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Under-Investment in Scotland's Oil and Gas Sector: Employment, Economic and Energy Transition Implications through CGE Modelling

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Abstract

This study employs a computable general equilibrium (CGE) model to examine the employment, economic and energy transition implications of under-investment in Scotland's oil and gas sector. Under current forecasts of declining upstream investments through the end of this decade, the study finds substantial job losses across multiple sectors, with an estimated total loss of about 19,509 jobs in Scotland by 2030. This includes 11,193 direct oil and gas sector jobs, with the sector expected to experience the fastest annual decline, losing about 1,865 jobs each year. Other affected sectors include manufacturing, construction, finance and insurance activities, and wholesale and retail trade. Adverse shifts in key macroeconomic indicators include a 2.11% decrease in GDP, a 0.37% increase in inflation, and declines in government income, capital formation and household consumption budgets. These findings have significant implications for an emerging renewables sector within the context of the broader energy transition in Scotland. Research shows that 90% of oil and gas roles have direct transferability to renewables, making the skills and experience of oil and gas workers critical for the successful development of Scotland's growing renewables industry. Policy implications are clear: mitigating the decline in oil and gas investment levels slows job losses and facilitates an orderly transition of sector expertise to Scotland's burgeoning renewables sector. This approach supports the energy transition, enhances energy security, fosters technological innovation and maintains the competitiveness of Scotland and the wider UK in the global energy space. It also ensures a smooth, inclusive and just transition in Scotland.

Keywords: Scotland; oil and gas; investment; employment; energy transition; CGE

1 Introduction

Oil and gas production in the UK Continental Shelf (UKCS), which includes Scotland's waters,[1] commenced in the early 1970s. Scotland's contribution to upstream UK oil and gas production includes a substantial portion of the output from the Central North Sea (CNS), as well as the entire production from the Northern North Sea (NNS) and West of Shetland (WoS) regions of the UKCS. The sector has long been a cornerstone of Scotland's economy, contributing significantly to regional development, employment and economic stability. In 2022 for example, the sector contributed about £25.2 billion in gross value added (GVA) to the Scottish economy, representing about 11.8% of Scotland's total gross domestic product (GDP) (see Scottish Government, 2024.a).

Historically, the sector has resiliently navigated the cyclical variations and risks inherent in global energy markets. However, in more recent years, the sector has faced an unprecedented array of challenges that threaten its long-term sustainability. These challenges have most notably manifested in the significant decline in upstream capital investments over the past ten years.

Data from the North Sea Transition Authority (NSTA, 2024), which regulates the UK upstream oil and gas industry, and the Offshore Energies UK (OEUK, 2023), which is the representative body for the UK offshore energy industry, as shown in Figure 1, indicates that over the past decade, there has been a notable decline in capital investments within the UKCS of which Scotland is a major component. Capital investment in 2013 was £16.00 billion and maintained a similar level in 2014, peaking at £16.20 billion. A significant downtrend began in the subsequent years, with investment decreasing sharply to £12.61 billion in 2015 and further plummeting to £8.92 billion in 2016.[2] The decline continued, reaching a low of approximately £3.76 billion by 2021. Although there was a slight recovery observed in the following years, with investment increasing to £4.61 billion in 2022 and £5.22 billion in 2023, these figures still represent a substantial decrease from the levels observed a decade earlier.

[1] Scotland's waters include Scotland's exclusive economic zone (EEZ) and continental shelf, as defined under the United Nations Convention on Law of the Sea (UNCLOS) (see United Nations, 1982).

[2] The decline in capital investments from 2014 to 2016 may partly be attributed to the plunge in oil prices during that period, which was influenced by the shale oil revolution in the United States and the resulting supply glut that followed.

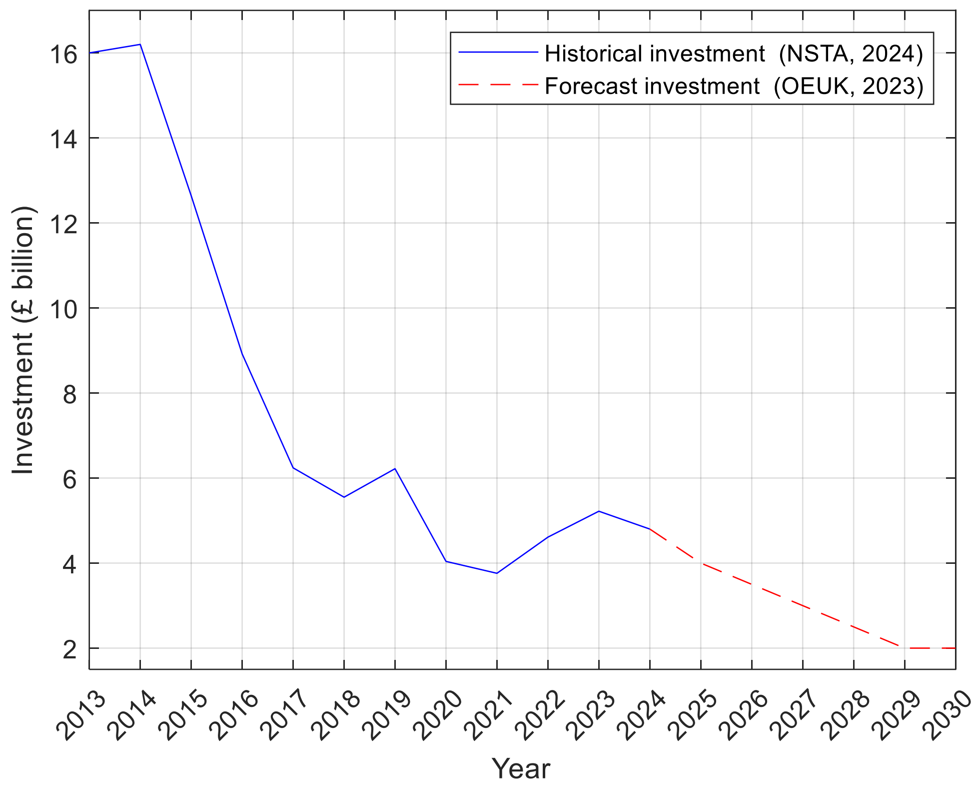


Figure 1: Historical and forecast oil and gas capital investments in the UK Continental shelf. (Source: author plot using OEUK (2023) and NSTA (2024) data)

The decline in capital investments can be partly attributed to the maturity of the UKCS basin. Having been extensively developed and exploited for decades, the basin now offers limited opportunities for high-impact offshore exploration and extraction activities. Since its development began in the 1970s, a total of 46.40 billion barrels of oil equivalent (bboe) have been produced from the basin (NSTA, 2021). The historically high production levels have substantially depleted the basin, and over 180 of the currently producing 283 fields are expected to cease production by 2030, highlighting the advanced stage of exploitation (see OEUK, 2023). However, it is important to acknowledge that while the UKCS is a mature basin, there are still opportunities for further exploration, development and production in the future, leveraging advanced technologies and innovative approaches (see e.g. Abdul-Salam et al., 2021). The NSTA and the OEUK estimate that about 10 to 15 bboe of prospective reserves remain to be exploited from the basin.

The motivation for this study stems from the more recent challenges faced by the oil and gas sector in Scotland and the rest of the UK, with a quadruple-whammy of threats which are set to contribute to a further decline in capital investments over the coming years. First, the aftermath of the global COVID-19 pandemic continues to cast a long shadow, with its dampening effects on investment in the sector expected to persist despite the pandemic's conclusion. Second, the sector continues to grapple with the impact of periodically persistent low and volatile oil and gas prices, which undermine financial stability and discourage capital allocation to oil and gas developments. Third, there is a growing shift towards investments in renewable energy sources such as offshore wind, carbon capture, utilisation and storage (CCUS), and hydrogen production in Scotland, as part of a broader UK energy transition agenda. This diverts funds and investor interest from traditional fossil fuels to more sustainable alternatives, further straining investment in traditional oil and gas operations (OGUK, 2021).

Fourth, adding to the above market challenges, in May 2022, the UK Government introduced a new upstream petroleum taxation regime imposing an Energy Profits Levy on the oil and gas sector.[3] This levy, effectively a windfall tax, substantially raised the headline tax rate on the oil and gas sector in Scotland and the rest of the UK from approximately 40% to 75%. Industry reactions have been starkly negative, with the OEUK (2022a) warning that the tax would "damage competitiveness and discourage energy companies from investing in the UK". A survey indicated that 95% of OEUK members felt negatively impacted by the tax and are contemplating investments elsewhere. Additionally, analysis from Wood Mackenzie, a consultancy known for its expertise in UKCS oil and gas, suggests that the windfall tax has erased an average of 40% from the value of UKCS producers (see Financial Times, 2023), further exacerbating the sentiment for reduced investments in the sector.

These factors are set to contribute to a bleak investment outlook for the oil and gas sector in Scotland and the rest of the UK over the course of this decade, extending a trend of declining investments observed in the sector over the previous decade. The forecasts shown in Figure 1 suggest a continuing trend of underinvestment in the period 2024 to 2030, with projections being £4.80 billion in 2024, £4.00 billion in 2025, decreasing progressively each year to just £2.00 billion annually by 2028 and maintaining that low through 2030. Overall, capital investments in the oil and gas sector in Scotland and the rest of the UK would have reduced from £16.20 billion in 2016 to approximately £2.00 billion by 2030, representing a decline of about 87.65%.

The reduction in capital investments has contributed to a corresponding decline in employment within the sector over the past decade, as shown in Figure 2. In 2016, the sector supported a

[3] The Energy Profits levy was revised in November 2022 and later.

total of about 326,900 UK jobs, categorised into direct, indirect, and induced jobs totalling 35600, 155100, and 136200 respectively (see OEUK, 2021; OEUK, 2022b). Direct oil and gas jobs involve individuals employed by firms directly engaged in extracting oil and gas, while indirect jobs are found within the extensive supply chain of companies that provide essential goods and services supporting production. Induced oil and gas sector jobs are created by the expenditure of earnings from the industry, supporting roles in sectors such as accommodation and services and so on (see OEUK, 2021; OEUK, 2022b).

In the following years after 2016, there was a notable decrease in job numbers, reaching a low in 2020 with total employment at 178,500, as direct jobs dwindled to 25,700, and indirect and induced jobs fell to 91,700 and 61,100 respectively. The significant decline in job numbers observed in 2020 can be attributed to the COVID-19 pandemic and its associated lockdowns and restrictions. Although there was a slight recovery observed in the subsequent years, with 2023 showing total employment of 220,000 jobs, a long-term declining trend is apparent in the data.

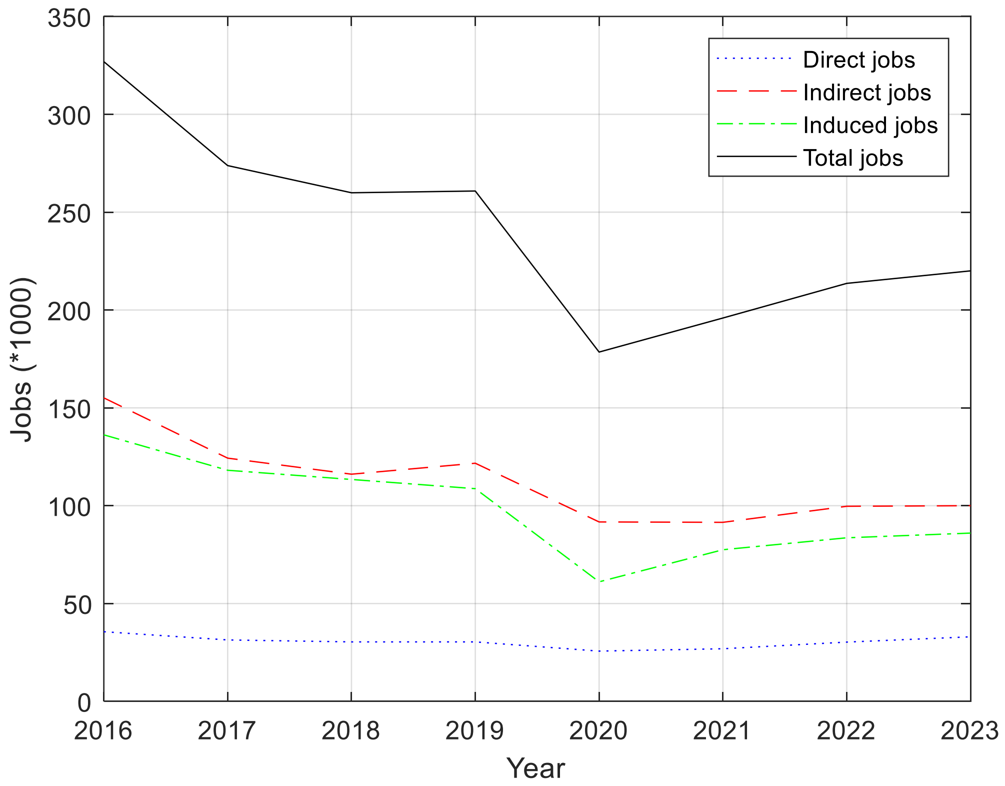


Figure 2: Employment supported by the UK oil and gas sector. (Source: author plot using data provided by OEUK, 2021 and OEUK, 2022)

By 2023, the UK oil and gas sector supported approximately 106,000 fewer jobs than in 2016, a substantial contraction that has impacted not only direct oil and gas operations but also the extensive supply chain and broader economic activities across Scotland and the rest of the UK that are linked to the sector. Scotland accounts for a significant proportion of the UK's overall oil and gas sector employment, highlighting its critical role in the industry. In 2021 for example, Scotland accounted for approximately 88.48% of the entire UK direct oil and gas jobs (see Figure 3). This underscores Scotland's dominance, strategic importance and vital contribution to the wider UK oil and gas sector. With forecasts indicating further declines in capital investments over the coming decade (as shown in Figure 1), the anticipated effects on employment within Scotland's oil and gas sector and its related supply chain could be profound, potentially exacerbating economic challenges in the wider Scottish economy.

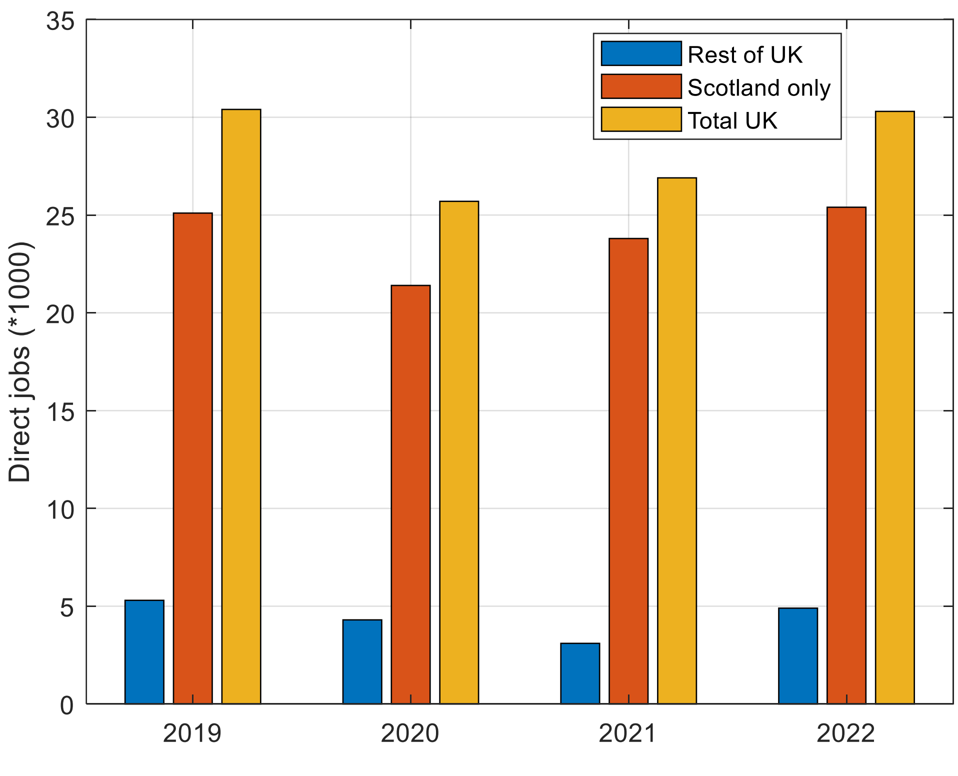


Figure 3: Direct UK and Scotland oil and gas sector jobs (Source: author plot using data provided by OEUK, 2022)

In this paper, we examine the employment, economic and energy transition implications of under-investment in Scotland's upstream oil and gas sector. Using a CGE model, the study explores these implications under three simulation scenarios, namely (1) a 'status quo investment decline' scenario; (2) an 'accelerated investment decline' scenario; and (3) a 'rapid investment decline' scenario. This study uniquely contributes to the literature by exploring how declining capital investments reshape the workforce landscape not only within the oil and gas sector but also across the broader Scottish economy. By focusing on Scotland, a region heavily reliant on oil and gas, the study provides important insights on the far-reaching implications of investment trends in the sector within the context of the broader energy transition.

Under the status quo NSTA (2024) and OEUK (2023) forecasts of declining upstream investments from 2024 to 2030, this study finds that the oil and gas sector would lose about 11,193 jobs by 2030 (compared to 2024 levels), with the sector experiencing the fastest annual decline of about 1,865 jobs each year. In total, about 19,509 jobs are projected to be lost in Scotland, including 3,670 in construction, 2,825 in wholesale and retail trade, 1,520 in manufacturing and 300 in finance and insurance activities. Estimates of job losses under the accelerated and rapid investment decline scenarios are even higher, with up to 29,287 jobs lost across Scotland under the rapid decline scenario.

Additionally, GDP is projected to decrease by 2.11% by 2030 (compared to 2024 levels) under the status quo investment decline scenario, with greater declines of 2.59% and 3.27% under the accelerated and rapid decline scenarios, respectively. Inflation is expected to rise, with the Consumer Price Index (CPI) increasing by 0.37% under the status quo scenario, 0.44% under the accelerated scenario, and 0.53% under the rapid decline scenario. Other macroeconomic indicators, such as government income, capital formation, and real household consumption budgets, also show significant deterioration under faster investment decline scenarios. These findings highlight the critical importance of sustaining investments in the oil and gas sector to mitigate adverse employment and economic outcomes in Scotland.

As previously alluded to, the decline in upstream oil and gas investments can be partly attributed to capital rationing within the energy industry in Scotland and the rest of the UK (Kemp and Stephen, 2014; Osmundsen et al., 2022; Abdul-Salam, 2024). Investment funds are increasingly being redirected from traditional fossil fuels to a growing renewables sector within the context of Scotland's broader energy transition agenda (see Zhou et al., 2021; Abdul-Salam et al., 2022; Hughes and Zabala, 2023). This shift has intensified competition for investments between the oil and gas sector and the renewables sector, partly contributing to a challenging environment for securing funding for oil and gas projects. Between 2024 and 2030 for example, capital investments in offshore wind are projected to grow from £8.2 billion to £14.9 billion, an increase of approximately 82.45%. In contrast, capital investments in oil and gas are expected to decrease from £4.8 billion in 2024 to £2 billion in 2030, a decline of about 58.33%. By 2030, renewable energy expenditure will account for 74% of the total offshore energy expenditure in the UKCS.

It is worth noting, however, that despite the competition for investment, the connection between the oil and gas sector and the renewables sector in terms of employment expertise is significant. With over 50 years of operational experience in the energy space, including offshore operations, the oil and gas sector possesses valuable skills relevant to offshore renewables such as wind, hydrogen, and CCUS. Research shows that 90% of oil and gas jobs have high or medium transferability to renewable energy roles, making the skills and experience of workers in the oil and gas industry critical for the successful development of an emerging renewables sector in Scotland (see OGUK, 2021; OEUK, 2022b; de Leeuw and Kim, 2023).

The projected job losses and economic contractions estimated in this study underscore the need for continued investment in oil and gas projects to slow the rate of job losses and to ensure a smooth and orderly transition of oil and gas workers to the growing renewable energy industry. A rapid decline in oil and gas investments risks a sudden, disruptive loss of jobs,[4] leaving displaced workers with limited immediate opportunities in the short term as the renewables sector gradually develops. This could result in a long-term loss of vital expertise necessary for the emerging renewables sector.

Sustaining investment levels in oil and gas is essential not only to mitigate projected employment declines but also to facilitate the critical transfer of skills to the renewables sector in an orderly and managed manner over time. As the energy mix evolves and demand from low-carbon sectors increases, opportunities for workers in the oil and gas industry to transfer their skills will also grow. Thus, sustaining investments in the oil and gas sector is crucial for a smooth, inclusive and just transition to a sustainable energy future (Shapovalova et al., 2023; Segall, 2021; Heffron and McCauley, 2022).

Finally, sustaining investments in the oil and gas sector enhances Scotland's energy security by ensuring a stable supply of domestic energy resources (Mitchell and Watson, 2013; Skea et al., 2012; Rogers-Hayden et al., 2011). Sustained investments can drive technological advancements that make oil and gas extraction and processing more efficient and environmentally friendly, aligning with the UK government's 'maximising economic recovery'

[4] OGUK (2021) describes demands for an abrupt and immediate halt to oil and gas investment and production as a 'cliff-edge' approach to energy transition.

policy (Abdul-Salam et al., 2021; Roberts, 2023; Mete et al., 2019; Kemp and Stephen, 2019). It will also help sustain the competitiveness of Scotland and the wider UK in the global energy space.

The rest of the paper is organised as follows: Section 2 presents a literature review on the impact of (under-) investment on employment in the oil and gas sector and the broader extractives industry. Section 3 outlines our methodology, detailing the CGE model used and its underlying assumptions. Section 4 discusses the data, while Section 5 covers the results. Finally, Section 6 concludes the paper with a discussion on the policy implications of our findings.

2 Literature Review – the impact of investment on employment

The relationship between investment and employment outcomes in the extractives industry, which includes the oil and gas sector, has been extensively studied using a range of methodologies in the literature. CGE and input-output (I/O) models are the most frequently used in these analyses (Agerton et al, 2017), as seen in studies such as Nejati and Bahmani (2020), Katherine (2008), Considine et al. (2009, 2010), Higginbotham et al. (2010), IHS Global Insight (2011), AlShehabi (2013) and Hutagalung et al. (2017). These studies typically analyse the direct and indirect employment effects resulting from investments in the industry. Kinnaman (2011) provides a critical review of a number of these studies as relates to the employment and wider economic impact of investments in shale gas in the United States.

Several studies have also examined the employment impacts of investments in the wider extractive sector using empirical methods. Black et al. (2005) for example used a treatment-effect design to investigate the effects of investments during coal booms on employment in the United States. They found evidence of employment spillovers into sectors trading goods locally but not into sectors trading goods nationally. Weber (2012) employed a triple-difference estimation approach to find that an additional million dollars in natural gas investment and production led to 2.35 additional jobs per county. In a follow-up study, Weber (2014), using first differenced estimation alongside other techniques found that increased investments in gas production created 18.5 jobs per billion cubic feet of gas produced, with no adverse effects on manufacturing or education levels, suggesting the absence of a resource curse. Marchand (2012) utilised a differential growth estimation approach to investigate the impact of energy investments and resulting energy booms on the Canadian labour market. The study found that for every ten energy extraction jobs created during an investment boom period, approximately three construction jobs, two retail jobs, and four and a half service jobs were created.[5] Other empirical studies, including those by Paredes et al. (2015), Hartley et al. (2015), Lee (2015) and Feyrer et al. (2016) further contribute to the nuanced understanding of the impact of investment on employment in the broader extractives industry.

In some cases, significant variations in the estimates of the effects of investment on employment arise due to methodological differences in the literature. For example, using an IO approach, Considine et al. (2009) estimate that investments in Pennsylvania's shale oil and gas industry created 29,284 jobs in 2008, with a follow-up study using the same approach estimating 44,098 jobs in 2009. In contrast, Agerton et al. (2017), using an empirical approach found that increased rig counts in Pennsylvania during the same period resulted in long-term job increases of only 1,812 in 2008 and 11,930 in 2009, respectively. An IHS Global Insight (2011) report also estimates that the shale gas industry in the United States supported over 600,000 jobs in 2010, including direct and indirect jobs. However, Agerton et al. (2017) found that the industry in the same period supported only up to 173,794 jobs when dynamic effects were accounted for, illustrating discrepancies in estimates arising from differing methodologies.

The dynamics of investment in the oil and gas sector and the broader extractive industries play a crucial role in shaping employment trends and economic outcomes. Tordo et al. (2013) emphasise that sustained investment is essential for maintaining operational capacity, fostering technological advancements and expanding the workforce. Conversely, underinvestment can lead to reduced operational efficiency and a contraction in skilled employment. Van der Ploeg (2011) highlights how underinvestment driven by volatile commodity prices can neglect non-extractive sectors, indirectly affecting broader economic employment. Similarly, the International Energy Agency (IEA, 2020) consistently shows that downturns in investment in oil and gas exploration correlate with significant layoffs and reduced hiring. In summary, the literature clearly links investment levels in the oil and gas sector and the wider extractives industry to employment outcomes in natural resource-producing economies.

[5] Weinstein (2014) analysed data from 2001 to 2011 for counties in the lower-48 states of the United States, finding that each oil and gas job created an additional 0.3 jobs in other sectors.

3 Methods

3.1 Computable General Equilibrium Models (CGE)

CGE models are complex numerical systems that capture the fundamental economic interactions within an economy. These models utilise data related to a country's economic structure, supported by a set of economic theory-based equations, to simulate the effects of economic policies or shocks on whole-economy systems (see e.g. Burfisher, 2021; Devarajan and Robinson, 2005). They are distinguished by their ability to detail the complex interdependencies among various economic sectors (such as agriculture, manufacturing, etc.), factor markets (such as labour and capital) and economic agents (such as government, households, and firms). This capability allows economists to investigate how economic policy changes or shocks can ripple through an economy, influencing various interconnected sectors and agents. CGE models are particularly valuable for analysing policies or shocks with indirect effects that are challenging to summarily identify and measure directly (Beckman et al., 2011; Dwyer, 2015).

CGE models are widely used by government bodies, such as the US Congressional Budget Office (see US CBO, 2004) and UK HM Revenue and Customs (see UK HMRC, 2013); international organisations like the World Bank (see e.g. Kabir and Dudu, 2020), the Organisation for Economic Co-operation and Development (OECD, 2023) and the International Monetary Fund (IMF) (see e.g. Hunt et al., 2020); as well as in academic research (see e.g. Turner et al., 2023; Alabi et al., 2022; Mabugu et al., 2013; Bhattarai et al., 2016).

3.2 The PEP-1-t CGE Model

This paper utilises the single-country recursive dynamic PEP-1-t CGE model (version 2.1), as developed by the Partnership for Economic Policy (PEP), a global research network known for its proficiency in CGE modelling techniques (see Decaluwé et al., 2013).

The application of the large-scale PEP-1-t CGE model in this study provides numerous advantages, especially its capacity to capture the complex intertemporal dynamics of economic variables. By integrating dynamic factors, the model offers a detailed perspective on how economic policies and shocks, such as declining capital investments in the oil and gas sector, may variedly impact various aspects of the wider Scottish economy over time.

Further, the model's robustness and versatility have been validated by its extensive application in academic research across diverse geographic and economic contexts (see e.g. Mabugu et al., 2013; Galindev and Decaluwe, 2022; Phomsoda et al., 2021; Lkhagva et al., 2019; Mitik and Engida, 2013). Its widespread use not only underscores its reliability and efficacy but also contributes to a growing body of knowledge around its application, hence enhancing the model's utility and relevance for economic analysis. The PEP-1-t CGE model is openly accessible under a Creative Commons License.

In the PEP 1-t model, firms are assumed to operate within a perfectly competitive market framework. Each industry's representative firm maximises profits by adhering to its production technology while treating the prices of goods, services and production factors as given, consistent with price-taking behaviour in a competitive market setting.

Figure 4 shows the nested structure of production in the PEP-1-t CGE model. At the highest level of production, the output for each sector in the economy combines value-added and intermediate consumption as inputs in fixed proportions under a Leontief production function specification. This means that these two aggregate inputs are strictly complementary, with no possibility for substitution. Descending to the second level, each sector's value-added comprises composite labour and composite capital, under a constant elasticity of substitution (CES) specification. Unlike the Leontief production function, the CES production function allows for input factor substitutability. Firms maximise profits (or minimise costs) by employing labour and capital until the value marginal product of each equals its price, which are the wage rate and the rental rate of capital, respectively. In the context of a CES production function, this behaviour determines the demand for labour relative to capital.

At the base level of the value-added side, various categories of labour are combined using CES technology, reflecting the imperfect substitutability between different types of labour. Firms choose their labour composition to minimise labour costs given the relative wage rates. Similarly, composite capital is formed as a CES combination of different categories of capital. Just like labour, different types of capital are considered imperfect substitutes. The demand for each type of capital stems from the firms' efforts to minimise costs. Returning to the second level, but focusing on the intermediate consumption side, aggregate intermediate consumption comprises various goods and services. Here, it is assumed that intermediate inputs are perfectly complementary and are combined using a Leontief production function, which allows no substitutions.

This nested structure of production within the PEP 1-t CGE model illustrates the complex interactions between various production factors and inputs, reflecting the detailed and realistic economic modelling necessary for accurate policy analysis. For a complete description and mathematical representation of the PEP 1-t CGE model, see Decaluwe et al. (2013).

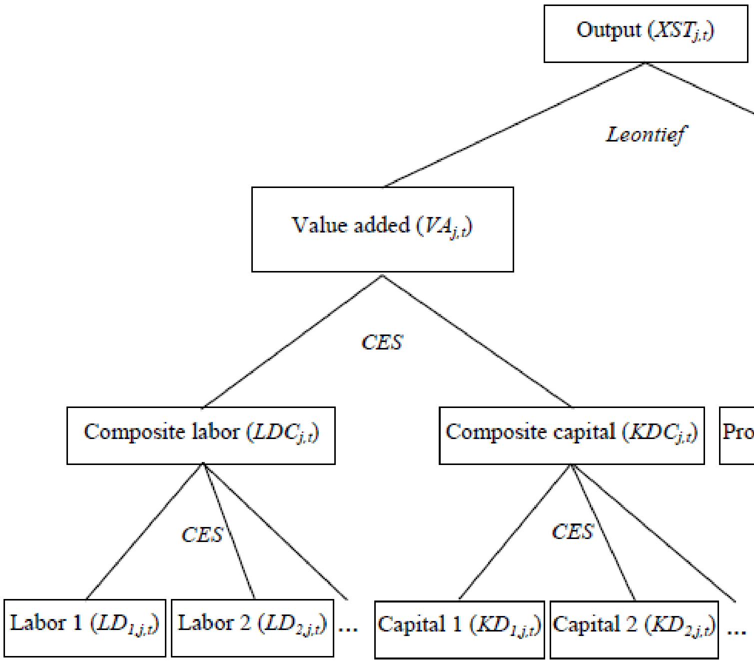


Figure 4: Nested structure of production in the PEP 1-t CGE model. (Source: Decaluwe et al., 2013)

3.3 The CGE Model Scenarios

Modelling the economic impact of a policy or shock within a CGE model framework is a complex undertaking requiring informed judgement and methodological rigour (Dwyer, 2015; Wing and Balistreri, 2018). CGE analyses involve conducting computer simulations under various economic policy or shock scenarios. Therefore, to effectively carry out a CGE analysis, it is important to first outline these scenarios. This process necessitates understanding of the fundamental aspects of the economic policy or shock under investigation.

To this end, in examining the effects of declining capital investments in the Scotland oil and gas sector on employment in the Scottish economy, this study models two main scenarios in the PEP 1-t CGE model framework.

3.3.1 The baseline business-as-usual scenario

This scenario is formulated through the calibration of the PEP 1-t CGE model equations and behavioural parameters which are anchored to the base year Scotland Social Accounting Matrix

(SAM) data (see Williamson et al., 2024.a.b). The resulting CGE model simulation under this scenario depicts the projected trajectory of the Scottish economy under normal conditions, marked by the absence of new economic policies or shocks. This scenario serves as a baseline against which the impact of deviations in the Scottish economy, stemming from investment decline shocks in the Scotland oil and gas sector, can be measured. Following Ross et al. (2019), we assume the Scottish economy to be in long-run equilibrium at the outset. This assumption implies that simulations of the baseline business-as-usual scenario indefinitely replicate the economic conditions of the base year, here 2024, for all future periods. This methodological approach sets the base year as a reference point and the focus of analysis is on examining deviations from this reference point induced by the decline in investments in the Scotland oil and gas sector.

3.3.2 The investment shock scenarios

CGE models operate by applying economic shocks to the baseline business-as-usual scenario described above. The subsequent analysis contrasts the economic conditions before the shock (i.e. the baseline business-as-usual scenario) with the economic environment following the imposition of a shock. Consequently, the investment shock scenarios in this paper are constructed by simulating three realistic trajectories of the decline in capital investment in the Scotland oil and gas sector, namely: (1) a 'status-quo investment decline' scenario, where investments decrease by approximately 8.30% annually, as is currently the case (see OEUK (2021) data); (2) an 'accelerated investment decline' scenario, with annual reductions of 10%; and (3) a 'rapid investment decline' scenario, where investments annually drop by 12.00%. Given that some upstream investments are already committed for the 2024–2030 period while others are pending approval and therefore at risk of not being realised, these scenarios represent the most realistic range of investment outcomes during this period.

Within the CGE model, the imposition of investment shocks in the Scotland oil and gas sector creates a new counterfactual equilibrium relative to the baseline business-as-usual scenario, hence enabling a *'what if'* comparison between the two economic equilibria (see e.g. Giesecke and Madden, 2013; Dixon and Rimmer, 1998; Capros et al, 1990). By comparing the baseline business-as-usual scenario with the investment shock scenarios, this study aims to elucidate the potential economic impacts of varying investment decline paths on employment, the wider economy and the energy transition in Scotland.

3.4 CGE Model Closure

For model closure, CGE models require specific assumptions regarding the labour market structure of economy under examination. These assumptions can significantly impact model outcomes. Two primary approaches are typically employed for model closure in labour markets (AlShehabi, 2013). The first approach fixes the quantity of labour supply, allowing wages to adjust endogenously. This approach implies full employment and flexible wages, where changes in wages reflect shifts in labour demand and unemployment levels. For instance, rising wages suggest increased labour demand and reduced unemployment, and vice versa. The alternative approach keeps wages fixed while allowing labour supply to endogenously adjust to achieve equilibrium. Here, labour supply curves are perfectly elastic, explicitly accounting for unemployment by permitting variations in employment rather than wages.

Both methods have merits. The fixed-wage approach is best suited for developing economies with significant labour market slack, where high unemployment leads to minimal wage pressure. However, Scotland's labour market, like those in many advanced economies, does not exhibit substantial labour market slack (Scottish Government, 2024.b; Bell and Blanchflower, 2014). The first approach, with exogenous labour supply and endogenous wages, provides a more reliable representation of labour demand dynamics in such an economy. This study adopts the first approach as it is also less sensitive to the model numeraire (see e.g. Devarajan and de Melo, 1987).

In this study, the CGE model closure features several other exogenous variables, including the 'exchange rate', which acts as the numeraire, 'current government expenditure on goods and services', 'minimum household commodity consumption', 'capital investment in public administration' and 'inventory change of commodities'. To preserve space, details on other model closure rules that pertain to rates and intercept variables are omitted from this discussion.

The PEP 1-t CGE model implemented in this study is developed as a balanced growth economy model. This means that exogenous variables in the economy grow at the same rate as labour supply while relative prices remain constant. A balanced growth economy is especially useful as a baseline business-as-usual scenario as it can be used to test model consistency and homogeneity (Decaluwe, 2013).[6] The model is written using the General Algebraic Modelling Systems (GAMS) software and language (GAMS, 2024). The computational operations in this

[6] The balanced growth test can be viewed as the dynamic equivalent of the homogeneity test in static models or the money-neutrality test in macroeconomic models (see Decaluwe, 2013).

study are performed using the CONOPT4 solver within GAMS. This solver is known for its efficient handling of large complex nonlinear optimisation problems (Drud, 2020).

3.5 The Transmission Mechanism of Changes in Capital Investments

To analyse the direct and immediate impact of an investment shock within a CGE model simulation, it is important to understand the transmission mechanism of the shock, namely here the decline in capital investment in the Scotland oil and gas sector. Introducing such an investment shock into the model initiates a process where the Scottish economy moves toward a new equilibrium, guided by the integrated system of equations, data and parameters that form the foundation of the PEP 1-t CGE model.

When an investment shock is introduced and the model simulated, the economy converges to a new equilibrium as determined by the system of equations, data and parameters underpinning the CGE model. This involves intricate calculations where the model adjusts to the disrupted investment levels by recalculating economic variables to reflect the new equilibrium. The PEP-1-t CGE model incorporates an intertemporal capital accumulation equation to specifically address investment shocks. This equation plays an important role in modelling how changes in sectoral investment affect the economy over time, thereby allowing the model to project how such shocks influence economic growth, sectoral performance, employment and other variables within the framework of a recalibrated economic landscape. The capital accumulation equation in the PEP-1-t CGE model is given as follows;

$$KD_{k,j,t+1} = KD_{k,j,t} \cdot \left(1 - \delta_{k,j}\right) + IND_{k,j,t} \tag{1}$$

where

Variable	**Description**
$KD_{k,j,t}$	Capital demand for type *k* capital in sector *j* in period *t*
$\delta_{k,j}$	Depreciation rate of type *k* capital in sector *j*
$IND_{k,j,t}$	New investment in type *k* capital in sector *j* in period *t*

The entry point of investment shocks is in the variable $IND_{k,j,t}$ as specified in equation (1). According to this equation, a decrease in investment initially lowers capital demand in the targeted sector, here the Scotland oil and gas sector.

As depicted in Figure 4, both capital and labour demands are direct inputs into the value-added component of production using a CES production technology. Consequently, a reduction in investment is expected to decrease capital demand, leading to a reduction in value added. As value added contracts, aggregate sectoral output, which incorporates both value added and intermediate consumption as inputs within a Leontief production technology, also decreases. This cascade of effects underscores the interconnectedness of investment levels with broader economic outputs in the CGE model. From Figure 4, it is expected that diminished capital investments in the Scotland oil and gas sector will result in diminished labour demand, since labour and capital are combined in the CES production technology to generate value added in the economy. Consequently, this forms the foundation for the expected decline in employment across the Scottish economy, arising from underinvestment in Scotland's oil and gas sector.

4 Data

4.1 Model calibration and parameterisation

To calibrate a CGE model, SAM data is utilised. A SAM serves as a complete representation of an economy, detailing the economic structure and the complex interplay of income and expenditure flows within a country. It essentially acts as a comprehensive economic database that records transactions among production activities, factors of production, institutions and international trade.

In this study, we utilise the 2018 Scotland SAM data as sourced from Williamson et al. (2024.a.b) at the University of Strathclyde's Fraser of Allander Institute, renowned for its expertise in generating Scotland-specific SAMs. The 2018 Scotland SAM is notably detailed, featuring 111 distinct accounts, including 98 sectors and commodities. To reduce the computational demands in the PEP 1-t CGE model used in this study, the SAM data was restructured by consolidating these sector and commodity accounts into 19 categories (see Appendices), consistent with the United Nation's International Standard Industrial Classification (ISIC) of all economic activities (United Nations, 2008). The SAM also features 4 agents, namely 'Households', Scottish 'Government', 'Firms' and the 'Rest of the world'. The 2018 Scotland SAM was nominally adjusted to allow for a 2024 base year projection.

CGE model outcomes are notably sensitive to the selection of exogenous elasticities and behavioural parameters (see Antimiani et al., 2015; Hertel et al., 2007; Agbahey et al., 2020). The exogenous parameters used this study are informed by econometric estimations and best guesses derived from existing literature, notably from Annabi et al. (2006) and Lecca et al. (2017). To ensure robustness and reliability, we adopt a conservative approach in setting several key parameters.

For all sectors, we follow Lecca et al. (2017) to set the Armington elasticity, which measures the elasticity of substitution between local and imported demand, to 2. The literature offers a broad range of estimates for the Armington elasticity. For instance, the Bank of England (Harrison et al., 2005) suggests values greater than 5, while Saito (2004) reports elasticities between 0.8 and 3.5 for various aggregate economic sectors. Significantly lower values are noted in Hooper et al. (2000). Given this variation, a middle-ground value of 2 is adopted to balance the extremes reported in these studies. The elasticity of transformation for domestic and export supply is also set to 2 for all sectors. This value aligns with the findings of Harrison et al. (2005) and Saito (2004). Following Lecca et al. (2017), we also set the elasticity of substitution between labour and capital to about 0.3 for most sectors. This value is corroborated by empirical evidence from Barnes et al. (2008), Harrison et al. (2005), and Harris (1989), reflecting the relatively low substitutability between these two factors of production.

An important parameter in the model is the elasticity of private investment demand relative to Tobin's q, which is set to 0.15. In the PEP 1-t CGE model, the allocation of new private capital across different sectors follows a modified version of the Jung and Thorbecke (2001) investment demand specification. Here, the volume of new capital allocated to business (i.e., non-public administration) sectors is proportional to the existing stock of capital. This proportion varies according to the ratio of the rental rate to the user cost of capital, interpreted as Tobin's q, as elaborated by Lemelin and Decaluwé (2007). Lastly, the elasticity of international demand for all exported commodities is set to 2. This parameter ensures that the model adequately captures the responsiveness of foreign demand to changes in the prices of exported goods. Other exogenous parameters such as Frisch parameter is set to -1 (see Annabi et al., 2006), and sectoral depreciation rates are based on EUKLEMS database estimates from Rincon-Aznar et al. (2017).

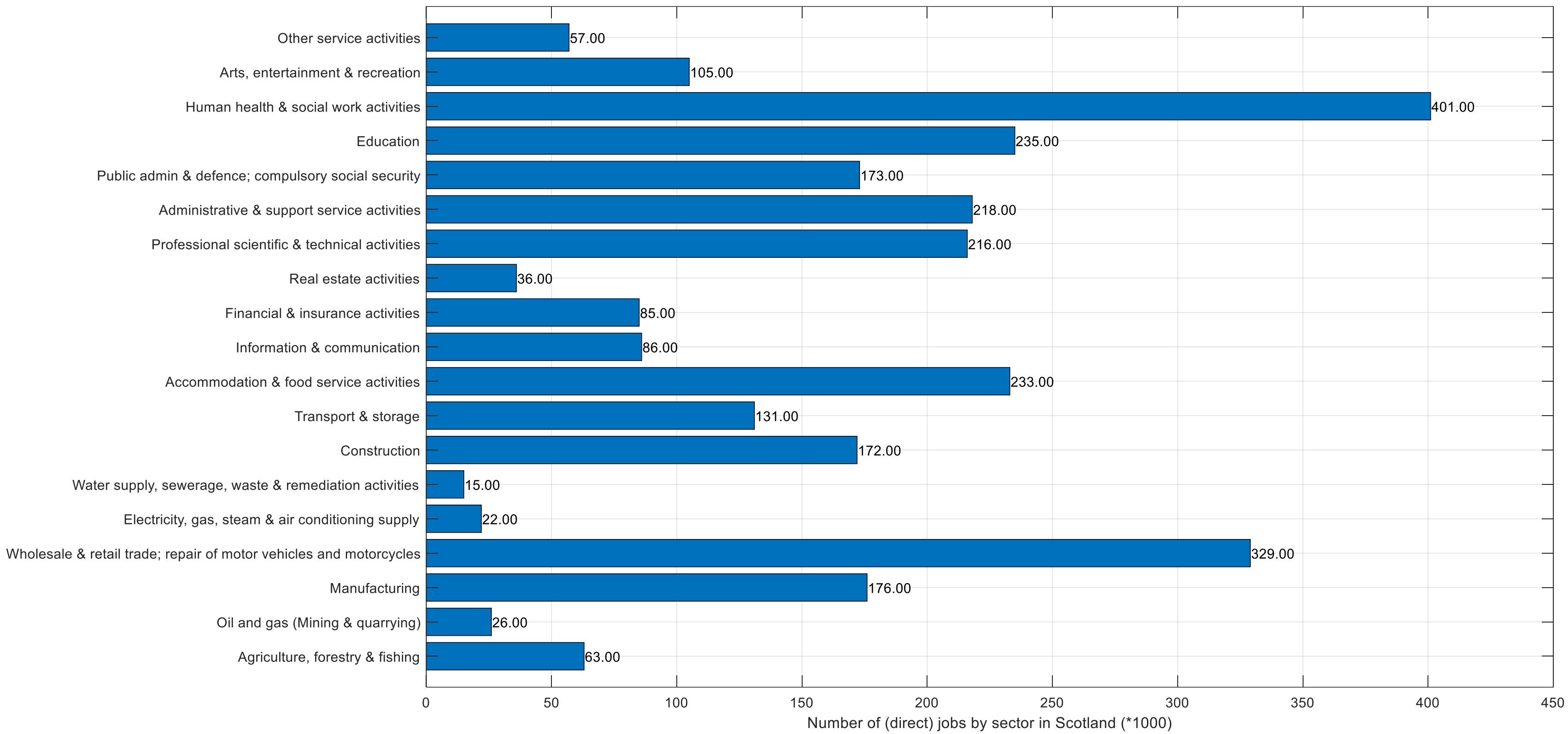
By carefully selecting these parameter values based on established literature and empirical evidence, the model is well-calibrated to provide reliable insights into the economic impacts of varying capital investment scenarios in Scotland's oil and gas sector.

4.2 Scotland jobs data

Figure 6 below shows the number of direct jobs supported by various sectors in Scotland's economy. The oil and gas sector directly supports about 26,000 jobs in Scotland. Although these jobs represent a small proportion of the 2.78 million jobs in Scotland, the sector's influence extends beyond its direct employment numbers. The oil and gas sector drives indirect job creation in several closely related industries which collectively represent about 61.50% of the total employment in Scotland.

Notably, the construction sector, with 172,000 jobs, heavily relies on the oil and gas industry for infrastructure projects and maintenance. Similarly, the manufacturing sector, employing 176,000 jobs, benefits from the demand for machinery and equipment used in oil and gas operations. The wholesale and retail trade sector, which supports 329,000 jobs, also has a strong connection to the oil and gas industry, supplying essential goods and services that facilitate sector activities. Financial and insurance activities, another critical sector with 85,000 jobs, plays a vital role by providing the necessary capital and financial services to support oil and gas projects. Other sectors closely associated with oil and gas include electricity supply (22,000 jobs), water supply (15,000 jobs), transport and storage (131,000 jobs), accommodation and food service activities (233,000 jobs), information and communications technology (ICT) (86,000 jobs), professional services (216,000 jobs), and administrative and support service activities (218,000 jobs). These sectors collectively enhance the operational efficiency and economic impact of the oil and gas industry in Scotland. Overall, the interconnected nature of these sectors underscores the broader economic influence of the oil and gas industry in Scotland.

Figure 5: Number of (direct) jobs by sector in Scotland (*1000) (Source: Author plot using UK Office for National Statistics (2024) data)



5 Results and Discussion

5.1 Base results: the status quo investment decline scenario

The status quo investment decline scenario reflects the current OEUK (2023) and NSTA (2024) forecasts of declining oil and gas investments from 2024 to 2030. All results are relative to the baseline business-as-usual scenario.

With respect to employment, the most notable outcome, as shown in Figure 6, is the substantial job losses estimated for the oil and gas sector. About 11,193 direct jobs in this sector are anticipated to be lost by 2030 (compared to 2024 levels). This decline is not just isolated to the oil and gas sector but extends to other closely related industries. The non-oil and gas sectors most affected include construction, financial and insurance activities, manufacturing, and wholesale and retail trade. Among these, the construction sector is expected to be the worst affected, with a projected loss of 3,670 jobs. The wholesale and retail trade sector follows closely, with an anticipated reduction of 2,825 jobs, while the manufacturing sector and financial and insurance activities are expected to lose 1,520 and 300 jobs, respectively.

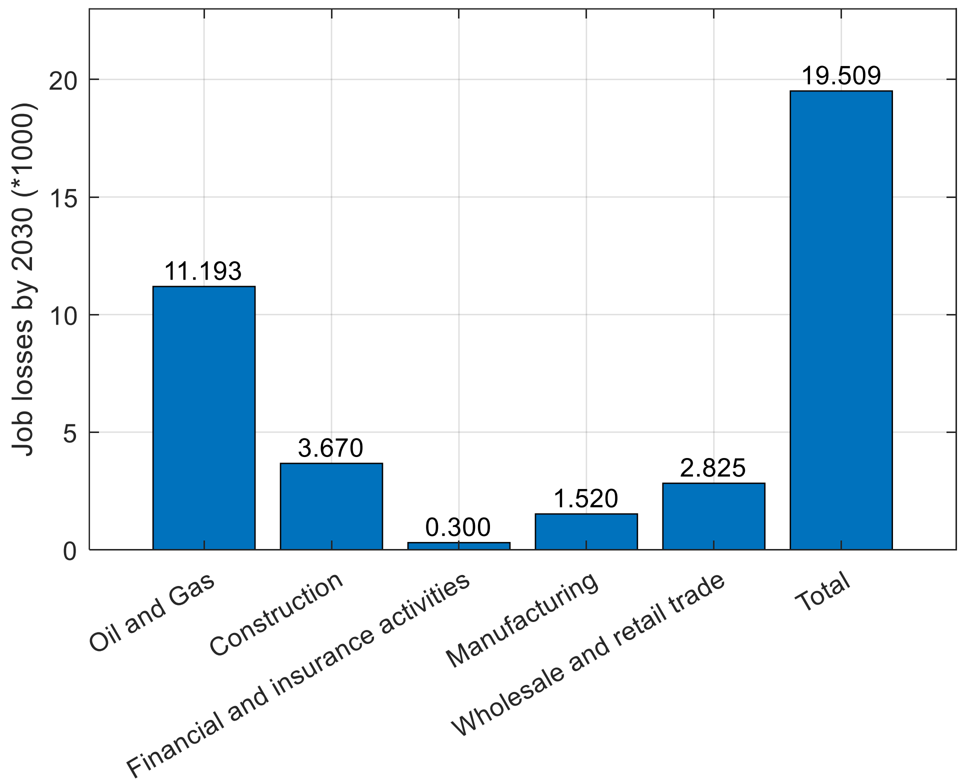
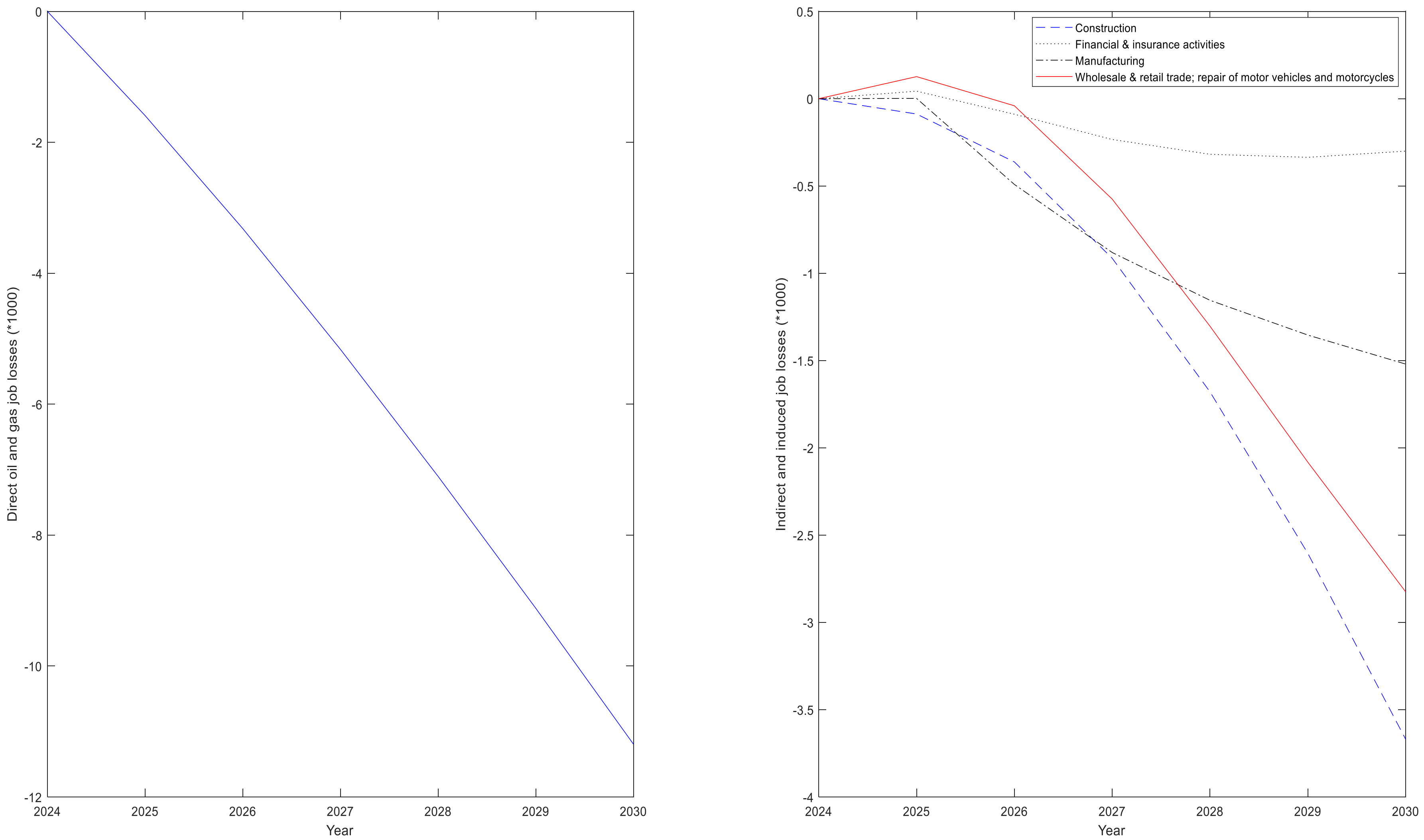


Figure 6: Sectoral job losses by 2030 under the status-quo investment decline scenario, compared to the baseline business-as-usual scenario.

The pace of job losses, shown in Figure 7, also provides important insights. The oil and gas sector is set to experience the fastest annual decline, losing about 1,865 jobs each year between 2024 and 2030. This rapid contraction reflects the sector's sensitivity to investment changes. In contrast, the construction sector will see an annual average job loss of approximately 611 positions, while the wholesale and retail trade sector will lose around 471 jobs per year. Manufacturing and financial and insurance activities will also face annual job losses of about 253 and 50, respectively.

Figure 7: Sectoral job losses over time under the status-quo investment decline scenario, compared to the baseline business-as-usual scenario.



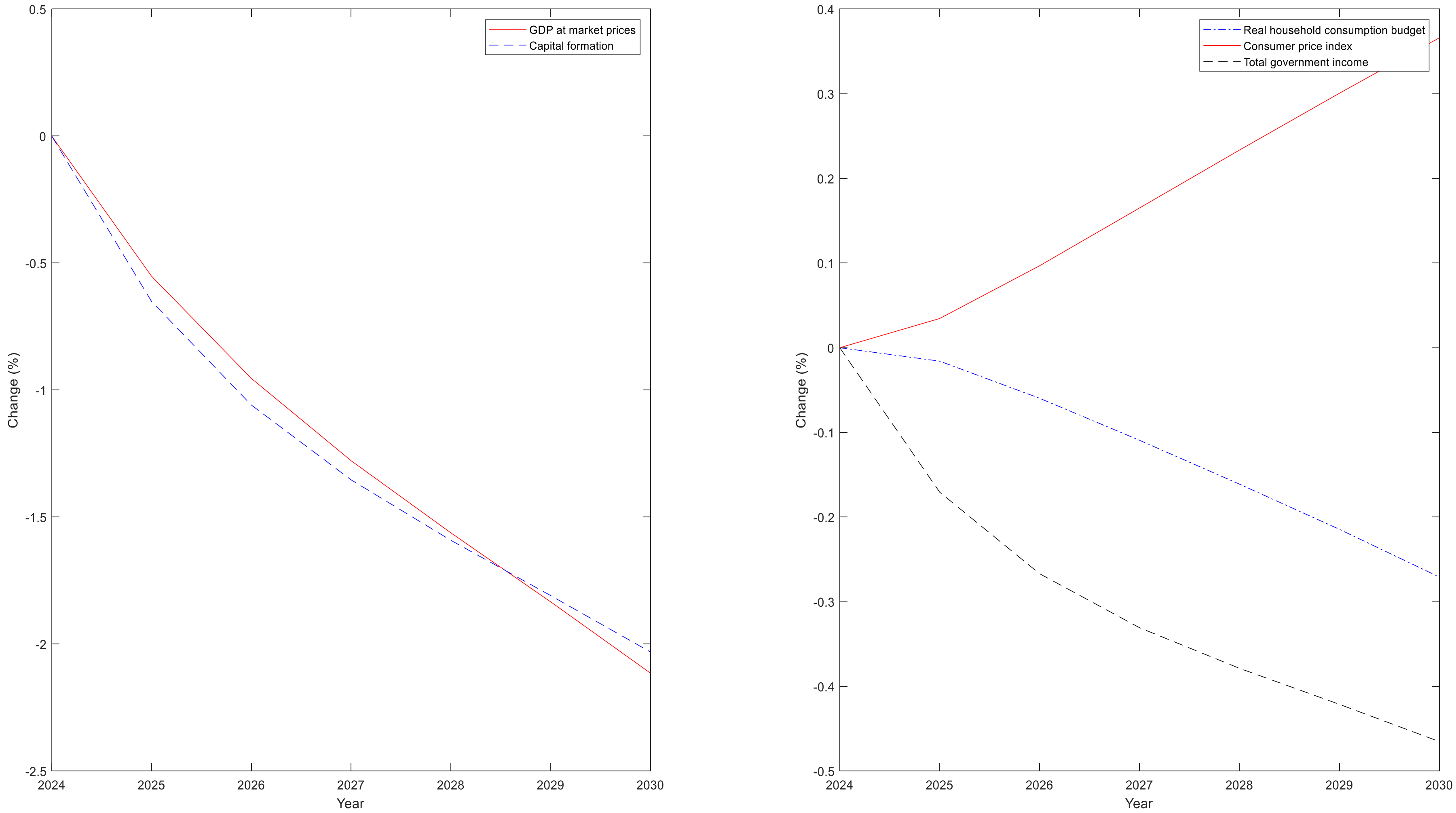
In aggregate, the total job losses across all sectors by 2030 amount to approximately 19,509. This figure encompasses 11,193 direct jobs in the oil and gas sector; and 8,316 indirect jobs in sectors such as construction, manufacturing, wholesale and retail trade, and financial and insurance activities. These losses underscore the extensive impact of reduced capital investment in the oil and gas industry on the broader Scottish economy.

To put the direct oil and gas sector job losses into context, data from the UK Office for National Statistics (2024), OEUK (2023; 2022b) and OGUK 2021) indicate that about 14,000 direct oil and gas sector jobs have been lost between 2014 and 2023, averaging 2,000 job losses per year over that period. The estimated job losses in this study align closely with the observed job losses in the industry over the past decade.

It should be noted that while the aforementioned sectors experience job losses, other sectors such as electricity supply, water supply and public administration see employment gains. Despite these increases, the net effect of job shifts across all sectors results in a 0.063% decrease in aggregate employment in Scotland.

The decline in employment is paralleled by adverse shifts in several key macroeconomic indicators, as shown in Figure 8. Scotland's GDP is projected to be about 2.11% lower in 2030 compared to 2024 levels, translating to an average annual decrease of 0.35%. This reduction highlights the significant negative impact on overall economic output resulting from diminished investment in a crucial sector. Furthermore, the CPI, an indicator of inflation, is expected to rise by 0.37% by 2030, averaging an annual increase of 0.06%. This inflationary pressure reflects the broader economic adjustments to reduced investment levels, indicating the strain on prices due to decreased investment and economic activity.

Figure 8: Changes in macroeconomic indicators over time under the status-quo investment decline scenario, compared to the baseline business-as-usual scenario



Total government income is expected to fall by 0.47% by 2030, with an average annual decrease of 0.08%, highlighting the fiscal challenges posed by a contracting economy. Capital formation, essential for long-term economic growth, is projected to decline by 2.03% by 2030, with an average annual decrease of 0.34%. This reduction in investment in physical assets underscores the broader economic slowdown and reflects diminished business confidence. Real household consumption budget, a key driver of economic activity, is also expected to diminish by 0.27% by 2030, reflecting an average annual decline of 0.05%. This decrease in household spending capacity further emphasises the adverse impacts on economic well-being and consumer confidence.

5.2 Sensitivity analysis

Table *1* summarises the sensitivity analysis for the various investment decline scenarios. The projected job losses by 2030 vary significantly across the different scenarios. Under the ‘status quo investment decline’ scenario, the total number of jobs lost by 2030 is 19,509. This figure increases to 23,799 under the ‘accelerated investment decline’ scenario and further escalates to 29,287 under the ‘rapid investment decline’ scenario. This trend underscores the more severe employment impacts associated with faster declines in investment.

Direct job losses in the oil and gas sector are particularly notable. By 2030, the ‘status quo investment decline’ scenario projects a loss of 11,193 direct jobs. This increases to 13,653 under the ‘accelerated investment decline’ scenario and to 16,684 under the ‘rapid investment decline’ scenario. The results reveal that a faster decline in investment could result in significantly higher job losses in the oil and gas sector, with 2,460 more jobs lost under the ‘accelerated’ scenario and 5,491 more jobs lost under the ‘rapid’ scenario compared to the ‘status quo’ projections.

The ripple effects of these job losses extend to other sectors. Compared to the ‘status quo investment decline’ scenario, the ‘accelerated investment decline’ scenario results in 1,830 more indirect jobs being lost. Under the ‘rapid investment decline’ scenario, the losses are even greater, with 4,288 more indirect jobs lost compared to the ‘status quo’ scenario. These figures highlight the extensive indirect employment impacts of faster investment declines.

Macroeconomic indicators also exhibit significant deterioration under faster investment decline scenarios. GDP under the ‘status quo investment decline’ scenario is projected to decrease by 2.11% by 2030. This decline is more pronounced under the ‘accelerated investment decline’ scenario, with a projected decrease of 2.59%, and even more severe under the ‘rapid investment decline' scenario, with a projected decrease of 3.27%. These figures illustrate the broader economic contraction associated with faster investment declines in the Scottish oil and gas sector.

Inflation, measured by the CPI, also rises more sharply with faster investment declines. By 2030, inflation is projected to increase by 0.37% under the ‘status quo’ scenario, by 0.44% under the ‘accelerated’ scenario, and by 0.53% under the ‘rapid’ scenario. This rising inflation reflects the pressure on prices resulting from reduced investment and economic activity.

Other macroeconomic indicators follow similar patterns of deterioration. Government income is projected to decrease by 0.47% under the ‘status quo’ scenario, by 0.57% under the ‘accelerated’ scenario, and by 0.73% under the ‘rapid’ scenario. Gross fixed capital formation, a critical driver of long-term economic growth, is projected to decline by 2.03% under the 'status quo' scenario, by 2.48% under the 'accelerated' scenario, and by 3.09% under the 'rapid' scenario. The real household consumption budget is also adversely affected, with projected declines of 0.27%, 0.33%, and 0.43% under the 'status quo', 'accelerated', and 'rapid' scenarios, respectively.

In summary, the sensitivity analysis demonstrates that faster rates of investment decline in the oil and gas sector lead to more severe job losses and greater economic contractions. These findings underscore the critical importance of sustaining investment levels to mitigate adverse economic and employment outcomes. Sustaining investment in the oil and gas sector is crucial for supporting broader economic stability in Scotland.

Table 1: Sensitivity analysis showing results for various simulation scenarios. All results are changes by 2030, relative to the baseline business-as-usual scenario.

Scenarios	**Status quo**	**Accelerated**	**Rapid**
Sectors	**Number of jobs lost**		
Oil and Gas	11,193	13,653	16,684
Construction	3,670	4,654	6,134
Finance and insurance activities	300	331	355
Manufacturing	1,520	1,863	2,322
Wholesale and retail trade	2,825	3,297	3,793
Total	19,509	23,799	29,287
Employment type	**Number of jobs lost**		
Direct	11,193	13,653	16,684
Indirect	8,315	10,145	12,603
Macroeconomy	**Percentage change (%)**		
Aggregate employment and wages	-0.06	-0.09	-0.15
Consumer price index (CPI)	0.37	0.44	0.53
Gross domestic prices (GDP)	-2.11	-2.59	-3.27
Total government income	-0.47	-0.57	-0.73
Gross fixed capital formation	-2.03	-2.48	-3.09
Household consumption budget	-0.27	-0.33	-0.43

6 Conclusion

Using a large-scale recursive dynamic CGE model, we examined different scenarios of investment decline in Scotland's oil and gas sector and their respective impacts on the Scottish economy by 2030. As expected, the results show that faster rates of investment decline result in significantly higher job losses and more severe economic contractions in Scotland.

Under the status quo investment decline scenario, Scotland is projected to lose approximately 19,509 jobs by 2030, with substantial impacts on the oil and gas sector and related industries such as construction, wholesale and retail trade, manufacturing, and financial and insurance activities. This scenario alone reflects a notable deterioration in macroeconomic indicators, including a 2.11% decrease in GDP, a 0.37% increase in inflation, and declines in government income, capital formation, and real household consumption budget by 2030.

The sensitivity analysis further highlights the exacerbated effects under accelerated and rapid investment decline scenarios. Job losses increase to 23,799 and 29,287, respectively, under these more severe scenarios. GDP is projected to decrease by 2.59% and 3.27% under the accelerated and rapid decline scenarios, respectively, with corresponding increases in inflation and deeper reductions in government income, capital formation, and household consumption. These findings reveal the critical importance of sustaining investment levels in the Scotland oil and gas sector to prevent severe economic and employment disruptions.

The results of this study have several important policy implications. First, policymakers must recognise the significant role that investment in the oil and gas sector plays in sustaining employment and economic stability in Scotland. Efforts to maintain or even increase investment levels in this sector could help mitigate or slow the adverse findings in this study. This might involve creating more favourable investment conditions through tax incentives or regulatory reforms aimed at attracting and retaining investment in the sector.

Second, investment is crucial not only to mitigate or slow the projected trend of employment decline but also to support the oil and gas sector's evolution and its critical role in the broader energy transition in Scotland. The oil and gas workforce possesses a wealth of expertise that is crucial for the burgeoning Scottish renewable energy sector. Continued investment ensures that this expertise is not suddenly and disruptively lost but rather managed and redirected over time to support emerging renewable energy sectors like offshore wind, hydrogen production and CCUS. This transition is essential as these areas are expected to play a significant role in achieving Scotland's ambitious decarbonisation goals.

Third, there is a need for targeted policies to support workers and communities most affected by job losses in the oil and gas sector, ensuring a just transition. Retraining and upskilling programmes could be implemented to help displaced workers move to other industries, particularly those with growing demand for labour. Additionally, regional development initiatives could focus on diversifying the economic base of areas heavily reliant on oil and gas, reducing their vulnerability to sector-specific downturns and wider economic dislocations. By prioritising these measures, policymakers can ensure that the transition to a renewable energy future is both equitable and inclusive, addressing the social and economic impacts on affected communities.

Fourth, maintaining a robust oil and gas sector also enhances energy security. By sustaining domestic production capabilities, Scotland and the wider UK can better manage their energy needs without excessive reliance on foreign energy imports, thus ensuring stability during global market fluctuations or geopolitical tensions. Furthermore, increased investment can drive technological advancements that make extraction and processing more efficient and environmentally friendly. Investing in modern technologies not only extends the life of existing fields but also reduces the environmental impact of operations.

Lastly, sustaining investment levels can help maintain the UK's position as a leader in the global energy market. This is vital not only for economic reasons but also for influencing global energy policies and practices towards more sustainable approaches. Technological innovation and efficiency improvements funded by ongoing investment can reinforce the UK's competitive edge and leadership in global energy transitions.

Future research should consider the long-term impacts of energy transitions on regional economies heavily dependent on oil and gas, using comparative analyses of different regions to gain insights into effective strategies for managing economic and social impacts. Additionally, longitudinal studies tracking the long-term outcomes of workers displaced from the oil and gas sector are essential to understand their employment trajectories, income levels, and overall well-being, thereby informing the design of effective retraining and support programmes.

In conclusion, this study highlights the significant negative impacts of declining investment in Scotland’s oil and gas sector on employment, economic performance and the energy transition. The government should consider the broader economic impacts of declining investment in the oil and gas sector when formulating energy and industrial policies. While transitioning to renewable energy sources is essential for long-term sustainability, it is crucial to manage this transition carefully to avoid severe economic dislocations. A balanced approach that supports both the development of renewable energy and the continued viability of the oil and gas sector during the transition period would be more beneficial.

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Appendices

Table 2: Detailed description of sectors and commodities

Sector	Description (see United Nations, 2008)
Oil and gas (mining and quarrying)	This section covers the extraction of naturally occurring minerals in solid (coal and ores), liquid (petroleum), or gas (natural gas) forms. Methods include underground or surface mining, well operation, and seabed mining.
Manufacturing	This sector involves the physical or chemical transformation of raw materials—derived from agriculture, forestry, fishing, mining, or other manufacturing activities—into new products. This includes substantial alteration, renovation, or reconstruction of goods.
Construction	This sector encompasses general and specialised construction activities for buildings and civil engineering works. It includes new constructions, repairs, additions, alterations, and the erection of prefabricated buildings or temporary structures. General construction covers a wide range of projects, including residential buildings, commercial properties, public utilities, civil engineering works like motorways, bridges, railways, harbours, irrigation systems, sewerage systems, industrial facilities, pipelines, electric lines, and sports facilities.
Financial and insurance activities	This sector comprises financial services, including insurance, reinsurance, and pension funding, as well as activities that support financial services. It also includes the activities of holding companies and the management of assets, such as trusts, funds, and similar financial entities.
Wholesale and retail trade; repair of motor vehicles and motorcycles	This sector covers the wholesale and retail sale of all types of goods without transformation, as well as services incidental to the sale of these goods. It represents the final steps in the distribution process, where merchandise is bought and sold. Additionally, this sector includes the repair of motor vehicles and motorcycles.
Accommodation and food service activities	This sector includes providing short-stay accommodation for visitors and travellers and offering complete meals and drinks for immediate consumption. It does not cover long-term residential accommodation, which falls

	under real estate activities, nor does it include the preparation of food and drinks not intended for immediate consumption, which is classified under manufacturing.
Administrative and support service activities	This sector encompasses a range of activities that provide support to general business operations. These services do not primarily focus on transferring specialised knowledge but instead offer essential operational support.
Agriculture, forestry and fishing	This sector encompasses the cultivation of plants and animals, including crop production, animal husbandry, and the harvesting of timber and other natural resources from farms and natural habitats.
Arts, entertainment and recreation	This sector covers a broad spectrum of activities designed to cater to cultural, entertainment, and recreational interests of the public, including live performances, museum operations, gambling, and sports and recreation activities.
Education	This sector encompasses all levels and types of education, including primary, secondary, and higher education, as well as vocational training, adult education, literacy programs, and specialised institutions such as military academies and prison schools. It includes both public and private education, delivered through various means such as in-person instruction, radio, television, and other communication methods.
Electricity, gas, steam and air conditioning supply	This sector encompasses the provision of electric power, natural gas, steam, and hot water through a permanent infrastructure of lines, mains, and pipes. It includes the distribution of these utilities in industrial parks and residential buildings, irrespective of the network's size.
Human health and social work activities	This sector includes short- and long-term hospital care, encompassing general, specialty, psychiatric, and substance abuse hospitals, as well as sanatoria, medical nursing homes, asylums, rehabilitation centres, and other health institutions with accommodation facilities providing diagnostic and medical treatment. It also covers medical consultations and treatments by general practitioners, specialists, surgeons, and dentists, along with orthodontic services. Additionally, it includes health services provided by paramedical practitioners

	legally recognised to treat patients outside of hospital settings.
Information and communication	This sector encompasses the production and distribution of information and cultural products, as well as the means for transmitting and distributing these products. It includes data and communication services, information technology activities, and data processing. Major components are publishing (including software), motion picture and sound recording, radio and TV broadcasting, telecommunications, and other information service activities.
Professional scientific and technical activities	This sector includes activities that require a high degree of training and provide specialised knowledge and skills. These activities encompass a wide range of professional, scientific, and technical services.
Public administration and defence; compulsory social security	This sector encompasses activities typically undertaken by the government, including the enactment, regulation, and judicial interpretation of laws, as well as the administration of programs based on these laws. It covers legislative activities, taxation, national defence, public order and safety, immigration services, foreign affairs, and the administration of government programs. Additionally, it includes activities related to compulsory social security.
Real estate activities	This sector involves acting as lessors, agents, and brokers in selling, buying, and renting real estate. It includes providing services such as real estate appraisal and acting as escrow agents. Activities may be conducted on owned or leased property, on a fee or contract basis, and can also involve building and maintaining ownership or leasing of structures.
Transport and storage	This sector encompasses the provision of passenger and freight transport via rail, pipeline, road, water, or air, whether scheduled or not. It also includes related activities such as terminal and parking facilities, cargo handling, and storage. Additionally, it covers the renting of transport equipment with drivers or operators, as well as postal and courier services.
Water supply; sewerage, waste management and remediation activities	This sector involves managing various forms of waste, including collection, treatment, and disposal of industrial or household waste and contaminated sites. It also includes water supply activities, often linked to sewage treatment

	processes, where the treated output can be either disposed of or used as an input for other production processes.
Other service activities	This residual category encompasses activities of membership organisations, the repair of computers and personal and household goods, and various personal service activities not included elsewhere in the classification.