



# Learning through informal local and global linkages: The case of Taiwan's machine tool industry

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## ABSTRACT

Most existing studies of successful late industrialization, which draw on findings from high-technology industries, emphasize the need to invest in formal channels of technology acquisition to allow latecomers to catch up. This line of reasoning neglects the fact that in some industries, including low- and medium-technology (LMT) sectors, much knowledge can be acquired by informal means. Through the study of Taiwan's machine tool (MT) industry, this article demonstrates the significance of informal learning activities in LMT industries and the possibility for latecomer clusters to climb the technological ladder through exploiting various local and global informal knowledge linkages.

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## 1. Introduction

The fast growth of some East Asian newly industrializing countries (NICs), such as South Korea, Singapore and Taiwan, has been touted as the most successful catching-up model for late-industrializing economies (World Bank, 1993). The phenomenal growth of high-tech industries in these countries, for example electronics and information technology (IT), has attracted a great deal of attention from academic researchers and policy makers who try to derive theoretical and policy implications for promoting economic development in the late industrializing countries (e.g. Amsden, 1989; Hobday, 1995; McKendrick et al., 2000; Mathews and Cho, 2000; Amsden and Chu, 2003). The findings from the successful experience of high-tech industries in these countries have not only seemed to dominate our understanding of the recent development of East Asian NICs, but have also led to the emergence of policy suggestions that emphasize an alleged need to invest in formal means of technology acquisition – for example, contractual cooperation with foreign technology suppliers or performing R&D with state support – to drive the technological upgrading of late industrializing economies.

However, many scholars have contended that generalizing from such high-tech centered theoretical models and policies has serious limitations. For instance, as noted by Hobday (1995), in the electronics industry the division of production tasks across

national boundaries is technologically feasible and advantageous to multinational corporations (MNCs) in industrialized countries. In addition, it is a manufacturing-driven, high-throughput industry where labor costs play a crucial part in competitive advantages (p. 187). Therefore, its experiences might not apply to industries with different characteristics.<sup>1</sup> The dominant science-based policy discourse has also been criticized for neglecting the significance of other dimensions of learning that are taking place in some non-high-tech industries in which technology building may be based largely on craftsmanship, apprenticeship, learning by doing, work routines, informal networks, employee training and experiential knowledge, etc. (Amin and Cohendet, 2004, p. 140; Malerba, 2005; von Tunzelmann and Acha, 2005).

In the same vein of thought, this paper argues that the existing high-tech industry-centered development models emphasizing formal learning channels should not be generalized to all other industrial sectors in NICs. For one thing, these models are insufficient to account for the catching-up of low- and medium-technology (LMT) industries in some NICs that do not share the characteristics of the electronics or IT industries as illustrated by Hobday. Furthermore, as opposed to the predominant view that stresses that the industrialization of Asian NICs has been stimulated by MNC-led or state-led formal learning mechanisms, I argue that the technological advance of a latecomer LMT industry may

<sup>1</sup> For instance, Hobday (1995) stresses that the lessons and experiences of electronics industry could be shared by the fast-growing consumer goods manufacturing industries like bicycles, apparel, footwear and sewing machines in these East Asian NICs, but may not apply to complex systems sectors, such as energy, aerospace, large-scale capital goods, etc.

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actually be nurtured by informal learning mechanisms established and exploited by local firms.

By using Taiwan's machine tool (MT) industry as a case in point, this article deals with issues related to the technological capability building and learning of LMT industries, especially in the context of late industrialization. Based on more than 60 in-depth interviews with decision-makers in MT firms, their suppliers, and related public and private agencies in Taiwan conducted in 2005 and 2006, I empirically investigate the strategies and resources used by Taiwanese MT firms to build their technological capabilities. On this basis, the article enhances our understanding of the factors contributing to, and the underlying mechanisms and institutional environment behind, the successful development of a particular LMT industry in an NIC.

I begin by discussing the limitation of the existing literature in explaining the successful technological upgrading of Taiwan's MT industry. The second section introduces some distinctive features of innovation and learning in the machinery industry in general, and the MT industry in particular, that influence decisions and affect the learning strategies of latecomer Taiwanese MT makers. The third section then discusses the various external knowledge channels utilized by Taiwanese MT firms for sourcing advanced technology, and how the learning mechanisms embedded in these channels contribute to their technological advance. In the final section, I conclude the research findings and discuss their policy implications.

## 2. Limitations of existing explanations of the catching-up of Taiwan's MT industry

Although the MT industry has not been studied in the same depth as the electronics industry in recent years, Taiwan was the world's fourth largest MT exporter and sixth largest MT producer in 2006 (Gardner Publications, 2007). Unlike other leading MT manufacturing countries such as Japan, Germany, the US and Italy, with more than a hundred years of history in machinery building, the MT industry in Taiwan did not begin until the late 1940s when Taiwan was still predominately an agricultural society with weak industrial capabilities. According to the earliest available data, in 1969, the total production of machine tools in Taiwan was only US\$ 9 million (Liu and Brookfield, 2000). By 2006, however, that figure amounted to US\$ 3.7 billion (Gardner Publications, 2007), a more than 400-fold increase.

The key to the fast growth of Taiwan's MT industry has been the existence of a well-articulated subcontracting-based production system composed of numerous small- and medium-sized MT manufacturers and specialized suppliers clustered in central Taiwan that have contributed to the flexibility and adaptability of the MT industry (Amsden, 1985; Brookfield, 2000; Liu and Brookfield, 2000).<sup>2</sup> This experience mirrors the studies carried out since the 1980s on local enterprise clusters in certain areas of the world harboring and nurturing many SMEs (small- and medium-sized enterprises) that were able to enter global markets competitively (Brusco, 1982; Saxenian, 1994; Porter, 2000; Guerrieri et al., 2001). An ability to obtain collective production efficiency (Schmitz, 1995) as well as interactive learning advantages (Maskell and Malmberg, 1999) through industrial clustering, however, is just part of the story that explains the success of Taiwan's MT industry. Like other latecomer clusters, many of those technologies that Taiwanese MT firms required to sustain their competitiveness as well as to catch up were mostly developed by their counterparts in industri-

alized countries rather than generated locally within the cluster. To better comprehend the development of Taiwan's MT industry, we also need to determine the mechanisms through which crucial extra-local knowledge is found and assimilated by Taiwanese MT firms.

In the studies of the successful catching-up of East Asian NICs, the existing literature stresses the knowledge inflows into these countries through the MNC-led or state-led learning mechanisms. In the former case, the argument goes that it is the foreign MNCs who have assisted in channeling technological resources to their latecomer partners through contractual arrangements in the forms of direct investments, joint ventures, licensing, OEM (original equipment manufacture) or ODM (own-design manufacture) partnerships, etc. (Gereffi and Korzeniewicz, 1994; Hobday, 1995; Lall, 1996; Ernst, 2002; Schmitz, 2004). On the other hand, the proponents of the state-led model, especially those who draw conclusions from the experiences of electronics sector, emphasize the critical role of latecomer governments in facilitating the acquisition of foreign technology through such means as establishing public research institutes or funding R&D activities (Kim, 1997; Amsden and Chu, 2003; Mazzoleni and Nelson, 2007).

The importance of external knowledge in precipitating the development and further upgrading of late industrializing countries seems to have become received wisdom. However, little evidence can be found to support the thesis that formal mechanisms of technology acquisition among latecomers, or learning stimulated and mediated by either foreign MNCs or the state, have much power to account for the upgrading trajectory of the Taiwanese MT industry, in which those widely cited MNC-led and state-led formal learning mechanisms have been only weakly present. In this paper, I argue that the existing literature not only fails to recognize the heterogeneity of the technology building process of different latecomer sectors, but also neglects the fact that in some industries, such as machine tools, much knowledge has been acquired and accumulated by informal means. Furthermore, in the case of Taiwan's MT industry, I contend that it is the informal learning mechanisms established by local firms, not the formal ones led by the MNCs or the state, that nurture the sustained upgrading capability of the industry.

Before laying out findings and explanations, we need to understand some features of technological learning in the machinery industry, or the MT industry in particular, which have a direct impact on the particular technology acquisition strategies and learning behavior of Taiwanese MT manufacturers.

## 3. Distinctive features of innovation and learning in the MT industry

### 3.1. Innovations in the machinery industry

Innovation differs considerably across sectors (Pavitt, 1984; Malerba, 2005; von Tunzelmann and Acha, 2005). In the so-called knowledge-intensive, or high-tech, industries like electronics, IT or biotechnology, knowledge inputs are often derived from reviews of existing research, and knowledge generation is often radical in nature and based on the application of widely shared and understood scientific principles and methods through formal R&D activities. Innovations in the machinery industry, however, are often based on the application or novel combination of obtainable knowledge with low levels of R&D (Dosi, 1988; Malerba, 2005; von Tunzelmann and Acha, 2005). They are largely incremental and often arise from the machinery firms' persistent efforts to satisfy requests from customers (Lissoni, 2001).

<sup>2</sup> In Taiwan, more than 60% of the MT manufacturers are agglomerated in central Taiwan, including Taichung, Nanto and Changhwa (MIRL, 1999, p. 3–107).

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