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Framing policy on low emissions vehicles in terms of economic gains: Might the most straightforward gain be delivered by supply chain activity to support refuelling?

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ABSTRACT

A core theme of the UK Government's new Industrial Strategy is exploiting opportunities for domestic supply chain development. This extends to a special ‘Automotive Sector Deal’ that focuses on the shift to low emissions vehicles (LEVs). Here attention is on electric vehicle and battery production and innovation. In this paper, we argue that a more straightforward gain in terms of framing policy around potential economic benefits may be made through supply chain activity to support refuelling of battery/hydrogen vehicles. We set this in the context of LEV refuelling supply chains potentially replicating the strength of domestic upstream linkages observed in the UK electricity and/or gas industries. We use input-output multiplier analysis to deconstruct and assess the structure of these supply chains relative to that of more import-intensive petrol and diesel supply. A crucial multiplier result is that for every £1million of spending on electricity (or gas), 8 full-time equivalent jobs are supported throughout the UK. This compares to less than 3 in the case of petrol/diesel supply. Moreover, the importance of service industries becomes apparent, with 67% of indirect and induced supply chain employment to support electricity generation being located in services industries. The comparable figure for GDP is 42%.

1. Introduction

Like many countries around the world, in the summer of 2017 the UK Government declared a commitment to ban the sale of new petrol and diesel powered vehicles by 2040 (DEFRA, 2017), one that was effectively accelerated by eight years to 2032 at devolved level by the Scottish Government (2017). While the headline around this UK commitment is primarily set in the context of reducing roadside emissions of nitrogen dioxide (and other roadside emissions), the link between improving local air quality and reducing greenhouse gas emissions is explicitly drawn with the statement that “the UK Government will continue to develop solutions which reduce NO_2 and carbon” (DEFRA, 2017, p.1). However, the traditional trilemma of clean, secure and affordable energy is increasingly recognised as having a fourth axis in terms of maximising economic growth. This paper explores this new axis in the context of the UK's new Industrial Strategy (HM Government, 2017), where opportunities for domestic supply chain development, particularly in the context of the nation's exit from the EU, are emphasised. This policy framing is present in a special ‘Automotive Sector Deal’ that focuses on the shift to low emissions vehicles (LEVs), but with the strategy in this respect giving attention to domestic supply chain activity to support vehicle and battery production and innovation. We argue that supply chain activity to support refuelling/powering of battery/hydrogen vehicles may offer a more straightforward source of economic gains.

In this paper, we present the first attempt to assess the economy-wide economic impacts of moving to electric vehicles using a relatively straightforward and transparent input-output multiplier approach that establishes the extent to which strong domestic supply chains may develop around electric vehicle power trains. Given that domestic supply chain development may be more challenging in the context of manufacturing electric vehicles and batteries, we focus in this first instance on how they may be fuelled. In particular, our approach assesses the benefit of adopting electric power trains against the losses of abandoning current fossil fuel power trains. In this respect our analysis is based on the fact that the UK electricity and gas supply chains that will play a role (directly or indirectly) in refuelling electric cars and/or their batteries already have much stronger upstream linkages within the domestic economy than is the case with petrol and diesel.

The remainder of the paper is structured as follows. In Section 2, we

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review the existing literature around the economic impacts of electric vehicles, which is largely limited in focus to techno-economic analysis of impacts at household or distribution grid levels, and consider how this may be extended to consider wider economic impacts, with specific focus on supply chain impacts. In Section 3 we then introduce the input-output multiplier method applied to this end in the current paper. Section 4 describes the UK dataset used for analysis in Section 5. Conclusions and implications for policy are considered in Section 6, along with our thoughts on how research may progress in the area of considering the wider economic impacts of a large scale shift to electric vehicles.

2. How should we consider the wider economic impacts of a shift to electric vehicles?

There is a growing literature that focuses on the economic and environmental impacts of the uptake of different types of hybrid, ‘plug-in’ battery and fuel cell electric vehicles. This is largely focussed on what may be considered micro-level or single sector level. For example, Granovskii et al. (2006) conduct an analysis that considers impacts at production and utilisation stages on the price of different vehicles and fuels over the vehicle life and driving range, and on associated greenhouse gas and air pollution emissions. Shiau et al. (2009) focus attention on hybrid vehicles with attention to the impact of the weight of batteries and charging patterns on both running and life-time costs, as well as on GHG emissions. Green et al. (2011) also focus on hybrid vehicles, but broaden focus to the level of distribution networks to consider economic impacts for both producers (of electricity) and consumers (using the vehicles). The OECD/IEA, EU and many nation states have commissioned a significant number of reports focussing on economic, technical and/or environmental aspects of switching away from fossil-fuelled transport (for example, Dodds and Ekins, 2014; E4tech and Element Energy, 2016; IEA, 2017; Office for Low Emissions Vehicles, 2011). These publications tend to focus on or report from ‘bottom-up’ studies, seeking to quantify variables such as the probable cost of producing vehicles, the cost of providing infrastructure and the likely consumer costs of refuelling (hydrogen) or charging, along with consideration of total lifetime vehicle and environmental costs.

The key advantage of these ‘bottom up’ types of study is that they capture and incorporate a high level of detail on characteristics, technical features and related costs of different vehicle, vehicle use and refuelling options. This constitutes a necessary part of the wider evidence base for understanding the potential impacts of what are expected to be large-scale shifts towards electric vehicles in many countries. However, such analyses do not attempt to consider what the supply chain and wider inter-sectoral and macroeconomic impacts may look like. The outcome is a rich but limited evidence base: smaller scale ‘bottom-up models’, while capturing a high degree of micro-level detail on the technological characteristics of supply and use behaviour and activity, do not capture macro-level phenomena such as indirect market and supply chain responses. Thus, in considering the wider economic impacts of low carbon developments such as large scale shifts to electric vehicles, there is a real need to introduce some extent of ‘top-down’ economy-wide analysis to the evidence base that informs policymakers.

The most commonly used (by both academic and policy communities) ‘top-down’, multi-sector, economy-wide modelling approach, applied to both energy and non-energy related policy problems is applied or computable general equilibrium (CGE) analysis. At UK government level, CGE modelling has been more traditionally used for fiscal analysis, with limited application to date on energy or climate policy issues (fuel duty analysis in HMRC/HMT (2014), and carbon budgeting work, for example see HoC EAC, 2010). On the other hand, the CGE approach has been extensively developed to consider environmental and energy issues (see, for example, the recent review by Babatunde et al., 2017). Moreover, CGE methods can, and indeed already have (see, for example, Li et al., 2017) been applied to consideration of issues around the roll out of electric vehicles.

A simpler, first stage analysis to help policymakers start to think about the type of supply chain issues involved in such a shift can be achieved using a more basic multi-sector economy-wide modelling framework, termed input-output (IO) multiplier analysis. IO methods have been applied in various supply chain contexts (see for example, Albino et al., 2002, on process analysis to help improve design and management of supply chains at local level in the context of global sustainable development) and combined with life cycle analysis for multi-objective analysis of new technologies (see for example, You et al., 2012, on biofuel supply chains).

The greatest and most transparent explanatory power of IO methods in an applied policy context is often located in the more fundamental construction and analysis of industry level ‘multipliers’ (see Miller and Blair, 2009). IO multiplier analysis of direct, indirect and induced supply chain impacts of industry-level activity has a long history (starting with Leontief, 1936), particularly in the regional science literature. In recent years, these methods have also been applied to assessing impacts of different energy-using activities, such as electricity generation (e.g. Allan et al., 2007, on alternative renewable and thermal technologies) and low carbon ‘bioenergy’ industries (e.g. see Henderson et al., 2017, on wood pellet manufacturing). In this paper we calculate and decompose industry multipliers for different energy/fuel supply industries in the UK to consider the nature and extent of likely supply chain impacts of the shift in fuel demand that would accompany a roll out of electric vehicles in the UK.

3. Input-output multiplier method

The most straightforward and transparent way to get a clear and simple picture of the structure of direct, indirect and induced supply chain linkages supported by demand for the output of any given industry is to work with an input-output (IO) accounting and modelling framework. IO data are produced for most developed countries under the United Nations System of National Accounts.[1] IO tables describe the structure of the economy in a given year in terms of each and all industries therein (with industries/industry groupings categorised by the Standard Industrial Classification, SIC) that: (a) sell to one another, to domestic consumers (domestic households, government and capital formation) and to exports; and, (b) how much they pay out in terms of incomes to labour and other value-added, and in imports and net taxes on products and production.

Through a series of straightforward mathematical (matrix algebra) processes a simple and transparent demand-driven IO model (originating with Leontief, 1936; detailed exposition in Miller and Blair, 2009) can be developed to conduct multiplier analysis of domestic supply chain interdependencies. This model focuses on how gross output in the economy and/or key variables such as gross-value added (GDP) and employment are determined by final (or end-use) demands via vectors of industry output multipliers.

For the analysis and decomposition of industry-level multipliers reported in this paper, we decompose the traditional headline industry multipliers to consider two core underlying matrices. The first, directly derived from the IO table, is the matrix of input-output coefficients, or symmetric **A**-matrix, with elements a_{ij}, $= x_{i,j}/x_j$ that (in the column) for any industry j, record the total direct input requirement from each other industry i as a share of the total input requirement, x_j (for $i = j = 1,..,N$ industries). Where we are interested in induced (consumption and income) multiplier elements, **A** includes a row for payments to labour

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[1] Information on IO accounting under the United Nations System of National Accounts 1993 (UN SNA 1993) can be found at https://unstats.un.org/unsd/EconStatKB/KnowledgebaseArticle10053.aspx.