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Knowledge, natural resource abundance and economic development: Lessons from New Zealand 1861–1939

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ABSTRACT

We explore the role of knowledge accumulation in the economic development of a natural resource-rich country. New estimates of commodity output and patenting are used to show New Zealand's exceptionally high incomes before 1939 rested on a knowledge-led utilization of her economic landscape. By investigating the cointegrating and causal relationships among the output of 25 industries we show that a small number of leading industries formed development blocks. In turn most leading industries were driven by knowledge growth as reflected in patent statistics. Knowledge accumulation helped to transform the farming landscape and integrate farm and factory within a New Zealand system of mass production.

1. Introduction

A variety of natural resource abundant economies were drawn into trading relationships with the industrializing economies of north–west Europe in the eighteenth and nineteenth centuries. Some resource-rich economies, most obviously the USA, became industrial powers, while others, including much of south Asia and the southern cone of the Americas remained dominated by their staple exports before World War II. The disparate experiences of resource-rich economies offer a rich milieu for gauging the forces of their economic development. Endogenous growth theory places knowledge creation firmly within the economic system and highlights the importance of innovation and human capital for economic growth (Romer, 1990; Grossman and Helpman, 1991). Yet technology's role in the development of natural resource abundant economies other than in the USA has been neglected (David and Wright, 1997; Magee, 2000). The case of New Zealand illustrates how knowledge-related enterprise both utilized and constructed natural resource abundance to promote unusually high income per capita.

New data sets for commodity output and for patents are used with modern time series methods to gauge the causal relationships between technology and New Zealand's economic development. The new output estimates show that New Zealand's average income per capita was around one-third higher in 1900 than reported by Maddison (2001), and concomitantly 43% above US income per capita in that year; by this measure it was the highest in the world.[1] National estimates often hide wide variations, and Easterlin's (1971) regional data for US Pacific states imply that income per capita there exceeded New Zealand's by around 14% in 1900, but that the North East and North Central regions of the USA trailed New Zealand average incomes by around 5% and 39% respectively. In the wider world New Zealand's average incomes in 1900 were 30–46% above those of the UK and Australia, and more than twice the level of Argentina, Canada and Uruguay. Other than in comparison to the richer parts of the USA, New Zealand incomes per capita were exceptionally high by the beginning of the twentieth century. New Zealand's average income growth

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[1] The estimate is based on back-projecting Maddison's estimate of New Zealand GDP per capita in 1939 with the commodity output index reported here and population data. Dowie (1966) and Greasley and Oxley (2000a) discuss New Zealand GDP estimates.

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slowed after 1900 although the country's income per capita was similar to that of the USA in 1939 and remained above that of the UK and the other western offshoots. Here we gauge how knowledge-related enterprise as reflected in New Zealand's patenting activity influenced its economic development 1861–1939.

The attractions of her natural resources, initially timber, seals and whales, and by the 1850s and 1860s tussock grass and gold, eventually drew New Zealand into the international economy (Condliffe, 1930; Hawke, 1985; Lloyd-Prichard, 1970). Staple trades and the concomitant flows of people and capital were at the core of New Zealand's early economic development, but natural resources did not offer a simple growth pathway. Gold production peaked in 1871 and exports of wool and kauri gum offered limited development prospects.[2] Knowledge-related opportunities for re-invigorating development were connected primarily to closer settlement, to the more intensive use of land by cultivation of grasses, and to the integration of farm and factory within a New Zealand system of mass production.

New Zealand governments from the 1870s sought to promote development, most obviously by borrowing for public works and assisting immigration (Reeves, 1902). Hawke (1979) argues that New Zealand, as a small colony of largely British immigrants, had a singular social purpose which allowed the state to be a positive instrument for development.[3] Homogeneity among populations may have advantages connected to trust and public investment in education and health (La Porta et al, 1997), although Alesina and La Ferrara (2005) argue that heterogeneity may be more conducive to creativity. In Hawke's view settlers and state were united in their preoccupation with development. Thus they were willing to countenance the revocation of private property rights or constrain private enterprise in some areas including transport, insurance, and finance, if that served a collective development purpose.[4] In relation to land taxation and the promotion of closer settlement, state legislation was distinctive, and framed against a backcloth of land congestion and urban discontent and, in the 1880s, net out-migration. The compulsory re-purchase of land for re-sale to smaller farmers contributed to closer settlement after 1890 (Clark, 1945; Gould, 1970, 1976). At issue is whether or not the wider economic landscape shaped by New Zealand's governments and the settlers was conducive to enterprise and knowledge-led growth.

Historians have utilized patents data widely to measure inventive activity (Sullivan, 1989; Khan and Sokoloff, 1990; Magee, 1996; Nuvalori, 2004, and Greasley and Oxley, 2007). New Zealand's patents legislation essentially followed a British template and, in conjunction with the Paris convention of 1883 which harmonized patent rules internationally, set the standards for securing intellectual property rights. New Zealand patents data are used here to reflect the proclivity of its settlers to assimilate and utilize new knowledge. Our contention is not that New Zealand technology generally led the world, although it did for certain refrigeration technology, but rather that the country's patenting activity provides a proxy for knowledge adoption and utilization.[5]

Several strands of the technology central to New Zealand's economic development, including the centrifugal separation of cream, had overseas origins (O'Rourke, 2007). How they were assimilated is central to New Zealand attaining high average incomes. On New Zealand farms integrated machine-milking and centrifugal cream separation forged ahead more quickly than in the USA (Philpott, 1937). Further, farm and factory were integrated in a distinctive New Zealand system of mass dairy production (Belshaw, 1927; Greasley and Oxley, 2009; Wood and Pawson, 2008). By the 1920s New Zealand's largest co-operative dairy factories in the Waikato region had twice the capacity of, and higher productivity than, plants in Wisconsin (Russell and Macklin, 1926). The quality yardstick of price parity with Danish dairy products on the London market was also attained in the 1920s (Greasley and Madsen, 2006). How New Zealand's capacity for knowledge-related enterprise shaped the growth of the country's industries will be explored via a statistical analysis of the relationship between patenting and commodity output.

By estimating the cointegrating relationships among 25 categories of commodity output we show that a small block of industries with multiple causal linkages drove New Zealand's economic development.[6] The dairy sector was central, but other kinds of manufacturing, including printing and publishing, had leading causal linkages. In turn we demonstrate how patenting activity associated with 40 industry groups had causal links with the key industries. On balance, patenting activity led commodity output. By implication, New Zealand's technological capacity promoted the pastoral production which in turn led other industries. Knowledge-led enterprise helped to transform the farming and natural resource landscape by augmenting the productivity of smaller land-intensive dairy and mixed farms, and by integrating farm and factory in a New Zealand system of mass production. Ultimately it was the local technological responses to the opportunities of global trade in pastoral products that underpinned New Zealand's high per capita income in the first half of the twentieth century.

Section 2 (and Appendix A.1) reports the new estimates of commodity output, while Section 3 utilizes these data and modern time series methods to identify New Zealand's key development blocks. Section 4 introduces the new patents data and constructs a taxonomy which shows the volume of patenting connected to key industry use groups. Section 5 establishes the relationships between commodity output and patenting using cointegration and causality analysis, and Section 6 concludes.

2. Commodity output: new estimates

Colonial governments reported piecemeal economic statistics of New Zealand from 1840, but their scope and frequency increased greatly in 1861 with the publication of *Agricultural and Pastoral Statistics*, and in 1873 with the annual *Statistics of New*

[2] Kauri gum is the fossil resin of kauri pine and is used as a varnish and in linoleum manufacture.
[3] Hawke draws upon Tawney's (1921) idea that property rights not justified by social purpose should be removed.
[4] Acemoglu, Johnson and Robinson (2002) and Galor, Moav and Vollrath (2009) discuss possible consequences.
[5] Critchell and Raymond (1912), ch. 27 discuss early developments of mechanical refrigeration of meat.
[6] The method of identifying 'development blocks' by a combination of cointegration analysis and Granger causality has also been used by Enflo, Kander and Schon (2008) and Greasley and Oxley (2000b).