Chapter 8
Production Networks, Profits, and Innovative Activity: Evidence from Malaysia and Thailand

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Abstract Cross-border production networks have been playing an increasingly important role in the Association of Southeast Asian Nations (ASEAN) countries' trade in recent years, but micro-level studies of their impacts are rare. This chapter uses firm-level data from the two ASEAN countries that are most active in production networks (Thailand and Malaysia) and examines the effect of participating in production networks on profits and technological capabilities of firms. The empirical results suggest that participating in production networks raises profits. The evidence further suggests that participation in production networks is positively correlated with technological upgrading, measured by a technological capabilities index.

Keywords Trade, multinational firms • International business, industrialization • Manufacturing and service industries • Choice of technology

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8.1 Introduction

There is little doubt that production fragmentation, first identified by Jones and Kierzkowski (1990), has transformed the global and Asian trade landscape in recent decades.[1] It is associated with the emergence of the global factory in Asia, the industrial success of the People's Republic of China (PRC), and unprecedented prosperity in the region (Baldwin 2011). The slicing of production and relocation of activities across geographical space in Asia was fostered by many influences including rising factor costs in home production bases, a reduction of trade barriers, rapid advancements in production technology, and a decrease in transport and communication costs.

Numerous studies have examined the impact of production fragmentation on trade flows and trade patterns (see, for instance, Yeats 2001; Ng and Yeats 2003; Yi 2003, 2010; Grossman and Rossi-Hansberg 2008). The fact that trade in production networks has grown faster than manufacturing trade underlines the importance of production network trade (Athukorala 2011). While there is a body of such macro-level work on production networks and trade, micro-level research on the workings of firms in production networks is largely absent. Despite the growing importance of production networks in ASEAN countries, little work has been conducted to examine the effects of production networks on firms and innovative activities or technological capabilities at firm-level.

This chapter undertakes a micro-level econometric study of enterprise behavior in production networks in Malaysia and Thailand. First, by way of background, it updates the macro-level findings of Athukorala (2011) and uses trade in parts and components in selected categories as a proxy for trade caused by the emergence of production networks. The results show that global trade in production networks more than tripled between 1992 and 2013. Furthermore, the share of Asian countries—led by the People's Republic of China (PRC) and the Association of Southeast Asian Nations (ASEAN) countries—in this trade has risen significantly since 1992. By 2013, the PRC accounted for over 20 % of global production networks trade and ASEAN countries for almost 10 %.

Second, the chapter attempts to narrow the research gap on micro-level impacts, by using firm-level data from Malaysia and Thailand. These countries combined account for more than 40 % of ASEAN's trade in production networks and play a notable role in the region's electronics and automobile industries. Using a sample of over 2,000 firms, the chapter examines the effects of participation in the global production network on value-added and technological upgrading measured using a technological capabilities index (TI). It defines participants in production networks as firms that import inputs but also export.

[1] The term fragmentation is often attributed to pioneering work by Jones and Kierzkowski (1990). Production sharing (Drucker 1977), vertical specialization (Hummels et al. 2001), outsourcing (Grossman and Helpman 2005), and global value chains (Gereffi et al. 2005) refer to a similar phenomenon.

However, the results are also tested for robustness to using alternative potential definitions. The research on Malaysian and Thai firms was inspired by a number of theoretical insights and empirical contributions. These include: theoretical work by Glass and Saggi (2001) on the links between participation in production networks, profits, and technological upgrading; empirical work by Görg and Hanley (2011) on outsourcing and research and development (R&D) activities in Irish firms; and the literature on technological capabilities in developing countries conceptualized by Lall (1987, 1992) with empirical work on a TI by James and Romijn (1997), Wignaraja (2002, 2008, 2012a), Rasiah (2003), and Iammarino et al. (2008).

The econometric results suggest that participating in production networks raises profits in firms in Malaysia and Thailand. Participation in production networks is also positively correlated with technological upgrading, measured by a TI. The remainder of the chapter will use the term "participants in production network" to describe firms that import a certain part of their inputs from abroad and also export. The results are also checked for variations of this definition.

8.2 Literature Review

8.2.1 A New Trend in Trade: Production Network Trade

Reductions of trade barriers, rapid advancements in production technology, and a decrease in transport and communication costs in the last decade enabled firms to exploit differences in factor prices around the world (Blinder 2006; Baldwin 2011). Globally-acting firms exploited these price differences (for instance for inputs or low-skilled labor) by splitting up the production process into different stages that can be performed anywhere in the world. This phenomenon has been described by various terms in the economic literature: slicing up the value chain (Krugman et al. 1995), fragmentation (Deardorff 2001),[2] and vertical specialization (Hummels et al. 2001) all refer to the same phenomenon.

The first sectors to participate in production fragmentation were the electronics and the clothing sectors. The semi-conductor industry is one of the earliest examples of a production network. Semi-conductors which have a high value, were designed and fabricated in the United States (US), air-freighted to Asia for assembly, and then returned to the US for final testing and shipment to the customer. Subsequently, final testing facilities were established in Asia which is the final destination of some of the products anyhow. Hence, Asia's share of semi-conductor sales has almost doubled between 1984 and 2004 (Brown and Linden 2005).

Over time, the global production network deepened and spread also into other sectors such as automobiles, televisions, and cameras. This deepening of production networks also meant that countries specialized in certain steps of the production and

[2] Production fragmentation can occur within and across countries (Deardorff 2001).

hence more and more countries participated in the production of one final good.[3] The deepening of production networks also means that some firms decided to re-locate the final assembly in order to exploit cost differences and/or to be close to the final customer. One example of such a deep production network is the case of Japanese car manufacturers such as Honda and Toyota which located entire assembly plants in low cost countries like Thailand and sourced inputs from neighboring countries (Techakanont 2008; Athukorala 2011). Major Japanese auto parts suppliers (like Denso) also set up plants in Thailand, following car manufacturers.

8.2.2 *Quantifying the Trade in Production Networks*

Several studies show that this trend of deepening production networks has changed the trade landscape considerably, especially in Asia (Ando and Kimura 2005). The measurement of production network trade is not straightforward. Earlier studies rely on data from Organisation for Economic Co-operation and Development (OECD) countries and are focused on the European Union (EU) and the US (Görg 2000; Feenstra 1998). These studies use data from outward processing trade (OPT). Under a special customs scheme goods can be exported from the EU territory for processing and resulting final goods can be released for free circulation within the EU. However, not all products are covered under the OPT scheme and the product coverage varies over time. Also, the importance of such tariff concessions may be somewhat reduced by unilateral trade and investment liberalization. Furthermore, one has to treat the EU as one block as the final destination of the goods is unclear.

Another way to measure production network trade is to use input-output tables to compute the level of vertical integration (e.g., Hummels et al. 2001). A variant using input-output tables traces value-added in production networks and suggests that value-added is a more accurate means of capturing production network activity than trade data (e.g., WTO IDE-JETRO 2011). The approach of measuring value-added is attracting increasing interest in academic circles. Nonetheless, it remains a work in progress as far as empirical application is concerned in most developing countries. Since input-output tables are not available over the past years for Malaysia, Thailand, and other ASEAN countries it was not possible to use this methodology in this chapter.

An alternative and convenient way of measuring production network trade is to use data from the United Nations (UN)-COMTRADE database. Yeats (2001) describes how one can derive proxies for production network trade from the UN database. This methodology has been adopted by Ng and Yeats (2003) and Ando and Kimura (2005), among others. The disadvantage of this method is that trade

[3] An illustrative example is a Barbie Doll described by Feenstra (1998) who quotes Tempest (1996). The producing firm sources raw materials from Taipei,China and Japan, produces the dolls in Indonesia and Malaysia, using doll clothing from the PRC and paints from the US.

data are a less accurate representation of detailed production network activities than value-added data, particularly between countries. However, the main advantage is that the trade data set is comprehensive and covers most countries for a of years. Accordingly, it can be readily applied to show trends in production networks for ASEAN countries as useful background for this research.

A recent example of this approach is Athukorala (2011) who uses data from firm surveys in Malaysia and Thailand to identify product groups of production network trade. The author identifies the following industries in which production network trade is heavily concentrated: office machines and automatic data processing machines (US Standard International Trade Classification, SITC 75), telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), road vehicles (SITC 78), professional and scientific equipment (SITC 87), and photographic apparatus (SITC 88). Using this definition, the study confirms the sharp increase in global production network trade. According to Athukorala (2011), global production network trade flows grew from about US$1 billion in 1992–93 (about 23.8 % of total exports) to more than US$4.5 billion (45.5 %) in 2006–07. The share of developing countries in total world production networks exports increased from 22 to 45 %. This trend was mostly driven by the rise of the PRC, but the share of ASEAN countries also grew faster than the regional average, reflecting the vital role of ASEAN countries.

8.2.3 Effect on Wages and Employment: Concerns in the Developed World

Given the enormous growth of production network trade in past decades, it is not surprising that the trend toward outsourcing of both goods and services and the subsequent trade within production networks has received a lot of attention from the public and academia in the developed world.[4] These concerns are based on the economic intuition that firms that participate in production networks have access to cheaper inputs and the countries will specialize in certain production steps. For developed countries, this implies a change toward more skill-intensive activities. This argument is in line with a Heckscher–Ohlin model of trade. In the developed country there will be a change from low-skill to high-skill intensive sectors. This means that jobs may be lost in the low-skill intensive industries and these workers might not be able to find work in the high-skill intensive sectors due to market imperfections (Davidson and Matusz 2000; Feenstra and Hanson 1996). Some empirical findings, however, cast doubt on the argument that outsourcing has overall negative effects on the countries in terms of wages and employment (Geishecker and Görg 2008; Amiti and Wei 2005).

[4] See Feenstra (2008) for an overview of the academic debate.

8.2.4 Links Between Outsourcing and Innovation in Firms

This chapter focuses on the effects of participating in production networks on firms. The research was inspired by Görg and Hanley (2011). The authors use Irish firm-level panel data and find a positive relationship between service outsourcing and R&D activities measured by the ratio of R&D over sales. This is true for international as well as domestic outsourcing of services though the magnitude of this effect is smaller for domestic service outsourcing. The authors also find a positive relationship between international service outsourcing and profitability of firms. This effect is insignificant for domestic service outsourcing. This study and the study by Görg and Hanley (2011) are based on the theoretical work by Glass and Saggi (2001) who develop a dynamic theoretical model of the effects of outsourcing on wages. In their two country model (a developed North and a developing South) they argue that access to the low-wage workforce of the South increases profits of the outsourcing firms in the North. Glass and Saggi (2001) argue that these excess profits create an incentive for the Northern firms to improve products through costly innovations. These positive effects of outsourcing via innovative activities may actually offset the potential negative effects on the wages for low-skilled workers in the North.

8.2.5 Building Technological Capabilities at Firm-Level

It is important to clarify the concept of innovation in the context of developing countries like Malaysia and Thailand for the purposes of this chapter. R&D in the sense of creating entirely new products and processes at world technological frontiers—more typically found in firms in advanced countries with well-developed national innovation systems—is limited in Malaysia and Thailand. The existing theoretical literature recognizes the role of innovation and learning for exporting manufactures, especially in developing countries. Innovation and learning at the firm-level in developing countries is often defined as the acquisition of technological capabilities, i.e., the skills and information needed to use imported technologies efficiently (Lall 1987, 1992; Bell and Pavitt 1993; Westphal 2002). This typically spans a wide spectrum of technological activities including acquisition, use, modification, improvement, and creation of technology. Firms in developing countries generally lack domestic capabilities and rely instead on a range of mechanisms to import technology, including technology transfer by multinational corporations (MNCs) and foreign buyers of output. The evolutionary theory of technical change emphasizes that difficult firm-specific processes are involved in building technological capabilities as well as complex interactions between firms and institutions (Nelson and Winter 1982; Nelson 2008). Differences in the efficiency with which capabilities are created are themselves a major source of competitiveness between countries. Innovative activity in this chapter is thus viewed in terms of acquisition of technological capabilities at firm-level rather than R&D *per se*. Firms in production networks are more likely to have invested in acquiring technological capabilities and exhibit higher levels of technological capabilities than firms outside production networks.

The Lall (1987, 1992) taxonomy of technological capabilities provides a comprehensive matrix of technical functions required for firms in developing countries to set up, operate, and transfer imported technology efficiently. Lall groups these functions under three sets of capabilities: investment, production, and linkages. The Lall taxonomy of technological capabilities has been successfully used in case study research to assess firm-level technological development in developing countries and also in the formulation of a technological capabilities index in studies of firm-level exports (for a survey, see Wignaraja 2012a).

8.2.6 Research Gap

Despite the important role of production networks for developing countries and especially for Asian economies, only a few studies have looked at the relationship between participating in production networks and innovative activity at micro-level (Kimura and Obashi 2010).

One example from a developed country in Asia is the study by Hijzen et al. (2010) who use Japanese data from 1994 to 2000. The study finds that intra-firm offshoring (sourcing of intermediate inputs from foreign affiliates within a firm) has a positive effect on productivity, though this effect is not confirmed if a firm sources from an unaffiliated foreign firm. However, intra-firm offshoring is not the phenomenon that we would like to investigate here. This chapter will focus on a production network of individual firms that participate in global production networks.

Paul and Yasar (2009) use Turkish plant level data from 1990 to 1996 and show that in textile and apparel, firms' labor productivity is 64 % higher in firms that engage in input sub-contracting than in firms which do not. The authors find that more productive plants initiate outsourcing and also increase their productivity after they started outsourcing.

Harvie, Narjoko, and Oum (2010) use firm-level data from a pooled sample of ASEAN countries (Thailand, Indonesia, Malaysia, Philippines, Viet Nam, Cambodia, and Lao PDR) to explore factors affecting participation of small and medium enterprises (SMEs) in production networks. They find that foreign ownership, labor productivity, and technological capability are positively and significantly related to participation. Using a larger pooled sample of ASEAN firms, Wignaraja (2012b) tests the hypothesis that firm size, technological capabilities, human capital, and various control variables (e.g., foreign ownership or access to credit) influence participation of SMEs in production networks. He finds a significant positive relationship with size, ownership, and technological capabilities. The focus of these two studies is on SMEs and separate dummy variables are used to represent different aspects of technological capabilities (e.g., ISO 9000, patenting activity, and foreign technology licenses). The present study expands on the methodology of these studies by looking at how the relationships vary in different firm size classes employing a composite technological capabilities index and estimating separate models for value-added and technological capabilities.

Given the scarce empirical evidence on the effects of outsourcing and innovation, this chapter will further narrow the research gap on the correlation between participating in production networks, profits, and innovative activities. In our definition, a firm participates in a production network if a firm procures materials by a firm or source abroad and also exports. All remaining firms form our control group.

8.2.7 Hypotheses

Based on the theoretical model by Glass and Saggi (2001), this chapter will test the following hypotheses in the context of Southeast Asia:

- Firms that participate in production networks have higher profits than firms that do not participate;
- Firms that participate in production networks are more innovative (measured by a technology index based on the taxonomy of technological capabilities developed by Lall (1987, 1992)) than firms that do not participate in production networks.

8.3 Mapping Production Networks

To measure the magnitude of trade caused by production networks, the definition of production networks trade by Athukorala (2011) is applied and the numbers, where available, are updated to 2013 or the most recent year with available data. Using data from the UN-COMTRADE database, we define production network trade as the sum of trade exports in parts and components in selected five-digit product groups from within the following product groups under SITC, Rev. 3: office machines and automatic data processing machines (SITC, Rev. 3 75), telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), road vehicles (SITC 78), professional and scientific equipment (SITC 87), and photographic apparatus (SITC 88); and manufacturing trade (the total value of exports that fall under SITC 5–8). The results are shown in Table 8.1.

Worldwide, the trade in production networks more than tripled between 1992 and 2013. The share of developing East Asia in production network trade rose from 14 % in 1992–93 to about 43 % in 2013. The major Asian players are the PRC and the ASEAN countries which accounted for about 31 % of worldwide production

Table 8.1 Evolution of production network exports 1992–2013

	Share of total manufacturing trade (%)					
	1992–93	2006–07	2013	1992–93	2006–07	2013
East Asia	28.3	34	**39.3**	32.2	40.3	**50.7**
Japan	12.3	7.2	**5.6**	18.4	9.5	**7.3**
Developing East Asia	16	26.8	**33.7**	13.8	30.9	**43.4**
PRC	4.5	14.3	**18.5**	2.1	14.5	**21.6**
Hong Kong, China	1.8	0.7	**3.8**	1.3	0.7	**6.6**
Taipei,China	2.9	2.5	**2.7**	2.7	3.2	**4.0**
Republic of Korea	2.3	3.4	**4.3**	2.1	4.7	**6.0**
ASEAN	4.5	6	**7.1**	5.6	7.8	**9.5**
Indonesia	0.6	0.6	**0.6**	0.1	0.5	**0.4**
Malaysia	1.2	1.7	**1.3**	1.8	2.6	**2.0**
Philippines	0.3	0.7	**0.4**	0.4	1.2	**0.7**
Singapore	1.5	1.4	**2.6**	2.5	1.9	**3.9**
Thailand	0.8	1.3	**1.5**	0.8	1.6	**1.9**
Viet Nam	0	0.3	**0.7**	0	0.1	**0.7**
South Asia	0.9	1.3	**2.2**	0.1	0.3	**0.6**
India	0.6	1	**1.8**	0.1	0.3	**0.6**
North American Free Trade Agreement (NAFTA)	17.2	14	**13.7**	22.6	16.4	**16.0**
Mexico	1.2	2.2	**2.6**	2	3.3	**4.4**
EU15	41.3	35.4	**34.3**	37	30.3	**26.6**
World	100	100	**100**	100	100	**100**
Total exports in billion US$	2,651	8,892	**11,380**	1,207	4,525	**4,231**

Sources: Data for 1992–1993 and 2006–2007: Athukorala (2011). Data for 2011–2013: Author's computations based on UN COMTRADE. Data for Taipei,China: Council for Economic Planning and Development

Notes: South Asia: India, Pakistan, Bangladesh (2011 for manufacturing trade, no available data on SITC product groups comprising production network trade). Developing East Asia: ASEAN; PRC; Republic of Korea; Hong Kong, China (2012); Taipei,China (2011). East Asia: Developing East Asia plus Japan. EU15: Austria (2012). ASEAN: Viet Nam (2012), data not available for Lao PDR and Myanmar

network trade in 2013. The analysis in this chapter will focus on Thailand and Malaysia, which are two of the main ASEAN economies in production networks in 2013.

Looking at the detailed composition of exports confirms the strong role of these countries in production network trade. The top exports of Malaysia are machinery and electronics (SITC 77) (20 % of exports). Analyzing the export profile of Thailand yields similar results. Road vehicles (SITC 78) and machinery and electronics (SITC 77) were Thailand's top exports in 2013, together making up 20 % of total exports.

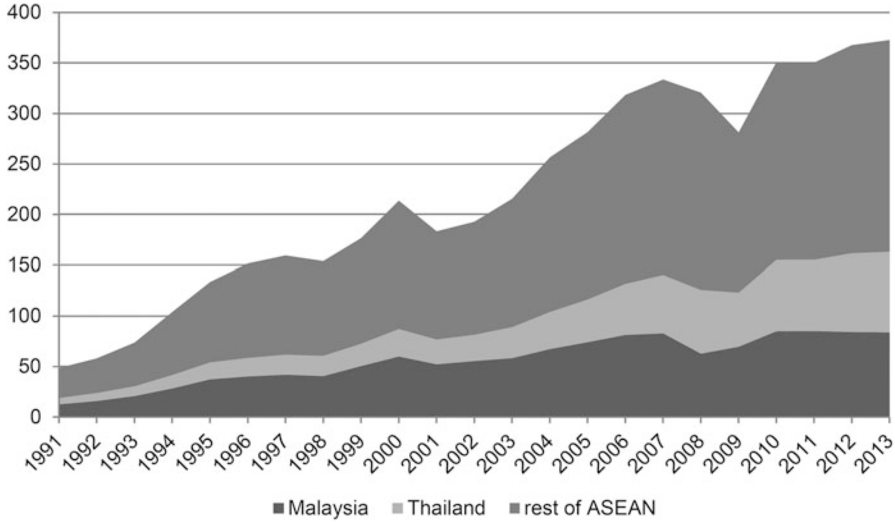

Fig. 8.1 Total production network trade exports, 1991–2013 (US$ billion). Note: We use the definition by Athukorala (2011) and define production network trade as exports of selected five-digit products from SITC, Rev. 3, 7 (Machinery and Transport Equipment) and SITC, Rev. 3, 8 (Miscellaneous Manufacturing) (Source: Author's computation based on UN-COMTRADE data)

Figure 8.1 shows that production network trade in ASEAN[5] has risen dramatically in the last decade. Since 2000, ASEAN countries have experienced a boom in production network trade, which, since the global financial crisis that started in 2008, has recovered and continued to grow steadily, though less rapidly.

Figure 8.1 also shows that Thailand and Malaysia have been the most important developing countries in ASEAN in terms of production network trade and would be interesting case studies for establishing the relationship between participation in production networks, enterprise profits, and innovative activities of firms.

8.4 Evidence from Firm-Level Data

8.4.1 Dataset

The firm-level analysis uses data from the productivity and investment climate surveys in Malaysia and Thailand collected by the World Bank in 2007. The surveys provide cross-sectional, firm-level information on sales, production

[5] The ASEAN countries are: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.

costs, employment, ownership, human capital, technology, access to credit, and aspects of the policy regime. The data from both countries are nationally representative.[6] Stratified random sampling with replacement was the sampling methodology used. Face-to-face interviews using a common questionnaire were conducted with senior management of firms.

The raw data contain 1,115 firms in Malaysia and 1,043 firms in Thailand, which results in a pooled sample size of 2,158 firms. Deleting firms with inconsistent or missing data leaves us with 2,057 observations.

Table 8.2 shows means and median values of basic firm characteristics by country and for the entire sample. Value-added is defined as total revenue less

Table 8.2 Basic enterprise characteristics by country

		Mean	Median	N
Thailand	Value-added	6,303,012	1,216,559	1,025
	Participates in production network (%)	31.22	0.00	1,025
	Firm size	237.38	76.00	1,025
	Technology index	0.43	0.40	1,025
	Firms exports (%)	52.29	100.00	1025
	Firms provides training (%)	64.00	100.00	1,025
	GM expertise in years	10.99	10.00	1,025
	Firm age	14.44	13.00	1,025
Malaysia	Value-added	16,400,000	1,544,372	1,032
	Participates in production network (%)	40.60	100.00	1,032
	Firm size	141.75	43.00	1,032
	Technology index	0.29	0.30	1,032
	Firm exports (%)	59.21	100.00	1,032
	Firm provides training (%)	88.76	100.00	1,032
	GM expertise in years	10.22	7.00	1,032
	Firm age	19.15	17.50	1,032
Total	Value-added	11,400,000	1,375,888	2,057
	Participates in production network (%)	44.77	0.00	2,057
	Firm size	189.40	58.00	2,057
	Technology index	0.36	0.40	2,057
	Firms exports (%)	55.76	100.00	2,057
	Firm provides training (%)	76.42	100.00	2,057
	GM expertise in years	10.60	9.00	2,057
	Firm age	16.80	15.00	2,057

Source: Author's computations based on World Bank enterprise data
GM general manager
All monetary values in international dollars using purchasing power conversion factors from the World Development Indicators.

[6] For more details, see World Bank (2008).

total expenses (excluding wages and interest fees). The overall mean value is about US$11 million in purchasing power parity (PPP) terms. The median values, are much lower and similar in Malaysia and Thailand, which shows that the mean is driven by a few firms with extremely high value-added. About every third firm in our sample participates in production networks. Around 10 % more Malaysian than Thai firms participate. Firms in Thailand are considerably larger (237 employees on average) than in Malaysia (141 employees on average). Similar to value-added, the distribution of firm size is skewed as the low median values show. Roughly every second firm both in Malaysia and Thailand participates in the export market. The distributions of the expertise of the general manager in years and the firm age are neither skewed nor do they differ substantially across countries. On average, a general manager has about 10 years of experience and the average firm is about 16 years old.

8.4.2 Key Variables

Table 8.3 shows the key variables for the empirical investigation by sector. Firms that source material abroad and also export are defined as participants in production networks. The first column of Table 8.3 shows the percentage of firms per sector that participate in production networks in Malaysia and Thailand. On average, 36 % of the firms participate in production networks. Auto parts, electronics, chemicals, and garments are the sectors that are most involved in production networks, with more than half of the firms sourcing materials from abroad and exporting. The values for Thailand and Malaysia do not vary substantially. If anything, the values for participation rates in production networks are slightly higher in Malaysia.[7]

Columns two and three report the mean values by sector of two measures for the innovative activity of firms. The technology index (TI) reported in column 2 is an index based on the taxonomy of technological capabilities by Lall (1987, 1992). This chapter applies the modification that has been used in Wignaraja (2008, 2012a). It consists of eight components covering: firms' competence in the following areas: (i) upgrading equipment, (ii) licensing technology, (iii) International Organization for Standardization (ISO) quality certification, (iv) process improvement, (v) minor adaptation of products, (vi) introduction of new products, (vii) research and development (R&D) activity, and (viii) technology linkages. A firm can score either 1 or 0 and each of the components is weighted equally which results in a TI between 1 and 0.[8]

The results reported in Table 8.3 show that the average score of the TI is 0.36. Auto parts and electronics (typical industries of the new production networks) show

[7] The detailed statistics by country are available from the authors upon request.

[8] Details about the composition of the TI are included in the Appendix (Table 8.7).

Table 8.3 Production network participation, TI, and R&D/sales by sector

	Participating in production network (%)	TI	R&D/sales
Processing food	26.11	0.328	0.021
N	337	337	337
Auto parts	45.71	0.489	0.021
N	140	140	140
Electronics	62.70	0.466	0.036
N	185	185	185
Rubber and plastic	31.27	0.358	0.023
N	518	518	518
Furniture	25.00	0.351	0.037
N	200	200	200
Machinery/equipment	42.60	0.343	0.033
N	169	169	169
Wood products	10.71	0.175	0.000
N	28	28	28
Textile/garment	51.49	0.351	0.012
N	402	402	402
Chemicals	55.13	0.356	0.034
N	78	78	78
Total N	35.93	0.361	0.024
	2,057	2,057	2,057

Source: Author's computations based on World Bank enterprise data
R&D research and development, *TI* Technology index.

the highest score of the TI. The results from using the R&D ratio as a proxy for innovative activity of a firm are slightly different. Firstly, the variation of the indicator is smaller than the variation of the TI index. Secondly, besides typical production networks sectors such as machinery or auto parts which have a high R&D ratio, the furniture sector also has a high R&D over sales ratio. We argue that these two findings suggest that the TI is a more plausible measure of innovative activity than the R&D ratio. Thus, we will primarily use the TI as a measure for innovative activities.

Having established the presence of sectoral differences we now turn to differences between companies that participate in production networks and companies that do not. The results are reported in Table 8.4.

The means of all indicators chosen in Table 8.4 differ significantly between firms that participate in production networks and firms that do not. In line with the hypothesis by Glass and Saggi (2001), firms in production network have a higher value-added per worker than firms that do not participate.[9]

[9] We find that the variances between the groups differ. Hence, a test is used that assumes unequal variances.

Table 8.4 Enterprise characteristics by participation in production networks

	Value-added per worker (US$, PPP)	Firm size	Technology index	R&D/ intensity	Firm age	Expertise of GM in years	% of female owners
Not participating in production network	43,498	124.080	0.311	0.015	16.346	10.005	60.24 %
	1,318	1,318	1,318	1,318	1,318	1,318	1318
Participating in production network	70,860	419.939	0.451	0.039	17.618	11.663	65.49 %
	739	739	739	739	739	739	739
T test	**	***	***	***	***	***	***
Total	53,338	230.37	0.361	0.024	16.80	10.60	62.13 %
	2,057	2,057	2,057	2,057	2,057	2,057	2,057

Source: Author's computations based on World Bank enterprise data
Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ are p-values from a *T* test testing the null hypothesis that the mean values are equal between the two categories.
Firm size: number of full-time employees in the past year; Technology Index: (see Appendix) R&D intensity, expenditure on R&D/sales
GM general manager, *PPP* purchasing power parity, *R&D* research and development
All monetary values in international dollars using purchasing power conversion factors from the World Development Indicators.

Also, firms in production networks are on average over three times bigger (419 employees) than firms that do not participate. The causality for this effect runs in both directions. It could be that a certain investment in market research is necessary before entering a production network and, as smaller firms do not have access to sufficient funds, bigger firms self-select themselves into the production network. On the other hand, it is possible that firms who enter the production network can exploit international cost differences and hence start to grow.

Both indicators used here to measure innovative activity (TI and R&D intensity) show that firms in production networks report more innovative activities than firms outside production networks.

Although the variables representing firm age and the expertise of the general manager (measured in years) differ significantly between the firms who participate in production networks and those that do not, the magnitude of the difference is not large. Therefore, the findings of other studies that most of the firms that participate in production networks are recently established and led by relatively young general managers cannot be confirmed. Neither does the research does not detect any gender imbalances—more than half of the enterprises' owners are female, both inside and outside production networks.

8.4.3 Econometric Analysis

We now turn to a formal analysis of the relation between value-added and participating in international production networks. In particular, the following equation is estimated:

$$\ln Y_i = \beta_1 pn\_dummy_i + \beta_2 Z_i + \varepsilon_i \tag{8.1}$$

In (8.1) Y_i stands for the value-added of firm i. Value-added is defined as the natural log of total revenue less total expenses (excluding wages and interest fees). *pn_dummy* is a dummy variable that takes the value 1 if a firm participates in the international production network, meaning the firm imports inputs and also exports. Vector Z_i represents a number of control variables. These control variables include a dummy that takes the value 1 if the firm provides in-house training for production workers, the expertise of the general manager measured by years of work experience, the age of a firm in years since establishment, and a dummy that takes the value 1 if the general manager has a college degree. Furthermore, we control for differences in value-added caused by differences by inputs by including the logarithm of the capital stock (measured by the replacement value of all machinery and equipment), and the logarithm of labor inputs (number of full-time employees). Finally, a full set of sector dummies is included to control for sectoral heterogeneity. ε_i represents a random error term.

The estimation results could be influenced by a number of biases. Reverse causality between participating in production networks and value-added might be an issue. In our case this means that we assume that firms that plug into production networks are able to increase value-added due to, for instance, cheaper inputs or the economies of scale that they can exploit. However, it is not implausible that firms are able to export because of a rise in value-added that enables them to pay potential costs of exporting (e.g., search for potential clients). Despite the cross-sectional character of our data set we know which year a firm started exporting. The majority of firms for which we have data report having started exporting in the same year the enterprise was set up. This lends support to the view that reverse causality is not an issue for our estimation. Even though there is some data to suggest that reverse causality is not a problem, we cannot control for the fact that firms might export for an unobserved reason that is correlated with value-added. For instance, more motivated enterprise owners could be more likely to seek out export opportunities and hence their firms could earn higher value-added than firms with less motivated owners. Further, we cannot control for reverse causality between low value-added and not participating in production networks. One way to solve the issue of reverse causality would be to use an instrumental variable. Our data set does not contain a variable that would be suitable for use as an instrumental variable, however. Tests for heteroskedasticity were also conducted using visual inspection and a Breusch Pagan test. The tests do not lend support to the hypothesis that heteroskedasticity is an issue for the estimation results. The correlation matrix in the Appendix (Table 8.8) and the fact that most of the coefficients are significant when all controls are included suggest that multicollinearity is not an issue either.

Furthermore, the data set enables us to control for indirect participation in production networks. (e.g., a local enterprise that interacts with a firm that participates in production networks). Such effects imply a potential downward bias on our results because the comparison group may include some firms that are indirectly involved in production networks. Further, measurement error might bias the estimation results downwards.

Table 8.5 reports the results from estimating (8.1) using ordinary least squares (OLS). All of the specifications show that participating in production networks has a positive effect on value-added. The coefficients of the other control variables have the expected signs. Providing in-house training and the general manager having a college education have significant positive effects in most specifications.

Since a Cobb-Douglas production function is assumed, the F-statistic and p-values of an F-test for constant returns to scale are reported. The F tests in models 1 and 4 show that the coefficients of labor and capital add up to 1. This cannot be found in models 2 and 3. However, the sum of the coefficients in models 2 and 3 is close to 1 and the hypothesis that the coefficients are unequal to 1 can only just be rejected.[10] In column 5, the results are reported without sector and country

[10] We also estimated a constant elasticity of substitution production function. The main results did not change.

Table 8.5 OLS regression: dependent variable: in value added

	(1)	(2)	(3)	(4)	(5)
	Pooled	Pooled	Thailand	Malaysia	Pooled
Ln capital	0.1328*** (0.0176)	0.5626*** (0.0938)	0.3236*** (0.1122)	0.6121*** (0.1727)	0.1413*** (0.0177)
Ln labor	0.8847*** (0.0266)	0.7140*** (0.1051)	0.6912*** (0.1109)	0.7255** (0.3168)	0.6926*** (0.0306)
Participation in production networks		0.3680*** (0.0641)	0.4552*** (0.0670)	0.2503** (0.1181)	0.5462*** (0.0681)
Training		0.3070*** (0.0672)	0.4294*** (0.0794)	0.1284 (0.1408)	0.5804*** (0.0691)
GM expertise		0.0029 (0.0038)	0.0004 (0.0051)	0.0085 (0.0056)	−0.0003 (0.0040)
GM has college degree		0.2020*** (0.0632)	0.0659 (0.0692)	0.3257** (0.1266)	0.1109* (0.0641)
Firm Age		0.0001 (0.0032)	−0.0014 (0.0044)	0.0031 (0.0050)	0.0076** (0.0034)
Constant		8.0967*** (0.2051)	8.4525*** (0.2384)	8.4903*** (0.3696)	8.5358*** (0.2104)
Country dummies	Yes	Yes	No	No	No
Sector dummies	Yes	Yes	Yes	Yes	No
Country dummy significant	Yes	Yes			
P value joint significance sector dummies	0.000	0.000	0.000	0.000	
N	1683	1683	1005	678	1683
Adjusted R-squared	0.6334	0.6485	0.7089	0.5881	0.5970
F statistics constant returns to scale	0.6271	10.0047	14.2071	1.5722	33.9546
P value constant returns to scale	0.4285	0.0016	0.0002	0.2103	0.0000

Source: Author's computations based on World Bank enterprise data
Notes: Robust standard errors parentheses; *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$
GM general manager

dummies. The main findings are not altered. Also, results from a joint F test on the joint significance of the sector dummies shows that the dummies are jointly significantly different from zero. Overall, the results from Table 8.5 confirm the hypothesis that firms that participate in production networks have higher value-added than firms that do not. These findings are robust in variations of the definition of participation in production networks and across countries.[11]

In a second step, we analyze the correlation between the technological capabilities of firms and the participation in production networks using the following specification:

$$TI = \beta_1 X_i + \beta_2 pn\_dummy_i + \varepsilon_i \tag{8.2}$$

Technological capabilities of firms are measured using the TI (for details about its composition see the Appendix). The TI ranges from 0 to 1 and has been used in numerous other studies. The vector X_i represents the same control variables as described above.[12]

The results from estimating (8.2) are presented in Table 8.6. Again, we are unable to rule out the endogeneity between the TI and participating in production networks due to the lack of a suitable instrument. The results are shown using OLS and Tobit estimates. Only 10 % of the sample are censored and hence it is not surprising that the results using OLS do not differ substantially from those using a Tobit model. Again, we could not detect any evidence that heteroskedasticity or multicollinearity are an issue for the estimates. The results using the pooled sample of Malaysia and Thailand are presented in column 1. The findings reveal that training activities, the experience of the general manager, and the college dummy have a significant and positive impact on the TI, which is in line with expectations. Also, participating in production networks significantly increases the TI. There is also some evidence that younger firms have a slightly higher TI and that bigger firms have a higher TI. In columns 3 and 4, we present the findings of individual country regressions. In both country regressions the participation in production networks dummy remains highly significant and positive. In the Thailand regression, the expertise of the general manager and firm age have the same sign but become insignificant compared with the pooled sample. In the Malaysia regression, the training dummy and firm age are no longer significant. These changes are most likely due to measurement errors.

To sum up, the analysis showed that participating in production networks has a positive effect on value-added of firms. Despite the cross-sectional nature of our data set, there is some evidence that exporting causes higher value-added and not vice versa. Hence, the findings suggest that participating in production networks leads to higher value-added that in turn is positively correlated to technological upgrading.

[11] The questionnaires in Malaysia do not ask directly for profit or value added of the enterprises. Therefore, we cannot test the robustness of our results to using reported gross profit as dependent variable.

[12] We also included firm size to control for the fact that it might be that only bigger firms find it profitable to invest in innovation. The coefficient was highly significant.

Table 8.6 Dependent variable: technology index, OLS and tobit estimations

	(1) Pooled OLS	(2) Pooled Tobit	(3) Thailand OLS	(4) Malaysia OLS
Participation in production networks	0.1055*** (0.0102)	0.1125*** (0.0108)	0.0727*** (0.0142)	0.1242*** (0.0126)
Training	0.0550*** (0.0106)	0.0546*** (0.0113)	0.1082*** (0.0127)	−0.0090 (0.0175)
College	0.0566*** (0.0094)	0.0619*** (0.0102)	0.0395*** (0.0126)	0.0607*** (0.0124)
Size	0.0001*** (0.0000)	0.0001*** (0.0000)	0.0000*** (0.0000)	0.0001*** (0.0000)
GM expertise	0.0015*** (0.0005)	0.0018*** (0.0006)	0.0012 (0.0009)	0.0015** (0.0006)
Firm age	−0.0013*** (0.0004)	−0.0016*** (0.0005)	−0.0012 (0.0007)	−0.0010* (0.0005)
Constant	0.2523*** (0.0136)	0.2429*** (0.0148)	0.2523*** (0.0169)	0.1649*** (0.0237)
Country dummies	Yes	Yes	No	No
Sector dummies	Yes	Yes	Yes	Yes
N	2057	2057	1025	1032
Log pseudolikelihood		152.0325		
Adjusted R-squared	0.270		0.231	0.239

Source: Author's computations based on World Bank enterprise data
Notes: Robust standard errors parentheses; *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$
GM general manager

8.5 Conclusions

This chapter focuses on micro-level factors associated with the participation of firms in production networks—a hitherto under-explored area in the literature on fragmentation and production networks—in Malaysia and Thailand. It updates previous research by Athukorala (2011) on trends in global production network trade using parts and components trade data. Then, using firm-level data, it attempts to test the theoretical insight by Glass and Saggi (2001) that firms in production networks are different from firms outside production networks. In particular, firms which participate in international production networks are able to exploit international cost differences and therefore realize higher profits. These profits are in turn re-invested in technological upgrading. To explore this, econometric models of value-added and technological capabilities were estimated for Thai and Malaysian firms. The empirical analysis of technological upgrading applies concepts from the literature on technological capabilities in developing countries including a taxonomy of technological capabilities by Lall (1987, 1992) and a technological capabilities index used in subsequent research.

The study finds that global production network trade has increased significantly since 1992, driven partly by the rising volume of this trade by the PRC along with ASEAN economies like Malaysia and Thailand. Using data from the World Bank enterprise surveys, the firm-level econometric analysis of production networks in Malaysia and Thailand shows two other interesting results. First, there is indeed a significantly positive association between enterprise profits and participating in production networks. Second, participating in production networks significantly increases value-added and participation in production networks is also positively correlated with technological upgrading, proxied by an index of technological capabilities.

The econometric results indicate that micro-level investigation of production networks based on firm survey data is a fruitful endeavor which usefully complements macro-level analysis using trade data. Further work might usefully refine and extend the analysis in this chapter in several directions. One could be to explore factors affecting the participation of firms in less developed ASEAN economies (such as Cambodia, the Lao PDR, and Myanmar) which may face higher initial barriers to entry and policy-induced distortions to participating in production networks. Another might be to use panel data estimation test the robustness of cross-section estimation, providing the requisite firm-level data are available from the World Bank or other sources. Finally, it would be interesting to examine the influence of national and regional policy factors on firm-level participation in production networks including trade policy, free trade agreements, cross-border infrastructure, and trade facilitation.

Appendix

Table 8.7 Detailed composition of the technology index (TI)

The technology index is composed of eight of the following questions that we evaluate with either 0 or 1
1. Upgrading equipment
(a) 1 if the value of new investment on production machinery and equipment > industry average in 2006, 0 otherwise
2. Licensing and technology
(a) 1 if the firm obtained a new licensing agreement in the past 2 years, 0 otherwise
3. Licensing and technology
(a) 1 if the firm received any ISO (e.g. 9000, 9002 or 14,000) certification, 0 otherwise
4. Process improvement
(a) 1 if the firm upgraded equipment and machinery within last 2 years (since 2004), 0 otherwise
(b) 1 if the firm increased capacity utilization in the past 2 years (since 2004), 0 otherwise
5. Minor adaptation of products
(a) 1 if the firm upgraded an existing product line, 0 otherwise
6. Introduction of new products
(a) 1 if the firm developed a new product line in 2006, 0 otherwise
7. Research and development (R&D) activity
(a) 1 if the firm's spending on R&D was bigger than the industry average in 2006, 0 otherwise
8. Technology linkages
(a) 1 if the firm uses marketing tools (web & e-mail), 0 otherwise

Table 8.8 Correlation matrixes for variables included in Tables 8.5 and 8.6

	ln value-added	Participation in production network	ln capital	Ln labor	Training	GM expertise	College	Firm age
ln value-added	1							
Participation in production network	0.4303	1						
ln capital	0.5368	0.2692	1					
Ln labor	0.7251	0.3779	0.5476	1				
Training	0.3622	0.2503	0.156	0.2906	1			
GM expertise	0.1239	0.0759	0.1042	0.1646	0.0009	1		
College	0.2616	0.1832	0.2718	0.2875	0.0597	−0.039	1	
Firm age	0.1388	0.0615	0.0867	0.1014	0.1579	0.2792	−0.0255	1

	Technology index	Participation in production network	Training	College	Firm size	GM expertise	Firm age
TI2	1						
Participation in production network	0.3018	1					
Training	0.1004	0.2011	1				
College	0.299	0.1928	0.0359	1			
Firm size	0.3026	0.2574	0.1494	0.1716	1		
Training	0.1073	0.0909	0.0038	−0.0161	0.1435	1	
Firm age	−0.0718	0.0603	0.1491	−0.0102	0.1126	0.2421	1

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