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CHAPTER 6
EMPLOYMENT

6.1 INTRODUCTION

This chapter focuses on the employment embodied in the hydrogen supply chain activity implied by the headline input-output 'multiplier' values introduced in Chapter 3 and decomposed for output and total value-added (GDP) in Chapter 4. Here attention is on considering the composition of hydrogen supply chain multipliers in terms of the sectoral location of jobs and the associated generation of wage income. The latter gives some indication of the 'quality of jobs' associated with particular areas of the hydrogen economy. This is in so far as wage income is an element of value-added at the economy-wide level (GDP by an income measure) and to the individuals who receive earnings from paid employment. Given that jobs in the input-output framework are reported in full-time equivalent (FTE) units (for reasons of aggregation across sectors) it is not possible to consider the quality of jobs from a part-time vs. full-time perspective. However, Chapter 7 does go on to consider skills requirements, which is another important indicator of the quality of jobs/employment (and one that may, to some extent correlate with wage incomes)

As in Chapter 4, the focus is on decomposing multipliers (here, employment and wage income) for different UK industries that are directly impacted, to identify ones where activity is indirectly required or supported by direct players in different stages of the transition to a hydrogen economy. In doing so, it highlights whether any boost to activity in a given sector is likely to be temporary (investment activity) or on-going (operation of the hydrogen economy). The analysis continues (at this stage) to focus 'at the margin', with impacts considered in terms of supply chain activity required per £1million of production to serve final demand activity generated by the shift to a hydrogen economy, with scaled scenario simulations reserved for Chapter 9. However, again, the marginal analysis in the current chapter helps inform analysis of the nature of the industrial and employment base required to respond to opportunities and challenge presented by the shift to a hydrogen economy. In particular, the focus on employment and wage income will help inform analysis of the shorter and longer terms skills requirement in Chapter 7.

Similar also to Chapter 4, a crucial issue that must be highlighted up front, and one which again frames the analysis at this stage, is that **any transition to hydrogen as a fuel vector will require a reallocation of spending and related supply chain activity away from traditional fossil fuels, and associated employment, rather than an outright boost to employment and wage income across the UK economy**. In Chapter 3 three key phases to achieve the replacement of traditional refined fossil fuels with a hydrogen based energy source(s) were identified.

Again, the first task in the current chapter is to consider the employment and wage income impacts of the first of these phases, which is characterised by a contraction in expenditure on traditional refined fossil fuels, mainly petrol and diesel. This is the focus of Section 6.2 below. Then, from Section 6.3, the impacts of potential expansion through the second and third phases – respectively involving uptake of hydrogen as a fuel and investment to support/enable this shift – on employment and wage incomes are considered. Again, this begins with consideration of how

employment and wage income in a hydrogen supply industry – proxied by a sector that is similar in its input structure to current (2010) UK gas or electricity supply – may offset job and wage losses in the supply of traditional refined fuels.

6.2 EMPLOYMENT AND WAGE INCOME ASSOCIATED WITH SUPPLY CHAIN CONTRACTION LINKED TO REDUCED DEMAND FOR UK 'REFINED FUEL'
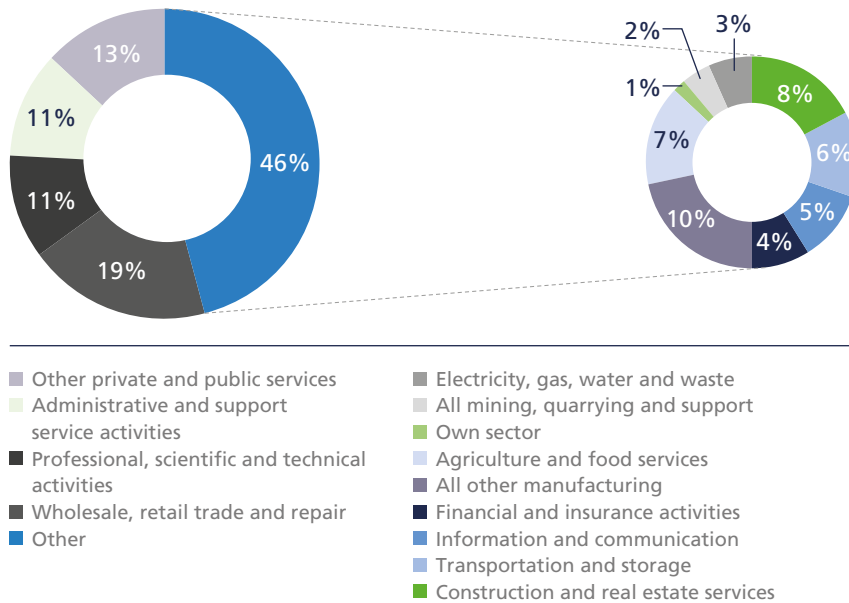
In relation to Section 4.2 (Chapter 4), this section provides an overview of the employment and wage income embodied in the supply chain of 'Manufacture of coke and refined petroleum products' (SIC 19).[52] The focus here is to show where there may be potential gross losses in employment and wage income if spending is reallocated from refined fuels to hydrogen fuels. In chapter 9, the number of FTE jobs losses in the 'Refined Fuel' industry and the potential FTE jobs created from reallocating fuel spend to hydrogen (using electricity and gas proxies) are considered in more details.

In terms of employment, the 'Refined Fuel' industry's direct output-employment multiplier is 2.93 FTE jobs per £1million of final demand spending on petrol or diesel. As noted in Chapter 3, and similarly to output and value-added in Chapter 4, this ranks as the smallest output-employment multiplier across all 103 UK industries. Therefore, any £1 million reallocation of household spending away from petrol or diesel to hydrogen will result in 2.93 gross FTE job losses in the UK supply chain.

The direct employment component of the total 2.93 FTE multiplier (i.e. FTE employment related to the £1million direct final demand) is 0.38 so that the composition of the remaining 2.55 is illustrated in Figure 6.1. The larger pie chart in Figure 6.1 shows that wholesale/retail, professional/technical, administrative/support and other public/private service industries contribute the largest shares of the indirect and induced FTE employment requirements for the UK 'Refined fuel' sector. **These service industries are, therefore, the industries that will be most impacted (alongside the 'Refined fuel' sector itself) by the gross contraction in employment associated with reduced spending on petrol and diesel.** However, note that this pattern of sectoral impacts **contrasts with the findings reported in Chapter 4 for output and value-added** (Figures 4.1 and 4.2 respectively), where the negative impacts of reduction in demand for petrol and diesel were found to be more on (less labour intensive) resource extraction (mining and mining support), construction and financial services industry groupings.

52 "The reader is reminded of the qualifications discussed in Section 4.2.1 regarding how the structure of the sector may have shifted since 2010,the input-output base accounting year used to identify multipliers."

Figure 6.1 Composition of indirect and induced supply chain employment requirements for the UK Refined Fuel sector.

- Other private and public services
- Administrative and support service activities
- Professional, scientific and technical activities
- Wholesale, retail trade and repair
- Other

- Electricity, gas, water and waste
- All mining, quarrying and support
- Own sector
- Agriculture and food services
- All other manufacturing
- Financial and insurance activities
- Information and communication
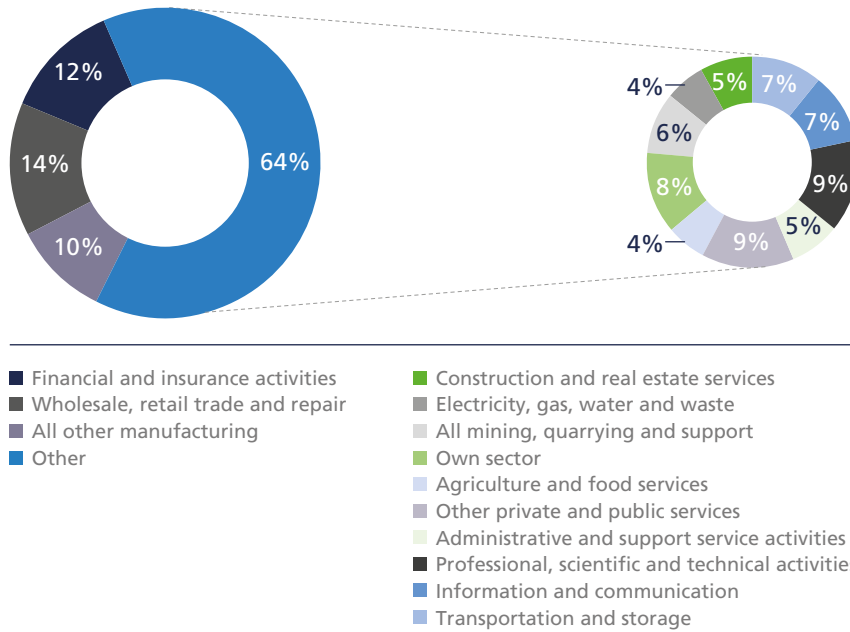- Transportation and storage
- Construction and real estate services

Alternatively, if attention focusses on wage income, as an indicator of quality of jobs, the picture is somewhat different. Figure 6.2 shows the 0.09 (9p in the £, or £90k per £1milion) indirect and induced component of the 0.19 'Refined Fuel' industry output-wage income multiplier across the UK 103 industries.[53] As with the employment (and other) multiplier(s), the 'Refined fuel' industry ranks lowest of all the UK industries, primarily reflects the weakness of its backward supply linkages in the UK economy. Figure 6.2 shows that in terms of the quality of jobs – as indicated by average wage rates – in the 'Refined fuel' industry supply chain, there is more of mix across a range of industries than with employment. The key point to note is that higher average wage sectors, such as the 'Finance and insurance activities' industry gain more importance, as does mining/mining support activities, when attention is on wage income effect rather than absolute employment levels.

However, a key point to note is that the strength of 'own sector' indirect and induced supply chain impacts increases markedly when attention is on wage income rather than employment levels. Added to the fact that direct component of the wage income multiplier is much more important than that for employment emphasises that **the quality of jobs impacted by contraction in demand for petrol and diesel may be of more concern than the number of jobs lost. This is particularly in the 'Refined fuel' sector itself, where job and wage income losses are less likely to be compensated by a shift to hydrogen fuels**.

53 The direct component of the wage income multiplier is proportionately larger than for the employment multiplier reflects relatively high wage intensity per worker within 'Refined Fuels' itself.

Figure 6.2 Composition of indirect and induced supply chain wage-income requirements for the UK Refined Fuel sector.

- ■ Financial and insurance activities
- ■ Wholesale, retail trade and repair
- ■ All other manufacturing
- ■ Other
- ■ Construction and real estate services
- ■ Electricity, gas, water and waste
- ■ All mining, quarrying and support
- ■ Own sector
- ■ Agriculture and food services
- ■ Other private and public services
- ■ Administrative and support service activities
- ■ Professional, scientific and technical activities
- ■ Information and communication
- ■ Transportation and storage

Overall, the same point as made in Chapter 4 with regard to output and value-added should be made here. This is that, given the relatively weak employment and wage income multipliers for 'Refined fuels', outside of the own sector employment and wage income losses, it is likely that a reallocation of spending will have net positive impacts across the UK as a whole. However, again, this is dependent on any spend withdrawn from petrol and diesel is spent within the UK (rather than on imported goods and services).

6.3 PROXY HYDROGEN SUPPLY SECTORS: EMPLOYMENT AND WAGE INCOME EMBEDDED IN SUPPLY CHAIN STRUCTURES FOR THE GAS AND/OR ELECTRICITY PROXIES

This section examines implications and impacts on employment and wage income within the supply chain of the gas and electricity industries as candidate proxies for hydrogen supply. As discussed in Chapters 3 and 4, these industries may be considered as appropriate proxies for the uptake of hydrogen on the basis of similar infrastructure in the case of gas and the sharing of secondary energy supply characteristics in the case of electricity.

Thus, focus is on which industries within the supply chains of the current UK gas and/or electricity supply sectors may absorb the skill-content, quantity and/or quality of jobs shifted away from the 'Refined fuels' supply chain. For the case of the gas supply proxy, Figure 6.3 shows a breakdown of indirect and induced (6.02 FTE job

per £1million) components of the overall current 8.04FTE UK gas sector output-employment multiplier.[54]

Figure 6.3 Composition of indirect and induced supply chain employment requirements for the UK Gas sector.

- Other private and public services
- Administrative and support service activities
- Professional, scientific and technical activities
- Wholesale, retail trade and repair
- Other
- Other utilities
- All mining, quarrying and support
- Own sector
- Agriculture and food services
- All manufacturing
- Financial and insurance activities
- Information and communication
- Transportation and storage
- Construction and real estate services
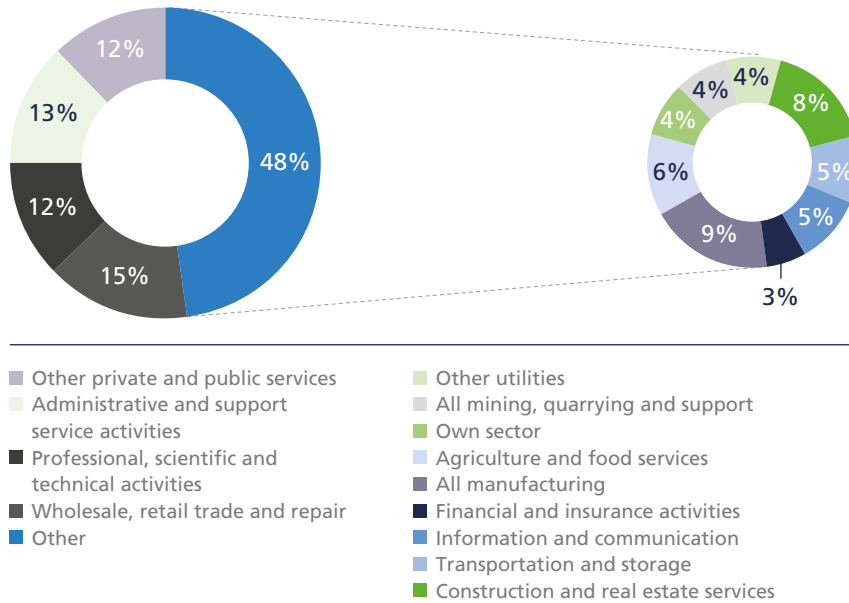
The crucial point to note from the results in the larger pie chart in Figure 6.3 is the similarity compared to Figure 6.1 for 'Refined fuels' in terms of the types of industries with the largest indirect and induced employment impacts of a switch in demand. **That is, there is potential for compensation and absorption of the employment impacts of reallocated demand and spending from petrol/diesel to hydrogen**, where the supply chain for the latter is similar its domestic supply chain to the current gas supply proxy. Figure 6.3 implies that there will be retention of FTE jobs in the same services industries as will be negatively impacted through contraction of the refined fuel supply chain. Moreover, with a higher overall output-employment multiplier (8.04 FTE jobs per £1m spend on the gas proxy compared to 2.93 in 'Refined fuels') there is a higher employment intensity spread across the gas supply chain so that net positive impacts are more likely.

The potential for compensation of reduced supply chain employment when demand for petrol/diesel contracts is not limited to services. For example, the trade-off in jobs in extraction (mining and mining support) linked to contraction in the 'Refined fuels' supply chain (smaller pie chart in Figure 6.1) is likely to be compensated by jobs supported in this sector in the gas supply proxy supply chain. The same is true in the case of utilities (split to identify gas as 'own sector' in Figure 6.3). The shares of gas supply chain jobs in the wholesale, other private and public services and

54 In contrast to the findings for output and value-added in Chapter 4, the contribution of the UK off-shore oil and gas industry to the output-employment multipliers for either the gas or electricity proxies is relatively small. This is due to the relatively low labour intensity of this and other mining and mining support industries. However, when attention turns to wage income this issue becomes more important again, though still less so than was found for value-added (given the capital intensity of UK extraction industries).

professional scientific & technical industry groupings are smaller than for 'Refined fuels'. However, again, the overall multiplier for which these shares are reported is larger in the case of gas supply so that below it is found that there will still be a net positive impact if there is a pound for pound (£1m for £1m) reallocation of spending.

Figure 6.4 **Composition of indirect and induced supply chain wage-income requirements for the UK Gas sector.**

Professional, scientific and technical activities
Wholesale, retail trade and repair
All mining, quarrying and support
All manufacturing
Other

Transportation and storage
Construction and real estate services
Other utilities
Own sector
Agriculture and food services
Other private and public services
Administrative and support service activities
Financial and insurance activities
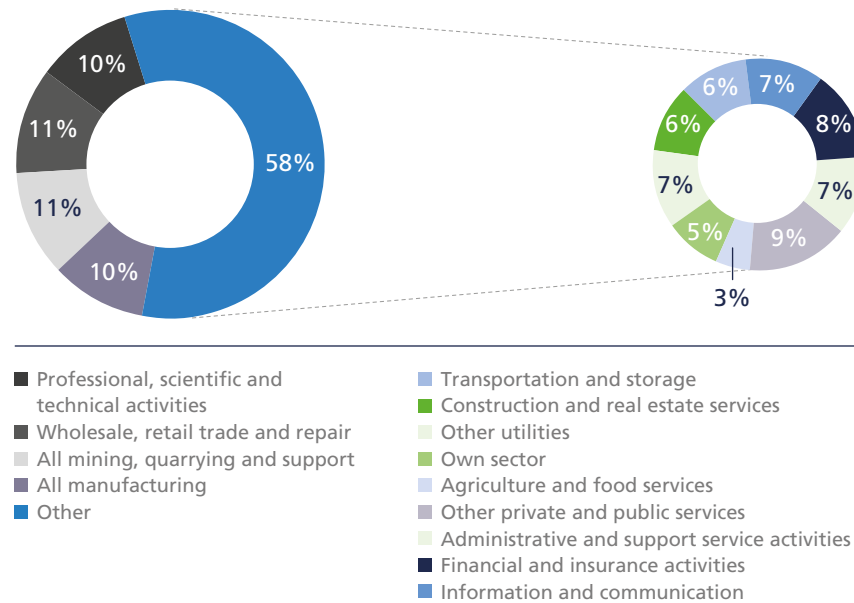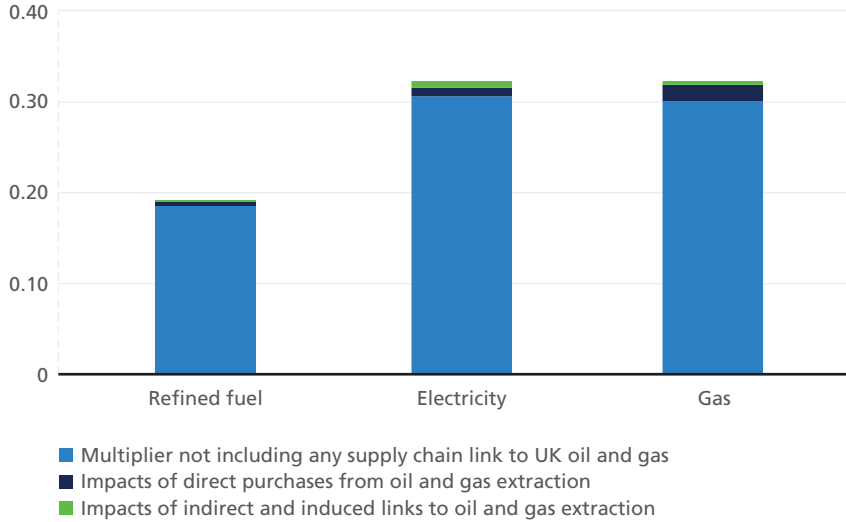Information and communication

Figure 6.4 shows the distribution of the 0.22 (220k per £1million) indirect and induced component of the 0.32 output-wage income of UK 'Gas supply' industry. Again, (as with 'Refined fuels'), the higher value jobs (as judged by average wage rates) are located in services, extraction and manufacturing industries with the UK gas supply chain proxy. This again provides the potential that, outside of the 'Refined fuels' industry itself, there is potential to absorb both the quality and quantity of jobs following a reduction in spend on refine petrol and diesel. This is despite the fact that the share of jobs and wage income sectors such as finance and insurance are smaller in Figure 6.4 relative to Figure 6.2; again this is because Figure 6.4 shows shares for a larger overall output-wage income multiplier (0.32 relative to 0.19).

Note on the declining importance of impacts in the UK oil and gas extraction industry when considering employment and wage income.

Figure 6.5 shows the impacts on the gas supply output- wage income multiplier (which here includes the direct component of 10p in the pound that is excluded from Figure 6.4) of removing the indirect and induced impacts located in SIC 6 extraction industry. It gives a comparison with 'Refined fuel' and the alternative proxy of 'Electricity supply'. Moreover, given that income generation in the off-shore oil and gas extraction industry is also driven by the use of UK oil and gas in other industries in each of the supply chains, the multiplier is also shown excluding only the impact of the target industry's own purchases.

Figure 6.5 Impacts on UK gas, electricity and refined fuel output-income multiplier of the remaining impacts of upstream supply chain reliance on UK oil and gas extraction.

■ Multiplier not including any supply chain link to UK oil and gas
■ Impacts of direct purchases from oil and gas extraction
■ Impacts of indirect and induced links to oil and gas extraction

	Refined Fuel	Electricity	Gas
Total multiplier effect	0.19	0.32	0.32
Excluding impacts of indirect and induced links to oil and gas extraction	0.187	0.313	0.305
	2%	3%	6%
Excluding any supply chain link to UK oil and gas	0.19	0.31	0.30
	3%	5%	7%

Albeit to a lesser extent than output or value added in Chapter 4, for both electricity and gas supplies, particularly the latter, the impact of discounting these elements is noteworthy. Nonetheless, the multipliers are still larger than that for refined fuel, with or without these elements included (and the impact of removing them is less). **If focus is on number of FTE employment, given the low labour (but relatively high wage) intensity of the off-shore industry, the impact on the multipliers of removing off-shore elements from the multipliers falls to less than 1% in all three industries.**

To more fully consider the alternative hydrogen supply proxy of the current electricity industry, Figure 6.6 shows the composition of the indirect and induced (7.11 FTE jobs per £1m) component of the 8.05 'Electricity supply' industry output-employment multiplier. The first thing to note is that while the overall multiplier is similar to that of the gas supply proxy, the indirect and induced (rather than direct) elements are more important in the case of electricity supply. However, Figure 6.6 demonstrates that the sectoral composition of the indirect and induced components is similar for gas and electricity. The main visible difference between Figures 6.3 and 6.6 for the gas and electricity proxies is the greater proportionate importance of manufacturing

in the latter. However, again, it should be noted that Figure 6.6 is a distribution for a smaller number of indirect and induced jobs.

Figure 6.6 Composition of indirect and induced supply chain employment requirements for the UK Electricity sector.
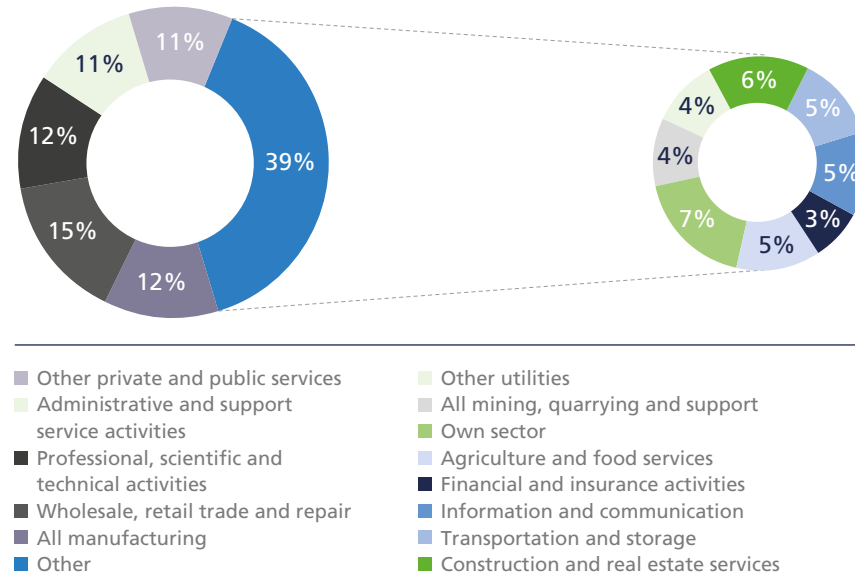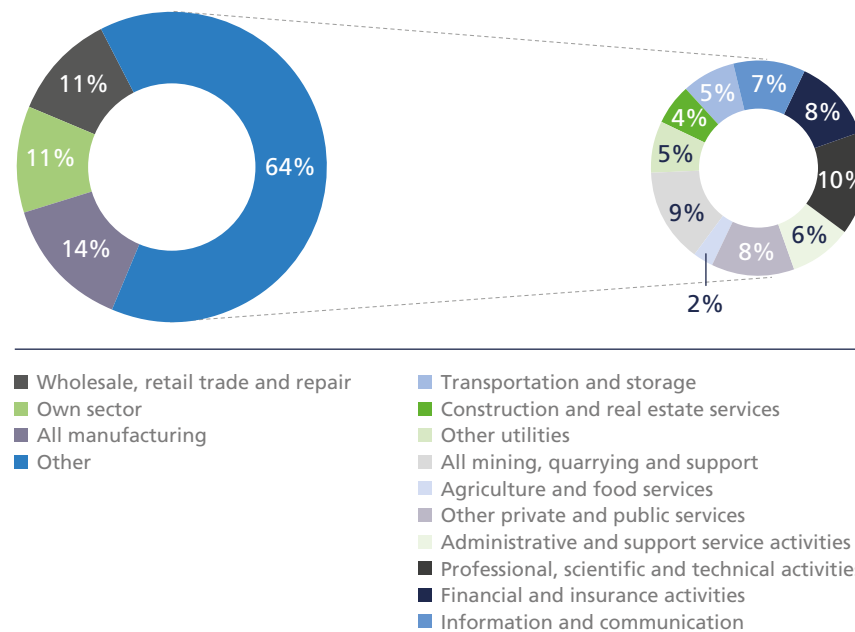

- ◼ Other private and public services
- ◼ Administrative and support service activities
- ◼ Professional, scientific and technical activities
- ◼ Wholesale, retail trade and repair
- ◼ All manufacturing
- ◼ Other

- ◼ Other utilities
- ◼ All mining, quarrying and support
- ◼ Own sector
- ◼ Agriculture and food services
- ◼ Financial and insurance activities
- ◼ Information and communication
- ◼ Transportation and storage
- ◼ Construction and real estate services

Figure 6.7 Composition of indirect and induced supply chain wage-income requirements for the UK Electricity sector.

- ◼ Wholesale, retail trade and repair
- ◼ Own sector
- ◼ All manufacturing
- ◼ Other

- ◼ Transportation and storage
- ◼ Construction and real estate services
- ◼ Other utilities
- ◼ All mining, quarrying and support
- ◼ Agriculture and food services
- ◼ Other private and public services
- ◼ Administrative and support service activities
- ◼ Professional, scientific and technical activities
- ◼ Financial and insurance activities
- ◼ Information and communication

In terms of wage income, the overall output-wage income multiplier for the electricity proxy is almost identical to that of gas, at 0.32, or £320k per £1m of final demand spending. However again, there is variation in terms of both the contribution and nature of indirect and induced elements therein. For electricity, the indirect and

induced element is 0.26 (260k per £1million, compared to 0.22 for gas). However, Figure 6.7 demonstrates the broad similarities in terms of the industrial composition of indirect and induced impacts, with the main differences being in terms of the greater role of 'own sector' impacts in the case of electricity and slightly larger relative contribution of mining/mining support in the case of the gas proxy. This reflects the findings reported above in Figure 6.5, where the impacts of removing the SIC 6 off-shore oil and gas extraction (a component of mining/support in Figure 6.7) are slightly larger in the case of the gas supply proxy.

Comparing Figures 6.6 and Figure 6.7 (employment and wage income respectively), the key point to note is that **the contribution of manufacturing, own sector and other utilities is greater when wage income rather than employment is the focus of attention**. This reflects the given relative high average wages in these sectors. **On the other hand, the contribution of service industries, particularly agriculture, wholesale/retail and administrative services contracts if income from rather than employment itself is considered, reflecting lower wage intensities**. Thus, in terms of the quality of employment (as reflected in wage levels and contribution to value-added) this reflects the different nature of the manufacturing, service and other (particularly utilities/mining) to the hydrogen economy.

6.4 NET MULTIPLIER EFFECTS OF A SHIFT IN FUEL SOURCE FOR TRANSPORTATION (EMPLOYMENT AND WAGE INCOME)

As highlighted above, and assessed for output and value-added in Chapter 4 (Section 4.4) it is necessary to consider the *net impacts* of shifting from the use of petrol and diesel to hydrogen in running vehicles, rather than focussing on the potential gross impacts of spending on hydrogen as a fuel. Therefore, analogous to Section 4.4, this section considers the net economy-wide impacts of a pound for pound (£million for £1million) shift in spending between petrol diesel (as outputs of the 'Refined fuels' industry) to hydrogen to run vehicles (considering both gas and electricity proxies). Again, the key point to note is that 'Refined Fuels' has the lowest multipliers (both output and value-added in Chapter 4, and employment and wage income here) of all 103 UK industries. Thus, the total net impact of reallocating spending towards any other UK produced good or service (rather than imports) will result in a net positive impact on employment and wage income earned across the UK economy. However, there will be sectoral 'winners' and 'losers'.

Using the examples of a pound for pound reallocation of fuel spending, the first step in assessing the net impacts on the UK economy may simply involve using the headline multipliers for refined fuel in comparison to hydrogen supply proxy industries. The direct/total output-employment multiplier for the gas and electricity supply proxies (respectively 8.05 FTE and 8.04 FTE jobs per £1million of final spending) are both relatively high compared to that for the 'Refined Fuels' industry (2.9 FTE per £1million). **Thus multiplier results suggest a positive overall boost in UK employment and wage income for every pound or £million reallocated of spending between refined fuel and either hydrogen proxy**. The difference between total multiplier values suggests that any £1million reallocated from 'Refined Fuels' to hydrogen, this

will lead to 5.12 FTE jobs created across the UK economy if the electricity proxy is used, or 5.11 FTE jobs based on the gas supply proxy.

Similarly, for wage income, using the headline multipliers for the Refined Fuels industry against the gas or electricity proxies for hydrogen, a net potential boost to wage income from a £1million reallocation of spend would be around £0.132m under either proxy (£132,226 with gas and £132,072 with electricity). The headline results are decomposed in Table 6.2.

However, it is crucial to focus in on industries within the groupings in Table 6.2 where there may be potential gross losses in employment and wage income. Therefore Table 6.1 shows that the shift to either proxy (gas or electricity) is likely to result in net negative impacts in a few manufacturing industries, primarily the 'Refined Fuels' sector itself. In this industry 0.4 of an FTE job will be lost for every £1million reduction in final demand for output (again, this does not include taxes or distribution margins). To provide some idea of scale, in 2010, UK households spent £6,556million on the output of the 'Refined fuels' sector.

Table 6.1 Identification of industry location and magnitude of potential gross losses from the shift from petrol/diesel to hydrogen.

		Employment		Wage	
SIC	Sectors names	Refined fuel to Electricity proxy	Refined fuel to Gas proxy	Refined fuel to Electricity	Refined fuel to Gas proxy
10.4	Manufacture of vegetable, animal oils and fats	0.00	0.00	-£2	-£7
19	Manufacture refined petroleum products	-0.40	-0.41	-£10,184	-£10,242
20.3	Manufacture of industrial gases	0.00	0.00	-£91	-£141
20.4	Manufacture of petrochemicals	0.00	0.00	£43	-£823

Source: Author's calculations based on UK input-output data produced by the Fraser of Allander Institute.

However, more generally, Table 6.1 focuses on gross losses only. In Table 6.2 the net impacts for all industries groupings were included, the results in each column would sum to the total net increases derived from the headline multipliers above. Table 6.2 shows that the utility industries gain most. In terms of employment and wage income if gas supply is used as proxy for hydrogen supply, while services industries (particularly wholesale/retail and information/communication services) gain more under the electricity supply proxy. **However, under either hydrogen supply proxy, employment or wage income impacts in service industries are again revealed as important in considering the nature of the hydrogen economy.**

Table 6.2 Net impacts on UK industry groupings of a £1million reallocation of final spending from petrol/diesel to hydrogen.

		Employment		Wage	
SIC	Sector name	Refined fuel to electricity proxy	Refined fuel to gas proxy	Refined fuel to electricity proxy	Refined fuel to gas proxy
01–03, 67,68	Agriculture and food	0.17	0.15	£3,175	£2,905
04–07	All mining, quarrying and support	0.23	0.20	£17,390	£19,583
19	Manufacture of refined petroleum products	-0.40	-0.41	-£101,838	-£102,418
08–48	All other Manufacturing	0.63	0.30	£24,915	£11,718
52–57	Other utilities	1.66	2.41	£97,992	£124,301
58,77,78	Construction and real estate services	0.23	0.28	£6,255	£7,768
49–51, 59,60	Wholesale, retail trade and repair	0.60	0.41	£16,187	£11,325
61–66	Transportation and storage	0.18	0.15	£7,103	£5,909
69–73	Information and communication	0.23	0.19	£11,377	£9,541
74–76	Financial and insurance activities	0.09	0.07	£9,688	£7,013
79–85	Professional, scientific and technical activities	0.56	0.46	£17,193	£14,023
86–92	Administrative and support service activities	0.48	0.50	£9,588	£9,650
93–103	Other private and public services	0.47	0.40	£13,047	£10,909
	Total	5.12	5.10	£132,072	£132,226

Source: Author's calculations based on UK input-output data produced by the Fraser of Allander Institute.

6.5 ENABLING THE USE OF HYDROGEN AS A FUEL: POTENTIAL FOR EMPLOYMENT AND WAGE-INCOME EXPANSION IN THE UK

The analysis above assumes a pound for pound reallocation of spending between petrol/diesel and hydrogen fuels. However, it is not necessary in general to make this assumption while working with multipliers. Chapter 4 (Section 4.5) discussed the potential for expansion in the UK vehicle manufacturing industry if funds saved from spending on petrol/diesel not required for hydrogen fuels may be reallocated to spending on vehicles. More generally, however, hydrogen-ready vehicles are necessary to enable the use of hydrogen fuels. Therefore, it is appropriate to consider

potential multiplier impact if the UK vehicle manufacturing industry is able to exploit opportunities to increase domestic sales (and/or exports) of hydrogen-ready vehicles. This is done using the existing (2010) multipliers for 'Manufacture of motor vehicles, trailers and semi-trailers' industry (SIC 45), while noting that some adjustment in input mix may be required in shifting from production of petrol/diesel run cars to hydrogen-ready ones.

As previously discussed in Chapter 4, there is potential for expansion in output and value added in the UK vehicle manufacturing industry to enable the use of hydrogen fuel in transportation. This also has potential to create new FTE jobs through specialization and in support of potential increased domestic and export demand as the market for UK branded hydrogen vehicles becomes appealing to domestic and foreign households.

The headline output-employment and output-wage income multiplier for the UK vehicle manufacturing industry are identified as 13.6 FTE jobs and 10.4 per £million supported throughout the UK economy. To get some idea of scale, taking the 2010 export demand of £23,621million for goods produced in the UK vehicle manufacturing industry, and applying the output-employment multiplier, there is a total of 321,463 FTE jobs directly supported (75,480), indirectly required through supply chain linkages (160,573) and induced through spending of labour income (85,410) as a result of this export demand.

Figure 6.8 Composition of indirect and induced supply chain employment requirements for the UK Motor Vehicles sector.

- Other private and public services
- Professional, scientific and technical activities
- Wholesale, retail trade and repair
- All other manufacturing
- Other
- Transportation and storage
- Construction and real estate services
- Electricity, gas, water and waste
- All mining, quarrying and support
- Own sector
- Agriculture and food services
- Administrative and support service activities
- Financial and insurance activities
- Information and communication
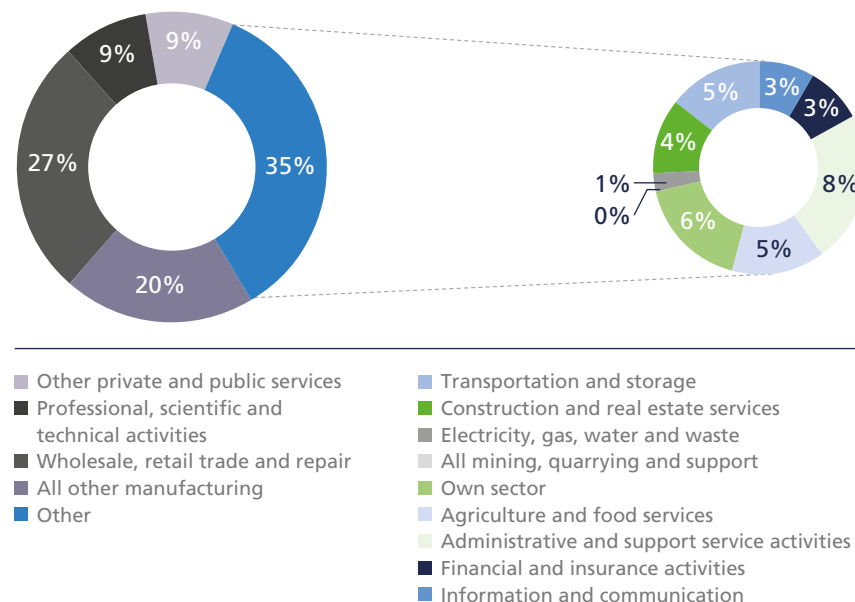
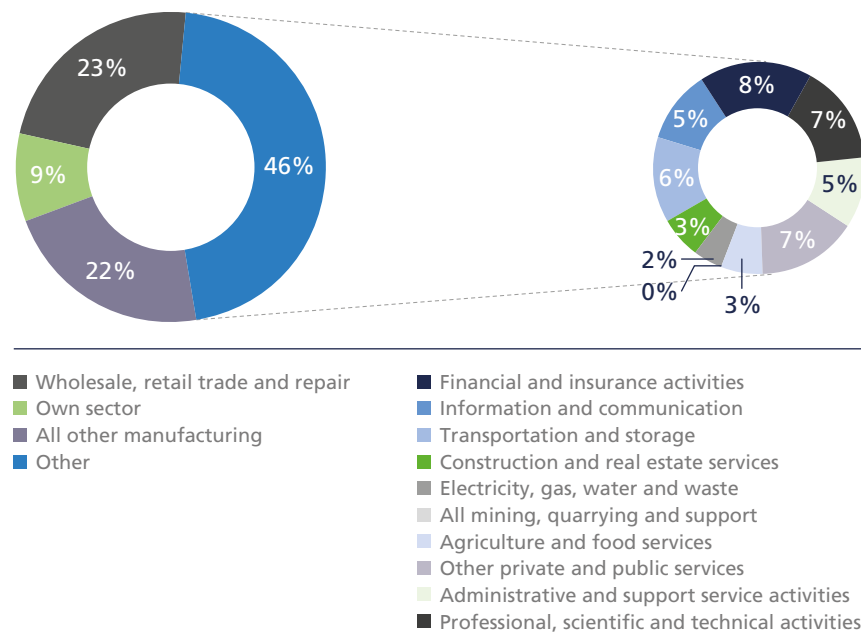To consider the potential marginal impacts of a net increase in demand (foreign or domestic) for UK vehicles, Figure 6.8 shows where the 10.4 indirect and induced elements/components of the total 13.6 FTE jobs per £1million of final demand spending are located within the UK motor vehicle supply chain (other 3.2 jobs are direct). The main thing to note is that, while there are similarities in terms of the share located in

'own sector' and other manufacturing, the distribution of supported employment is somewhat different to what was found for output and valued added in Figure 4.8 and Figure 4.9 in Chapter 4. Again, this is due to differences in labour intensity, and the importance of service sectors is more pronounced in the decomposition of supported employment. In particular, 27% of indirect and induced employment is located in the 'Wholesale, retail trade and repair' industry which provides distribution and repair services. This contrasts with only 17% of output and 20% value-added in Chapter 4. On the other hand, while the share of employment in higher value-added sectors under the 'Professional, scientific and technical services' grouping is high relative to output, the share located in financial and insurance activities is low relative to the findings for output and value-added. **However, in general, service sector employment is clearly important in the car manufacturing supply chain.**

On the other hand, if attention focuses on wage income from employment rather FTE jobs, the importance of relatively high wage service sectors, such as finance and insurance, increases. Moreover, the higher wage rates associated with manufacturing jobs more generally push up the share located in own sector and other manufacturing to 31%, compared to 26% of employment. If higher wage rates are reflective of skills levels, this result does imply that it **will be important to focus attention on building skills to support the transition to a successful vehicle manufacturing industry in a hydrogen economy.** However, the results also imply that **attention must also be given to ensuring appropriate skills in to ensure capacity in the supporting service industries**.

Figure 6.9 Composition of indirect and induced supply chain wage-income requirements for the UK Motor Vehicles sector.

- ■ Wholesale, retail trade and repair
- ■ Own sector
- ■ All other manufacturing
- ■ Other
- ■ Financial and insurance activities
- ■ Information and communication
- ■ Transportation and storage
- ■ Construction and real estate services
- ■ Electricity, gas, water and waste
- ■ All mining, quarrying and support
- ■ Agriculture and food services
- ■ Other private and public services
- ■ Administrative and support service activities
- ■ Professional, scientific and technical activities

6.6 EMPLOYMENT AND WAGE INCOME LINKED TO UK INDUSTRIES THAT MAY BE DIRECT 'INVESTMENT' TARGETS IN FACILITATING THE SHIFT TO A HYDROGEN ECONOMY: FOCUS ON R&D AND CONSTRUCTION

A key point raised in Chapter 4 (section 4.6.1) is that R&D will play an important role in move to a hydrogen economy. This is from initial exploratory stages of understanding how different required elements of hydrogen supply and use may work to more advanced and sustained hydrogen base in the energy system. At all stages, this will involve direct private and public investment in R&D to facilitate a strong domestic hydrogen-economy and developing comparative advantage in international energy systems and markets. Therefore, understanding indirect and induced employment requirements within the supply chain of the 'Scientific research and development' (SIC 72) is important. This industry already features in the analysis above of energy supply chains, as part of the 'Professional, scientific and technical activities' grouping (which also includes activities such as architectural services and advertising). As per Section 4.6.1, activity in the R&D industry that features in output, employment etc. supported by demand for other industries is part of the operational or routine spending of the driving industry. However, the current section is concerned with the employment and wage income impacts if a boost to R&D activity is required to enable a major step-up in capability and/or capacity in the context of the shift to a hydrogen economy. Again as per Section 4.6.1, this includes, but is not be limited to, any R&D required to make activities like CCS a reality and would require additional spending, potentially in the form of government and/or non-profit sector final spending.

Figure 6.10 Composition of indirect and induced supply chain employment requirements for the UK Scientific Research and Development sector.

- ■ Other private and public services
- ■ Administrative and support service activities
- ■ Professional, scientific and technical activities
- ■ Wholesale, retail trade and repair
- ■ Other
- ■ Construction and real estate services
- ■ Electricity, gas, water and waste
- ■ All mining, quarrying and support
- ■ Own sector
- ■ Agriculture and food services
- ■ All manufacturing
- ■ Financial and insurance activities
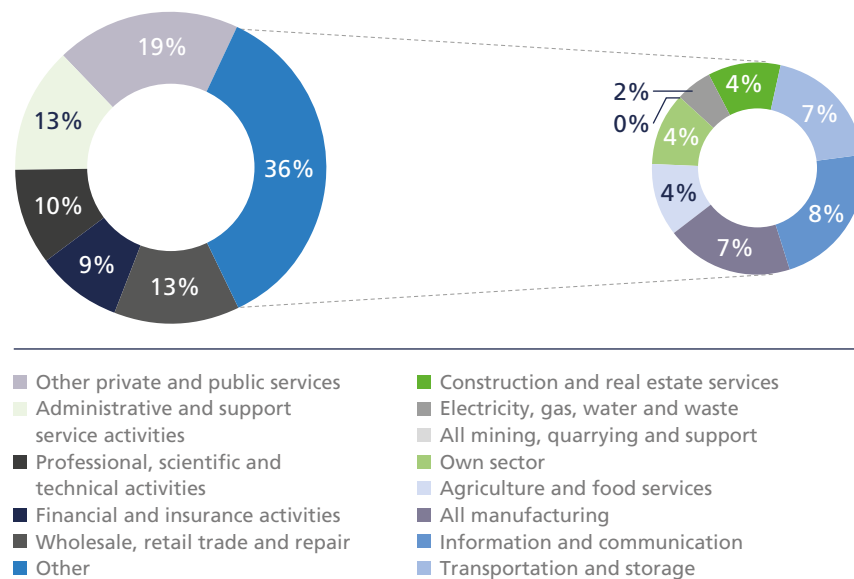- ■ Information and communication
- ■ Transportation and storage
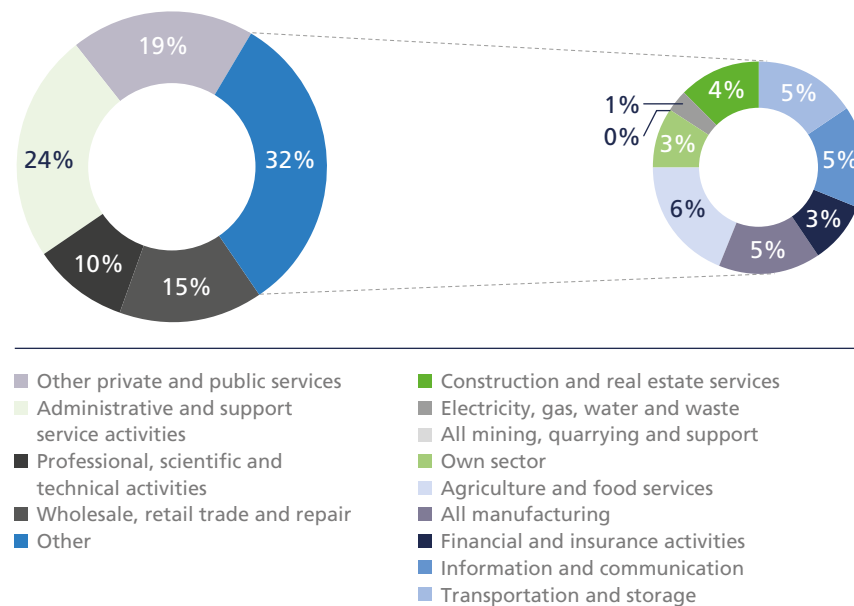
As noted in Chapter 3, the UK R&D industry has a relatively high employment intensive supply chain, with its output-employment multiplier of 25.31 FTE jobs per

£1million of final demand ranking 16th among the 103 UK industries. While this is a lower ranking than for its value-added or wage income multipliers, where it ranks second only to the UK Education sector, it is still a relatively high and important supply chain employment multiplier. On the other hand, the point made in Section 4.6.1 that the timeframe over which any boost to activity in R&D will last and thereby impact employment throughout the wider economy must be considered in applying multiplier results in 2 scenerio analysis.

Figure 6.10 shows the results of decomposing the indirect and induced employment components (13.64 FTE jobs) of the total 25.31 output-employment multiplier per £1million spend on UK R&D. Before considering the results in Figure 6.10 **Note that around half of the jobs supported are direct within the R&D industry itself**. In terms of the indirect and induced effects captured in Figure 6.10, **once again there would be an important boost in employment particularly across services industries within the R&D industry supply chain**. Most noticeable is the share of induced and indirect employment in the 'Administrative and support service activities' and 'Other public and private service' industry groupings, which together account for 43% of the total. This contrasts with the findings for output and value-added in Section 4.6.1 where the corresponding shares were 26% and 29%. This finding, combined with the importance of other professional, scientific and technical activities and the wholesale/retail industries is important in terms of the diversity of job creation to support R&D activity to build a hydrogen economy in UK universities and research institutes. While it cannot be fully examined here (using a single country input-output model), it is important to note that any expansion in capacity of R&D provides the potential to boost both GDP and employment with further allocation of spend linked to international collaboration with other countries with similar hydrogen vision.

Figure 6.11 Composition of indirect and induced supply chain wage-income requirements for the UK Scientific Research and Development sector.

- Other private and public services
- Administrative and support service activities
- Professional, scientific and technical activities
- Financial and insurance activities
- Wholesale, retail trade and repair
- Other
- Construction and real estate services
- Electricity, gas, water and waste
- All mining, quarrying and support
- Own sector
- Agriculture and food services
- All manufacturing
- Information and communication
- Transportation and storage

In the case of wage income associated with employment, the R&D direct wage income multiplier value of 0.99 per £1million is ranked the second highest wage-income multiplier across all 103 UK industries. **Again, most of this is direct and, reflecting a relatively high average wage rate in the R&D industries**, so that only 0.41 (410k per £1million) of the total 0.9 wage income multiplier is associated with the indirect and induced components in Figure 6.11. **As with employment, the distribution of wage income supported in the R&D supply chain is concentrated in service industries**. However, comparing Figure 6.11 with 6.10 the importance of higher wage sector, such as in the 'Financial & insurance activities' grouping is higher.

The second industry identified in Chapter 4 (Section 4.6.1) that is likely to be a direct recipient of investment spending to enable the shift to a hydrogen economy is UK Construction (SIC 41–42, including civil engineering and specialised construction services as well as building activity). It is important to note that the impacts of increased Construction activity may not last much longer than the project in question. However, given the scale of the shift required, there may be many substantial projects that take a number of years to complete.

Figure 6.12 shows the results of decomposing the indirect and induced components (11.2 of a total 19.2) of the UK construction industry output-employment multiplier. Figure 6.13 then considers the related indirect and induced wage income content, that is the 0.36 (360k per £1million) of the total 0.57 multiplier for wage income that is not directly generated in the construction sector itself.

Figure 6.12 Composition of indirect and induced supply chain employment requirements for the UK Construction sector.
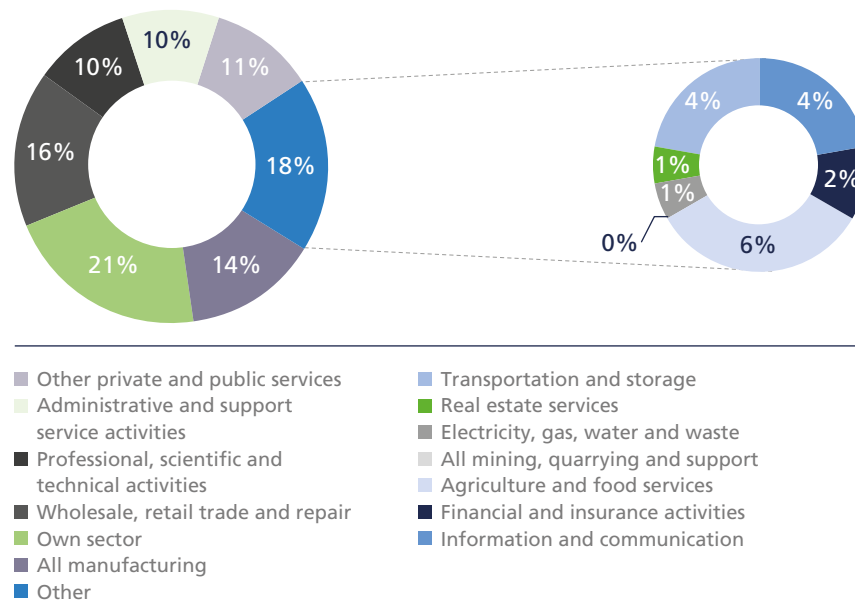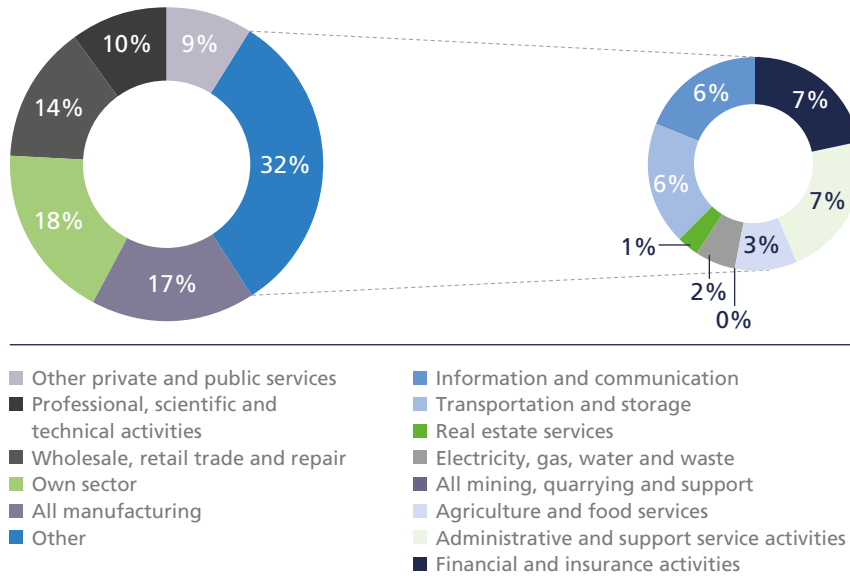

- Other private and public services
- Administrative and support service activities
- Professional, scientific and technical activities
- Wholesale, retail trade and repair
- Own sector
- All manufacturing
- Other
- Transportation and storage
- Real estate services
- Electricity, gas, water and waste
- All mining, quarrying and support
- Agriculture and food services
- Financial and insurance activities
- Information and communication

Figure 6.13 Composition of indirect and induced supply chain wage-income requirements for the UK Construction sector.

- ■ Other private and public services
- ■ Professional, scientific and technical activities
- ■ Wholesale, retail trade and repair
- ■ Own sector
- ■ All manufacturing
- ■ Other
- ■ Information and communication
- ■ Transportation and storage
- ■ Real estate services
- ■ Electricity, gas, water and waste
- ■ All mining, quarrying and support
- ■ Agriculture and food services
- ■ Administrative and support service activities
- ■ Financial and insurance activities

A key point to note from in Figure 6.12 is that any £1 million spend on the UK 'Construction' industry will boost UK employment particularly in the service industries, with the only other notable areas being indirect own sector (21%), which may (as discussed in Section 4.6.1. reflect an over-aggregation of construction activities, and manufacturing (14%).

Similarly, Figure 6.13 demonstrates that **positive impacts on wage income generated through the UK supply chain will be concentrated in the service industries**, with the distributions comparted to that in Figure 6.12 being explained by differences in average wage rates. Generally in this respect, Figure 6.13 reflects a slight drop in the quality of jobs (as judged by wage income) in the service industries with **higher wage effects being located in the manufacturing industry and selected service industries (e.g. 'Financial and insurance activities' and 'information & communication')**.

6.7 CONCLUSIONS

This chapter has focussed on examining the employment and wage income embedded in the supply chains of UK industries that are likely to be directly impacted through the three key economic phases identified in Chapter 3 as likely for the UK economy to move through in realising the actualisation of a hydrogen-economy. It has done so in a similar manner to the analysis of output and GDP in Chapter 4. This is by examining the composition of industry level multipliers in terms of full-time equivalent (FTE) employment and associated wage income in different UK industries required or supported by key industries that are identified as direct players in the 'hydrogen economy'. Again, as per Chapter 4, the analysis in this Chapter has also highlighted whether any boost to activity in a given sector is likely to be temporary (investment activity) or on-going (operation of the hydrogen economy).

In terms of employment and wage income supported in fuel supply chains, again **the central argument of the analysis is the need to consider the *net impacts* of moving away from petrol and diesel in transport activity (thereby triggering a contraction in the relevant supply chain) and towards hydrogen based fuel.**

The key finding of Chapter 4 was that, provided actual hydrogen supply shares the type of relatively strong UK supply chain linkages of current gas and electricity supply, net impacts on the UK economy are likely to be significantly positive. This finding applies throughout Chapter 6 as well, but with focus on the location of employment and wage income impacts.

The key distinction in particularly the employment results reported here is that a much smaller share of positive and negative impacts from a shift in the fuel supply originate in the off-shore oil and gas industry. This is because of a relatively low labour intensity. However, when attention turns to wage income, the impacts in the off-shore industry become more important albeit to a lesser extent (due the high capital intensity of the oil gas extraction industries) compared to output and value-added in Chapter 4.

The other key argument emerging from the employment and wage income multiplier analysis in this chapter, but this time corresponding with the output and value-added results in Chapter 4, **is the importance of impacts in UK service sector industries**. Thus, the findings suggest a need to ensure that attention to development of the UK skills base to enable a hydrogen economy includes attention to required service sector provision.

Although numbers of jobs and GDP enhancement figures are given in the various analysis sections, it would be dangerous to take those figures as being literal predictions. Modelling would need to be more sophisticated than herein and able to capture aspects of HFC such as it being a more distributed economic activity than the current UK refined fuels model. As noted elsewhere that factor alone is likely to mean that the figures given are underestimates. The main feature however is clear, that subject to qualifications, a transition to hydrogen from traditional refined road fuels can be expected to result in significant increases in UK economic activity, value creation and employment. This has not previously been assessed/considered.