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Modelling creative destruction: Technological diffusion and industrial structure change to 2050☆

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Abstract

Future disruptive, pervasive technologies will have important consequences for industrial structure, economic growth and the environment. Drawing on theories of technological diffusion, industrial evolution and long-term technological change this paper explores the effect of the development and diffusion of two future pervasive technologies on five industrial sectors in three regions during the 21st century in terms of their effect on economic structural change. Through semi-structured interviews with over 100 experts in the two technologies, the paper quantifies the effects of future biotechnologies and nanotechnologies on the industrial structure of the EU, USA and China in 2020 and 2050. The paper finds that as a result of the development and diffusion of future biotechnologies and nanotechnologies, some industries grow whilst others decline and some new ones emerge. The evidence suggests that the effect is different across countries and time; whereas the experts commonly believe that effect of the technologies on the industrial structure of the EU and US is likely to be similar, the effect in China is considered to be less by 2020 but the same as in the EU and US by 2050. This finding has important implications for the location of production, economic growth and energy demand in the future.

Keywords: Biotechnologies; Nanotechnologies; Technological diffusion; Industrial structure; Energy

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1. Introduction

Technological change, industrial sector change and global environmental change are intimately connected [1]. Over the last 250 years, five successive 'techno-economic paradigms', associated with a 'cluster' of inter-related radical and incremental innovations (product, process, technical, organisational and managerial) have had a pervasive effect throughout the whole economy [2,3]; facilitating increased production of more goods and services and influencing the level of aggregate energy demand (and methods of energy supply). The next 100 years will be no different and future disruptive, pervasive technologies will have important consequences for industrial structure, economic growth and the environment. From a neo-Schumpeterian standpoint, this paper builds on previous work [4–7] to demonstrate a method by which one can quantify the effect of technological change on industrial structure over the next century. Dewick et al. [4] and Miozzo et al. [5] describe the method by which one can consider the long-term effects of technological change on the environment and Kohler [6] and Pan [7] demonstrate how these concepts can be incorporated into a macro-economic model.

Dewick et al. [4] described a methodology built on notions of 'Kondratiev long waves' and using an industrial classification based on technological characteristics [8,9]. The paper provided a qualitative assessment of the effects of biotechnologies, information technologies and nanotechnologies (the so-called BIN technologies) on four industries in the EU. The results suggested that the assimilation and effective use of the BIN technologies would have a significant effect on industrial structure, levels of production and energy demand to 2050. The main drawback of the paper is that the findings are qualitative and do not lend themselves to quantitative macro-econometric modelling. Also, given that technological diffusion is a global phenomenon, influenced by the movement of international capital, the operation of multinationals, etc., the consideration of the EU in isolation limits the implications one can draw from the study. Drawing on theories of international production from international business and innovation, Miozzo et al. [5] assess the impact of long-term technological change and changes in international production on the international division of labour and energy demand. By assessing two industrial sectors with different technological characteristics (the textile, clothing and footwear sector, and the chemical sector) Miozzo et al. examine the effects of the globalisation of production and of technological change in the two industries on the level of industrial production and resource intensity in different regions/countries over the last 30 years. The findings of the paper highlight the important role technological change has played in shaping the international division of labour and resource efficiency of industrial production since 1970. What Miozzo et al. [5] provide is a retrospective analysis of the effects of the development and diffusion of information technologies; they do not attempt to consider explicitly the future effects of biotechnologies or nanotechnologies. Again, the findings are qualitative and require further interpretation to be useful for a macro-econometric model.

Kohler [6] develops a simulation model of long-term technical change. He argues that, due to deficiencies in data, the unsuitability of econometrics for modelling beyond the short-to-medium term as well as the number of socio-economic variables to be considered means that there is no generally accepted theory to date on long-term technical change for incorporation into a macro-modelling structure. Based on Freeman and Louca's [10] descriptive theory (see also [2,3]), which encompasses the ideas on long waves from Kondratiev and Schumpeter, Kohler argues that socio-economic activity since the late 1700s can be interpreted using a dynamic macroeconomic model. Learning by doing and falling production costs are combined with an investment bubble and a lagged supply response to generate the boom phase of a Kondratiev wave. The six phases of Freeman and Louca's [10] technology life cycle are