Highlighting the need for policy coordination: the economic impacts of UK trade-enhancing industrial policies and their spillover effects on the energy system

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This paper summarises analysis given in:

Ross, A. G., Allan, G., Figus, G., McGregor, P. G., Roy, G., Swales, J. K., & Turner, K. (2018a). The economic impacts of UK trade-enhancing industrial policies and their spillover effects on the energy system. *UK Energy Research Centre working paper*. Available from: http://www.ukerc.ac.uk/asset/F3F35874%2D924C%2D46C0%2D91F2218707C20A4B/

Acknowledgements

This research was undertaken by the Fraser of Allander Institute & the Centre for Energy Policy at the University of Strathclyde as part of the research programme of the UK Energy Research Centre, supported by the UK Research Councils under EPSRC award EP/L024756/1. We also thank participants of the UKERC General Meeting in London (October 2017) for useful comments, and thank Jim Watson for feedback on earlier versions of the working paper.

Abstract

The wider impacts of energy policy on the macro-economy are increasingly recognised in the academic and policy-oriented literature. Given the interdependence of energy and the wider economy, any economic policy change will impact on the energy system. However, such ‘spillovers’ on the energy system have not been extensively researched. This article analyses the impact of export promotion policies - a key element of the UK’s Industrial Strategy - on the energy system and energy policy goals. As the impacts of such policies are, in large part, transmitted via their effects on the economy, we use a computable general equilibrium model - UK-ENVI – to fully capture impact. Our results suggest that an across-the-board stimulus to exports

significantly increases total energy use, not directly via energy exports but indirectly via linkages between the energy sector and other sectors. We show that export-led growth has significant impacts on energy use and, in turn, on emission targets. Policy makers need to be aware that the successful implementation of the UK Industrial Strategy may create significant tensions with the UK's Clean Growth Strategy and wider energy policy goals. The scale of such impacts depend upon both the mix of UK goods and services exports and the success of low-carbon policies. A knowledge of the nature and scale of the spillover effects of economic policies on the energy system provides a platform for more effective and efficient policy making.

1. Introduction

The wider impacts of energy policy on the macro-economy are increasingly recognised in the academic and policy-oriented literatures. Within policy communities there is a developing recognition that the wider impacts of energy efficiency policies should be taken into account as proposed in the "multiple benefits" approach of the International Energy Agency (2015), rather than focussing exclusively *per se* on energy (and emissions) savings.

Indeed, some governments emphasise energy efficiency improvements explicitly as economic development policies (e.g. the Scottish Government, 2017), as well as a potential source of energy savings. Of course, these developments reflect the fundamental interdependence of energy (and emissions) and the economy: policy actions in any one system generate spillover effects in the other. Neglect of this interdependence may prove problematic for policy.

The interdependence of the energy systems and the economy naturally also implies that any changes in the economy impact on the energy system. The experience of the Great Recession, for example, provides dramatic evidence of such dependence, with total UK energy consumption falling by over 6% between 2008 and 2009 when the UK economy contracted by around 4% (BEIS, 2017a). However, these spillovers are not necessarily negative, and "double dividends" (or even "multiple benefits") are possible, where policies simultaneously stimulate economic activity and reduce emissions (and potentially also contribute to other policy goals).

While this interdependence is, of course, widely recognised, it has not featured prominently in assessing the likely impact of economic policies, such as industrial and fiscal policies: such assessments have tended to focus on the primary economic objectives of such policies, including their impact on Gross Domestic Product (GDP) and employment.

In principle, (non-energy) economic policies are likely to have a significant influence on the energy system, the neglect of which may lead to inefficiencies in the design of appropriate energy and economic policies. The importance of this in practice depends on the strength of the interdependencies between both systems and, in particular, the scale of the impact of economic on energy policy goals.

Our primary focus is on the comparatively unexplored impacts of economic policies on the energy system and their effects on energy policy goals such as energy use (and emissions), energy intensity and energy security. However, the impacts of such policies are, in large part, transmitted via their impact on the economic system, so that we have to adopt an approach that fully captures such interdependence.

In this article we analyse the potential impacts of successful UK industrial, business and innovation policy on the UK economic and energy systems, as well as the corresponding energy policy goals. Two key pillars of the UK Industrial Strategy are concerned with 'encouraging trade' and 'boosting productivity' (BEIS, 2017b). Although 'trading more, not less' seems to be key, precise policies or quantifiable measures are not explicitly stated[5]. Despite being concerned with coordinating policy, the strategy does not consider explicitly trade-offs (or complementarities) across policies, and how such tensions and conflicting demands could be overcome. As we illustrate in analytical and empirical analysis, increasing trade has a significant impact on the energy system, and energy policy goals in particular. This analysis therefore has two objectives; first, to explore how economic policies impact the energy system, and, second, to demonstrate the potential usefulness of the CGE modelling approach in capturing and quantifying the interdependencies between the economy and energy systems.

Here we analyse the system-wide effects of successful export strategies on the economy and the energy system. As part of a UK Energy Research Centre (UKERC) project we are also investigating the 'the economic impacts of UK labour productivity-enhancing industrial policies and their spillover effects on the energy system', and the impacts of UK (and Scottish) fiscal policies on the energy system, which we shall publish in due course.

[5] Although the recently published UK Export Strategy (DIT, 2018) now sets a target to "raising exports as a proportion of GDP from 30% to 35%". We shall explore in future the system-wide implications of reaching this target. However, the Export Strategy currently does not provide detail on the precise policy instruments used.

We employ a multi-sectoral computable general equilibrium (CGE) approach which captures the interdependence of the economy and energy systems and allows us automatically to track the impact of key energy and economic policy interventions on the main goals of both sets of policies and so can be used ultimately to develop a more *holistic* perspective on the conduct of policy. In particular, the intention is ultimately to create a framework that explicitly recognises, and seeks to quantify, the scale of spillovers from economic and energy policies to energy and economic policy goals respectively. Where these spillovers prove to be significant, accounting for them through better coordination of economic and energy policies would create the potential to deliver improved outcomes for both.

This article is organised as follows. Section 2 gives a brief overview of our energy-economy-environment model of the UK economy, and the simulation strategy. We present results in Section 3, and brief conclusions in Section 4.

2. Model and simulation strategy

In practice it seems likely that the Export Strategy will involve sectoral targeting of export promotion and this could have a significant influence on the impact on both the economic and energy sub-systems. However, since at the time of writing these sectors have not been identified explicitly, we focus here on an across-the-board stimulus. Such stimulus would increase exports as a proportion of GDP, which is currently an explicit target within the strategy. Accordingly, for now we proxy the impact of a successful trade-enhancing policies by an exogenous (and costless) 5% increase in international export demands across all sectors.

We simulate the economic and energy system impacts of such an increase in international export demands using a computable general equilibrium (CGE) model of the UK, UK-ENVI. Ross et al., (2018) provide a detailed description of the main characteristics of the model, with a particular emphasis on the linkages between the economic and energy sub-sectors, and a full mathematical account of the model.

For our analysis, however, it is important to note that 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 & 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.

2.1. The labour market

Our default model specification embodies a wage curve which reflects an inverse relation between the rate of unemployment and the real wage. Wages are thereby determined within the UK in an imperfectly competitive context, according to the following bargained real wage (BRW) specification:

$$\ln\left[\frac{wb_t}{cpi_t}\right] = \rho - \varepsilon \ln(u_t) \quad \text{where } wb_t = \frac{w_t}{1+\overline{\tau}_t} \tag{1}$$

In equation 1, w_t / cpi_t is the real take home wage, ρ is a parameter calibrated to the steady state, ε is the elasticity of wage related to the level of unemployment, u_t, and $\overline{\tau}_t$ is the income tax rate. So here the real consumption (after tax) wage is negatively related to the rate of unemployment (Blanchflower & Oswald, 2005), which is an indicator of workers' bargaining power.

The working population is assumed to be fixed and exogenous. This model implies the presence of involuntary unemployment (with BRW lying above the competitive supply curve for labour).

Conventional CGEs of national economies often make the simplifying assumption of an entirely exogenous labour supply (with both population and the participation rate invariant): that is labour supply exhibits a zero elasticity with respect to the real wage. This exogenous labour supply (ELS) vision of the market implies that employment is fixed.

$$Ls = \overline{Ls} \tag{2}$$

Of course, this vision of the labour market implies that the UK operates under a very tight supply constraint. Note that, in the short run, both capital and labour are fixed in each sector in this case, and so too is value-added. Aggregate GDP can only vary in response to disturbances that alter the allocation of activity across sectors. Furthermore, employment is effectively fixed even in the longer-term, and is, of course, invariant to any change in demand, although capital stocks can adjust in response to changes in rental rates.[6]

Some take the view that workers in the UK bargain to maintain their real wage - 'real wage resistance' - that results in a fixed real wage (FRW) model (at least in the absence of productivity growth). This model implies:

$$\frac{w_t}{cpi_t} = \frac{w_{t=0}}{cpi_{t=0}} \tag{3}$$

This case effectively implies an infinitely elastic supply of labour over the relevant range. In stark contrast to the ELS case, here the real wage is fixed, and any demand disturbances will be reflected only in employment changes (over a range).

The ELS and FRW cases represent limiting cases of the responsiveness of the effective supply of labour to the real consumption wage, with elasticities of zero and infinity respectively. The BRW case represents an intermediate case in which the effective (bargaining-determined) level of employment varies positively with the real consumption wage.

While these cases provide a useful range of alternative visions of the UK labour market, recent experience casts some doubt on the current relevance of the BRW or FRW hypotheses, since real wages have been falling despite a fall in the unemployment rate. There is clearly some evidence of a degree of nominal wage inflexibility. Here we illustrate the likely implications of this by exploring the limiting case of a fixed nominal wage (FNW):

$$w_t = w_{t=0} \tag{4}$$

The next section outlines our simulation results.

3. Simulation results

We start by discussing the aggregate long-run results for the FNW-FRW closures since this is a useful benchmark, whose properties are well-known (see Ross et al., (2018) for a detailed discussion). We then outline the main differences between the FNW-FRW, BRW (our default

[6] In the longer-term population and labour supply can, of course, increase through natural population growth. For simplicity we abstraction from that here. Migration flows could also alter labour supply, but we assume that net migration is zero here. However, the fixed real wage model, discussed below, emulates many of the features of a system with endogenous (flow) migration.

model), and ELS closures. This is followed by a detailed discussion of the potential impacts on the energy systems, sectoral results, and a discussion of short-run results.

Table 1: Short and Long-run effects of a 5% increase in international exports. In % changes from base year.

	Long-run			Short-run			
	FRW-FNW	BRW	ELS	FNW	FRW	BRW	ELS
GDP	2.08	0.95	0.23	0.64	0.30	0.19	-
CPI	-	0.75	1.24	0.92	1.09	1.24	1.40
Unemployment rate (pp difference)	-1.80	-0.71	-	-0.98	-0.46	-0.29	-
Total employment	1.91	0.75	-	1.04	0.49	0.31	-
Nominal gross wage	-	1.61	2.68	-	1.09	1.58	2.28
Real gross wage	-	0.86	1.43	-0.91	-	0.34	0.87
Households wealth	1.36	1.06	0.87	0.43	0.50	0.55	0.61
Households consumption	1.46	1.16	0.96	0.70	0.56	0.75	0.83
Labour income	1.91	2.38	2.69	1.04	1.58	1.90	2.28
Capital income	2.35	1.99	1.76	3.84	2.97	2.83	2.43
Government budget	-7.03	-2.42	0.59	-1.00	0.22	0.76	1.55
Investment	2.35	1.28	0.59	3.35	2.46	2.01	1.36
Total energy use (intermediate+final)	2.53	1.72	1.21	1.30	1.04	1.03	0.93
- Electricity	2.03	1.26	0.77	1.16	0.83	0.81	0.68
- Gas	1.98	1.35	0.94	0.81	0.63	0.70	0.68
Energy use in production (total intermediate)	2.36	1.41	0.80	0.79	0.55	0.52	0.42
Energy consumption (total final demand)	2.91	2.44	2.15	1.56	1.49	1.59	1.64
- Households	1.43	1.30	1.21	0.75	0.68	0.92	1.05
- Investment	2.27	1.26	0.60	2.24	1.55	1.40	1.05
- Exports	5.00	4.11	3.53	2.66	2.63	2.55	2.49
Energy output prices	-	0.50	0.82	0.92	0.98	1.06	1.13
Energy intensity (Total energy use/GDP)	0.44	0.76	0.98	0.66	0.74	0.84	-
Territorial CO2 emissions	2.77	1.69	1.00	0.66	0.46	0.43	0.35
Emission intensity (territorial CO2/GDP)	0.67	0.73	0.77	0.02	0.16	0.24	-
Total imports	2.12	2.77	3.19	3.07	3.06	3.28	3.41
Total exports	5.00	3.63	2.75	3.00	2.73	2.49	2.25
Net exports (exports-imports)	-0.19	-0.04	0.06	0.04	0.05	0.09	0.12
- Electricity	2.18	2.27	2.33	2.42	2.25	2.41	2.45
- Gas	2.29	2.46	2.58	2.68	2.53	2.70	2.77

Note: Short- and long-run are two conceptual time periods. The short run (SR) is the period immediately after the introduction of the exogenous shock. Capital stocks are fixed in the SR at industry level. In the long run (LR) capital stocks fully adjust, across all sectors, to the shock, and are again equal to their desired levels. The short-run applies to a period of a year; the adjustment period to the long-run varies but is typically complete within 7-12 years. CO2 Emissions are calculated according to the method given in Allan et al. (2018).

The short- and long-run macroeconomic simulation results for a 5% increase in international exports, reported in percentage changes from base year, across the different labour market closures, are summarised in Table 1.

The adjustments seen in the long-run for the FRW-FNW 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). 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 5%. The increase in exports stimulates aggregate demand, which increases consumption, investment, and GDP, by 1.46%, 2.35% and 2.08% respectively. Capital stocks rise in the long run by 2.35%, with net investment driven by the gap between the capital rental rate and the user cost of capital that opens in the short run.

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 1.91%, and the unemployment rate falls by 1.8 percentage points. Labour income and capital income both rise, by 1.91% and 2.35%, respectively. Export industries tend to be more capital intensive than the aggregate economy, so that the demand for capital increases slightly more than that for labour.

The public sector deficit falls by 7.3% in the long run, a fall from £98bn to £91bn, as tax revenues rise in response to the stimulus to economic activity[7]. Imports increase by 2.12% along with increases in domestic demand. In the base period net exports are negative i.e. the UK economy imports more than it exports. The stimulus to exports thereby decreases the negative trade balance by 0.19%.

When considering the BRW case, the stimulus to the real economy is significantly less (as compared to FRW/FNW) because real wages and prices rise in response to the excess demand for labour. So GDP in the BRW case increases by 0.95%, which is less than half of the 2.08% stimulus under FRW/FNW. The rise in the real and nominal wage pushes up the CPI (by 0.75%), reducing competitiveness and crowding out some of the stimulus to exports, which now rise by

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

only 3.63% in the long run. The rise in consumption of 1.16% is less than under FRW (1.46%), but the decline is mitigated by the fact labour income actually rises more in this case, with the higher real wage more than offsetting the lower employment impact (0.75% as against 1.91%).

Next we consider the ELS case of continuous full-employment. Employment is unchanged, but the real wage and the CPI rise by 1.43% and 1.24%, significantly more than under the BRW (0.86% and 0.75%). This results in much greater crowding out of exports, which now only rise by 2.75%, and a much bigger stimulus to imports (of 3.19%). The sectoral distribution of effects does result in a modest stimulus to GDP of 0.23%, but this is significantly less than under the BRW and FRW-FNW closures.

The short-run impacts are muted given that the capital stock is fixed in the short run both in total and in its distribution across sectors, and prices increase in all cases so that there is some induced loss in competitiveness, and exports are always crowded out to a degree. As anticipated, the GDP (and employment) effects in the short run are ranked as: FNW›FRW›BRW›ELS (and indeed the impact is zero in this case).

These results therefore appear reassuring for the conduct of UK industrial strategy in that key economic indicators move in the desired direction as a consequence of a successful export promotion strategy. However, there are substantial impacts on the energy system, which we now discuss. We focus on the BRW case, our preferred model.

Energy use increases across the board in response to the export stimulus. Furthermore, energy use increases significantly relative to GDP, employment and investment. Energy intensity, defined here as energy use per unit of GDP, increases. In fact, this is true across all labour market models: energy intensity increases significantly as a consequence of a successful export promotion strategy. It appears that exports are thereby rather energy intensive. This is a potentially important spillover from a successful UK industrial strategy to the energy system.

Energy output prices increase by 0.5% reflecting the stimulus to energy demand created by the expansion, as well the increase in labour and material costs.

Figures 1 and 2 summarise selected long-run results at the individual sector level for the 5% increase in international exports, for the BRW. Although we do not discuss these sectoral results in more detail here (see Ross et al., (2018) for a detailed discussion), it is evident that aggregate energy impacts are driven by key characteristics of individual sectors. Although all sectors receive the same percentage export demand shock, sectoral impacts vary significantly because of their heterogeneous nature. This highlights potential policy trade-offs, particularly at the individual sector level. Increasing exports may generate inadvertent, negative impacts on energy policy goals, if the impacted sectors are also energy intensive.

Given that real wages (and capital incomes) are rising, households experience rising incomes and wealth and so their total consumption - of energy and non-energy goods & services – increases, as we have already noted. Figure 6 summarises the long-run impacts on households' consumption, income, the share of income spent on Electricity & Gas, and non-energy goods & services, across household quintiles, where HH1 is the lowest income quintile. The share of income spent on energy- and non-energy goods and services increases across all Household quintile groups.

The time path adjustments for GDP, employment, and total energy use are detailed in Figure 4. This figure shows how these variables increase throughout all of the simulation periods. Moreover, these results highlight that total energy use increases more than proportionately to GDP, so that there is a significant negative spillover effect from successful export promotion policies to the energy system.

Figure 1: Long-run effects on output, employment, and energy use by individual sectors of a 5% increase in international exports, BRW closure. In % changes from base year.

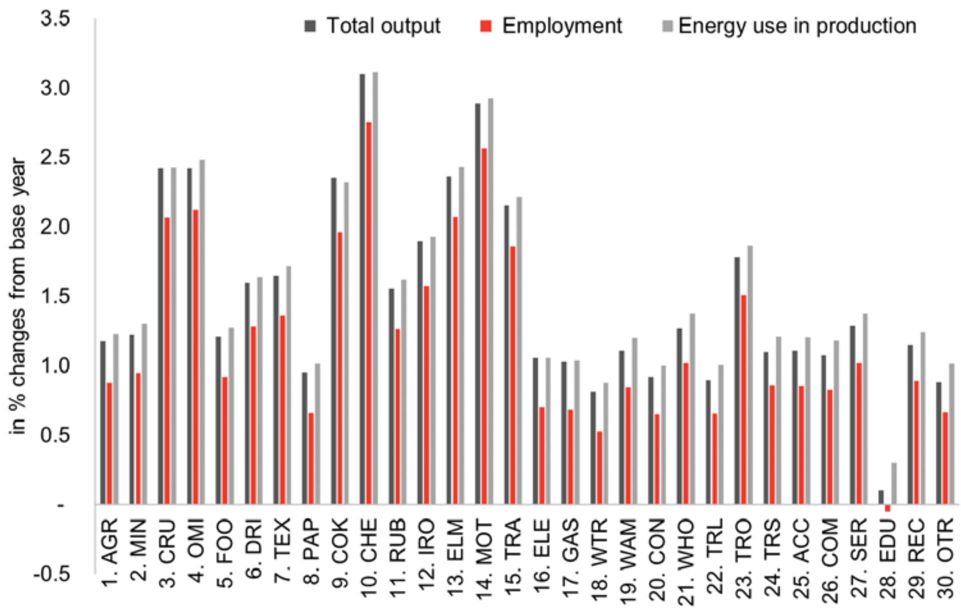


Figure 2: Long-run effects on output price, imports and exports at individual sectors of a 5% increase in international exports, BRW closure. In % changes from base year.

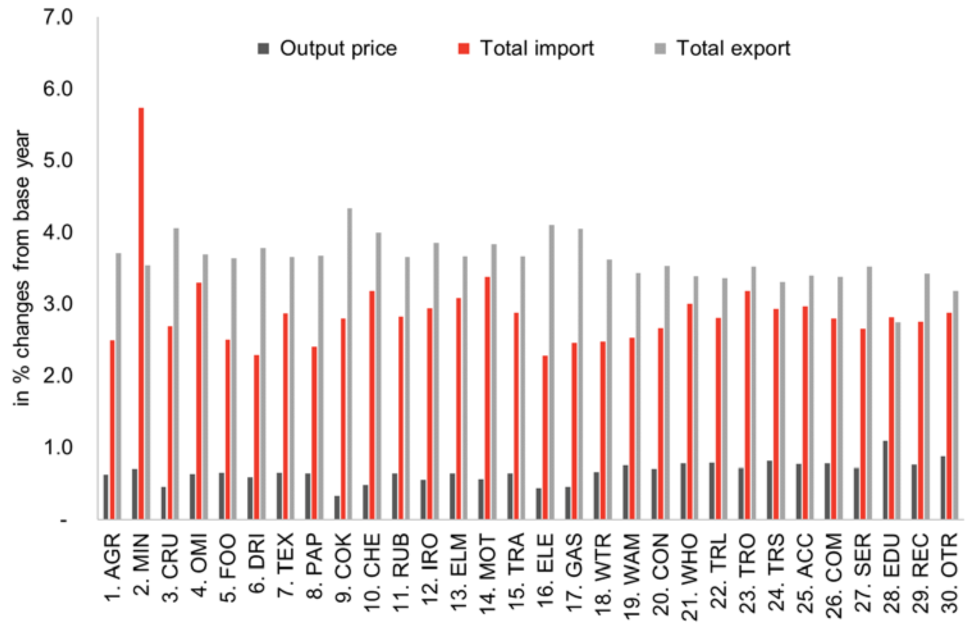


Figure 3 Long-run effects on Household quintiles of a 5% increase in international exports, BRW closure. In % changes from base year.

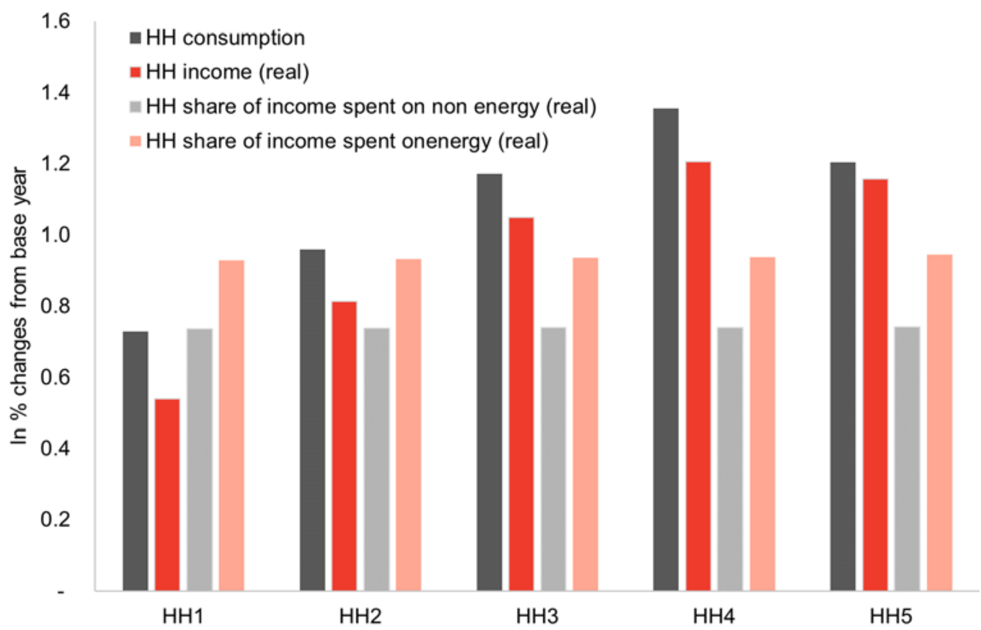
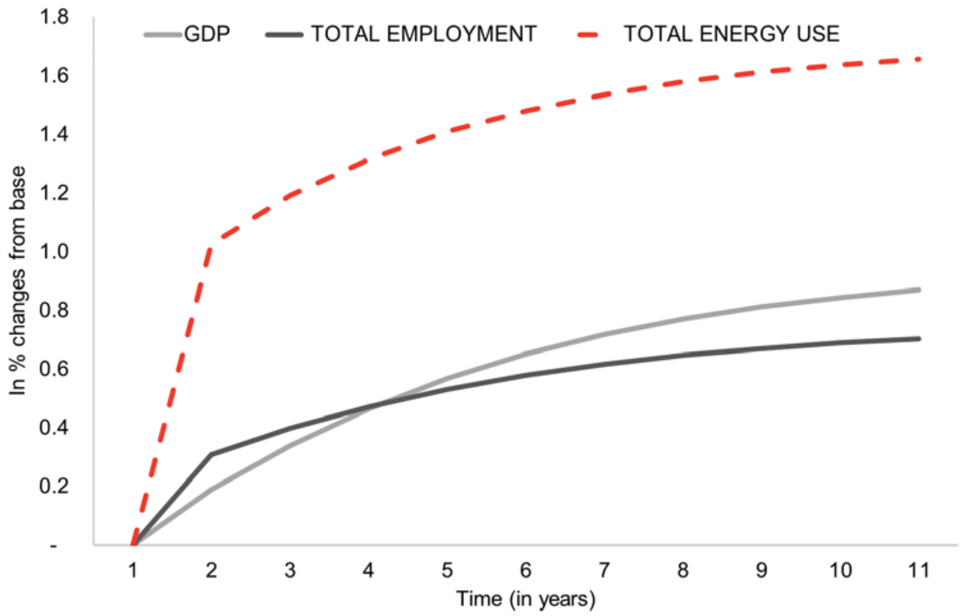


Figure 4 Aggregate transition path for GDP, employment, and total energy use of a 5% increase in international exports. In % changes from base year.



4. Summary & conclusions

The wider impacts of energy policy on the macro-economy are increasingly recognised in academic and policy discussions around the appropriate use of energy policy. For example, recent analyses on energy efficiency policies emphasise the stimulus to economic activity that these typically generate and their potentially beneficial impacts on distributional issues.

However, the potential impact of economic policies on the energy system have been comparatively neglected and, in particular there has been no system-wide analysis of the spillover effects from economic policies to the energy system (Cox et al., 2016). Neglect of such spillovers in policy formulation may lead to inefficiencies and unforeseen conflicts (or complementarities) between energy and economic policy goals. This could be avoided by a more *holistic* perspective.

We begin by analysing the potential impacts of a successful UK industrial, business and innovation policy on the UK analyse the system-wide effects of successful export promotion policies on the energy system. However, since the energy system impacts of such policies are, in large part, transmitted via their impact on the economic system, it is necessary to adopt an approach that fully captures such interdependence. We do so by employing a UK computable general equilibrium (CGE) model, UK-ENVI.

At one level the results of our analysis may be regarded as re-assuring from the perspective of successful UK export promotion policies in that all the major indicators of UK economic activity, including GDP, employment, consumption and investment are typically significantly stimulated. So the major objectives of UK industrial policy are positively impacted by export promotion.

However, there are significant, and typically *negative* spillover effects to the energy system. Most notably, UK exports are, on average, energy intensive, so that export-driven expansion is associated with a greater stimulus to total energy use than to GDP: hence the energy intensity of economic activity increases as a result. Furthermore, while not modelled here explicitly, this result could translate into increased CO_2 emissions if action is not taken at the same time to decarbonise the economy in line with the Industrial Strategy challenge on Clean Growth. General, across-the-board, export-driven growth is typically not "green" in nature. However, it may be possible to target such policies at specific sectors so as to stimulate "green growth".

Although we do not attempt to investigate the impacts on precise measures of fuel poverty (or poverty in general) we can identify the impact on the share of household disposable income spent on energy and non-energy goods across income quintiles. Our results suggest that the proportion of the lowest household income group's spending on energy increases and so on that basis fuel poverty increases. On the other hand, however, that group's total income and total expenditure on all goods also increase. Other goals of energy policy are similarly adversely affected: affordability (as indicated by an increase in the price of energy) declines, although real incomes actually increase by more than energy prices so that the "real" price of energy and hence affordability is improved.

Energy security is a complex issue with a wide range of indicators (e.g. UK Energy Research Centre, 2018). Here we report that the ratio of imported energy to GDP increases. Some would interpret this as a deterioration in security of supply, although that is controversial and imports can and have been used to augment security (e.g. during the miners' strike). Given this we conclude that the impact of export promotion on security of supply is ambiguous (and will vary depending on the source of imports, supply routes and the mix of sources and fuels). As noted above, fuel poverty and affordability can also be included within the energy security framework.

Overall, it is very clear that, while successful export growth strategies are likely to have the desired effect on the economy and the stated goals of industrial policy, they could have significant negative spillover effects on the energy system and energy policy goals. Neglecting these spillover effects creates a source of inefficiency in the conduct of policy, and a knowledge of their likely scale could be used to develop a more holistic, coordinated approach to policy formation and implementation. For example, pursuit of the Clean Growth Strategy could mitigate/offset any increase in emissions that would otherwise result from an export promotion policy. This would minimise the prospect of conflicts between UK industrial and green growth strategies.

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