DEFINE-UK

Model Manual | Version 1.1

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1. Introduction

This document describes the technical details of version 1.1 of the DEFINE (Dynamic Ecosystem FINance-Economy)-UK model. DEFINE-UK is a country-specific application of the DEFINE modelling framework first developed by Dafermos et al. (2017). Drawing on the stock-flow consistent approach, DEFINE provides a coherent framework for the analysis of the interactions between the macroeconomy, the financial system, and the ecosystem. It does so by explicitly formulating the accounting structure of monetary and physical variables and by integrating key features of the post-Keynesian and the ecological economics tradition, such as endogenous money, path dependency, the role of demand as a driver of economic activity and the biophysical limits of a finite planet.

The application of the DEFINE framework to the UK has the following key features. First, the structure of the model is derived using UK national accounting data following the approach presented in George et al. (2025). Therefore, the models' accounting structure is derived directly from UK national accounting data. The main source of these data is the ONS blue book and economic accounts which provides national accounting data for the UK (ONS, 2022). One implication of this is that the model's stocks, flows, and institutional sectors are consistent with the structure of the UK economy. To ensure data consistency, while keeping the model reasonably tractable we have introduced residual terms in the transactions and balance sheet matrices, as in Zezza and Zezza (2019, 2022). In the case of flows, we introduced a residual transaction that captures the net position of flows that are not included in the model and in the case of stocks, we add a residual financial instrument that reflects the net asset position of the stocks excluded from the model. Second, although the behavioural equations draw on the same theoretical foundations as the DEFINE model, they have been developed such that they fit the UK context. Crucially, the key behavioural equations have been econometrically estimated to make sure that the parameter values fit the UK economy. Third, compared to DEFINE, the DEFINE-UK model provides a more disaggregated analysis of emissions (distinguishing between electricity and non-electricity emissions), makes a distinction between monetary and non-monetary financial institutions and formulates the housing market.

DEFINE-UK 1.1 introduces four extensions to the DEFINE-UK 1.0 model. First, the model incorporates limited forward-looking behaviour in response to policy announcements. Second, regulatory policies can directly depreciate the capital stock of affected sectors, capturing stranded asset effects. Third, the government sector is extended to permit direct ownership of production assets, specifically non-fossil power capital, allowing analysis of strategic public ownership as a decarbonisation instrument. Fourth, the model introduces a green sovereign bond instrument to finance green public investment in certain scenarios.

The document is structured as follows. Section 2 describes the models overall structure, Section 3 describes the model equations in detail, Section 4 describes the econometric estimations approach, finally Section 5 provides a list of parameter values and initial conditions.

2. Model overview

2.1. High level model structure

A high level overview of the model is presented in Figure 1. The DEFINE-UK model is a medium-large structural model, with 7 sectors: non-financial corporations, the power sector, households, monetary financial institutions, non-monetary financial institutions, the government, and the rest of the world, additionally there is a supplementary production module.

Many of the transactions in the model involve the production process, which is the combination of general production and power generation. GDP expenditure in the form of consumption ($CONS$), gross capital formation (GCF), and exports (EXP) less imports (IMP) flows into the production module. Meanwhile, GDP income in the form of wages, gross operating surplus (GOS_P), and indirect taxes on production ($INDTAX$) flows out of the production module. The separation of production in this way allows the model to reflect the fact that in the UK production occurs across many sectors to greater or lesser degrees. As shown in Figure 1, the production module is different to other sectors in that it does not have any assets or liabilities and simply serves as a way to track overall inflows and outflows to the production process.

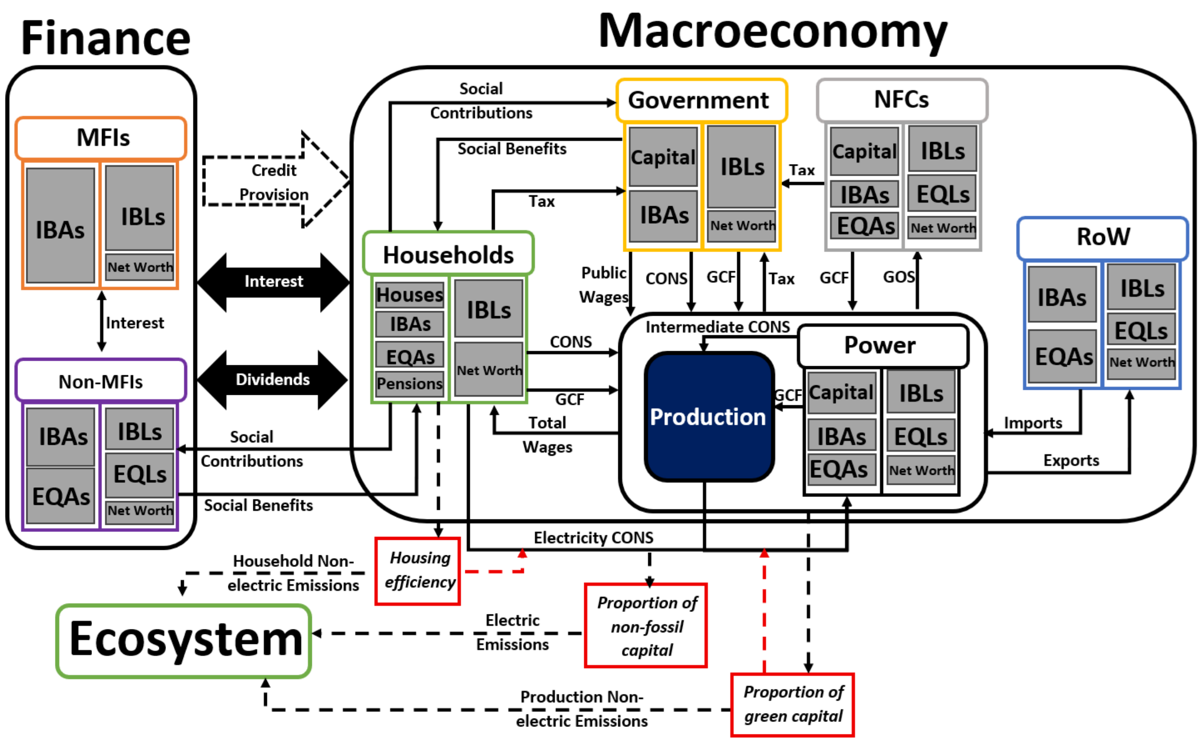
In order to account for the role of electricity generation in the economy, the industrial sectors in the model are split between the power sector (D35 in the European system of accounts NACE categorisation) and all other industrial sectors, which are then included in the production module of the model. Therefore, the production module accounts for the productive activity of all private and public firms aside from those which primarily generate electricity. Final consumption is divided between the final consumption of general production products ($CONS_P$) and the final consumption of power sector products ($CONS_{PS}$), the latter mainly being the consumption of electricity by households. Input-output interactions are included, in the form of intermediate consumption between the production and power sectors. Intermediate consumption of the production sector for products of the power sector (IC_{PSP}) accounts primarily for the consumption of electricity by industrial sectors, while intermediate consumption of the power sector for products of the production sector (IC_{PPS}) accounts for inputs into the electricity generation process, notably fossil fuels. Both the production and power sectors also have internal intermediate consumption that completes the input-output structure.

We have separated monetary financial institutions (MFIs), which describe the traditional banking sector, from non-monetary financial institutions (NMFIs), which describe other financial institutions such as investment funds and private pension funds. All sectors receive interest from the MFI sector based on their holding of interest bearing assets and pay interest to the MFI sector based on their holding of interest bearing liabilities. Dividend payments occur between many sectors and dividend payments are administered through the NMFI sector. Social contributions are paid by households to the government and NMFI sectors, and social benefits are paid to households by those same sectors. Other income (OI) and pension adjustment ($PENS_{ADJ}$) are paid by NMFIs to the household sector. A residual transaction for each sector is used to bring model-determined net lending in line with the net lending level from national accounts.

Total emissions are separated by source, with energy use being separated between industrial energy use in the production sector and the energy used directly by households. Energy use is further separated for these sectors into electricity and direct energy consumption with these different energy sources, resulting in different emissions levels based on the composition of different types of sectoral capital stock.

Although much of this structure is standard to macroeconomic models, and particularly SFC models, it can be seen how the empirical SFC approach has led to different considerations to other models. Some examples that illustrate this: the separation of production is non-standard, but is necessary to reflect that production does not occur uniquely in one national accounting sector; pensions are not always included in SFC models but are found to be a highly significant household asset within the UK so are included in the model; social contributions and social benefits are rarely modelled but are found to be highly significant flows within the UK national accounts and therefore need to be included in the model.

Figure 1: Simplified Model Overview



2.2. Model accounting structure

The accounting structure of the model has been derived using UK national accounting data, following the approach presented in George et al. (2025). Therefore, the model's accounting structure is derived directly from UK national accounting data. The main source of these data is the ONS blue book and economic accounts which provides national accounting data for the UK (ONS, 2022). The derived model is "data consistent" insofar as there is a direct connection, across time between the stocks and flows in the model and the national accounting element on which they are based (George et al., 2025).

In order to maintain data consistency without deriving an overly complicated model, we choose to use residual terms (Zezza and Zezza, 2019, 2022; George et al., 2025) for both model flows and stocks. These terms are used to capture any flows and stocks which we decide are not necessary to be explicitly included in the model. Generally, for this model, this choice has been made based on the size of the respective stocks and flows such that when they are particularly small,[1] they are moved to the residuals. As in George et al. (2025), in the case of flows, we introduce a *residual transaction* that captures the net position of flows that are not explicitly included in the model. In the case of stocks, we add a *residual financial instrument* that reflects the net asset position of stocks not explicitly included in the model.

The accounting structure of the model can be described through three matrices, the transaction flow matrix, the balance sheet matrix, and the stock-flow matrix. The transaction flow matrix, given by Table 1, shows all the monetary flows tracked within the economic model. We present values derived from UK accounting data in this table, where the size of flows are presented as a percentage of GDP averaged over the 2000-2022 period. For example, the outflow of household consumption spending takes the value of -59.8 in the table, which corresponds to household consumption spending being 59.8% of overall GDP. In the table, the signs refer to inflows and outflows. Positive signs correspond to monetary inflows, while negative signs are outflows. Therefore, every row sums to 0 as, following the principles of stock-flow consistency, every monetary outflow must have a corresponding monetary inflow. Every column ultimately sums to the net-lending position of each sector which will then drive stock adjustments, once again ensuring that all monetary values are recorded across model periods.

The balance sheet matrix, given by Table 2, shows all stock values in the model, both real and financial. Once again, the data are presented in terms of percentages of GDP averaged over the 2000-2022 period. For example, the total value of NFC capital stock is on average 105.6% of GDP. The sign of the numbers in this table now reflects whether we are referring to an asset of a liability. Positive signed values refer to assets, while negative signed values refer to financial liabilities. Real assets do not have corresponding liabilities by definition, however, for financial assets once again every row must sum to 0 as every financial asset must have a corresponding financial liability such that the sum across sectors must always equal 0 in order to satisfy the principle of stock consistency. The sum of columns gives the overall net-worth of each sector.

The connection between monetary flows and the evolution of financial stocks over time is described in the Stock-flow matrix, Table 3. This table shows how period by period gross capital formation, net-lending positions, and other financial transfers lead to updated values of various model stocks and ultimately changing sectoral net worth positions. In Table 3, data is presented in £ million over a year period, to show how the closing stock at the end of 2021 is updated to the closing stock at the end of 2022. Again, it is important to understand the signs of these values carefully. Financial transactions related to an increase in net financial assets are denoted by a plus sign, while financial transactions associated with a decline in net financial assets are denoted by a minus sign. Therefore, an increase in the value of a liability will be denoted by a negative sign. This means once more that, excluding real assets, all rows must sum to zero as net-financial asset transactions must be zero in order to maintain stock-flow consistency.

2.3. Model equations and calibration approach

The model features three high-level equation categories:

- **Identities**: Equations that are directly derived from the transactions and balance sheet matrices such that stock-flow consistent principles are adhered to. These include equations

[1] We consider a flow to be "small" when it is less than 1% of GDP.

Table 1: Transactions flow matrix, UK data in percent (%) of GDP, 2000-2022 average

Transaction Flow Matrix									
Flows		Sector							
	Production	**NFC**	**PS**	**MFI**	**Non-MFI**	**GVT**	**HH**	**RoW**	**Total**
GDP Expenditure									
Consumption (Production)	+79.1					-19.3	-59.8		0
Consumption (Power)			+0.7				-0.7		0
Gross Capital Formation	+20.6	-11.9	-0.5			-3.1	-5.1		0
Exports	+32.1							-32.1	0
Imports	-32.5							+32.5	0
Intermediate Consumption									
Prod → PS	-1.3		+1.3						0
PS → Prod	+1.8		-1.8						0
GDP Income									
Wages	-61.4						+61.4		0
Taxes	-12.4		- 0.1			+12.5			0
Gross operating surplus	-26.1	+26.1							0
Transactions									
Interest Paid to MFIs		-2.7	-0.1	+20.1	-3.6	-3.9	-3.9	-5.9	0
Interest Received from MFIs		+0.9	+0.02	-16.8	+5.6	+0.6	+1.5	+8.2	0
Dividends Paid to NMFIs		-8.2	-0.2		+12.9			-4.5	0
Dividends Received from NMFIs		+3.5	+0.1		-12.8		+5.0	+4.2	0
Taxes on income		-2.4				+14.9	-12.5		0
Social Contributions					+7.4	+8.5	-15.9		0
Social Benefits					-3.9	-14.2	+18.1		0
Other Income					-4.8		+4.8		0
Pension Adjustment					-3.5		+3.5		0
Residual Transaction		-5.2	0	-1.3	+2.0	-1.8	+6.5	-0.2	0
Net lending		0.0	-0.4	+2.6	-0.7	-5.9	+2.9	+1.5	0

Notes: A '+' sign represents a monetary inflow, while a '-' sign represents a monetary outflow. NFCs: Non-Financial Corporations; MFIs: Monetary Financial Institutions; NMFIs: Non-Monetary Financial Institutions; RoW: Rest of the World.

like NFCs model determined net lending position:

$$LEND_{NFCMt} = RP_{NFCt} - GCF_{NFCt}$$

where net-lending is equal to firms net-retained profits minus any gross capital formation undertaken. This is the lending budget constraint of the NFC sector and is required such that the net-lending position of this sector is equal to total monetary outflows minus total monetary inflows. As such, equations of this type are defined by the model structure itself and do not require any estimation.

- **Behavioural equations**: These equations determine how certain variables depend on other variables in the model based on behavioural parameters. An example is household consumption of production products:

$$\Delta \mathbf{L}(CONS_{HHPt}) = \epsilon_{CHHP}\big(\alpha_{0CHHP} + \alpha_{1CHHP}\mathbf{L}(YD_{HHt-1}) + \alpha_{2CHHP}\mathbf{L}(FNW_{HHt-1}) - \mathbf{L}(CONS_{HHPt-1})\big)$$

Other examples include investment equations, price inflation and productivity. These equations are driven by parameters that define the behaviour of the equations. For example, α_{1CHHP} in the above equations describes the long run relationship between household in-

Table 2: Balance Sheet matrix, UK data in percent (%) of GDP, 2000-2022 average

Balance Sheet								
Assets/liabilities	Sector							
	NFC	**PS**	**MFI**	**Non-MFI**	**GVT**	**HH**	**RoW**	**Total**
Real assets								
Capital (firms)	+105.6							+105.6
Capital (public)					+33.6			+33.6
Capital (power)		+4.8						+4.8
Housing						+335.9		+335.9
Financial Assets								
Interest Bearing Assets	+50.8	+1.4	-681.0	+192.8	+18.2	+89.6	+328.2	0
Interest Bearing Liabilities	-78.1	-2.6	+704.2	-141.3	-91.1	-89.7	-301.4	0
Equity Assets	+62.8	+1.7		-228.2		+51.1	+112.6	0
Equity Liabilities	-173.4	-3.7		+311.5			-134.4	0
Pensions				-139.6		+139.6		0
Insurance				-44.2		+44.2		0
Residual Instrument	-30.1	-0.9	+7.1	+13.6	+8.3	+0.9	+1.1	0
Net Worth	-62.3	-0.8	+7.5	-6.2	-31.0	+571.5	-0.3	+479.9

Notes: A '+' sign represents a positive value on a sectors balance sheet, while a '-' sign represents a negative one. NFCs: Non-Financial Corporations; MFIs: Monetary Financial Institutions; NMFIs: Non-Monetary Financial Institutions; RoW: Rest of the World.

come and consumption from production. These parameters need to be estimated, from data or other sources.

- **Technical relationships**: These are calibrated equations that are neither identities nor behavioural equations. Some technical relationships are definitions, such as the definition of the wage share:

$$W_{St} = \frac{W_t}{GDP_t} \tag{1}$$

Where these definitions are generally well established. In other cases technical relationships can be variables which are projected to follow a defined baseline path for example other government consumptions:

$$OCONS_{GVTt} = \alpha_{OCONSGVT} GDP_{t-1} \tag{2}$$

Where it is assumed that this variable maintains a fixed relationship with the previous periods GDP. Fixed relationships like this could be driven by behavioural equations, however it has been decided to model them exogenously. The justification for such a choice can vary, for other government consumption it is assumed that government spending is a policy variable such that the government can choose its level of spending. Therefore, it can be assumed to follow a constant ratio in the baseline but could also be adjusted based on government spending forecasts.

Table 3: Stock-flow matrix, 2021 - 2022 (£ million), UK

		NFC	PS	MFI	Non-MFI	GVT	HH	RoW	Total
Opening net worth (2021) (1)		-1048.0	-20.2	-103.9	-399.0	-826.9	+7398.8	+49.9	+5050.7
Gross capital formation (2)		+221.2	+9.0			+77.4	+116.1		+423.7
Depreciation of real assets (3)		-203.4	-10.4			-52.3	-105.9		-372.0
Other changes in real assets (4)		+204.9				+54.4	+135.8		+395.1
Changes in real assets (5)=(2)-(3)+(4)		+222.7	-1.4			+79.5	+146.0		+446.8
Changes in net financial assets arising from financial transactions	Interest-bearing assets*	+3.3	+0.1	-297.0	+184.2	-44.4	+63.1	+90.7	0
	Interest-bearing liabilities**	-125.8	-3.5	+453.9	+30.7	-93.3	-75.9	-186.1	0
	Equity assets*	+95.7	+2.7		-75.4		-45.1	+22.1	0
	Equity liabilities**	+43.7	+1.2		-101.9			+57.0	0
	Pensions				-83.8		+83.8		0
	Insurance				+7.0		-7.0		0
	Residual FI	+5.7	-26.0	-63.8	+7.2	+21.6	-24.5	+79.8	0
Actual net lending (6)		+22.6	-25.5	+93.1	-32.0	-116.1	-5.6	+63.5	0
Other changes in net financial assets	Interest-bearing assets*	-55.2	-1.6	+112.5		+2.1	+7.4	-65.2	0
	Interest-bearing liabilities**	+191.7	+5.4	+65.8		-20.7	-0.8	-241.4	0
	Equity assets*	-82.1	-2.3		+107.7		-62.2	+38.9	0
	Equity liabilities**	+47.3	+1.3		-335.7			+287.1	0
	Pensions				+898.9		-898.9		0
	Insurance				+114.0		-114.0		0
	Residual FI	+250.4	+33.2	-576.5	+265.2	-85.1	-99.2	+212.0	0
Total other changes in net financial assets (7)		+352.1	+36.0	-398.2	+1050.1	-103.7	-1167.7	+231.4	0
Change in net financial assets (8)=(6)+(7)		+374.7	+10.5	-305.1	+1018.1	-219.8	-1173.3	+294.9	0
Closing net worth (2022) (9)=(1)+(5)+(8)		-450.6	-11.1	-409.0	+619.1	-967.2	+6371.5	+344.8	+5497.5

Notes: Financial transactions related to an increase in net financial assets are denoted by a plus sign, while financial transactions associated with a decline in net financial assets are denoted by a minus sign. NFCs: Non-Financial Corporations; MFIs: Monetary Financial Institutions; Non-MFIs: Non-Monetary Financial Institutions; RoW: Rest of the World; FI: Financial Instrument.
*Liabilities for the financial corporations
**Assets for the financial corporations

3. Full Model Description

3.1. Ecosystem

The ecological side of the model considers primarily the role of energy use, through electricity or direct energy use and emissions derived from the generation of said energy. Energy is an input to the production process, so economic activity always leads to greater energy use, which then can lead to higher emissions. Unlike the global DEFINE model of Dafermos and Nikolaidi (2022) we do not include matter or climate damages and instead focus on power generation and transition policy. Climate damage could be considered, but unlike a global model, the stock of greenhouse gases is not an endogenous variable, with UK emissions only making up a small fraction of global emissions[2]. Therefore, damages would be driven exogenously based on the predicted level of global emissions. Such an analysis would be valuable for exploring the UKs medium to long term exposure to climate risk however currently the model focuses on the short to medium term analysis of the effectiveness of transition policy. The inclusion of matter is also an area of interest; however, much matter in the UK is imported and the global stock of materials is not going to be heavily impacted by the UK material use.[3] The current environmental structure of the model is well placed to analyse the impacts of policies targeting the expansion of non-fossil fuel energy generation and investment in greening the UK housing stock. These are areas that are high on the green policy agenda in the UK.

[2]UK territorial emissions make up approximately 1% of global emissions (ONS, 2025)
[3]This will be something to include in future extensions of the model.

3.1.1. Energy

Energy is considered in an aggregate way, similar to the DEFINE-GLOBAL model. However, unlike the global DEFINE, a distinction is made between the energy produced by households from activities within the home, such as heating and the use of electrical appliances, and the energy used in production, which includes all other final energy use. This distinction helps us isolate energy use in homes, which is mostly independent of economic activity from other energy use. Household energy use in homes is a relatively large proportion of final energy use within the UK, so this extension allows us to consider more directly the role of households in UK energy use and also allows us to look at policy scenarios that directly target the household sector.

Rather than directly distinguishing between fossil fuel and non-fossil fuel energy, as is the case within the global DEFINE model, the model instead distinguishes between electricity and direct energy use. This distinction is consistent with country-specific ecological models such as EUROGREEN (D'Alessandro et al., 2020). Electricity refers to all energy drawn from the electricity grid, whereas direct energy consumption refers to all other energy use such as the direct burning of fossil fuels in vehicles or houses. Electricity can be provided by either fossil fuel or non-fossil fuel sources, whereas direct energy consumption is assumed to be entirely fossil fuel based. This allows the model to more directly assess the transition of the electricity grid towards non-fossil fuel sources and the impact of electrification, including the price of electricity, on the wider economy. The total energy use (E) is calculated as the sum of the energy use from production (E_P) and the energy use from housing (E_H) (Eq.(1)). The energy use for production (E_P) is the product of overall economic activity, represented by the real gross output of production (GO_{PR}) and the energy efficiency of production (ϵ). The total use of household energy (E_H) is given by the sum of household electricity use (E_{ELECH}) and direct energy consumption (E_{DH}).

$$E_t = E_{Pt} + E_{Ht} \tag{1}$$

$$E_{Pt} = \epsilon_t GO_{PRt} \tag{2}$$

$$E_{Ht} = E_{ELECHt} + E_{DHt} \tag{3}$$

The total electricity (E_{ELEC}) is the sum of the electricity for production (E_{ELECP}) and electricity for housing (E_{ELECH}) (9). The maximum electricity ($E_{ELECMAX}$) that can be generated at an time is given as the sum of the capital efficiency of the fossil fuel and non-fossil fuel electricity capital (EFF_{FF} & EFF_{NFF}) multiplied by the respective real capital of fossil fuel and non-fossil fuel power capital (K_{PSFFR} & K_{PSNFFR}) (Eq. (5)). In this context, the efficiency parameters capture several properties, including the average capacity factor, defined as the ratio between average electricity production to maximum electricity production (Bolson et al., 2022), technological improvements to electricity production, the conversion between monetary capital value and electricity production and implicitly the operating hours of power plants. Fossil fuel efficiency is set as a constant; this is due to UK fossil fuel sources being almost entirely gas-fired power plants which have limited scope for further energy efficiency improvements, with these plants already operating at almost 80% of Carnot efficiency[4] Non-fossil fuel efficiency can and will change over time and this process is described by Equation (**??**). It is worth highlighting that in general, the non-fossil fuel capital efficiency is lower than the fossil fuel capital efficiency, mainly due to the variable nature of renewable energy production, leading to a lower capacity factor for non-fossil fuel capital. This

[4] Carnot efficiency refers to the theoretical maximum efficiency of a heat engine.

means that, as is common in the environmental literature (Hirth and Steckel, 2016), non-fossil fuel electricity production is more capital intensive than fossil fuel production.

$$E_{ELECt} = E_{ELECPt} + E_{ELECHt} \tag{4}$$

$$E_{ELECMAXt} = CF_{FF}K_{PSFFRt} + CF_{NFFt}(K_{PSNFFRt} + K_{GVTNFFRt}) \tag{5}$$

Non-fossil fuel electricity is assumed to be used prior to fossil fuel electricity to meet electricity demand. This is due to the cost of non-fossil fuel energy production being primarily the initial cost of capital Timilsina (2021), such that the marginal cost of non-fossil fuel power production is low resulting in it always being able to offer a competitive price to energy markets when compared with fossil fuel electricity generation . Therefore, the output of non-fossil fuel electricity ($E_{ELECNFF}$) is equal to its maximum generation capacity (i.e. $CF_{NFFt}K_{PSNFFR}$) until the point where its capacity is greater than the total electricity demand (E_{ELECt}) (Eq. 6). The constant σ_{ELEC} is included in Eq. (6) , where this constant is slightly lower than one, in order to capture the effect that even in a full non-fossil fuel energy transition scenario it is likely that a small proportion of electricity will not be able to be provided by non-fossil fuel sources due to weather effects or unexpected short-term increases in electricity demand. Fossil fuel electricity (E_{ELECFF}) then covers the remainder of electricity demand (Eq. 7), this means that even though the efficiency of fossil fuel generation is higher than that of non-fossil fuel generation, fossil fuel capital tends to be underutilised, with fossil fuel sources only being used when electricity demand cannot be satisfied by non-fossil fuel sources.

$$E_{ELECNFFt} = min(E_{ELECt}\sigma_{ELEC}, CF_{NFFt}K_{PSNFFRt}) \tag{6}$$

$$E_{ELECFFt} = E_{ELECt} - E_{ELECNFFt} \tag{7}$$

The demand for electricity from production (E_{ELECP}) is based on the intensity of the electricity demand for the production energy (θ_P) multiplied by the total energy demand for production (E_P). The electricity use of houses (E_{ELECH}) defined in Eq. (9) is based on the number of houses under different classifications: inefficient houses (H_I) efficient non-electric houses (H_{EN}) and efficient fully-electric houses (H_{EE}). These different house classifications have been constructed in the UK based on Energy Performance Certificate (EPC) data (UK Department for Levelling UP, Housing & Communities, 2025). Inefficient houses have an EPC rating of D or below, reflecting low energy efficiency within these houses. The other two categorisations are houses with an EPC rating of C or above, reflecting much higher energy efficiency and fully-electric houses are those where the primary energy source of the house is electric as opposed to a gas boiler as is common in most UK houses. Therefore, in Eq. 9 only a portion of the energy demand of inefficient and efficient non-electric houses is electricity based, whereas all energy demand of efficient electic houses will be electricity based. In this equation, the θ's represent the energy efficiency of houses of each type, while the value β_{ELECHH} reflects the proportion of use of electricity in non-fully electric houses[5].

$$E_{ELECPt} = \theta_{Pt}E_{Pt} \tag{8}$$

$$E_{ELECHt} = (\theta_{HI}H_{It} + \theta_{HEN}H_{ENt})\beta_{ELECH} + \theta_{HEE}H_{EEt} \tag{9}$$

The total direct energy consumption (E_D) is the sum of the direct energy consumption related to

[5]Relating to common electrical uses from household white goods etc.

production (E_{DP}) and the direct energy consumption related to housing (E_{DH}) (10). The demand for direct energy from production (E_{DP}) is defined as the proportion of energy for production not provided by electricity $(1 - \theta_P)$ multiplied by the total energy demand for production (E_P). The direct energy consumption of houses (E_{DH}) defined in Eq. (12) is calculated similarly to Eq. (9) with the remainder of inefficient (H_I) and efficient non-electric (H_{EN}) energy demand being drawn from direct energy sources.

$$E_{Dt} = (E_{DPt} + E_{DHt}) \tag{10}$$

$$E_{DPt} = (1 - \theta_{Pt})E_{Pt} \tag{11}$$

$$E_{DHt} = (\theta_{HI}H_{It} + \theta_{HEN}H_{ENt})(1 - \beta_{ELECH}) \tag{12}$$

3.1.2. Emissions

The total greenhouse gas emissions ($EMIS$) are split into direct energy consumption emissions ($EMIS_D$) and electricity emissions ($EMIS_{ELEC}$) (Eq. (13)). Direct energy consumption emissions, which arise from entirely fossil fuel based direct energy use, are calculated as the product of the direct energy consumption emission intensity (ω_D) and total direct fossil energy consumption (E_{Dt}) (Eq. (14)). Electricity emissions are then calculated as the product of the electricity emission intensity (ω_{ELEC}) and the provision of fossil fuel-based electricity (E_{ELECFF}) (Eq. (15)).

$$EMIS_t = EMIS_{Dt} + EMIS_{ELECt} \tag{13}$$

$$EMIS_{Dt} = \omega_{Dt}E_{Dt} \tag{14}$$

$$EMIS_{ELECt} = \omega_{ELECt}E_{ELECFFt} \tag{15}$$

These equations are highly aggregated, so the model cannot look at changes within the direct energy mix nor changes to the fossil fuel electricity energy mix. The latter is justified for the UK somewhat by the dominance of gas generation and little scope to green fossil fuel electricity production (aside from moving to non-fossil fuel sources). On direct energy consumption, again the model cannot look at changes to the energy mix, in the time period of the model scenarios (around 15 years) this is somewhat justifiable; however, there are important technological changes that could be ignored here such as low carbon hydrogen which is a focus of UK government policy (UK Department for Energy Security and Net Zero, 2021). Such technologies are still in their infancy in the UK and there is limited reliable data or projections to assess them directly at this stage; if this changes then the model could be expanded to consider hydrogen and other direct energy use more explicitly. Therefore, for the purposes of this model, the aggregated form of direct energy consumption and electricity emissions is sufficient and it is possible to implicitly capture technological improvement through efficiency parameters, which will be described in the next set of equations.

3.1.3. Ecological efficiency and technology

This section now presents the ecological efficiency and technology parameters that are the key channels through which macroeconomic variables and policies impact the ecological side of the model. For the following five equations, logistic equations have been employed in all cases. The use of logistic functions here allows the model to account for learning processes and positive spillover effects while also allowing the setting of theoretical maximum and minimum values for many of these efficiency-based parameters, in line with UK projections[6] in a way similar to the global DEFINE model (Dafermos and Nikolaidi, 2022).

The energy efficiency of production (ϵ) is driven by the ratio of green productive capital to conventional productive capital, the higher the use of green capital, the less energy is required per unit of real output, reflected by a reduction in the value of ϵ (Eq. (16)). The capacity factor of non-fossil fuel electricity production (CF_{NFF}) is variable and is reduced according to the ratio between non-fossil fuel and fossil fuel energy production (Eq. (17)). It may seem counter-intuitive that the non-fossil capacity factor falls as electricity production rises, in reality there are two effects occurring at the same time, a positive technological effect and a negative capacity volatility effect. For technological change, greater use of non-fossil capital, along with general exogenous efficiency improvements to the technology, would be expected to increase non-fossil fuel efficiency over time. However, in the short term this is likely to be smaller than the negative impact of higher non-fossil fuel electricity production resulting from non-fossil fuel energy sources including renewable energy which generates intermittent electricity based on weather conditions; as the prevalence of non-fossil fuel electricity increases, it is expected that this intermittence will result in a higher frequency of periods where non-fossil electricity is effectively wasted, thus reducing the average capacity factor of non-fossil fuel electricity production. This is calibrated based on recent data on non-fossil fuel electricity production in the UK which suggests a negative relationship between the proportion of non-fossil fuel capital in the energy mix and its efficiency level. This implicitly assumes no major technological changes to electricity storage in the UK, which could mitigate against this effect. Furthermore, changes to the non-fossil fuel energy mix, such as an increase in nuclear electricity generation, would mitigate against this issue. Therefore, Eq. (17) has been parametrised to be less pessimistic than past UK data would suggest, in order to partially account for the development of other forms of non-fossil electricity generation.

The proportion of electricity used in the production process (θ_P) is driven by the ratio of green productive capital to conventional productive capital, the higher the use of green capital, the greater the use of electricity in the productive process (Eq. (18)). The intensity of direct energy consumption emissions (ω_D) is driven similarly by the ratio of green productive capital to conventional productive capital, with a greater use of green capital resulting in a lower emission intensity (Eq. (19)).[7] Finally, the emission intensity of electricity production (ω_{ELEC}) reduces based on the ratio between non-fossil fuel and fossil fuel energy production(Eq. (20)). This captures the merit-order effect[8] resulting in a fall in average emissions of fossil fuel electricity production as there is greater non-fossil fuel penetration in energy markets.

$$\epsilon_t = \epsilon_{min} + \frac{(1+\pi_1)\cdot(\epsilon_{max}-\epsilon_{min})}{1+\pi_1 e^{\kappa_1 (K_{PGt-1}/K_{PCt-1})}} \tag{16}$$

$$CF_{NFFt} = CF_{min} + \frac{(1+\pi_2)\cdot(CF_{max}-CF_{min})}{1+\pi_2 e^{\kappa_2 (E_{ELECNFFt-1}/E_{ELECFFt-1})}} \tag{17}$$

[6]For the importance of these processes in energy systems and renewable energy technologies, see Kahouli-Brahmi (2009) and Tang and Popp (2016).

[7]This effect is however relatively small and there are only marginal reductions in direct energy consumption emission intensity possible within the model, this is in line with past UK data and the current UK energy mix which is predominantly oil (petrol) and gas based.

[8]As lower cost non-fossil fuel energy sources expand this changes the order in which power plants are dispatched to meet energy demand with the least efficient, most costly, plants ceasing their operations first.

$$\theta_{Pt} = 1 - \frac{1 + \pi_3}{1 + \pi_3 e^{-\kappa_3 K_{PGt-1}/K_{PCt-1}}} \tag{18}$$

$$\omega_{Dt} = \omega_{dmin} + \frac{(1 + \pi_4) \cdot (\omega_{dmax} - \omega_{dmin})}{1 + \pi_4 e^{(\kappa_4 K_{PGt-1}/K_{PCt-1})}} \tag{19}$$

$$\omega_{ELECt} = \omega_{emin} + \frac{(1 + \pi_5) \cdot (\omega_{emax} - \omega_{emin})}{1 + \pi_5 e^{\kappa_5 (E_{ELECNFFt-1}/E_{ELECFFt-1})}} \tag{20}$$

3.2. High-level macroeconomic variables

The macroeconomy in the model is made up of several sectors that interact with each other through monetary and financial relationships. The sum of these interactions generates high-level macroeconomic variables, in particular the gross domestic product (GDP) and the total level of employment. This section will describe these high-level variables before looking at the individual sectors in the following sections.

Total GDP is defined following the expenditure approach as consumption ($CONS$), plus gross capital formation (GCF), plus exports (EXP) minus imports (IMP) (Eq. (21)), with consumption being the sum of household ($CONS_{HH}$) and government ($CONS_{GVTt}$) consumption (Eq. (22)) and gross capital formation being the sum of the capital formation of households (GCF_{HH}), non-financial corporations (GCF_{NFC}), the power sector (GCF_{PSG}), and the government (GCF_{GVT}) (Eq.(23)). By defining GDP in this way, it is implicitly assumed that the economy's output is driven by demand, in line with post-Keynesian tradition (Palley, 1996; Lavoie, 2014; Hein, 2023). Total gross output in the economy[9] (GO) is defined as the sum of gross output for the two input-output sectors in the model; gross output from production (GO_P) and gross output from the power sector (GO_{PS}).

While high level macroeconomic variables are demand determined there are supply constraints in the model. The role of supply in post-Keynesian analysis is often under-emphasised when compared to demand. This may be in part in opposition to the fully supply-determined approach of many main macroeconomic models such as DSGE and CGE approaches, although it is also due to the post-Keynesian argument that supply-side factors, such as technology and productivity, will respond to some extent to demand pressures (Stockhammer, 2023). Setterfield (2023) argue that supply side constraints can and should be integrated into post-Keynesian macroeconomic models and Stockhammer (2008) show how post-Keynesian inflation theory introduces a form of labour supply constraint. Furthermore, ecological macroeconomic models such as EUROGREEN and DEFINE (D'Alessandro et al., 2020; Dafermos et al., 2017) both include a form of supply constraints. There are several areas where supply will constrain the model, most notably through the relationship between prices and employment. However, the model does not feature a non-accelerating inflation rate of unemployment (NAIRU), which is often assumed in mainstream macroeconomic approaches. As output can also expand the supply constraint, lower unemployment, despite leading to higher wages, is not necessarily inflationary. This is in line with criticisms of the NAIRU by Storm and Naastepad (2011), with the model rejecting the binary trade-off between unemployment reduction and controlling inflation.

$$GDP_t = CONS_t + GCF_t + EXP_t - IMP_t \tag{21}$$

$$CONS_t = CONS_{HHt} + CONS_{GVTt} \tag{22}$$

[9] Including intermediate inputs to production.

$$GCF_t = GCF_{NFCt} + GCF_{PSt} + GCF_{GVTt} + GCF_{HHt} \tag{23}$$

$$GO_t = GO_{Pt} + GO_{PSt} \tag{24}$$

Real GDP (GDP_R) is defined as real consumption ($CONS_R$), plus real gross capital formation (GCF_R), plus real exports (EXP_R) minus real imports (IMP_R) (Eq. (25)). Real consumption, gross capital formation, and gross output are all defined as their nominal values divided by the overall production price deflator (P_P) (Eqs. (26), (27) & (28)). A point to highlight here is that in general the model behavioural equations are presented in nominal terms and then converted to real values through prices. There are several reasons for taking this approach; the first is pragmatic, the "raw" national accounting data is nominal and requires the calculation of some deflator to convert to a real series, this approach allows us to work more with actual observed data and rely less on price calculations. However, there is also a theoretical reason to do this, based on the post-Keynesian tradition, money is not neutral and nominal changes will impact real outcomes (Asensio et al., 2012; Lavoie, 2014). This is particularly important for the implementation of supply constraints in the model, where the distinction between nominal and real variables allows real variables to be constrained through prices. This interaction facilitates a model that is demand-determined, in line with post-Keynesian tradition, while also being supply constrained through prices, which better reflects the structure of individual economies.

$$GDP_{Rt} = CONS_{Rt} + GCF_{Rt} + EXP_{Rt} - IMP_{Rt} \tag{25}$$

$$CONS_{Rt} = \frac{CONS_t}{P_{Pt}} \tag{26}$$

$$GCF_{Rt} = \frac{GCF_t}{P_{Pt}} \tag{27}$$

$$GO_{Rt} = \frac{GO_t}{P_{Pt}} \tag{28}$$

Overall (quarterly) GDP growth (g) is then defined based on its change between period t and $t-1$ (Eq. (29)). While the overall GDP price deflator (P) is defined as the ratio between nominal (GDP) and real (GDP_R) GDP (Eq. (30)).

$$g_t = \frac{GDP_t}{GDP_{t-1}} \tag{29}$$

$$P_t = \frac{GDP_t}{GDP_{Rt}} \tag{30}$$

Turning to supply within the model, the model employs a Leontief-type production function for both labour and capital. Therefore, the productivity of both labour and capital must be defined within the model. Labour productivity per worker (λ) is set as a function of real growth GDP_R as a Kaldor-Verdoorn relationship (Kaldor, 1975), while also including the growth of real productive investment (excluding housing investment) as an additional factor of productivity growth a la Thirlwall (2007) (Eq. (31)). This allows the model to account for demand-driven productivity growth as per the post-Keynesian tradition, while allowing productive investment to have an additional positive impact on the growth of productivity through capital deepening. Real capital productivity (ν) is defined as a constant based on its initial value (Eq. (32)), this is a reasonable assumption as the implied value of real capital productivity in the UK is mostly constant over past data. This implies that the capital constraint in the model can only be moved through investment in new capital.

$$\Delta\mathbf{L}\lambda_t = \alpha_{0\lambda} + \alpha_{1\lambda}\Delta(\mathbf{L}(GDP_{Rt})) + \alpha_{2\lambda}\Delta(\mathbf{L}(GCF_{Rt} - GCF_{HHRt})) \tag{31}$$

$$\Delta\nu_t = 0 \tag{32}$$

Employing the Leontief-type production function for labour leads to the definition of total employment (EMP) as equal to real GDP (GDP_R) divided by labour productivity per worker (Eq. (33)). Employment is then split between public- and private-sector employment. Public sector employment (EMP_{PUB}) is effectively a policy variable; for the model it is assumed that the size of public sector employment, relative to the size of the labour force (LF), is constant and therefore public sector employment grows based on the growth rate of the labour force (Eq. (34)). The remaining employment is covered by the private sector such that private sector employment (EMP_{PRI}) is defined as total employment minus public sector employment (Eq. (35)).

$$EMP_t = \frac{GDP_{Rt}}{\lambda_t} \tag{33}$$

$$EMP_{PUBt} = \frac{LF_t}{LF_{t-1}} EMP_{PUBt-1} \tag{34}$$

$$EMP_{PRIt} = EMP_t - EMP_{PUBt} \tag{35}$$

Now to define the supply constraint explicitly, real full employment GDP (GDP_{RFE})[10] is equal to the total labour force (LF) multiplied by labour productivity (λ) (Eq. (36)). Real full capital utilisation GDP (GDP_{RFK})[11] is equal to the total real productive capital (K_{PR}) multiplied by capital productivity (ν) (Eq. (37)). Taken together, these two constraints generate the maximum real GDP (GDP_{RMAX}) which is defined as the minimum of these supply constraints (Eq. (38)). This is similar to the approach taken in the DEFINE model (Dafermos et al., 2017), where maximum GDP is the minimum of several separate supply side constraints.

$$GDP_{RFEt} = \lambda_t LF_t \tag{36}$$

$$GDP_{RFKt} = \nu_t K_{PRt} \tag{37}$$

$$GDP_{RMAXt} = min(GDP_{RFEt}, GDP_{RFKt}) \tag{38}$$

Both the labour force (LF)[12] and the total population (POP) are driven exogenously based on data from the Office for Budget Responsibility (OBR, 2025) (Eqs. (39) & (40)). The employment rate (re) is defined as the total number of people employed (EMP) divided by the labour force (LF) (Eq. (41)) with the unemployment rate (ru) being defined as the remainder (Eq. (42)). The capital utilisation rate (u) is then defined as the ratio between real GDP (GDP_R) and capital determined maximum GDP (GDP_{RFK}) (Eq. (43)).

[10]This is the labour supply constraint.

[11]This is the capital supply constraint.

[12]The labour force is defined as adults who are willing and able to work and is the sum of all employed and unemployed people.

$$LF_t = g_{LFOBR} LF_{t-1} \tag{39}$$

$$POP_t = POP_{OBRt} \tag{40}$$

$$re_t = \frac{EMP_t}{LF_t} \tag{41}$$

$$ru_t = 1 - re_t \tag{42}$$

$$u_t = \frac{GDP_{Rt}}{GDP_{RFKt}} \tag{43}$$

3.3. Production

This section will focus on how the production module behaves within the model. A key challenge that is faced is that production is not isolated to a single sector with this problem exacerbated by a lack of sufficient whom-to-whom data.[13] To address this, the production module is defined separately from any one model sector. The production module is therefore initially defined as the destination of all GDP expenditure flows and the origin of all GDP income flows.[14]

This would be sufficient if there were no input-output relationships to model; however, we have chosen to separate the power generation sector in order to better consider its relationship with the rest of the economy and its role in a green transition. This again raises a similar issue to that of production; industries, as defined within input-output tables can span across multiple accounting sectors and are not only based within the non-financial corporation sector. This issue is highlighted by Thomsen et al. (2025) where the authors find that a third of agricultural gross value added is attributed to the household sector in Denmark. Fortunately, in the case of the UK, the power generation sector is largely privatised and thus can be assumed to be a part of the wider non-financial corporation sector. Therefore, when separating the power sector, it is possible to simply reduce values within the non-financial corporation sector to account for the removal of power sector firms from the wider non-financial corporation sector and this is the approach that will be taken for this model.

Separating the power sector now also means that the production module no longer contains all GDP income and expenditure flows as consumption of electricity will now be an inflow to the power generation sector. In this simple input-output extension the production module and power sector are considered as two industries where the production module, by definition, contains all industries apart from the power sector.

3.3.1. Domestic production module

The majority of production occurs within the domestic production module. The final demand for production products (F_P) is equal to the household consumption of production products ($CONS_{HHP}$), the total consumption of the government ($CONS_{GVT}$) and exports (EXP) (Eq. (44)). The real final demand for production products (F_{PR}) is then given as the sum of the real

[13]For example there is data for both household and government consumption outflows but a lack of data for consumption inflows. In national accounts final consumption includes the purchase of goods and services from the private sector but also includes items such as governments consumption of its own products or households derived services from owner-occupied dwellings. For a similar assumption, see Zezza and Zezza (2022).

[14]It is important to note that the production module is not a sector in the traditional sense; it does not hold any financial assets or liabilities.

components of the final demand (Eq. (45)). The real gross output of the production (GO_{PR}) sector is then calculated from the coefficients of the Leontief inverse matrix multiplied by the real final demand for the two input output sectors in the model (Eq. (46)). Nominal gross output from production (GO_P) is then derived by multiplying the real gross output of production (GO_{PR}) by the production price deflator (P_P) (Eq. (47)). Total input costs of the production module ($COST_P$) are defined as the sum of total wages (W), indirect taxation on production ($ITAX_P$), intermediate consumption of production products (IC_{PP}), intermediate consumption of power sector products (IC_{PSP}) which is predominately electricity used for production, and imports from the rest of the world (IMP) (Eq. (48)).

$$F_{Pt} = CONS_{HHPt} + CONS_{GVTt} + GCF_t + EXP_t \tag{44}$$

$$F_{PRt} = CONS_{HHPRt} + CONS_{GVTRt} + GCF_{Rt} + EXP_{Rt} \tag{45}$$

$$GO_{PRt} = L_{PPt}F_{PRt} + L_{PPSt}F_{PSRt} \tag{46}$$

$$GO_{Pt} = GO_{PRt}P_{Pt} \tag{47}$$

$$COST_{Pt} = W_t + ITAX_{Pt} + IC_{PPt} + IC_{PSPt} + IMP_t \tag{48}$$

The production price deflator (P_P) is defined based on a simple mark-up (MU) over the unit costs (UC) in the previous period (Eq. (49)).[15] Unit costs (UC) are defined as the total nominal cost of production divided by the real output of production (GO_{PR}) (Eq. (50)). The mark-up (MU) itself varies according to the capital capacity utilisation rate (u) (Eq. (51)). This partially addresses a common critique of fixed mark-up pricing[16] which posits that the mark-up should vary based on macroeconomic conditions. Capacity utilisation serving as a driver of price mark-ups is similar to country models such as EUROGREEN (D'Alessandro et al., 2020). However, unlike EUROGREEN, the definition of the mark-up means that if capacity utilisation falls, firms will reduce their mark-ups in an attempt to attract more customers and restore their rate of capacity utilisation.

$$P_{Pt} = (1 + MU_t)UC_{t-1} \tag{49}$$

$$UC_t = \frac{COST_{Pt}}{GO_{PRt}} \tag{50}$$

$$MU_t = \alpha_{MU}u_t \tag{51}$$

The production sector is the source of all wage payments to workers in the model, including all public sector and private sector wages. A part of government consumption ($CONS_{GVT}$) includes public sector wages and this is simply distributed through the production module. Power sector wages are also paid through the production module as these are relatively small; this means that part of the intermediate consumption of the power sector for production products is made up by power sector wage payments to their employees.

The wage share (W_S) is defined as the total wage bill divided by GDP. The wage share evolves based on a logistic equation, where it depends negatively on the unemployment rate (ru) (Eq.

[15]This is consistent with the post-Keynesian approach of analysing prices as primarily a mark up on costs (see Lavoie (2014)).

[16]Such as Halevi (2016).

(52)). The dynamics of the wage share are similar to the approach of the global DEFINE model (Dafermos et al., 2017). This is consistent with the analysis of Stirati and Paternesi Meloni (2021) where a 'structural' Phillips-type relationship is found between the unemployment rate and the wage share. The wage rate (W_R), or wage per employee, is defined as the total wage ($W_S GDP$) divided by the total number of employees (EMP) (Eq. (53)). The wage rate is marginally different for public and private sector employees, with employees in the private sector receiving slightly more on average in the UK. Therefore, the respective public (WR_{PUB}) and private (WR_{PRI}) wage rates are defined as multiples of the total wage rate (Eqs. (54) & (55)).[17]

$$W_{St} = \frac{1}{1 + e^{-(\alpha_{0WS} - \alpha_{1WS} ru_t)}} \tag{52}$$

$$WR_t = W_{St} \frac{GDP_t}{EMP_t} \tag{53}$$

$$WR_{PRIt} = \beta_{WRPRI} WR_t \tag{54}$$

$$WR_{PUBt} = \beta_{WRPUB} WR_{t-1} \tag{55}$$

$$W_{PRIt} = WR_{PRIt} EMP_{PRIt} \tag{56}$$

$$W_{PUBt} = WR_{PUBt} EMP_{PUBt} \tag{57}$$

$$W_t = W_{PRIt} + W_{PUBt} \tag{58}$$

Direct energy prices and costs are also defined within the production module, as the power sector only covers electricity production, with these values having a behavioural impact on proportions of green investment within the model. The price of direct energy consumption (P_D) is defined as a fixed mark-up over the prices of gas (P_{GAS}) and oil (P_{OIL}), with the proportion of these different fuels in the direct energy consumption mix being assumed to remain constant during the simulation period (Eq. (59)). Gas and oil prices are assumed to be based on global prices and are therefore exogenous to the model, growing according to OBR forecasts (OBR, 2025). The price of direct energy consumption including taxes (P_{DT}) is given by adding the indirect tax per unit of direct energy ($ITAX_D/E_D$) to the non-taxed price of direct energy consumption (Eq.(59)). The price of fuel (P_{FUEL}) which the production sector sells to the power sector is set as proportional to the wholesale price of gas, reflecting that fossil fuel electricity generation in the UK is now entirely gas-based (Eq. (61)). The total cost of direct energy ($COST_D$) is given as the price of direct energy (P_D) multiplied by total direct energy use (E_D) (Eq. (62)). The real total cost of all energy use in the economy, including energy taxes, is given as the sum of the cost of direct energy ($COST_D$), the total tax paid on direct energy use ($ITAX_D$), the final consumption of electricity by households ($CONS_{HHPS}$ and the intermediate consumption of electricity by the production module (IC_{PSP}); all divided by the level of production price (P_P) (Eq. (63).

$$P_{Dt} = \alpha_D(\beta_{DGAS} P_{GASt} + \beta_{DOIL} P_{OILt}) \tag{59}$$

$$P_{DTt} = P_{Dt} + \frac{ITAX_{Dt}}{E_{Dt}} \tag{60}$$

[17] Note that the public wage rate is based on the lag of the overall wage rate; this is due to public wage rates directly determining the level of government consumption, which is a component of GDP, therefore this must be lagged to avoid a circular dependency between equations.

$$P_{FUELt} = \alpha_{PFUEL} P_{GASt} \tag{61}$$

$$COST_{Dt} = P_{Dt} E_{Dt} \tag{62}$$

$$COST_{ERt} = \frac{COST_{Dt} + ITAX_{Dt} + CONS_{HHPSt} + IC_{PSPt}}{P_{Pt}} \tag{63}$$

Productive capital (K_P) in the model is defined as all non-housing capital so is given by the total capital stock of non-financial corporations (K_{NFC}) and the government (K_{GVT}) (Eq. (64)). For both NFCs and the government, the productive capital is divided into green and conventional capital stocks with the total green (K_{PG}) and conventional (K_{PC}) defined as the sum of the respective green and conventional NFC and government capital stocks (Eqs. (65) & (66)). Real productive capital levels are defined similarly on the basis of the real NFC and government capital stocks (Eqs. (67), (68) & (69)). The depreciation of productive capital (δ_{KP}), which is assumed to be the same rate for NFC and government capital, is constant (Eq. (70)). As described in the Energy Efficiency and Technology Section, the ratio between green and conventional capital is a key driver of energy efficiency and emission reduction within the model. This follows the approach of Dafermos et al. (2017) and means that decarbonisation requires a certain level of investment. However, there is no explicit innovation process that governs energy efficiency, as is the case for the EUROGREEN model (D'Alessandro et al., 2020).

$$K_{Pt} = K_{NFCt} + K_{GVTt} \tag{64}$$

$$K_{PGt} = K_{NFCGt} + K_{GVTGt} \tag{65}$$

$$K_{PCt} = K_{NFCCt} + K_{GVTCt} \tag{66}$$

$$K_{PRt} = K_{NFCRt} + K_{GVTRt} \tag{67}$$

$$K_{PGRt} = K_{NFCGRt} + K_{GVTGRt} \tag{68}$$

$$K_{PCRt} = K_{NFCCRt} + K_{GVTCRt} \tag{69}$$

$$\delta_{KPt} = \delta_{kpc} \tag{70}$$

3.3.2. The power generation sector

The power generation sector is the other input output sector outside of the production sector which is involved in the input-output system. This sector is defined as the industry 'Electricity, gas, steam and air conditioning supply (D.35)' in the ONS input output tables. The final demand for products from the power sector, which is assumed to be completely electricity demand (F_{PS}), is equal to the household consumption of electricity ($CONS_{HHPS}$) (Eq. (71)). The real final demand for power sector products (F_{PSR}) is then given as the real value of household consumption (Eq. (72)). The real gross output of the power sector (GO_{PSR}) is then calculated from the coefficients of the Leontief inverse matrix multiplied by the real final demand for the two input output sectors in the model (Eq. (73)). Nominal gross output of the power sector (GO_{PS}) is then derived by multiplying the real gross output of the power sector (GO_{PSR}) by the price of electricity (P_{ELEC}) (Eq. (74)). The total input costs of the power sector ($COST_{PS}$) are defined as the sum of indirect taxation on the power sector ($ITAX_{PS}$), intermediate consumption of production products (IC_{PPS})[18] and intermediate consumption of products of the power sector

[18] This includes wages paid to employees in the power sector and any imports of the power sector.

(IC_{PSPS}) which is predominantly electricity used within the electricity production process (Eq. (75)).

$$F_{PSt} = CONS_{HHPSt} \tag{71}$$

$$F_{PSRt} = CONS_{HHPSRt} \tag{72}$$

$$GO_{PSRt} = L_{PSPt}F_{PRt} + L_{PSPSt}F_{PSRt} \tag{73}$$

$$GO_{PSt} = GO_{PSRt}P_{ELECt} \tag{74}$$

$$COST_{PSt} = ITAX_{PSt} + IC_{PPSt} + IC_{PSPSt} \tag{75}$$

$$GOS_{PSt} = GO_{PSt} - COST_{PSt} \tag{76}$$

The power sector generates electricity from both fossil fuel (E_{ELECFF}) and non-fossil fuel ($E_{ELECNFF}$) sources. The ratio between non-fossil fuel electricity and total electricity (β_{NFF}) is defined in Eq. (77). The total operating cost for non-fossil fuel energy production ($COST_{PSNFF}$) is defined as the total indirect taxes on non-fossil fuel energy production ($ITAX_{PSNFF}$), a share of the non-fossil fuel based intermediate consumption, with the share assumed to be proportional to the amount of non-fossil fuel energy in the energy mix (β_{NFF}) and the total depreciation of non-fossil fuel capital ($\delta_{KPS}K_{PSNFF}$) (Eq. 78). The total operating cost for fossil fuel energy production ($COST_{PSFF}$) is defined similarly except all intermediate consumption for fuel production (IC_{FUELPS}) is attributed to fossil fuel generation costs (Eq. (79)). The average costs of non-fossil (AC_{NFF}) and fossil (AC_{FF}) electricity are then defined based on their total costs divided by the share of the respective energy source multiplied by the real output of the power sector (GO_{PSR}) (Eqs. (80) & (81)).

$$\beta_{NFFt} = \frac{E_{ELECNFFt}}{E_{ELECt}} \tag{77}$$

$$COST_{PSNFFt} = ITAX_{PSNFFt} + (IC_{PSPSt} + IC_{OPPSt})\beta_{NFFt-1} + \delta_{KPSt}K_{PSNFFt-1} \tag{78}$$

$$COST_{PSFFt} = ITAX_{PSFFt} + IC_{FUELPSt} + (IC_{PSPSt} + IC_{OPPSt})(1 - \beta_{NFFt-1}) + \delta_{KPSt}K_{PSFFt-1} \tag{79}$$

$$AC_{NFFt} = \frac{COST_{PSNFFt}}{GO_{PSRt}\beta_{NFFt}} \tag{80}$$

$$AC_{FFt} = \frac{COST_{PSFFt}}{GO_{PSRt}(1 - \beta_{NFFt})} \tag{81}$$

Although average costs are tracked in the model, electricity prices are set on the basis of marginal costs, where the electricity price is driven by the cost of producing an additional unit of electricity. This better replicates how electricity is priced in reality within the UK (Stirati and Paternesi Meloni, 2021) and has a significant impact on the behaviour of the model. Therefore, the marginal cost of fossil fuel electricity production (MC_{FF}) is defined based on the variable costs of fossil fuel production: the cost of fuel input IC_{FUELPS} and the cost of emissions due to emission pricing $COV_{ETSPS}P_{ETS}EMIS_{ELEC}$ divided by the total fossil fuel electricity use E_{ELECFF}, where COV_{ETSPS} is the coverage of the carbon price over the sectoral fossil fuel output[19] and P_{ETS} is

[19] This is generally less than one due to exemptions and free carbon credits provided to firms.

the carbon price (Eq. (82)).[20] For non-fossil fuel generation, there is no fuel input or emission tax, so it is assumed that the marginal cost of non-fossil fuel electricity production is effectively zero, as pointed out by Heal (2022).[21]

Now, these two marginal costs must be used to define the total marginal cost of electricity that will drive the electricity price. Given that the marginal cost of fossil fuels is always higher than that of non-fossil fuels, one approach would be to define the marginal cost of electricity as equal to that of fossil fuels until a full non-fossil fuel transition is achieved. However, this would be misleading for several reasons. The first reason is that energy demand and the energy mix vary significantly over time; this volatility means that at around 60–70% non-fossil energy production it becomes likely that, at least temporarily, the electricity grid will be supplied by entirely non-fossil sources. This is supported in the case of the UK by Carbon Brief (2024) where it is observed that the share of electricity in the UK generated from fossil fuels fell to a record low of 2.4% on April 15th, 2024, despite average yearly fossil fuel electricity generation still accounting for around 40% of total electricity generation. Given that wholesale electricity prices in the UK adjust every 30 minutes, even an hour of fully non-fossil electricity production could significantly lower electricity prices temporarily. To account for this the model employs a non-linear relationship where, as the proportion of non-fossil fuel electricity provision rises, the marginal cost of electricity production falls, accounting for greater frequency of fully non-fossil fuel based electricity production; this non-linear relationship is described in Eq. (83). The price of electricity (P_{ELEC}) is then set based on a fixed mark-up over the marginal cost of electricity production (Eq. (84)).[22]

$$MC_{FFt} = \frac{IC_{FUELPSt} + COV_{ETSPSt} P_{ETSt} EMIS_{ELECt}}{E_{ELECFFt}} \tag{82}$$

$$MC_{ELECt} = MC_{FFt}(1 - \beta_{NFFt})^{\mu_{MCELEC}} \tag{83}$$

$$P_{ELECt} = (1 + MU_{ELEC}) MC_{ELECt} \tag{84}$$

The investment behaviour of the power sector is driven by several utilisation functions. The utilisation of fossil-based and non-fossil-based capital, respectively, is calculated by dividing their respective electricity outputs (E_{ELECFF} & $E_{ELECNFF}$) by their respective maximum output levels, calculated by multiplying their capacity factors (CF) by real capital levels (K_{PSFFR} & $K_{PSNFFRt}$) (Eqs. (85) & (86)). Note that for non-fossil utilisation the denominator now includes government non-fossil capital ($K_{GVTNFFRt}$) alongside power sector non-fossil capital. Overall power sector utilisation is derived as current electricity demand E_{ELEC} divided by maximum electricity generation $E_{ELECMAX}$ (Eq. (87)).

$$u_{FFt} = \frac{E_{ELECFFt}}{CF_{FF} K_{PSFFRt}} \tag{85}$$

$$u_{NFFt} = \frac{E_{ELECNFFt}}{CF_{NFFt}(K_{PSNFFRt} + K_{GVTNFFRt})} \tag{86}$$

[20] This equation form assumes that the relationship between fossil fuel inputs and fossil fuel electricity output is constant; while this is unlikely to be the case in reality it is a fair assumption for modelling purposes.

[21] However, as already discussed, capital intensity and capital costs for non-fossil fuel generation are higher than for fossil fuels; this has practical implications which will be explored in the scenarios and results discussion.

[22] If energy demand outstrips all available supply then this equation is changed to be based on average costs, reflecting the change in individual firms' ability to freely set prices.

$$u_{PSt} = \frac{E_{ELECt}}{E_{ELECMAXt}} \tag{87}$$

DEFINE-UK 1.1 introduces a form of forward-looking expectations for the power sector for when fossil fuel production is banned at a future period B. In this case the expected utilisation rate at some future time period L ($\mathbf{E}(u_{PSt,L})$) is split such that when the ban comes into force at time B the power sector calculates future expected utilisation by removing all fossil-based power capital from the equation, as shown in Eq. (88). When expected future utilisation values vary, we introduce a form of hyperbolic discounting, similar to (Laibson, 1997), where the value of future utilisation is reduced by a discount parameter δ to give a weighted forward-looking utilisation rate ($\mathbf{F}(u_{PS})$) shown in Eq. (89). For this equation $N = \sum_{\tau=0}^{T} \delta^{\tau}$ such that the weighting is normalised around the current utilisation rate and $0 < \delta < 1$ such that future utilisation rates are valued less than current rates. T reflects the planning horizon and can take any reasonable value. The $CRED$ parameter captures the perceived credibility of the policy, taking a value between 0 and 1, such that a higher value reflects a greater proportion of agents believing the policy will be implemented.

$$\mathbf{E}(u_{PSt,L}) = \begin{cases} \dfrac{E_{ELECt}}{CF_{FF}K_{PSFFRt} + CF_{NFFt}K_{PSNFFRt}} = u_{PSt} & \text{if } B < L + t \\ \dfrac{E_{ELECt}}{CF_{NFFt}K_{PSNFFRt}} > u_{PSt} & \text{if } B \geq L + t \end{cases} \tag{88}$$

$$\mathbf{F}(u_{PSt}) = CRED \cdot \frac{1}{N} \sum_{\tau=0}^{T} \delta^{\tau} \mathbf{E}(u_{PSt+\tau}) + (1 - CRED) \cdot u_{PSt} \tag{89}$$

Unlike the production module, the power sector is an asset holding sector with a sectoral net-lending and net worth position; it therefore holds assets, has property income and its own fixed capital formation. This reflects one of the innovations of this model, as most models with input-output sectors, even when they follow a stock-flow consistent approach (such as D'Alessandro et al. (2020); Thomsen et al. (2025)), generally do not include financial balances for the individual input-output sectors, choosing instead to consider these balances at the aggregate firm level. This is due mainly to data availability issues as financial balance data is far less disaggregated than the input-output flow data. This is an issue in the UK as well; however by using available data on the loans to the power sector, and assuming the power sector stocks are a fixed proportion based on said loans, it is possible to approximate a financial structure for this sector. While such an approximation is unlikely to be fully accurate, it does allow the model to consider changes to financial balances for this sector and financial constraints at the sectoral level.

Interest payments to the power sector are based on respective rates of return on interest bearing assets (IBA^{PS}) and interest bearing liabilities (IBL^{PS}) (Eqs.(90)&(91)). Disposable income of the power sector (YD_{PS}) is then defined as the gross operating surplus of the sector plus its net interest payments (Eq. (92)). Note that in DEFINE-UK 1.1 the government's share of gross operating surplus is accounted for in the government sector disposable income equation rather than being deducted here. Dividends received by the power sector ($DIVR_{PS}$) are a proportion of the dividends paid by NMFIs multiplied by the share of PS equity assets among all equity assets (Eq. (93)). Dividends paid by the power sector are set as a fixed proportion of their gross output (Eq. (94)). This leaves the retained profit of the power sector (RP_{PS}), to be used for investment, as their disposable income after accounting for dividend transactions (Eq. (95)).

$$INTR_{PSt} = r_{IBAPSt} IBA_{PSt-1} \tag{90}$$

$$INTP_{PSt} = r_{IBLPSt} IBL_{PSt-1} \tag{91}$$

$$YD_{PSt} = GOS_{PSt} + INTR_{PSt} - INTP_{PSt} \tag{92}$$

$$DIVR_{PSt} = \beta_{dps} \frac{EQA_{PSt}}{EQL_{NMFIt}} \cdot DIVP_{NMFIt} \tag{93}$$

$$DIVP_{PSt} = \alpha_{DIVPPS} GO_{PSt} \tag{94}$$

$$RP_{PSt} = YD_{PSt} + DIVR_{PSt} - DIVP_{PSt} \tag{95}$$

The desired investment in power sector capital (GCF_{PSD}) is driven primarily by capacity utilisation, similarly to what we will see later for the NFC sector. Firms have a desired capacity utilisation rate u_T, based on historical values, and will change their investment levels based on their proximity to this target (Eq. (96)). For this equation, we use the forward-looking weighted utilisation $\mathbf{F}(u_{PS})$ described in Eq. (89). Therefore, following the post-Keynesian tradition, electricity supply will adjust to meet demand, although investment does take time and sudden changes in electricity demand can still put pressure on electricity supply. Desired power sector investment is then split between desired fossil fuel (GCF_{PSFFD}) and non-fossil fuel (GCF_{PSNFFD}) based on the desired proportion of non-fossil investment ($prop_{NFF}$) (Eqs. (97) & (98)). The desired proportion of non-fossil investment is driven primarily by the difference between profit rates of non-fossil (r_{KNFF}) and fossil (r_{KFF}) based capital (Eq. (99)).

$$\frac{GCF_{PSDt}}{K_{PSt-1}} = \alpha_{0GCFPS} + \alpha_{1GCFNFC}(\mathbf{F}(u_{PSt-1}) - u_T) + \alpha_{2GCFNFC} \frac{GCF_{PSDt-1}}{K_{PSt-2}} \tag{96}$$

$$GCF_{PSFFDt} = (1 - prop_{NFFt}) GCF_{PSDt} \tag{97}$$

$$GCF_{PSNFFDt} = prop_{NFFt} GCF_{PSDt} \tag{98}$$

$$prop_{NFFt} = \frac{1}{(1 + e^{-(\alpha_{0bNFF} + \alpha_{1bNFF}(r_{KNFFt-1} - r_{KFFt-1})))}} \tag{99}$$

Actual fossil fuel (GCF_{PSFF}) and non-fossil fuel (GCF_{PSNFF}) gross capital formation are subject to credit rationing where it is assumed that firms seek finance to cover their desired level of investment and that only a portion of this finance is provided based on the level of power sector credit rationing (CR_{PS}) (Eqs. (100) & (101)). This allows the model to capture that the availability of credit is a major barrier to investment in non-fossil fuel energy (Taghizadeh-Hesary and Yoshino, 2020) and reflects the importance of credit constraints highlighted by Dafermos and Nikolaidi (2022). The sum of these two gross capital formations gives the overall gross capital formation for the power sector (GCF_{PS}) (Eq. (102)). Real gross capital formation levels are defined by dividing the nominal gross capital formation by the production price deflator (P_P) (Eqs. (103), (104) & (105)). The net-lending position of the power sector ($LEND_{PS}$) is then defined as the retained profits of the sector minus actual sectoral investment (Eq. (106)).

$$GCF_{PSFFt} = (1 - CR_{PSt}) GCF_{PSFFDt} \tag{100}$$

$$GCF_{PSNFFt} = (1 - CR_{PSt}) \cdot GCF_{PSNFFDt} \tag{101}$$

$$GCF_{PSt} = GCF_{PSNFFt} + GCF_{PSFFt} \tag{102}$$

$$GCF_{PSRt} = GCF_{PSFFRt} + GCF_{PSNFFRt} \tag{103}$$

$$GCF_{PSFFRt} = \frac{GCF_{PSFFt}}{P_{Pt}} \tag{104}$$

$$GCF_{PSNFFRt} = \frac{GCF_{PSNFFt}}{P_{Pt}} \tag{105}$$

$$LEND_{PSt} = RP_{PSt} - GCF_{PSt} \tag{106}$$

Interest bearing ($IBATR_{PS}$) and equity asset ($EQATR_{PS}$) transfers are assumed to equal a fixed proportion of the gross output (GO_{PS}) of the power sector (Eqs. (107) & (108)). Equity liability transfers ($EQLTR_{PS}$) equal a portion of the equity acquisitions of the NMFI sector which is assumed to hold the counterpart equity assets to all equity liabilities within the model (Eq. (109)). Interest bearing liability transfers ($IBLTR_{PS}$) serve as the residual stock transfer and equal the net transfers of all other financial assets (Eq. (110)). The residual financial instrument transaction of the power sector ($RESTR_{PS}$) grows exogenously as a fixed proportion of GDP (Eq. (111)).

$$IBATR_{PSt} = \alpha_{IBAPS} GO_{PSt} \tag{107}$$

$$EQATR_{PSt} = \alpha_{EQAPS} GO_{PSt} \tag{108}$$

$$EQLTR_{PSt} = \theta_{psb} EQATR_{NMFIt} \tag{109}$$

$$IBLTR_{PSt} = (IBATR_{PSt} + EQATR_{PSt} + RESTR_{PSt}) - (LEND_{PSt} + EQLTR_{PSt}) \tag{110}$$

$$RESTR_{PSt} = \eta_{PSB} GDP_{t-1} \tag{111}$$

Other transfers, which include price revaluations and other changes in asset value, are driven in a variety of ways within the model (Eqs. (112) - (115)). Other transfers relating to interest-bearing assets (OT_{IBAPS}) are assumed to follow a fixed exogenous rate, reflecting these assets include safe assets such as deposits that do not vary significantly based on other model variables (Eq. (112)). Other transfers relating to equity assets (OT_{EQAPS}) are given as a portion of the other transfers of NMFI equity liabilities ($OT_{EQANMFI}$) (Eq. (113)). Other transfers relating to equity liabilities are assumed to be set such that equity prices are positively related to dividend payments by the power sector while being reduced by the current interest rate on interest bearing liabilities of the government, which serves as an approximation for the so-called 'risk-free' interest rate (Eq. (114)). Other transfers relating to interest-bearing liabilities (OT_{IBLPS}) are relatively large and require some individual attention. Other transfers of interest-bearing liabilities are mostly made up of defaults on loans; it is therefore assumed that their rate of change is entirely driven by defaults (Eq. (116)). The default rate of the power sector (DEF_{PS}) is then proportional to the illiquidity ratio ($ILLIQ_{PS}$) where higher illiquidity of the power sector leads to higher defaults (Eq. (117)).

$$OT_{IBAPSt} = \delta_{IBAPS}(IBA_{PSt-1}) \tag{112}$$

$$OT_{EQAPSt} = \beta_{dps} \frac{EQA_{PSt-1}}{EQL_{NMFIt-1}} OT_{EQLNMFIt} \tag{113}$$

$$OT_{EQLPSt} = \frac{DIVP_{PSt}}{r_{IBLGVTt} + \beta_{EQLPS}} - EQL_{PSt-1} \tag{114}$$

$$OT_{RESPSt} = \delta_{RESPS}(RES_{PSt-1}) \tag{115}$$

$$OT_{IBLPSt} = -DEF_{PSt} \cdot (IBL_{PSt-1}) \tag{116}$$

$$DEF_{PSt} = \frac{def_{max}}{1 + def_{0PS} e^{def_1 - def_2 ILLIQ_{PSt-1}}} \tag{117}$$

The financial stocks of the power sector develop according to their respective financial transfers and other transfers (Eqs. (118) - (121)). Total financial assets and liabilities are defined in Eqs. (122) & (123). Financial assets minus liabilities give the power sector model determined financial net worth (FNW_{PSM}) (Eq. (124)). The residual financial instrument develops similarly to other financial assets (Eq. (125)) and is then added to the model determined financial net worth to give the overall power sector financial net-worth FNW_{PS} (Eq. (126)).

$$IBA_{PSt} = IBA_{PSt-1} + IBATR_{PSt} + OT_{IBAPSt} \tag{118}$$

$$IBL_{PSt} = IBL_{PSt-1} + IBLTR_{PSt} + OT_{IBLPSt} \tag{119}$$

$$EQA_{PSt} = EQA_{PSt-1} + EQATR_{PSt} + OT_{EQAPSt} \tag{120}$$

$$EQL_{PSt} = EQL_{PSt-1} + EQLTR_{PSt} + OT_{EQLPSt} \tag{121}$$

$$FA_{PSt} = IBA_{PSt} + EQA_{PSt} \tag{122}$$

$$FL_{PSt} = IBL_{PSt} + EQL_{PSt} \tag{123}$$

$$FNW_{PSMt} = FA_{PSt} - FL_{PSt} \tag{124}$$

$$RES_{PSt} = RES_{PSt-1} + RESTR_{PSt} + OT_{RESPSt} \tag{125}$$

$$FNW_{PSt} = FNW_{PSMt} + RES_{PSt} \tag{126}$$

The capital stock of the power sector is split into fossil fuel and non-fossil fuel capital stock, with the real value of power capital being used as a proxy for the electricity production capacity of both fossil and non-fossil electricity. The real value of fossil fuel (K_{PSFFR}) and non-fossil fuel (K_{PSNFFR}) are increased through real gross capital formation, while a portion of the previous period's real capital stock is lost to depreciation (Eqs. (127) & (128)). These stocks are summed to give the overall real capital stock (K_{PSR}) of the power sector (Eq. (129)). Nominal capital stock values are then calculated by multiplying real capital by the production price deflator (Eqs. (131) - (133)). Power sector net worth is defined as the sum of net financial and real assets (Eq. (134)).

$$K_{PSFFRt} = (1 - \delta_{KPSt})K_{PSFFRt-1} + GCF_{PSFFRt} \tag{127}$$

$$K_{PSNFFRt} = (1 - \delta_{KPSt})K_{PSNFFRt-1} + GCF_{PSNFFRt} \tag{128}$$

$$K_{PSRt} = K_{PSFFRt} + K_{PSNFFRt} \tag{129}$$

$$\delta_{KPSt} = \delta_{KPSt-1} \tag{130}$$

$$K_{PSt} = K_{PSNFFt} + K_{PSFFt} \tag{131}$$

$$K_{PSFFt} = K_{PSFFRt} P_{Pt} \tag{132}$$

$$K_{PSNFFt} = K_{PSNFFRt} P_{Pt} \tag{133}$$

$$NW_{PSt} = FNW_{PSt} + K_{PSt} \tag{134}$$

The leverage ratio of the power sector (LEV_{PS}) is defined as the ratio between the interest-bearing liabilities of the sector and the total capital stock of the sector (Eq. (135)). The illiquidity ratio of the power sector ($ILLIQ_{PS}$) captures the ratio between cash outflows and cash inflows for the sector (Eq. (136)). Note that in DEFINE-UK 1.1 the illiquidity ratio includes any subsidy payments received ($SUBS_{PS}$) on the inflows side, reflecting that subsidies improve the liquidity position of the sector. The debt-service ratio of the power sector (DSR_{PS}) is the ratio of disposable income less depreciation of capital and before interest payments to total interest payments (Eq. (137)). The level of credit rationing (CR_{PS}), which constrains the level of investment of the power sector, is driven by a logistic equation. The rate of credit rationing depends negatively on the sector's debt service ratio and positively on the ratio of MFI liabilities to MFI assets (Eq. (138)). Therefore, credit is constrained both when power sector firms lack sufficient income to cover their interest payments and also when MFIs (i.e. the traditional banking sector) financial position worsens.

$$LEV_{PSt} = \frac{IBL_{PSt}}{K_{PSt}} \tag{135}$$

$$ILLIQ_{PSt} = \begin{pmatrix} INTP_{PSt} + ITAX_{PSt} + DIVP_{PSt} + GCF_{PSt} + \delta_{KPSt}K_{PSt} \\ + IBATR_{PSt} + EQATR_{PSt} + IC_{PPSt} + IC_{PSPSt} \end{pmatrix} \Big/ \\ (GO_{PSt} + INTR_{PSt} + DIVR_{PSt} + EQLTR_{PSt} + IBLTR_{PSt} + SUBS_{PSt}) \tag{136}$$

$$DSR_{PSt} = \frac{YD_{PSt} - \delta_{KPSt}K_{PSt-1} + INTP_{PSt}}{INTP_{PSt}} \tag{137}$$

$$CR_{PSt} = \frac{1}{1 + e^{-(\alpha_{0CRPS} + \alpha_{1CRPS}CR_{PSt-1} - \alpha_{2CRPS}DSR_{PSt-1} + \alpha_{3CRPS}(FL_{MFIt-1}/FA_{MFIt-1}))}} \tag{138}$$

3.3.3. Input-output calculations

This section will describe the simple two sector input output system present within the model.[23] The approach taken to input-output relationships is standard; see Miller and Blair (2009) for more information on input output data and modelling.

The technical coefficients of real intermediate consumption are defined such that some are constant and assumed to follow a long-term stable relationship, while some vary based on changes in environmental variables (Eqs. (139)-(144)). In particular, the technical coefficient governing electricity use by production (α_{PSP}) decreases through lower energy intensity (ϵ_t) and increases through greater electrification of production (θ_P) (Eq. (140)). The technical coefficient for fuel input into electricity production (α_{FUELPS}) is directly related to the share of fossil fuel electricity production in the electricity generation process (Eq. (143)). The use of technical coefficients for power that vary according to the energy mix and technological change is similar to the approach taken by the EUROGREEN model for the energy supply industries (D'Alessandro et al., 2020).

[23]In this section and elsewhere subscripts are ordered such that the product appears first and the sector receiving the product is second; therefore α_{FUELPS} refers to the technical coefficient for the power sector purchasing fuel products.

$$\alpha_{PPt} = \alpha_{PPLR} \tag{139}$$

$$\alpha_{PSPt} = \epsilon_t \theta_{Pt} \tag{140}$$

$$\alpha_{PSPSt} = \alpha_{PSPSLR} \tag{141}$$

$$\alpha_{OPPSt} = \alpha_{OPPSLR} \tag{142}$$

$$\alpha_{FUELPSt} = (1 - \beta_{NFFt-1})\alpha_{FUELPSR} \tag{143}$$

$$\alpha_{PPSt} = \alpha_{FUELPSt}\frac{P_{FUELt}}{P_{Pt}} + \alpha_{OPPSt} \tag{144}$$

These technical coefficients are then used to calculate the intermediate consumption levels of the sectors; inter-sectoral intermediate consumption is calculated in real terms and then converted to nominal intermediate consumption through the respective product price (Eqs. (145)-(153)).

$$IC_{PSPRt} = \alpha_{PSPt}GO_{PRt} \tag{145}$$

$$IC_{FUELPSRt} = \alpha_{FUELPSt}GO_{PSRt} \tag{146}$$

$$IC_{OPPSRt} = \alpha_{OPPSt}GO_{PSRt} \tag{147}$$

$$IC_{PPt} = \alpha_{PPt}GO_{Pt} \tag{148}$$

$$IC_{PSPt} = IC_{PSPRt}P_{ELECt} \tag{149}$$

$$IC_{PSPSt} = \alpha_{PSPSt}GO_{PSt} \tag{150}$$

$$IC_{PPSt} = IC_{FUELPSt} + IC_{OPPSt} \tag{151}$$

$$IC_{FUELPSt} = IC_{FUELPSRt}P_{FUELt} \tag{152}$$

$$IC_{OPPSt} = IC_{OPPSRt}P_{Pt} \tag{153}$$

Finally, the Leontief coefficients, which are used to calculate real output of each sector, are calculated by taking the inverse of the matrix of technical coefficients. As there are only two input-output sectors, this can be presented directly below[24] (Eqs: (154)-(158)).

$$det_{IAt} = ((1 - \alpha_{PPt})(1 - \alpha_{PSPSt})) - ((\alpha_{PPSt})(\alpha_{PSPt})) \tag{154}$$

$$L_{PPt} = \frac{(1 - \alpha_{PSPSt})}{det_{IAt}} \tag{155}$$

$$L_{PPSt} = \frac{\alpha_{PPSt}}{det_{IAt}} \tag{156}$$

$$L_{PSPt} = \frac{\alpha_{PSPt}}{det_{IAt}} \tag{157}$$

$$L_{PSPSt} = \frac{(1 - \alpha_{PPt})}{det_{IAt}} \tag{158}$$

Although the two-sector input-output system presented here is simple, it would be possible to

[24] These equations describe a simple 2×2 matrix inversion.

extend this to other sectors by adding relevant technical coefficients and then inverting a larger Leontief matrix.

3.4. Sectoral equations

3.4.1. Non-financial corporations

The model utilises a consolidated version of the non-financial corporation sector with the exception of private firms which are involved in the electricity generation process, which are moved to the power sector.

The primary income of non-financial corporations (YP_{NFC}) is the sum of the gross operating surplus of the production module (GOS_P), interest received ($INTR_{NFC}$) minus interest paid ($INTP_{NFC}$) (Eq.(159)). The equations for interest payments are based on respective rates of return on interest-bearing assets (IBA_{NFC}) and interest-bearing liabilities (IBL_{NFC}) (Eqs.(160)&(161)). NFC disposable income (YD_{NFC}) is then given as primary income minus income tax (Eq.(162)).

$$YP_{NFCt} = GOS_{Pt} + INTR_{NFCt} - INTP_{NFCt} \tag{159}$$

$$INTR_{NFCt} = r_{IBANFCt} IBA_{NFCt-1} \tag{160}$$

$$INTP_{NFCt} = r_{IBLNFCt} IBL_{NFCt-1} \tag{161}$$

$$YD_{NFCt} = YP_{NFCt} - INTAX_{NFCt} \tag{162}$$

Dividends received by firms ($DIVR_{NFC}$) are a proportion of the dividends paid by NMFIs multiplied by the share of NFC equity assets (Eq. (163)). Dividends paid by firms ($DIVP_{NFC}$) are given as a fixed proportion of their disposable income (Eq. (164)). This leaves NFCs' retained profit (RP_{NFC}), to be used for investment, as their disposable income after accounting for dividend transactions (Eq. (165)).

$$DIVR_{NFCt} = \frac{\beta_{dnfc} EQA_{NFCt}}{EQL_{NMFIt}} \cdot DIVP_{NMFIt} \tag{163}$$

$$DIVP_{NFCt} = \alpha_{DIVPNFC} YD_{NFCt} \tag{164}$$

$$RP_{NFCt} = YD_{NFCt} + DIVR_{NFCt} - DIVP_{NFCt} \tag{165}$$

NFC gross capital formation demand (GCF_{NFCD}) captures the desired investment level of the firm sector (Eq. (166)). A Kaleckian approach is followed when estimating this equation, as described by Blecker (2002), where investment depends positively on the rate of capacity utilisation. However, for desired NFC investment, the profit rate of firms was not found to have a significant impact on desired investment; therefore the investment equation is driven primarily by the deviation between the current rate of capacity utilisation (u) and the target capacity utilisation (u_T).[25] This effectively means that firms will seek to increase investment levels whenever capital is highly utilised as this is a signal that they require more capital to satisfy future demand. The actual level of NFC gross capital formation (GCF_{NFC}) is subject to credit rationing where it is assumed that firms seek finance to cover their desired level of investment and that only a portion of this finance is provided based on the level of NFC credit rationing (CR_{NFC}) (Eq. (167)).

[25] It should be highlighted that, while desired investment is not impacted by profits, lower income will reduce NFC debt-service ratio and increase the level of credit constraints on the sector, effectively reducing investment through the financial channel.

$$\frac{GCF_{NFCDt}}{K_{NFCt-1}} = \alpha_{0GCFNFC} + \alpha_{1GCFNFC}(u_t - u_T) + \alpha_{2GCFNFC}\frac{GCF_{NFCDt-1}}{K_{NFCt-2}} \tag{166}$$

$$GCF_{NFCt} = (1 - CR_{NFCt})GCF_{NFCDt} \tag{167}$$

The NFC gross capital formation is divided between green and conventional capital, with β_{nfc} representing the portion of the gross capital formation allocated to green capital. Green capital is assumed to be both less energy intensive and favour electricity over direct fuel sources, therefore, the proportion of green investment is driven by the relative price of electricity versus direct energy consumption along with the total cost of energy relative to energy use (Eq. (168)). So, the decision between green and conventional technologies is primarily based on relative costs along with the overall cost of energy. The relative cost term that relates direct energy to electricity prices uses a sigmoid function, in this case the hyperbolic tangent (**Tanh**) to reflect that the price elasticity effect is unlikely to be linear, and as one energy price diverges significantly from the other the impact on the proportion of green investment would be expected to decline. This ratio then defines the level of green and conventional capital investment (Eqs. (169) & (170).

$$\beta_{nfct} = \alpha_{0betaNFC} + \alpha_{1betaNFC}\mathbf{Tanh}(\frac{P_{Dt}}{P_{ELECt}}) + \alpha_{2betaNFC}\frac{COST_{ERt-1}}{E_{t-1}} \tag{168}$$

$$GCF_{NFCGt} = \beta_{nfct}GCF_{NFCt} \tag{169}$$

$$GCF_{NFCCt} = GCF_{NFCt} - GCF_{NFCGt} \tag{170}$$

The real levels of gross capital formation are then defined by dividing the nominal levels by the production price deflator (P_P) (Eqs. (171) - (173)).

$$GCF_{NFCRt} = GCF_{NFCGRt} + GCF_{NFCCRt} \tag{171}$$

$$GCF_{NFCGRt} = \frac{GCF_{NFCGt}}{P_{Pt}} \tag{172}$$

$$GCF_{NFCCRt} = \frac{GCF_{NFCCt}}{P_{Pt}} \tag{173}$$

Non-financial corporation model determined net lending ($LEND_{NFCM}$) is defined as their retained profits less gross capital formation spending (Eq. (174)). The lending discrepancy is driven exogenously as a portion of GDP (Eq. (175)) with the actual NFC net lending position defined as the model determined net lending plus the lending discrepancy (Eq. (176)).

$$LEND_{NFCMt} = RP_{NFCt} - GCF_{NFCt} \tag{174}$$

$$DISC_{NFCt} = \eta_{NFCT}GDP_{t-1} \tag{175}$$

$$LEND_{NFCt} = LEND_{NFCMt} + DISC_{NFCt} \tag{176}$$

Interest bearing ($IBATR_{NFC}$) and equity asset ($EQATR_{NFC}$) transfers are assumed to equal a fixed proportion of the gross output (GO_P) of the production module (Eqs. (177) & (178)). Equity liability transfers ($EQLTR_{NFC}$) equal a portion of the equity acquisitions of the NMFI sector which is assumed to hold the counterpart equity assets to all equity liabilities within the model

(Eq. (179)). Interest-bearing liability transfers ($IBLTR_{NFC}$) serve as the residual stock transfer and equal the net transfers of all other financial assets (Eq. (180)). The residual transaction of the financial instruments of the NFC sector ($RESTR_{NFC}$) grows exogenously as a fixed proportion of GDP (Eq. (181)).

$$IBATR_{NFCt} = \alpha_{IBANFC} GO_{Pt} \tag{177}$$

$$EQATR_{NFCt} = \alpha_{EQANFC} GO_{Pt} \tag{178}$$

$$EQLTR_{NFCt} = (1 - \theta_{psb})(EQATR_{NMFIt}) \tag{179}$$

$$IBLTR_{NFCt} = (IBATR_{NFCt} + EQATR_{NFCt} + RESTR_{NFCt}) - (LEND_{NFCt} + EQLTR_{NFCt}) \tag{180}$$

$$RESTR_{NFCt} = \eta_{NFCB} GDP_{t-1} \tag{181}$$

Other transfers, which include price revaluations and other changes in asset value, are driven in a variety of ways within the model (Eqs. (182) - (187)), similar to the power sector. Other transfers relating to interest-bearing assets (OT_{IBANFC}) are assumed to follow a fixed exogenous rate, reflecting that these assets include safe assets such as deposits that do not vary significantly based on other model variables (Eq. (182)). Other transfers relating to equity assets (OT_{EQANFC}) are given as a portion of the other transfers of NMFI equity liabilities ($OT_{EQANMFI}$) (Eq. (183)). Other transfers relating to equity liabilities are assumed to be set such that equity prices are positively related to dividend payments by the NFC sector while being reduced by the current interest rate on interest bearing liabilities of the government, which serves as an approximation for the so-called 'risk-free' interest rate (Eq. (184)). Other transfers relating to interest-bearing liabilities (OT_{IBLNFC}) are relatively large and require some individual attention. Other transfers of interest-bearing liabilities are mostly made up of defaults on loans; it is therefore assumed that their rate of change is entirely driven by defaults (Eq. (185)). The default rate of the NFC sector (DEF_{NFC}) is then proportional to the illiquidity ratio ($ILLIQ_{NFC}$) where higher illiquidity of the NFC sector leads to higher defaults (Eq. (186)).

$$OT_{IBANFCt} = \delta_{IBANFC}(IBA_{NFCt-1}) \tag{182}$$

$$OT_{EQANFCt} = OT_{EQLNMFIt} - (OT_{EQAHHt} + OT_{EQAPSt}) \tag{183}$$

$$OT_{EQLNFCt} = \frac{DIVP_{NFCt}}{r_{IBLGVTt} + \beta_{EQLNFC}} - EQL_{NFCt-1} \tag{184}$$

$$OT_{IBLNFCt} = -DEF_{NFCt} \cdot IBL_{NFCt-1} \tag{185}$$

$$DEF_{NFCt} = \frac{def_{max}}{1 + def_{0NFC} e^{def_1 - def_2 ILLIQ_{NFCt-1}}} \tag{186}$$

$$OT_{RESNFCt} = \delta_{RESNFC}(RES_{NFCt-1}) \tag{187}$$

The financial stocks of the NFC sector develop according to their respective financial transfers and other transfers (Eqs. (188) - (191)). Total financial assets and liabilities are defined in Eqs. (192) & (193). Financial assets minus liabilities give the NFC sector model determined financial net worth (FNW_{NFCM}) (Eq. (194)). The residual financial instrument develops similarly to other financial assets (Eq. (195)) and is then added to the model determined financial net worth to give the overall NFC sector financial net-worth FNW_{NFC} (Eq. (196)).

$$IBA_{NFCt} = IBA_{NFCt-1} + IBATR_{NFCt} + OT_{IBANFCt} \tag{188}$$

$$EQA_{NFCt} = EQA_{NFCt-1} + EQATR_{NFCt} + OT_{EQANFCt} \tag{189}$$

$$IBL_{NFCt} = IBL_{NFCt-1} + IBLTR_{NFCt} + OT_{IBLNFCt} \tag{190}$$

$$EQL_{NFCt} = EQL_{NFCt-1} + EQLTR_{NFCt} + OT_{EQLNFCt} \tag{191}$$

$$FA_{NFCt} = IBA_{NFCt} + EQA_{NFCt} \tag{192}$$

$$FL_{NFCt} = IBL_{NFCt} + EQL_{NFCt} \tag{193}$$

$$FNW_{NFCMt} = FA_{NFCt} - FL_{NFCt} \tag{194}$$

$$RES_{NFCt} = RES_{NFCt-1} + RESTR_{NFCt} + OT_{RESNFCt} \tag{195}$$

$$FNW_{NFCt} = FNW_{NFCMt} + RES_{NFCt} \tag{196}$$

The capital stock of the NFC sector is split into conventional and green capital stock. The real value of conventional (K_{NFCCR}) and green (K_{NFCGR}) capital are increased through real gross capital formation, while a portion of the previous period's real capital stock is lost to depreciation (Eqs. (197) & (198)). These stocks are summed to give the overall real capital stock (K_{NFCR}) of the NFC sector (Eq. (199)). The nominal capital stock values are then calculated by multiplying the real capital by the production price deflator (Eqs. (200) - (202)). NFC sector net worth is defined as the sum of net financial and real assets (Eq. (203)).

$$K_{NFCCRt} = (1 - \delta_{KPt})K_{NFCCRt-1} + GCF_{NFCCRt} \tag{197}$$

$$K_{NFCGRt} = (1 - \delta_{KPt})K_{NFCGRt-1} + GCF_{NFCGRt} \tag{198}$$

$$K_{NFCRt} = K_{NFCCRt} + K_{NFCGRt} \tag{199}$$

$$K_{NFCt} = K_{NFCCt} + K_{NFCGt} \tag{200}$$

$$K_{NFCCt} = K_{NFCCRt}P_{Pt} \tag{201}$$

$$K_{NFCGt} = K_{NFCGRt}P_{Pt} \tag{202}$$

$$NW_{NFCt} = FNW_{NFCt} + K_{NFCt} \tag{203}$$

The leverage ratio of the NFC sector (LEV_{NFC}) is defined as the ratio between the interest-bearing liabilities of the sector and the total capital stock of the sector (Eq. (204)). The illiquidity ratio of the NFC sector ($ILLIQ_{NFC}$) captures the ratio between cash outflows and cash inflows for the sector (Eq. (205)). The debt-service ratio of NFCs (DSR_{NFC}) is defined in the same way as the power sector as the ratio of disposable income less depreciation of capital and before interest payments to total interest payments (Eq. (206)). The level of credit rationing (CR_{NFC}), which constrains the level of investment of the NFC sector, is defined similarly to that of the power sector. It depends negatively on the sector's debt service ratio and positively on the ratio of MFI liabilities to MFI assets (Eq. (207)). Therefore, as with the power sector, credit is constrained both when firms lack sufficient income to cover their interest payments and also when MFIs (i.e. the traditional banking sector) financial position worsens.

$$LEV_{NFCt} = \frac{IBL_{NFCt}}{K_{NFCt}} \tag{204}$$

$$ILLIQ_{NFCt} = \left(\begin{array}{c} INTP_{NFCt} + INTAX_{NFCt} + DIVP_{NFCt} + GCF_{NFCt} + \delta_{KPt} K_{NFCt} \\ + IBATR_{NFCt} + EQATR_{NFCt} \end{array} \right) \Big/ \\ (GOS_{Pt} + INTR_{NFCt} + DIVR_{NFCt} + EQLTR_{NFCt} + IBLTR_{NFCt}) \tag{205}$$

$$DSR_{NFCt} = \frac{YD_{NFCt} - \delta_{KPt} K_{NFCt-1} + INTP_{NFCt}}{INTP_{NFCt}} \tag{206}$$

$$CR_{NFCt} = \frac{1}{1 + e^{-(\alpha_{0CRNFC} + \alpha_{1CRNFC} CR_{NFCt-1} - \alpha_{2CRNFC} DSR_{NFCt-1} + \alpha_{3CRNFC} (FL_{MFIt-1}/FA_{MFIt-1}))}} \tag{207}$$

3.4.2. Monetary financial Institutions

The monetary financial institution (MFI) sector represents traditional banks whose primary role is to hold the interest bearing assets (deposits etc.) of the sectors in the model and provide interest bearing liabilities (loans etc.) to these same sectors. MFIs play a relatively passive role in the model, although they do ration credit to the power sector and NFC sector through Eqs. (138) & (207). Therefore, banks are not simply intermediaries of loanable funds, consistent with the arguments of Jakab and Kumhof (2018), and the MFI sector creates money endogenously when it provides loans to the rest of the institutional sectors, consistent with post-Keynesian theory (Lavoie, 2014).

For MFIs, the model net lending position ($LEND_{MFIM}$) is the net of interest received by MFIs ($INTR_{MFI}$) and interest paid by MFIs ($INTP_{MFI}$) (Eq.(208)). MFI interest received and paid is the sum of respective rates of returns and stock levels (Eqs.(209)&(210)). The lending discrepancy is driven exogenously as less the sum of all the other exogenously driven discrepancies within the model (Eq. (211)) with the actual MFI net lending position defined as the model determined net lending plus the lending discrepancy (Eq. (212)).

$$LEND_{MFIMt} = INTR_{MFIt} - INTP_{MFIt} \tag{208}$$

$$INTR_{MFIt} = INTP_{NFCt} + INTP_{PSt} + INTP_{NMFIt} + INTP_{GVTt} + INTP_{HHt} \tag{209}$$

$$INTP_{MFIt} = INTR_{NFCt} + INTR_{PSt} + INTR_{NMFIt} + INTR_{GVTt} + INTR_{HHt} + INTN_{RoWt} \tag{210}$$

$$DISC_{MFIt} = -(DISC_{NFCt} + DISC_{NMFIt} + DISC_{GVTt} + DISC_{HHt} + DISC_{RoWt}) \tag{211}$$

$$LEND_{MFIt} = LEND_{MFIMt} + DISC_{MFIt} \tag{212}$$

The total MFI financial assets (FA_{MFI}) are given as the sum of all other sectors' interest-bearing liabilities, while the total MFI financial liabilities are given as the sum of all other sectors' interest-bearing assets (Eqs. (213) & (214)). Financial assets minus liabilities give the MFI sector model determined financial net worth (FNW_{MFIM}) (Eq. (215)). The residual financial instrument is given as less the sum of all the other residual financial instruments in the model[26] (Eq. (216))

[26] So the MFI sector is the counterpart to all residual financial instruments by assumption.

and is then added to the model determined financial net worth to give the overall MFI financial net-worth FNW_{MFI} (Eq. (217)).

$$FA_{MFIt} = IBL_{NFCt} + IBL_{PSt} + IBL_{NMFIt} + IBL_{GVTMFIt} + IBL_{HHt} + IBL_{RoWt} \tag{213}$$

$$FL_{MFIt} = IBA_{NFCt} + IBA_{PSt} + IBA_{NMFIt} + IBA_{GVTt} + IBA_{HHt} + IBA_{RoWt} \tag{214}$$

$$FNW_{MFIMt} = FA_{MFIt} - FL_{MFIt} \tag{215}$$

$$RES_{MFIt} = -(RES_{HHt} + RES_{NFCt} + RES_{NMFIt} + RES_{PSt} + RES_{GVTt} + RES_{RoWt}) \tag{216}$$

$$FNW_{MFIt} = FNW_{MFIMt} + RES_{MFIt} \tag{217}$$

3.4.3. Non-monetary financial Institutions

Non-monetary financial institutions (NMFIs) represent all non-bank financial institutions, including investment funds and pension funds. The separation of this sector from traditional banks reflects the importance of non-monetary financial activity in the UK and a similar separation is made by Burgess et al. (2016) in their SFC model for the UK. This sector acts as the counterpart for all dividend transfers in the model, and its asset position has a direct impact on the value of pension and insurance assets held by households. In the UK, the NMFI sector is particularly large with almost the same total financial assets/liabilities as the traditional banking (MFI) sector. Including it as a separate sector in this way allows the model to look at a wider range of financial effects and is prudent due to the differing role MFIs and NMFIs have in the economy.

NMFIs disposable income (YD_{NMFI}) is defined as the sum of their interest and dividend receipts minus their interest and dividend payments (Eq. (218)). The interest received and the interest paid are equal to the sum of the relevant rates multiplied by the associated stock values (Eqs. (219) & (220)). NMFI dividends received are equal to the sum of the dividend payments of the other model sectors as it is assumed that the NMFI sector is the destination of all dividend payments and the source of all dividend flows (Eq.(221)). The dividends paid by NMFIs are then given as a fixed proportion of their available net-income prior to dividend payments, where ($\alpha_{DIVPNMFI}$) is between 0 and 1 (Eq. (222)).[27]

$$YD_{NMFIt} = (INTR_{NMFIt} + DIVR_{NMFIt}) - (INTP_{NMFIt} + DIVP_{NMFIt}) \tag{218}$$

$$INTR_{NMFIt} = r_{IBANMFIt} IBA_{NMFIt-1} + r_{IBLGVTt} IBL_{GVTNMFIt-1} \tag{219}$$

$$INTP_{NMFIt} = r_{IBLNMFIt} IBL_{NMFIt-1} \tag{220}$$

$$DIVR_{NMFIt} = DIVP_{NFCt} + DIVP_{PSt} \tag{221}$$

$$DIVP_{NMFIt} = \alpha_{DIVPNMFI}(DIVR_{NMFIt} + INTR_{NMFIt} - INTP_{NMFIt}) \tag{222}$$

Investment income related to pension ($PENSR$) and insurance schemes ($INSR$) that is payable to households are defined based on the disposable income of NMFIs and the relative share of

[27] This approach will inevitably lead to overestimating dividend flows to and from NMFIs. However, the net flows are consistent with the data and this approach is a convenient way of dealing with a lack of data on whom-to-whom dividend flow data.

pensions and insurance assets (Eqs. (223) & (224)).[28] These equations mean that the return on pension and insurance schemes is impacted directly by the economic health of the NMFI sector and if this sector receives lower income, the return on these assets will decrease. Social contributions to the NMFI sector ($SOCC_{NMFI}$) are then equal to the investment income from pensions plus a proportion of household wage income (Eq. (225)). Social benefits paid by NMFIs ($SOCB_{NMFI}$) are predominantly pension-related transfers and are therefore modelled as proportional to the overall value of pension schemes (Eq. (226)). The pension adjustment ($PENS_{ADJ}$) is defined as the net social contribution minus social benefit of the NMFI sector (Eq. (227)).[29]

$$PENSR_t = \alpha_{PENSR} YD_{NMFIt-1} \cdot \frac{PENS_{t-1}}{PENS_{t-1} + INS_{t-1}} \tag{223}$$

$$INSR_t = \alpha_{INSR} YD_{NMFIt-1} \cdot \frac{INS_{t-1}}{PENS_{t-1} + INS_{t-1}} \tag{224}$$

$$SOCC_{NMFIt} = PENSR_t + \alpha_{SOCCW} W_t \tag{225}$$

$$SOCB_{NMFIt} = \alpha_{SOCBPENS} PENS_{t-1} \tag{226}$$

$$PENS_{ADJt} = SOCC_{NMFIt} - SOCB_{NMFIt} \tag{227}$$

NMFI model determined net lending ($LEND_{NMFIM}$) is defined as their disposable income and net flows related to pension and insurance schemes (Eq. (228)). The lending discrepancy is driven exogenously as a portion of GDP (Eq. (229)) with the actual NMFI net lending position defined as the model determined net lending plus the lending discrepancy (Eq. (230)).

$$LEND_{NMFIMt} = YD_{NMFIt} - INSR_t - PENSR_t + SOCC_{NMFIt} - SOCB_{NMFIt} - PENS_{ADJt} \tag{228}$$

$$DISC_{NMFIt} = \eta_{NMFIT} GDP_t \tag{229}$$

$$LEND_{NMFIt} = LEND_{NMFIMt} + DISC_{NMFIt} \tag{230}$$

Interest bearing asset transfers ($IBATR_{NMFI}$) are set exogenously as equal to a fixed proportion of gross output (GO) (Eq. (231)). Equity liability transfers ($EQLTR_{NMFI}$) are equal to the sum of all other equity asset transfers for domestic sectors and the net equity transfer of the rest of the world (Eq. (232)), this is due to the assumption that the NMFI sector serves as the counterpart to all equity assets in the model. NMFI equity asset transfers ($EQATR_{NMFI}$) are then equal to a fixed proportion of the equity liability transfers (Eq. (233)). Interest-bearing liability transfers ($IBLTR_{NMFI}$) serve as the residual stock transfer and equal the net transfers of all other financial assets (Eq. (234)). The residual financial instrument transaction of the NMFI sector ($RESTR_{NMFI}$) grows exogenously as a fixed proportion of GDP (Eq. (235)).

[28]It should be highlighted that these flows, while payable to households, do not actually represent accessible household income. They are the income of pension and insurance schemes which increase the value of these funds held by households. The national accounting convention of recording this as household property income is followed; however, in the model both these flows will directly end up as household pension and insurance transfers leading to growth of these respective assets.

[29]This is an imputed flow paid to households by NMFIs; however it will be used to define the pension transfers of the household sector.

$$IBATR_{NMFIt} = \alpha_{IBANMFI} GO_t \tag{231}$$

$$EQLTR_{NMFIt} = EQATR_{NFCt} + EQATR_{PSt} + EQATR_{HHt} + EQNTR_{RoWt} \tag{232}$$

$$EQATR_{NMFIt} = \psi_{EQNMFI} EQLTR_{NMFIt} \tag{233}$$

$$\begin{aligned} IBLTR_{NMFIt} = {} & (IBATR_{NMFIt} + EQATR_{NMFIt} + IBLTR_{GVTNMFIt} + RESTR_{NMFIt}) \\ & - (LEND_{NMFIt} + EQLTR_{NMFIt} + PENSTR_t + INSTR_t) \end{aligned} \tag{234}$$

$$RESTR_{NMFIt} = \eta_{NMFIB} GDP_{t-1} \tag{235}$$

Other transfers, which include price revaluations and other changes in asset value, are set mainly as exogenous rates for the NMFI interest-bearing assets, liabilities and the residual financial instrument (Eqs. (236) - (238)). Other transfers related to equity assets ($OT_{EQANMFI}$) are defined based on the other transfers of equity amongst the other sectors in the model (Eq. (239)). Other transfers related to equity liabilities are assumed to be established so that equity prices are positively related to dividend payments by the NMFI sector while being reduced by the current interest rate on interest-bearing liabilities of the government, which serves as an approximation for the so-called 'risk-free' interest rate (Eq. (240)). Other transfers relating to pensions (OT_{PENS}) and insurance schemes (OT_{INS}) are based on the other transfers of other net-assets of the NMFI sector, reflecting that the revaluations of these assets are based primarily on the net financial changes within the NMFI sector (Eqs. (241) & (242)).

$$OT_{IBANMFIt} = \delta_{IBANMFI} IBA_{NMFIt-1} \tag{236}$$

$$OT_{IBLNMFIt} = \delta_{IBLNMFI} IBL_{NMFIt-1} \tag{237}$$

$$OT_{RESNMFIt} = \delta_{RESNMFI} RES_{NMFIt-1} \tag{238}$$

$$OT_{EQANMFIt} = OT_{EQLNFCt} + OT_{EQLPSt} \tag{239}$$

$$OT_{EQLNMFIt} = \frac{DIVP_{NMFIt}}{r_{IBLGVTt} + \beta_{EQLNMFI}} - EQL_{NMFIt-1} \tag{240}$$

$$\begin{aligned} OT_{PENSt} = {} & (OT_{IBANMFIt} + \beta_{IBLGVTNMFI} \, OT_{IBLGVTt} + OT_{EQANMFIt} \\ & - OT_{IBLNMFIt} - OT_{EQLNMFIt}) \cdot \frac{PENS_{t-1}}{PENS_{t-1} + INS_{t-1}} \end{aligned} \tag{241}$$

$$\begin{aligned} OT_{INSt} = {} & (OT_{IBANMFIt} + \beta_{IBLGVTNMFI} \, OT_{IBLGVTt} + OT_{EQANMFIt} \\ & - OT_{IBLNMFIt} - OT_{EQLNMFIt}) \cdot \frac{INS_{t-1}}{PENS_{t-1} + INS_{t-1}} \end{aligned} \tag{242}$$

The financial stocks of the NMFI sector develop according to their respective financial transfers and other transfers (Eqs. (243) - (246)). Total financial assets and liabilities are defined in Eqs. (247) & (248). Financial assets minus liabilities give the NMFI sector model determined financial net worth (FNW_{NMFIM}) (Eq. (249)). The residual financial instrument develops similarly to other financial assets (Eq. (250)) and is then added to the model determined financial net worth to give the overall NMFI financial net-worth FNW_{NMFI} (Eq. (251)).

$$IBA_{NMFIt} = IBA_{NMFIt-1} + IBATR_{NMFIt} + OT_{IBANMFIt} \tag{243}$$

$$EQA_{NMFIt} = EQA_{NMFIt-1} + EQATR_{NMFIt} + OT_{EQANMFIt} \tag{244}$$

$$IBL_{NMFIt} = IBL_{NMFIt-1} + IBLTR_{NMFIt} + OT_{IBLNMFIt} \tag{245}$$

$$EQL_{NMFIt} = EQA_{HHt} + EQA_{NFCt} + EQA_{PSt} + EQN_{RoWt} \tag{246}$$

$$FA_{NMFIt} = IBA_{NMFIt} + IBL_{GVTNMFIt} + EQA_{NMFIt} \tag{247}$$

$$FL_{NMFIt} = IBL_{NMFIt} + EQL_{NMFIt} + PENS_t + INS_t \tag{248}$$

$$FNW_{NMFIMt} = FA_{NMFIt} - FL_{NMFIt} \tag{249}$$

$$RES_{NMFIt} = RES_{NMFIt-1} + RESTR_{NMFIt} + OT_{RESNMFIt} \tag{250}$$

$$FNW_{NMFIt} = FNW_{NMFIMt} + RES_{NMFIt} \tag{251}$$

3.4.4. Government

The government sector is an active part of the economy, reflecting its crucial role in the UK economy. It sets tax levels, including environmental taxes, pays government wages, and decides on levels of government consumption and investment. It is assumed that the government is free to make choices about all these variables without political constraints. In the baseline, government spending is based on OBR estimates and implied rates from past data.

Government disposable income (YD_{GVT}) is equal to the sum of indirect taxation, income taxes, social contributions, and interest received, less social benefits paid, interest payments, and any income derived from electricity investments via government-owned non-fossil power capital (Eq.(252)). The government's share of electricity market income is determined by the share of total electricity generation capacity accounted for by government non-fossil capital (GVT_{ELECS}), multiplied by the gross operating surplus of the power sector (GOS_{PS}). The total indirect tax receipts ($ITAX$) are equal to the indirect taxes on production ($ITAX_P$) and indirect taxes on the power sector ($ITAX_{PS}$). The indirect tax on production is then defined as the indirect tax rate multiplied by gross output plus environmental taxes linked to direct energy consumption emissions ($ITAX_D$) (Eq. (254)). Direct energy consumption taxes are equal to the coverage of the carbon pricing scheme (COV_{ETSP}))[30] multiplied by the emission trading scheme (ETS) carbon price (P_{ETS}) all multiplied by the total direct emissions in the economy[31] multiplied by the emission trading scheme (ETS) carbon price (P_{ETS}) all multiplied by total direct energy consumption emissions (Eq. (255)). The indirect tax rate on production ($ITAXR_P$) is assumed to tend to a set long-run value based on the adjustment speed (τ_{gvt})[32] (Eq. (256).

$$YD_{GVTt} = (ITAX_t + INTAX_t + SOCC_{GVTt} + INTR_{GVTt}) - (SOCB_{GVTt} + INTP_{GVTt}) \tag{252}$$

[30]This is assumed to be constant in the baseline scenario

[31]It is assumed that the carbon tax for household direct energy use is attributed to the production sector and then passed in through higher prices.

[32]This term is introduced due to the implied initial tax rates being far from historical norms due to the COVID-19 pandemic and other sources of volatility, using an adjustment speed allows these values to gradually return to more normal levels rather than creating a sudden change at the initial condition.

$$ITAX_t = ITAX_{Pt} + ITAX_{PSt} \tag{253}$$

$$ITAX_{Pt} = ITAXR_{Pt}GO_{Pt} + ITAX_{Dt} \tag{254}$$

$$ITAX_{Dt} = COV_{ETSP}P_{ETSt}EMIS_{Dt} \tag{255}$$

$$ITAXR_{Pt} = ITAXR_{Pt-1} - \tau_{gvt}(ITAXR_{Pt-1} - ITAXR_{PLR}) \tag{256}$$

The indirect tax on the power sector is defined similarly to that of the production module as the indirect tax rate multiplied by gross output plus environmental taxes linked to electricity emissions (Eq. (257)). The indirect tax rate on the power sector ($ITAXR_P$) is assumed to tend to a set long run value based on the adjustment speed (τ_{gvt}) (Eq. (258)). The baseline carbon price of the emission trading scheme (P_{ETS}) is set to follow a baseline path where it increases marginally over the period (Eq. (259)). This carbon price can be set higher by the government in different scenarios.[33]

$$ITAX_{PSt} = ITAXR_{PSt}GO_{PSt} + COV_{ETSPSt}P_{ETSt}EMIS_{ELECt} \tag{257}$$

$$ITAXR_{PSt} = ITAXR_{PSt-1} - \tau_{gvt}(ITAXR_{PSt-1} - ITAXR_{PSLR}) \tag{258}$$

$$P_{ETSt} = P_{ETSRBt} \tag{259}$$

Income tax receipts ($INTAX$) are defined as the sum of income tax from non-financial corporations ($INTAX_{NFC}$) and households ($INTAX_{HH}$). Both income taxes are modelled as a fixed proportion of the wage bill (Eqs. (261) & (262)). The respective income tax rates are assumed to tend to set long-run values based on the adjustment speed (τ_{gvt}) (Eqs. (263) & (264)).

$$INTAX_t = INTAX_{NFCt} + INTAX_{HHt} \tag{260}$$

$$INTAX_{NFCt} = INTAXR_{NFCt}W_t \tag{261}$$

$$INTAX_{HHt} = INTAXR_{HHt}W_t \tag{262}$$

$$INTAXR_{NFCt} = INTAXR_{NFCt-1} - \tau_{gvt}(INTAXR_{NFCt-1} - INTAXR_{NFCLR}) \tag{263}$$

$$INTAXR_{HHt} = INTAXR_{HHt-1} - \tau_{gvt}(INTAXR_{HHt-1} - INTAXR_{HHLR}) \tag{264}$$

The equations for government interest payments are based on respective rates of return on interest-bearing assets (IBA_{GVT}) and interest bearing liabilities (IBL_{GVT}) (Eqs.(265)&(266)). Social contributions that households pay to the government ($SOCC_{GVT}$) are treated as an additional income tax taken from overall wages (Eq. (267)). The social contribution rate is assumed to tend to a set long-run value based on the adjustment speed (τ_{gvt}) (Eq. (268)). Social benefits paid by the government ($SOCB_{GVT}$), as a share of GDP, are driven by an econometrically calibrated equation, partly driven by a constant exogenous factor (α_{0SOCB}) and also by the rate of unemployment (ru) where higher unemployment rates lead to higher levels of unemployment benefit payments and thus higher government social benefit payments (Eq. (269)).

$$INTR_{GVTt} = r_{IBAGVTt}IBA_{GVTt-1} \tag{265}$$

[33]The UK has an emission trading scheme, rather than a direct carbon tax so arguably the government cannot control the price so easily and rather controls the maximum emissions through a cap and trade system. To simplify the modelling, it is assumed that the government effectively sets a cap to achieve an average carbon price over a given period and adjusts the cap if that price is not met.

$$INTP_{GVTt} = r_{IBLGVTt} IBL_{GVTt-1} \tag{266}$$

$$SOCC_{GVTt} = SOCCR_{GVTt} W_t \tag{267}$$

$$SOCCR_{GVTt} = SOCCR_{GVTt-1} - \tau_{gvt}(SOCCR_{GVTt-1} - SOCCR_{GVTLR}) \tag{268}$$

$$\frac{SOCB_{GVTt}}{GDP_t} = \alpha_{0SOCB} + \alpha_{1SOCB} \frac{SOCB_{GVTt-1}}{GDP_{t-1}} + \alpha_{2SOCB} ru_t \tag{269}$$

Consumption of the government sector ($CONS_{GVT}$) is the sum of public wages (W_{PUB})[34] and other government consumption ($OCONS_{GVT}$) (Eq. (270)). Other government consumption ($OCONS_{GVT}$) is assumed to follow an exogenous path based on nominal GDP (Eq. (271)). Government gross capital formation (GCF_{GVT}) is discretionary government spending and is assumed to follow a baseline path based on OBR estimates (Eq. (272)). As with the NFC sector, government gross capital formation is divided between green and conventional capital, with β_{gvt} representing the portion of the gross capital formation allocated to green capital. It is assumed in the baseline that the behavioural effect of energy costs and prices is the same for the government as it is for non-financial corporations, so β_{gvt} is set equal to β_{nfc} (Eq. (273)). This ratio then defines the level of green and conventional capital investment (Eqs. (274) & (275)). Government non-fossil power capital (K_{GVTNFF}) is tracked separately from general government green capital, as it generates electricity and income for the government sector; its real value evolves through gross capital formation in government non-fossil power assets ($GCF_{GVTNFFRt}$) less depreciation (Eq. (276)).

$$CONS_{GVTt} = W_{PUBt} + OCONS_{GVTt} \tag{270}$$

$$OCONS_{GVTt} = \alpha_{OCONSGVT} GDP_{t-1} \tag{271}$$

$$GCF_{GVTt} = GCF_{GVTBASEt} \tag{272}$$

$$\beta_{gvtt} = \beta_{nfct} \tag{273}$$

$$GCF_{GVTGt} = \beta_{gvtt} GCF_{GVTt} \tag{274}$$

$$GCF_{GVTCt} = GCF_{GVTt} - GCF_{GVTGt} \tag{275}$$

$$K_{GVTNFFRt} = (1 - \delta_{KPSt}) K_{GVTNFFRt-1} + GCF_{GVTNFFRt} \tag{276}$$

The real levels of government consumption and gross capital formation are then defined by dividing the nominal levels by the production price deflator (P_P) (Eqs. (277) - (280)).

$$CONS_{GVTRt} = \frac{CONS_{GVTt}}{P_{Pt}} \tag{277}$$

$$GCF_{GVTRt} = GCF_{GVTGRt} + GCF_{GVTCRt} \tag{278}$$

$$GCF_{GVTGRt} = \frac{GCF_{GVTGt}}{P_{Pt}} \tag{279}$$

$$GCF_{GVTCRt} = \frac{GCF_{GVTCt}}{P_{Pt}} \tag{280}$$

The government model determined net lending ($LEND_{GVTM}$) is defined as their disposable income less consumption, gross capital formation, and any subsidy spending ($SUBS_{GVTt}$) (Eq.

[34] In national accounting public wages are recorded as consumption of the government sector.

(281)). The lending discrepancy is driven exogenously as a portion of GDP (Eq. (282)) with the actual government net lending position defined as the model determined net lending plus the lending discrepancy (Eq. (283)).

$$LEND_{GVTMt} = YD_{GVTt} - (CONS_{GVTt} + GCF_{GVTt} + SUBS_{GVTt}) \tag{281}$$

$$DISC_{GVTt} = \eta_{GVTT} GDP_{t-1} \tag{282}$$

$$LEND_{GVTt} = LEND_{GVTMt} + DISC_{GVTt} \tag{283}$$

Interest bearing asset transfers ($IBATR_{GVT}$) are assumed to equal a fixed proportion of the gross output (GO) (Eq. (284)). Interest bearing liability transfers ($IBLTR_{GVT}$) serve as the residual stock transfer and equal the net transfers of all other financial assets (Eq. (285)). Government bonds, which make up a large portion of government interest-bearing liabilities, are held by multiple sectors in the model. The economic accounts data does not provide the whom-to-whom transactions required to establish the transfers of each sector; however, there are experimental flow-of-funds data for 2020 (ONS, 2020) which gives an estimate that can be used. This data suggests that government interest bearing liabilities are equally split between MFIs, NMFIs and RoW. Therefore, the government interest liability transfers are defined to be equal for each of these sectors based on the fixed proportion derived from the flow-of-funds data and assuming these proportions remain constant (Eqs (286)-(288)). The residual financial instrument transaction of the government sector ($RESTR_{GVT}$) grows exogenously as a fixed proportion of GDP (Eq. (289)).

$$IBATR_{GVTt} = \alpha_{IBAGVT} GO_t \tag{284}$$

$$IBLTR_{GVTt} = IBATR_{GVTt} + RESTR_{GVTt} - LEND_{GVTt} \tag{285}$$

$$IBLTR_{GVTMFIt} = \beta_{IBLGVTMFI} IBLTR_{GVTt} \tag{286}$$

$$IBLTR_{GVTNMFIt} = \beta_{IBLGVTNMFI} IBLTR_{GVTt} \tag{287}$$

$$IBLTR_{GVTRoWt} = \beta_{IBLGVTRoW} IBLTR_{GVTt} \tag{288}$$

$$RESTR_{GVTt} = \eta_{GVTB} GDP_{t-1} \tag{289}$$

Other transfers, which include price revaluations and other changes in asset value, are set as exogenous rates for the government sector (Eqs. (290) - (292)).

$$OT_{IBAGVTt} = \delta_{IBAGVT}(IBA_{GVTt-1}) \tag{290}$$

$$OT_{IBLGVTt} = \delta_{IBLGVT}(IBL_{GVTt-1}) \tag{291}$$

$$OT_{RESGVTt} = \delta_{RESGVT}(RES_{GVTt-1}) \tag{292}$$

The financial stocks of the government sector develop according to their respective financial transfers and other transfers (Eqs. (293) - (297)). Total financial assets and liabilities are defined in Eqs. (298) & (299). Financial assets minus liabilities give the government sector model determined financial net worth (FNW_{GVTM}) (Eq. (300)). The residual financial instrument develops similarly to other financial assets (Eq. (301)) and is then added to the model determined financial net worth to give the overall government sector financial net-worth FNW_{GVT} (Eq. (302)).

$$IBA_{GVTt} = IBA_{GVTt-1} + IBATR_{GVTt} + OT_{IBAGVTt} \tag{293}$$

$$IBL_{GVTt} = IBL_{GVTMFIt} + IBL_{GVTNMFIt} + IBL_{GVTRoWt} \tag{294}$$

$$IBL_{GVTMFIt} = IBL_{GVTMFIt-1} + IBLTR_{GVTMFIt} + \beta_{IBLGVTMFI}OT_{IBLGVTt} \tag{295}$$

$$IBL_{GVTNMFIt} = IBL_{GVTNMFIt-1} + IBLTR_{GVTNMFIt} + \beta_{IBLGVTNMFI}OT_{IBLGVTt} \tag{296}$$

$$IBL_{GVTRoWt} = IBL_{GVTRoWt-1} + IBLTR_{GVTRoWt} + \beta_{IBLGVTRoW}OT_{IBLGVTt} \tag{297}$$

$$FA_{GVTt} = IBA_{GVTt} \tag{298}$$

$$FL_{GVTt} = IBL_{GVTt} \tag{299}$$

$$FNW_{GVTMt} = FA_{GVTt} - FL_{GVTt} \tag{300}$$

$$RES_{GVTt} = RES_{GVTt-1} + RESTR_{GVTt} + OT_{RESGVTt} \tag{301}$$

$$FNW_{GVTt} = FNW_{GVTMt} + RES_{GVTt} \tag{302}$$

The capital stock of the government sector is split into conventional and green capital stock. The real value of conventional (K_{GVTCR}) and green (K_{GVTGR}) capital are increased through real gross capital formation, while a portion of the previous period's real capital stock is lost to depreciation (Eqs. (303) & (304)). These stocks are summed to give the overall real capital stock (K_{GVTR}) of the government sector (Eq. (305)). The nominal capital stock values are then calculated by multiplying the real capital by the production price deflator (Eqs. (306) - (308)). Government sector net worth is defined as the sum of net financial and real assets (Eq. (309)).

$$K_{GVTCRt} = (1 - \delta_{KPt})K_{GVTCRt-1} + GCF_{GVTCRt} \tag{303}$$

$$K_{GVTGRt} = (1 - \delta_{KPt})K_{GVTGRt-1} + GCF_{GVTGRt} \tag{304}$$

$$K_{GVTRt} = K_{GVTCRt} + K_{GVTGRt} \tag{305}$$

$$K_{GVTt} = K_{GVTCt} + K_{GVTGt} \tag{306}$$

$$K_{GVTCt} = K_{GVTCRt}P_{Pt} \tag{307}$$

$$K_{GVTGt} = K_{GVTGRt}P_{Pt} \tag{308}$$

$$NW_{GVTt} = FNW_{GVTt} + K_{GVTt} \tag{309}$$

3.4.5. Households

Households are the main consumers in the economy and also invest in the building of houses. Households are considered in the aggregate within the model; therefore, inequality effects are not explicitly modelled. Housing stock is included as the main real asset on the household balance sheet while also considering different forms of housing based on their electricity use and energy efficiency. This allows the model to explore the impacts of policies aimed at greening the UK housing stock, which is an important part of achieving climate goals within the UK.

The primary income of the household sector (YP_{HH}) is the sum of wage income (W), interest payments received ($INTR_{HH}$), dividends ($DIVR_{HH}$) less interest payments ($INTP_{HH}$) (Eq. (310)). The equations for interest payments are based on respective rates of return on interest-bearing assets (IBA_{HH}) and interest-bearing liabilities (IBL_{HH}) (Eqs.(311)&(312)). The dividends received by households ($DIVR_{HH}$) are a proportion of the dividends paid by NMFIs multiplied by the share of HH equity assets (Eq. (313)).

$$YP_{HHt} = W_t + (INTR_{HHt} + DIVR_{HHt}) - (INTP_{HHt}) \tag{310}$$

$$INTR_{HHt} = r_{IBAHHt} IBA_{HHt-1} \tag{311}$$

$$INTP_{HHt} = r_{IBLHHt} IBL_{HHt-1} \tag{312}$$

$$DIVR_{HHt} = \beta_{dhh} \frac{EQA_{HHt}}{EQL_{NMFIt}} DIVP_{NMFIt} \tag{313}$$

The disposable income of the household sector (YD_{HH}) is taken as households' primary income including net social contributions/benefits and minus income tax payments ($INTAX_{HH}$) (Eq. (314)). The total social contributions and benefits of the households are given by the sum of the respective values of the NMFI and the government sectors (Eqs. (315) & (316)).

$$YD_{HHt} = YP_{HHt} + (SOCB_t) - (SOCC_t + INTAX_{HHt}) \tag{314}$$

$$SOCC_t = SOCC_{NMFIt} + SOCC_{GVTt} \tag{315}$$

$$SOCB_t = SOCB_{NMFIt} + SOCB_{GVTt} \tag{316}$$

Household consumption ($CONS_{HH}$) is given as the sum of household consumption from production ($CONS_{HHP}$) and from the power sector ($CONS_{HHPS}$) (Eq. (317)). The nominal consumption of production is based on post-Keynesian theory, where there is a positive relationship between household disposable income (YD_{HH}) and consumption and also between the financial wealth of the household (FA_{HH}) and consumption. This aims to capture the distinction between consumption out of wages and consumption out of profits, with the latter generally found to be lower (Lavoie, 2014). This equation is estimated econometrically with a significant long-term relationship found between these variables (Eq. (318)). Real household consumption from production is then equal to the nominal consumption divided by the production price deflator (P_P) (Eq. (319)). The nominal consumption of the power sector ($CONS_{HHPS}$) is equal to the real consumption ($CONS_{HHPSR}$) multiplied by the price of electricity (P_{ELEC}) (Eq. (320)). The level of real household consumption of electricity is equal to the electricity use of households, with electricity assumed to make up the majority of household consumption related to this sector (Eq. (321)). The total savings of households (SAV_{HH}) for investment purposes is equal to their disposable income less consumption spending (Eq. (322)).

$$CONS_{HHt} = CONS_{HHPt} + CONS_{HHPSt} \tag{317}$$

$$\begin{aligned} \Delta \mathbf{L}(CONS_{HHPt}) = \epsilon_{CHHP} \big(& \alpha_{0CHHP} + \alpha_{1CHHP} \mathbf{L}(YD_{HHt-1}) \\ & + \alpha_{2CHHP} \mathbf{L}(FA_{HHt-1}) - \mathbf{L}(CONS_{HHPt-1}) \big) \end{aligned} \tag{318}$$

$$CONS_{HHPRt} = \frac{CONS_{HHPt}}{P_{Pt}} \tag{319}$$

$$CONS_{HHPSt} = CONS_{HHPSRt} P_{ELECt} \tag{320}$$

$$CONS_{HHPSRt} = E_{ELECHt} \tag{321}$$

$$SAV_{HHt} = YD_{HHt} - CONS_{HHt} \tag{322}$$

Households make investments, predominantly related to housing. This gross capital formation is divided into two main categories: house building[35] and home improvements. Total household gross capital formation (GCF_{HH}) is given as the sum of gross capital formation of new build houses (GCF_{HHNB}) and home improvements (GCF_{HHHI}). Household investment in housebuilding (GCF_{HHNB}) is primarily driven by the total value of properties, where higher property values make household investment more attractive; this is expressed in an econometrically estimated co-integration equation (Eq. (324)) and it should be noted that while there is a positive relationship between prices and house building, this response is relatively weak.[36] The gross capital formation of households on home improvements (GCF_{HHHI}) follows the overall growth of GDP (Eq. (325)).

$$GCF_{HHt} = GCF_{HHNBt} + GCF_{HHHISt} \tag{323}$$

$$\begin{aligned}\Delta \mathbf{L}(GCF_{HHNBt}) = \epsilon_{GCFNB}\big(- \alpha_{0GCFNB} + \alpha_{1GCFNB}\mathbf{L}(HVAL_{t-1}) \\ - \mathbf{L}(GCF_{HHNBt-1})\big) - \delta_{1GCFNB}\Delta\big(\mathbf{L}(GCF_{HHNBt-1})\big)\end{aligned} \tag{324}$$

$$GCF_{HHHIt} = \alpha_{HHHI}GDP_{t-1} \tag{325}$$

The real levels of gross capital formation are then defined by dividing the nominal levels by the production price deflator (P_P) (Eqs. (326) - (328)).

$$GCF_{HHRt} = \frac{GCF_{HHt}}{P_{Pt}} \tag{326}$$

$$GCF_{HHNBRt} = \frac{GCF_{HHNBt}}{P_{Pt}} \tag{327}$$

$$GCF_{HHHIRt} = \frac{GCF_{HHHIt}}{P_{Pt}} \tag{328}$$

The real investment in home improvements is then divided between regular home improvements (GCF_{HIHINR}) and energy-based home improvements (($GCF_{HHHIENR}$) in Eqs.(329 & 330). The division between regular and energy-based home improvements is given by Eq. (331) where there is an exogenous trend towards increasing energy-based home improvements over time and this is further increased based on the difference between direct energy (P_D) and electricity (P_{ELEC}) prices. Energy-based home improvements are then divided further between efficiency improvements and electrification. Efficiency improvements are investments used to turn an energy inefficient house into an efficient one by measures such as wall insulation and window glazing, whereas electrification energy improvements turn efficient houses fully electric by installing electrical heating devices such as heat-pumps. The split between these two types of energy efficiency home improvements is given by Eqs. (332) & (333) with the difference being partly driven by the ratio between inefficient homes (H_I) and efficient non-electric homes (H_{EN}) such that as the number of inefficient homes decreases, there is a shift towards greater electrification as the next step in improving energy efficiency.

[35]It is assumed that when a house is built and subsequently purchased by a household this is recorded as gross fixed capital formation of the household sector; this is consistent with national accounting conventions.

[36]This is in line with UK data where there has been a large increase in house prices over the last two decades but a relatively moderate increase in house building; the model cannot assess the impact of other policies that could impact house building, such as planning permission and regulation.

$$GCF_{HHHIERt} = \beta_{GCFHHt} GCF_{HHHIRt} \tag{329}$$

$$GCF_{HHHINRt} = GCF_{HHHIRt} - GCF_{HHHIERt} \tag{330}$$

$$\beta_{GCFHHt} = \alpha_{0betaHH} + TREND_{betaHH} t + \alpha_{1betaHH} (P_{DTt-1} - P_{ELECt-1}) \tag{331}$$

$$GCF_{HHHIENRt} = GCF_{HHHIERt} \frac{\kappa_{hie} H_{It-1}}{\kappa_{hie} H_{It-1} + H_{ENt-1}} \tag{332}$$

$$GCF_{HHHIEERt} = GCF_{HHHIERt} - GCF_{HHHIENRt} \tag{333}$$

Households model determined net lending ($LEND_{HHM}$) is defined as their total savings, less gross capital formation spending plus pension and insurance related flows[37] (Eq. (334)). The lending discrepancy is driven exogenously as a portion of GDP (Eq. (335)) with the actual household net lending position defined as the model determined net lending plus the lending discrepancy (Eq. (336)).

$$LEND_{HHMt} = SAV_{HHt} - GCF_{HHt} + INSR_t + PENSR_t + PENS_{ADJt} \tag{334}$$

$$DISC_{HHt} = \eta_{HHT} GDP_{t-1} \tag{335}$$

$$LEND_{HHt} = LEND_{HHMt} + DISC_{HHt} \tag{336}$$

For household financial stock transfers, it is assumed that interest bearing asset transfers of households ($IBATR_{HH}$) are derived residually (Eq. (337)). Equity asset transfers ($EQATR_{HH}$) are assumed to be a negative fixed proportion of household equity stock, reflecting households withdrawing from their stock of equities as a way to fund financial transactions (Eq. (338)). Pension transfers ($PENSTR$) are equal to the derived pension adjustment consistent with ONS data (Eq. (339)). Insurance transfers ($INSTR_{HH}$) are equal to the return on insurance funds less net payouts on insurance schemes (Eq. (340)). Interest bearing liability transfers ($IBLTR_{HH}$), which for households are mainly related to mortgage borrowing, are set as a fixed proportion of the total value of housing stock (Eq. (341)). The residual financial instrument transaction of the household sector ($RESTR_{HH}$) grows exogenously as a fixed proportion of GDP (Eq. (342)).

$$IBATR_{HHt} = LEND_{HHt} + IBLTR_{HHt} - (EQATR_{HHt} + RESTR_{HHt} + PENSTR_t + INSTR_t) \tag{337}$$

$$EQATR_{HHt} = -\alpha_{EQAHH} EQA_{HHt-1} \tag{338}$$

$$PENSTR_t = PENS_{ADJt} \tag{339}$$

$$INSTR_t = INSR_t - \alpha_{INSTR} INS_{t-1} \tag{340}$$

$$IBLTR_{HHt} = \alpha_{IBLTR} HVAL_t \tag{341}$$

$$RESTR_{HHt} = \eta_{HHB} GDP_{t-1} \tag{342}$$

Other transfers, which include price revaluations and other changes in asset value, are set as exogenous rates for the household sector (Eqs. (343) - (346)).

[37] Recall these flows are an accounting convention and are not accessible income for households.

$$OT_{IBAHHt} = \delta_{IBAHH}(IBA_{HHt-1}) \tag{343}$$

$$OT_{EQAHHt} = \delta_{EQAHH}(EQA_{HHt-1}) \tag{344}$$

$$OT_{IBLHHt} = \delta_{IBLHH}(IBL_{HHt-1}) \tag{345}$$

$$OT_{RESHHt} = \delta_{RESHH}(RES_{HHt-1}) \tag{346}$$

The financial stocks of the household sector develop according to their respective financial transfers and other transfers (Eqs. (347) - (351)). Total financial assets and liabilities are defined in Eqs. (352) & (353). Financial assets minus liabilities give the household sector model determined financial net worth (FNW_{HHM}) (Eq. (354)). The residual financial instrument develops similarly to other financial assets (Eq. (355)) and is then added to the model determined financial net worth to give the overall household sector financial net-worth FNW_{HH} (Eq. (356)).

$$IBA_{HHt} = IBA_{HHt-1} + IBATR_{HHt} + OT_{IBAHHt} \tag{347}$$

$$EQA_{HHt} = EQA_{HHt-1} + EQATR_{HHt} + OT_{EQAHHt} \tag{348}$$

$$PENS_t = PENS_{t-1} + PENSTR_t + OT_{PENSt} \tag{349}$$

$$INS_t = INS_{t-1} + INSTR_t + OT_{INSt} \tag{350}$$

$$IBL_{HHt} = IBL_{HHt-1} + IBLTR_{HHt} + OT_{IBLHHt} \tag{351}$$

$$FA_{HHt} = IBA_{HHt} + EQA_{HHt} + PENS_t + INS_t \tag{352}$$

$$FL_{HHt} = IBL_{HHt} \tag{353}$$

$$FNW_{HHMt} = FA_{HHt} - FL_{HHt} \tag{354}$$

$$RES_{HHt} = RES_{HHt-1} + RESTR_{HHt} + OT_{RESHHt} \tag{355}$$

$$FNW_{HHt} = FNW_{HHMt} + RES_{HHt} \tag{356}$$

The total number of houses (H) is given by the sum of the three types of housing: inefficient houses (H_I) taken as houses with EPC ratings D and below, efficient non-electric houses (H_{EN}) taken as houses with EPC ratings C and above where the primary energy source is non-electric and efficient electric houses (H_{EE})[38] taken as houses with EPC ratings C and above where the primary energy source is electricity based (Eq.(357)).[39] These three housing stocks develop based on house building and efficiency and electrification based home improvements. The number of houses built (HB) is directly proportional to the real household investment in new houses (Eq. (358)). It is assumed that all new build houses are efficient and a portion (β_{HBE}) of them are fully electric.[40] Inefficient houses are transformed into efficient non-electric houses through real energy

[38]Note there is no inefficient electric house category, where properties primary energy source is electricity based while the properties EPC rating is D and below, houses do exist in this category however there are very few in the UK as fully electric houses tend to be efficient, not least because energy efficiency is generally a pre-requisite to using electric heating technologies such as heat-pumps.

[39]The EPC ratings are taken directly from EPC data (UK Department for Levelling UP, Housing & Communities, 2025)

[40]This is consistent with what is observed in the UK where the overwhelming majority of new build properties will have at least and EPC rating of C.

home improvements (GCF_{HIENR}) which can then be transformed into efficient electric houses through real electrification home improvement (GCF_{HIEER}) with both these transformation rates being determined by the cost of energy and electrification home upgrades (Eqs. (359) - (361)). $COST_{HIENR}$ and $COST_{HIEER}$ are the real costs of the upgrades to efficiency and electrification, respectively, and are set to remain constant unless reduced by a policy such as a subsidy (Eqs (362) & (363)).

$$H_t = H_{It} + H_{ENt} + H_{EEt} \tag{357}$$

$$HB_t = \alpha_{HB} GCF_{HHNBRt} \tag{358}$$

$$H_{It} = H_{It-1} - \frac{GCF_{HHHIENRt}}{C_{HIENRt}} \tag{359}$$

$$H_{ENt} = H_{ENt-1} + (1 - \beta_{HBE})HB_t + \frac{GCF_{HHHIENRt}}{C_{HIENRt}} - \frac{GCF_{HHHIEERt}}{C_{HIEERt}} \tag{360}$$

$$H_{EEt} = H_{EEt-1} + \beta_{HBE} HB_t + \frac{GCF_{HHHIEERt}}{C_{HIEERt}} \tag{361}$$

$$C_{HIENRt} = C_{HIENRB} \tag{362}$$

$$C_{HIEERt} = C_{HIEERB} \tag{363}$$

The total value of housing stock ($HVAL$) is equal to the average house price (P_H) multiplied by the number of houses (H) (Eq. (364)). House prices (P_H) per worker have a long run co-integrating relationship with disposable income per worker and interest bearing liabilities per worker, showing that housing demand can be based both on income but can also be financed through increased indebtedness (Eq. (365)). Household sector net worth is defined as the sum of net financial and real assets (Eq. (366)).

$$HVAL_t = H_t P_{Ht} \tag{364}$$

$$\Delta \mathbf{L} \frac{P_{Ht} H_t}{LF_t} = \epsilon_{PH} \left(\alpha_{0PH} + \alpha_{1PH} \mathbf{L} \left(\frac{YD_{HHt-1}}{LF_{t-1}} \right) + \alpha_{2PH} \mathbf{L} \left(\frac{IBL_{HHt-1}}{LF_{t-1}} \right) - \mathbf{L} \frac{P_{Ht-1} H_{t-1}}{LF_{t-1}} \right) \tag{365}$$

$$NW_{HHt} = FNW_{HHt} + HVAL_t \tag{366}$$

3.4.6. Rest of the world

The rest of the world interacts with the domestic economy primarily through import and export flows along with the holding of domestic assets and liabilities. The income from production (YP_{RoW}) of the rest of the world is given as total imports (IMP) minus exports (EXP) (Eq. (367)). We define domestic output (DY) as the sum of consumption, gross capital formation and export flows, in effect GDP less imports (Eq. (368)). Nominal demand in the RoW (RoW_D) is calculated based on real demand in the RoW (RoW_{DR}) multiplied by foreign prices (P_F) (Eq. (369)). The total nominal imports (IMP) are mainly driven by domestic output, reflecting the role of imports as an intermediate input to production (Eq. (370)). The share of different forms of gross capital formation (GCF) in domestic output also has an impact on imports, with gross capital formation being more import intensive than other forms of domestic input while the formation of gross capital of the power sector is even more import intensive, reflecting the high component of imported machinery used in investments in non-fossil power. In addition, imports are driven by the ratio between import prices (P_I) and domestic prices (P_P). Counter-intuitively, the value of the α_{4IMP} parameter is positive, which is due to the fact that this is a nominal import equation, so a positive value reflects that rising import prices increase nominal imports. However, the value of α_{4IMP} is less than 1, which implies that the long-term relationship between import volumes and this price ratio is, in fact, negative as expected. Nominal exports (EXP) are mainly driven by nominal demand in the rest of the world (RoW_D) along with the real effective exchange rate ($REER$) (Eq. (371)). Again, the parameter α_{3EXP} is slightly positive, implying that a reduction in price competitiveness of exports leads to an increase in exports. Once again, this is driven by the price effect and export volumes will still fall significantly when $REER$ increases.

$$YP_{RoWt} = IMP_t - EXP_t \tag{367}$$

$$DY_t = CONS_t + GCF_t + EXP_t \tag{368}$$

$$RoW_{Dt} = RoW_{DRt} \cdot P_{Ft} \tag{369}$$

$$\mathbf{L}IMP_t = \alpha_{0IMP} + \alpha_{1IMP}\mathbf{L}IMP_{t-1} + \alpha_{2IMP}\mathbf{L}DY_{t-1} + \alpha_{3IMP} \mathbf{L}\left(\frac{\beta_{1IMP}GCF_t + \beta_{2IMP}GCF_{PSt}}{DY_t}\right) + \alpha_{4IMP}\mathbf{L}\frac{P_{It}}{P_{Pt}} + \delta_{1IMP}\Delta\mathbf{L}DY_t \tag{370}$$

$$\mathbf{L}EXP_t = \alpha_{0EXP} + \alpha_{1EXP}\mathbf{L}EXP_{t-1} + \alpha_{2EXP}\mathbf{L}RoW_{Dt-1} + \alpha_{3EXP}\mathbf{L}REER_{t-1} + \delta_{1EXP}\Delta\mathbf{L}RoW_{Dt} \tag{371}$$

RoW real demand (RoW_{DR}) is set to grow based on the exogenous growth rate (RoW_{Dg}) in line with forecasts for real growth rates globally (Eq. (372)). Real imports (IMP_R) and real exports (EXP_R) are calculated by dividing by their respective price deflators P_I and P_E (Eqs. (373) & (374)).

$$RoW_{DRt} = RoW_{Dg}RoW_{DRt-1} \tag{372}$$

$$IMP_{Rt} = \frac{IMP_t}{P_{It}} \tag{373}$$

$$EXP_{Rt} = \frac{EXP_t}{P_{Et}} \tag{374}$$

While exchange rate and price effects are included in the equations above, in this version of DEFINE-UK the dynamics of these variables are kept constant or exogenous in most cases. The nominal exchange rate (ER) is assumed to remain constant in our forecast, which is justified by a relatively stable GBP exchange rate in the UK over recent periods (Eq. (375)). The foreign price level (P_F) is driven by an exogenous growth rate (RoW_{Pg}) based on global forecasts (Eq. (376)). Export prices (P_E) are assumed to follow domestic price trends (Eq. (377)). Import prices (P_I) are defined based on foreign prices, the nominal exchange rate and an adjustment term (I_{ADJ}) which is used to account for the basket of import goods not corresponding to the general basket of goods in the rest of the world which is used to calculate P_F (Eq. (378)). The import adjustment term (I_{ADJ}) is assumed to remain constant over the model projections (Eq. (379)). Finally, the real effective exchange rate ($REER$) is defined as the ratio between export prices (P_E) and exchange rate (ER) adjusted foreign prices (P_F) (Eq. (380)).

$$ER_t = ER_{t-1} \tag{375}$$

$$P_{Ft} = RoW_{Pg}P_{Ft-1} \tag{376}$$

$$P_{Et} = P_{Pt} \tag{377}$$

$$P_{It} = P_{Ft}ER_tI_{ADJt} \tag{378}$$

$$I_{ADJt} = I_{ADJt-1} \tag{379}$$

$$REER_t = \frac{P_{Et}}{ER_tP_{Ft}} \tag{380}$$

Unlike other sectors, the model considers property income flows with the rest of the world sector in net, rather than gross terms. This is done for both pragmatic and theoretical reasons. First, the RoW sector is mostly exogenous to the model, and recording gross flows as opposed to net flows is not necessary for any behavioural relationships within the model. Additionally, some of the model assumptions around gross interest and dividend payments are harder to justify for the RoW sector, which includes foreign firms and foreign financial institutions. Generally, net flows are sufficient to show open economy financial effects, so this is the approach that is taken for the model. Net RoW interest received ($INTN_{RoW}$) is the sum of interest received on the RoW's share of government liabilities (IBL_{GVTRoW}) and their net holding of other interest-bearing assets (IBN_{RoW}) (Eq. (381)). Net RoW dividends received ($DIVN_{RoW}$) are given as a fixed proportion of RoW net equity holding (EQN_{RoW}) (Eq. (382)). RoW model determined net lending ($LEND_{RoWM}$) is defined as their income from production plus their net interest and dividend income received (Eq. (383)). The lending discrepancy is driven exogenously as a portion of GDP (Eq. (384)) with the actual RoW net lending position defined as the model determined net lending plus the lending discrepancy (Eq. (385)).

$$INTN_{RoWt} = r_{IBLGVTt}IBL_{GVTRoWt-1} + r_{IBNRoWt}IBN_{RoWt-1} \tag{381}$$

$$DIVN_{RoWt} = \alpha_{DIVNRoW}EQN_{RoWt-1} \tag{382}$$

$$LEND_{RoWMt} = YP_{RoWt} + INTN_{RoWt} + DIVN_{RoWt} \tag{383}$$

$$DISC_{RoWt} = \eta_{RoWT}GDP_{t-1} \tag{384}$$

$$LEND_{RoWt} = LEND_{RoWMt} + DISC_{RoWt} \tag{385}$$

Net RoW interest-bearing asset transfers ($IBNTR_{RoW}$) are set as the residual of all other financial transactions (Eq. (386)). Net equity asset transfers ($EQNTR_{RoW}$) are set as proportional to RoW income from production (Eq. (387)). The residual financial instrument transaction of the RoW sector ($RESTR_{RoW}$) grows exogenously as a fixed proportion of GDP (Eq. (388)).

$$IBNTR_{RoWt} = LEND_{RoWt} - (IBLTR_{GVTRoWt} + EQNTR_{RoWt} + RESTR_{RoWt}) \tag{386}$$

$$EQNTR_{RoWt} = \alpha_{EQNTRRoW}YP_{RoWt} \tag{387}$$

$$RESTR_{RoWt} = \eta_{RoWB}GDP_{t-1} \tag{388}$$

$$OT_{IBARoWt} = \delta_{IBARoW}(IBN_{RoWt-1}) \tag{389}$$

$$OT_{EQNRoWt} = \delta_{EQNRoW}(EQN_{RoWt-1}) \tag{390}$$

$$OT_{RESRoWt} = \delta_{RESRoW}(RES_{RoWt-1}) \tag{391}$$

The net-financial stocks of the RoW sector develop according to their respective financial transfers and other transfers (Eqs. (392) & (393)). The sum of net financial assets gives the RoW sector model determined financial net worth (FNW_{RoWM}) (Eq. (394)). The residual financial instrument develops similarly to other financial assets (Eq. (395)) and is then added to the model determined financial net worth to give the overall RoW sector financial net-worth FNW_{RoW} (Eq. (396)).

$$IBN_{RoWt} = IBN_{RoWt-1} + IBNTR_{RoWt} + OT_{IBARoWt} \tag{392}$$

$$EQN_{RoWt} = EQN_{RoWt-1} + EQNTR_{RoWt} + OT_{EQNRoWt} \tag{393}$$

$$FNW_{RoWMt} = IBN_{RoWt} + EQN_{RoWt} + IBL_{GVTRoWt} \tag{394}$$

$$RES_{RoWt} = RES_{RoWt-1} + RESTR_{RoWt} + OT_{RESRoWt} \tag{395}$$

$$FNW_{RoWt} = FNW_{RoWMt} + RES_{RoWt} \tag{396}$$

3.4.7. Rates of return

The base rate is set based on a simple Taylor rule, where the long-run Bank of England base rate (r_{BOE}) is based on the current level of inflation (Eq. (397)). This equation uses logged values which ensures the base rate cannot fall below the zero lower bound.

$$\Delta \mathbf{L} r_{BOEt} = \epsilon_{rboe}(\alpha_{rboe}\mathbf{L}INF_{t-1} - \mathbf{L}r_{BOEt-1}) \tag{397}$$

Interest rates on interest-bearing assets for model sector j (r_{IBAjt}) tend towards a long run interest rate with adjustment speed (τ_{raj}) (Eq. (398)). The long run asset interest rates are set as the maximum of a mark-down on the base rate and a minimum value ($minr_j$) which is used to respect the zero lower bound for interest rates in the model (Eq. (399)).

$$r_{IBAjt} = r_{IBAjt-1} + \tau_{raj}(r_{IBAjLRt} - r_{IBAjt-1}) \tag{398}$$

$$r_{IBAjLRt} = max(minr_j, r_{BOEQt} - spr_{ja}) \tag{399}$$

Interest rates on interest-bearing liabilities for model sector j (r_{IBLjt}) tend towards a long run interest rate with adjustment speed (τ_{rlj}) while also being directly impacted by short run adjustments in the base rate, accounting for the observed phenomenon of interest bearing liability rates reacting more quickly to changes in the base rate (Eq. (400)). The long run liability interest rates are set as a mark-up over the interest bearing asset interest rate for the sector and an additional risk premium, which is calculated based on the depreciation rate of the sector's liabilities (δ_j) and the financial health of the MFI sector, proxied as the ratio between its financial liabilities and assets (Eq. (401)).

$$r_{IBLjt} = r_{IBLjt-1} + \tau_{rlj}(r_{IBLjLRt} - r_{IBLjt-1}) + \delta_{rlj}\Delta r_{BOEQt} \tag{400}$$

$$r_{IBLjLRt} = r_{IBAjLRt} + (spr_{jl} + \delta_{jt})(1 + \sigma_j r_{BOEQt})\frac{FL_{MFIt-1}}{FA_{MFIt-1}} \tag{401}$$

4. Baseline scenario & model calibration

4.1. Baseline scenario

The combination of econometrically estimated behavioural equations, identities, and technical relationships results in a model that generates a baseline projection. However, there are significant uncertainties around the parameter values, particularly with regard to some of the environmental parameters in the model. To set reasonable estimates for these parameters, the model draws on a range of external data sources to estimate a baseline scenario, which can be used as the basis for policy scenario analysis. The baseline of the model and the scenarios will run until 2035, this reflects the focus of scenarios on medium-term energy transition goals, as opposed to the longer-term environmental and ecological scenarios covered in models such as the global DEFINE (Dafermos and Nikolaidi, 2022), which runs until 2100, or EUROGREEN, which has projections until 2050 (D'Alessandro et al., 2020).

For macroeconomic data, the model relies mainly on estimates from the UK Office for Budgetary Responsibility OBR (2025). The OBR, set up in 2010 produces detailed forecasts for the economy and public finances and is intended to serve as an independent evaluator of government policy. The OBR uses various tools to generate their economic and fiscal outlook, including their macroeconomic model (OBR, 2013). OBR economic forecasts are short-term with a five-year horizon, therefore, data are available until 2030 for calibrating the baseline. It is assumed that economic variables after 2030 follow a similar growth rate as later years in the forecast.[41] Initial values and parameters are adjusted to achieve similar trajectories as the OBR for variables such as headline GDP growth, the debt-GDP ratio, and the rate of price inflation. As the OBR forecasts feature detailed projections for various forms of government spending, this data will be used to calibrate the technical relationships in the model related to government spending such as forms of government consumption and investment.

For environmental variables, in particular territorial emissions, the objective is to establish a reasonable "current policies" baseline where existing environmental policy commitments are included, but no additional policies or unexpected behaviour change occurs. The emission pathway of the model is close to the current policy projection of the National Energy System Operator (NESO, 2025), who provide independent forecasts of net zero pathways within a specific UK context. Other sources are also used, such as the Network for Greening the Financial System (NGFS) scenario data (NGFS, 2025), although their projections only include emission data at 5-year intervals and take a more global perspective. This means that there is a reduction in emissions in the model; however, the emission reduction falls significantly short of the UK's 2035 NDC target (GOV.UK, 2025) to reduce greenhouse gas emissions by at least 81% by 2035 compared to 1990 levels.

Although other studies are used to calibrate the baseline, this should not be taken as an endorsement of any particular projections. Rather, this is a pragmatic approach in order that the model develops in a way more or less consistent with future expectations for the macroeconomy and environmental systems for the UK. The baseline of the model should also not be seen as a prediction or forecast; What is of primary interest in this research is the effect of different scenarios on the model. Therefore, this thesis is primarily concerned with how various scenarios change variables from the baseline as opposed to making any predictive forecasts for specific variables.

[41] The OBR forecasts mostly converge to a steady growth rate by the end of the forecast period so for the baseline it is assumed that this steady rate can be extrapolated.

Several key baseline variables are shown in Table 4. Most variables are relatively steady. Unemployment, starts low with lower labour force participation following the COVID pandemic but then trends upwards. The population and labour force increase steadily, in line with UK projections. The proportion of non-fossil fuel electricity production increases, but falls far short of the goal of fully non-fossil fuel production by 2030. Total emissions do fall, due to higher electricity use and green investment and efficiency improvements, but again this falls short of UK emission reduction targets. The emission price is set to increase modestly during the baseline period. Green investment, as a percentage of GDP, also increases modestly over the period. NFC and power sector credit rationing rates decrease slightly over the baseline period; this is mainly due to the fact that the start of the baseline scenario is still being affected by the high inflation, low growth, and high interest rates of the early 2020s. Imports and exports maintain a stable relationship with headline GDP, both increasing marginally over the model period, consistent with higher RoW growth than domestic growth in the UK. The real effective exchange rate index is near constant over the baseline projection period.

Table 4: Key characteristics of the baseline scenario

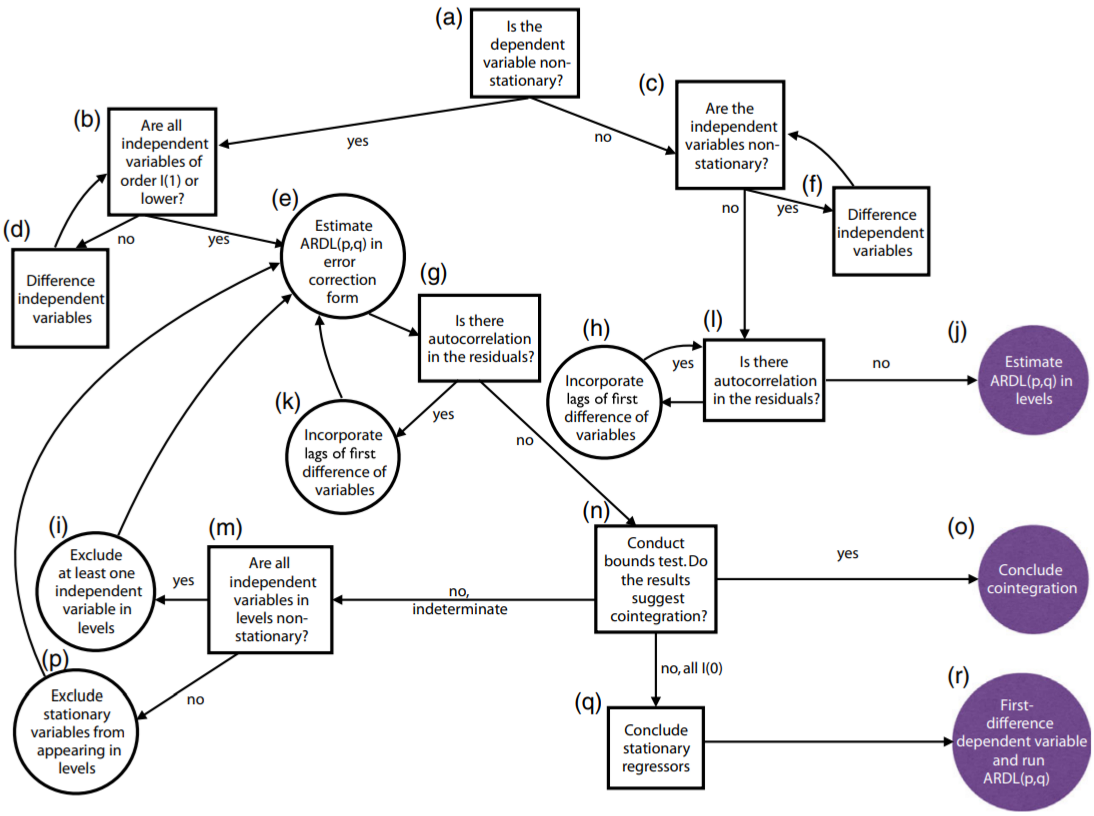
Variable	2025	2030	2040	Mean	St. deviation
Real GDP growth (%)	4.96	2.35	2.01	2.35	0.71
Unemployment (%)	4.31	4.73	4.72	4.71	0.14
Population (millions)	55.66	57.74	61.61	58.68	1.87
Labour Force (millions)	35.97	37.12	39.13	37.62	1.00
Proportion of non-fossil electricity generation (%)	57.93	61.77	77.14	65.92	6.35
Total emissions ($MTCO_{2e}$/year)	407.32	381.76	324.37	367.10	25.46
Emission price (£/TCO_{2e})	8.01	10.58	15.71	11.86	2.44
Green investment (% of GDP)	1.00	1.07	1.30	1.13	0.10
NFC default rate (%)	0.28	0.33	0.45	0.36	0.05
NFC credit rationing (%)	3.81	2.56	4.79	3.49	0.74
Power Sector default rate (%)	0.16	0.11	0.13	0.12	0.01
Power Sector credit rationing (%)	47.22	35.44	21.09	30.64	9.04
Imports (% of GDP)	39.99	39.97	41.18	40.31	0.51
Exports (% of GDP)	38.58	40.19	44.15	41.21	1.80
Real effective exchange rate (index, 2022 = 1)	1.00	1.00	0.98	0.99	0.01

Notes: All quarterly values are annualised and the mean and standard deviation are calculated from 2025-2040.

4.2. Econometric approach

When carrying out econometric estimation we follow the approach of Philips (2018) who present a multistep procedure, including the necessary stationarity and autocorrelation tests, as well as using the well established bound testing procedure to assess cointegration (Pesaran et al., 2001). This systematic approach is shown in Figure 2.

Figure 2: The ARDL-Bounds Procedure's Comprehensive Approach to Time-Series Analysis. Source: Philips (2018).



This approach is used to estimate several key behavioural equations within the model. The behavioural equations estimated in this are household consumption, firm investment, household new-build housing investment, the wage share, the default rate of firm loans, the credit rationing rate on firm loans, the governments social benefit payments and house prices. Therefore, econometric estimates cover the majority of final demand equations, in addition to key financial and fiscal relationships.

For these estimates, household consumption of production goods was found to be positively driven by household disposable income and financial net worth, according to post-Keynesian tradition (Lavoie, 2014). Firm investment was only found to have a significant relationship with the level of capital capacity utilisation, with disposable income not being found to be a significant driver of investment in our estimates. Investment in new build houses is driven primarily by the total value of housing stock, with higher house values incentivising more house building. The wage share is found to have a negative long-run relationship with the unemployment rate, creating a Phillips curve relationship. Firms' default rates are found to depend positively on the illiquidity ratio of the firm, and as illiquidity increases, firms are more likely to default on loans. Credit rationing, on the other hand, is found to depend negatively on firms debt-service ratio such that if the cost of firms servicing their debt is high relative to their disposable income, then banks will be less inclined to provide them with finance. The drivers of default rates and credit rationing are similar to those of the DEFINE model (Dafermos and Nikolaidi, 2022). Government social benefit payments depend positively on the rate of unemployment, reflecting that as unemployment increases, the government is required to provide more social security payments to unemployed workers. This is similar to the model of Byrialsen and Raza (2020). Finally, house prices, relative to population, are driven primarily by per-capita income. By considering house prices per capita, the model can capture how increased housing supply can reduce house prices. The complete econometric and parameter results are shown in the following subsection.

This approach was applied to more equations than the ones presented here. However, in some cases, it proved difficult to find statistically significant results. In other cases, the results were significant but not meaningful from an economic standpoint.[42] Following the pragmatic approach already outlined, when the estimation results were deemed too poor to form the basis of the behavioural equations, other approaches were used to derive technical relationships between variables. In many cases these derivation still used past data. For example, interest rate equations, for which econometric results were likely negatively skewed by the long zero lower bound interest rate period, still used estimated interest rate spreads from past UK data to parameterise the interest rate equations. A complete list of parameter estimates and their sources is included in Section 5 Table **??**.

[42]Such as having the incorrect sign, for example when calibrating the firm investment equation, disposable income of firms consistently had a negative impact on investment. Given that this is hard to justify on a theoretical basis, these variables were removed from that equation.

5. Model parameters and initial values for endogenous variables

Table 5: Symbols and values for parameters and exogenous variables (baseline scenario)

Symbol	Description	Parameter category	Value	Source/remarks
CF_{FF}	Capacity factor of fossil fuel energy generation	Free	1.132	Calculated based on past values and assumed to be constant over time
CF_{max}	Upper bound of the non-fossil fuel electricity capacity factor	Free	2	Selected as a reasonable maximum value based on UK data
CF_{min}	Lower bound of the logistic function for non-fossil fuel electricity capacity factor	Free	0.5	Selected as a reasonable minimum value based on UK data
CO_{NFF}	Crowding out coefficient for government green GCF	Free	0.5	Set as a reasonable estimate pending empirical evidence
def_{0NFC}	Parameter of the default rate function for NFCs	Model-constrained	12580	Calculated from Eq. (201)
def_{0PS}	Parameter of the default rate function for NFCs	Model-constrained	24820	Calculated from Eq. (201)
def_1	Parameter of the default rate function	Free	8.53	Taken from DEFINE-GLOBAL
def_2	Parameter of the default rate function	Free	11.05	Taken from DEFINE-GLOBAL
def_{max}	Maximum default rate of loans	Free	0.2	selected from a reasonable range of values
exp_{KPSFF}	Exponent governing the curvature of the FF capital decommissioning trajectory	Free	3	Calibrated to generate a realistic pace of FF capital retirement
FNW_{MFIT}	Target MFI FNW ratio	Free	0.008084	Calculated based on recent data
g_{ETSB}	Growth rate of ETS carbon price in the baseline	Model-constrained	0.0001283	Set based on reasonable projections
$g_{PETSsce2}$	Quarterly growth rate of ETS prices under sce2 beyond the initial jump	Model-constrained	0.0306	Based on policy scenario design
$GCF_{PSGVTsce1}$	Quarterly government renewable power investment per activated unit under sce1 (£ billion at 2022 prices)	Free	0.415	Calibrated to generate the baseline scenario
$GCF_{PSGVTsce3}$	Quarterly government renewable power investment per activated unit under sce3 (Green Power Subsidy) (£ billion at 2022 prices)	Free	3.33	Based on policy scenario design
$INTAXR_{HHLR}$	Long run income tax rate on the HH sector set by the government	Free	0.2185	Based on past data and OBR fiscal forecasts
$INTAXR_{NFCLR}$	Long run income tax rate on the NFC sector set by the government	Free	0.04927	Based on past data and OBR fiscal forecasts
$ITAXR_{PLR}$	Long run indirect tax rate on production set by the government	Free	0.05961	Based on past data and OBR fiscal forecasts
$ITAXR_{PSLR}$	Long run indirect tax rate on the power sector set by the government	Free	0.01341	Based on past data and OBR fiscal forecasts
$minr_{boe}$	Minimum inflation rate floor in the BoE Taylor rule (1%)	Free	0.01	Prevents log of zero in the Taylor rule
$minr_{gvt}$	Minimum lower bound GVT deposit interest rate	Free	0.006119	Calculated based on the 2010s zero lower bound interest rate period
$minr_{hh}$	Minimum lower bound household deposit interest rate	Free	0.002509	Calculated based on the 2010s zero lower bound interest rate period
$minr_{nfc}$	Minimum lower bound NFC deposit interest rate	Free	0.003204	Calculated based on the 2010s zero lower bound interest rate period
$minr_{nmfi}$	Minimum lower bound NMFI deposit interest rate	Free	0.004289	Calculated based on the 2010s zero lower bound interest rate period
$minr_{row}$	Minimum lower bound RoW deposit interest rate	Free	-0.01033	Calculated based on the 2010s zero lower bound interest rate period

Symbol	Description	Parameter category	Value	Source/remarks
PT_{ETS}	Pass through of carbon pricing to electricity prices	Free	1	Reasonable estimate based on research of carbon prices
RoW_{Dg}	Exogenous Growth of RoW Demand	Free	1.007	Taken as a reasonable estimate
RoW_{Pg0}	Initial annual growth rate of rest of world prices	Free	1.03	Taken as a reasonable estimate
RoW_{PgLR}	Long-run annual growth rate of rest of world prices	Free	1.025	Taken as a reasonable estimate
$sh_{INTPGVTMFI}$	Share of GVT bond interest income in the MFI long-run interest calculation	Free	0.6667	Based on ON experimental flow of funds data 2020 assuming MFI and NMFI together hold 2/3 of GVT bonds
$SOCCR_{GVTLR}$	Long run social contribution rate on the HH sector set by the government	Free	0.1393	Based on past data and OBR fiscal forecasts
spr_{gvta}	Mark down on government deposit interest rates	Free	-0.002054	Based on average of the pre 2010s zero lower bound period
spr_{gvtl}	Interest rate spread on GVT liabilities interest rates	Free	0.001794	Based on recent values
spr_{hha}	Mark down on household deposit interest rates	Free	0.003593	Based on average of the pre 2010s zero lower bound period
spr_{hhl}	Interest rate spread on HH liabilities interest rates	Free	0.00577	Based on recent values
spr_{nfca}	Mark down on NFC deposit interest rates	Free	0.005769	Based on average of the pre 2010s zero lower bound period
spr_{nfcl}	Interest rate spread on NFC liabilities interest rates	Free	-0.0008321	Based on recent values
spr_{nmfia}	Mark down on NMFI deposit interest rates	Free	0.002524	Based on average of the pre 2010s zero lower bound period
spr_{nmfil}	Interest rate spread on NMFI liabilities interest rates	Free	0.001641	Based on recent values
spr_{psl}	Interest rate spread on PS liabilities interest rates	Free	-0.0008321	Based on recent values
spr_{rowa}	Mark down on RoW deposit interest rates	Free	-0.008781	Based on average of the pre 2010s zero lower bound period
$t_{ELECswitch}$	Time index (quarter) for the switch in the electricity price long-run formation rule	Free	153	Set as the first period beyond the initial OBR projection horizon
$T_{KPSFFoffset}$	Time offset (quarters) added to the simulation horizon in the FF capital decommissioning trajectory	Free	10	Calibrated to generate a realistic pace of FF capital retirement
$t_{LFswitch}$	Time index (quarter) for the switch from annualised to quarterly labour force growth scaling	Free	152	Based on initial OBR projection period length
$T_{PETSdelay}$	Quarters from simulation start before the sce2 ETS price growth formula becomes active	Model-constrained	9	Based on policy scenario design
u_T	Target capacity utilisation	Free	0.8035	Taken as the mean of past utilisation values
$\alpha_{0\beta HH}$	Parameter in the equation for green home improvements	Free	0.2	Estimate based on green housing investment data
$\alpha_{0\beta NFC}$	Parameter in the equation governing the proportion of gross green NFC gross capital formation	Free	-0.03826	Calibrated to generate the baseline scenario
α_{0CHHP}	Constant parameter in the household consumption equation	Free	-0.006027	Calculated from Eq. (351)
α_{0CRNFC}	Parameter in the NFC credit rationing equation	Model-constrained	4.351	Calculated from Eq. (222)
α_{0CRPS}	Parameter in the power sector credit rationing equation	Model-constrained	2.736	Calculated from Eq. (152)
α_{0EXP}	Parameter in the nominal export equation	Model-constrained	0.6516	Calculated from Eq. (405) to match initial condition

Symbol	Description	Parameter category	Value	Source/remarks
α_{0GCFFF}	Parameter in the power sector fossil fuel investment equation	Model-constrained	0.01465	Calculated from Eq. (102)
α_{0GCFNB}	Parameter in the HH gross capital formation for new builds equation	Free	7.679	Econometrically estimated
$\alpha_{0GCFNFC}$	Parameter in the NFC gross capital formation equation	Free	0.02012	Calibrated to match initial condition
$\alpha_{0GCFNFF}$	Parameter in the power sector non-fossil fuel investment equation	Model-constrained	0.02144	Calculated from Eq. (106)
α_{0IMP}	Parameter in the nominal import equation	Model-constrained	-0.3641	Calculated from Eq. (404)
α_{0PH}	Parameter in the house price equation	Free	1	Econometrically estimated
α_{0SOCB}	Parameter in the GVT social benefit equation	Model-constrained	0.05561	Calculated from Eq. (294)
α_{0WS}	Constant parameter in the wage share equation	Model-constrained	0.4697	Calibrated so 58 equation equals observed 58[L] at t=L
$\alpha_{1\beta HH}$	Parameter in the equation for green home improvements	Free	0.3038	Estimate based on green housing investment data
$\alpha_{1\beta NFC}$	Parameter in the equation governing the proportion of gross green NFC gross capital formation	Free	0.1	Calibrated to generate the baseline scenario
α_{1CHHP}	Autoregressive parameter	Free	0.8136	Econometrically estimated
α_{1CRNFC}	Parameter in the credit rationing equation for the NFC sector	Free	0	Econometrically estimated
α_{1EXP}	Parameter in the nominal export equation	Free	0.7221	Econometrically estimated
α_{1GCFNB}	Parameter in the HH gross capital formation for new builds equation	Free	1.224	Econometrically estimated
$\alpha_{1GCFNFC}$	Parameter in the NFC gross capital formation equation	Free	0.02948	Econometrically estimated
α_{1IMP}	Lagged dependent variable parameter in the nominal import equation	Free	0.474	Econometrically estimated
$\alpha_{1lambda}$	Parameter in the productivity equation relating real GDP growth to productivity growth	Free	0.725	Reasonable estimate based on past values, UK studies and calibrated to generate the baseline projections
α_{1MU}	Linear relationship between production price mark-up and unit costs	Model-constrained	0.1943	Calibrated so LR markup at initial utilisation equals mean of 45:88 and 109:132 (excl. COVID and GFC)
α_{1PH}	Parameter in the house price equation	Free	1.04	Econometrically estimated
α_{1SOCB}	Parameter in the GVT social benefit equation	Free	0.5263	Econometrically estimated
α_{1WS}	Unemployment rate parameter in the wage share equation	Free	1.759	Econometrically estimated
$\alpha_{2\beta NFC}$	Parameter in the equation governing the proportion of gross green NFC gross capital formation	Free	0.4	Calibrated to generate the baseline scenario
α_{2CHHP}	Long run propensity to consume out of disposable income	Free	0.1092	Econometrically estimated
α_{2CRNFC}	Parameter in the credit rationing equation for the NFC sector	Free	0.1258	Econometrically estimated
α_{2EXP}	Parameter in the nominal export equation	Free	0.2779	Econometrically estimated and rescaled so LR elasticity to world demand = 1
$\alpha_{2GCFNFC}$	Parameter in the NFC gross capital formation equation	Free	0.3049	Econometrically estimated
α_{2IMP}	Lagged domestic demand parameter in the nominal import equation	Free	0.526	Econometrically estimated and rescaled so LR elasticity to 403 = 1

Symbol	Description	Parameter category	Value	Source/remarks
$\alpha_{2lambda}$	Parameter in the productivity equation relating real GCF growth to productivity growth	Free	0.025	Reasonable estimate based on past values and UK studies
α_{2PH}	Parameter in the house price equation	Free	0.539	Econometrically estimated
α_{2SOCB}	Parameter in the GVT social benefit equation	Free	0.151	Econometrically estimated
α_{3CHHP}	Long run propensity to consume out of household financial assets	Free	0.05427	Econometrically estimated
α_{3CRNFC}	Parameter in the credit rationing equation for the NFC sector	Free	-5.005	Econometrically estimated
α_{3EXP}	Parameter in the nominal export equation	Free	0.08626	Econometrically estimated
α_{3IMP}	Investment share of domestic demand parameter in the nominal import equation	Free	0.1646	Econometrically estimated
α_{4IMP}	Relative import price parameter in the nominal import equation	Free	0.5522	Econometrically estimated
$\alpha_{DIVPNFC}$	Rate of NFC sector dividend payments relative to disposable income	Free	0.4129	Set as the mean of past implied values
$\alpha_{DIVPNMFI}$	Proportion of primary NMFI net income distributed as dividends	Free	0.7965	Set as the mean over past values
α_{DIVPPS}	Rate of power sector dividend payments relative to output	Free	0.05453	Set as the mean of past implied values
α_{EQAHH}	Relationship between HH EQA transfers and household equity stock	Model-constrained	0.005407	Calculated from Eq. (373)
α_{EQANFC}	Relationship between NFC EQA transfers and total output from production	Model-constrained	0.01117	Calculated from Eq. (193)
α_{EQAPS}	Relationship between PS EQA transfers and total output from production	Model-constrained	0.01298	Calculated from Eq. (117)
α_{EQNRoW}	Relationship between RoW EQA transfers and total output	Model-constrained	0.0159	Calculated from Eq. (422)
$\alpha_{EQNTRRoW}$	Relationship between net RoW equity transfers and RoW income	Model-constrained	1.363	Calculated from Eq. (422)
$\alpha_{FUELPSLR}$	Long run technical coefficient of fuel input to the power sector	Free	0.3233	Assumes fossil fuel electricity is output is proportional to fuel input and that at the initial condition fuel price is normalised to equal 1
α_{HB}	Conversion between real investment in new houses and the building of new houses	Model-constrained	0.00239	Calculated from Eq. (393)
α_{HHHI}	Parameter relating household home improvement investment to overall GDP levels	Free	0.008546	Estimated based on past values
α_{IBAGVT}	Relationship between GVT IBA transfers and total output from production	Model-constrained	0.004549	Calculated from Eq. (311)
α_{IBANFC}	Relationship between NFC IBA transfers and total output from production	Model-constrained	0.0109	Calculated from Eq. (192)
$\alpha_{IBANMFI}$	Relationship between NMFI IBA transfers and total output from production	Model-constrained	0.02613	Calculated from Eq. (252)
α_{IBAPS}	Relationship between PS IBA transfers and total output from power sector	Model-constrained	0.0121	Calculated from Eq. (116)
α_{IBLHH}	Relationship between HH IBL transfers and total output from production	Model-constrained	0.01583	Calculated from Eq. (376)

Symbol	Description	Parameter category	Value	Source/remarks
α_{IBLTR}	Parameter relating total housing value to household interest bearing liability transfers	Free	0.00175	Calculated based on ONS stock data
α_{INS}	Relationship between HH insurance transfers and total output	Model-constrained	0.0008336	Calculated from Eq. (385)
α_{INSR}	Parameter relating NMFI disposable income to investment income on insurance schemes	Free	1.372	Calculated based on past implied values
α_{INSTR}	Insurance transfer payout rate	Free	0.003204	Calculated from past data
α_{NELEC}	Pass through from gas and oil prices to overall non-electric energy costs	Free	2.557	Calculated using the mean over past data
$\alpha_{OCONSGVT}$	Parameter relating GDP output to total government other consumption	Free	0.1011	Set based on OBR projections of government spending and past
α_{OPPSLR}	Long run technical coefficient of other inputs to the power sector	Free	0.0503	Taken as the average implied technical coefficient over past data
α_{PENS}	Relationship between HH insurance transfers and total output	Model-constrained	0.06668	Calculated from Eq. (385)
α_{PENSR}	Parameter relating NMFI disposable income to investment income on pension schemes	Free	1.213	Calculated based on past implied values
α_{PFUEL}	Relationship between wholesale gas prices and the price of a fuel input to the power sector	Free	10.98	Based on initial data
α_{PPLR}	Long run technical coefficients of internal production intermediate consumption	Free	0.2762	Taken as the average implied technical coefficient over past data
α_{PSPSLR}	Long run technical coefficient of internal power sector intermediate consumption	Free	0.3836	Taken as the average implied technical coefficient over past data
α_{rboe}	Parameter relating to inflation in the BoE Taylor rule	Free	0.9092	Set to generate observed early period baseline behavior
$\alpha_{SOCBPENS}$	Rate of social benefit payments relative to total value of pension schemes	Model-constrained	0.008159	Calculated from Eq. (247)
α_{SOCCW}	Rate of wage contribution to household social contribution for pension schemes (Defined contribution)	Model-constrained	0.05693	Calculated from Eq. (246)
β_{1IMP}	Proportion of overall GCF contribution to imports	Free	0.965	Estimated from IO data
β_{2IMP}	Proportion of power sector GCF contribution to imports	Free	1.884	Estimated from IO data
β_{dhh}	Relationship between household equity holding and dividend distribution	Model-constrained	1.333	Calculated from Eq. (346)
$\beta_{DIVNRoW}$	Net dividend payment rate to the RoW sector	Free	0.00349	Taken as a reasonable estimate based on past values
β_{dps}	Relationship between power sector holding and dividend distribution	Model-constrained	0.773	Calculated from Eq. (99)
β_{ELECH}	Proportion of electric energy use in total energy use for non-electric houses	Free	0.205	Calculated from UK EPC data
β_{EQLNFC}	Parameter determining NFC equity liability price revaluation rate	Model-constrained	0.001676	Calculated from Eq. (199)
$\beta_{EQLNMFI}$	Parameter determining NMFI equity liability price revaluation rate	Model-constrained	0.008593	Calculated from Eq. (260)
β_{EQLPS}	Parameter determining power sector equity liability price revaluation rate	Model-constrained	0.001676	Calculated from Eq. (123)
β_{HBE}	Proportion of new build properties which are fully electric	Free	0.08422	Based on implied UK data and assumed constant

Symbol	Description	Parameter category	Value	Source/remarks
$\beta_{IBLGVTMFI}$	Proportion of government borrowing held by the MFI sector	Free	0.3333	Based on ON experimental flow of funds data 2020 and assumed constant in simulations
$\beta_{IBLGVTNMFI}$	Proportion of government borrowing held by the NMFI sector	Free	0.3333	Based on ON experimental flow of funds data 2020 and assumed constant in simulations
$\beta_{IBLGVTRoW}$	Proportion of government borrowing held by the RoW sector	Free	0.3333	Based on ON experimental flow of funds data 2020 and assumed constant in simulations
$\beta_{NELECGAS}$	Proportion of non-electric energy provided by gas	Free	0.55	Taken from 2023 data and assumed constant
$\beta_{NELECOIL}$	Proportion of non-electric energy provided by oil	Free	0.45	Taken from 2023 data and assumed constant
β_{WRPRI}	Parameter linking private sector wage rate to overall economy wage rate	Model-constrained	1.01	Calculated from Eq. (60)
β_{WRPUB}	Parameter linking public sector wage rate to overall economy wage rate	Model-constrained	0.973	Calculated from Eq. (61)
δ_{1EXP}	Parameter in the nominal export equation	Free	2.044	Econometrically estimated
δ_{1GCFNB}	Parameter in the HH gross capital formation for new builds equation	Free	0.1647	Econometrically estimated
δ_{1IMP}	Short-run domestic demand parameter in the nominal import equation	Free	1.928	Econometrically estimated
$\delta_{COVETS2}$	Increase in ETS coverage for production and power sector under sce2 (Carbon Price Increase)	Free	0.5	Based on policy scenario design
δ_{EQAHH}	Revaluation rate of HH EQAs	Model-constrained	0.005405	Calculated from EQ. (379)
δ_{EQANFC}	Revaluation rate of NFC EQAs	Model-constrained	0.001397	Calculated from EQ. (198)
δ_{EQAPS}	Revaluation rate of PS EQAs	Model-constrained	0.001397	Calculated from EQ. (122)
δ_{EQLNFC}	Revaluation rate of NFC EQLs	Model-constrained	0.008192	Calculated from EQ. (199)
δ_{EQLPS}	Revaluation rate of PS EQLs	Model-constrained	0.008192	Calculated from EQ. (123)
δ_{EQNRoW}	Revaluation rate of RoW EQAs	Model-constrained	0.005344	Calculated from EQ. (425)
$\delta_{GCFPSGVT}$	Quarterly decay rate of government PS investment when the investment trigger is inactive	Free	0.9	Reflects gradual wind-down of past committed spending
δ_{IBAGVT}	Revaluation rate of GVT IBAs	Model-constrained	0.0007799	Calculated from EQ. (318)
δ_{IBAHH}	Revaluation rate of HH IBAs	Model-constrained	0.0007537	Calculated from EQ. (378)
δ_{IBANFC}	Revaluation rate of NFC IBAs	Model-constrained	0.001064	Calculated from EQ. (197)
$\delta_{IBANMFI}$	Revaluation rate of NMFI IBAs	Model-constrained	-0.0001727	Calculated from EQ. (257)
δ_{IBAPS}	Revaluation rate of PS IBAs	Model-constrained	0.001064	Calculated from EQ. (121)
δ_{IBARoW}	Revaluation rate of RoW IBAs	Model-constrained	0.0006782	Calculated from EQ. (424)
δ_{IBLGVT}	Revaluation rate of GVT IBLs	Model-constrained	-0.0008064	Calculated from 1. (319)
δ_{IBLHH}	Revaluation rate of NFC IBLs	Model-constrained	-1.215e-06	Calculated from EQ. (200)
δ_{IBLNFC}	Revaluation rate of NFC IBLs	Model-constrained	-0.004033	Calculated from EQ. (200)

Symbol	Description	Parameter category	Value	Source/remarks
$\delta_{IBLNMFI}$	Revaluation rate of NMFI IBLs	Model-constrained	0.0009828	Calculated from EQ. (258)
δ_{IBLPS}	Revaluation rate of PS IBLs	Model-constrained	-0.004033	Calculated from EQ. (124)
δ_{INS}	Revaluation rate of Insurance	Model-constrained	-0.01428	Calculated from EQ. (385)
δ_{kpc}	Constant depreciation rate of productive capital	Free	0.02375	Calculated from implied rates based on capital stock data
$\delta_{OTEQLNMFI}$	Revaluation rate of NMFI residual financial instrument	Model-constrained	0.1996	Calculated from EQ. (260)
δ_{RESGVT}	Revaluation rate of GVT residual financial instrument	Model-constrained	0.009843	Calculated from EQ. (321)
δ_{RESHH}	Revaluation rate of HH residual financial instrument	Model-constrained	-0.6181	Calculated from EQ. (381)
δ_{RESNFC}	Revaluation rate of NFC residual financial instrument	Model-constrained	-0.009206	Calculated from EQ. (202)
$\delta_{RESNMFI}$	Revaluation rate of NMFI residual financial instrument	Model-constrained	-0.1662	Calculated from EQ. (263)
δ_{RESPS}	Revaluation rate of PS residual financial instrument	Model-constrained	-0.09403	Calculated from EQ. (126)
δ_{RESRoW}	Revaluation rate of RoW residual financial instrument	Model-constrained	-0.01354	Calculated from EQ. (426)
δ_{rlgvt}	Short run adjustment speed of GVT interest rates to long run rate	Free	0.8	Reasonable number selected from a range of values
δ_{rlnfc}	Short run adjustment speed of NFC interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
δ_{rlnmfi}	Short run adjustment speed of NMFI interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
δ_{rlps}	Short run adjustment speed of PS interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
ϵ_{GCFNB}	Parameter in the HH gross capital formation for new builds equation	Free	0.5646	Econometrically estimated
ϵ_{GDP}	Adjustment factor to GDP in order to compare model GDP with data based GDP	Free	1.119	Calculated from initial data
ϵ_{max}	Maximum energy intensity of production	Free	2	Selected as a reasonable maximum value based on UK past data
ϵ_{min}	Minimum energy intensity of production	Free	0.1	Selected such that it is reasonably higher than 0
ϵ_{PH}	Parameter in the house price equation	Free	0.06219	Econometrically estimated
ϵ_{rboe}	Adjustment parameter in the BoE Taylor rule	Free	0.125	Set to generate observed early period baseline behavior
η_{GVTB}	Long run residual transaction discrepancy of GVT sector relative to GDP	Free	-0.00292	Taken as the mean of past data
η_{GVTT}	Long run lending discrepancy of government sector relative to GDP	Free	-0.01744	Taken as the mean of past data
η_{HHB}	Long run lending discrepancy of H sector relative to GDP	Free	-0.0044	Taken as the mean of past data
η_{HHT}	Long run lending discrepancy of H sector relative to GDP	Free	0.06538	Taken as the mean of past data
η_{MFIT}	Long run lending discrepancy of MFI sector relative to GDP	Free	-0.01416	Taken as the mean of past data
η_{NFCB}	Long run residual transaction discrepancy of NFC sector relative to GDP	Free	-0.002919	Taken as the mean of past data
η_{NFCT}	Long run lending discrepancy of NFC sector relative to GDP	Free	-0.05316	Taken as the mean of past data
η_{NMFIB}	Long run residual transaction discrepancy of NMFI sector relative to GDP	Free	0.00573	Taken as the mean of past data

Symbol	Description	Parameter category	Value	Source/remarks
η_{NMFIT}	Long run lending discrepancy of NMFI sector relative to GDP	Free	0.01969	Taken as the mean of past data
η_{PSB}	Long run residual transaction discrepancy of PS sector relative to GDP	Free	-0.05263	Taken as the mean of past data
η_{RoWB}	Long run residual transaction discrepancy of RoW sector relative to GDP	Free	0.0006092	Taken as the mean of past data
η_{RoWT}	Long run lending discrepancy of RoW sector relative to GDP	Free	-0.0003021	Taken as the mean of past data
κ_1	Scaling parameter governing the sensitivity of energy intensity to the green/conventional non-electric capital ratio; higher values mean energy intensity responds more sharply to capital composition	Free	40	Calibrated such that the model generates the baseline scenario
κ_2	Scaling parameter governing how strongly the non-fossil/fossil electricity ratio drives the non-fossil capacity factor; controls the speed of transition to higher utilisation	Free	0.4	Calibrated such that the model generates the baseline scenario
κ_3	Scaling parameter governing the sensitivity of the electric/non-electric energy mix in production to green capital accumulation	Free	2	Calibrated such that the model generates the baseline scenario
κ_4	Scaling parameter governing the sensitivity of non-electric energy emission intensity to green/conventional capital composition; higher values mean emission intensity falls more sharply as green capital accumulates	Free	20	Calibrated such that the model generates the baseline scenario
κ_5	Scaling parameter governing the sensitivity of fossil fuel electricity emission intensity to the green/conventional capital ratio; controls how quickly fossil generators become cleaner as non-fossil capital expands	Free	0.5	Calibrated such that the model generates the baseline scenario
κ_{hie}	Adjusting constant for the balance between energy efficiency and electrification home improvements (£ billion)	Model-constrained	2.765	Calculated from Eq. (366)
MU_{ELEC}	Mark up of electricity prices above the marginal cost of electricity production	Free	1.228	Calculated based on past data
μ_{MCELEC}	Parameter relating the marginal cost of fossil fuel electricty to the overall marginal cost of electricity	Free	0.325	Set as a reasonable estimate to generate the baseline scenario
ω_{emax}	Maximum emission intensity of electric fossil fuel based energy production	Free	0.8	Selected as a reasonable maximum value based on UK data
ω_{emin}	Minimum emission intensity of electric fossil fuel based energy production	Free	0.3	Selected such that it is reasonably higher than 0
ω_{nemax}	Maximum emission intensity of non-electric energy production	Free	1	Selected as a reasonable maximum value based on UK data
ω_{nemin}	Minimum emission intensity of non-electric energy production	Free	0.225	Selected such that it is reasonably higher than 0

Symbol	Description	Parameter category	Value	Source/remarks
$\phi_{LFBdecay}$	Fractional reduction in the labour force growth rate by the end of the simulation (0 = constant, 1 = fully declines to zero)	Free	0.35	Taken from OBR labour market projections
$\phi_{PETSinitsce2}$	Initial ETS price multiplier (scaling above baseline) applied at the start of sce2 (Carbon Price Increase)	Model-constrained	5.5	Based on policy scenario design
π_1	Parameter linking green to conventional non-electric capital ratio with the energy intensity of production	Model-constrained	-1.468	Calculated from Eq. (18)
π_2	Parameter linking non-fossil fuel to fossil fuel electricity generation ratio with the capacity factor of non-fossil fuel electricity generation	Model-constrained	-1.164	Calibrated such that 19[L+1]=19[L]
π_3	Parameter linking green to conventional non-electric capital ratio with the ratio between electric and non-electric energy use in production	Model-constrained	-1.728	Calculated from Eq. (20)
π_4	Parameter linking green to conventional non-electric capital ratio with the emission intensity of non-electric energy	Model-constrained	-1.147	Calculated from Eq. (omega)
π_5	Parameter linking green to conventional non-electric capital ratio with the emission intensity of fossil fuel electricity production	Model-constrained	-1.971	Calculated from Eq. (omega)
ψ_{EQNMFI}	Ratio determining NMFI EQA transfers based on their liability transfers from other sectors	Model-constrained	0.3921	Calculated from Eq. (254)
σ_{ELEC}	Upper bound of non-fossil fuel electricity share (0–1); set at 0.975 to preserve a minimal fossil fuel backstop for grid stability	Free	0.975	Consistent with UK National Grid assumptions
σ_{gvt}	Parameter driving the size of the interest rate spread on GVT liabilities	Free	-22.92	Based on recent values
σ_{hh}	Parameter driving the size of the interest rate spread on HH liabilities	Free	24.3	Based on recent values
σ_{nfc}	Parameter driving the size of the interest rate spread on NFC liabilities	Free	34.85	Based on recent values
σ_{NFFcap}	NFF capacity utilisation threshold (ratio of NFF capacity to total electricity demand) triggering government renewable investment	Free	1.1	Set as a threshold implying moderate excess NFF capacity
σ_{nmfi}	Parameter driving the size of the interest rate spread on NMFI liabilities	Free	21.63	Based on recent values
σ_{ps}	Parameter driving the size of the interest rate spread on PS liabilities	Free	34.85	Based on recent values
τ_{gvt}	Adjustment speed to long run government income and spending rates	Free	0.05	Set based on reasonable estimate and to generate the baseline scenario
τ_{ragvt}	Adjustment speed of GVT interest rates to long run rate	Free	0.75	Reasonable number selected to be faster than general rates based on observed past interest rate behavior

Symbol	Description	Parameter category	Value	Source/remarks
τ_{rahh}	Adjustment speed of HH interest rates to long run rate	Free	0.2	Reasonable number selected to be slower than general rates based on observed past interest rate behavior
τ_{ranfc}	Adjustment speed of NFC interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
τ_{ranmfi}	Adjustment speed of NMFI interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
τ_{raps}	Adjustment speed of PS interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
τ_{rlgvt}	Adjustment speed of GVT interest rates to long run rate	Free	0.75	Reasonable number selected to be faster than general rates based on observed past interest rate behavior
τ_{rlhh}	Adjustment speed of HH interest rates to long run rate	Free	0.1391	Reasonable number selected to be slower than general rates based on observed past interest rate behavior
τ_{rlnfc}	Adjustment speed of NFC interest rates to long run rate	Free	0.5271	Reasonable number selected from a range of values
τ_{rlnmfi}	Adjustment speed of NMFI interest rates to long run rate	Free	0.5271	Reasonable number selected from a range of values
τ_{rlps}	Adjustment speed of PS interest rates to long run rate	Free	0.5271	Reasonable number selected from a range of values
τ_{rnrow}	Adjustment speed of RoW interest rates to long run rate	Free	0.5	Reasonable number selected from a range of values
θ_{divp}	Proportion of NMFI dividends distributed to other sectors	Model-constrained	1.125	Calculated from Eq. (242)
θ_{HEE}	Energy intensity of efficient electric housing stock	Model-constrained	0.9783	Calculated from Eq. (11)
θ_{HEN}	Energy intensity of efficient non-electric housing stock	Model-constrained	2.242	Calculated from Eq. (14)
θ_{HI}	Energy intensity of inefficient housing stock	Free	5.607	Calculated from UK EPC data
θ_{psb}	Fixed share used to apportion NFC financial variables to the power sector	Free	0.02744	Based on the ratio of power sector to total NFC loans from Bank of England data
θ_{socb}	Payment rate on NMFI insurance stock	Model-constrained	0.02552	Calculated from Eq. (247)
$TREND_{\beta HH}$	Parameter in the equation for green home improvements	Free	0.0005668	Estimate based on green housing investment data

Table 6: Symbols and initial values for endogenous variables (baseline scenario)

Symbol	Description	Variable category	Initial value	Source/remarks
AC_{FF}	Average cost of power sector fossil fuel electricity production (£ billion)	Model-constrained	0.6176	Calculated from Eq. (89)
AC_{NFF}	Average cost of power sector non-fossil fuel electricity production (£ billion)	Model-constrained	0.2039	Calculated from Eq. (88)
C_{HIEER}	Average cost per property of converting an energy efficient home to full electric heating in 2022 prices (£ billion per million homes, i.e. £10,000 per property)	Free	10	Based on heat pump installation cost estimates at 2022 prices
C_{HIENR}	Average cost per property of upgrading from EPC D/below to EPC C/above (non-electric) in 2022 prices (£ billion per million homes, i.e. £7,529 per property)	Free	7.529	Based on cost of energy efficiency installations at 2022 prices
CF_{NFF}	Capacity factor of non-fossil fuel electricity production	Model-constrained	0.7215	Calculated from Eq. (7)
$CONS$	Consumption (£ billion)	Model-constrained	460.1	Calculated from Eq. (25)
$CONS_{GVT}$	Government consumption (£ billion)	Model-constrained	119.5	Calculated from Eq. (295)
$CONS_{GVTR}$	Government consumption 2022 prices (£ billion)	Model-constrained	115.5	Calculated from Eq. ($CONS_{GVTPR}$)
$CONS_{HH}$	Household consumption (£ billion)	Free	340.6	Taken from the ONS UK economic accounts 2024 adjusting for rents and FISIM
$CONS_{HHP}$	Household consumption (£ billion)	Model-constrained	333.3	Calculated from Eq. (350)
$CONS_{HHPR}$	Household consumption from production 2022 prices (£ billion)	Model-constrained	322	Calculated from Eq. (354)
$CONS_{HHPS}$	Household consumption from the power sector (£ billion)	Free	7.314	Taken from the ONS supply and use tables 2024
$CONS_{HHPSR}$	Household consumption from the power sector 2022 prices (£ billion)	Model-constrained	22.87	Calculated from Eq. (355)
$CONS_{HHR}$	Household consumption 2022 prices (£ billion)	Model-constrained	329.1	Calculated from Eq. (353)
$CONS_{R}$	Real Consumption 2022 prices (£ billion)	Model-constrained	444.6	Calculated from Eq. (29) and consumption deflators
$COST_{ER}$	Total economy energy costs from electric and non-electric sources including taxes (£ billion)	Model-constrained	47.69	Calculated from Eq. ($COST_{ET}$)
$COST_{NELEC}$	Cost of non-electric energy (£ billion)	Free	27.86	Taken from DUKES table 1.1.6 non-electric energy cost
$COST_{P}$	Total "cost" in production module (£ billion)	Model-constrained	993.1	Calculated from Eq. (52)
$COST_{PS}$	Total "cost" in power sector (£ billion)	Model-constrained	43.19	Calculated from Eq. (83)
$COST_{PSFF}$	Total cost of power sector fossil fuel electricity production (£ billion)	Model-constrained	30.08	Calculated from Eq. (87)
$COST_{PSNFF}$	Total cost of power sector non-fossil fuel electricity production (£ billion)	Model-constrained	14.75	Calculated from Eq. (86)
COV_{ETSP}	Proportion of production emissions subject to ETS	Free	0.1882	Taken as a rate consistent with UK ETS revenue in 2022
COV_{ETSPS}	Proportion of power sector emissions subject to ETS	Free	0.5	Taken as an estimate based on OBR emission and tax forecasts
CR_{NFC}	Credit rationing rate for NFCs	Free	0.1188	Constructed from credit conditions index while assuming maximum rationing rate of 40%

Symbol	Description	Variable category	Initial value	Source/remarks
CR_{PS}	Credit rationing rate for power sector	Free	0.1188	Constructed from credit conditions index while assuming maximum rationing rate of 40%
$DEBT_{GDP}$	Debt to GDP ratio (%)	Free	79.29	Calculated from initial Government debt and 23 levels
DEF_{NFC}	NFC default rates assumed to be proportional to NFC Revaluations	Model-constrained	0.0005203	Calculated from EQ. (200)
DEF_{PS}	PS default rates assumed to be proportional to PS Revaluations	Model-constrained	0.0005203	Calculated from EQ. (124)
det_{IA}	Determinant of I - A matrix for calculating Leiontief matrix coefficients	Model-constrained	0.39	Calculated from Eq. (169)
$DISC_{GVT}$	Lending discrepancy for the government sector (£ billion)	Model-constrained	-8.852	Calculated from Eq. (310)
$DISC_{HH}$	Lending discrepancy for the HH sector (£ billion)	Model-constrained	10.77	Calculated from Eq. (371)
$DISC_{MFI}$	Lending discrepancy for the MFI sector (£ billion)	Model-constrained	-21.13	Calculated from Eq. (226)
$DISC_{NFC}$	Lending discrepency for the NFC sector (£ billion)	Model-constrained	-35.54	Calculated from Eq. (191)
$DISC_{NMFI}$	Lending discrepancy for the NMFI sector (£ billion)	Model-constrained	81.8	Calculated from Eq. (251)
$DISC_{RoW}$	Lending discrepancy for the RoW sector (£ billion)	Model-constrained	-27.04	Calculated from Eq. (420)
$DIVN_{RoW}$	Net-Dividends received by the RoW sector (£ billion)	Free	-5.44	Taken from the ONS UK economic accounts 2024
$DIVP_{NFC}$	Dividends paid by the NFC sector (£ billion)	Free	44.34	Taken from the ONS UK economic accounts 2024
$DIVP_{NMFI}$	Dividends paid by the NMFI sector (£ billion)	Model-constrained	57.44	Calculated from Eq. (242)
$DIVP_{PS}$	Dividends paid by the power sector (£ billion)	Free	1.251	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$DIVR_{HH}$	Dividends received by the Household sector (£ billion)	Free	32.47	Taken from the ONS UK economic accounts 2024
$DIVR_{NFC}$	Dividends received by the NFC sector (£ billion)	Free	24.28	Taken from the ONS UK economic accounts 2024
$DIVR_{NMFI}$	Dividends received by the NMFI sector (£ billion)	Model-constrained	51.04	Calculated from Eq. (242)
$DIVR_{PS}$	Dividends received by the power sector (£ billion)	Free	0.685	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
DY	Domestic outpout	Model-constrained	812.3	Calculated from Eq. (403)
E	Total final energy use (TwH)	Free	365.2	Taken from ONS DUKES table 1.1.5
E_{ELEC}	Total final electricity use (TwH)	Free	66.88	Taken from ONS DUKES table 1.1.5
E_{ELECFF}	Total final electricity use from fossil fuel sources (TwH)	Model-constrained	26.91	Calculated from Eq. (8)
E_{ELECH}	Total domestic final electricity use (TwH)	Free	22.87	Taken from ONS DUKES table 1.1.5
$E_{ELECMAX}$	Maximum electrical energy production (TwH)	Model-constrained	127.3	Calculated from Eq. (6)
$E_{ELECNFF}$	Total final electricity use from non-fossil fuel sources (TwH)	Free	39.97	Calculated from non-fossil fuel energy supply proportions from UK energy trends table 5.1
E_{ELECP}	Electric energy use in production (TwH)	Model-constrained	44.01	Calculated from Eq. (5)
E_H	Total final domestic energy use (TwH)	Free	107.9	Taken from ONS DUKES table 1.1.5

Symbol	Description	Variable category	Initial value	Source/remarks
E_{NELEC}	Total final non-electric energy use (TwH)	Model-constrained	298.4	Calculated from Eq. (12)
E_{NELECH}	Non-electric energy use in housing (TwH)	Model-constrained	85.03	Calculated from Eq. (3)
E_{NELECP}	Total final production non-electric energy use (TwH)	Model-constrained	213.3	Calculated using Eq. (13)
E_P	Total final energy use from production (TwH)	Model-constrained	257.3	Calculated from Eq. (1)
$EMIS$	Total greenhouse gas emissions (MtCO2e)	Free	101.5	Taken from DESNZ final greenhouse gas emissions table 1.2
$EMIS_{ELEC}$	Total greenhouse gas emissions from electricty (MtCO2e)	Free	13.72	Taken from DESNZ final greenhouse gas emissions table 1.2
$EMIS_{NELEC}$	Total greenhouse gas emissions from non-electric energy (MtCO2e)	Model-constrained	87.83	Calculated from Eq. (15)
EMP	Total employed people (millions)	Free	32.81	Taken from the ONS labour market survey 2023
EMP_{PRI}	Total employed people in the private sector (millions)	Model-constrained	27.01	Calculated from Eq. (36)
EMP_{PUB}	Total employed people in the public sector (millions)	Free	5.802	Taken from the ONS labour market survey 2023
EQA_{HH}	Equity assets of the HH sector (£ billion)	Free	1070	Taken from the ONS UK economic accounts 2024
EQA_{NFC}	Equity assets of the NFC sector (£ billion)	Free	1379	Taken from the ONS UK economic accounts 2024
EQA_{NMFI}	Equity assets of the NMFI sector (£ billion)	Model-constrained	3857	Calculated as the sum of other sector equity liabilities
EQA_{PS}	Equity assets of the power sector (£ billion)	Free	38.92	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$EQATR_{HH}$	Equity asset net-transfers of the HH sector (£ billion)	Free	-19.04	Taken from the ONS UK economic accounts 2024
$EQATR_{NFC}$	Equity asset net-transfers of the NFC sector (£ billion)	Free	13.59	Taken from the ONS UK economic accounts 2024
$EQATR_{NMFI}$	Equity assets transfers of the NMFI sector (£ billion)	Model-constrained	-15.75	Calculated from Eq. (254)
$EQATR_{PS}$	Equity asset net-transfers of the power sector (£ billion)	Free	0.3836	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
EQL_{NFC}	Equity liabilities of the NFC sector (£ billion)	Free	3751	Taken from the ONS UK economic accounts 2024
EQL_{NMFI}	Equity liabilities of the NMFI sector (£ billion)	Model-constrained	2522	Calculated as the sum of other sector equity assets
EQL_{PS}	Equity liabilities of the power sector (£ billion)	Free	105.8	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$EQLTR_{NFC}$	Equity liabilities net-transfers of the NFC sector (£ billion)	Free	-15.31	Taken from the ONS UK economic accounts 2024
$EQLTR_{NMFI}$	Equity liability transfers of the NMFI sector (£ billion)	Model-constrained	-83.46	Calculated from Eq. (253)
$EQLTR_{PS}$	Equity liabilities net-transfers of the power sector (£ billion)	Free	-0.4321	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
EQN_{RoW}	Equity assets of the RoW sector (£ billion)	Free	34.07	Taken from the ONS UK economic accounts 2024
$EQNTR_{RoW}$	Equity asset net-transfers of the RoW sector (£ billion)	Free	-78.4	Taken from the ONS UK economic accounts 2024

Symbol	Description	Variable category	Initial value	Source/remarks
ER	Nominal exchange Rate Index	Free	1	Taken from ONS exchange rate index data and normalised around initial condition
EXP	Total Exports (£ billion)	Free	236.4	Taken from the ONS UK economic accounts 2024
EXP_R	Total exports 2022 prices (£ billion)	Model-constrained	227.9	Calculated from Eq. (408)
F_P	Final demand for production sector products	Model-constrained	805	Calculated from EQ. (48)
F_{PR}	Final demand of the production sector £ billion) (IMP_R)	Model-constrained	777.8	Calculated from Eq. (49)
F_{PS}	Final demand of the power sector (£ billion)	Model-constrained	7.314	Calculated from Eq. (79)
F_{PSR}	Final demand of the power sector £ billion)	Model-constrained	22.87	Calculated from Eq. (80)
FA_{GVT}	Financial assets of the GVT sector (£ billion)	Model-constrained	465	Calculated from Eq. (328)
FA_{HH}	Financial assets of the HH sector (£ billion)	Model-constrained	6785	Calculated from Eq. (387)
FA_{MFI}	Financial assets of the MFI sector (£ billion)	Model-constrained	7701	Calculated from Eq. (228)
FA_{NFC}	Financial assets of the NFC sector (£ billion)	Model-constrained	2654	Calculated from Eq. (207)
FA_{NMFI}	Financial assets of the NMFI sector (£ billion)	Model-constrained	9090	Calculated from Eq. (268)
FA_{PS}	Financial assets of the power sector (£ billion)	Model-constrained	74.88	Calculated from Eq. (131)
FL_{GVT}	Financial liabilities of the GVT sector (£ billion)	Model-constrained	2517	Calculated from Eq. (329)
FL_{HH}	Financial liabilities of the HH sector (£ billion)	Model-constrained	2083	Calculated from Eq. (388)
FL_{MFI}	Financial liabilities of the MFI sector (£ billion)	Model-constrained	7591	Calculated from Eq. (232)
FL_{NFC}	Financial liabilities of the NFC sector (£ billion)	Model-constrained	5380	Calculated from Eq. (208)
FL_{NMFI}	Financial liabilities of the NMFI sector (£ billion)	Model-constrained	9191	Calculated from Eq. (269)
FL_{PS}	Financial liabilities of the power sector (£ billion)	Model-constrained	151.8	Calculated from Eq. (132)
FNW	Overall financial net worth - should equal 0 by definition	Model-constrained	3.411e-13	Calculated from Eq. (463)
FNW_{GVT}	Financial net-worth of the GVT sector (£ billion)	Free	-1854	Taken from the ONS UK economic accounts 2024 adjusted to account for Maastricht debt
FNW_{GVTM}	Model determined financial net-worth of the GVT sector (£ billion)	Model-constrained	-2052	Calculated from Eq. (330)
FNW_{HH}	Financial net-worth of the HH sector (£ billion)	Free	4382	Taken from the ONS UK economic accounts 2024
FNW_{HHM}	Model determined financial net-worth of the HH sector (£ billion)	Model-constrained	4701	Calculated from Eq. (389)
FNW_M	Overall model determined financial net worth - should equal 0 by definition	Model-constrained	5.684e-13	Calculated from Eq. (462)
FNW_{MFI}	Financial net-worth of the MFI sector (£ billion)	Model-constrained	40.74	Calculated from Eq. (235)
FNW_{MFIM}	Model determined financial net-worth of the MFI sector (£ billion)	Model-constrained	110.3	Calculated from Eq. (233)
FNW_{NFC}	Financial net-worth of the NFC sector (£ billion)	Free	-2991	Taken from the ONS UK economic accounts 2024
FNW_{NFCM}	Model determined financial net-worth of the NFC sector (£ billion)	Model-constrained	-2726	Calculated from Eq. (209)
FNW_{NMFI}	Financial net-worth of the NMFI sector (£ billion)	Free	161.8	Taken from the ONS UK economic accounts 2024

Symbol	Description	Variable category	Initial value	Source/remarks
FNW_{NMFIM}	Model determined financial net-worth of the NMFI sector (£ billion)	Model-constrained	-100.9	Calculated from Eq. (270)
FNW_{PS}	Financial net-worth of the power sector (£ billion)	Free	-84.4	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
FNW_{PSM}	Model determined financial net-worth of the power sector (£ billion)	Model-constrained	-76.91	Calculated from Eq. (133)
FNW_{RoW}	Financial net-worth of the RoW sector (£ billion)	Free	344.7	Taken from the ONS UK economic accounts 2024
FNW_{RoWM}	Model determined financial net-worth of the RoW sector (£ billion)	Model-constrained	143.8	Calculated from Eq. (429)
g	Nominal GDP growth rate	Model-constrained	1.019	Calculated from Eq. (32)
GCF	Gross fixed capital formation (£ billion)	Model-constrained	115.8	Calculated from Eq. (26)
GCF_{GVT}	Gross capital formation of the government sector (£ billion)	Free	20.76	Taken from the ONS UK economic accounts 2024
GCF_{GVTC}	Conventional gross capital formation of the GVT sector (£ billion)	Model-constrained	19.9	Calculated from Eq. (302)
GCF_{GVTCR}	Conventional gross capital formation of the GVT sector 2022 prices (£ billion)	Model-constrained	19.3	Calculated from Eq. (306)
GCF_{GVTG}	Gross capital formation of the GVT sector (£ billion)	Free	0.8578	Taken by assuming government has the same initial proportion of green investment as the NFC sector
GCF_{GVTGR}	Green gross capital formation of the GVT sector 2022 prices (£ billion)	Model-constrained	0.832	Calculated from Eq. (305)
GCF_{GVTR}	Gross capital formation of the GVT sector 2022 prices (£ billion)	Model-constrained	20.14	Calculated from Eq. (304)
GCF_{HH}	Gross capital formation of the household sector (£ billion)	Free	29.33	Taken from the ONS UK economic accounts 2024
GCF_{HHHI}	Household Gross capital formation in home improvement 2022 prices (£ billion)	Model-constrained	1.559	Calculated from Eq. (357)
$GCF_{HHHIEER}$	Gross fixed capital formation in electrification home improvements 2022 prices (£ billion)	Model-constrained	0.06804	Calculated from Eq. (367)
$GCF_{HHHIENR}$	Gross fixed capital formation in energy efficiency home improvements 2022 prices (£ billion)	Free	0.1437	Calculated such that initial value is reasonable
GCF_{HHHIER}	Gross fixed capital formation in energy efficient home improvements 2022 prices (£ billion)	Model-constrained	0.2117	Calculated from Eq. (364)
GCF_{HHHINR}	Gross fixed capital formation in non-energy home improvements 2022 prices (£ billion)	Model-constrained	1.3	Calculated from Eq. (365)
GCF_{HHHIR}	Gross fixed capital formation in home improvements 2022 prices (£ billion)	Model-constrained	1.512	Calculated from Eq. (361)
GCF_{HHNB}	Gross fixed capital formation in new houses 2022 prices (£ billion)	Model-constrained	27.77	Calculated from Eq. (361)
GCF_{HHNBR}	Gross fixed capital formation in new houses 2022 prices (£ billion)	Free	26.94	Taken from the ONS UK economic accounts 2024
GCF_{HHR}	Gross fixed capital formation in new houses (£ billion)	Model-constrained	28.45	Calculated from Eq. (361)
GCF_{NFC}	Gross capital formation of the NFC sector (£ billion)	Free	63.53	Taken from the ONS UK economic accounts 2024

Symbol	Description	Variable category	Initial value	Source/remarks
GCF_{NFCC}	Conventional gross capital formation of the NFC sector (£ billion)	Model-constrained	60.9	Calculated from Eq. (185)
GCF_{NFCCR}	Conventional gross capital formation of the NFC sector 2022 prices (£ billion)	Model-constrained	59.07	Calculated from Eq. (188)
GCF_{NFCD}	Desired NFC gross capital formation	Model-constrained	72.09	Calculated from Eq. (182)
GCF_{NFCG}	Green gross capital formation of the NFC sector (£ billion)	Free	2.625	Based on UK Government Green Financing: Allocation Report 2024
GCF_{NFCGR}	Green gross capital formation of the NFC sector 2022 prices (£ billion)	Model-constrained	2.546	Calculated from Eq. (187)
GCF_{NFCR}	Gross capital formation of the NFC sector 2022 prices (£ billion)	Model-constrained	61.62	Calculated from Eq. (186)
GCF_{PSFF}	Gross capital formation of fossil fuel power capital (£ billion)	Model-constrained	0.6638	Calculated from Eq. (107)
GCF_{PSFFD}	Desired PS fossil fuel gross capital formation	Model-constrained	0.7533	Calculated from Eq. (107)
GCF_{PSFFR}	Gross capital formation of fossil fuel power capital 2022 prices (£ billion)	Model-constrained	0.6438	Calculated from Eq. (137)
GCF_{PSNFF}	Gross capital formation of non-fossil fuel power capital (£ billion)	Model-constrained	1.489	Calculated from Eq. (108)
GCF_{PSNFFD}	Desired PS non-fossil gross capital formation	Model-constrained	1.69	Calculated from Eq. (108)
GCF_{PSNFFR}	Gross capital formation of non-fossil fuel power capital 2022 prices (£ billion)	Model-constrained	1.444	Calculated from Eq. (143)
GCF_{PSR}	Gross capital formation of the power sector 2022 prices (£ billion)	Model-constrained	2.088	Calculated from Eq. (112)
GCF_R	Real gross fixed capital formation 2022 prices (£ billion)	Model-constrained	112.3	Calculated from Eq. (30) and GFCF deflators
GDP	Gross domestic product (£ billion)	Model-constrained	584.5	Calculated from Eq. (23)
GDP_R	Real gross domestic product 2022 prices (£ billion)	Model-constrained	562.6	Calculated from Eq. (28)
GDP_{RFE}	Labour-determined potential GDP (£ billion)	Model-constrained	584.3	Calculated using Eq. (45)
GDP_{RFK}	Capital-determined potential GDP (£ billion)	Model-constrained	690.3	Calculated using Eq. (47)
GDP_{RMAX}	Maximum real supply constrained GDP (£ billion)	Model-constrained	584.3	Calculated using Eq. (41)
GO	Total output (£ billion)	Model-constrained	1191	Calculated from Eq. (27)
GO_P	Gross output from production (£ billion)	Model-constrained	1152	Calculated from Eq. (51)
GO_{PR}	Production sector gross output 2022 prices (£ billion)	Model-constrained	1113	Calculated from Eq. (50)
GO_{PS}	Gross output from the power sector (£ billion)	Model-constrained	38.71	Calculated from Eq. (51)
GO_{PSR}	Power sector gross output 2022 prices (£ billion)	Model-constrained	121	Calculated from (81)
GO_R	Total output (£ billion 2022 prices)	Model-constrained	1150	Calculated from Eq. (31)
GOS_P	Gross operating surplus from production (£ billion)	Model-constrained	158.7	Calculated from Eq. (53)
GOS_{PS}	Gross operating surplus of the power sector (£ billion)	Model-constrained	-4.479	Calculated Eq. (84)
H	Total number of UK properties (millions)	Free	30.06	From UK census data

Symbol	Description	Variable category	Initial value	Source/remarks
H_{EE}	Total number of UK energy efficient electric properties (EPC rating C and above with electric primary fuel) (millions)	Free	0.9634	From UK EPC data
H_{EN}	Total number of UK energy efficient non-electric properties (EPC rating C and above with non-electric primary fuel) (millions)	Free	16.69	From UK EPC data
H_I	Total number of UK non-energy efficient non-electric properties (EPC rating D and below) (millions)	Free	12.4	From UK EPC data
HB	Number of houses built in the UK (millions)	Model-constrained	0.021	Calculated as the change in house numbers based on housing data
$HVAL$	Total value of housing stock (£ billion)	Model-constrained	8727	Calculated from Eq. (399)
I_{ADJ}	Import price index adjustment based on changing basket of import goods	Model-constrained	1.038	Calculated from Eq. (414)
IBA_{GVT}	Interest bearing assets of the government sector (£ billion)	Free	465	Taken from the ONS UK economic accounts 2024
IBA_{HH}	Interest bearing assets of the HH sector (£ billion)	Free	2151	Taken from the ONS UK economic accounts 2024
IBA_{NFC}	Interest bearing assets of the NFC sector (£ billion)	Free	1274	Taken from the ONS UK economic accounts 2024
IBA_{NMFI}	Interest bearing assets of the NMFI sector (£ billion) excluding government borrowing	Free	4394	Taken from the ONS UK economic accounts 2024
IBA_{PS}	Interest bearing assets of the power sector (£ billion)	Free	35.96	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$IBATR_{GVT}$	Interest bearing asset net-transfers of the GVT sector (£ billion)	Free	-9.236	Taken from the ONS UK economic accounts 2024
$IBATR_{HH}$	Interest bearing asset net-transfers of the HH sector (£ billion)	Free	15.41	Taken from the ONS UK economic accounts 2024
$IBATR_{MFI}$	Interest bearing asset transfers of the MFI sector (£ billion)	Model-constrained	-155.3	Calculated from Eq. (229)
$IBATR_{NFC}$	Interest bearing asset net-transfers of the NFC sector (£ billion)	Free	-37.73	Taken from the ONS UK economic accounts 2024
$IBATR_{NMFI}$	Interest bearing asset net-transfers of the NMFI sector (£ billion)	Free	-141.5	Taken from the ONS UK economic accounts 2024
$IBATR_{PS}$	Interest bearing asset net-transfers of the power sector (£ billion)	Free	-1.065	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
IBL_{GVT}	Interest bearing liabilities of the government sector (£ billion)	Free	2517	Taken from UK government Maastricht debt data
IBL_{GVTMFI}	Interest bearing liabilities of the government sector held by MFIs (£ billion)	Free	838.9	Taken as a proportion of total government IBLs based on flow of funds data
$IBL_{GVTNMFI}$	Interest bearing liabilities of the government sector held by NMFIs (£ billion)	Free	838.9	Taken as a proportion of total government IBLs based on flow of funds data
IBL_{GVTRoW}	Interest bearing liabilities of the government sector held by RoW (£ billion)	Free	838.9	Taken as a proportion of total government IBLs based on flow of funds data
IBL_{HH}	Interest bearing liabilities of the HH sector (£ billion)	Free	2083	Taken from the ONS UK economic accounts 2024
IBL_{NFC}	Interest bearing liabilities of the NFC sector (£ billion)	Free	1628	Taken from the ONS UK economic accounts 2024
IBL_{NMFI}	Interest bearing liabilities of the NMFI sector (£ billion)	Free	3105	Taken from the ONS UK economic accounts 2024

Symbol	Description	Variable category	Initial value	Source/remarks
IBL_{PS}	Interest bearing liabilities of the power sector (£ billion)	Free	45.94	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$IBLTR_{GVT}$	Interest bearing liabilities net-transfers of the GVT sector (£ billion)	Free	65.64	Taken from the ONS UK economic accounts 2024
$IBLTR_{GVTMFI}$	Interest bearing liabilities transfers of the government sector held by MFIs (£ billion)	Free	21.88	Taken as a proportion of total government IBLs based on flow of funds data
$IBLTR_{GVTNMFI}$	Interest bearing liabilities transfers of the government sector held by NMFIs (£ billion)	Free	21.88	Taken as a proportion of total government IBLs based on flow of funds data
$IBLTR_{GVTRoW}$	Interest bearing liabilities transfers of the government sector held by RoW (£ billion)	Free	21.88	Taken as a proportion of total government IBLs based on flow of funds data
$IBLTR_{HH}$	Interest bearing liabilities net-transfers of the HH sector (£ billion)	Free	15.36	Taken from the ONS UK economic accounts 2024
$IBLTR_{MFI}$	Interest bearing liability transfers of the MFI sector (£ billion)	Model-constrained	-146.3	Calculated from Eq. (230)
$IBLTR_{NFC}$	Interest bearing liabilities net-transfers of the NFC sector (£ billion)	Free	-51.33	Taken from the ONS UK economic accounts 2024
$IBLTR_{NMFI}$	Interest bearing liability net-transfers of the NMFI sector (£ billion)	Free	-139.8	Taken from the ONS UK economic accounts 2024
$IBLTR_{PS}$	Interest bearing liabilities net-transfers of the power sector (£ billion)	Free	-1.448	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
IBN_{RoW}	Interest bearing assets of the RoW sector (£ billion)	Free	-729.2	Taken from the ONS UK economic accounts 2024
$IBNTR_{RoW}$	Interest bearing asset net-transfers of the RoW sector (£ billion)	Free	27.85	Taken from the ONS UK economic accounts 2024
IC_{FUELPS}	Intermediate consumption of the power sector for fuel products	Free	15.75	Taken from the ONS supply and use tables 2024
$IC_{FUELPSR}$	Intermediate consumption of the power sector for fuel products (£ bn 2022 prices)	Model-constrained	15.75	Calculated from Eq. (167)
IC_{OPPS}	Intermediate consumption of the power sector for other production products (£ billion)	Model-constrained	8.833	Calculated from Eq. (166)
IC_{OPPSR}	Intermediate consumption of the power sector for other products (£ bn 2022 prices)	Model-constrained	8.535	Calculated from Eq. (168)
IC_{PP}	Internal intermediate consumption of the production sector	Free	322.2	Taken from the ONS supply and use tables 2024
IC_{PPR}	Real internal intermediate consumption of the production sector	Free	311.3	Calculated from Eq. (162)
IC_{PPS}	Intermediate consumption of the power sector for production products	Free	24.58	Taken from the ONS supply and use tables 2024
IC_{PSP}	Intermediate consumption of the production sector for power sector products	Free	14.07	Taken from the ONS supply and use tables 2024
IC_{PSPR}	Real intermediate consumption of the production sector for power sector products (£bn 2022 prices)	Model-constrained	44.01	Calculated from Eq. (159)
IC_{PSPS}	Internal intermediate consumption of the power sector	Free	17.32	Taken from the ONS supply and use tables 2024
$ILLIQ_{PS}$	Illiquidity ratio of the power sector	Model-constrained	1.046	Calculated from Eq. (150)

Symbol	Description	Variable category	Initial value	Source/remarks
IMP	Total Imports (£ billion)	Free	227.8	Taken from the ONS UK economic accounts 2024
IMP_R	Total imports 2022 prices (£ billion)	Model-constrained	222.3	Calculated from Eq. (407)
INF_A	UK annual CPI inflation rate	Free	0.107	From ONS CPI data
INS	Total Insurance stock - asset of households and a liability of the NMFI sector (£ billion)	Free	970.5	Taken from the ONS UK economic accounts 2024
$INSR$	Income payable on insurance entitlements	Free	3.14	Taken from the ONS UK economic accounts 2024
$INSTR$	Total Insurance stock net transfers - asset of households and a liability of the NMFI sector (£ billion)	Free	-2.347	Taken from the ONS UK economic accounts 2024
$INTAX$	Total income tax received by the government (£ billion)	Model-constrained	99.07	Calculated from Eq. (285)
$INTAX_{HH}$	Income tax paid by the household sector (£ billion)	Free	79.91	Taken from the ONS UK economic accounts 2024
$INTAX_{NFC}$	Income tax paid by the NFC sector (£ billion)	Free	19.16	Taken from the ONS UK economic accounts 2024
$INTAXR_{HH}$	Income tax rate of Households	Model-constrained	0.2193	Calculated from Eq. (288)
$INTAXR_{NFC}$	Income tax rate of NFCs	Model-constrained	0.05261	Calculated from Eq. (286)
$INTN_{RoW}$	Net-Interest received by the RoW sector (£ billion)	Free	19.52	Taken from the ONS UK economic accounts 2024
$INTP_{GVT}$	Interest paid by the GVT sector (£ billion)	Free	32.87	Taken from the ONS UK economic accounts 2024
$INTP_{HH}$	Interest paid by the HH sector (£ billion)	Free	15.46	Taken from the ONS UK economic accounts 2024
$INTP_{MFI}$	Interest paid by the MFI sector (£ billion)	Model-constrained	66.65	Calculated from Eq. (225)
$INTP_{NFC}$	Interest paid by the NFC sector (£ billion)	Free	10.28	Taken from the ONS UK economic accounts 2024
$INTP_{NMFI}$	Interest paid by the NMFI sector (£ billion)	Free	18.85	Taken from the ONS UK blue book 2023, annual data converted to quarterly using cubic spline interpolation
$INTP_{PS}$	Interest paid by the power sector (£ billion)	Free	0.2902	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$INTR_{GVT}$	Interest received by the GVT sector (£ billion)	Free	3.089	Taken from the ONS UK economic accounts 2024
$INTR_{HH}$	Interest received by the HH sector (£ billion)	Free	5.36	Taken from the ONS UK economic accounts 2024
$INTR_{MFI}$	Interest received by the MFI sector (£ billion)	Model-constrained	77.75	Calculated from Eq. (224)
$INTR_{NFC}$	Interest received by the NFC sector (£ billion)	Free	4.206	Taken from the ONS UK economic accounts 2024
$INTR_{NMFI}$	Interest received by the NMFI sector (£ billion)	Free	34.35	Taken from the ONS UK blue book 2023, annual data converted to quarterly using cubic spline interpolation
$INTR_{PS}$	Interest received by the power sector (£ billion)	Free	0.1187	Taken from the ONS UK economic accounts 2024 with the power sector accounting for a fixed proportion of NFC financial variables
$ITAX$	Total indirect tax received by the government (£ billion)	Model-constrained	65.98	Calculated from Eq. (274)
$ITAX_{NELEC}$	ETS tax on non-electric energy production	Model-constrained	0.1101	Calculated from Eq. (276)
$ITAX_P$	Total indirect taxes - subsidies on production (£ billion)	Free	64.69	Taken from the ONS UK economic accounts 2024

Symbol	Description	Variable category	Initial value	Source/remarks
$ITAX_{PS}$	Total indirect taxes - subsidies on the power sector (£ billion)	Free	1.289	Taken from the ONS supply and use tables 2024
$ITAX_{PSFF}$	Indirect tax of the power sector on fossil fuel electricity production (£ billion)	Model-constrained	0.5461	Calculated from Eq. (281)
$ITAX_{PSNFF}$	Indirect tax of the power sector on non-fossil fuel electricity production (£ billion)	Model-constrained	0.7432	Calculated from Eq. (282)
$ITAXR_{P}$	Indirect tax rate (excluding ETS) of the production sector	Model-constrained	0.05607	Calculated from Eq. (277)
$ITAXR_{PS}$	Indirect tax rate (excluding ETS) of power sector	Model-constrained	0.03213	Calculated from Eq. (280)
K_{GVT}	GVT capital(£ billion)	Model-constrained	886.7	Calculated from Eq. (336)
K_{GVTC}	Conventional GVT capital(£ billion)	Model-constrained	851.2	Calculated from Eq. (337)
K_{GVTCR}	Conventional GVT capital stock 2022 prices (£ billion)	Model-constrained	825.6	Calculated from Eq. (333)
K_{GVTG}	Green GVT capital(£ billion)	Model-constrained	35.47	Calculated from Eq. (338)
K_{GVTR}	Capital stock of the GVT sector 2022 prices (£ billion)	Free	860	Taken from the ONS capital stock tables 2023
K_{NFC}	NFC capital(£ billion)	Model-constrained	2501	Calculated from Eq. (215)
K_{NFCC}	Conventional NFC capital(£ billion)	Model-constrained	2401	Calculated from Eq. (216)
K_{NFCCR}	Conventional NFC capital stock 2022 prices (£ billion)	Model-constrained	2329	Calculated from Eq. (212)
K_{NFCG}	Green NFC capital(£ billion)	Model-constrained	100	Calculated from Eq. (217)
K_{NFCR}	Capital stock of the NFC sector 2022 prices (£ billion)	Free	2426	Taken from the ONS capital stock tables 2023
K_{P}	Total production capital (£ billion)	Model-constrained	3388	Calculated from Eq. (72)
K_{PC}	Total conventional production capital (£ billion)	Model-constrained	3252	Calculated from Eq. (74)
K_{PCR}	Real total conventional production capital 2022 prices (£ billion)	Model-constrained	3155	Calculated from Eq. (77)
K_{PG}	Total green production capital (£ billion)	Model-constrained	135.5	Calculated from Eq. (73)
K_{PGR}	Real total green production capital 2022 prices (£ billion)	Model-constrained	131.4	Calculated from Eq. (76)
K_{PR}	Real total production capital 2022 prices (£ billion)	Model-constrained	3286	Calculated from Eq. (75)
K_{PS}	Capital stock of the power sector(£ billion)	Free	132.5	Taken from the ONS capital stock tables 2023 assuming D351 capital is proportion to the sectors GVA in the supply and use tables 2023
K_{PSFF}	Power sector fossil fuel capital (£ billion)	Model-constrained	79.51	Calculated from Eq. (146)
K_{PSFFR}	Power sector fossil fuel capital 2022 prices (£ billion)	Model-constrained	77.12	Calculated from Eq. (136)
K_{PSNFF}	Power sector non-fossil fuel capital (£ billion)	Model-constrained	57.11	Calculated from Eq. (146)
K_{PSNFFR}	Non-fossil fuel capital stock of the power sector (£ billion)	Free	55.4	Calculated using DUKES table 5.7
K_{PSR}	Capital stock of the power sector 2022 prices (£ billion)	Free	132.5	Taken from the ONS capital stock tables 2023 assuming D351 capital is proportion to the sectors GVA in the supply and use tables 2023
L_{PP}	Leiontief coefficient for internal intermediate consumption of the production sector	Model-constrained	1.417	Calculated from Eq. (170)

Symbol	Description	Variable category	Initial value	Source/remarks
L_{PPS}	Leiontief coefficient for the powersector intermediate consumption of the production products	Model-constrained	0.5143	Calculated from Eq. (171)
L_{PSP}	Leiontief coefficient for the production sector intermediate consumption of the power products	Model-constrained	0.1014	Calculated from Eq. (172)
L_{PSPS}	Leiontief coefficient for internal intermediate consumption of the power sector	Model-constrained	1.847	Calculated from Eq. (173)
$LEND$	Overall net lending - should equal 0 by definition	Model-constrained	0	Calculated from Eq. (461)
$LEND_{GVT}$	Net-lending position of the GVT sector (£ billion)	Free	-41.27	Taken from the ONS UK economic accounts 2024
$LEND_{GVTM}$	Model determined net-lending position of the government sector (£ billion)	Model-constrained	-32.42	Calculated from Eq. (308)
$LEND_{HH}$	Net-lending position of the HH sector (£ billion)	Free	-0.471	Taken from the ONS UK economic accounts 2024
$LEND_{HHM}$	Model determined net-lending position of the HH sector (£ billion)	Model-constrained	-11.24	Calculated from Eq. (369)
$LEND_{M}$	Overall model determined net lending - should equal 0 by definition	Model-constrained	5.44	Calculated from Eq. (460)
$LEND_{MFI}$	Net-lending position of the MFI sector (£ billion)	Free	-15.47	Taken from the ONS UK economic accounts 2024
$LEND_{MFIM}$	Model determined net lending of the MFI sector (£ billion)	Model-constrained	11.1	Calculated from Eq. (223)
$LEND_{NFC}$	Net-lending position of the NFC sector (£ billion)	Free	14.29	Taken from the ONS UK economic accounts 2024
$LEND_{NFCM}$	Model determined net-lending position of the NFC sector (£ billion)	Model-constrained	49.83	Calculated from Eq. (189)
$LEND_{NMFI}$	Net-lending position of the NMFI sector (£ billion)	Free	66.38	Taken from the ONS UK economic accounts 2024
$LEND_{NMFIM}$	Model determined net-lending position of the NMFI sector (£ billion)	Model-constrained	-15.42	Calculated from Eq. (249)
$LEND_{PS}$	Net-lending position of the power sector (£ billion)	Model-constrained	-7.37	Calculated from Eq. (115)
$LEND_{RoW}$	Net-lending position of the RoW sector (£ billion)	Free	-16.09	Taken from the ONS UK economic accounts 2024
$LEND_{RoWM}$	Disposable income of the rest of the world (£ billion)	Model-constrained	10.96	Calculated from Eq. (416)
LEV_{NFC}	Leverage ratio of the NFC sector	Model-constrained	0.651	Calculated from Eq. (219)
LEV_{PS}	Leverage ratio of the power sector	Model-constrained	0.3467	Calculated from Eq. (149)
LF	Labour force (millions)	Free	34.08	Taken from the ONS labour market survey 2023
$MAAS_{ADJ}$	Maastricht debt adjustment to interest bearing liability stock of the government sector	Free	-94.69	Calculated from past data
MC_{ELEC}	Marginal cost of overall electricity generation (£ bn/ TwH)	Model-constrained	0.4365	Calculated from Eq. (92)
MC_{FF}	Marginal cost of fossil fuel electricity generation (£ bn/ TwH)	Model-constrained	0.5868	Calculated from Eq. (91)
NW_{GVT}	GVT net worth (£ billion)	Model-constrained	-967.2	Calculated from Eq. (342)
NW_{HH}	HH net worth (£ billion)	Model-constrained	13110	Calculated from Eq. (401)
NW_{NFC}	NFC net worth (£ billion)	Model-constrained	-489.9	Calculated from Eq. (218)
NW_{PS}	Net worth of the power sector (£ billion)	Model-constrained	48.12	Calculated from Eq. (148)

Symbol	Description	Variable category	Initial value	Source/remarks
$OCONS_{GVT}$	Other consumption of the Government sector (£ billion)	Free	58.03	Taken from the ONS UK economic accounts 2024 by deducting government wages and gross operating surplus from total government consumption
OT_{EQAHH}	Revaluations of equity assets of the HH sector (£ billion)	Model-constrained	57.13	Calculated from Eq. (383)
OT_{EQANFC}	Revaluations of equity assets of the NFC sector (£ billion)	Model-constrained	-42.8	Calculated from Eq. (198)
$OT_{EQANMFI}$	Revaluations of equity assets of the NMFI sector (£ billion)	Model-constrained	180.3	Calculated from Eq. (259)
OT_{EQAPS}	Revaluations of equity assets of the power sector (£ billion)	Model-constrained	-1.208	Calculated from Eq. (122)
OT_{EQLNFC}	Revaluations of equity liabilities of the NFC sector (£ billion)	Model-constrained	175.3	Calculated from Eq. (199)
$OT_{EQLNMFI}$	Revaluations of equity liabilities of the NMFI sector (£ billion)	Model-constrained	127.1	Calculated from Eq. (260)
OT_{EQLPS}	Revaluations of equity liabilities of the power sector (£ billion)	Model-constrained	4.948	Calculated from Eq. (123)
OT_{EQNRoW}	Revaluations of equity assets of the RoW sector (£ billion)	Model-constrained	114	Calculated from Eq. (425)
OT_{IBAGVT}	Revaluations of interest bearing assets of the GVT sector (£ billion)	Model-constrained	-3.454	Calculated from Eq. (318)
OT_{IBAHH}	Revaluations of interest bearing assets of the HH sector (£ billion)	Model-constrained	-1.288	Calculated from Eq. (382)
OT_{IBANFC}	Revaluations of interest bearing assets of the NFC sector (£ billion)	Model-constrained	-0.5874	Calculated from Eq. (197)
$OT_{IBANMFI}$	Revaluations of interest bearing assets of the NMFI sector (£ billion)	Model-constrained	-149.3	Calculated from Eq. (257)
OT_{IBAPS}	Revaluations of interest bearing assets of the power sector (£ billion)	Model-constrained	-0.01658	Calculated from Eq. (121)
OT_{IBARoW}	Revaluations of interest bearing assets of the RoW sector (£ billion)	Model-constrained	71.83	Calculated from Eq. (424)
OT_{IBLGVT}	Revaluations of interest bearing liabilities of the GVT sector (£ billion)	Model-constrained	7.012	Calculated from Eq. (319)
OT_{IBLHH}	Revaluations of interest bearing liabilities of the HH sector (£ billion)	Model-constrained	-0.567	Calculated from Eq. (386)
OT_{IBLNFC}	Revaluations of interest bearing liabilities of the NFC sector (£ billion)	Model-constrained	34.72	Calculated from Eq. (200)
$OT_{IBLNMFI}$	Revaluations of interest bearing liabilities of the NMFI sector (£ billion)	Model-constrained	-63.68	Calculated from Eq. (258)
OT_{IBLPS}	Revaluations of interest bearing liabilities of the power sector (£ billion)	Model-constrained	0.9797	Calculated from Eq. (124)
OT_{INS}	Revaluations of insurance assets of the HH sector (£ billion)	Model-constrained	244.8	Calculated from Eq. (385)
OT_{PENS}	Revaluations of pension assets of the HH sector (£ billion)	Model-constrained	37.02	Calculated from Eq. (384)
OT_{RESGVT}	Revaluations of residual financial instrument of the GVT sector (£ billion)	Model-constrained	-34.38	Calculated from Eq. (331)
OT_{RESHH}	Revaluations of residual financial instrument of the HH sector (£ billion)	Model-constrained	-286.8	Calculated from Eq. (390)
OT_{RESNFC}	Revaluations of residual financial instrument of the NFC sector (£ billion)	Model-constrained	-38.31	Calculated from Eq. (210)

Symbol	Description	Variable category	Initial value	Source/remarks
$OT_{RESNMFI}$	Revaluations of residual financial instrument of the NMFI sector (£ billion)	Model-constrained	371.4	Calculated from Eq. (271)
OT_{RESPS}	Revaluations of residual financial instrument of the power sector (£ billion)	Model-constrained	6.692	Calculated from Eq. (134)
OT_{RESRoW}	Revaluations of residual financial instrument of the RoW sector (£ billion)	Model-constrained	-0.8433	Calculated from Eq. (430)
P	GDP price deflator indexed at Q4 2022	Model-constrained	1.039	Calculated from Eq. (33)
P_E	Export prices	Free	1.035	Taken from the ONS UK economic accounts 2024 and normalised around the initial condition
P_{ELEC}	Price of electricity (£billion/TwH)	Model-constrained	0.3198	Calculated by dividing implied prices to households and production and taking the average
P_{ELECLR}	Long run electricity price (£bn / TwH)	Model-constrained	0.3198	Set equal to initial electricity price
P_{ETS}	ETS Price £ bn/MtCO2e adjusted for 2024 pricing	Free	0.006662	Based on initial government income from the ETS scheme in 2022
P_F	Global Price index	Free	1	Taken from world bank data
P_{FUEL}	Price of fuel inputs to the power sector	Model-constrained	1	Calculated from Eq. (157)
P_{GAS}	Wholesale gas price in the UK	Free	0.06182	From OBR estimates 2024
P_H	House prices (£ billion per million houses)	Free	290.3	Taken as the average house price from the UK house price index
P_I	Import prices	Free	1.038	Taken from the ONS UK economic accounts 2024 and normalised around the initial condition
P_{NELEC}	Price of non-electricity energy (£billion/TwH)	Free	0.09337	Calculated by dividing total non-electric costs from DUKES table 1.1.6 by non-electric energy use
P_{NELECT}	Non-electric energy price including energy taxes (£ billion)	Model-constrained	0.09374	Calculated from Eq. (69)
P_{OIL}	Wholesale oil price in the UK	Free	0.05404	From OBR estimates 2024
P_P	Production sector price level	Model-constrained	1.035	Calculated
$PENS$	Total pension scheme stock - asset of households and a liability of the NMFI sector (£ billion)	Free	2594	Taken from the ONS UK blue book accounts 2023 - converted to quarterly data using cubic spline interpolation
$PENS_{ADJ}$	Adjustment to pension entitlements as defined within the SNA (£ bn)	Model-constrained	21.44	Calculated from Eq. (248)
$PENSR$	Income payable on pension entitlements	Free	21.39	Taken from the ONS UK economic accounts 2024
$PENSTR$	Total pension scheme stock net transfers - asset of households and a liability of the NMFI sector (£ billion)	Free	21.44	Taken from the ONS UK blue book accounts 2023 - converted to quarterly data using cubic spline interpolation
POP	Total 16+ population (millions)	Free	54.55	Taken from OBR data
r_{BOE}	Bank of England annual base rate	Free	0.0225	From Bank of England data
r_{BOEQ}	Quarterly Bank of England interest rate	Model-constrained	0.005578	Calculated from Eq. (433)
r_{IBAGVT}	rate of return on GVT interest bearing assets	Model-constrained	0.006466	Calculated from Eq. (290)
$r_{IBAGVTLR}$	Long run interest bearing asset interest rates for the GVT sector	Model-constrained	0.007632	Calculated from Eq. (441)
r_{IBAHH}	rate of return on HH interest bearing assets	Model-constrained	0.002509	Calculated from Eq. (344)

Symbol	Description	Variable category	Initial value	Source/remarks
$r_{IBAHHLR}$	Long run interest bearing asset interest rates for the household sector	Model-constrained	0.002509	Calculated from Eq. (443)
r_{IBANFC}	rate of return on NFC interest bearing assets	Model-constrained	0.003204	Calculated from Eq. (175)
$r_{IBANFCLR}$	Long run interest bearing asset interest rates for the NFC sector	Model-constrained	0.003204	Calculated from Eq. (435)
$r_{IBANMFI}$	rate of return on NFC interest bearing assets	Model-constrained	0.004994	Calculated from Eq. (240)
$r_{IBANMFILR}$	Long run interest bearing asset interest rates for the NMFI sector	Model-constrained	0.004289	Calculated from Eq. (439)
r_{IBAPS}	rate of return on PS interest bearing assets	Model-constrained	0.003204	Calculated from Eq. (96)
$r_{IBAPSLR}$	Long run interest bearing asset interest rates for the Power sector	Model-constrained	0.003204	Calculated from Eq. (437)
r_{IBLGVT}	rate of return on GVT interest bearing liabilities	Model-constrained	0.01345	Calculated from Eq. (291)
r_{IBLHH}	rate of return on HH interest bearing liabilities	Model-constrained	0.007475	Calculated from Eq. (345)
r_{IBLNFC}	rate of return on NFC interest bearing liabilities	Model-constrained	0.006253	Calculated from Eq. (176)
$r_{IBLNMFI}$	rate of return on NMFI interest bearing liabilities	Model-constrained	0.005697	Calculated from Eq. (241)
r_{IBLPS}	rate of return on PS interest bearing liabilities	Model-constrained	0.006253	Calculated from Eq. (97)
r_{IBNRoW}	rate of return on RoW interest bearing assets	Model-constrained	-0.01033	Calculated from Eq. ($INTR_{RoW}$)
$r_{IBNRoWLR}$	Long run net interest bearing asset interest rates for the RoW sector	Model-constrained	0.01436	Calculated from Eq. ($r_{IBARoWLR}$)
re	Rate of employment	Free	0.9627	Taken from the ONS labour market survey 2023
$REER$	Real effective exchange rate	Model-constrained	1.035	Calculated from Eq. (415)
RES_{GVT}	Residual financial instrument of the GVT sector (£ billion)	Model-constrained	197.9	Calculated from Eq. (332)
RES_{HH}	Residual financial instrument of the H sector (£ billion)	Model-constrained	-319.2	Calculated from Eq. (391)
RES_{MFI}	Residual financial instrument of the MFI sector (£ billion)	Model-constrained	-69.54	Calculated from Eq. (235)
RES_{NFC}	Residual financial instrument of the NFC sector (£ billion)	Model-constrained	-265.3	Calculated from Eq. (211)
RES_{NMFI}	Residual financial instrument of the NMFI sector (£ billion)	Model-constrained	262.7	Calculated from Eq. (272)
RES_{PS}	Residual financial instrument of the power sector (£ billion)	Model-constrained	-7.486	Calculated from Eq. (135)
RES_{RoW}	Residual financial instrument of the RoW sector (£ billion)	Model-constrained	200.9	Calculated from Eq. (431)
$RESTR_{GVT}$	Residual financial instrument transfer of the GVT sector (£ billion)	Model-constrained	33.6	Calculated from Eq. (312)
$RESTR_{HH}$	Residual financial instrument transfer of the HH sector (£ billion)	Model-constrained	-0.5674	Calculated from Eq. (372)
$RESTR_{MFI}$	residual financial instrument transfers of the MFI sector (£ billion)	Model-constrained	-6.416	Calculated from Eq. (231)
$RESTR_{NFC}$	Residual financial instrument transfer of the NFC sector (£ billion)	Model-constrained	-28.23	Calculated from Eq. (195)
$RESTR_{NMFI}$	Residual financial instrument transfer of the NMFI sector (£ billion)	Model-constrained	-2.405	Calculated from Eq. (255)

Symbol	Description	Variable category	Initial value	Source/remarks
$RESTR_{PS}$	Residual financial instrument transfer of the PS sector (£ billion)	Model-constrained	-8.569	Calculated from Eq. (119)
$RESTR_{RoW}$	Residual financial instrument transfer of the RoW sector (£ billion)	Model-constrained	12.58	Calculated from Eq. ($IBATR_{RoW}$)
RoW_{DR}	Real RoW Demand	Free	22.27	Taken from global output data
RP_{NFC}	Retained profits of the NFC sector (£ billion)	Model-constrained	113.4	Calculated from Eq. (101)
RP_{PS}	Retained profits of the power sector (£ billion)	Model-constrained	-5.217	Calculated from Eq. (101)
ru	Rate of unemployment	Model-constrained	0.03725	Calculated from Eq. (46)
SAV_{HH}	Household savings (£ billion)	Model-constrained	-27.88	Calculated from Eq. (356)
$SOCB$	Total social benefits received by the Household sector (£ billion)	Model-constrained	103.5	Calculated from Eq. (349)
$SOCB_{GVT}$	Social benefits paid by the Government sector (£ billion)	Free	82.8	Taken from the ONS UK economic accounts 2024
$SOCB_{NMFI}$	Social benefits paid by the NMFI sector (£ billion)	Free	20.68	Taken from the ONS UK economic accounts 2024
$SOCC$	Total social contributions paid by the Household sector (£ billion)	Model-constrained	97.5	Calculated from Eq. (348)
$SOCC_{GVT}$	Social contributions received by the Government sector (£ billion)	Free	55.38	Taken from the ONS UK economic accounts 2024
$SOCC_{NMFI}$	Social contributions received by the NMFI sector (£ billion)	Free	42.13	Taken from the ONS UK economic accounts 2024
$SOCCR_{GVT}$	Social contribution rate on government social contributions	Model-constrained	0.152	Calculated from Eq. (292)
$SPEND_{GVT}$	Total Government spending (excl. wages)	Model-constrained	161.6	Calculated from Eq. (299)
u	Rate of capital capacity utilisation	Free	0.815	Based on data from the directorate General for Economic and Financial Affairs - 2021 and 2022 extrapolated
u_{FF}	Utilisation of fossil based electricity capital	Model-constrained	0.3083	Calculated from Eq. (103)
u_{NFF}	Utilisation of non-fossil based electricity capital	Model-constrained	1	Calculated from Eq. (104)
u_{PS}	Utilisation of ovewrall electricity capital	Model-constrained	0.5255	Calculated from Eq. (105)
UC	Unit costs of the production module	Model-constrained	0.8924	Calculated from Eq. (55)
W	Total wages including mixed income (£ billion)	Free	364.3	Taken from the ONS UK economic accounts 2024
W_{PRI}	Total private wages (£ billion)	Model-constrained	302.8	Calculated from Eq. (64)
W_{PUB}	Total public wages (£ billion)	Free	61.49	Taken from the ONS UK blue book accounts 2023 - converted to quarterly data using cubic spline interpolation
W_S	Wage share of GDP	Model-constrained	0.6233	Calculated from Eq. (58)
WR	Overall wage rate (£ thousands)	Model-constrained	11.1	Calculated from Eq. (59)
WR_{PRI}	Private sector wage rate (£ thousands)	Model-constrained	11.21	Calculated from Eq. (62)
WR_{PUB}	Public sector wage rate (£ thousands)	Model-constrained	10.6	Calculated from Eq. (63)
YD_{GVT}	Government disposable income (£ billion)	Model-constrained	107.9	Calculated from Eq. (273)
YD_{HH}	Household disposable income (£ billion)	Model-constrained	312.8	Calculated from Eq. (347)

Symbol	Description	Variable category	Initial value	Source/remarks
YD_{NFC}	NFC disposable income (£ billion)	Model-constrained	133.4	Calculated from Eq. (177)
YD_{NMFI}	NMFI disposable income (£ billion)	Model-constrained	9.106	Calculated from Eq. (239)
YD_{PS}	Disposable income of the power sector (£ billion)	Model-constrained	-4.651	Calculated from Eq. (98)
YP_{HH}	Household income from production (£ billion)	Model-constrained	386.7	Calculated from Eq. (343)
YP_{NFC}	NFC income from production (£ billion)	Model-constrained	152.6	Calculated from Eq. (174)
YP_{RoW}	RoW income from production (£ billion)	Model-constrained	-8.568	Calculated from Eq. (402)
α_{FUELPS}	Technical coefficient for the power sector intermediate consumption of fuel products	Model-constrained	0.1301	Calculated from Eq. (167)
α_{OPPS}	Technical coefficient for the power sector intermediate consumption of other production products	Model-constrained	0.07051	Calculated from Eq. (168)
α_{PP}	Technical coefficient for internal intermediate consumption of the production sector (real terms)	Model-constrained	0.2798	Calculated from Eq. (162)
α_{PPS}	Technical coefficient for the power sector intermediate consumption of production products	Model-constrained	0.2006	Calculated from Eq. (158)
α_{PSP}	Technical coefficient for the production sector intermediate consumption of the power products	Model-constrained	0.03955	Calculated from Eq. (154)
α_{PSPS}	Technical coefficient for internal intermediate consumption of the power sector	Model-constrained	0.4474	Calculated from Eq. (165)
β_{GCFHH}	Estimate of initial proportion of home improvement spending on energy efficiency	Free	0.14	Estimate based on ONS data and to generate the baseline scenario
β_{gvt}	Proportion of government green investment	Model-constrained	0.04132	Calculated from Eq. (301)
β_{nfc}	Proportion of NFC green investment	Model-constrained	0.04132	Calculated from Eq. (184)
β_{NFF}	Share of non-fossil fuel electrical energy in total electrical energy production	Model-constrained	0.5976	Calculated from Eq. (85)
δ_{KP}	Depreciation rate of Production sector capital	Free	0.02149	Calculated from the ONS capital stock tables 2023
δ_{KPSFF}	Depreciation rate of power sector fossil capital	Free	0.01227	Calculated from the ONS capital stock tables 2023
δ_{KPSNFF}	Depreciation rate of power sector non-fossil capital	Free	0.01227	Calculated from the ONS capital stock tables 2023
ϵ	Energy intensity of production (TwH)	Model-constrained	0.2312	Calculated from Eq. (2)
λ	Labour productivity rate - GDP per employee	Model-constrained	17.14	Calculated using Eq. (39)
μ	Mark up over unit costs for the domestic production module	Model-constrained	0.1704	Calculated from Eq. (54), floored at 0.001 for log stability
ν	Capital productivity rate	Model-constrained	0.2101	Calculated from Eq. (40)
ω_{ELEC}	Emission intensity of fossil fuel electric energy production (MtCO2e/TwH)	Model-constrained	0.5098	Calculated from Eq. (17)
ω_{NELEC}	Emission intensity of non-electric energy production (MtCO2e/TwH)	Model-constrained	0.2944	Calculated from Eq. (16)

Symbol	Description	Variable category	Initial value	Source/remarks
θ_P	Share of electric energy for production in total energy for production (TwH)	Model-constrained	0.171	Calculated from Eq. (10)

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