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From oil wealth to green growth - An empirical agent-based model of recession, migration and sustainable urban transition☆

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ABSTRACT

This paper develops an empirical, multi-layered and spatially-explicit agent-based model that explores sustainable pathways for Aberdeen city and surrounding area to transition from an oil-based economy to green growth. The model takes an integrated, complex systems approach to urban systems and incorporates the interconnectedness between people, households, businesses, industries and neighbourhoods. We find that the oil price collapse could potentially lead to enduring regional decline and recession. With green growth, however, the crisis could be used as an opportunity to restructure the regional economy, reshape its neighbourhoods, and redefine its identity in the global economy. We find that the type of the green growth and the location of the new businesses will have profound ramifications for development outcomes, not only by directly creating businesses and employment opportunities in strategic areas, but also by redirecting households and service businesses to these areas. New residential and business centres emerge as a result of this process. Finally, we argue that industries, businesses and the labour market are essential components of a deeply integrated urban system. To understand urban transition, models should consider both household and industrial aspects.

1. Introduction

Many cities emerge and become successful because of their unique geographic location (such as being a port) or proximity to natural resources (such as coal and oil). There is a strong path dependence in the development of a city based on its initial competitive advantage in the industrial structure. However, as technologies progress and industries move away from being location-dependent or resource-intensive, many industrial cities struggle to find a new niche in the global economy. The transition from a conventional resource-based economy to a knowledge-based one is not always a smooth path. Those that have failed to do so have suffered decades of decline and shrinkage (Martinez-Fernandez et al., 2012; Audirac et al., 2012).

Urban decline is a global phenomenon. It has happened in Europe, Japan, Australia and the United States (Martinez-Fernandez et al., 2016). It is a multidimensional process often featuring a fall in investment and job opportunities, followed by high unemployment rate, large-scale emigration and population loss (Fol, 2012). Rink, Haase, Grossmann, Couch and Cocks (Rink et al., 2012) look at the long-term shrinkage of the former East Germany city of Leipzig, and of Liverpool in the UK, where populations shrank by 38.7% and 49.5% respectively between 1933 and 2001. Besides political and historic reasons, the authors associate the decline of the two cities to the massive loss of industrial jobs: Leipzig lost 85% of its industrial jobs within a few years after the reunification in 1989; Liverpool lost a third of all its employment between 1971 and 1985 due to the decline in factory and port-related jobs.

Worse still, the decline of the city often entails selective migration: the young, the rich and the qualified are the first to leave the city, leaving behind the old, the poor and the uneducated (Martinez-Fernandez et al., 2012; Fol, 2012; Lang, 2000). Martinez-Fernandez et al. (2012) and Martinez-Fernandez and Wu (2007) describe the disappearing knowledge, skills and innovation during urban decline: as people with skills and knowledge leave the city for job opportunities elsewhere, they also take with them the very assets the city would need to prosper in a knowledge and innovation-based economy. Moreover, because this process is gradual and silent, it tends to be overlooked until it is too late. Once the brain drain starts, it becomes increasingly difficult for the region to attract new businesses and skilled labour and to keep existing ones, both of which the region needs to recover from the decline. A vicious circle has been triggered.

Local people who lost their jobs during the industry decline can be

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stuck in long-term unemployment if they cannot be reemployed soon. Research shows that the probability of obtaining a job decreases the longer a person has been unemployed (Calvo-Armengol and Jackson, 2004), and that long term unemployment itself reduces a person's chance of leaving unemployment (Jackman and Layard, 1991). For example, in Britain in early 1984, only 4% of people who were unemployed for more than four years found a job in each quarter, compared with 40% of people who have only been unemployed for three months (Jackman and Layard, 1991). Data also suggest that a substantial number of long-term unemployed people become discouraged and cease to be active in job searching (Autor and Duggan, 2003; Katz, 2014). From a human resource point of view, workers accumulate skills on the job and lose skills during unemployment (Ljungqvist and Sargent, 1998; Acemoglu, 1995). In other words, skills depreciate if not put to use (Edin and Gustavsson, 2008; Laureys, 2014; Görlich and De Grip, 2008). Thus the longer a person stays unemployed, the fewer marketable skills they have left. Structural changes in the economy also make it harder to adapt and acquire new skills the longer a person stays out of the job market (Katz, 2014; Layard, 1999). Finally, factors such as social exclusion (Kieselbach, 2003) and social norms (Clark, 2003) also contribute to the stickiness of long-term unemployment.

In urban land-use simulation modelling literature, the economic and employment aspects of a region are often treated as exogenous, if they are considered at all. Most regard urban outcomes as a result of households' residential choices, demographic type and preferences, and do not consider employment opportunities and economic growth as an integral part of urban dynamics (Brown et al., 2004; Caillault et al., 2013; Filatova et al., 2013; Gaube and Remesch, 2013; Millington et al., 2009; Jackson et al., 2008; Haase et al., 2010). For example, Haase et al. (2010) develop an agent-based model of residential mobility in the shrinking city of Leipzig, Germany, and treat economic and population growth as exogenous factors. Similarly, Gaube and Remesch (2013) develop an agent-based model of household residential decisions in Vienna, a city that has gone through negative population growth for decades until the 1990s. The authors consider the impact of urban planning and household demographic shifts, but not the industrial structure in the region.

The general economic literature, on the other hand, regards major shocks to a region's economy as mere disturbances that cause the region to deviate from its equilibrium growth path. It does not, however, explain why regions starting at similar conditions have very different development paths. Simmie and Martin (2010) compared the development paths of Cambridge and Swansea in the UK, and found that although the two regions had similar economic and employment conditions in 1970s and both had been through nation-wide economic recessions, they have led very different growth paths since then. By 2000, Cambridge had become one of the world's leading hubs for high-tech industry and innovation, whereas Swansea had suffered from permanent contraction in economic activity and employment. The authors argue that the development of a region is highly path-dependent: the pre-existing infrastructure, human resources, skills and connections enabled Cambridge to create growth opportunities, and thus has successfully upgraded and diversified its economy. Cities, they argue, are more like organic, self-regulated complex systems that are constantly evolving and adapting to a changing environment, than (quasi-)linear systems converging to equilibrium (Simmie and Martin, 2010; Batty, 2007; Jabareen, 2013; Boschma, 2015).

One of the founding stones of urban economics is the Alonso (1964), Muth (1969), Mills (1972) (AMM) framework, which formalizes the density and spatial distribution of population driven by transport cost, land price and wages. The original AMM framework is based on closed monocentric cities where all employment and production takes place in the Central Business District (CBD) and feature homogenous utility-maximizing agents, although recent extensions have modelled polycentric cities (Lemoy et al., 2017), heterogeneous agents (Olner et al., 2015) and open cities (Larson and Yezer, 2015). The AMM model assumes that the location of firms and services are fixed and regardless of households' residential choice; whereas in reality, firms tend to stay close to the market, especially those providing services to households. The AMM model achieves equilibrium when no agent in the model has an incentive to relocate; whereas in real life, as people go through different stages of life, their preferences will change, so will their optimal residence. The static equilibrium will not last if we take a dynamic approach and allow people to grow in life. Urban dynamics can then be influenced by gradual demographic shifts in the population. Finally, in the AMM framework, households' residential choice is highly simplified and based only on transport cost, space, wage and housing price. They do not consider other aspects such as neighbourhood and school quality, the quality and type of the house itself and their availability. The model presented in this paper will address these issues not considered in the AMM framework.

This paper conducts a case study of Aberdeen City and Shire in Northeast Scotland, UK; home to more than 400,000 people. The economy of Aberdeen has been heavily reliant on the North Sea oil and gas industry since the 1970s. Thanks to the oil wealth, for decades prior to the collapse in oil price in late 2014, Aberdeen had seen rapid economic and population growth and a swell of prosperity, and still has among the highest income per capita and lowest unemployment rate in the UK. However, since the oil price collapse, the local economy has been in turmoil with significant job losses and pay cuts in the oil and gas sector. The loss of customers, businesses and financial supporters from the oil industry also affects other local businesses. Moreover, reduction in tax income affects the council's ability to provide public services when it is most needed: the number of people that applied for unemployment benefits surged after the oil price collapse (Ambrose, 2016). Now, almost three years later, there are few signs of recovery.

Meanwhile, people start to question the dominant role of North Sea oil and gas in Aberdeen's economy and the future of the city (Davies, 2017). Research shows that cities relying heavily on a single sector are especially susceptible to economic shocks (Lang, 2005). The solution, many argue, is to develop a green industry that could make use of the existing knowledge and expertise in the energy sector. In fact, both Aberdeen City and Shire councils already have plans to promote green energy businesses that could be built on the region's rich oil and gas heritage, such as carbon capture and storage technology, hydrogen, onshore and offshore renewable energy. The recent oil crisis could just be the push needed (Vaughan, 2017), although to convert existing knowledge and resources into new competences is not always straightforward (Maskell and Malmberg, 2007). Once again, Aberdeen is at the critical point of change many cities have faced before: should it successfully upgrade its industrial structure after the crisis, it will become a stronger and more resilient region. If not, the once prosperous city may fall into a long-term decline. The stakes are high.

The GLAMURS[1] (Green Lifestyles, Alternative Models and Upscaling Regional Sustainability) project was funded by the European Commission's Seventh Framework Programme to research alternative ways of life that are more environmentally sustainable, and investigate the scope for upscaling them to the regional level. The decline of the oil industry in the Aberdeen area provides a backdrop against which to explore opportunities for regional restructuring leading to more sustainable ways of living in the area. Life stage transitions are critical opportunities for intervention, as people are developing new habits. The context of wider regional transition makes this case study particularly interesting. The project included a regional questionnaire survey of the area's inhabitants, and another survey of workers in the local municipality.

This paper develops a multi-layered, spatially-explicit agent-based model that includes the dynamic interactions between people, households, businesses, industries and neighbourhoods to study the impact of

[1] See http://glamurs.eu/for more information about the project.