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SUCCESS IN SECTORAL EXPORT PROMOTION AND ECONOMIC AND ENVIRONMENTAL INDICATORS: A MULTISECTORAL MODELLING ANALYSIS

BY

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Success in sectoral export promotion and economic and environmental indicators: a multisectoral modelling analysis for the UK

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Abstract

UK policymakers are seeking to use the levers of a more active industrial policy to develop economic opportunities, including through new and expanded trading opportunities. At the same time, the UK Government has committed to a net zero greenhouse gas emissions target by 2050. While increases in exports are expected to raise economic activity, it is unclear what impact this will have on UK energy use and emissions. With a main plank of the UK strategy the development of "Sector Deals", it is unknown whether this is also true for *specific industrial sectors*. We examine this empirically in a multisectoral Computable General Equilibrium model of the UK that captures the interdependence between economic activity, energy use and emissions. Our results suggest that while economic outcomes move in the desired direction there are mixed impacts on energy use, UK territorial industrial emissions, and the energy- and emissions-intensity of the UK economy. Notably, we identify instances where growing exports in specific sectors helps to meet the objectives of both the Clean Growth Strategy and Industrial Strategy.

Keywords: energy policy, industrial strategy, trade policy, emissions.
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1 Introduction

In the UK there is a growing momentum towards emissions reductions, particularly since the statement in July 2019 that the UK Government will legislate for a 2050 “net zero" target for greenhouse gas emissions. This target will require a raft of policies to reduce the UK’s use of fossil fuels both in the energy system, but also require contributions across all sectors of the economy. In addition to reducing emissions, it is anticipated that there will also be economic benefits for the UK from decarbonisation. Such economic ambitions are central to the UK’s Industrial Strategy (UK Government, 2017b), the Export Strategy (UK Government, 2018a), and in specific Sector Deals (UK Government, 2018j). The UK 2017 Clean Growth Strategy put the objectives for higher economic growth alongside reductions in emissions, and sought to build on the UK’s “broad range of low carbon industries, including some sectors in which we have world leading positions" (UK Government, 2017a, p.8).

Previous work (Ross et al., 2018) has addressed the link between changes in aggregate exporting activity and economic, energy and emissions impacts. This found that an across-the-board stimulus to growth through exports – in the absence of mitigating steps – is not typically “green” in nature, stimulating both energy and emissions, as well as increasing both the energy- and emissions-intensity of UK economic activity (Ross et al., 2018). This work argued that knowledge of the likely scale of such spillover effects could be used to develop a more holistic, coordinated approach to policy formation and implementation. It empirically showed the extent to which successful decarbonisation policies would be necessary to mitigate/offset increases in emissions that would otherwise result from an export promotion policy.

The central purpose of this paper is to extend that previous work and reflect the detailed industrial focus of the UK Government’s “Sector Deals" by looking below the aggregate level. We wish to focus on the incremental changes in economic activity, territorial industrial emissions and energy use (as well as the indicators of emissions- and energy-intensity of GDP) that could arise from success in increasing exports in *specific industrial sectors*. The opportunities and challenges for the UK at a sectoral level to benefit from international activity in low carbon sectors is, for instance, the focus of work by Carvalho and Fankhauser (2017). That work does not however examine the consequences of the UK of achieving export growth at the sectoral level, or the quantitative scale of such impacts, or any trade-off’s between successes in different low carbon sectors.

Through this examination we can identify whether it may be possible to target export policies at specific sectors which would stimulate "greener" growth, i.e. positive impacts on economic indicators with (desirable) reductions in energy use and/or emissions. While we might expect that such sectors could include those with lower energy and emissions per unit of output, or smaller links to energy-using sectors, the full (economic and environmental) system-wide consequences of increasing exports at the sectoral level can be examined using an appropriately detailed CGE model of the UK. Specifically, we are interested in the following question: are there differences in the consequences for economic, energy and emissions indicators when policies are successful in raising exports for individual sectors of the UK economy?

We are not the first paper to explore the impact of trade on a countries emissions using multisectoral models. There is already impressive analysis of the UK's carbon footprint, published annually by DEFRA (Department for Environment, Food and Rural Affairs, 2019). The latest data shows that the emissions in the UK has fallen by 33 per cent between 1997 and 2017, while those on a footprint basis - which includes the full global emissions caused by UK consumption has fallen by only 4 per cent. With global supply chains, and international trade, emissions associated with UK consumption of goods and services have risen in the rest of the world, while the UK's own emissions have fallen (i.e. the "gap" between territorial and footprint measures for the UK, like many other countries, has grown larger over time).

Other papers and approaches have also been used to assess the nature of employment in low carbon economic activities. These have included analyses employing multisectoral detail on employment in energy sectors to assess the level of employment supported by such activities both directly and in the rest of the economy (Allan and Ross, 2019), or the links between skills shortages and training through the transition to a low carbon economy in the UK (Jagger et al., 2013). Such papers offer more detail on the labour market than our own analysis, however the focus of our work is to specifically link successful economic policy outcomes to their implications for the broader economy, and the environmental and energy consequences.

The rest of the paper is organised as follows. Section 2 provides a brief overview of the sectoral focus of the 2017 Industrial Strategy, including the current Sector Deals (as of December 2019), as well as the link between economic and other objectives of UK policy. Sections 3 and 4 outline the model, the data, and the simulation strategy we pursue. Section 5 discusses the main results, and Section 6 provides a sensitivity analysis. Lastly, Section 7 discusses the findings and summarises the main conclusions.

2 Sectors in the Industrial Strategy: Exports and opportunities

The Industrial Strategy brought together the new focus of industrial policy on the role for the “strategic state" which would intervene in the economy, working with the private sector to deliver economic objectives for the UK as a whole. While part of this was focused on the aggregate economy, a sectoral focus to the strategy was clear, with the then-Prime Minister Theresa May’s foreward talking of “the industries that are of strategic value to our economy [...] a partnership between government and industry to nurture them. In doing so, it will help propel Britain to global leadership of the industries of the future - from artificial intelligence and big data to clean energy and self-driving vehicles." (UK Government, 2017b, p.5).

The Export Strategy (UK Government, 2018a, p. 5) talks of “the government prioritis[ing] resources towards high-potential sectors, markets, and opportunities”. On the UK’s strengths it is noted (UK Government, 2017b, p.24):

> “the UK has a significant number of large, internationally competitive sectors. We are relatively specialised in areas as diverse as financial services, insurance and pensions services, cultural and recreational services, chemicals (including pharmaceutical products), other business services (which includes R&D, consultancy and trade-related services), transportation (including vehicles, aircraft and spacecraft), food products and defence equipment."

One major novelty of the Industrial Strategy was its focus upon developing Sector Deals, defined as "partnerships between government and industry aiming to increase sector productivity." (UK Government, 2017b, p.164). These were trailed in the Green Paper, and set out a collaborative model, “where specific sectors could come together under clear leadership and make a compelling case to negotiate a Sector Deal with the government to boost the earning power and productivity of that sector." (UK Government, 2017b, p.192). The specific elements of Sector Deals would depend upon the negotiations between government and the private sector and would be aware of sector-specific issues and challenges ("the right approach will vary from sector to sector" (UK Government, 2017b, p.118).

The UK Government has developed ten “Sector Deals” (as of December 2019) and these are shown in the first column of Table 1[1]. These Deals typically focus on raising productivity,

[1]In addition to those shown in Table 1, the Tourism Sector Deal has also been agreed, with tourism noted as being

improve the skills of the workforce, and leveraging private investment alongside “unlocking" public funding to the sector. In this paper we focus on the exporting ambition at sectoral level including within the Sector Deals. In addition to targets for the sector, each Sector Deal pays particular attention to export markets and opportunities for UK goods and services to find a global market. Some of these include sector-specific ambitions for growing exports (as shown in the second column of Table 1).

The Clean Growth Strategy, as well as noting the ambitions for the UK, identified that there were economic opportunities for the UK from the global shift towards clean energy, for instance, in Offshore wind, electric vehicles, as well as low carbon and financial services (UK Government, 2017a). The document notes that, “ ... action on clean growth means that we have nurtured a broad range of low carbon industries, including some sectors in which we have world leading positions" (UK Government, 2017a, p.8). The same strategy also highlights the importance of “clean growth" and specifically exports for overall economic growth.

It is therefore important to consider the impact that raising exports in specific industries could have on economic objectives, and UK environmental and energy-related indicators. We note some limitations of our approach here, and return to this in Section 7. First, we cannot specifically focus on the Sector Deals definitions of sectors as our multisectoral models use the definition of industries provided in economic accounts. Some of the Sector Deals focuses on firms which are active in specific activities, defined by end products, and include firms which are active through the supply chain for each “Sector". The Offshore Wind Sector Deal, for instance, brings together firms involved in developing, testing, constructing new farms and managing existing projects - spanning activities across multiple industries, as defined in the national accounts [2].

Additionally, as our focus is on aggregate and sectoral economic impacts, we do not capture all of the more disaggregated elements which could be relevant for policymakers. Where - as noted above - there is an interest in the impacts on jobs in different skills, our analysis does not talk to this, nor does it extend to issues about the specific geography of impacts across the UK. Some Sector Deals do acknowledge that “clustering" of activities is likely to mean that such policies will produce impacts in specific geographies.

"one of the country's most important industries and the third largest service export" (UK Government, 2019b, p. 6). We do not include Tourism as a sector here as activity in the Tourism economy is defined by consumption, i.e. whether the person making the purchase is a tourist, rather than the nature of the item being produced, and so this differs from other definitions of sectors used in this paper. We return to definitional issues about industrial sectors in Section 7.

[2] More details on the identification of the Offshore Wind sector in the UK can be found in Allan et al. (2019).

Table 1: UK Sector Deals and sectoral export ambitions, as of July 2019

Specific Sector Deal	**Comments/targets related to increasing UK exports**
Aerospace (December 2018)	"Future Flight Challenge will open new aviation markets through demonstration of aviation systems, incorporating low environmental impact, autonomous air vehicles and airspace management by 2025. The challenge will transform connectivity, boost UK exports..." (UK Government, 2018b, p. 16)
Artificial Intelligence (May 2019)	"We have a fantastic opportunity to export our AI expertise too. The government is committed to helping our AI businesses succeed globally." (UK Government, 2018c, p. 32)
Automotive (January 2018)	"£250 million to position the UK as a global leader in the development and deployment of connected and autonomous vehicles (CAVs)." (UK Government, 2018d, p.12)
Construction (July 2019)	"...to establish the UK as a global leader by increasing exports of UK construction products and services." (UK Government, 2018e, p. 32)
Creative Industries (March 2018)	"If we can get the conditions right[creative industries]exports will increase by 50% by 2023, they will be worth £150 billion and create 600,000 new jobs." (UK Government, 2018f, p. 3)
Life sciences (V.2) (December 2018)	"The UK's capability in this field means we are securing highly-skilled jobs and accessing a global market estimated to be worth between £9-14 billion per year by 2025." (UK Government, 2018g, p. 31)
Nuclear (June 2018)	"a more competitive supply chain, with more UK companies using advanced manufacturing methods and entering domestic and export markets for nuclear goods and services..." (p. 3) and "The government and sector will also work together to develop a coordinated global campaign for promoting the UK's nuclear expertise overseas to maximise future export orders across the nuclear life cycle." (UK Government, 2018h, p. 10-11)
Offshore wind (March 2019)	"Setting an ambition of increasing exports fivefold to £2.6 billion by 2030." (p. 4) and "a growing global market offers unique opportunities for the UK supply chain" (UK Government, 2019a, p. 7)
Rail (December 2018)	"As part of this plan to grow manufacturing capacity and productivity, and to capitalise on export opportunities, it identified a series of core aims. These included commitments to, by 2025: more than double exports". (UK Government, 2018i, p. 32)

3 Method and data

We simulate the economic and energy system impacts of increases in sectoral exports using the UK-ENVI computable general equilibrium (CGE) model of the UK. Versions of this model have been employed previously to analyse the impacts of increases in aggregate exports (i.e. a simultaneous "across the board" increase in exports) (Ross et al., 2018) as well as increased energy efficiency in industrial and household use (Allan et al., 2007; Figus et al., 2018; Lecca et al., 2014). We adopt here the forward-looking variant of the model, in which households' consumption and firms' investment are governed by intertemporal optimisation. In the following sections we provide a description of the main characteristics of the model, with a particular emphasis on the linkages between the economic and energy sub-sectors. [3]

3.1 Consumption and trade

Consumption is modelled to reflect the behaviour of a representative household that maximises its discounted intertemporal utility, subject to a lifetime wealth constraint. In each time period t we model the aggregate consumption decision of each of the five representative households h as follows:

$$C_{h,t} = YNG_{h,t} - SAV_{h,t} - HTAX_{h,t} - CTAX_{h,t} \tag{1}$$

where total consumption C is a function of income YNG, savings SAV, income taxes $HTAX$, and taxes on consumption $CTAX$. The solution of the household optimisation problem gives the optimal time path for consumption of the bundle of goods C_t.

To capture information about household energy use, consumption is allocated within each period between "residential energy" and "transport and non-energy" goods and services as indicated in the top level of the consumption structure shown in Figure 1. This choice is made in accordance with the following constant elasticity of substitution (CES) function:

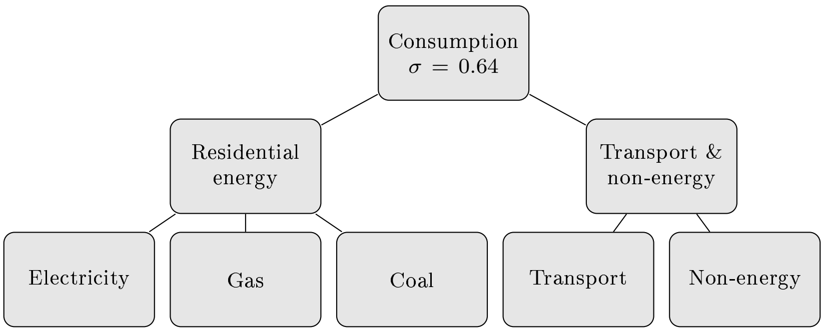
$$C_{h,t} = \left[\delta_h^E (\gamma EC_{h,t})^{\frac{\varepsilon_h - 1}{\varepsilon_h}} + \left(1 - \delta_h^E\right) TNEC_{h,t}{}^{\frac{\varepsilon_h - 1}{\varepsilon_h}}\right]^{-\frac{\varepsilon_h}{\varepsilon_h - 1}} \tag{2}$$

where ε is the elasticity of substitution in consumption, and measures the extent to which consumers substitute residential energy consumption, EC, for non-energy and transport consumption, $TNEC$, $\delta \ \varepsilon$ (0,1) is the share parameter, and γ is the efficiency parameter of energy

[3] A full mathematical description of the model is given in Ross et al. (2018).

consumption. For simplicity (and in the absence of better information), in all households we impose a value, 0.61, for ε this is the long-run elasticity of substitution between energy and non-energy estimated by Lecca et al. (2014). The consumption of residential energy includes electricity, gas and coal, as shown in Figure 1, although the share of coal consumed by households represents less than 0.01% of total energy consumption. Given that we do not focus on inter-fuel substitution in the analysis below, within the energy bundle we impose a small but positive elasticity. In both equations (1) and (2) the h subscript reflects the fact that household results are available disaggregated by income quintiles.

Figure 1: The structure of consumption



Moreover, we assume that the individual can consume goods produced both domestically and imported, where imports are combined with domestic goods under the Armington assumption of imperfect substitution (Armington, 1969), so that:

$$QH_{i,t} = \gamma_i^f \cdot \left[\delta_i^{hir} \cdot QHIR_{i,t}^{\rho_i^A} + \delta_i^{hm} \cdot QHM_{i,t}^{\rho_i^A} \right]^{\frac{1}{\rho_i^A}} \tag{3}$$

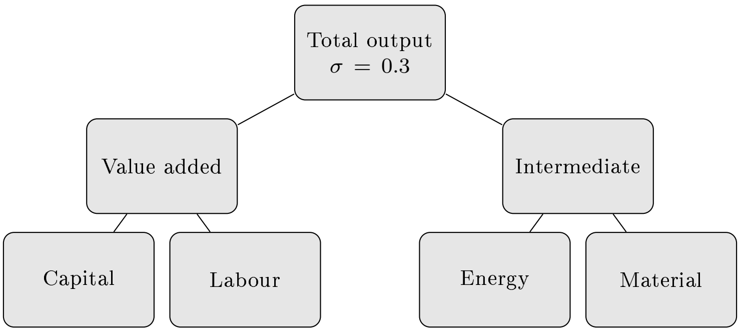
where QH is total household consumption by sector, $QHIR$ is consumption of locally produced goods, and QHM is consumption of imported goods. With the price of imports being exogenous, substitution between imported and domestically produced goods depends on variations in national prices.

It must be noted that the Armington assumption has implications for the decisions of both producers and consumers. The choice over imported or domestic inputs for firms depends on their relative prices, as well as the Armington elasticity. Similarly, consumers choose over imported and domestic goods depending on relative prices and the Armington elasticity. Intermediate purchases in each industry are modelled as the demand for a composite commodity with fixed (Leontief) coefficients (see following section for more detail). These are substitutable for imported commodities via an Armington link, which is sensitive to relative prices.

3.2 Production and investment

The production structure of each of the thirty production sectors is characterised by a capital, labour, energy and materials (KLEM) nested CES function. As we show in Figure 2, the combination of labour and capital forms value added, while energy and materials make up intermediate inputs. In turn, the combination of intermediates and value added comprise total output in each sector.

Figure 2: The structure of production



The value-added production function for each activity, i, related to the left hand branch of the production hierarchy, is given as:

$$VA_{i,t} = \left[a_i(\lambda L_{i,t})^{\frac{\varepsilon_i - 1}{\varepsilon_i}} + (1-\alpha_i)(\gamma K_{i,t})^{\frac{\varepsilon_i - 1}{\varepsilon_i}} \right]^{-\frac{\varepsilon_i - 1}{\varepsilon_i}} \tag{4}$$

where L and K are labour and capital inputs, λ and γ are labour and capital productivity parameters (initially set to one); and ϵ is the elasticity of substitution between capital and labour.

Following Hayashi (1982), we derive the optimal time path of investment by maximising the value of firms, V_t, subject to a capital accumulation function K_t, so that:

$$Max\ V_t \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t [\pi_t - I_t (1 + g(x_t))] \qquad subject\ to\ K_t = I_t - \delta K_t \tag{5}$$

where π_t is the firm's profit, I_t, is private investment, $g(x_t)$ is the adjustment cost function with $x_t = I_t/K_t$ and δ is the depreciation rate. The solution of the optimisation problem gives us the law of motion of the shadow price of capital, λ_t , and the adjusted Tobin's q time path of investment.

3.3 The labour market

Model outcomes are sensitive to the operation of the labour market. We discuss the implications of alternative labour market models in our sensitivity analysis in Section 6. Our default labour market closure embodies a wage curve (Blanchflower and Oswald, 2005). It implies that wages are determined within the UK in an imperfectly competitive context, according to the following bargained real wage (BRW) specification:

$$\ln\left[\frac{w_t}{cpi_t}\right] = \rho - \varepsilon \ln(u_t) \tag{6}$$

where ε is the elasticity of wage related to the level of unemployment, u, and ρ is a parameter calibrated to the steady state. The working population is assumed to be fixed and this model implies the presence of involuntary unemployment, with BRW lying above the competitive supply curve for labour.

3.4 Government

In the simulations reported in in this paper, government expenditure, $GEXPT$, is held constant in real terms. Government income in time period t, GY_t, is given by the share, d_g, of capital income, KY, that is transferred to the Government, Indirect business taxes, IBT, revenues from labour income LY, taxed at the rate τ, and foreign remittance FE, which are taken to be exogenous.[4] Therefore:

$$GY_t = d_g KY_t + IBT_t + \bar{\tau}_t \cdot LY_t + FE_0 \tag{7}$$

The Government budget surplus, $GOVBAL$, is then equal to the difference between government income and government spending so that:

$$GOVBAL_T = GY_T - \overline{GEXP_T} \tag{8}$$

3.5 Data

Calibration follows a common procedure for dynamic CGE models which is to assume that the economy is initially in steady state equilibrium (Adams and Higgs, 1990). The data base employed is the UK Social Accounting Matrix (SAM) for 2010, the latest data available at

[4]Note that the income tax is levied at a fixed rate τ which is calibrated to the base-year data set.

the time of writing.[5] The UK-ENVI model has 30 separate production sectors, including the main energy supply industries that encompass the supply of coal, refined oil, gas and electricity. These are detailed in Appendix A. We also identify the transactions of UK households (by income quintile), the UK Government, imports, exports and transfers to and from the rest of the World (ROW).

The SAM constitutes the core dataset of the UK-ENVI model. However other parameter values are required to inform the model. These often specify technical or behavioural relationships, such as production and consumption function substitution and share parameters. Such parameters are either exogenously imposed, based on econometric estimation where available, or determined through the calibration process. Base year industrial territorial CO_2 emissions are calculated, and linked to the CGE sectoral primary fuel use according to Allan et al. (2018).

4 Simulation strategy

The main focus of this paper is to empirically identify the impacts of successful sectoral export promotion on the UK economy, as well as on UK energy use and territorial emissions. While it may be helpful to explore the transmission mechanisms of trade-enhancing policy instruments that are targeted on individual sectors, and assess their efficacy explicitly, we do not perform this here. The previously noted UK policy documents currently do not provide the necessary detail on such targeting or on how the 'success' of these policies is measured in terms of scale of impacts, time-frames, or the precise policy instruments used.

Accordingly, we proxy the impact of successful sectoral trade-enhancing policies by an assumed exogenous (and costless) £10bn increase in international export demands in each of the 30 sectors of the economy as represented in our sectoral aggregation of the model (see Section 3.5 for more detail). As such, we model an increase in demand for exports in each sector in turn (i.e. we introduce this shock in *sector 1 only* in one simulation, then sector 2 only, and so on). Using the same £10bn increase for each sector allows for a systematic comparison of the simulation results. This approach allows us to explicitly identify the (differing) impact of individual sectoral export interventions on other sectors of the economy, as well as against economic, emissions and energy criteria for the UK economy as a whole.

The economy is taken to be in long-run equilibrium prior to the stimulus to exports, so that

[5] Emonts-Holley et al. (2014) give a detailed description of the methods employed to construct these data. The SAM is available for download at: https://doi.org/10.15129/bf6809d0-4849-4fd7-a283-916b5e765950

when the model is run forward in the absence of any disturbance it simply replicates the base year SAM in each period. The results presented here are the long-run percentage changes in the endogenous variables relative to this unchanging equilibrium over which capital stocks are fully adjusted. All of the effects reported are therefore directly attributable to the exogenous increase in export demands.

It must be stated – as noted earlier – that all results assume that there is no change in the rest of the economy, either policy driven or from technological developments. While the impacts of other policies could be modelled using the same framework, our focus here is on identifying the pure consequences - other things being held equal – of *only* success in raising exports from each sector of the UK economy. One important element, particularly for territorial emissions, will be the changes in the scale and (technological) mix of electricity generation, which is likely to be affected by a number of different policies. Decarbonisation of this sector therefore is highly likely although this is not explicitly introduced into the analysis, as we are focusing on the consequences of an increase in exports by each sector.

Clearly, the assumed increase in ROW exports could be large or small relative to the sectors themselves, and the existing level of international exports by each sector. From Appendix A we can see that ROW exports make up a different amount of the total output for each sector, ranging from 68% and 60% of the output of the "Chemicals and Pharmaceuticals" and "Manufacture of Motor Vehicles, Trailers and Semi-Trailers" sectors respectively, to other sectors where output is primarily concentrated on domestic consumption, such as "Gas; Distribution of Gaseous Fuels + Air Conditioning Supply" and "Natural Water Treatment + Supply Services; Sewerage Services". The focus of Sector Deals, as discussed earlier, includes sectors where exports already comprise an important element of demand for that sector, rather than being applied across all sectors. This therefore reinforces that the results for some sectors are illustrative of the system-wide consequences of increasing exports in this activity, and do not relate to the plausibility or the scope of policy to achieve the modelled increase in exports.

5 Simulation results

We outline the simulation results for the increase in international exports in the following subsections. We start by outlining in detail the adjustment mechanisms and the aggregate system-wide results seen when increasing the exports in the Manufacture of Motor Vehicles sector in Section 5.1, and proceed by outlining the impacts this has on the other sectors of the economy in Section 5.2[6]. In Sections 5.3 and 5.4 we compare key aggregate and sectoral results across all of our simulations (i.e. increasing international exports for every sector in turn). Last, we know from previous research that the specification of the labour market will be important for model results, and so we consider the potential implications of different labour market assumptions in sensitivity analysis in Section 6.

5.1 Aggregate results: stimulus to the Manufacture of Motor Vehicles sector

We illustrate the main adjustment mechanisms producing impacts at the aggregate level briefly for the illustrative case where exports are increased in the Manufacture of Motor Vehicles sector (MOT). Table 2 details the key macroeconomic long-run results, in percentage changes, for a £10bn increase in international exports in the Manufacture of Motor Vehicles sector.

Table 2 shows that following the export demand stimulus there is an increase in prices, quantities, revenues, and profits and thereby also an increase in net investment. This increase in investment in the long run in turn further increases the demand for labour, decreasing unemployment. The stimulus to the Motor Vehicles sector therefore increases Gross Domestic Product (GDP) by 0.61%. Employment increases by 0.67% pushing up the real wage by 0.75%, as governed by the bargained real wage function, and so the consumer price index (CPI) rises by 0.66%. Household consumption and investment increase by 0.90% and 0.53% respectively.

Exports rise by 3.69%, and imports expand along with the increased domestic demand, increasing by 3.06%. Notably, the stimulus to exports does not reach its full potential as exports are in part crowded out due to competitiveness effects, i.e. the rise in prices. The public sector deficit falls by 1.87% in the long run as tax revenues rise in response to the stimulus to economic activity[7].

These results therefore appear reassuring for the conduct of UK economic policy in that key economic indicators move in the desired (positive) direction as a consequence of a successful export promotion strategy in the Motor Vehicles sector. The impacts on emissions and energy consumption are shown in the lower half of Table 2.

[6]We select this sector as it closely resembles the Automotive sector, which is the focus of the Automotive Sector Deal.

[7]Ross et al. (2018) investigate the consequences of closing the Government budget constraint in a sensitivity analysis

Table 2: Long-run effects of a £10bn export demand stimulus to the Manufacture of Motor Vehicles sector. % changes

GDP	0.61
CPI	0.66
Unemployment rate (pp difference)	-0.63
Total employment	0.67
Nominal gross wage	1.41
Real gross wage	0.75
Households wealth	0.86
Households consumption	0.90
Labour income	2.09
Capital income	1.14
Government budget	-1.87
Investment	0.53
Total imports	3.06
Total exports	3.69
Total energy use (intermediate+final)	0.71
- Electricity	1.07
- Gas	1.32
Energy use in production (total intermediate)	1.03
Energy consumption (total final demand)	0.28
- Households	1.03
- Investment	0.59
- Government	0.00
- Exports	-0.75
Energy output prices	0.44
Energy intensity (Total energy use/GDP)	0.09
Territorial CO_2 emissions	0.36
Emission intensity (territorial CO_2/GDP)	-0.25

The expansion in economic activity arising from the increase in MOT exports stimulates the demand for energy, so that total energy use (the sum of intermediate plus final demand) increases (by 0.71%), reflecting increases in energy use in both production and final demand. Energy use in production (total intermediate) increases by 1.03%, driven by the increase in intermediate demands from the Motor Vehicle sector and its linkages to energy intensive sectors (we explore this in more detail when considering sectoral results in Section 5.2).

The use of energy in consumption (total final demand) sees an increase of 0.28%. This increase is mainly driven by household consumption of energy. However, energy output prices increase by 0.44% reflecting the stimulus to energy demand created by the expansion, as well the increase in labour and material costs. This in turn dampens household energy consumption, for example. Also, the increase in energy output prices crowd out energy exports (by 0.75%).

Energy use increases across the board in response to the export stimulus in the MOT sector. Furthermore, energy use increases by more than GDP, employment and investment. Energy intensity, defined here as energy use per unit of GDP, increases by 0.09%. It appears that Motor Vehicle exports are thereby rather energy intensive.

Industrial territorial CO_2 emissions increase by 0.36%. This is the incremental change in emissions that is likely to arise from the increase in exports alone. Emissions intensity, defined as territorial CO_2 emissions per unit of GDP, falls by 0.25%, indicating that while emissions increase, the increase is lower than the expansion in GDP. This identifies the additional challenge to meeting the Government's emission targets that is solely attributable to the increase in exports.

Of course, in practice, energy policies directed at decarbonisation are in place, and it is instructive to consider how these might be adjusted to counter any adverse effects on emissions generated by the expansion in exports. An idea of the scale of the change required is to consider by how much the emissions in the electricity producing sector would need to fall so as to offset entirely the emissions directly attributable to the increase in exports. A fall of 1.04% in emissions in the electricity sector would offset the increase in emissions arising from the £10bn export stimulus to the Motor Vehicles sector. Given that emissions in the electricity production sector have fallen by nearly 50% in the UK over the last years it is feasible that these emissions could be offset. This said, other things being equal some adjustment in energy policy at the margin would be required to offset the additional emissions associated with an expansion in exports.

While the the increase in MOT exports increases economic activity, both energy use and emissions rise. Therefore, there might be a trade-off between the main economic and energy policy goals. As noted previously, in practice energy policies aimed at limiting emissions operate simultaneously. However, we have sought here to isolate the impact of export policies in the Motor Vehicles sector on key elements of the energy system, so that an assessment can be made of the extent to which they act to worsen or alleviate trade-off's between economic and environmental objectives at the margin.

We identify the impacts of increasing exports in the MOT sector on other sectors of the UK economy in the following section.

5.2 Sectoral results: stimulus to the Manufacture of Motor Vehicles sector

From Section 5.1 we looked at the aggregate results of a £10bn increase in ROW exports in the MOT sector. Table 3 details the long-run results at the individual sector level. We start by outlining the impacts on the MOT sector itself, and then consider the impacts on the other sectors of the economy.

The £10bn stimulus to exports in the MOT sector corresponds to a 82.26% in exports. The increased demand leads to an expansion in the MOT sector so that investment, employment, and total output expand by 58.14%, 57.76%, and 58.20% respectively. Output prices increase by 0.48%, driven by the increase in wages, as workers see their wage bargaining power increase due to higher demand for labour. Imports rise by 32.28% along with the increased domestic production (input) demands. Energy use in production increases by 58.25%, slightly more than total output.

There are two important points to note. First, the £10bn stimulus to exports in the Motor Vehicles sector is crowded out in part here due to the increase in prices, driven by the assumption that workers are able to bid up their wages. We consider a number of alternative labour market models in our sensitivity analysis (see Section 6) where exports are not crowded out at all, and a case in which exports are nearly choked off entirely[8]. Second, the MOT sector is itself not directly energy- or emissions intensive (see Appendix A). As such, the impact on total energy use and emissions of additional export demand for the MOT sector depends mainly on domestic linkages between the MOT sector and other sectors, and *those* sectors energy and emission intensity. As such, we identify the impacts on the other sectors of the economy.

Even though the aggregate results in Section 5.1 show that output, investment, employment, exports, and energy use in production expand, this is not observed across all individual sectors. Sectors that are not directly simulated - recall only the MOT sector experiences the (exogenous) export demand stimulus in this simulation - show a more diverse picture. The demand linkages of the stimulated sector, labour market assumption, and other sectoral characteristics, drive these results. This becomes - as we shall explore later - crucial for the aggregate results on indicators.

[8]In a case where wages are not pushed up, prices would remain unchanged and so exports would not be crowded out. Therefore, output would increase in all sectors. For example, such an outcome would arise from application of demand-driven Input Output modelling of an exogenous increase in demand to one sector. In contrast, in a case where workers are able to push up wages even higher, we would see prices increase further, and so output would be falling even more.

Table 3: Sectoral long-run effects of a £10bn export demand stimulus to the Manufacture of Motor Vehicles sector. % changes

	Total output	Output price	Employment	Value added	Total import	Total export	Capital stock	Investment	Households consumption	Energy use in production
1. AGR	0.03	0.54	-0.23	-0.08	1.48	-1.08	0.01	0.01	0.91	0.07
2. MIN	0.75	0.62	0.51	0.56	4.81	-1.22	0.75	0.75	0.96	0.82
3. CRU	-0.14	0.40	-0.45	-0.23	1.22	-0.79	-0.21	-0.21	0.95	-0.14
4. OMI	-0.51	0.55	-0.77	-0.61	1.33	-1.09	-0.53	-0.53	0.93	-0.46
5. FOO	0.12	0.57	-0.13	-0.09	1.78	-1.14	0.11	0.11	0.90	0.18
6. DRI	-0.08	0.51	-0.35	-0.24	1.50	-1.02	-0.11	-0.11	0.91	-0.04
7. TEX	0.90	0.57	0.64	0.70	4.01	-1.12	0.88	0.88	0.93	0.95
8. PAP	0.06	0.56	-0.19	-0.12	1.74	-1.11	0.05	0.05	0.93	0.12
9. COK	-0.04	0.28	-0.38	-0.32	0.97	-0.57	-0.14	-0.14	1.00	-0.07
10. CHE	0.15	0.42	-0.14	-0.02	3.38	-0.84	0.10	0.10	0.95	0.17
11. RUB	2.33	0.56	2.07	2.12	6.97	-1.12	2.31	2.31	0.91	2.38
12. IRO	4.08	0.48	3.80	3.84	7.92	-0.96	4.04	4.04	0.93	4.12
13. ELM	0.44	0.56	0.19	0.25	4.08	-1.12	0.43	0.43	0.92	0.50
14. MOT	58.20	0.48	57.76	57.84	32.28	82.26	58.14	58.14	0.96	58.25
15. TRA	0.51	0.56	0.25	0.30	3.99	-1.11	0.49	0.49	0.93	0.56
16. ELE	0.96	0.38	0.65	0.80	2.19	-0.75	0.89	0.89	1.04	0.96
17. GAS	1.03	0.40	0.72	0.85	2.35	-0.80	0.96	0.96	1.04	1.03
18. WTR	0.60	0.58	0.35	0.51	2.08	-1.15	0.59	0.59	0.89	0.66
19. WAM	-0.19	0.66	-0.41	-0.31	1.99	-1.30	-0.17	-0.17	0.87	-0.11
20. CON	0.13	0.62	-0.10	0.01	1.71	-1.23	0.14	0.14	0.88	0.20
21. WHO	1.01	0.68	0.79	0.86	4.18	-1.34	1.03	1.03	0.90	1.10
22. TRL	0.39	0.69	0.17	0.23	2.26	-1.37	0.41	0.41	0.91	0.48
23. TRO	-0.10	0.62	-0.33	-0.27	2.40	-1.24	-0.10	-0.10	0.93	-0.03
24. TRS	0.18	0.72	-0.03	0.01	2.20	-1.42	0.21	0.21	0.91	0.28
25. ACC	0.35	0.68	0.13	0.20	2.53	-1.34	0.37	0.37	0.92	0.44
26. COM	0.11	0.68	-0.11	-0.02	2.11	-1.35	0.13	0.13	0.90	0.20
27. SER	0.29	0.62	0.06	0.20	2.33	-1.24	0.29	0.29	0.90	0.36
28. EDU	-0.02	0.96	-0.15	-0.12	2.31	-1.88	0.09	0.09	0.85	0.16
29. REC	0.23	0.66	0.01	0.12	2.27	-1.32	0.25	0.25	0.91	0.32
30. OTR	0.21	0.77	0.02	0.09	2.33	-1.52	0.26	0.26	0.89	0.33

Consider first those sectors that benefit from the expansion in MOT export demands. For example, the Rubber, Cement, Glass (RUB) sector, the Iron, Steel and Metal (IRO) sector, the Electricity, Transmission and Distribution (ELE), and the Wholesale and Retail Trade (WHO) sector, see an expansion in demand. These sectors see a rise in output, investment, employment, prices, and energy use. Exports fall in these sectors due to adverse competitiveness effects, and their imports increase. These are sectors with strong domestic intermediate demand (backward) linkages to the MOT sector, i.e. their output is used in the MOT sector (Miller and Blair, 2009). These sectors are also energy- and emissions-intensive (comprising a total of 46% of the UK territorial emissions).

In contrast, there are also sectors that do not benefit from the expansion in motor vehicle exports. The Water Management and remediation (WAM) sector, for example, sees falling output, employment, investment, and energy use, while the Education health and defence (EDU) sector, sees a 0.02% fall in output. Both sectors mainly serve the domestic (i.e. UK) market and thereby do not benefit from the stimulus to the Motor Vehicles sector. Moreover, the EDU sector is also labour intensive, around 49% of total expenditures in that sector go to labour (see Appendix A) so it is particularly impacted by the increase in wages with sectoral employment falling by 0.15%. [9]

Our results highlight that there are a number of sectors that benefit from the increased demand in motor vehicle exports. However, there are also sectors that do not experience any benefit and, in some cases, see a contraction in their output. This is a key issue not mentioned within the various government strategies.

As such, it is important to note that the potential impact of export promotion on emissions identified here need not in fact materialise. If the same production processes for (new models of) electric vehicles was followed as for current vehicle production (with identical links as the existing MOT sector, as given in the SAM/IO table) our results show that expanding trade in motor vehicles, the corresponding supply chain activities would need to be decarbonised to achieve energy and economy goals simultaneously[10]. First, if export promotion is focussed on those elements of the 'Motor Vehicle sector' with demand linkages to comparatively low emission sectors, the rise in energy use and emissions would be mitigated. Second, if other policies – such as the Clean Growth Strategy – results in further decarbonisation of the energy sector, the increased motor vehicle exports (and knock-on economic impacts) could occur without a corresponding increase in emissions. However, our simulations isolate the effects that are solely attributable to an export stimulus in the MOT sector and the results suggest that it is very likely

[9] With around 68% of total incomes in the Education sector coming from government, this sector would likely see a increase in output if Government revenues were to be recycled (see Ross et al. (2018) for a more detailed discussion).

[10] By only examining the production of vehicles - as the sector is defined in the economic accounts, we do not examine the emissions in the use of electric vehicles (EVs) or seek to compare EVs to the use of internal combustion (diesel or petrol) engines.

that this would be associated with higher territorial CO_2 emissions. It is, however, possible that low carbon electric cars will employ different production technologies, altering the consequences through the supply chain of increases in exports by the motor vehicle production sector.

5.3 Aggregate results compared for each sector in turn

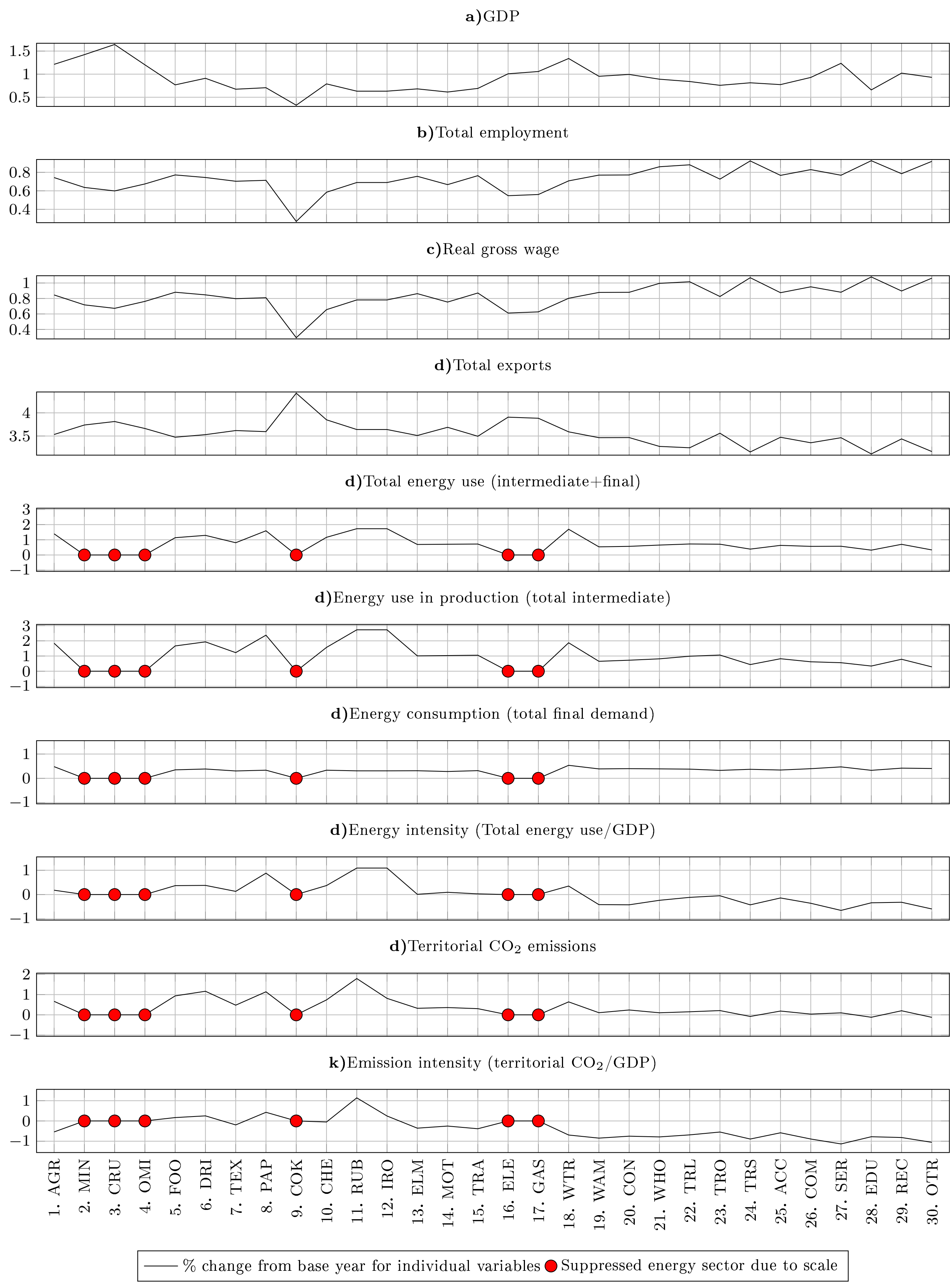
In this section we compare the aggregate impacts of increasing international exports in each of the sectors sequentially. The long-run macroeconomic simulation results for a £10bn increase in international exports, in each sector of the economy in turn, reported in percentage changes from base year, are summarised in Figure 3.[11] A full set of results is given in Appendix B and Appendix C, respectively reporting key economic and environmental results.

As we would expect from the previous discussions, we can see that the increased export demand has expansionary impacts on prices, quantities, revenues, and profits (and thereby also an increase in net investment which in the long run in turn further increases the demand for labour). For example, Figure 3 shows that the £10bn export stimulus in sector 1, Agriculture, forestry and fishing (AGR), increases GDP, employment and the real wage by 1.21%, 0.74% and 0.85% respectively. The £10bn stimulus to exports in the Agriculture sector increases total exports by 3.53% - the stimulus to exports is, however, crowded out in part due to competitiveness effects i.e. the rise in prices.

It is evident from our analysis that the 'economic' impacts are qualitatively similar across all simulations, in that key economic variables are impacted in the desired direction. Key economic indicators - GDP, employment, and real wages - increase in all simulations. There are, however, qualitative differences. The impact on GDP varies between 0.33% and 1.64% depending on the sector that experiences the direct stimulus. The median increase in GDP is 0.83%. Similarly, total employment increases between 0.27% and 0.92% (median of 0.74%), and the real wage increases between 0.29% and 2.03% (median of 0.85%). The largest increase in GDP of 1.64% is seen when sector 3, Crude Petroleum (CRU), is stimulated. This sector has strong demand linkages to the domestic market. In contrast, the smallest impact to GDP of 0.33% is generated when sector 9, Coke & refined petroleum (COK), receives the export stimulus. This sector does not have strong demand linkages to domestic sectors. To recall, sector characteristics as given in the base year economic accounts are detailed in Appendix A.

[11]Note that sector 2 Mining & quarrying (MIN) is not directly shocked and thereby not reported in our results because of anomalies in the base-year data.

Figure 3: Long-run effects of a £10bn export demand stimulus to each of the sectors in turn. % changes



The GDP impact does not necessarily translate into similar rankings of total employment and real wage impacts. In the case of the stimulus to the Coke & refined petroleum sector, the relatively small impact GDP also results in the smallest stimulus to employment and the real wage, which increase by 0.27% and 0.29% respectively. In contrast, the large stimulus to GDP arising from the stimulus to the Crude Petroleum sector does not rank this sector highest in terms of total employment and real wage impacts. Sectors that embody large proportions of total employment, such as sector 21, Wholesale & Retail (WHO), and sector 28, Education health & defence, generate large impacts on total employment where employment increases by 0.86% and 0.93% respectively. However, sectors with strong domestic demand linkages, such as sector 24, Transport support (TRS), can generate relative large impacts on employment (0.92%), despite only covering a small proportion of total employment themselves. This also holds for the impact on the real wage - where sectoral labour intensities and corresponding domestic demand linkages significantly influence aggregate results.

Considering the impacts on key elements of the energy system in Figure 3 it can be seen that total energy use, energy use in production and consumption increase across all simulations. The energy sectors are suppressed in Figure 3 due to scaling since a stimulus to these sectors generates significantly larger impacts as compared to a stimulus to a non-energy sector.

To recall from Appendix A, the energy sectors are: sector 2, Mining & quarrying (MIN); sector 3, Crude Petroleum & Natural Gas & Metal Ores & coal (CRU); sector 4, Other Mining & mining services (OMI); sector 9, Coke & refined petroleum products; sector 16, Electricity, transmission & distribution (ELE), and sector 17 Gas; distribution of gaseous fuels through mains; steam & air conditioning supply (GAS). Stimulating exports in energy sectors typically generates a significant increase in total energy use (between 11.22% and 20.67%) - where the percentage increase in energy consumption is greater than the increase in energy use in production which is mainly driven by the increased energy exports (see Appendix C for detailed results).

When exports of non energy producing sectors are increased, energy use increases between 0.32% (when sector 28 is stimulated) and 1.73% (when sector 11 is stimulated). The percentage increase in energy use in production outpaces the increase in energy use in consumption (and total energy exports fall in these cases as energy prices rise), when non-energy sectors receive the direct export stimulus.

The impact on energy intensity, territorial CO_2 emissions, and emission intensity, however, are quantitatively and qualitatively different depending on the sector that experiences the £10bn increase in export demand. Energy intensity increases significantly when the energy sectors are directly stimulated (between 8.51% and 19.47%). However, when the non-energy sectors receive the direct stimulus, the impact on energy intensity is more ambiguous. Energy intensity increases when sectors 1 to 18 receive the direct export stimulus, and it falls when sectors 19 to 30 receive the export demand stimulus. This is mainly due to sectoral energy intensities and demand linkages. UK territorial emissions increase in the majority of cases. Of course, in practice, energy policies directed at decarbonisation are in place. However, other things being equal some adjustment in energy policy at the margin would be required to offset the additional emissions associated with an expansion in exports. We have sought here to isolate the impact of the increase in exports on the energy system, so that an assessment can be made of the extent to which they act to worsen or alleviate trade-off's between economic and environmental objectives at the margin.

Notably, when three sectors – 24, Transport support, sector 28, Education, and sector 30, Other private services – receive the direct export stimulus, overall emissions actually fall. In these cases there is a shift in the fuel mix consumed by sectors. This shift entails a fall in emissions from oil (and coal), while those from gas increase. The fall in oil emissions is sufficient here to counter the rise in gas emissions, resulting in a fall in total industrial territorial CO_2 emissions to fall. Moreover, emission intensity falls in a large number of cases (but does not fall when energy sectors receive the direct export stimulus).

Table 4 summarises the whole economy results for the increased exports in each sector, across five indicators – GDP, Employment, Energy intensity, Emissions intensity and (total, UK) emissions. Arrows indicate the change seen in each indicator from the successful promotion of export policies for each sector in turn. We term "desired outcomes" as those which would see increases in GDP and Employment, reductions in Energy- and Emissions intensity, and reductions in total emissions. Red and green colours denote for each sector where the modelled outcome differs or is the same as the "desired" outcome, respectively. First, we can see from Table 4 that there are positive (aggregate) economic outcomes irrespective of the sector directly seeing the increase in exports – i.e. there are increased GDP and Employment in each case. Second, we can see the clear distinction after Sector 18 (WTR) on the change in energy intensity: energy use increases faster than GDP where sector 1 through 18 see higher exports - and so an (undesirable) increase in energy intensity, while the opposite result is found for sectors 19 onwards. Third, we see the movement towards the desired outcomes for policy across all five indicators for the three sectors of Transport support, Education and Other private services.

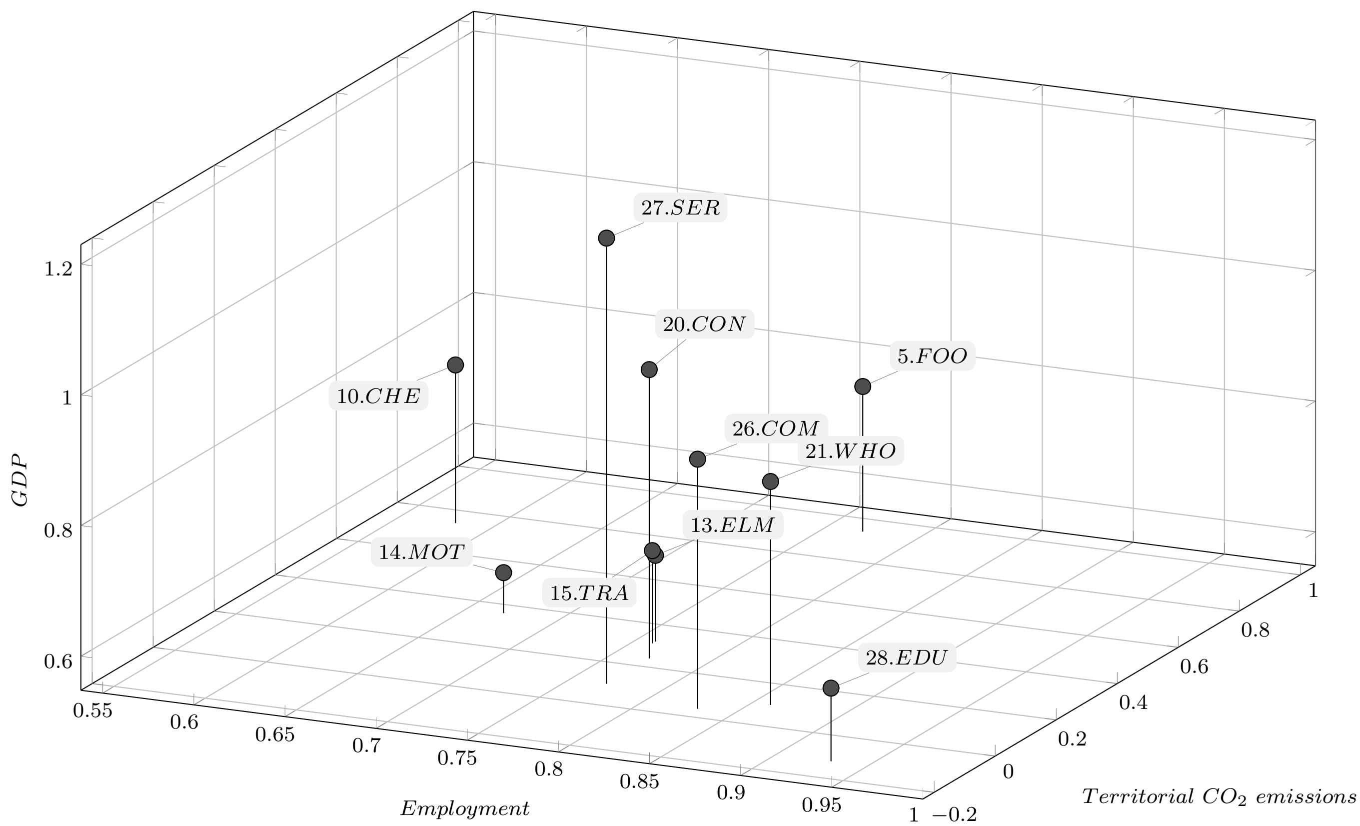
Table 4: Possible aggregate trade-off's from increases in sectoral exports under, BRW closure

	GDP	Employment	Energy intensity	Emission intensity	Emissions
1. AGR Agriculture, forestry & fishing	⇑	⇑	⇑	⇓	⇑
2. MIN Mining & quarrying	⇑	⇑	⇑	⇑	⇑
3. CRU Crude Petroleum + Natural Gas & Metal Ores + coal	⇑	⇑	⇑	⇑	⇑
4. OMI Other Mining & mining services	⇑	⇑	⇑	⇑	⇑
5. FOO Food (+ Tobacco)	⇑	⇑	⇑	⇑	⇑
6. DRI Drink	⇑	⇑	⇑	⇑	⇑
7. TEX Textile, Leather & Wood	⇑	⇑	⇑	⇓	⇑
8. PAP Paper & Printing	⇑	⇑	⇑	⇑	⇑
9. COK Coke & refined petroleum products	⇑	⇑	⇑	⇑	⇑
10. CHE Chemicals & Pharmaceuticals	⇑	⇑	⇑	⇓	⇑
11. RUB Rubber, Cement, + Glass	⇑	⇑	⇑	⇑	⇑
12. IRO Iron, steel + metal	⇑	⇑	⇑	⇑	⇑
13. ELM Electrical Manufacturing	⇑	⇑	⇑	⇓	⇑
14. MOT Manufacture of Motor Vehicles, Trailers & Semi-Trailers	⇑	⇑	⇑	⇓	⇑
15. TRA Transport equipment + other Manufacturing (incl Repair)	⇑	⇑	⇑	⇓	⇑
16. ELE Electricity, transmission & distribution	⇑	⇑	⇑	⇑	⇑
17. GAS Gas; distribution of gaseous fuels through mains...	⇑	⇑	⇑	⇑	⇑
18. WTR Natural water treatment & supply services; sewerage services	⇑	⇑	⇑	⇓	⇑
19. WAM Water Management & remediation	⇑	⇑	⇓	⇓	⇑
20. CON Construction - Buildings	⇑	⇑	⇓	⇓	⇑
21. WHO Wholesale & Retail Trade	⇑	⇑	⇓	⇓	⇑
22. TRL Land Transport	⇑	⇑	⇓	⇓	⇑
23. TRO Other transport	⇑	⇑	⇓	⇓	⇑
24. TRS Transport support	⇑	⇑	⇓	⇓	⇓
25. ACC Accommodation & Food Service Activities	⇑	⇑	⇓	⇓	⇑
26. COM Communication	⇑	⇑	⇓	⇓	⇑
27. SER Services	⇑	⇑	⇓	⇓	⇑
28. EDU Education health & defence	⇑	⇑	⇓	⇓	⇓
29. REC Recreational	⇑	⇑	⇓	⇓	⇑
30. OTR Other private services	⇑	⇑	⇓	⇓	⇓

Notes:
Desired outcomes = ⇑ ⇑ ⇓ ⇓ ⇓
Energy intensity is defined as total change in energy use divided by GDP
Emission intensity is the ratio of (UK) territorial CO_2 emissions divided by GDP.

Putting these results differently, the tradeo-offs between quantitative outcomes become more apparent. Figure 4 illustrates further the potential conflicts between economic and environmental objectives in the GDP-Employment-Emission space for a number of selected sectors (all of which key to the various UK government strategies outlined in previous sections). For example, if we were to focus solely on GDP, the £10bn would generate the largest impact in the Services (SER) sector. If a large increase employment is the goal, then a stimulus to the Education (EDU) sector would generate the largest impact. Similarly, if the goal is to reduce emissions, then (again) the Education sector would be selected. Multiple positive outcomes would be possible here with the stimulus to the Education sector as emissions fall along with increasing GDP and employment.

Figure 4: Sectoral GDP, Employment, and CO_2 Emission trade-off



From our results it is evident that the economic and emissions impacts are driven by key economic and structural characteristics of individual sectors. Sectors differ in terms of, for example, energy intensity, export intensity and domestic demand linkages (including links to energy-intensive sectors) and these seem to be driving aggregate impacts on energy, for example (we explore this in more detail in the following section). As such, the impacts on the whole economy will depend, and significantly so, on the sector that receives the stimulus to exports. Importantly, however, our results empirically illustrate that it is possible to achieve a 'double dividend' where GDP increases along with a fall in CO_2 emissions, or a GDP increase with a fall in energy- and emission intensity.

5.4 Focusing on changes in non-directly stimulated sectors

Figure 5 summarise the long-run impacts on sectoral output following a £10bn ROW export demand stimulus to a number of selected sectors. The sector that received the direct demand stimulus is set to zero for scaling purposes to highlight the impacts on the other sectors of the economy (Appendix D gives a full set of results). For example, the results in Figure 5d correspond to these results given in column one of Table 3 for the stimulus to the Motor Vehicles sector. As previously, all sectors highlighted here are key to the various UK government strategies outlined in Section 2.

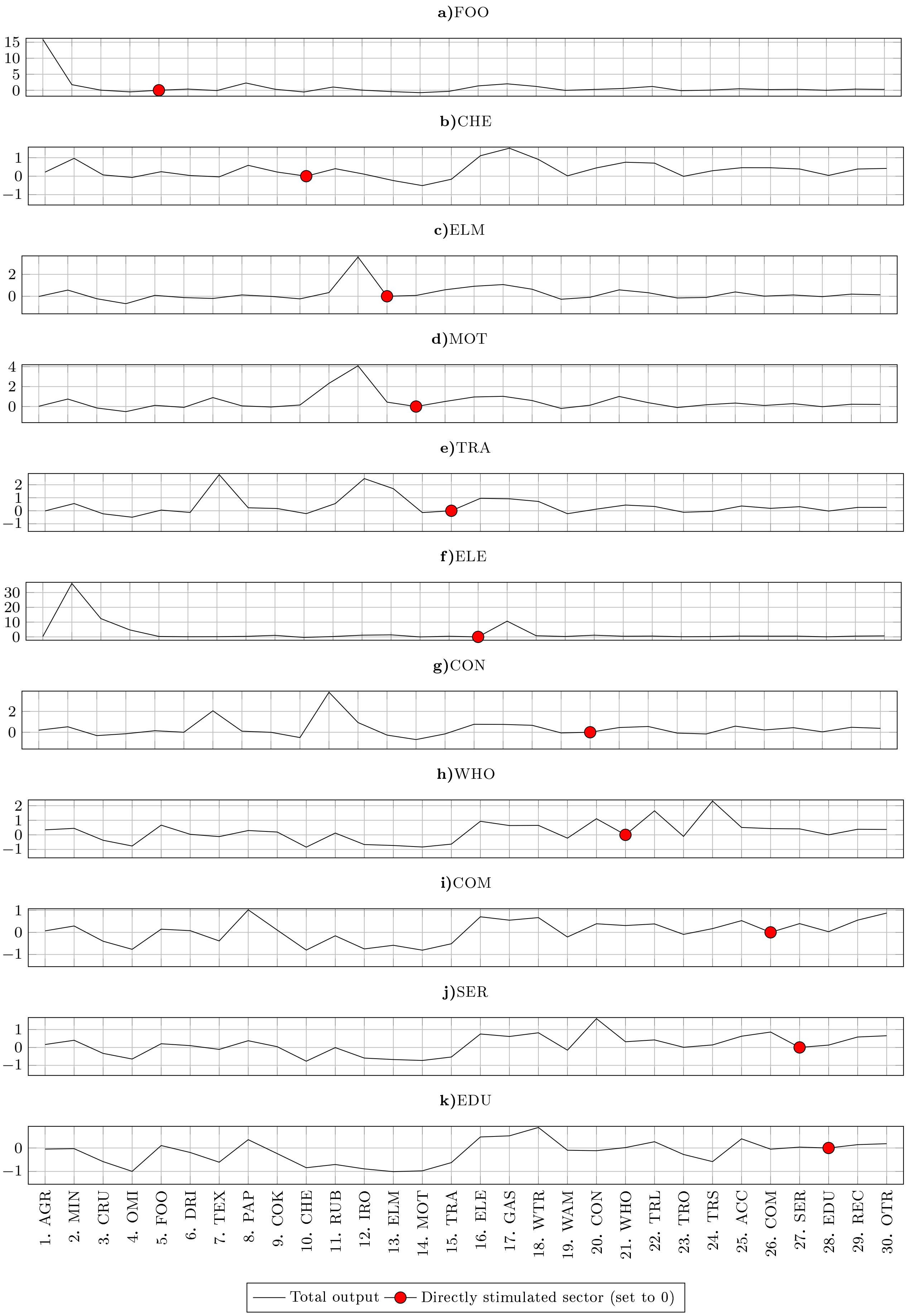
As discussed previously in Section 5.2, for the Motor Vehicles sector, a number of sectors benefit from a expansion in economic activity in MOT sector, and there are some sectors that do not see beneficial impacts. For example, Figure 5a it can be seen that when sector 5, Food (FOO), receives the export stimulus, sector 1, Agriculture, forestry & fishing (AGR) experiences a significant (positive) demand impact due to its upstream relationship to the Food sector. However, the stimulus to the Food sector crowds out output in other sectors due to competitiveness effects. One of these sectors is the Motor Vehicle sector (MOT) which sees a 0.75% fall in total output. Figure 5 therefore gives an indication of domestic connectivity across industrial sectors.

We summarise the impacts on output in Figure 6 where the median impact on output is ranked across sectors. That is, we take the median of the first row in Appendix D (but across all sectors, excluding the impact of the direct export demand stimulus on the own sector). This identifies which sectors benefit on average irrespectively of which sector of the economy receives the direct export demand stimulus. This is similar to the approach taken by Cardenete and Sancho (2012) in their CGE multiplier analysis of industrial sectors. Figure 6 also shows the export intensities (as detailed in Appendix A), i.e. the share of total income from exports.

Most importantly, Sector 16, Electricity, transmission & distribution (ELE) – at the far right of Figure 6 – sees on average a large and positive impact irrespective of which sector of the economy receives the direct export stimulus. This is followed by sector 17, Gas, and sector 18, Natural water treatment & supply services (WTR). These sectors are characterised by strong domestic demand linkages and low export intensities (and include two of the energy sectors). In contrast, Sector 14, Motor Vehicles (MOT), sector 4, Other mining (OMI), and sector 10, Chemicals & Pharmaceuticals, – at the left hand side of Figure 6 see negative impacts on average. These sectors are characterised by strong forward linkages to external markets (and so are more negatively affected by increased prices crowding out sectoral activity).

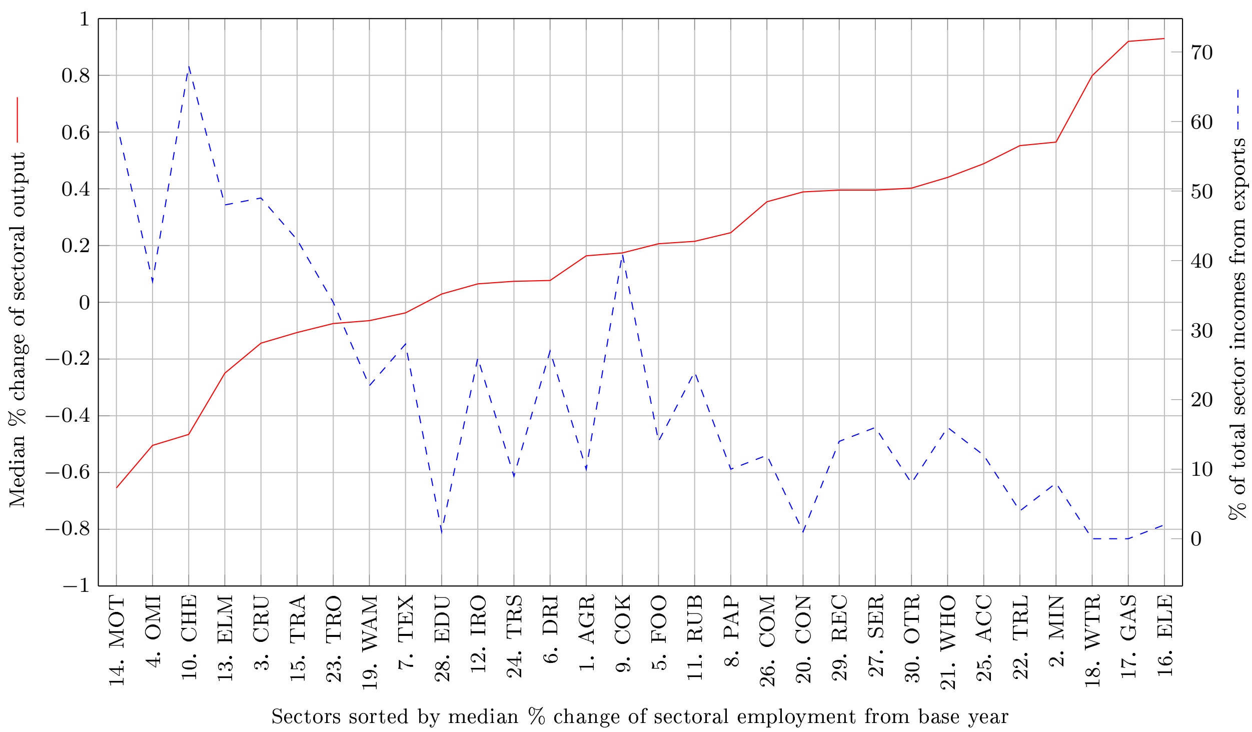
As such, there are not only potential trade-off's across goals of Industrial and Clean Growth strategies, but also trade-off's within export promotion between different sectors of the economy.

Figure 5: Long-run sectoral output effects of a £10bn export demand stimulus to each of the sectors in turn. % changes



As we saw in Section 1, all published Sector Deals aim to increase the value of goods exported from the UK. However, from our analysis it is evident that increased exports in one sector has effects on other sectors, through both backward linkages, and competitiveness channels affecting exports for sectors not directly benefiting from the increased exports. However, our treatment of the labour market is important here as the crowding out of exports depends critically on the ability of workers to exert upward pressure on wages. We discuss this more in the following section when – for illustrative purposes – we look at the sensitivity of these results for the particular case of the MOT sector.

Figure 6: Median % change of sectoral output from base year and sector export intensities



6 Sensitivity analysis

Model outcomes are sensitive to a number of elements, including the operation of the labour market, key parameter values in the UK-ENVI model, and the recycling of additional government revenues generated by the export stimulus, for example. Ross et al. (2018) provide a detailed sensitivity analysis around these issues. We illustrate in Section 6.1 how different labour market assumptions could affect aggregate impacts in a theoretical ex-ante labour market analysis of an export demand stimulus. In Section 6.2 we further illustrate the importance of labour market assumptions empirically in the illustrative case of the MOT sector.

6.1 Ex-ante labour market analysis

Our default model specification embodies a wage curve which reflects an inverse relation between the rate of unemployment and the real wage. There is substantial international evidence in support for such a model specification. Blanchflower and Oswald (2005), for example, provide a review on recent research literature on wage curves found across different countries. Empirical evidence for the existence of a wage curve in the UK is given, amongst others, by e.g. Barth et al. (2002); Bell et al. (2002); Black and FitzRoy (2000); Collier (2000). While, there is compelling international evidence in favour of our default wage curve specification, we consider a number of alternative labour market closures, so as to reflect alternative visions of how the UK labour market operates.

We do this for two main reasons. First, there exists genuine uncertainty about the way that the aggregate UK labour market currently operates and there has been considerable controversy surrounding the issue (e.g. Bell and Blanchflower, 2018). Secondly, we wish to check the extent to which spillovers from economic policies to the energy system vary with alternative visions of UK labour market behaviour. This allows us, as far as is practical within the UK-ENVI model, to check that our conclusions are robust with respect to the choice of any particular model of the UK labour market.

We provide some analytical insight into the factors underlying the impact of the export demand stimulus that would result from a successful 'Global Britain' UK trade promotion policy. We focus on the labour market to highlight the implications of alternative perspectives. For simplicity, we assume that the increase in demand is insufficient to generate a reaction from the Bank of England's Monetary Policy Committee, so that no financial 'crowding out' occurs.[12]

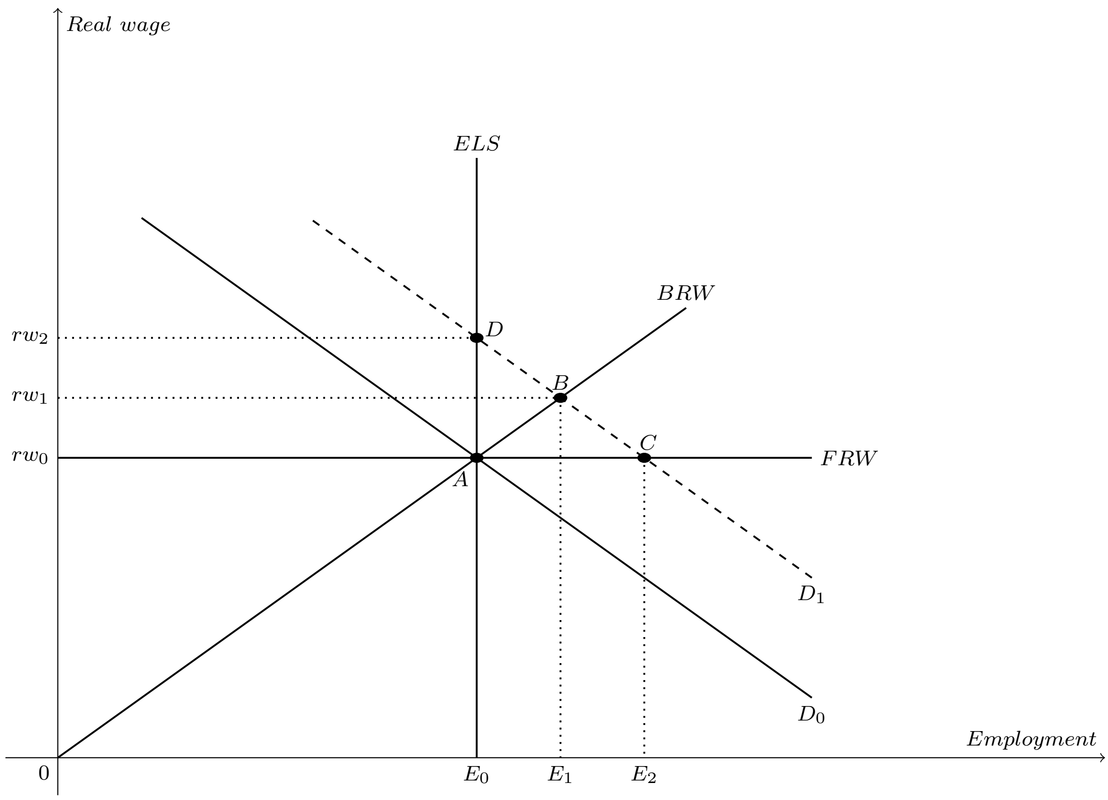
Figure 7 represents the long-run interactions of the general equilibrium labour demand and supply curves in the UK labour market. The analysis is comparative static in that it can be used to illustrate the impact on the equilibrium real wage and employment, of exogenous export disturbances to the UK economy. In Figure 7, the demand for labour is a general equilibrium relationship, which incorporates the entire system-wide consequences of a change in the real wage.

The curve does not necessarily have a negative slope in employment-real wage space, because as the real wage falls so too does labour income and demand. However, for the default parameter values of our CGE model the beneficial competitiveness effects of a reduction in the real wage,

[12] In effect we treat the UK as if is operating in a liquidity trap.

which stimulates exports, dominates the adverse income effects. This is what we would expect for a comparatively 'small' (as a proportion of total world trade), open economy like the UK.

Figure 7: The system-wide labour market impact of a stimulus to export demands



The initial equilibrium is represented in Figure 7 by the intersection of the labour demand and supply curves, at point A, generating the initial equilibrium employment and real wage levels rw_0, and E_0. The stimulus to exports shifts the general equilibrium demand curve for labour to the right, indicating that more labour is demanded at each real wage. The labour demand curve shifts from D_0 to D_1.[13] Of course, the alternative visions of the effective supply of labour, or labour market closures, are crucial to determining the impact of this stimulus to demand on wages and employment. These alternatives are reflected in Figure 7.

Under our default assumption and benchmark case, workers are able to bargain higher wages as the labour market tightens. This is illustrated in Figure 7 in the employment-real wage space, where the wage curve, or bargained real wage function (BRW), is illustrated with an upward sloping curve, reflecting the positive relation between the level of employment and workers' bargaining power. At the initial equilibrium an excess demand for labour is created and the

[13]In the short run, where sectoral capital stocks are fixed, the rightward shift is limited. However, this tends to push up capital rates, spurring sectors to invest in capital, and leads to increased capacity and a greater demand for labour in the long run.

increased bargaining power of workers exerts upward pressure on the real wage. This leads to a degree of crowding out through the induced loss in competitiveness. The new long-run equilibrium is established at point B, where both and employment and the real wage increase to E_1 and rw_1 respectively. Since economic activity is stimulated, so too is the demand for energy used in both production (intermediates) and final demand. This corresponds to the simulation results outlined in previous sections.

One alternative vision of the labour market is that it is characterised by excess capacity over a range, so that any changes in labour demand can be met by a corresponding change in the level of employment, but at a fixed real wage (FRW), $w_t/cpi_t = w_{t=0}/cpi_{t=0}$ where w/cpi is the real take home wage. Such a case could also be motivated in terms of the presence of 'real wage resistance': workers seek to maintain the real value of their take home pay, regardless of the nature of any macroeconomic demand disturbance. In this case, the effective labour supply curve is horizontal through point A, and employment adjusts in response to labour demand through changes in the unemployment and participation rates. Essentially, only quantities change since prices are invariant across long-run equilibria, with the new equilibrium at point C in Figure 7, and there is no crowding out of economic activity . The real wage is, of course, unchanged, but employment increases significantly to E_2. This corresponds to the simple Keynesian multiplier case, and the multi-sectoral results emulate the behaviour of an Input-Output system with entirely passive supply side in the long run. Since the stimulus to economic activity is greater in this case than for BRW, we expect the use of energy to be greater too, both in production and in final demands.[14]

A further alternative perspective on the labour market, often assumed by national CGE models, assumes continuous full-employment (see e.g. Partridge and Rickman (2010) for a brief discussion). Here we assume an exogenous labour supply (ELS) curve (and participation rate), $L^S = \bar{L^S}$. Employment is effectively fixed, as is reflected in the vertical ELS curve through point A in Figure 7. Following the demand stimulus, a new long-run equilibrium is established where the real wage rises to rw_2: the real wage rises until it dampens the stimulus to demand entirely at point D. Of course, there is complete crowding out in terms of employment, which remains fixed at E_0. In a multi-sectoral context GDP may change as resources are reallocated across sectors in response to the demand stimulus and significant upward pressure on real wages, but the direction will depend on sectoral export, labour and intermediate intensities and key

[14] Under present assumptions a fixed nominal wage (FNW) case, $w_t = w_{t=0}$, generates the same results as the FRW case in the long run, since prices (and real and nominal wages) do not change.

elasticities. However, if GDP increases, it is likely to be a much more modest change than is associated with either the BRW or FRW variant. Accordingly, we would expect any stimulus to energy use in production and final demands to be less than in the other cases.

6.2 Different labour market closures

We illustrate the importance of labour market assumptions empirically by rerunning the increase in exports in the Manufacture of Motor Vehicles sector, using our different labour market models. Table 5 gives the long-run results of a £10bn increase in international exports in the Manufacture of Motor Vehicles sector. We start by discussing the aggregate long-run results for the FRW closures since this is a useful benchmark, whose properties are well-known. We then discuss the main differences between the FRW, BRW (our default model), and ELS closures.

Table 5: Long-run effects of a £10bn increase in international exports in the Manufacture of Motor Vehicles sector. In % changes

	FRW	BRW	ELS
GDP	1.59	0.61	-0.03
CPI	0.00	0.66	1.09
Unemployment rate (pp difference)	-1.58	-0.63	0.00
Total employment	1.68	0.67	0.00
Nominal gross wage	0.00	1.41	2.37
Real gross wage	0.00	0.75	1.26
Government budget	-5.89	-1.87	0.80
Investment	1.45	0.53	-0.08
Total imports	2.49	3.06	3.44
Total exports	4.88	3.69	2.91
Total energy use (intermediate+final)	1.40	0.71	0.25
Energy use in production (total intermediate)	1.86	1.03	0.49
Energy consumption (total final demand)	0.67	0.28	0.03
- Households	1.15	1.03	0.95
- Investment	1.47	0.59	0.01
- Exports	0.00	-0.75	-1.24
Energy output prices	0.00	0.44	0.73
Energy intensity (Total energy use/GDP)	-0.19	0.09	0.28
Territorial CO_2 emissions	1.29	0.36	-0.25
Emission intensity (territorial CO_2/GDP)	-0.30	-0.25	-0.22

The adjustments seen in the long run for the FRW closures are akin to the results found in IO modelling. With no supply restrictions applying, prices remain unchanged in the long run (McGregor et al., 1996).[15] The increase in exports stimulates aggregate demand, which increases investment, and GDP, by 1.45% and 1.59% respectively. The stimulus to investment and enhanced capacity reinforces the expansion (and the impact on employment). This expansion stimulates the demand for labour so that employment rises by 1.68%, and the unemployment rate falls by 1.58 percentage points. The public sector deficit falls by 5.89% in the long run as tax revenues rise in response to the stimulus to economic activity. Imports increase by 2.49% along with increases in domestic demand. As expected, territorial emissions increase along with total energy use.

The results fro the BRW case are outlined in previous sections. However, it is evident from our analytical discussion that the stimulus to the real economy is significantly less (as compared to FRW) because real wages and prices rise in response to the excess demand for labour. So GDP in the BRW case increases by 0.61%, which is less than half of the 1.59% stimulus under FRW. The rise in the real and nominal wage pushes up the CPI (by 0.66%), reducing competitiveness and crowding out some of the stimulus to exports, which now rise by only 3.69% in the long run.

Next we consider the ELS case of continuous full-employment, where we assume an exogenous labour supply curve (and participation rate). As we know, following the demand stimulus the real wage rises so as to choke off any excess demand for labour at the original level of employment. So employment is unchanged, but the real wage and the CPI rise by 1.26% and 1.09%, significantly more than under the BRW (0.75% and 0.66%). This results in much greater crowding out of exports, which now only rise by 2.91%, and a much bigger stimulus to imports (of 3.44%). As noted in our theoretical analysis, GDP does not necessarily increase. The sectoral distribution of effects result in this case in a fall 0.03% fall in GDP. Notably, there is a fall in territorial emission in this case due to compositional effects of different types of energy used.

Our analytical and empirical analysis highlight that labour market assumptions are crucially important in determining aggregate impacts. This is particularly important given that there is genuine uncertainty about the way that the aggregate UK labour market currently operates - although our baseline model provides a robust approximation. Moreover, these impacts will be different depending on the sector that receives the initial stimulus to exports given that each sector has unique export and labour intensities.

[15] The long-run results for the FRW and the FNW closures are the same as they both tie down wages in the long-run with no changes in prices. As there are no changes in prices (CPI remains unchanged from base), there is no crowding out of exports in the long run so that exports increase by the full stimulus to exports.

7 Discussion and conclusion

In this paper, we have sought to complement the detailed industrial focus of the UK Government's "Sector Deals" and look below the aggregate level of export promotion (studied in (Ross et al., 2018)) to examine the incremental changes in economic activity, territorial emissions and energy use (as well as the partner indicators of emissions- and energy-intensity of GDP) that could arise from success in increasing exports by £10 billion in *specific industrial sectors*. It is noted that the current arrangements for Sector Deals encourage export promotion in each case, so it is sensible to consider both whether such outcomes could lead to desired changes in not only economic outcomes but also improvements in emissions and energy use consistent with the UK Government's Clean Growth Strategy.

A second intention of the paper was to identify whether it might be possible to target export policies at specific sectors which would stimulate "greener" growth. That is to say, whether in the absence of other policies – such as productivity, taxation aimed at energy use, or supply technologies – positive economic outcomes might be observed without expansion in energy use or emissions.

We find that successfully increasing UK exports by each sector in turn has a positive impact on aggregate economic outcomes. The scale of the aggregate economic boosts to GDP are broadly similar when each sector is stimulated in turn: between 0.33% and 1.64% depending on which sector sees the direct export stimulus. Energy and emissions outcomes are far more heterogenous, depending on the degree of openness of the sector - and how it is affected by the crowding out of its exports when other sectors are directly stimulated - its embeddedness into the UK economy and its direct and indirect energy and emissions-intensity. In fact, we actually see outcomes where successfully increasing international exports in three specific sectors reduces emissions - while preserving the positive economic outcomes.

Some caveats are required. First, while the extent to which emissions increase in response to the increase in sectoral exports is very modest compared to the historical reductions in emissions, some further adjustment of energy policies would be required to ensure these are offset. That is, we have identified possible consequences of successful export promotion policies *in the absence of any other policies.* These demonstrate the extent to which it may be necessary to introduce policies to mitigate any undesired impacts of the successful exporting outcomes. A related point is that a "double dividend" is possible as key economic and energy policy goals are simultaneously improved. Nonetheless, in these circumstances export-led growth does - in some cases - add to the challenge faced in meeting emissions targets.

In addition, we stimulate exports in each of the sectors in turn, we focus our analysis on a number of sectors that are key within the UK Industrial Strategy (UK Government, 2017b), the Export Strategy (UK Government, 2018a), the Clean Growth Strategy (UK Government, 2017a), and corresponding Sectoral Deals (UK Government, 2018j), as outlined in previous sections. It must be noted, however, that disentangling these activities from the sectoral aggregation provided in the UK Input-Output (IO) tables (the foundation of the SAM database used in the model) is problematic. That is, even though 'sectors' with particular policy attention are identified within the various strategies it is a challenging task to explicitly identify these same activities within the economic accounts. The 'policy' definition of sectors may cover activities otherwise classified in the economic accounts as sub-sectors; or cover a number of sectors; and/or are not explicitly identified. This is likely to be more of a problem where the 'policy sector' defined makes products which are more broadly defined, or where there is no clear separation between the goods and services which are the target of policy and the wider "supply chain" for that technology[16].

It is clear that data available in economic accounts may not fully reflect the sectors targeted within each policy. For example, each of the strategies noted above highlight 'electrical (low carbon) vehicles'. These are, however, not separately identified in current economic accounts. Without access to supporting micro-data about these activities within the economic accounts, we have to make the simplifying assumption that the production of 'electrical (low carbon) vehicles' will not be drastically different to current motor vehicle production - we can, however, comment on likely implications. Similarly, current economic accounts do not separately identify low carbon or renewable energy production e.g. offshore wind or nuclear, within the 'Electric power generation, transmission and distribution' sector. Allan and Ross (2019, p.31), for example, note that the "electricity sector itself is composed of many different generation technologies, and activities related to transmission, distribution and supply which are not related to the generation mix in the UK, and that generation technologies can have quite different linkages to the rest of the economy".

Further, while the framework used here permits us to simultaneously consider a range of outcomes, there may be additional policy targets which are not addressed in this current configuration. For instance, the Offshore Wind sector deal discusses its intention to create skilled

[16]For instance, Allan et al. (2017) outlined some of the difficulties in consistent and reproducible definitions of the Low Carbon and Renewable Energy sector.

jobs, rather than simply an increase in employment[17]. In addition, by focusing purely on the consequences of successful export promotion, we have not considered any additional impacts on, or consequences of, changes in desired outcomes in terms of increased productivity, R& D activity and innovation, or the geographics of economic impact which could follow from each of the targeted Sector Deals.

[17] Previous work has examined the occupation- and skills-intensity of sectoral employment in the UK in a more simple economic framework (Allan and Ross, 2019)

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Note: Authors in alphabetical order. Individual contributions: conceptualisation: GA&AR; model development and analysis, including sensitivity analysis and simulations: AR; writing and editing: GA&AR; review of policy documents and initial model simulations AS&CB.

Appendices

Appendix A

Appendix A: Sector characteristics by key income and expenditure components from UK Social Accounting Matrix for 2010

		% share of costs (expenditures)						% share of incomes (receipts)						
		Activities	Energy (2,3,4,9,16 and 17)	Labour	OVA	Taxes on expenditures	ROW imports	Activities	Households	Government	Capital formation	Stock	ROW exports	% share of total industrial territorial CO_2 emissions
1. AGR	Agriculture, forestry & fishing	47	3	17	31	-9	14	54	32	0	4	0	10	2
2. MIN	Mining & quarrying	47	17	28	7	5	13	97	30	0	0	-36	8	0
3. CRU	Crude Petroleum + Natural Gas & Metal Ores + coal	26	12	7	61	1	5	46	4	0	1	-1	49	5
4. OMI	Other Mining & mining services	33	9	17	36	2	11	54	7	1	1	0	37	0
5. FOO	Food (+ Tobacco)	57	3	23	5	1	15	50	35	1	0	0	14	2
6. DRI	Drink	57	4	17	15	2	8	50	22	0	0	1	27	0
7. TEX	Textile, Leather & Wood	35	2	28	10	1	26	55	13	1	4	0	28	1
8. PAP	Paper & Printing	37	5	28	11	2	23	70	15	1	3	0	10	1
9. COK	Coke & refined petroleum products	21	15	10	3	5	62	34	25	0	0	0	41	8
10. CHE	Chemicals & Pharmaceuticals	34	3	17	17	1	30	28	3	0	1	0	68	0
11. RUB	Rubber, Cement, + Glass	37	6	28	7	2	26	73	2	0	1	1	24	2
12. IRO	Iron, steel + metal	37	3	27	6	2	29	64	2	0	5	3	26	5
13. ELM	Electrical Manufacturing	40	2	30	10	1	20	36	4	0	11	1	48	1
14. MOT	Manufacture of Motor Vehicles, Trailers & Semi-Trailers	53	1	18	5	1	23	24	13	0	2	1	60	0
15. TRA	Transport equipment + other Manufacturing (incl, Repair)	47	2	27	7	1	18	40	8	1	9	0	43	1
16. ELE	Electricity, transmission & distribution	67	53	6	11	2	14	67	30	1	1	0	2	35
17. GAS	Gas; distribution of gaseous fuels & air conditioning supply	57	45	10	12	3	18	56	44	0	0	0	0	1
18. WTR	Natural water treatment & supply services; sewerage services	29	4	20	43	5	2	31	69	0	0	0	0	0
19. WAM	Water Management & remediation	50	1	21	16	6	7	38	13	25	2	0	22	0
20. CON	Construction - Buildings	49	1	22	19	3	7	47	1	0	52	-1	1	3
21. WHO	Wholesale & Retail Trade	39	2	35	15	4	7	24	57	1	3	0	16	4
22. TRL	Land Transport	43	3	35	12	2	8	53	40	1	1	0	4	1
23. TRO	Other transport	46	2	23	9	3	19	12	53	0	0	0	34	21
24. TRS	Transport support	52	1	33	7	3	5	86	4	1	0	0	9	1
25. ACC	Accommodation & Food Service Activities	35	1	32	12	8	13	13	72	1	2	0	12	1
26. COM	Communication	32	1	35	20	2	12	50	25	2	11	0	12	0
27. SER	Services	35	1	23	33	2	6	45	37	0	3	0	16	2
28. EDU	Education health & defence	29	1	49	6	5	11	16	14	68	1	0	1	4
29. REC	Recreational	35	1	28	24	5	8	28	50	5	4	0	14	1
30. OTR	Other private services	22	1	47	21	4	6	37	43	4	8	0	8	0

Appendix B

Appendix B: Economy-wide impacts on economic indicators of successful export promotion in each (row) sector sequentially

	GDP	CPI	Unemployment rate (pp difference)	Total employment	Nominal gross wage	Real gross wage	Households wealth	Households consumption	Labour income	Capital income	Government budget	Investment	Total imports	Total exports
1. AGR	1.21	0.74	-0.70	0.74	1.59	0.85	1.13	1.28	2.34	2.66	-2.72	1.96	3.01	3.53
3. CRU	1.64	0.59	-0.56	0.60	1.26	0.67	1.12	1.35	1.87	3.87	-2.98	3.30	2.39	3.81
4. OMI	1.20	0.67	-0.63	0.67	1.43	0.76	1.06	1.21	2.12	2.68	-2.59	2.04	2.57	3.66
5. FOO	0.77	0.77	-0.73	0.77	1.65	0.88	1.02	1.08	2.44	1.49	-2.24	0.76	2.91	3.47
6. DRI	0.91	0.74	-0.70	0.74	1.59	0.85	1.04	1.13	2.35	1.88	-2.35	1.18	2.69	3.53
7. TEX	0.67	0.69	-0.66	0.70	1.49	0.80	0.92	0.97	2.21	1.28	-2.01	0.63	2.98	3.62
8. PAP	0.71	0.70	-0.67	0.71	1.52	0.81	0.94	1.00	2.24	1.36	-2.07	0.70	2.92	3.59
9. COK	0.33	0.25	-0.25	0.27	0.55	0.29	0.37	0.40	0.82	0.66	-0.85	0.42	3.56	4.42
10. CHE	0.79	0.57	-0.55	0.58	1.23	0.66	0.83	0.92	1.82	1.65	-1.95	1.11	3.01	3.85
11. RUB	0.63	0.68	-0.65	0.69	1.46	0.78	0.89	0.94	2.16	1.18	-1.94	0.54	2.98	3.64
12. IRO	0.63	0.68	-0.65	0.69	1.46	0.78	0.89	0.94	2.16	1.18	-1.94	0.54	2.98	3.64
13. ELM	0.68	0.75	-0.71	0.76	1.62	0.86	0.98	1.02	2.39	1.27	-2.11	0.56	2.92	3.51
14. MOT	0.61	0.66	-0.63	0.67	1.41	0.75	0.86	0.90	2.09	1.14	-1.87	0.53	3.06	3.69
15. TRA	0.69	0.76	-0.72	0.76	1.63	0.87	0.99	1.04	2.41	1.29	-2.13	0.58	2.89	3.49
16. ELE	1.01	0.54	-0.51	0.55	1.15	0.61	0.86	0.99	1.71	2.25	-2.13	1.74	2.77	3.91
17. GAS	1.06	0.55	-0.53	0.56	1.18	0.63	0.89	1.03	1.75	2.37	-2.21	1.85	2.73	3.88
18. WTR	1.34	0.70	-0.67	0.71	1.51	0.80	1.14	1.30	2.23	3.02	-2.81	2.34	2.28	3.59
19. WAM	0.95	0.77	-0.72	0.77	1.65	0.88	1.08	1.17	2.44	1.97	-2.45	1.25	2.43	3.46
20. CON	0.99	0.77	-0.73	0.77	1.65	0.88	1.09	1.19	2.44	2.08	-2.50	1.35	2.53	3.47
21. WHO	0.89	0.87	-0.81	0.86	1.87	1.00	1.16	1.23	2.75	1.76	-2.53	0.94	2.49	3.28
22. TRL	0.84	0.89	-0.83	0.88	1.91	1.02	1.16	1.22	2.81	1.61	-2.51	0.78	2.58	3.25
23. TRO	0.76	0.72	-0.68	0.73	1.55	0.83	0.97	1.03	2.29	1.49	-2.15	0.81	2.76	3.56
24. TRS	0.81	0.93	-0.87	0.92	2.01	1.07	1.20	1.25	2.95	1.52	-2.55	0.64	2.53	3.16
25. ACC	0.77	0.76	-0.72	0.77	1.64	0.87	1.02	1.08	2.42	1.50	-2.24	0.78	2.53	3.47
26. COM	0.93	0.83	-0.78	0.83	1.79	0.95	1.13	1.22	2.63	1.87	-2.53	1.09	2.62	3.35
27. SER	1.23	0.77	-0.72	0.77	1.66	0.88	1.17	1.31	2.44	2.71	-2.78	1.98	2.43	3.46
28. EDU	0.66	0.94	-0.87	0.93	2.03	1.08	1.15	1.18	2.97	1.12	-2.38	0.24	2.57	3.11
29. REC	1.02	0.78	-0.74	0.79	1.69	0.90	1.12	1.22	2.49	2.14	-2.56	1.40	2.45	3.44
30. OTR	0.93	0.92	-0.86	0.92	2.00	1.06	1.23	1.31	2.94	1.83	-2.69	0.95	2.44	3.16

Appendix C

Appendix C: Economy-wide impacts on energy and emissions indicators of successful export promotion in each (row) sector sequentially

	Total energy use (intermediate+final)	- Electricity	- Gas	Energy use in production (total intermediate)	Energy consumption (total final demand)	- Households	- Investment	- Exports	Energy output prices	Energy output	Non energy output	Energy intensity (Total energy use/GDP)	Territorial CO_2 emissions	Emission intensity (territorial CO_2/GDP)
1. AGR	1.39	1.91	1.43	1.84	0.48	1.41	1.84	-0.84	0.49	0.99	1.45	0.18	0.67	-0.54
3. CRU	11.22	1.31	1.56	3.25	25.14	1.45	7.86	58.68	0.39	14.34	0.64	9.42	16.40	12.67
4. OMI	9.81	1.57	2.55	2.87	24.83	1.33	1.43	58.37	0.44	13.81	0.47	8.51	34.28	24.63
5. FOO	1.14	1.48	2.23	1.66	0.35	1.23	1.12	-0.88	0.51	0.88	1.34	0.37	0.94	0.17
6. DRI	1.29	1.62	2.58	1.93	0.38	1.26	1.17	-0.85	0.49	1.08	1.40	0.38	1.16	0.25
7. TEX	0.81	1.09	1.78	1.22	0.30	1.10	0.56	-0.79	0.46	0.52	1.01	0.13	0.48	-0.20
8. PAP	1.59	2.28	2.88	2.37	0.34	1.13	1.73	-0.80	0.47	1.16	1.03	0.88	1.14	0.43
9. COK	13.75	1.57	1.79	10.66	24.77	0.45	1.83	59.42	0.16	14.57	0.08	13.38	11.52	10.03
10. CHE	1.16	1.60	2.08	1.57	0.33	1.02	1.57	-0.65	0.38	0.72	1.15	0.37	0.74	-0.05
11. RUB	1.73	2.03	4.10	2.73	0.31	1.06	1.55	-0.77	0.45	1.28	1.00	1.09	1.79	1.14
12. IRO	1.73	2.03	4.10	2.73	0.31	1.06	1.55	-0.77	0.45	1.28	1.00	1.09	0.81	0.24
13. ELM	0.69	1.03	1.40	1.01	0.31	1.17	0.50	-0.85	0.50	0.44	1.05	0.01	0.32	-0.36
14. MOT	0.71	1.07	1.32	1.03	0.28	1.03	0.59	-0.75	0.44	0.47	1.28	0.09	0.36	-0.25
15. TRA	0.72	1.05	1.20	1.05	0.32	1.18	0.53	-0.86	0.51	0.47	1.14	0.03	0.31	-0.38
16. ELE	20.67	33.24	10.26	17.21	25.23	1.08	22.03	58.78	0.36	23.12	0.45	19.47	10.61	8.68
17. GAS	17.96	7.18	82.69	13.66	25.14	1.12	16.75	58.74	0.37	20.39	0.40	16.73	50.56	32.88
18. WTR	1.69	2.73	1.28	1.87	0.54	1.43	3.38	-0.80	0.47	1.18	1.28	0.35	0.64	-0.69
19. WAM	0.54	0.85	0.81	0.65	0.39	1.32	0.48	-0.88	0.51	0.31	1.33	-0.41	0.11	-0.85
20. CON	0.57	0.86	1.02	0.72	0.40	1.34	0.44	-0.88	0.51	0.34	1.34	-0.42	0.24	-0.75
21. WHO	0.65	1.06	0.87	0.81	0.39	1.40	0.69	-0.99	0.58	0.38	1.07	-0.24	0.10	-0.79
22. TRL	0.72	0.97	0.84	0.99	0.38	1.39	0.62	-1.01	0.59	0.44	1.06	-0.12	0.15	-0.69
23. TRO	0.71	0.82	0.72	1.06	0.33	1.17	0.41	-0.82	0.48	0.46	1.20	-0.05	0.21	-0.55
24. TRS	0.39	0.72	0.73	0.44	0.37	1.43	0.28	-1.06	0.62	0.14	1.19	-0.42	-0.08	-0.89
25. ACC	0.63	0.93	0.93	0.82	0.34	1.22	0.64	-0.87	0.51	0.36	1.05	-0.14	0.19	-0.59
26. COM	0.57	0.96	0.78	0.62	0.40	1.37	0.74	-0.94	0.55	0.25	1.01	-0.36	0.04	-0.89
27. SER	0.57	0.97	0.81	0.56	0.47	1.45	0.82	-0.88	0.51	0.29	1.27	-0.65	0.10	-1.14
28. EDU	0.32	0.63	0.79	0.34	0.33	1.36	0.24	-1.07	0.63	0.04	0.75	-0.34	-0.12	-0.78
29. REC	0.70	1.13	0.97	0.79	0.42	1.37	1.00	-0.89	0.52	0.40	1.13	-0.32	0.20	-0.82
30. OTR	0.33	0.63	0.67	0.29	0.40	1.48	0.34	-1.05	0.62	0.05	0.82	-0.59	-0.12	-1.06

Appendix D

Appendix D: Long-run sectoral output effects of a £10bn export demand stimulus to key sectors in turn. % changes

	S5	S10	S13	S14	S15	S16	S20	S21	S26	S27	S28
1. AGR	15.88	0.22	- 0.02	0.03	- 0.01	0.26	0.20	0.34	0.07	0.16	- 0.05
2. MIN	1.75	0.96	0.56	0.75	0.55	36.17	0.53	0.45	0.29	0.40	- 0.03
3. CRU	0.03	0.07	- 0.23	- 0.14	- 0.23	12.37	- 0.32	- 0.37	- 0.40	- 0.33	- 0.58
4. OMI	- 0.50	- 0.07	- 0.68	- 0.51	- 0.50	4.70	- 0.14	- 0.76	- 0.77	- 0.65	- 1.00
5. FOO	38.27	0.24	0.08	0.12	0.05	0.29	0.15	0.67	0.14	0.21	0.10
6. DRI	0.37	0.03	- 0.12	- 0.08	- 0.13	0.11	0.00	0.04	0.08	0.10	- 0.19
7. TEX	- 0.10	- 0.04	- 0.20	0.90	2.78	0.15	2.06	- 0.12	- 0.39	- 0.11	- 0.61
8. PAP	2.27	0.59	0.12	0.06	0.23	0.36	0.10	0.30	1.02	0.38	0.35
9. COK	0.32	0.22	- 0.01	- 0.04	0.17	1.04	- 0.00	0.19	0.10	0.04	- 0.24
10. CHE	- 0.54	34.83	- 0.24	0.15	- 0.22	- 0.38	- 0.51	- 0.84	- 0.80	- 0.77	- 0.84
11. RUB	1.01	0.41	0.34	2.33	0.55	0.25	3.84	0.12	- 0.16	- 0.01	- 0.70
12. IRO	0.04	0.11	3.58	4.08	2.47	1.16	0.93	- 0.67	- 0.75	- 0.59	- 0.89
13. ELM	- 0.41	- 0.24	38.17	0.44	1.70	1.37	- 0.27	- 0.73	- 0.58	- 0.67	- 1.01
14. MOT	- 0.75	- 0.51	0.07	58.20	- 0.14	- 0.01	- 0.70	- 0.83	- 0.81	- 0.73	- 0.97
15. TRA	- 0.33	- 0.17	0.59	0.51	44.49	0.43	- 0.16	- 0.64	- 0.52	- 0.53	- 0.62
16. ELE	1.36	1.11	0.91	0.96	0.95	43.43	0.77	0.93	0.70	0.75	0.47
17. GAS	2.01	1.51	1.07	1.03	0.92	10.64	0.75	0.64	0.55	0.61	0.52
18. WTR	1.20	0.91	0.64	0.60	0.72	0.78	0.67	0.65	0.67	0.82	0.88
19. WAM	- 0.03	0.02	- 0.27	- 0.19	- 0.23	0.29	- 0.06	- 0.23	- 0.21	- 0.15	- 0.10
20. CON	0.26	0.45	- 0.09	0.13	0.13	1.15	13.47	1.11	0.39	1.61	- 0.12
21. WHO	0.57	0.76	0.58	1.01	0.44	0.45	0.45	7.36	0.31	0.32	0.02
22. TRL	1.19	0.71	0.32	0.39	0.33	0.56	0.55	1.65	0.38	0.42	0.27
23. TRO	- 0.13	- 0.01	- 0.16	- 0.10	- 0.11	0.13	- 0.08	- 0.11	- 0.09	0.01	- 0.28
24. TRS	0.05	0.29	- 0.11	0.18	- 0.05	0.20	- 0.16	2.32	0.17	0.14	- 0.58
25. ACC	0.47	0.46	0.39	0.35	0.37	0.54	0.59	0.51	0.53	0.63	0.39
26. COM	0.21	0.46	0.01	0.11	0.19	0.50	0.22	0.43	12.53	0.86	- 0.05
27. SER	0.29	0.39	0.12	0.29	0.31	0.52	0.44	0.41	0.40	3.69	0.04
28. EDU	- 0.01	0.04	- 0.03	- 0.02	- 0.02	0.06	0.04	0.00	0.03	0.13	4.58
29. REC	0.36	0.39	0.19	0.23	0.26	0.54	0.48	0.38	0.55	0.58	0.14
30. OTR	0.27	0.42	0.13	0.21	0.26	0.68	0.38	0.37	0.87	0.65	0.18

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