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Learning and technological capability building in emerging economies: The case of the biomass power equipment industry in Malaysia

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ABSTRACT

There is increasing recognition that the transfer of foreign technology to developing countries should be considered in light of broader processes of learning, technological capability, formation and industrial development. Previous studies that have looked at this in the context of cleantech industries in emerging economies tend to overlook firm-level specifics. This paper contributes to filling this gap by utilising in-depth qualitative firm-level data to analyse the extent to which the use of different learning mechanisms can explain differences in the accumulation of technological capabilities. This is explored via an examination of eight firms in the biomass power equipment industry in Malaysia during the period 1970–2011. The paper finds that firms relying on a combination of learning from foreign technology partners and internal learning by planned experimentation make most progress in terms of technological capability. Nevertheless, local spill-over effects were found to be important for some firms who learned principally from imitation of local competitors, although significantly, firms learning from local spillovers failed to advance beyond extra basic operating technological capabilities. Those firms who proactively pursued learning from foreign partners, on the other hand, advanced further, reaching basic innovative levels of technological capabilities. These findings are relevant for a wider range of industrial sectors in emerging economies.

1. Introduction

There is often a tendency to think of sustainable development separately from processes of technological capability development in developing countries via the transfer/import of foreign technologies. For example, recent special issues of the development studies journal *World Development* dealt separately with the topics of "Sustainable Development, Energy and Climate Change" (Halsnæs et al., 2011) and "Foreign Technology and Indigenous Innovation in the Emerging Economies" (Fu et al., 2011). An emerging literature, however, is beginning to highlight how these issues are in fact inextricably linked and how an understanding of the latter might make a critical contribution to realising the former, i.e. sustainable development pathways that incorporate lower carbon energy technologies, contributing to climate change mitigation whilst simultaneously meeting critical development priorities (Mathews, 2007; Altenburg, 2008; Walz, 2010; Ockwell et al., 2010; Berkhout, 2012). But simply transferring lessons from research on conventional technology imports and indigenous innovation is not enough. Climate change and technologies for its mitigation or adaptation pose a range of unique challenges and considerations which are currently under researched and under theorised (Ockwell and Mallett, 2012). These include temporal concerns relating to the urgency of climate change mitigation (i.e. achieving extensive low carbon technology transfer as quickly as possible), the global good nature of the benefits of low carbon technologies which are not captured in the market (Mowery et al., 2010), ignored needs of the poorest people where market incentives are also lacking (Sagar, 2009), and the early stage of commercial development and adoption of many low carbon technologies, raising multiple risks to their commercial use and barriers to investment. However, despite the lack of an empirical or conceptual base upon which to build, in many development organisations, including donors, NGOs, and international development banks, the use of phrases such as "low carbon development", "climate compatible development" and "green growth" has become increasingly widespread and are shaping funding agendas. There is therefore an urgent need for empirically grounded research which explores theories of foreign technology and

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indigenous innovation explicitly within the context of low carbon energy technologies, and the contexts of climate change and development policy more broadly. It is within this context that this paper seeks to contribute.

A number of studies have recently begun to analyse how low carbon energy technology industries in emerging economies have evolved and proliferated in parallel with rapidly expanding renewable energy markets and overseas investments. A key question addressed in these studies is the extent to which foreign investment has increased indigenous capabilities in developing countries to engage in advanced product development (Brewer, 2008; Altenburg, 2008; Lema and Lema, 2012). Existing work pays particular attention to the role of national political and institutional conditions for industry development (see e.g. Huang and Wu, 2007; Mathews et al., 2011; Pueyo et al., 2011; Walz and Delgado, 2012). A number of other studies use aggregate R&D and patent statistics to assess both the underlying processes of learning and whether innovative capabilities have developed at the industry level (see e.g. Walz et al., 2008; Tan, 2010; Walz and Weidemann, 2011; Dutch and Sharma, 2012; Wu and Mathews, 2012). This work therefore often misses potential intra-industry differences and firm-level specifics. Moreover, the economic indicators used only indirectly assess learning as an output of technological efforts. With notable exceptions, e.g. Lewis (2007, 2011), Mizuno (2007), Marigo (2009), Marigo et al. (2010), few empirical studies based on firm-level data have undertaken in-depth, longitudinal studies of learning and accumulation of innovation capabilities in individual firms.

One important question concerns the critical factors that underlie differences in the accumulation of innovation capabilities at the firm level. This has critical implications for understanding how foreign technology imports, and interactions between indigenous firms and international technology owning firms, might contribute more broadly to building low carbon innovation capabilities in developing countries and thus how policy and practice might target such capability building. One potential factor that might underlie inter-firm variance in capability building is the nature of the learning mechanisms individual firms employ to develop their in-house technological capabilities. This paper therefore sets out to explore the extent to which the use of different learning mechanisms can explain inter-firm differences in the accumulation of technological capabilities. This question will be explored by examining the dynamics of firm-level learning in relation to boiler manufacturing in the biomass power equipment industry in Malaysia from 1970 to 2011.

The paper is structured as follows: Section 2 develops the conceptual framework; Section 3 sets out the methodology; Section 4 introduces the empirical context, before the main findings are presented in Section 5. The paper concludes in Sections 5 and 6 with a discussion of the results and drawing some conclusions.

2. Conceptual framework

This paper draws on two key theoretical distinctions made within the innovation studies literature to guide its empirical analysis. The first theorises a continuum of technological capabilities in developing country firms, from productive through to innovative. The second theorises a twofold categorisation of different learning mechanisms that firms might adopt and which might explain the accumulation of technological capabilities. The latter also facilitates elaboration of the theoretical underpinnings of assessing the role different learning mechanisms play in technological capability formation.

2.1. Accumulation of technological capabilities in latecomer firms

This paper builds on the literature on technological learning and accumulation of technological capabilities in firms in developing economies – known as latecomer firms (see e.g. Amsden, 1989; Lall, 1992; Dutrénit, 2004; Bell, 2006). In this literature, firm-level "technological capabilities" are broadly defined as the resources needed to generate and manage technological change, including skills, knowledge, experience and organisational systems (Kim, 1997; Figueiredo, 2001). The accumulation of capabilities is thus conceptualised as a process whereby firms accumulate knowledge and skills over time that improve their ability to implement and handle technical change. Following Bell and Pavitt (1993), this paper makes a distinction between "innovation" capabilities and "production" capabilities. Production capabilities refer to the basic and routine-based capabilities necessary to produce industrial goods at different levels of efficiency, given various input combinations such as equipment, labour skills, product and input specifications, and the organisational methods and systems used. Essentially, such production capabilities represent the firms' ability to use, operate, and make small productive efficiency improvements in existing technologies and production systems. Innovation capabilities, on the other hand, denote the resources that firms need to create new, or to implement more substantial, changes in products and product process organisation (Lall, 1992).

Production and innovation capabilities may, according to Bell and Pavitt (1993; 1995), be considered to be at opposite ends of a continuum of sophistication of firms' innovative technological activities. Various studies have elaborated taxonomies to identify different degrees or levels of innovation capabilities of latecomer firms (see e.g. Katz, 1987; Lall, 1992; Ariffin, 2000; Dutrénit, 2000; Marcelle, 2004; Tacla and Figueiredo, 2006). These levels typically range from the basic operational production capability, at the lower end, towards more complex and advanced engineering and R&D-based activities, at the higher end, across various technical functions in the firm. As Bell (2007) and Plechero (2012) conceptualise, with an increase in innovative capability, firms are capable of mastering the generation of innovations with increasing degrees of novelty and complexity. At the lower end of the spectrum, innovations may be "new to the firm" and with increasing innovative capability, firms may generate innovations that are "new to the local industry" (or local market) and "new to the world" market (Fagerberg, 2005; OECD, 2005). It should be noted that in this context "innovation" can be taken to refer to both incremental and adaptive innovation, as opposed to simply radical (new to the world) type innovation. These former types of innovation, which may involve adapting technologies (including designs and organisational practices) to local contexts or incrementally improving technologies to move towards the technological frontier, are often of far more relevance in a developing country context (Mani and Romijn, 2004).

Building on this distinction between productive and innovative capabilities, a typology for assessing technological capability accumulation is presented in Table 1. It should be noted, however, that, as Bell and Figueiredo (2012) argue, the boundary between production and innovation capabilities is often fuzzy and not straightforward. Whereas other taxonomies, such as those elaborated in Ariffin (2000) and Figueiredo (2001), comprise indicators to assess the level of technological capability across a number of technical functions in the firm (such as process, product, equipment, or investment-related), this paper focuses exclusively on the product side. In the context of the case study of boiler manufacturing, this conceptualisation encompasses vital boiler and power plant components such as the grate, super-heater, economiser, fuel pre-treatment and fuel feeding system, as well as the complete power plant design and related engineering.