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Historic paths and future expectations: The macroeconomic impacts of the offshore wind technologies in the UK

Marcello Graziano[a,b,*], Patrizio Lecca[c,e], Marta Musso[d]

[a] Laurence Mee Centre for Society and the Sea, Scottish Association for Marine Science, Oban PA37 1 QA, UK
[b] Department of Geography, Central Michigan University, Dow Science Complex 279, MI 48859, USA
[c] European Commission, DG Joint Research Centre, Seville, Spain
[d] European University Institute, Via dei Roccettini 9, 50014 San Domenico di Fiesole, Italy
[e] Fraser of Allander Institute, University of Strathclyde, Glasgow G40GE, UK

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ABSTRACT

Offshore wind power (OSW) plays a key role within the UK strategy for a transition towards a low-carbon economy, offering vast potential for establishing a high-tech manufacturing industry. Previous experiences in the onshore sector (OWP) suggest the UK might fail in fully capturing these macroeconomic benefits. In this work, we investigate the history of UK renewable policies, comparing its national strategy to those of other major OSW-export countries. Through the use of a numerical general equilibrium model, we quantify the macroeconomic impacts under three scenarios: a baseline, which relies on previous estimates and foresee limited local content; a 'contamination' scenario, where the UK content reaches the same levels of OWP; and a 'non-myopic' scenario, where investors expect governmental support to decrease or disappear, replicating a common path of past renewable policies. We identify the UK as a FDI-oriented country. Our results suggest that increasing the share of locally-sourced capital goods in OSP to OWP-level could generate larger income and employment effects in the UK economy. We find that under forward-looking investors the economic benefits are significantly lower than the case of myopic agents. Our results show an inherent conflict with stated purposes of UK policy for OSW.

> "*Industry and Government work together to build a competitive and innovative UK supply chain that delivers and sustains jobs, exports and economic benefits for the UK, supporting offshore wind as a core and cost-effective part of the UK's long-term electricity mix.*" (HM Government, 2013, p.5)

1. Introduction

1.1. Role of onshore/offshore wind (OSW) within UK: low-carbon, manufacturing and energy security

Offshore wind energy (OSW) is amongst the most popular and fastest growing renewable energy technologies (RETs) in Europe (Kern et al., 2014; Dawley et al., 2015). In the UK, the country with the largest OSW installed capacity worldwide (IRENA, 2013d), the adoption of this technology is driven by three main objectives: lowering the overall carbon emissions of the country, increasing energy security through the exploitation of a domestic resource, and providing new manufacturing jobs (Dawley et al., 2015; HM Government, 2013; McNeil et al., 2013; The Scottish Government, 2010, 2011). Although the first two objectives can be achieved by simply increasing the installed capacity and the electricity output produced using OSW and other renewables, the third objective depends on 'where' the supply chain of OSW is located. Understanding the economic impact of OSW is one of the major focuses in the recent stream of literature in the UK and its sub-regions, particularly Scotland, where most of the OSW potential is located.

For example, CEBR (2012) estimated the employment impacts and contribution to GDP that the OSW would provide to the UK economy, using scenarios based on installed capacity projections for the years 2020 and 2030. The authors used an input-output approach based on previously calculated, sector-specific multipliers, and previously developed local content estimates (CEBR, 2012). The report found that OSW could increase the UK's GDP (0.3–0.6% by 2030), creating about 40,000 full time equivalent

* Corresponding author at: Department of Geography, Central Michigan University, Dow Science Complex 279, MI 48859, USA.
E-mail addresses: grazi1m@cmich.edu (M. Graziano), marta.musso@eui.eu (M. Musso).

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(FTEs) jobs by 2020, and 60,000 by 2030. More significantly, the report highlights how OSW would have the potential to become a major export-oriented industry, possibly re-balancing the trade gap through increased exports of electricity (CEBR, 2012). The reliance on electricity exports features prominently in CEBR's assumptions, making it possible to achieve positive net trade impacts, and only two, long-term (2030) estimates finding larger goods/services exports greater than imports in the OSW sector. This assumption, although grounded in the vast OSW resource endowment of the UK, carries a few sources of risk: it relies on the expectation that an electricity infrastructure will be built, and that other EU countries do not possess and/or will not tap their own OSW or other renewable resources within the same time frame. The depiction of OSW-generated electricity as an export commodity for the UK might be over-optimistic, at least within the assumed time frame.

In another work, Lecca et al. (2017) used a multi-sectoral energy-economy-environmental model to evaluate the macroeconomic and energy impacts of reduction in the OSW levelized cost of energy, as foreseen by the UK Department of Energy and Climate Change (DECC). Their work found that if agents are myopic then substitution among generation technologies is not considered. More importantly, the authors found that, if the installation objectives are to be reached (22 GW by 2030), the OSW would increase GDP between 0.03% and 0.15% from the base-year values, and employment between 0.03% and 0.13%, assuming UK content slightly increases by 2030.

Similar magnitudes of contribution to employment and GDP were found by other studies reviewed by McNeil et al. (2013). This study has highlighted the volatility of the impacts depending not only on the total installed capacity, but mainly on the share of 'domestic' content (i.e. UK) assumed in the capital and operational expenses (CAPEX and OPEX). In addition, the local content influences the overall economic impact of the OSW sector through another element: the value of exports in goods and services to other EU and non-EU countries, which serves as a driver for sustaining the new domestic production beyond the capacity of internal demand, and has been sought after by the Scottish Government for rebuilding advanced manufacturing capacity (Scottish Government, 2010).

Despite different overall results, the literature on OSW economic impacts[1] recognizes the importance of correctly quantifying the local content of goods and services for understanding the larger economic impacts of OSW (e.g. Roberts et al., 2014; Gilmartin and Allan, 2015). The location of the supply chain, in turn, is highly driven by the industrial policies, which play a fundamental role as firms' determinants, both spatially and organizationally (Lund, 2009; Lewis and Wiser, 2007; Kern et al., 2014; Dawley et al., 2015). The policies driving the rise of a new industrial sector are not created in a vacuum, but rather they arise from path-dependent processes occurring through time and across regions (Boschma and Frenken, 2006, 2011; Martin, 2010; Dawley et al., 2015). Because of this path-dependency, modelling the future economic impacts of the OSW sector can be better understood looking at the past and current support policies, domestically and in other (potentially competitor-like) countries, as well as at similar, more mature sectors (Wang, 2010), which often include the same firms. In the case of OSW, this sector is onshore wind power (OWP) (Söderholm and Pettersson, 2011; Nemet, 2012; Weiss et al., 2013; Gernaat et al., 2014).

In this work, we investigate the policies which have shaped the current OSW sector in the UK, and parallel policies implemented in Germany, Denmark, and Spain, which represent the largest OSW export countries in Europe (IRENA, 2013a, 2013b, 2013c). Furthermore, in Germany wind power has had lower generation costs than any other form of generation (Burger, 2017a, 2017b). This historic policy analysis includes both OSW policies and policies that have influenced a parallel sector, on-shore wind power. Building upon this historic policy analysis, we model and evaluate the economic impact of expanding OSW capacity in the future utilizing the UKENVI model, a general equilibrium modelling framework for the UK (Allan et al., 2007; Lecca et al., 2014, 2017), - focusing primarily *a) on* the overall impacts of an increased UK content, up to the levels reached in the OWP sector, which represents the 'premium' for implementing one or a combination of the policies other European countries have implemented; and *b) on* the effects of allowing economic agents, investors in particular, to expect incentives to end in the future (non-myopic), thus showing the difference between continuous support and uncertainty related to support policies.

The reminder of the paper is organized as follows. In Section 2, we investigate the OSW-related policies in the UK, and compare them to other major wind power countries for understanding the historic path that has led the UK to be a large adopter and a small manufacturer of OSW. In Section 3, the methods and the simulation strategy adopted to evaluate the economic effects of OSW are described while the results of alternative scenarios are discussed in Section 4. Finally, conclusions and policy implications are drawn in Section 5.

2. The broken path of wind: a review of the 'arrested development' of British technology

The history of UK wind power dates to the 1700s, when about 2% of the national power requirements where met using wind-mills (Jones and Bouamane, 2011). In 1891 it was a Scotsman, James Blyth, who patented the first turbine for electricity generation (Twidell and Brice, 1992). In 1895, the first start-up venture for wind machines started to operate in London, the Rollason Wind Motor Company (Jones and Bouamane, 2011). Despite this tradition, however, steam power and large coal mines halted the development of a system of research and development in wind energy (Jones and Bouamane, 2011). After the 1973 oil shock, when green energy sources started to gather attention and other countries invested in wind, Britain had very few engineers trained in wind power, and it was concluded that it was a medieval technology, not fit for the contemporary world (Grubb, 1990a).

The lost decade of the 1970s caused the UK to stay behind in production, and to become a net importer of onshore wind technology (Bossany, 1983). In 1981, the first large-scale wind-power generator installed in the Orkney Isles (55 kW) came from Denmark; another 200 kW machine installed at Carmarthen Bay came from the US (Bossany, 1983). When in 1982 Howden Ltd, the UK leader in the construction of wind turbines, tried to enter the California market, serious reliability issues caused it to withdraw only two years later (Jones and Bouamane, 2011), and to close its wind turbine manufacturing altogether in 1989 (Townsley, 1989). Furthermore, nothing impelled the British government to carry out a serious investment programme in wind energy: by 1985 the counter-oil shock had collapsed oil prices, and wind power was not supported by environmentalist movements, which on the contrary attacked the aesthetic impact of wind towers (McKie, 1985).

In 1989, the Electricity Act that privatised electricity generation seemed to bring about a new era for the UK wind power industry. The law included the adoption of a Non-Fossil Fuel Obligation (NFFO) that required the new private Regional Electricity Companies (RECs) to make power-purchase contracts with non-fossil fuel generated electricity, at levels set by the Secretary of State for Energy. The additional costs of these contracts would be covered by the State through a new tax on fossil fuels generation (Elliott, 1992). The NFFO was designed to promote nuclear power,

[1] For a comprehensive review of the literature see McNeil et al. (2013).