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Making the macroeconomic case for near term action on CCS in the UK? The current state of economy-wide modelling evidence

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Key Messages:

- Developing an **economic narrative** on the role of CCS (Carbon Capture and Storage) in the wider economy will help extend the current policy debate to involve a wider stakeholder audience – this is critical if we are to move the discussion forward.
- The most compelling narrative at this stage in the UK policy context may be the **'sustained contribution' narrative**, which focusses on **the potential role of CCS in enabling the sustained contribution of sectors where we have already invested, from which we currently realise value, and from which we need to realise growing value.** This relates directly to themes in the UK Industrial Strategy.
- Two types of industries are particularly relevant to this narrative: the **energy-using/emitting industries** that may engage in CO_2 capture, and the fossil fuel supplying **oil and gas industry**, where much of the **skills, expertise and physical infrastructure** that would be required **to set up a CO_2 transport and storage network already exist**.
- From our initial exploration of the evidence, we suggest that due to their capital intensity, **jobs are difficult to create in CCS-relevant industries**, while, due to the strength of their domestic upstream supply linkages, the **loss of any one job is likely to have relatively large knock-on negative effects on other jobs**.
- Experimental work on **price pressures** suggests important but potentially very different patterns of **how and by whom CCS may ultimately be 'paid for'**. Where there may be impacts on the competitiveness of high value industries in some contexts and on consumer energy bills in others, these would have very different economic and political implications.

The views expressed herein are those of the author

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1. Developing a narrative to build public, policy and industry understanding of the potential wider economic impacts of Carbon Capture and Storage (CCS)

In a previous comment[1] on 'Making the Macroeconomic Case for CCS' we focussed on the challenge of engaging Government departments concerned with wider economic affairs, including national treasuries, in consideration of the merits of any form of public support for CCS. For these actors, CCS may seem a complex, expensive pollution control system that requires extensive up-front investment and adds to production costs.

Bringing these stakeholders into the conversation around CCS is critical to moving the debate forward and establishing a credible pathway for the CCS deployment implied by our climate change policies. Ultimately, this is likely to involve incorporating carbon capture, transport, storage and potential utilisation activities within the type of modelling frameworks familiar to and trusted by economic affairs and finance ministry actors for the assessment of (often competing) policy options.[2] However, a useful first step is to consider the type of economic narratives and metrics that wider stakeholder consensus may build around to inform evidence (including modelling) needs as we move towards near term decision points, such as the sixth UK Carbon Budget (in 2020).

The Industrial Strategy is the key anchor for any economic narrative in the UK. Coupled with the Clean Growth Strategy, the Industrial Strategy sets the long-term strategic framework for industrial, infrastructure and economic policy.[3] To move forward, CCS decisions, including the timing of fully considering the case for and potentially taking action on CCS in different sectors and regions of the country, must integrate with this policy framework. The Industrial Strategy recognises that firms and policymakers need to work together to address the dual challenges of decarbonisation and enhancing productivity and competitiveness. This is set in an economic context that requires focus on safeguarding and creating high quality jobs, ensuring downstream competitiveness and building up domestic supply chain capacity and capability.

So what kind of potential narratives are we looking at? Our project identified various forms, each of which relate to sources of potential direct or indirect value associated with the introduction of CCS. First, we have considered the potential for direct economic value which may arise from, either, the capture and potential use of CO_2, or developing capacity and capability in delivering transport and storage services. However, we also focused on how indirect value may be of more fundamental importance in that CCS may enable the continued

[1] Turner and Race (2016).
[2] See HCCPA (2017) and HCEAC (2016) on the need for UK BEIS and HM Treasury (HMT) to "agree a way of appraising the costs and benefits of energy policies" (HCCPA, 2017, p.7) and the potential role of economy-wide CGE modelling used by HMT to assess a wide range of potential and actual policy actions at sectoral/market level and/or macroeconomic level (see, for example, HMRC, 2013; HMRC/HMT, 2014).
[3] HM Government (2017a,b)

performance of existing high value sectors and/or areas with high innovation potential. While the latter is important – including but not limited to the potential role of hydrogen in decarbonising our heating needs – a key outcome emerging from our stakeholder engagement is that it is the former that may constitute the key driver for moving forward consideration of CCS in the near term.

The key point emerging is **the potential role of CCS in enabling sustained contribution of sectors where we have already invested, which we currently realise value from, and from which we need to realise growing value**. This relates directly to themes in the UK Industrial Strategy, where emphasis is placed on building low carbon prosperity on a platform of the things that already contribute to our success.

2. What might be important in a 'sustained contribution' narrative?

Our stakeholder discussions focussed on how CCS enables continuation of two broad types of industrial activity.

The first is energy-using industries currently subject to various climate policy instruments. Over time, least-cost decarbonisation options for these industries may include changes in production methods, for example, to use 'green' gases, which may or may not involve CCS at some point in the feedstock supply chain; however, currently firms are faced with paying for or reducing emissions into the atmosphere. This suggests a potential role for CCS, where integration with a broader industrial strategy framework requires focus on what it may offer in terms of building on what we already do well and making that as competitive as possible to drive exports and both retention and creation of high value jobs. Given the system requirements of CCS, it also suggests a focus on sectors where regional clustering may provide economies in all elements of the carbon capture, potential use, transport, and storage chain.

In this regard high value innovative industries such as petrochemicals with key existing sites in areas such as Teeside, Chester and Grangemouth emerge as key areas of focus for CCS, where policy attention is already focussed on issues such as the competitiveness and productivity of feedstock supply chains. Moreover, the current picture of evolving clusters in high value activities provides opportunities for stimulating innovation in areas identified in the other narratives considered in this project, such as enabling a hydrogen industry and providing further opportunities to leverage existing activity to address multiple policy objectives.

The second type of existing industrial activity where CCS could potentially enable continued generation of economic value is the oil and gas industry. This is both in terms of continued demand for the fossil fuel output of what is one of the most productive sectors of the UK

economy, and how the physical and skills assets of the oil and gas industry may be utilised in the move towards a low carbon economy. A key issue for CCS is that much of the skills, expertise and physical infrastructure that would be required to set up a carbon transport and storage network already exist within the oil and gas industry.

From a UK industrial and fiscal policy perspective, a key implication is that the development of a domestic CCS network could potentially provide a continued and additional return to the already considerable UK Government investment made in the North Sea since the 1970s. It would also impact the required programme of decommissioning over the next few decades. Thus, again, there is potential to leverage advantage from a key existing sector in terms of both continuing to generate value (albeit with recognition that injection of CO_2 into North Sea fields is a lower value activity than extracting oil and gas) and driving innovation in new infrastructure and production capacity.

3. How can we assess the importance of sustaining such activities to the wider economy?

Economy-wide impact analysis is fundamental to considering how different sectors of the economy interact with and depend on each other, and what role CCS may come play in this regard. The Centre for Energy Policy has proposed research to address the challenge of more effectively bringing economic policy actors into the CCS conversation through introduction of carbon capture, transport and storage as service activities within a multi-sector economy-wide 'CGE' model.[4]

Such research would support quantification of how different configurations and capacities of CCS may add or subtract value in different areas of the economy over timeframes of interest to both economic and energy/climate policymakers. It would do so by incorporating 'bottom up' information from engineering techno-economic models on the costs and characteristics of services provided via carbon capture, transport and storage activities. It would involve scenario analysis including (but not limited to) consideration of issues such as:

- economy-wide implications (social opportunity costs) of devoting resources to CCS (in terms of additional multiplier but also displacement effects), set alongside the relative (private and social) costs of current climate and energy policy interventions;
- the impact of different potential policy actions to reduce risk elements of cost by making sure timely transport and storage provision is available for all CO_2 captured;

[4] A CGE model is a large-scale numerical economy-wide model that simulates the core economic interactions between different sectors, actors and markets. HM Treasury uses a CGE model outlined in HMRC (2013) and applied in HMRC/HMT (2014).

- the potential impacts of emerging 'markets' for utilising captured carbon and/or transport and storage services.

Generally, such an economy-wide analytical focus would complement both engineering-focussed CCS projects and a wider range of analyses on energy affordability, security and CO_2 emissions.

However, this research has yet to be given the 'go ahead'. So what can be done at this stage to build consensus on the potential economic role of CCS and what action may be required in the very near future to support consensus-building?

The immediate need is to shift the policy discourse on how the potential role of CCS in our economy and society is assessed, understood and communicated. The discussion in the first two sections of this Policy Brief suggests that the best starting point may be common concerns regarding the continued performance and growth of things we already do well. We have labelled this a 'sustained contribution' narrative, and a solid starting point is to consider metrics that communicate the extent and nature of value we currently realise from those energy-using industries that may capture CO_2 and from the oil and gas industry, which currently supplies fossil fuels and may be the future supplier of CO_2 transport and storage services.

In this regard, we do already have a useful and familiar analytical tool: economic multipliers are generated using the input-output (IO) tables that are produced as a standard part of our national accounts. IO tables report transactions occurring between different sectors of the economy, which translate to interactions and interdependences supporting employment and the generation of value-added (GDP). Thus, we can report 'multiplier' relationships in term of total activity generated throughout the wider economy for every pound spent or person employed in any one sector. This is an approach we have previously adopted for the UK in considering CCS in the context of enhanced oil recovery (EOR) and hydrogen (H2) fuel supplies. [5]

[5] See Turner (2015) and Martin et al. (2017),

Building a dataset

There are some important problems to iron out in terms of the nature and frequency of IO data produced by the Office for National Statistics (ONS) for credible and effective multiplier analysis. [6] The industry (rather than product) level reporting required to compute multipliers for key indicators such as employment are not publicly reported by ONS. As a result, our previous analyses for EOR and H2 have relied on conversions of published data rather than official data. [7] These data may be used again here. On the other hand, given the need to develop a more solid and credible evidence base, here we draw on industry level employment multiplier data produced by ONS (for the reporting year of 2010) at the suggestion of BEIS. [8]

4. The economy-wide evidence currently available to inform the 'sustained contribution' narrative

(a) BEIS/ONS data on IO employment multipliers for UK industries

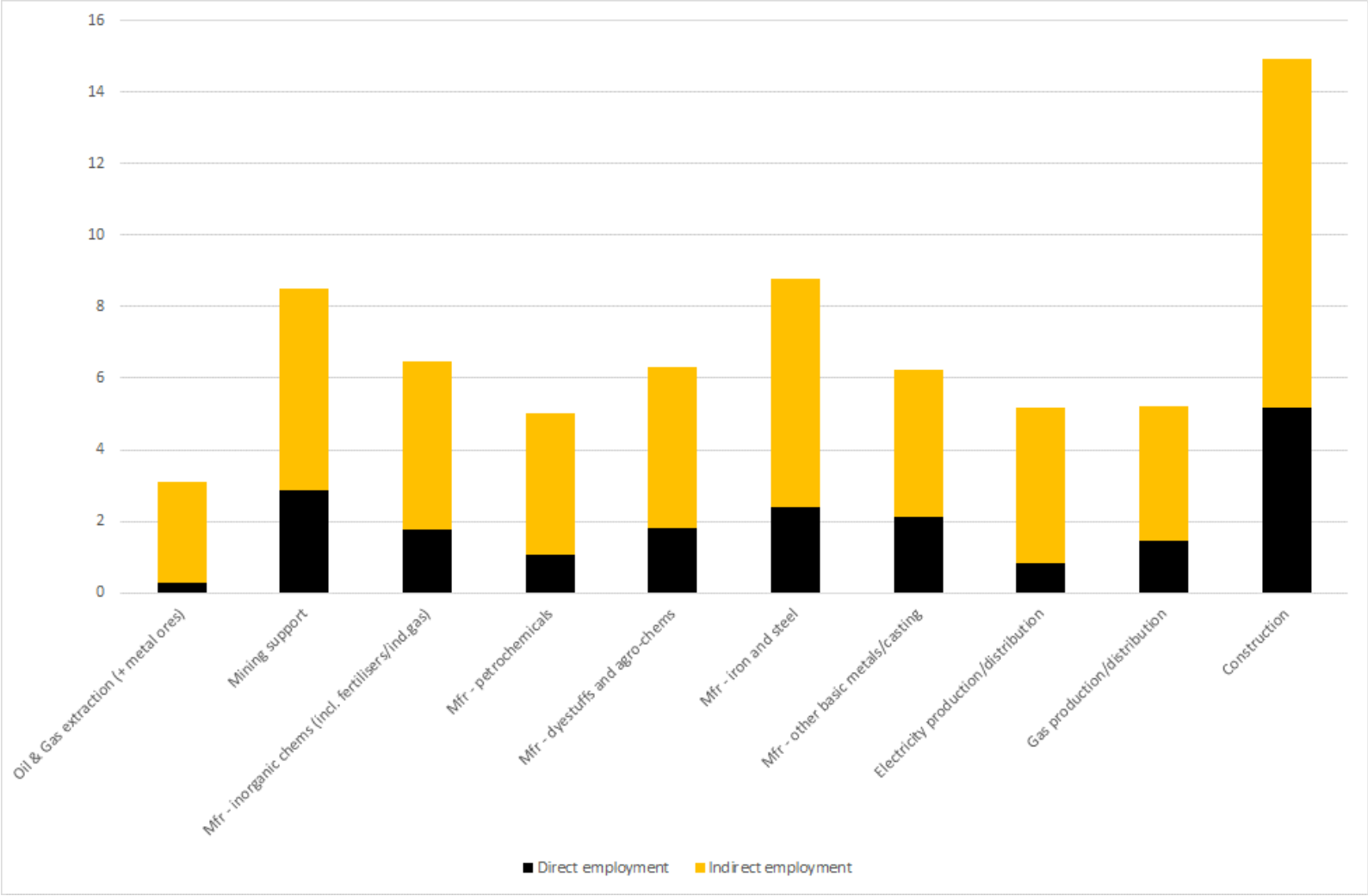
The ONS-BEIS industry level employment multiplier data set reports on two metrics[9]:

1. 'Employment effects', or what is sometimes referred to as the **output-employment multipliers**. This metric reports the total number of full-time equivalent (FTE) jobs across all UK industries required per £1million of final demand for each sector's output.
2. 'Employment multipliers', often referred to as the **employment-employment multipliers**. This metric reports (based on total employment implied by application of the multipliers in (1)) the total number of full-time equivalent (FTE) jobs across all UK industries required for every direct job in the target industry.

Both types of multipliers are reported for all 127 industries[10] identified in the UK IO framework. In Figures 1 and 2 we focus on 10 of the 127 that may be important in the context of delivery and/or use of a CCS system in the UK economy.

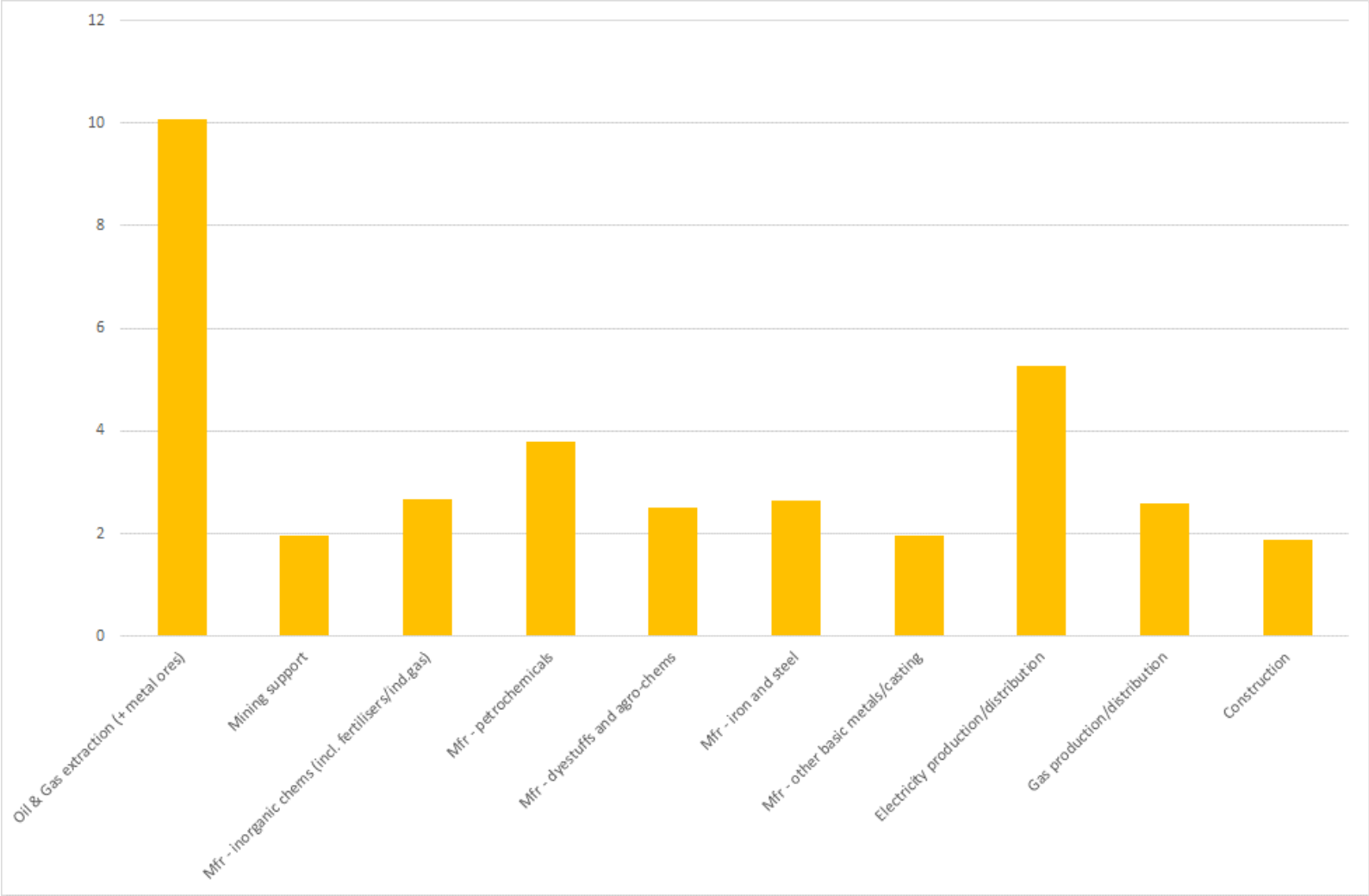
[6] Multiplier analysis requires IO data in 'analytical' format, reported by ONS at https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/ukinputoutputanalyticaltablesdetailed.
[7] Data conversions have been carried out by the Fraser of Allander Institute at the University of Strathclyde: https://www.strath.ac.uk/media/1newwebsite/departmentsubject/economics/fraser/Uk_analytical_Table.xlsx
[8] Employment multiplier data used here are available via archive at http://webarchive.nationalarchives.gov.uk/20150908115359/http:/www.ons.gov.uk/ons/about-ons/business-transparency/freedom-of-information/what-can-i-request/published-ad-hoc-data/econ/december-2014/provisional-estimates-of-type-uk-employment-multipliers-and-effects.xls.
[9] In both cases, the ONS-BEIS data focus on 'direct and indirect effects'; that is, direct jobs in the industry in question required to deliver the output and all indirect jobs associated with the upstream UK supply chain. This is often referred to as a Type I multiplier, ignoring any 'induced' or consumption and income effects generated as a result of households spending income they earn via employment. On this basis, the multipliers reported below can be taken as conservative.
[10] IO industries are classified using the Standard Industrial Classification 2007 (https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities/uksic2007).

Figure 1. Output-employment multipliers for selected UK industries: FTE jobs across the UK per £1million industry output produced to meet final demand



Source: ONS-BEIS data set for accounting year 2010. Direct/indirect split calculated using information reported in Figure 2.

Figure 2. Employment-employment multipliers for selected UK industries: FTE jobs across the UK economy per direct industry FTE job



Source: ONS-BEIS data set for accounting year 2010.

What are the key messages that emerge from Figures 1 and 2? Note the relatively small share of total employment that is direct in most of the industries in Figure 1. In the case of Oil and Gas Extraction, only around 1 in 11 of total jobs supported by the industry are directly located within the industry; in Petrochemicals the figure is around 1 in 5. This is due to relatively low direct labour intensity in what are largely capital-intensive processes in these industries. However, as we move to Figure 2, the message emerges that, **while direct jobs are hard to create, the loss of one could have large negative indirect employment impacts across the economy.** Figure 2 implies that the loss of one direct Oil and Gas extraction job could come at the cost of the loss of a further 10 FTE jobs across the UK economy. In the case of Petrochemicals, the message in Figure 2 is less dramatic; however, the (almost) 4 FTE jobs that accompany each direct job may be important in terms of the location and nature of the jobs involved.

This latter point is not something we can investigate using the ONS-BEIS data set. In terms of the **status of this type of evidence**, to consider the industry location and wage profile of supported jobs would require availability of the full underlying industry analytical IO tables. This may be a key issue as CCS deployment in a wider industrial context could play a role in generating important regional impacts that the UK and other governments may wish to see happen. In the UK context, consideration of location issues within the IO multiplier framework requires a level of regional reporting not conducted by ONS, and with the Scottish Government being the only devolved UK administration that routinely reports IO accounts. In an EU context, there has been EC Joint Research Centre (JRC) activity in producing IO accounting data at regional level across member states, including the UK, that could be utilised in future research.

(b) Previous UK IO multiplier analysis using unofficial data

Where full underlying UK national IO data are available, our previous multiplier studies for CCS linked to EOR (Turner, 2015) and hydrogen in transport fuel/energy supply (Smith et al. 2017) have shown that it is possible to decompose the type of headline multiplier metrics in Figures 1 and 2 to consider the sectoral locations of indirect jobs. Both these earlier studies (using UK IO data adjusted by the Fraser of Allander Institute) included consideration of induced effects, which depend on how UK household incomes generated through employment are spent, and thus cannot be directly related to the results above. However, key findings include the importance of service sector jobs (including those in high wage sectors like finance) particularly in the Oil and Gas Extraction industry case. Both the previous studies also extended the multiplier focus to GDP, with the H2 study also computing multipliers relating to income from employment, as a measure of the quality of jobs identified in basic employment multipliers.

In terms of the **status of this type of evidence**, given the continued availability of underlying IO data, it would be possible to extend and tailor work from the Turner and Smith et al. studies to the focus identified here within a short timeframe. The quality and credibility of results would be enhanced if researchers were given access to the full data underpinning the ONS-BEIS results reported in Figures 1 and 2, or, ideally, equivalent data for a more recent accounting year (ONS have constructed IO data for the UK up to 2015).

(c) Experimental 'price multiplier' work

Policymakers are most familiar with the type of up-stream focussed multipliers reported in Figures 1 and 2. However, it is also possible to generate multipliers with a down-stream focus. These may be particularly useful in terms of identifying price pressures throughout the economy that may manifest if the input costs of any one industry are pushed up, for example as a result of paying for capture, transport and/or storage of CO_2. We have computed and used an IO 'price multiplier' model in previous work for waste management and disposal.[11] At present, given the need to collect appropriate IO cost data for capture, transport and storage activities that do not yet exist in the UK economy, we have only conducted very early stage experimental work to identify potential price pressures if CCS generates additional costs in emitting sectors. Illustrative headline insights are as follows:

- If CCS is introduced in UK power generation, we would anticipate the main price pressure to be in the price of electricity – implying a cost ultimately borne by consumers. Important price pressures are also evident in more electricity-intensive sectors, including gas supply (thus also impacting consumers) along with a number of manufacturing industries, agriculture and construction, where impacts may be felt by both domestic and export consumers.
- If CCS is introduced in the petrochemicals industry, the main and dominant price pressure would again be anticipated in the emitting industry – but here with this mapping mainly to potential negative competitiveness impacts on export prices (around 2/3rds of the UK petrochemical industry's output is exported). Our experimental work suggests that some price impacts are indirect via supply chain activity within the IO industry classification of petrochemicals (within SIC 20), which may demand fuller study of more detailed data.

In terms of the **status of this type of evidence**, again, access to better and more timely UK IO data would enable good estimation work on a fairly short time frame. However, precise determination of potential price pressures from CCS would require information on costs of

[11] See Allan et al. (2007).

capture, transport and storage translated to IO format. It is also important to note that the price IO model only permits identification of price pressures, not responses to these pressures; development to a full CGE model is necessary in this regard.

5. Summary of key points emerging

This Policy Brief has reported on key outcomes from a short project conducted by the Centre for Energy Policy at the University of Strathclyde on the type of narrative and metrics that may be useful in helping to draw in a wider policy audience – particularly those concerned with economic affairs – into the discussion around the near term future of CCS in the UK.

The key point emerging is that there is one type of narrative around which consensus may be most likely to build. This **focuses on the potential role of CCS in enabling the sustained contribution of sectors where we have already invested, which we currently realise value from, and from which we need to realise growing value.** This in turn **relates directly to themes in the UK Industrial Strategy**, where emphasis is placed on building low carbon prosperity on a platform of the things that already contribute to our success.

In this regard, is appropriate to focus on the current contribution of two types of industries. These are the **energy-using/emitting industries** that may engage in CO_2 capture, and the fossil fuel supplying **oil and gas industry**, where much of the **skills, expertise and physical infrastructure** that would be required **to set up a CO_2 transport and storage network already exist**. In the case of the latter, there may be opportunities to further leverage significant levels of UK Government investment in the 1970s (when North Sea fields were discovered but markets disrupted by the OPEC oil crisis). In the case of the former, attention is drawn to the current picture of **evolving regional clusters in high value activities such as the petrochemicals industry and its up- and down-stream supply chains**. Generally, identifying key industry focus provides a context to explore opportunities for stimulating innovation in the context of a wider set of narratives that may become more pertinent in considering CCS, such as enabling a hydrogen industry.

In terms of existing metrics and evidence informing the 'sustained contribution' narrative, while this could be relatively easily built up over a short time frame, a key message emerges from existing data. This is that, due to their capital rather than labour intensity, **jobs are difficult to create in CCS-relevant industries**. On the other hand, the strength of their domestic upstream supply linkages mean that the **loss of any one job is likely to have significant negative impacts across the wider UK economy**.

Our experimental work on **price pressures** does suggest important but potentially very different patterns in terms of **how CCS may ultimately be 'paid for'**, with impacts on competitiveness of high value industries and consumer energy bills having different economic and political implications. Further investigation of these and other key issues in terms of just how CCS may be implemented in the UK will ultimately require fuller and more in-depth economy-wide analysis than has been possible in the project underpinning this briefing paper.

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