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Spatial takeoff in the first industrial revolution ☆

Alex Trew

School of Economics and Finance, University of St. Andrews, St. Andrews, Fife KY16 9AJ, United Kingdom

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ABSTRACT

Using the framework of Desmet and Rossi-Hansberg (forthcoming), we present a model of spatial takeoff that is calibrated using spatially-disaggregated occupational data for England in c. 1710. The model predicts changes in the spatial distribution of agricultural and manufacturing employment which match data for c. 1817 and 1861. The model also matches a number of aggregate changes that characterise the first industrial revolution. Using counterfactual geographical distributions, we show that the initial concentration of productivity can matter for whether and when an industrial takeoff occurs. Subsidies to innovation in either sector can bring forward the date of takeoff while subsidies to the use of land by manufacturing firms can significantly delay a takeoff because it decreases spatial concentration of activity.

1. Introduction

Economic takeoff is often a starkly geographical phenomenon with leading industries that are highly spatially concentrated and different regions that are affected in different ways. Such spatial heterogeneities are not, however, generally a part of the models we use to understand the timing and speed of transition from slow-growing agricultural economies to fast-growing industrial ones. As a result, we lack a framework for studying the dynamic effects of policies that are bound up in geography, such as subsidies for industrial hubs or expenditure on infrastructural development. This is partly because of analytical difficulties to do with modelling geography, but it is also because of a lack of sufficiently disaggregated data on the nature of spatial development through an entire period of takeoff. Using new data that captures the spatially-disaggregated nature of the industrial revolution in England, this paper builds on recent advances in modelling spatial development to construct a model of spatial *takeoff*.

Just how significant are geographical heterogeneities? Data for modern economies point to the importance of geography to the characterisation of aggregate growth, growth in cities and in sub-national regions (see, for example, Henderson et al., 2011). Historical data permit us to consider spatial development during a broader structural transformation, however.

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E-mail address: alex.trew@st-andrews.ac.uk.
URL: http://www.st-andrews.ac.uk/~awt2.

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Using occupational data from parish-level records, the groundbreaking work of Shaw-Taylor et al. (2010a) and the wider project described therein shows that early industrial England was characterised by concentrated geographical 'hotspots' of population growth in areas that were predominantly manufacturing based.[1] That data quantifies a number of spatially-heterogeneous features of the first industrial revolution, such as the *de*industrialisation of the South of England during the eighteenth century.

Using the framework of Desmet and Rossi-Hansberg (forthcoming), this paper introduces non-homothetic preferences into a dynamic model of endogenous innovation in two sectors – agriculture and manufacturing – where trade across a continuum of space is costly and where land is competed for as a factor of production. Agglomeration and transport costs matter for the locations of activity and the endogenous rate of technological progress in each sector. Innovation is subject to a fixed cost and so investment in innovation occurs when firms are large enough to amortise that cost over a sufficient quantity of output. Since the manufacturing innovations that underpinned the industrial revolution were energy-intensive, we make the assumption that the fixed cost to innovating in the manufacturing sector is proportional to the local energy costs. Those costs reflect both the location of natural resources (coal) and the (non-uniform) costs of transporting it. The framework is tractable enough for the model to be parameterised and for equilibrium outcomes to be studied quantitatively. The most novel item we calibrate is the initial spatial distribution of productivity in each sector. In particular, we use new data in Shaw-Taylor et al. (2010a) to estimate the geographical distribution of employment for c. 1710 and use that to calibrate the initial distribution of productivity. We then compare the spatial predictions of the model against the data for c. 1817 and 1861 from Shaw-Taylor et al. (2010a).

The model matches a number of the aggregate and geographically heterogeneous aspects of the first industrial revolution over the period 1710–1860. Initial innovation in agricultural production is concentrated in the South, around the population of London (cf. Allen, 2004). That slowly increases demand for the consumption of manufactured goods and leads to the emergence of manufacturing firms in the North with an associated migration of labour to work there. Once those firms reach a sufficient scale, manufacturing innovation begins endogenously. The takeoff in per capita growth proceeds at a time and place that matches the data. The ability to capture the structural change that results from agricultural innovation is much like in Desmet and Parente (2012). We establish, however, that the spatially heterogeneous nature of the economy was critical to whether and when an industrial takeoff occurs by simulating the model with a series of counterfactual geographical environments. We also look at the role of policy: Subsidies to manufacturing innovation bring forward the date of industrial takeoff and locate it closer to the source of cheap energy. In contrast, a subsidy to the use of land by manufacturing firms can significantly delay takeoff because it lowers the spatial concentration of manufacturing firms. We also find a significant role for international trade in explaining the timing of takeoff.

The rest of the paper is organised as follows: Section 2 reports evidence on the industrial takeoff in England and connects that to some extant models of takeoff. Section 3 introduces the model of spatial takeoff, which is based on Desmet and Rossi-Hansberg (forthcoming). The model is parameterised in Section 4 with equilibrium outcomes compared against the record for the first industrial revolution in Section 5. Section 6 considers a number of counterfactual initial distributions for manufacturing productivity. Section 7 considers the impact of including international trade and Section 8 looks at a number of policy interventions. Section 9 offers some concluding remarks.

2. The first industrial revolution

It is worth going over the macroeconomic facts of the industrial revolution before turning to its spatially-heterogeneous characteristics. The industrial revolution may be characterised by an aggregate shift of employment and incomes from agricultural to industrial activities along with a sustained increase in per capita output growth. We focus mainly on these two characteristics, though the quantitative modelling exercise in Section 5 will look to fit additional historical data for relative prices, wages and land rents.

2.1. Per capita growth and employment shares

The revisionist[2] view of per capita growth during the first industrial revolution, summarised in Crafts and Harley (1992) and reported in Table 1, has established that growth in the eighteenth century was more muted than once thought: A significant increase in aggregate growth was not observed until the second quarter of the nineteenth century. The Crafts–Harley view in turn implies that England was far wealthier than once thought as far back as the early 18th Century and that the macro-inventions of the eighteenth century took a long time to make an impact upon aggregate per capita growth.

The best estimates we have for employment shares during the period are from Shaw-Taylor et al. (2010a) which is based on occupational records from 1000 baptismal registers for c. 1710 and over 10 000 registers for subsequent

[1] To see this visually, see, e.g., Fig. 4 'Population densities at quasi-parish level for England and Wales c. 1670 and 1800–1891' on the project website: http://www.geog.cam.ac.uk/research/projects/occupations/englandwales1379-1911/.

[2] Cf. Deane and Cole (1967); the revisionist view is now generally accepted (see Mokyr, 2004) and has been confirmed under different methodologies (e.g., Antràs and Voth, 2003). An alternative perspective, which suggests somewhat higher growth in the early eighteenth century, is presented in Clark (2007).