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Technological Relatedness and Corporate Diversification, 1890-1995

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## Abstract

The pace at which the scientific and technological complexity of products is escalating has increased substantially in recent times. This is believed to have evolved out of the growing scientific knowledge base of industrial technology together with the establishment of increasingly pervasive technological paradigms or regimes over time.

The latter idea dates back to the work of Schumpeter (1939), the paradigmatic analysis of economic growth holding that the long-term progress of economic or business activity is underpinned by successive waves of technological development. In each historical period specific bundles of related technologies have provided the greatest opportunities for innovation, the relatedness of these innovations being derived from a reliance on a common underlying set of scientific principles and organisational methods, and supported by particular kinds of social institutions (Dosi, 1982). The major characteristic of the leading cluster of technologies which characterise each wave is that they are pervasive in nature i.e. they have an inherent ability to pervade (or become relevant to) a wide variety of industrial sectors, and thereby constitute the key explanatory variable in aggregate growth. As noted by Freeman and Perez (1988), steam power, electricity, oil-based technologies of mass production and microelectronics have each in their turn served to shape the business environment. However, the overall extent of technological relatedness appears to have been increasing steadily over time and to have reached a peak under the current ICT paradigm - Kodama (1986, 1992); Cantwell and Fai (1999); Cantwell and Santangelo (2000); Von Tunzelmann and Wang (1999).

## Technological Relatedness and Corporate Diversification

In the past, corporate diversification was seen to be an integral part of the growth and sustained competitive advantage of the modern industrial enterprise. In the latter part of the nineteenth and for most of the twentieth century (until around 1970), firms grew by capturing the joint economies of scale and scope through diversifying across products and geographical markets (Chandler, 1990). Latterly, whilst corporate diversification continues to occur, it has a more complex relationship with the spread of technological activity of firms, as a result of the wider diversity of technical expertise now needed to produce any particular product, and the potential in large firms for restructuring product diversification so as to take advantage of a greater degree of overall technological coherence (Cantwell and Fai, 1999; Cantwell and Santangelo, 2000). Drawing on the contributions of Granstrand and Sjölander (1990); Oskarsson (1990); Kodama (1986, 1992); and Patel and Pavitt (1997), the paper highlights the importance of growing technological interrelatedness in attempting to explain changing patterns of corporate technological diversification. Within an environment characterised by heightened technological relatedness (or technological convergence), large firms are seen to accumulate and diversify their activity across a much broader technological base, which in many cases far outstrips the firm's product range. While a proportion of this accumulated technological knowledge is not used in the direct production of products (but rather to facilitate the monitoring of supporting technologies), it helps these Multi-Technology Corporations become *knowledgeable purchasers* (Granstrand et al., 1997).

By using historical data, this paper seeks to measure technological relatedness and examines the degree to which this phenomenon has in fact increased through time. We view technological relatedness from an ex post perspective, as measured by the combinations of technologies selected (or not selected) by firms in practice. Rather than being determined by intrinsic linkages between specific technologies, a rise in observed relatedness is seen rather as a subjective and context-specific expression of widened technological capabilities and associated absorptive capacities. By adopting the methodology presented in Teece et al (1994) and using US patent data for large firms, we report on large firms' shared perception of complementarity between technologies over the period 1890-1995. We examine the degree to which technological relatedness has increased across the main macro groupings of technologies and we isolate the individual technologies across which this phenomenon is most prevalent. Further, we determine the industrial sectors (and particular groups of firms) that drive such patterns of technological diversification and suggest that this analysis better informs our understanding of the changing character of corporate technological diversification and growth over time.