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Host-site institutions, production networks and technological capabilities

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This article examines critically the literature on industrial policy, regional production specialization, global production sharing, global value chains and global production networks to analyse technological capability development in clothing, automotive and semiconductor firms in China and Southeast Asia. Host-site institutional support and regional production linkages were identified as having a strong influence on firm-level technological capabilities. The article then provides the justification and the structure of the automotive, clothing and semiconductor industries, which are characterized by strong international division of labour.

Keywords: China; global production; industrial policy; regional linkages; Southeast Asia

Introduction

This article seeks to expound the critical concepts and review the main theories to provide the direction for an empirical examination of firm-level technological capabilities with a focus on the automotive, clothing and semiconductor industries in China and Southeast Asia. Unlike Korea and Taiwan where national ownership has dominated industrialization, multinational corporations (MNCs) have played an important role in the expansion of the three industries in the countries examined here. China is the only exception where clothing manufacturing is considerably undertaken by national firms. Even in China, the production of automotive products and semiconductors are dominated by foreign MNCs.

Four major theories have emerged to explain how connecting with global value chains (GVCs) can offer the room for industrialization and technological capability development at host-sites. Original old industrial policy argument not only posits that latecomers have the opportunity to catch-up technologically faster than first movers (Veblen 1915; Gerschenkron 1952; Abramowitz 1956) but also offers a persuasive case for national infants to mature through the use of appraisal mechanisms to ensure that the rents (including tariffs and subsidies) created are translated productively towards industrial deepening (Johnson 1982; Amsden 1989). However, unlike the import-substitution for export-orientation route used by the successful industrializers of Japan, South Korea and Taiwan, countries that simply closed their borders for inward production performed badly. Also, import-substitution through quotas and tariffs is no longer a viable route now to promote industrialization in most countries following global liberalization initiatives undertaken through the World Trade Organization (WTO). It has to be recognized that the
developed countries that absorbed the initial exports of the rapid industrializers are no longer willing to continue with the Most Favoured Nations’ clause of the Generalized System of Preferences for countries other than selected Least Developed Countries.

In addition, the achievement of strong host-site technological upgrading is not a given thing, and is dependent on a number of factors. Despite enjoying over 40 years of experience connecting with GVCs, firms in a number of countries show little technological upgrading. Only Singapore among Southeast Asian countries shows a substantial technological upgrading into R&D activities in foreign MNCs and national firms with linkages to meso organizations in the country. The achievement of strong linkages where differentiated firms in particular sites facing increasing division of labour requires that the macro-instruments connect and coordinate effectively with the science and technology infrastructure (meso organizations) and the micro-agents (especially the small and medium enterprises (SMEs)). The development of a set of technological mechanisms to coordinate the flow of knowledge to synergize firm-level technological capabilities through macro-institutions, meso organizations and micro-agents will go a long way to stimulate the movement of firms to the technology frontier.

While trade in components and intermediate parts has increasingly grown faster than trade in final goods (Kimura and Ando 2005), the evidence on its impact on technology is less clear. Hence, this issue is focused on attempting to identify the forces that explain upgrading of firms in particular countries, in particular industries. The second section provides a review of the key theories dealing with production chains, and technological upgrading and industrial catch-up. The third section discusses the critical variables examined in the issue. The fourth section establishes the rationale behind the selection of industries and countries for the issue. The fifth section discusses the research instrument used to answer the questions raised in the issue. The final section presents the outline of the issue.

Theoretical considerations
We discuss the four main theories that have either directly or indirectly broached the integration of production in global or regional markets, and have made attempts to explain circumstances when upgrading can take place at developing county host-sites. Although much maligned and since the advent of the WTO its role has been seriously narrowed, industrial policy remains by far the most persuasive instrument that when successfully implemented, has offered the promise for technological catch-up and economic progress (Chang 2003; Reinert 2007). The other approaches that have enjoyed traction in policy circles are the global production sharing, GVCs and global production networks (GPNs). We subject them to their contribution to host-site technological upgrading.

Industrial policy
Industrial policy has been viewed as the basis for stimulating technological catch-up and rapid economic growth (Smith 1776). Indeed, as Young (1928) had argued, industry offers the greatest opportunity to drive differentiation and division of labour. Although there are various definitions used by economists, we take industrial policy to exist so long as there are efforts to provide a particular or set of industries preferential treatment over others. Hence, unlike the view held by some referring industrial policy to import-substitution strategies, we argue that efforts to intervene in markets through investments into technological upgrading activities such as in higher and science-based education, opening
of R&D labs and research universities and provision of incentives and grants to support high value-added activities such as R&D, and preferential allocation of land and labour for particular high value-added activities or to stimulate exports as aspects of industrial policy. In light of global developments in trade organizations (e.g. the WTO), the use of tariffs, quotas and subsidies have become difficult, and hence industrial policy interventions are increasingly likely to take different forms.

The industrial catch-up experiences of Britain (Reinert 2007), the USA (Hamilton [1791] 1913), Germany (List 1909; Veblen 1915), Japan (Johnson 1982), Korea (Amsden 1989) and Taiwan (Wade 1990) have been attributed to the use of industrial policy. In fact, Gerschenkron (1952) argued that latecomers helped shorten the catch-up period by skipping stages and avoiding errors. The introduction and enforcement of appraisal mechanisms and performance standards were identified by Johnson (1982) and Amsden (1989) as to why rents (subsidies) were successfully utilized productively in Japan and Korea, respectively.

However, the catastrophic failure of a number of badly planned industrial policy experiences have vulgarized the image of industrial policy, and hence have left governments to the moral hazard of serious government failure. Not only were rents targeted at consumers to the point of creating a highly costly chain of inflated input prices that undermined the competitiveness of many industries, but also the alternative pressures from a lack of competition from abroad, such as with the use of appraisal mechanisms through the introduction of performance standards were also absent from the import-substitution regimes in Philippines until the 1980s, India until the late 1980s and Indonesia until the end of the 1990s. Nevertheless, the successful industrial policy experiences of Germany (Veblen 1915), Japan (Johnson 1982), Korea (Amsden 1989) and Taiwan (Wade 1990) – all of which targeted export markets – does show that the development of host-site institutions matter in stimulating technological upgrading.

**Regional production specialization**

Akamatsu (1962) pioneered arguably the first regional trade and investment linkages theory. In this model, Akamatsu used the flight of a flock of geese to explain economic growth and structural change in a group of East Asian economies. Figure 1 presents a stylized framework of regional investment-trade synergies between Japan and its neighbours in East and Southeast Asia. Japan as the leading goose is given the lead role in this model as the driver of the flock of geese, and hence creates a division of labour through investment and trade linkages.

Japan initiates the flight of geese by specializing on raw materials-based industries first, importing from the next wedge of geese, i.e. the first-tier newly industrialized economies (NIEs). Processed raw materials (product I) are exported back from Japan to the first-tier NIEs. Japanese investment also flows into the first-tier NIEs to support the growing or mining of raw materials. As costs rise and with learning in the first-tier NIEs, Japan migrates to produce the next order manufactured goods that not only require more capital and technology but also generate more value added, say textiles and clothing (product II). Product I (processing of raw materials) shifts to the first-tier NIEs. The first-tier NIEs import raw materials from the second-tier NIEs while exporting processed raw materials to both Japan and the second-tier NIEs. This sequential process is expected to continue with Japan continuing to upgrade to the highest technology-intensive and value-added products, and the division of labour order remaining intact with the first-tier NIEs staying below Japan but ahead of the second-tier NIEs. Although Akamatsu (1962) did not
specifically foresee the component countries in each of the different wedges of geese, this sequence was expected to attract further regional economies until the numbers are exhausted. In Figure 1, Japan can be forecasted to progress from raw material processing (I) to textiles and clothing (II) to cars (III) to integrated circuits (ICs) (IV) and to supersonic jets (V) with the order based on technological intensities and value added. Investment flows in this model are always from the richer countries to the poorer countries, while trade occurs between all the countries in the flight of the geese.

The simple model advanced by Akamatsu (1962) also provides a rationale for economic development. Higher technological intensities are considered to raise value added, and hence the per capita incomes according to the products produced. The division of labour in this regional division of labour remains intact. Kojima (1978) added a number of neoclassical elements to this model by arguing that relative factor endowments define the specialization taken by each of the wedges of geese within the flock. When set in a neoclassical framework, product specializations shift when relative prices change.

However, while the model appeared to function well in the early decades after Akamatsu advanced its model, it lost steam following the successful catch-up leapfrogging enjoyed by national steel, shipbuilding, automotive, machinery and electronics firms in Korea and Taiwan. Not only have the Korean firms of Posco and Daewoo overtaken Japanese firms as
leading exporters of steel and ships, Samsung has also supplanted all Japanese firms in memory chip, refrigerators and washing machine technologies. Also, Taiwan’s Taiwan Semiconductor Manufacturing Corporation is the globe’s lead firm in logic chip technology. Besides, consistent with the arguments advanced by Johnson (1982) explaining the critical role of the Ministry of International Trade and Industry in technological catch-up of several Japanese industries, Korean industries appear to have adapted this framework to overtake competitors in several high technology industries.

**Global production sharing**

Another body of economists view production fragmentation internationally as a major channel through which production is separated through arms-length market transactions or internalized through a transnational division of labour (Feenstra 1998; Yeats 2001; Arndt and Kierzkowski 2001). Helleiner (1973) had made a persuasive argument to support the internationalization of production on the basis of factor prices to suggest the occurrence of economic convergence. Through both outsourcing and transnationalization of operations Ando and Kimura (2005) and Kimura and Ando (2005) and Athukorola and Yamashita (2006) provide empirical evidence to show the faster expansion in trade involving components and intermediate goods than final goods to argue that it has offered developing countries greater opportunity for global production sharing (GPS). Collier (2006) went further to argue that connecting in GVCs offers firms in developing sites the opportunity to grow and compete internationally.

While trade in components and intermediate goods have indeed grown more rapidly than final goods, trade economists have hardly broached the dynamics of upgrading at host-sites. Like the old free traders, the GPS advocates assume that the international division of labour defining the new geography will engender market-based efficient specialization through competition, whereby technological upgrading in particular sites will occur on the basis of changes in factor prices. It is the dynamics of evolving production networks and division of labour that defines the room for technological upgrading in such accounts, leaving markets as the only institution with the leading role to shape it. Given the dominant role of markets, then, there is really no need to examine the role of other institutions in shaping technological upgrading at host-sites, except for targeting non-market institutions when it does not occur. The value added this argument provides is the logic of sharing that global and regional integration provides so that allocative decisions are shaped by factor endowments and distance.

**Global value chains**

Gereffi and Korzeniewicz (1994) developed the global commodity chains framework that related the value-added chain directly to the production organization of industries. Unlike the work of trade economists, this work established the importance of control by arguing over the importance of new global buyers (primarily retailers and brand marketers) as the main drivers of globally decentralized and organizationally fragmented production and distribution. Gereffi (1994) referred to the ‘buyer-driven global commodity chain’ to show how global buyers explicitly created a highly competitive supply-base without direct ownership. By highlighting explicit coordination in disintegrated chains and contrasting them to the relationships contained within vertically integrated, or ‘producer-driven’ chains, the global commodity chains framework drew attention to the role of networks in driving the co-evolution of cross-border industrial organization.
Further work by Gereffi, Humphrey and Sturgeon (2005) began to expand further the earlier work of Gereffi (2005) to embrace a variety of network forms that have emerged in different industries. Dolan and Humphrey’s (2000) work on the horticulture industry, Schmitz and Knorringa’s (2000) work on the footwear industry, Sturgeon’s (2002) work on the electronics industry, nevertheless, reinforced Gereffi’s (1994) notion that global buyers (retailers, marketers and traders) can and do exert control spatially over dispersed value chains even when they do not own the production. Gereffi, Humphrey and Sturgeon (2005, 89) identified five GVC governance types: markets in which prices determine entirely the buyer–supplier relationships; modular in which turn-key suppliers manage component and material suppliers for the lead firm; relational in which a relational supplier manages component and material suppliers for the lead firm; captive in which the lead firm manages directly its suppliers; and hierarchy in which the firm internalizes in production chain.

While this differentiation of GVCs is important as it helps distinguish them by the degree of coordination and power asymmetry between buyers and suppliers, the focus is wholly on the production chain, including suppliers located at host-sites. While such postulations offer suppliers the opportunity to identify upgrading opportunities, it does not provide an assessment of the role of host-site institutions in stimulating technological upgrading.

Global production networks

Since the work of Granovetter (1985, 507), geographers have begun to explain GPNs and distribution as a dense social networks (Hughes 2000; Dicken et al. 2001; Henderson et al. 2002; Coe, Dicken, and Hess 2008).

Although geographers have an early history of attempting to explain the globalization of production, its dynamics and consequences (see Scott 1988), much of the empirical evidence used by the GPN scholars have been drawn from GVC experts. Also, unlike the early works of geographers, such as McGee (1967), Scott (1988) and Douglass and Friedmann (1987), those working on GPNs have hardly harnessed the disciplinary instruments of geography to spatially examine the international spread of production to capture the dynamics of control have impacted on particular spaces and industries. Hence, there is also hardly any effort by the GPN experts to explain the role of host-site institutions to address technological upgrading in particular locations.

Overall, it can be seen that the accounts by the GPS, GVC and GPN help explain the internationalization of production globally. However, by providing an illuminating account of control over the value chains the GVC approach stands out in demonstrating the nature of power relations in value chains that could be harnessed for evolving technological capabilities among supplier firms. However, none of these approaches seriously examine the role of host-site institutions in stimulating the development of technological capabilities. Although industrial policy has generated undue costs in a number of locations and the space available for its execution has been narrowed by trade and investment liberalization initiatives, its focus on institutional support at host-sites is still relevant. Hence, we assume a framework that incorporates institutional support with the GVC approach of production chains. To capture the effects production chains, we limit the scope of the analyses to regional (or domestic) production chains.

Critical variables

In this section we present the important variables that help explain technological upgrading at host-sites. Firm-level technological capability is the most important measure
of upgrading at host-sites. Institutional support and regional (domestic) production linkages are the next set of critical variables examined.

**Technological capabilities**

The word technology refers to the making, usage and knowledge of tools, machines, techniques, crafts, systems or methods of organization in order to solve a problem or perform a specific function, and also to the collection of such tools and machinery.

The specific categories, phases and processes of technological change were analysed lucidly by Rosenberg (1975). Rosenberg and Frischtak (1985) defined technological capability as a process of accumulating technical knowledge or a process of organizational learning. Dahlman, Ross-Larson and Westphal (1987) emphasized the underlying concept of trajectory of deepening capability, moving from technology-using production capabilities to innovation driving capabilities. They developed a sequence of capabilities running from production capability, via investment capability to innovation capability, which became the basis of Bell’s (1987) and Lall’s (1992) taxonomy of technological capabilities.

Bell (1987) grouped technology flows into three categories: Flow A consists of capital goods and technological, engineering and management services; Flow B consists of the skills and know-how to operate and maintain the newly established production technology; and Flow C consists of the knowledge and expertise for implementing technical change, or the know-why. In this framework, Flow A leads to improvement in production capability, Flow B contributes to technological capabilities at the basic, routine level and Flow C enables the firm to generate dynamic technical and organizational changes.

Lall (1992) outlined a functional categorization of technological capabilities based on the task facing a manufacturing firm. The task and associated capabilities are characterized into two groups: investment capabilities and production capabilities. These are further divided into three levels. The first level is simple and experienced based, the intermediate level is adaptive and duplicative in nature but is research based and the advanced level is innovative and risky but is also research based. Wei (1995) integrated Lall’s (1992) functional categories with Bell’s (1987) technology flow classification. He concluded that (1) not all technology flows generate technological capability and (2) linkages with local supplier and other groups within the local economy are critical for enhancing capabilities. Rasiah (2006) drew upon these contributions to focus on just technological capabilities, establishing in the process a typology of taxonomies and trajectories. This framework allows the benchmarking of the different types of technological capabilities – human resource, process technology and product technology.

It has been shown that foreign firms enjoy tremendous latent potential to generate spillover through export markets, technological linkages and demonstration effects (Caves 1974). As Hirschman (1970) and Rasiah (1995) have argued, it is the responsibility of host governments to create the conditions (absorptive capacity) to realize the spillover potential. In fact, Hirschman focused on export-oriented foreign firms where he argued that their growth would actually expand the backward linkage potential at host-sites. Countries, such as Singapore, Malaysia, Philippines, Thailand, Vietnam, Cambodia, Laos and Indonesia actually show high export-intensities of GDP to suggest that systematic efforts to evolve the absorptive capacities will stimulate considerable economic synergies for national SMEs.

To avoid extensive divergence in the measurement of economic activities across different types of industries, we have left the composition of technological capabilities to
be addressed by the individual industry articles. Firms generally do not participate in basic research activities but sufficiently big to undertake development and commercialization. MNCs can be expected to participate in commercialization activities if the embedding environment is supportive (see Amsden, Tschang, and Goto 2001).

**Institutional support**

Institutions and the intermediary (meso) organizations through which they are driven to raise technological capabilities in SMEs is the focus of this project. North (1993) defines institutions as the rules of the game, and firms and organizations as their players. Whether it is markets, government policy (including its enforcement), in-house command and trust, a blend of all of them are often instrumental in providing the fillip for firms to evolve technological capabilities, generate spillovers and appropriate them.

Governance of institutional coordination can happen directly through non-governmental meso organizations and networks as industry-wide business networks do exist to support firms’ activities for mutual benefits. The specific institutions and meso organizations they help create or coordinate with their roles are often industry-, location- and time-specific (Nelson 2008; Rasiah and Vinanchiarachi 2012), and hence the proxies that will be used in the three industries from the 10 countries studied. The individual articles will define the institutional support variable using this criteria.

Micro-agents, and in this case the firms, often require the setting up and fuelling of meso organizations to move up the technology trajectory. This is particularly the case when involving the delivery of public goods and goods (e.g. R&D) that involve collective action problems (e.g. standards certification). The significance of these organizations vary with the level of activity in which firms in particular countries are dominant on.

The knowledge intensity of firms connected through production chains will also vary with the state of the meso organizations and macro-institutions at the host-sites, which is consistent with the industrial organization argument that structure influences the conduct and performance of firms. Hence, any assessment of technological capabilities of host-site SMEs will require an extension of it to include an evaluation of the meso organizations and the macro-institutions. The assessment of meso organizations will also vary with the industry type and the location of firms in the technology trajectory. For example, semiconductor firms will look at research universities, supply of engineers and technicians and R&D grants as critical institutional support instruments to stimulate their participation in R&D activities (see Mazzoleni and Nelson 1998; Rasiah 2006).

As North (1993) had defined, institutions set the rules of the game, while the entrepreneurs and organizations are the players. Whenever public goods are involved where potential social returns exceed real private returns, interventions through the modes of trust and command will be necessary to provide the synergy and the reach to ensure the participation of as many as possible the micro-agents and the meso organizations. We recommend that the Nelson argument of allowing specificity of each economic activity and time to determine the coordination networks essential to drive innovation capability building and its connections with the knowledge nodes and users. It is for these purposes that Lundvall (1992) argued over the importance of interactive user-producer relations to effect horizontal knowledge flows.

To ensure that the ‘rules of game’ facing foreign MNCs and national SMEs are fair – taking account of the specificity of local conditions and the activity involved – legal statutes must be enacted and strengthened to protect intellectual property optimally to ensure that it acts as an inducement rather than a deterrent in both the development and
dissemination of new technology. The enactment and enforcement of fair regulatory instruments to stimulate knowledge flows will also attract foreign direct investment from abroad.

The focus on fostering cooperation to develop commercialization of knowledge requires policy governance in the development of incubators and R&D labs, which is critical to assist SMEs, strong efforts to build horizontal links between these organizations and firms and an intellectual property rights mechanism (see Table 1). The first is important to offer SMEs knowledge critical for participation in higher value-added and knowledge-intensive activities. The second is critical for SMEs to enjoy strong potential to access knowledge if the policy framework supports technology development in universities, incubators and R&D labs. This is particularly important to support high-tech firms à la the Silicon Valley, Route 128 and Hsinchu Science industrial Park (Taiwan), where incubators have become a major conduit for new firm creation. The third is vital for the development a high-tech economy for the generation and appropriation of knowledge with the highest stage being the one where the stage becomes compliant to the Trade-related Intellectual Property Rights agreement of the WTO.

SMEs are known to perform well when clustered around the critical meso organizations and foreign MNCs as the latter offers both technological synergies and market access. Clusters are here defined as regionally or locally networked set of economic agents (firms and institutions) that connect all critical economic agents necessary to drive learning, innovation and competitiveness. Clusters are considered to produce the most synergies when all the requisite institutions to drive learning, innovation and competitiveness are developed with strong connectivity and coordination between them to drive innovation and competitiveness through circular and cumulative causal processes. What Young (1928), Abramowitz (1956) and Kaldor (1957) had argued at an abstract and aggregate level can be presented in networks terms through the concept of clusters.

### Regional (domestic) production linkages

Regional (domestic) rather than global production linkages were preferred for assessment simply to evaluate the influence of such links on technological upgrading. Also, the Association of Southeast Asian Nations (ASEAN) Free Trade Area process effected by the common effective preferential tariff mechanism, as well as, the greater ASEAN

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Note: $N$ and $W$ refer to percentage shares in total national exports and world exports of the merchandise involved.

*Computed using data supplied by Lao officials from the National Economic Research Institute (NERI).

Source: Compiled from WTO (2012); NERI.
framework that has China, Japan, Korea and Taiwan engaged in a gradual tariff harmonization process has offered the room for the expansion of regional production linkages.

The choice of Cambodia, Laos and Myanmar is particularly important in clothing production chains where foreign-owned integrated clothing manufacturers and contract manufacturers from East Asia dominate production. Inputs such as buttons and fabric are also imported considerably by firms in these countries. Automotives have generated a distinct regional production networks in Southeast Asia with linkages to suppliers from China, Japan, Korea and Taiwan. The bulk of the semiconductor components from Southeast Asia are exported to China where they are assembled into computers, telecommunication and other final goods. Fabricated wafers are also either imported or produced domestically in the East Asian countries with East Asia having become the most important production base of wafers in the world since the 1990s.

The empirical data gathered will help distinguish production linkages between intermediate parts and component producers from arms-length transactions. It is the share of imports and exports bought from and sold to which is measured as direct production linkages. Flows of knowledge as instructions on order specifications, details and testing often accompany orders and sales, and hence can have a bearing on technological capabilities. Where the sales destination is less sophisticated, technological capabilities may be more correlated with domestic rather than regional production linkages. Singapore may be faced with this situation as it has stronger capabilities than the pressures the regional markets of China, and the rest of Southeast Asia could impose on its manufacturers.

Unlike the emphasis by Marshall (1890), knowledge appropriation is not costless as argued by Lall (1992). The historical sequence to the development of technological capabilities through industrial policy started in Britain when Henry the VII imposed taxes on exports of wool in 1485 (see Reinert 2007). A series of follow-up industrial policies helped the USA, Germany, Sweden, Japan, Korea and Taiwan achieve technological superiority in increasing returns industries. Coase (1937, 1991) and North (1991, 1993) discussed the significance of institutions in production allocation and capitalist development but come short by identifying markets as the superior institution in the process. Schumpeter (1961) had argued as to why ‘productive rents’ are critical to stimulate innovation when criticizing perfect competition. Freeman (1989) had demonstrated using the experience of Japan that international flows of stocks of knowledge from developed to developing economies take a sequential movement from imports to adaptation, assimilation and innovation – all of which are costly stages that countries typical go through in moving up the technology ladder. While the Marshallian systemic doctrine of knowledge flows remains critical in the generation and diffusion of technological spillovers, institutions other than markets – policies by governments, trust relationships supported by particular sociocultural and economic groups and intermediary organizations have been no less important in technological catch-up.

Governments can create or strengthen the institutions to promote clustering effects. Government can also screen particular clusters and identify bottlenecks, gaps and weaknesses to ease, fill and ameliorate these problems. Such problems can take the form of critical basic infrastructure, high-tech infrastructure or supplier firms. Given the problems of information asymmetries between government and firms, intermediary organizations such as chambers of commerce, training institutions and R&D labs often help resolve collective action problems. Interdependent relationships that are driven by the discipline of the market, participation of government when public goods are involved and
complementation through trust-loyalty to extract social commitment from the humans directing all of them is vital for the development of competitive clusters. Stakeholder coordination (e.g. through industry, government, consumer and labour coordination councils) often help root and expand social capital.

A lack of firm-level drive, human capital and high-tech institutions necessary to stimulate innovation and competitiveness have often undermined the capacity of clusters in ASEAN (e.g. Bangkok, Penang, Manila) to enjoy sustainable differentiation and division of labour, which are also the prime reasons for the stagnation that has characterized industrial estates in many developing economies. Technologically, frontier production sites enjoy support from intermediary organizations such as R&D labs, research universities, suppliers and venture capitalists. The US government continues to fund strategic research in the military, universities and other laboratories (NSF 2000).

**Choice of industries and countries**

Since the focus is on global, regional and domestic production linkages and host-site institutional support in generating technological capabilities, the questionnaire and the sampling procedure is critical. Unlike the usual random or stratified random sampling procedures, the methodology for this project requires the selection of a set of root firms first. The following industries have been identified to be suitable as there is evidence of strong global, regional and domestic production linkages and the industries are important for the respective countries, namely automotive, clothing and semiconductors.

Automotive vehicles, parts and components are one of the main industries characterized by differentiation of production and linkages, while semiconductors and clothing have dominated the internationalization of production. China was included for all three industries not only because of government initiatives to promote them but also because of the significance of exports (see Table 1). Automotive vehicles, parts and components were also chosen for Indonesia, Philippines and Thailand for the same reasons. The automotive industry had already become important in Indonesia, Philippines and Thailand in the period since the 1950s and 1960s. Clothing was also chosen for Laos and Myanmar as the industry figured prominently in national exports. Semiconductors were chosen for China, Malaysia and Singapore because of the importance of industrial promotion and exports.

When discussing industrial technological capabilities, it is necessary to examine government policies on small and medium industries, as in some countries governments have deliberately introduced policies to promote linkages, while in others multinationals have participated actively to achieve their own self-expansion plans. For example, in Malaysia, the government implemented industrial policies, *inter alia*, to promote supplier networks (Malaysia, 1996, 2006). In Thailand and Indonesia, multinationals have evolved supplier relationships with foreign, national and joint-venture firms to stimulate complimentary support activities (Poaongsakorn and Techakanont 2008; Amin 2011; Techakanont and Charoenporn 2011).

**Industry value chains**

Given that technological upgrading typically involves both horizontal (technological deepening in the same segment of the value chain) and vertical upgrading (movement upwards in the value chain), we present the value chains of the three industries that are analysed in this issue, namely automobiles, clothing and semiconductors.
Automotive

Figure 2 shows the typical value chain of the automotive industry. The brand holder body assembler drives the value chain putting together the completely knocked down (CKD) parts into completely built up (CBU) units. The nature of production in the automotive value chain has evolved to involve the modularization of CKDs. Because of the scarcity of highly skilled labour to undertake highly specialized tasks in distant locations, value chain drivers have preferred to confine their supplier activities to module assemblers who then link up with component suppliers. Hence, modularization has become important in relocation decisions since the 1990s. Significant amounts of horizontal upgrading has taken place in the industry so that process R&D and organizational and adaptive engineering is a requisite for component manufacturers and CKD assemblers to participate in automotive value chains.

However, when available suppliers lack the skills to participate in CKD or component manufacturing, CBU assemblers have jointly owned the CKD and component suppliers to stimulate technological deepening so that upgrading in the value chain is smoothly coordinated. Both Toyota and Honda have struck joint-ventures with local capital in Indonesia, and by themselves in Thailand and India to support such upgrading (see Rasiah and Vinanchiarachi 2012).
Clothing

Clothing value chains are driven by brand holders, including the upstream material developers of textile value chains. Textile manufacturing typically begins with the preparation of fibre for the manufacture of yarn through spinning (see Figure 3). Both natural (e.g. cotton and wool) and synthetic (e.g. polyester, nylon and acrylic) fibres are used to manufacture textiles. The yarn is then either woven or knitted into fabric. The dyeing process typically happens after fabric is woven but yarn is also dyed before knitting is carried out. Fabric is then bought by another set of firms who manufacture garments. Japanese and Taiwanese firms specialise on the manufacture of synthetic fibres, knitted and woven textiles – with separate subsidiaries undertaking each of these processes. Clothing firms then purchase both woven and knitted fabric and carry out fabric scanning, clothing design, cutting, stitching and finishing (including pressing) of garments. These processes do not use computers when involving low value-added clothing so that humans dominate labour-intensive work over the entire set of stages. Higher value-added clothing often use auto-scanning, computer-aided design and computer-aided manufacturing machinery and equipment, auto-aided embroidery designs and auto-controlled stitching of sleeves and pockets.

The clothing industry is largely a technology-using industry with advancements in materials technology (fibres) and advanced manufacturing technology (e.g. the use of information communication technology and computer-aided control in textile and clothing machinery and equipment) being the main drivers of technological upgrading. Logistics, especially the provision of infrastructure using information communications technology and shipping routes, is important to shorten delivery times.

Whereas all operations shown in Figure 3 can be found in China, clothing production in Laos and Myanmar are dominated by cut, make and pack operations (see Rasiah and Myint 2013). Since the focus here is only on clothing manufacturing, horizontal upgrading would involve improvements in productivity gained from training and skills development.

Figure 3. Clothing value chain, 2013. Source: adapted from Rasiah (2012).
of workers, improvements in processes and material use, adaptations to machinery and equipment, inventory control and testing equipment and organizational change. Vertical upgrading would involve integration of greater control over clothing manufacturing by participating in packaging and logistics, and eventually enjoying brand holder status.

**Semiconductors**

A stylized framework of technological upgrading in the semiconductor industry is shown in Figure 4. In the functional category, semiconductor firms evolve to integrate front- and back-end operations without significant increases in value added, while some relocate or upgrade to participate in R&D, IC design and wafer fabrication. Whereas the former refers to horizontal integration the latter refers to functional upgrading. We do not consider horizontal integration activities as upgrading if they are limited to the merging of lower value-added activities – e.g. the addition of assembly to test activities, or wafer bumping to wafer fabrication.

In the second dimension, semiconductor firms absorb best practices, including cutting edge inventory and quality control systems, and introduce adaptive engineering and R&D support to upgrade assembly and test activities to raise plant-level productivity that entrepreneurs can easily undertake. Training and skills development are important to ensure a high level of competency among the workers to perform continuous improvements (*kaizen*) at the workplace.

**Research instrument**

The articles rely on a survey questionnaire designed specially to capture ownership, sales and export structures; employment, fixed assets, technological intensities and capabilities; regional and global sales and purchases structure; and institutional support to facilitate the evaluation of the influences on firm-level technological capabilities. By targeting firms the questionnaire also enables the evaluation of the meso organizations and macro-

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**Figure 4.** Value chain of ICs, 2012. Source: Adapted from UNCTC (1987, 87–101).
instruments facing them. The choice of the methodologies to examine the relationships is made by the individual contributors.

Although the focus of this exercise is on technological capabilities, and institutional support and regional (domestic) production linkages, the questionnaire used had a broader objective, and hence also sought to gather data on economic structure, performance, marketing and finance. Answers to a number of the questions are used in the individual articles as control variables.

Outline
Following this introductory article, the next five articles examine the influence of host-site institutional support and production integration on firm-level technological capabilities in the automotive industry in China, Indonesia, Philippines and Thailand. Both influences show a strong impact on firm-level upgrading in these countries.

The subsequent three articles analyse the expansion of the clothing industry in China, Laos and Myanmar. China’s huge domestic market and production capabilities have stimulated massive exports. Although Laos and Myanmar have comparatively smaller markets and low production capabilities, the clothing industry has also enjoyed technological upgrading since integration into regional and GVCs.

The following three country articles evaluate the relationship between host-site institutional support and production linkages on firm-level technological capabilities in the semiconductor industry in China, Malaysia and Singapore. The semiconductor industry in both countries is integrated strongly in GVCs. Whereas Singapore, and to a less extent, China and Malaysia have enjoyed considerable high-tech support from the government, the institutional framework in Singapore is stronger than in China and Malaysia.

The final article presents the synthesis of findings and draws implications for theory and policy. The evidence shows that integration in the global, regional and domestic value chains have been instrumental in initiating rapid growth in output and exports, and employment. However, the evidence also shows that institutional support and production linkages matter in firm-level technological upgrading in all three industries.

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