects the error" by bringing variables back towards equilibrium.[6] This is denoted as $a*(logY(-1) - b*logX(-1))$ where: $logY(-1) = b*logX(-1)$, or ratio $b = logY(-1) / logX(-1)$, is the relationship holding between X and Y; parameter 'b' is the long-run coefficient; and parameter 'a' is the error correction, or speed of adjustment, coefficient (with 'a' greater than -1 and smaller than 0, that is $-1 < a < 0$).

- **Short-run part**. This captures quarter-on-quarter variation. In the short run, Y responds to: changes in past values of Y itself and of X according to short-run coefficients c_1 and c_2 respectively; and changes in current values of X and of other explanatory variables Z according to short-run coefficients c_3, d_1 and d_2.

3.6 We have three error correction equations:

- **Unemployment rate gap (UD)**. It is based on the Scottish output gap (YD) and the UK output gap (UKYD). It feeds into unemployment, employment, and private-sector wage setting.

$$dUD = a*(UD(-1) - b*YD(-1)) + c_1*dUD(-1) + c_2*dYD(-1) + c_3*dYD + d_1*dUKYD$$

- **Private-sector real hourly wage rate (RWPR)**. In the long run, it is based on trend productivity (PROD). In the short run, it is determined by the relative demand and supply of labour as proxied by the unemployment rate gap (UD) and the behaviour of inflation as proxied by changes in the GDP deflator (PY).

$$dlogRWPR = a*(logRWPR(-1) - b*logPROD(-1)) + c_1*dlogRWPR(-1) + c_2*dlogPROD(-1) + c_3*dlogPROD + d_1*dUD + d_2*dlogPY$$

- **Household consumption (C)**. In the long run, it depends on real personal disposable income (RPDI). It also depends on interest rates (UKIR) which capture the cost of borrowing and affect households savings.

$$dlogC = a*(logC(-1) - b*logRPDI(-1)) + c_1*dlogC(-1) + c_2*dlogC(-1) + c_3*dlogRPDI + d_1*dUKIR$$

[5] '(-1)' denotes period t-1, or first-order lag; 'd' denotes the change between periods t and t-1; 'log' denotes natural logarithm.
[6] Cointegration keeps the slopes symmetrical over time but the series can have a permanent gap between them in level terms.

Model parameterisation

3.7 This section outlines the process of finding values for the coefficients in the error correction models; this is important because endogenous forecasts are affected by the choice of parameters. In the previous section we described the explanatory factors we included in each endogenous equation. This section explains how we selected the constant values, or parameters, which define the way each endogenous variable (unemployment rate gap, private wages, consumption) responds to changes in the respective explanatory factors. Our model parameterisation strategy is set out below.

- Creating an initial equation design based on theory and judgement – as in previous section.
- Estimating the equations on Scottish economic data, and creating an initial parameterisation using estimated values.
- If necessary, calibrating the equations to achieve the desired model and forecast properties (for example more satisfactory diagnostics and better model fit).

3.8 We will review parameter values periodically. Because of COVID-19, economic data are more uncertain and prone to revision than usual, so we may need to update our model parameterisation more regularly than in normal times.

Estimation and calibration

3.9 Scottish data tend to be volatile and available for relatively short time periods. This can make estimation unreliable, in which case parameters must be calibrated to have a better performing forecasting model. We use estimated parameters except when calibration is needed to improve the models, while maintaining a data-driven approach to parameterisation. Figures 3.2 to 3.4 show how our final models, based on calibrated parameters, compare to models based on estimated parameters.

Figure 3.2: Parameter values in unemployment rate gap ECM

Variable	Model based on estimated parameters [1]	Model based on calibrated parameters (our final model)
Error correction parameter	-0.07 (-1.81)	-0.14
UD(-1)	+1.00	+1.00
YD(-1)	-0.38	-0.38
dUD(-1)	+0.14 (+1.31)	+0.13
dYD(-1)	-0.06 (-0.93)	-0.06
dYD	-0.06 (-0.91)	-0.08
dUKYD	-0.08 (-0.91)	-0.09

Source: Scottish Fiscal Commission

[1] t-statistic in brackets (not available for long-run coefficients, which are restricted). Estimation sample is 1998Q1 to 2019Q4.

Figure 3.3: Parameter values in real private wages ECM

Variable	Model based on estimated parameters [1]	Model based on calibrated parameters (our final model)
Error correction parameter	-0.09 (-2.20)	-0.08
logRWPR(-1)	+1.00	+1.00
logPROD(-1)	+0.80	+0.80
dlogRWPR(-1)	-0.16 (-1.45)	+0.06
dlogPROD(-1)	-6.32 (-0.54)	+0.20
dlogPROD	+7.17 (+0.60)	+0.80
dlogPY	-0.28 (-1.30)	-0.05
dUD	+0.007 (+1.61)	-0.0035

Source: Scottish Fiscal Commission
[1] t-statistic in brackets (not available for long-run coefficients, which are restricted). Estimation sample is 1998Q1 to 2019Q4.

Figure 3.4: Parameter values in household consumption ECM

Variable	Model based on estimated parameters [1]	Model based on calibrated parameters (our final model)
Error correction parameter	-0.06 (-3.16)	-0.045
logC(-1)	+1.00	+1.00
logRPDI(-1)	+1.00	+1.00
dlogC(-1)	+0.13 (+1.22)	+0.25
dlogRPDI(-1)	+0.04 (+0.46)	+0.08
dlogRPDI	+0.09 (+1.15)	+0.10
dUKIR	-0.001 (-0.46)	-0.004

Source: Scottish Fiscal Commission
[1] t-statistic in brackets (not available for long-run coefficients, which are restricted). Estimation sample is 1998Q1 to 2019Q4.

Focus of the model

Private and public sector labour market data

3.10 The model has a focus on employment and earnings, broken down between private and public sectors. As discussed in the previous chapters, the labour market is important because the model's endogenous part primarily involves the labour market, and the breakdown by private and public sectors was one of the main motivations for the new model given the interconnection of employment and earnings forecasts with income tax. Labour market forecasts for the private sector are endogenous while those for the public sector are exogenous.

3.11 The approach focuses on forecasts of whole-economy employment, which is endogenous as it adjusts in line with the closure of the output gap and the unemployment rate gap. Public-sector employment is fixed in the model, broadly based on the outlook for the government sector, while private-sector employment varies in line with whole-economy employment. A similar approach is followed for employees forecasts. We also assume that all public-sector workers are employees (public-sector self-employment is zero).

Figure 3.5: Summary of identity equations for employment

Employment = Labour force – Unemployment

Private employment = Employment – Public employment

Employees = Employment * Share of employees in employment

Public employees = Public employment

Private employees = Employees – Public employees

3.12 Public-sector average earnings forecasts are exogenous while private-sector average earnings forecasts can be calculated from private-sector hourly wage forecasts, which are endogenous, and our exogenous average hours worked forecasts. The implicit assumption is that average hours worked are the same for the private and public sectors.

Figure 3.6: Summary of identity equations for earnings

Private average earnings = Private hourly wage * Average hours worked

Average earnings = (Private average earnings * (Private employees/Employees)) + (Public average earnings * (Public employees/Employees)

Private wages and salaries = Private average earnings * Private employees

Public wages and salaries = Public average earnings * Public employees

Wages and salaries = Private wages and salaries + Public wages and salaries

3.13 This section provides information on our methodology for obtaining separate estimates of employment and earnings by private and public sector, and for producing exogenous forecasts of public-sector employment and earnings.

Private and public sector average nominal earnings

3.14 With regards to the historical period, our source of earnings data for the private and public sectors is the Annual Survey of Hours and Earnings (ASHE) micro dataset, available to us via the Data Access Agreement we have in place with the Office for National Statistics and the National Institute for Economic and Social Research. We use workplace-based mean annual gross pay for all workers, broken down between private sector (private companies, sole proprietors, partnerships, non-profit bodies or mutual associations) and public sector (central government, local authorities, public corporations and nationalised industries).

3.15 We then transform the data from annual to quarterly, obtaining the average earnings series in Figure 3.7. We can see that the private and public sectors had a similar level of average earnings until the global financial crisis in 2008-09, when private earnings were hit by the recession and overtaken by public earnings.

3.16 We can also derive wages and salaries by private and public sector (and therefore for the all economy) from ASHE by multiplying the number of private and public employees by the corresponding average earnings series in Figure 3.7. However whole-economy wages and salaries derived from ASHE are different in level terms from the Quarterly National Accounts for Scotland

(QNAS), our core dataset for the Scottish economy, as shown in Figure 3.8. This is why we use QNAS wages and salaries as a control total (top-down constraint) and apportion this to private and public sectors using the respective shares based on ASHE, thus obtaining a QNAS-consistent series of wages and salaries by private and public sector. Figure 3.9 illustrates the public-sector share of ASHE-derived wages and salaries; this is broadly similar to the public-sector share of employees derived from the Scottish Government's Public Sector Employment (PSE) statistics publication.

3.17 As a final step, taking the private and public employees series used previously, we divide QNAS-consistent wages and salaries for the private and public sectors by the number of employees in the respective sector to obtain QNAS-consistent average earnings by private and public sector. These are illustrated in Figure 3.10, alongside the corresponding ASHE series we used as starting point. Further dividing earnings by hours worked gives hourly wages by private and public sector.

Figure 3.7: Private and public average earnings from ASHE, quarterly

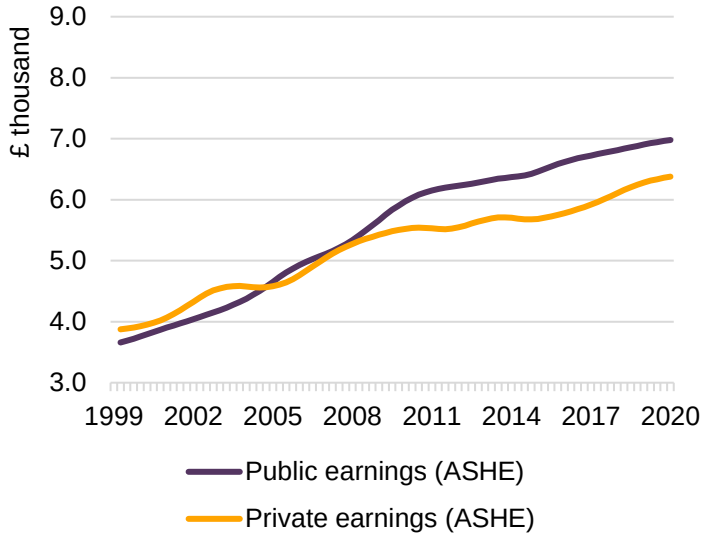


Figure 3.8: Whole-economy wages and salaries from QNAS and derived from ASHE, quarterly

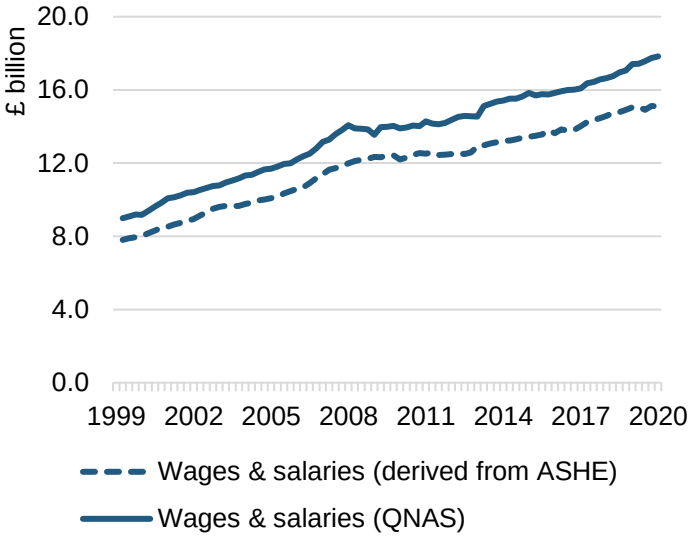


Figure 3.9: Public-sector shares of wages and salaries and of employees, quarterly

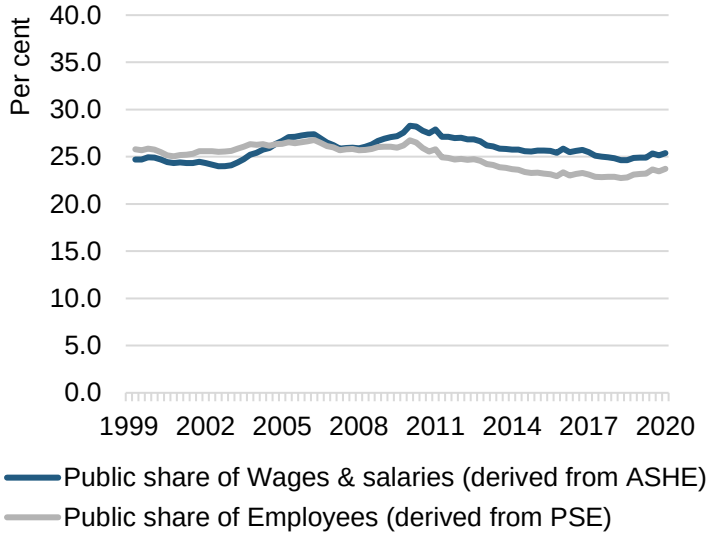
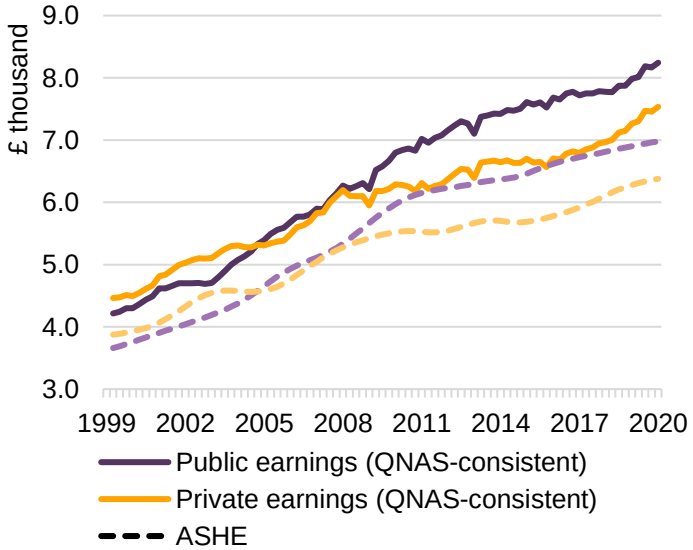


Figure 3.10: Private and public average earnings consistent with QNAS, quarterly



Source: Scottish Fiscal Commission, ASHE dataset – November 2020, Scottish Government (2020) Gross Domestic Product (GDP) Quarterly National Accounts: 2020 Quarter 2 (link), ONS (2020) HI11 Regional labour market: Headline indicators for Scotland – October 2020 (link), Scottish Government (2020) Public sector employment in Scotland: statistics for third quarter 2020 (link).

3.18 With regards to the forecast period, private earnings forecasts are endogenous because, as shown in Annex A, they are built up from private hourly wages which are determined in-model as a function of productivity, unemployment rate gap, and inflation. Public earnings forecasts are exogenous and, for Scotland's devolved public sector, are based on the Scottish Government's public sector pay policy – or a baseline pay growth assumption for the groups and years not covered by the pay deals.[7] Pay awards do not account for pay progression or promotions so we weight these up to overall earnings growth using analysis based on Survey of Personal Incomes data from our income tax model. For the reserved public sector, we use a pay growth assumption based on the UK Government's latest spending plans.

3.19 Average earnings forecasts are shown in Figure 3.11 broken down between private and public sectors, and in Figure 3.12 for the all economy along with corresponding series from the OBR for the UK and from ASHE as comparison.

Figure 3.11: Private and public average earnings, outturn and forecast, quarterly

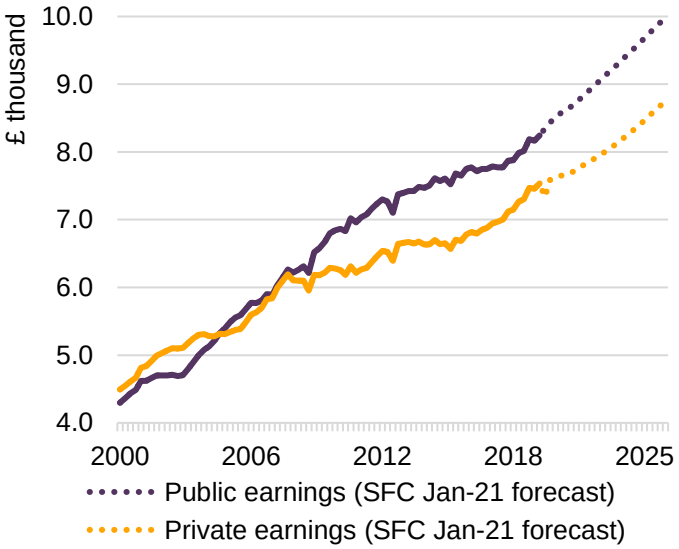
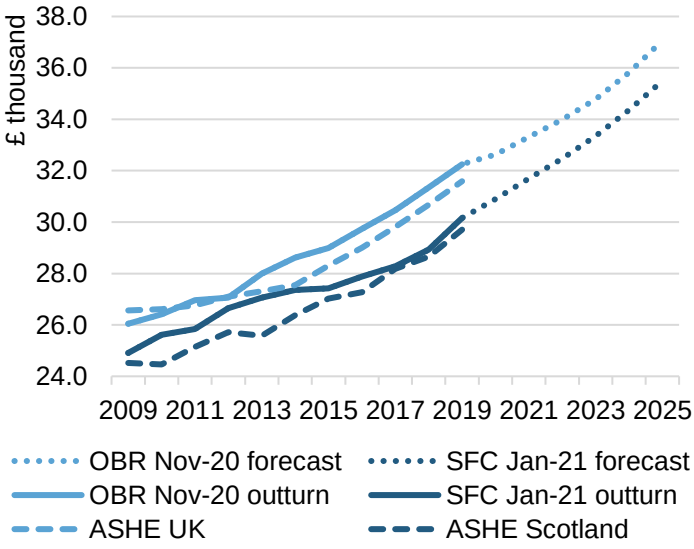


Figure 3.12: Whole-economy average earnings, outturn and forecast, Scotland and UK, annual



Source: Scottish Fiscal Commission, ONS (2020) ASHE access via Nomis (link).

Private and public sector employment

3.20 For the historical period, we use public-sector headcounts from the Scottish Government's Public Sector Employment (PSE) statistics publication as our measure of public-sector employment. We then subtract these estimates from Labour Force Survey (LFS) total 16+ employment to derive private-sector employment. This is broadly equivalent to splitting LFS total employment by applying the PSE public-sector share of total employment to the LFS. We use the PSE public-sector series excluding major reclassifications, such as the nationalisation of banks after the 2008-09 financial crisis, as these would introduce large discrepancies in the series. PSE headcounts are not seasonally adjusted, but this doesn't affect annual estimates which are the same with or without seasonal adjustment.

3.21 In contrast to earnings, ASHE may not be the best source for employment as it is likely to underestimate employment – for example because employees who don't have a valid work region or with missing or zero annual gross pay are filtered out – and so the disaggregation between private and public employees is also potentially unreliable.

[7] Scottish Government (2021) Public sector pay policy 2021-2022 (superseded) – 28 January 2021 (link), Scottish Government (2021) Public sector pay policy 2021-2022 (revised) – 24 March 2021 (link).

3.22 Figures 3.13 shows outturn data for the level of public-sector employment in Scotland. Figure 3.14 shows the public-sector share of total employment in Scotland and the UK from PSE statistics. The recent increase in the Scottish series reflects, in part, the expansion of employment in Scottish Government Agencies such as Social Security Scotland.

Figure 3.13: Public-sector employment, outturn, quarterly

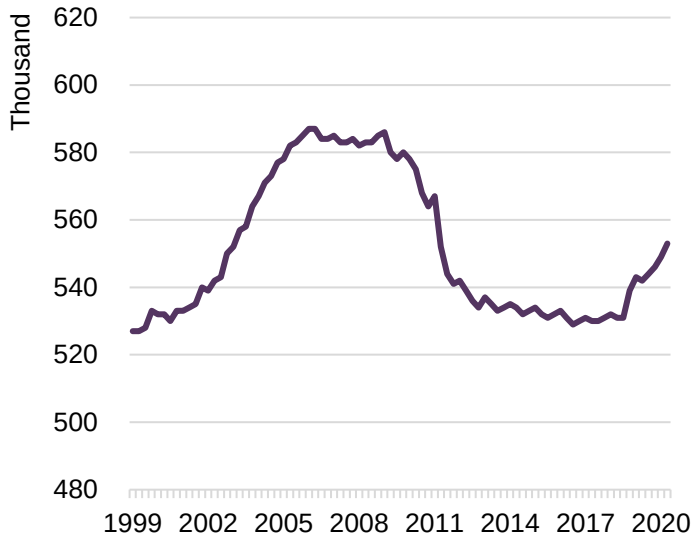
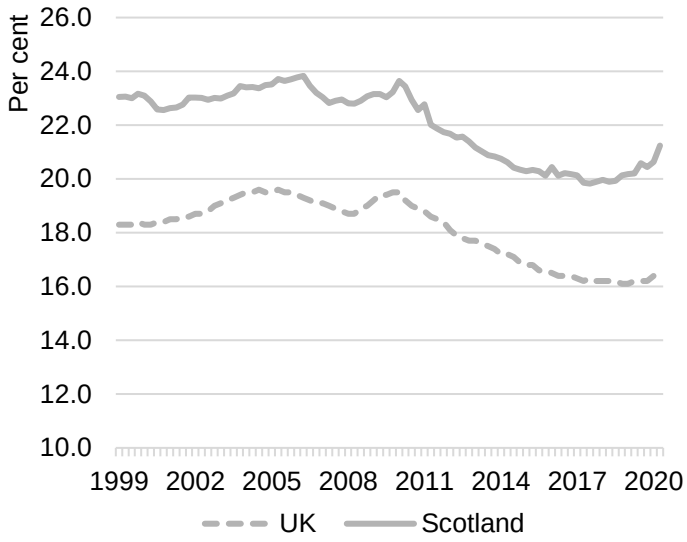


Figure 3.14: Public-sector share of total employment, outturn, quarterly



Source: Scottish Fiscal Commission, Scottish Government (2020) Public sector employment in Scotland: statistics for third quarter 2020 (link), ONS (2020) A01: Summary of labour market statistics – December 2020 (link).

3.23 For the forecast period, public-sector employment forecasts are obtained exogenously by dividing our Government consumption expenditure forecasts (proxy for total public sector output) by public-sector productivity forecasts (output per public sector employee).[8] Outturn and forecast series of public-sector productivity are derived at an earlier stage also using data on Government consumption expenditure and public-sector employment. These two steps in our public employment forecasting model are outlined in more detail below.

- **Implied public-sector productivity**. We divide General Government consumption expenditure outturn in Figure 3.15 by public-sector employment outturn in Figure 3.13 in order to derive estimates of public-sector productivity. We then obtain forecasts of public-sector productivity by applying our whole-economy trend productivity growth forecasts. The final series of implied public-sector productivity is shown in Figure 3.16.

- **Public-sector employment forecasts**. These are illustrated in Figure 3.17 and are the result of dividing our General Government consumption expenditure forecasts in Figure 3.15 by our implied public-sector productivity forecasts in Figure 3.16.

3.24 Figure 3.17 shows the output of our public employment forecasting model along with forecasts from an alternative method based on historical average growth in public-sector employment. Forecasts from our public employment forecasting model are relatively uncertain and volatile because of the COVID-19 shock affecting the Government consumption data and feeding through to our public-sector productivity series. For this reason, in our January 2021 forecast we used the historical average method, which produces similar but smoother forecasts. These forecasts are in line with a

[8] The approach of using changes in Government consumption expenditure to approximate movements in public sector employment ensures internal consistency with Government consumption figures but has limitations. Government consumption includes current expenditure on goods and services as well as staff costs, and excludes public corporations and nationalised industries which are part of the public sector (although public corporations employment represent a relatively small proportion, around 3 per cent, of Scotland's public sector employment).

ratio between public and total employment which is stable around its historical average, as shown in Figure 3.18. We will continue to monitor the data and keep our approach under review for the next forecasts.

Figure 3.15: General Government consumption expenditure, outturn and forecast, quarterly

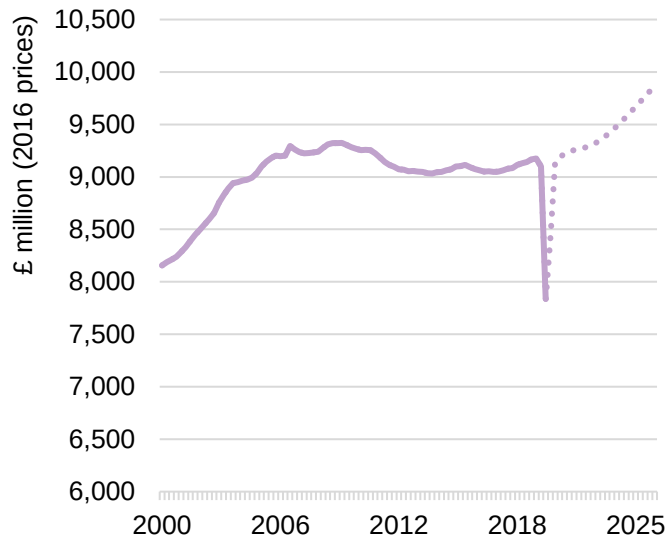


Figure 3.16: Implied public-sector productivity, outturn and forecast, quarterly

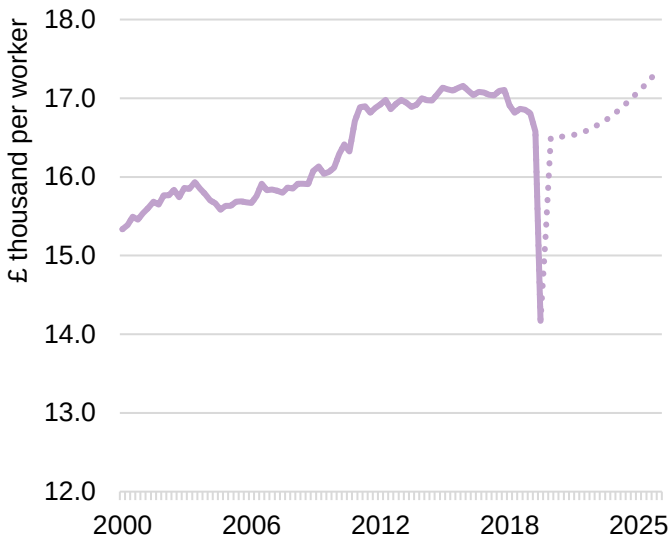


Figure 3.17: Public-sector employment, outturn and forecast, quarterly

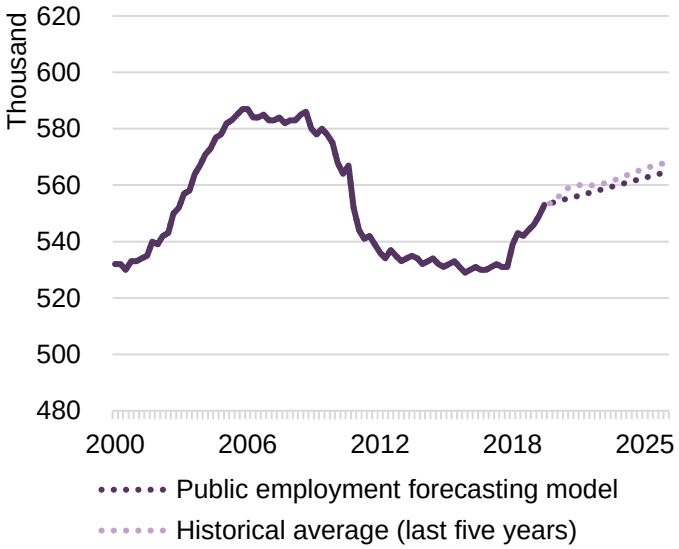
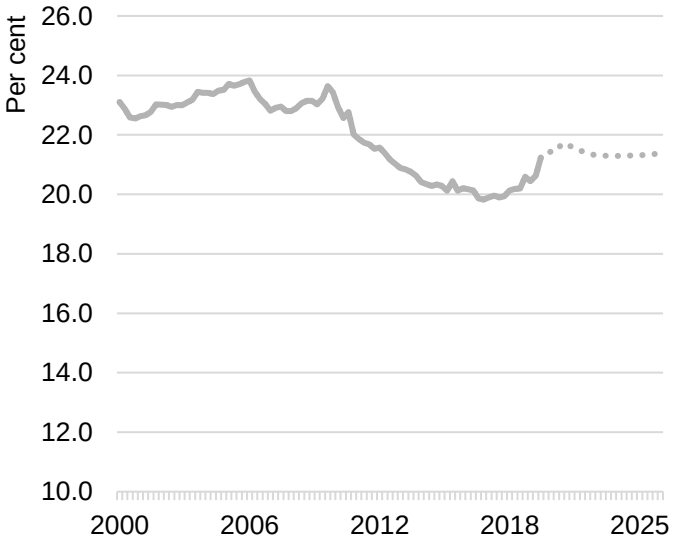


Figure 3.18: Public-sector share of total employment, outturn and forecast, quarterly



Source: Scottish Fiscal Commission, Scottish Government (2020) Gross Domestic Product (GDP) Quarterly National Accounts: 2020 Quarter 2 (link), Scottish Government (2020) Public sector employment in Scotland: statistics for third quarter 2020 (link).

3.25 As shown in Annex A, private-sector employment forecasts are calculated as the difference between our whole-economy employment forecasts, which are endogenous, and the exogenous public-sector employment forecasts. Employment forecasts are illustrated in Figure 3.19 for the whole economy and in Figure 3.20 for the private sector.

Figure 3.19: Whole-economy employment, outturn and forecast, quarterly

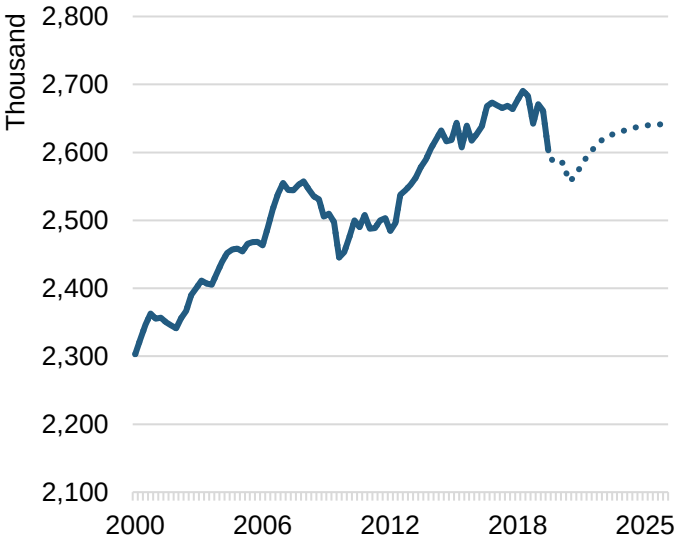
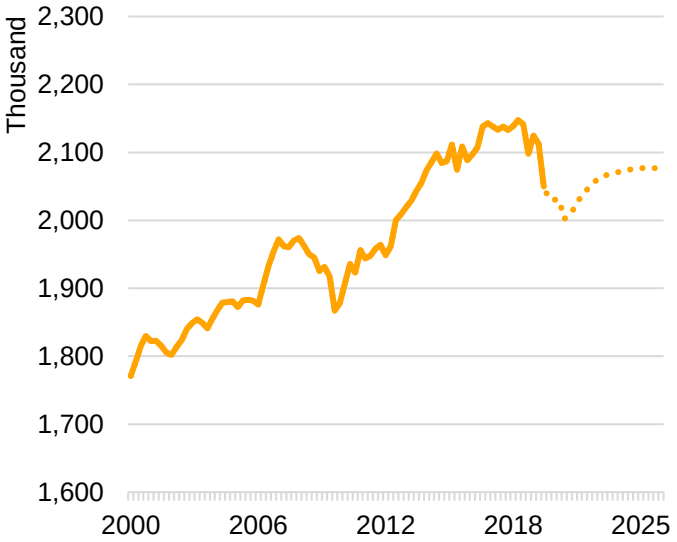


Figure 3.20: Private-sector employment, outturn and forecast, quarterly



Source: Scottish Fiscal Commission, LFS ONS (2020) HI11 Regional labour market: Headline indicators for Scotland – October 2020 (link).

Other household income sources

3.26 Like public employment and earnings, other sources of households income are also created off-model.

- **Social transfers, or social benefits**. We use a model based on population-adjusted OBR UK forecasts of social security expenditure, of which the largest component is pensioner spending (state pension and pension credit).

- **Other personal income**. This includes: mixed income (self-employment income and rental income); and non-labour income which comprises households' operating surplus (imputed rent), net property income (interests and dividends), employers' imputed social contributions, and net miscellaneous transfers. Our exogenous forecasts are obtained from a model based on the OBR's forecasts of mixed income and non-labour income for the UK as a whole, adjusted for different population growth in Scotland and the UK.

- **Taxes on household income**. We use a model based on: our Scottish Non-Saving Non-Dividend (NSND) income tax forecasts, growth in OBR UK savings & dividends income tax forecasts (derived by subtracting UK NSND from UK income tax), National Insurance Contributions (NICs) forecasts for Scotland (obtained as our Compensation Of Employees (COE) forecasts multiplied by the NICs share of COE for the UK), and OBR council tax forecasts for Scotland.

Annex A
Forecast equations

A.1 This Annex provides a list of the main variables in our macro model. For identity equations, we report the full list. Exogenous and endogenous variables are discussed throughout the paper and details on these can be found in Chapters 2 and 3. The EViews code as well as further information about any of our analysis are available on request.

Variable	Historical data source	Unit	Variable type or forecast equation
Unemployment rate gap (UD)	Derived (UR – URSTAR)	Percentage points	Endogenous
Private real hourly wages (RWPR)	Derived (WPR / CED * 100)	£/hour, CVM	Endogenous
Household consumption (C)	QNAS	£m, CVM	Endogenous
Labour force (LF)	LFS	000 people	Exogenous
Average hours worked (HOURS)	APS	Weekly hours	Exogenous
Population	NRS	000 people	Exogenous
Trend productivity (PROD)	SFC judgement	£/hour	Exogenous
Long-run unemployment rate (URSTAR)	SFC judgement	Rate	Exogenous
Trend GDP (YSTAR)	SFC judgement	£m, CVM	Exogenous
Public employment (EPU)	PSE	000 people	Exogenous
Public nominal average earnings (EARNPU)	Derived (Chapter 3)	£	Exogenous
Transfers (TRAN)	QNAS	£m	Exogenous
Other personal income (OPI)	QNAS	£m	Exogenous
Household taxes (TAX)	QNAS	£m	Exogenous
Government consumption (GC)	QNAS	£m, CVM	Exogenous
Government investment (GI)	QNAS	£m, CVM	Exogenous
Business investment (IB)	QNAS	£m, CVM	Exogenous
Housing investment (IH)	QNAS	£m, CVM	Exogenous
Exports (X)	QNAS	£m, CVM	Exogenous
Imports (M)	QNAS	£m, CVM	Exogenous
UK CED (UKCED)	OBR	Index	OBR forecast
UK GDP implied deflator (UKPY)	OBR	Index	OBR forecast

UK output gap (UKYD)	OBR	Per cent	OBR forecast
UK interest rates (UKIR)	OBR	Rate	OBR forecast
Consumer expenditure deflator (CED)	QNAS	Index	*CED(-1) * (UKCED / UKCED(-1))*
GDP implied deflator (PY)	QNAS	Index	*PY(-1) * (UKPY / UKPY(-1))*
Unemployment rate (UR)	LFS	Rate	*UD + URSTAR*
Unemployment (U)	LFS	000 people	*LF * UR / 100*
Employment (E)	LFS	000 people	*LF – U*
Private employment (EPR)	LFS, PSE	000 people	*E – EPU*
Share of employees in employment (EESHARE)	LFS, APS	Rate	*mean(EESHARE)*
Employees (EE)	LFS, APS	000 people	*E * EESHARE*
Public employees (EEPU)	PSE	000 people	*EPU*
Private employees (EEPR)	LFS, APS, PSE	000 people	*EE – EEPU*
Private nominal hourly wages (WPR)	Derived (EARNPR / HOURS)	£/hour	*RWPR * CED / 100*
Private nominal average earnings (EARNPR)	Derived (Chapter 3)	£	*WPR * HOURS*
Public wages and salaries (WSPU)	QNAS, ASHE	£m	*EARNPU * EEPU / 1000*
Private wages and salaries (WSPR)	QNAS, ASHE	£m	*EARNPR * EEPR / 1000*
Wages and salaries (WS)	QNAS	£m	*WSPU + WSPR*
Nominal earnings (EARN)	Derived	£	*WS / EE * 1000*
Nominal wages (WAGE)	Derived	£/hour	*(WS / (EE * HOURS)) * 1000*
Employers' social contributions (EMPSC)	QNAS	£m	*EMPSC(-1) * (WS / WS(-1))*
Compensation of employees (COMP)	QNAS	£m	*WS + EMPSC*
Change in net equity (EQ)	QNAS	£m	*EQ(-1)*
Personal disposable income (PDI)	QNAS	£m	*(COMP + TRAN + OPI + EQ) – TAX*
Real personal disposable income (RPDI)	QNAS	£m	*PDI / CED * 100*
Real GDP (Y)	QNAS	£m, CVM	*C + (GC + GI) + (IB + IH) + (X – M)*
Nominal GDP (YNOM)	QNAS	£m	*Y * PY / 100*
Output gap (YD)	Derived	Per cent	*((Y – YSTAR) / YSTAR) * 100*
Savings ratio (SAVRAT)	QNAS	Rate	*((RPDI – C) / RPDI) * 100*

Additional information

Abbreviations

APS	Annual Population Survey
ARIMA	Autoregressive Integrated Moving Average
ASHE	Annual Survey of Hours and Earnings
CED	Consumer Expenditure Deflator
COE	Compensation of Employees
CVM	Chained Volume Measure
ECM	Error Correction Model
GDP	Gross Domestic Product
LFS	Labour Force Survey
NAIRU	Non Accelerating Inflation Rate of Unemployment
NICs	National Insurance Contributions
NIESR	National Institute of Economic and Social Research
NRS	National Records of Scotland
NSND	Non-Savings and Non-Dividends
OBR	Office for Budget Responsibility
OECD	Organisation for Economic Co-operation and Development
ONS	Office for National Statistics
PAYE	Pay As You Earn
PSE	Public Sector Employment
QNAS	Quarterly National Accounts Scotland
RTI	Real Time Information
SFC	Scottish Fiscal Commission
SG	The Scottish Government
SGGEM	Scottish Government Global Economic Model
UK	United Kingdom

A full glossary of terms is available on our website:

https://www.fiscalcommission.scot/explainers/glossary/

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The Commission is committed to fulfilling our role as an Independent Fiscal Institution, in line with the principles set out by the Organisation for Economic Cooperation and Development (OECD).[9]

The Commission also seeks to adhere to the highest possible standards for analysis. While we do not produce official statistics, we voluntarily comply as far as possible with the UK Statistic Authority's Code of Practice for Statistics. Further details and our statement of voluntary compliance can be found on our website.[10]

[9] OECD (2014) Recommendation on Principles for Independent Fiscal Institutions (link)
[10] Scottish Fiscal Commission (2018) Compliance with the Code of Practice for Official Statistics (link)

Correspondence and enquiries

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All charts and tables in this publication have also been made available in spreadsheet form on our website. For technical enquiries about the analysis and data presented in this paper please contact the responsible analyst:

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