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Industry Dynamics in Growth Triangles: The E&E Industry in SIJORI 25 Years On

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Abstract

The SIJORI Growth Triangle, which encompasses Singapore, Johor (Malaysia) and Batam Island (Indonesia), was launched in 1989 as a ‘single investment destination’ offering differing factor endowments in close proximity. Singapore was the ‘core’ of the region with Johor and Batam occupying the land, labour, and resource-intensive ‘non-core’ spaces. During the 1990s, investment flows into the three territories, particularly in the electrical and electronics (E&E) industry, mirrored this division of labour. Through scrutinizing trends in E&E firm entries, nationality, and industry branch in Singapore, Johor, and Batam for the 1993-2012/14 period, this article sheds light on the recent evolution of the E&E sector in the erstwhile Growth Triangle. In doing so, it seeks to establish whether the core/non-core division of labour still persists and whether Johor and Batam have been able to successfully capture product spaces being vacated by Singapore as it upgrades.

Keywords: Electrical and Electronics; Growth Triangles; Strategic Coupling, Global Value Chains; Singapore; Malaysia; Indonesia

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1. Introduction

In the early 1990s, Growth Triangles and similar frameworks gained popularity as a way of understanding and promoting industrial development in border regions. Scalapino (1991) coined the phrase ‘natural economic territories’ to refer to economically dynamic areas that: crossed national boundaries; were linked to the global economy; and were inherently more viable than nation-states. Other terms such as cross-national growth zone and sub-regional economic zone also referred to the same phenomenon (Thant, Tang, and Kakazu 1994).

For many, the Singapore, Johor, and Riau Islands (SIJORI) Growth Triangle was, along with the Hong Kong-Shenzen manufacturing complex, an exemplar of this phenomenon in Asia. Driven by substantial cost advantages and proximity, cross-border industrialization processes started to link Singapore more closely with its two immediate neighbours – the Malaysian state of Johor to the north; and Riau Province in Indonesia to the south.

Launched in 1989 and initially encompassing Singapore, Johor, and the island of Batam in Riau Province, the Growth Triangle was used to market the three territories as a ‘single investment destination’ offering: close proximity; well-developed infrastructure and logistics connections; different cost structures; and a significant degree of political capital.

Over the next decade, Singapore-based multinationals and Singaporean firms were driven by the potential cost savings to relocate labour-intensive functions to Johor and Batam, whilst retaining more capital and skill-intensive functions in the city-state.

One of the industries most affected by these regional production networks was the electrical and electronics (E&E) sector. Attracted by the distinct comparative advantages and capabilities offered by the three locations, substantial levels of foreign direct investment (FDI) flowed into the constituent territories – most notably in the consumer electronics, electronic component, and electrical device branches. Due to its financial, technological, and managerial resources, Singapore was the ‘core’ of the region, with Johor and Batam occupying ‘non-core’ positions.

However, after a period of high visibility, the SIJORI Growth Triangle lost momentum in the late 1990s. In tandem with the initiative's trajectory, academic attention on the three locations and their inter-linkages dwindled. Recent research on the E&E sector has focussed on Singapore, documenting its impressive progress in increasing value-added and deepening capabilities. But, almost no research has been carried out on developments in the two non-core locations. Consequently, very little is known about the progress in upgrading in Johor and Batam, and what connections there are between Singapore and these two locations.

Research of this nature is timely for three reasons. First, while the Growth Triangle has faded from view, many of the cross-border production networks forged during the 1990s have remained, with substantial numbers of firms headquartered in Singapore possessing production facilities of some nature in either of the two locations. Second, the city-state's land and labour constraints have only intensified, with current policy frameworks looking to further discourage labour-intensive production within its borders. Third, while not mirroring the precise contours of the Growth Triangle, separate cross-border initiatives between Singapore and the two non-core locations have continued, indicating an enduring interest from governments and the private sector.

Framed by the global production network approach, and utilizing a unique database containing information on the establishment, closure, nationality and industry branch of firms in Singapore, Johor, and Batam, this article will focus on three research questions. First, how have the size, profile, and branch structure of the E&E industry in Singapore, Johor, and Batam evolved since the early 1990s. Second, have either of the two non-core territories moved into industry branches vacated by Singapore and, if so, which? Third, what are the future implications of the trends seen?

The remainder of this article is structured as follows. In the next section, we set out some conceptual 'tools' for analysing the evolution of the E&E sector. The subsequent sections will discuss the development of the industry in Southeast Asia and our methodological approach. In the main body of the article, we set out the evolution of the E&E industry in the three SIJORI territories. In an ensuing discussion section, we interpret the findings gleaned from our database in relation to the research aims. The final section concludes.

2. Global Production Networks and Strategic Coupling

As argued by Felker (2009), one aspect of Southeast Asia's industrialization process that distinguishes it from Japan, Taiwan and South Korea is its reliance on FDI – as opposed to domestic technological capabilities – as a driver for development. Thus, countries and territories in the region compete with one another to attract multinational corporations (MNCs) and encourage them to locate more sophisticated production functions within their borders.

Following this line of reasoning, Global Production Network (GPN) scholars have maintained that Southeast Asia's industrial development has been shaped, to a large degree, by the collective efforts and decisions made by regions or 'nodes' (Coe et al 2004; Coe and Yeung 2015).

Two further aspects of the GPN framework are salient. First, reflecting differences in their asset bases, regions and the firms within them assume specific roles in a production network. These roles, in turn, imply a certain position in a hierarchy of value. These positions range from: core and high order, where high value-added activities and functions take place; to peripheral, low-order and subordinated, where the least value-added assembly production-oriented activities are carried out.

Second, while these regions are geographically fixed, the level and sources of comparative advantage are not static, and corporate responses to them are in flux. Over time, specific nodes can attempt to move to branches and operations deemed as desirable. This process can be referred to as *strategic coupling*. Given that the development of an industry in a given location is an evolving amalgam of comparative advantage, government policy frameworks, industrial trends as well as corporate decisions, differing levels of commitment to specific industries and branches within them can have long-term implications. Thus, an industry in a region or 'node' can evolve along several differing pathways.

The pathway most featured in the literature is 'moving up'. In this case, the region is continuously endeavouring to augment its industrial structure. This can be achieved in two ways. First, new inter- or intra-industry branches develop that are distinct from existing ones due to their technological sophistication and value-added. Second, the region advances in terms of roles within GPNs, which can be termed 'value chain advancement'. From an agency perspective, the underlying dynamic is regions targeting – and firms allocating – new activities that are either technologically more sophisticated or functionally higher-order (OECD 2013; UNCTAD 2013).

The concept of *branching* warrants brief discussion. This can be understood as an inter- and intra-industry and firm-level process where an industry's configuration changes over time as some of the existing *varieties* of products dwindle and new ones are introduced. This occurs when: corporations and institutions introduce a new industry or segment to a territory (and others leave); corporations withdraw products and introduce new ones; or subsidiaries/establishments producing certain products abandon the region altogether and are replaced by new ones carrying different products (Boschma and Frenken 2011).

Moving up at the industry level can be conceptualized as local branching, whereby a technologically unsophisticated *variety* of products or product categories is augmented (initially) and/or gradually replaced by more sophisticated *variety* that may be *related* (belonging to the same product and technology family) or *unrelated* (embodying different technology from existing product groups). In the conceptualizations offered by MacKinnon (2012) and Yeung (2015), branching entails *decoupling* and *recoupling*.

Besides moving up, other obvious pathways for a country or region are: stability or stagnation (relative to other competing locations); downgrading to less value-added tasks; and decline (MacKinnon 2012, Yeung 2015). While networks maintain a given hierarchy of functions according to their degree of value-added, the geographic allocation of these functions is dynamic. This results in the mobility of nodes not only up but also down the hierarchy of value, as new locations or regions enter a production network by attracting investment, and/or established regions are excluded (Coe et al. 2004; Edgington and Hayter 2013a,b; Ernst 2002; OECD 2013; UNCTAD 2013).

Over time, regions that do not acquire greater capabilities and better assets – or lose them – may find themselves stuck in a low value-added position and an increasingly precarious situation as other nodes increase competitiveness. *Decoupling* – where a region disengages – is a distinct possibility. From an institutional perspective, it can refer to coupling losing its strategic and dynamic character, by deliberate or unconscious neglect. It may also refer to a deliberate pushing out of an industry, a specific branch or type of operations (e.g. assembly). From a firm perspective, it means that they lose commitment to a node (Edgington and Hayter 2013a, b).

There are three 'drivers' for a node to move along a pathway. The first is positive or negative developments in its endowments and competences, such as labour costs, skill base and ease of doing business. The second is 'micro-level' developments in firms and MNC subsidiaries, where they develop, acquire or lose capabilities and/or roles (OECD 2013; UNCTAD 2013). A common way of

tracking this is analysing the mandate changes of MNC subsidiaries, such as from mere production to an additional role in product adjustment and development (Edgington and Hayter 2013 a,b). The third driver is institutional commitment on the part of government agencies, research institutes, and business associations to diffuse knowledge and increase productivity (Lee 2010; Yeung and Coe 2015).

Because of their specific attributes, cross-border regionsⁱ can be important ‘nodes’ in global production networks. These attributes include: economic complementarity; proximity; and connectivity (Lee 1991; Thant, Tang, and Kakazu 1994). The former refers to differences in factor endowments or assets between constituent territories, such as labour, land, infrastructure, capital and technology. Geographical proximity reduces transaction costs and enables access to resources and assets in neighbouring locations. Besides industrial parks and good provision of utilities being necessary conditions, infrastructure development enhances connectivity between constituent territories, positively affecting the ease and costs of cross-border movement of goods and people (Lee 1991; Thant, Tang, and Kakazu 1994).

These factors enable a territorial division of labour across the constituent parts of a cross-border region. This can be understood as a regionally ‘sliced’ value chain. However, it is important to note that constituent nodes evolve in terms of their endowments (positive and negative). In addition, firms operating in them continue or discontinue to follow the logic of leveraging differential and dynamic comparative advantage of nodes/locations in close proximity. Furthermore, new firms or operations are attracted by dynamic comparative advantage. Last, institutional attitudes and behaviour evolve.

These aspects render a cross-border region and its constituent nodes open to dynamic (strategic) coupling and the differential pathways considered above. Before analysing the evolution of the E&E industry in the context of SIJORI, in the next section we offer a general account of this industry in Southeast Asia and of its early manifestation in the Growth Triangle.

3. The E&E Industry in Southeast Asia

Over the past decades, countries in East Asia have endeavoured to foster a local E&E industry for a number of reasons. Beyond increasing export earnings, other perceived benefits include

stimulating the development of downstream activities to supply specialized parts and inputs as well as increasing efficiency and productivity in other parts of the economy.

In the 1960s, Hong Kong, South Korea, Taiwan, and Singapore began to assemble light manufactures such as radio components and semiconductors for the American and Japanese markets. In the 1970s and 1980s, these four countries began to move into more technologically complex and skill-intensive areas of manufacturing. In particular, Singapore began to host regional headquarters and procurement centres (Hobday 1995, Henderson 1989).

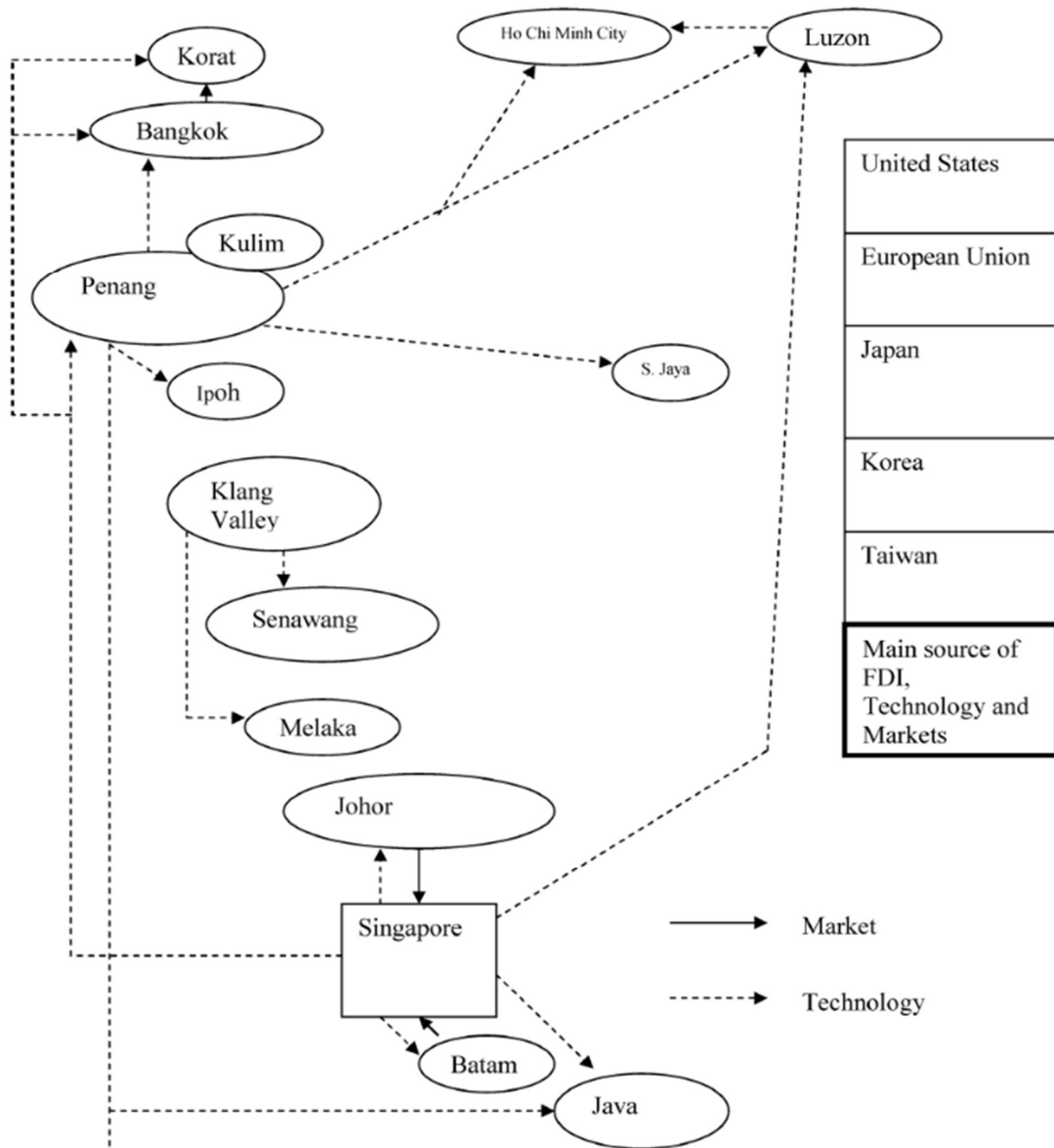
Leveraging on good macroeconomic policies and investment frameworks, Southeast Asian countries such as Malaysia, Thailand, the Philippines, and Indonesia began to move into the more labour-intensive sectors vacated by these four countries. And, MNCs began to create an intricate set of production networks across countries in the region, seeking to leverage different capabilities and prices (Yusuf 2004).

Rasiah (2009) provides one way of ‘mapping’ the various nodes in the region and the relationships between them (Figure 1). Reflecting their distinct local histories, institutional contexts, policy initiatives, and firm behaviour, there has been considerable variation in the development of the E&E industry across the different locations. Singapore and, to a lesser extent, Penang in Malaysia remain the leaders in terms of technology and production processes.

As noted earlier, cross-border regions have come to epitomize such corporate networks by following the logic of leveraging the comparative advantage of different locations, albeit in close proximity.

As regards SIJORI, Johor and Batam began to grow rapidly as ‘satellite’ developments of Singapore. From Singapore’s perspective, its industrial restructuring ‘push’ of targeting higher value-added and more sophisticated activities was accompanied by a regionalization strategy. This entailed a state-led yet market-guided intervention to persuade firms to relocate activities that no longer enjoyed comparative advantage in the city-state. This was assisted by the creation of new economic spaces beyond its territory, such as the establishment of industrial parks and other infrastructure by government-linked corporations (Pereira 2004; Yeoh, How, and Sim 2006).

Figure 1: Spaces in the Southeast Asian Electrical and Electronics Industry



Source: Rasiah 2009

While entering the E&E industry later than Singapore, Johor and Batam also managed to consolidate themselves as ‘nodes’ in the 1990s. Following a down-turn in commodity prices in the 1980s, Johor sought to: develop its manufacturing sector; attract ‘high-tech’ technology activities; and leverage its proximity to the city-state. To this end, the state government developed a network of strategically-located industrial parks and rolled out an array of investment incentives (JSEPU 1989). Similarly, Indonesian authorities liberalized the investment framework, removed restrictions on foreign equity, and simplified the taxation regime for operations based in Batam. This was complemented by substantial central government investment in infrastructure and commitments to addressing investor concerns (Pangestu 1991; Parsonage 1992).

These developments resulted in substantial resource flows into the two non-core location. From 1990-1997, Johor received an average USD \$800 million of foreign manufacturing investment per year – an almost four-fold increase relative to the previous decade. Similarly, FDI into Batam increased from negligible levels in the 1980s to average USD 230 million per year from 1990-1996 (Hutchinson 2015). While authorities in both Malaysia and Indonesia voiced concerns about the labour-intensive nature of the investment, these worried were over-ridden by the volume of investment and job generation.

Research carried out during the early period of the Growth Triangle confirmed these processes as well as SIJORI as: i) an integrated manufacturing complex; ii) an industry and corporate construct based on the complementarity of production factors located in close proximity; iii) a strategic construct from Singapore’s perspective that allowed the retention of industries and firms in the region whilst ‘moving up’ the value chain; iv) and, a space where non-core parts have assumed a sub-ordinate position (Lee 1991; Toh and Low 1993; Sparke et al. 2004; Yeoh, Sin, and Jialing 2004).

However, in the late 1990s, the attraction of Growth Triangle concept began to fade for a number of reasons. First, the governments of Malaysia and Indonesia included more states and provinces in the initiative, diluting its economic rationale. Subsequently, diplomatic relations between the three nations went into flux after the Asian Financial Crisis. And, political changes in Malaysia and Indonesia altered the ability of Johor and the Riau Islands to effectively court foreign direct investment. In Malaysia, the central government sought to brake integration processes between Johor and Singapore. In Indonesia, the country’s decentralization reforms increased the number, power, and

autonomy of sub-national governments, complicating the business context for international firms (Hutchinson 2015).

Recent research on the E&E industry has focussed exclusively on Singapore, documenting the city-state's impressive progress in increasing overall production and value-added. Along with this, the city-state's E&E sector has narrowed and specialized, with the semiconductor branch growing to account for more than half of exports. Less capital- and skill-intensive industry branches such as consumer electronics as well as computers and peripherals have shrunk (Toh 2013; van Grunsven 2013).

While available data provides some indication of how the industry has developed in Singapore, there is very little research on how the sector has developed in the two non-core locations, and even less about the extent and nature of linkages between the three territories. That said, the processes underway in Singapore have far-reaching implications for the non-core locations of Johor and Batam.

First, they could 'accompany' Singapore in its transformation process, through deepening capabilities and specializing in the same areas – notably the production of semiconductors and associated products. This would constitute strategic coupling through targeting newer and more value-added industry branches.

Second, they could seek to move into the industry branches being vacated by the city-state, such as consumer electronics, storage media, and computers. While more mature and potentially lower-value added, this choice could enable value chain advancement, as firms carry out more sophisticated functions within the established industry branches.

While strategically different, these two pathways could offer the two non-core locations additional investment and employment opportunities. Should Johor and/or Batam not seize either of these options, they would, in effect, be consciously or unconsciously de-coupling from the E&E sector.

4. Research Methodology

The E&E industry is comprised of an ever-expanding array of products and a multitude of ways of classifying it. This article defines the electrical and electronics industry as comprising the groups of products (or branches) – detailed at the four digit level of the Singapore Standard Industrial Classification Code (SSIC) – listed below.ⁱⁱ

The first six product groups are treated as discrete categories (semiconductors, consumer electronics, etc.), and the last four are classified under the rubric of ‘electrical devices’. This is complemented by two additional categories: ‘consumer electronics manufacturers’ which encompasses firms that provide integrated manufacturing, logistics, and often design services to flagship firms; and ‘other’, which refers to firms producing items that fall within the E&E industry, but not the other product groupings. This definition of the E&E industry excludes supporting industries such as precision engineering, metal stamping, and plastics.

Table 1: The Electrical & Electronics Industry

SSIC Code	Title
Electronics	
2611	Manufacture of Semiconductor Devices
2612	Manufacture of other Components and Boards
2620	Manufacture of Computer and Peripheral Equipment
2630	Manufacture of Communications Equipment
2640	Manufacture of Consumer Electronics
2680	Manufacture of Magnetic and Optical Media
Electrical Devices	
2710	Manufacture and Repair of Electrical Motors, Generators, Transformers, Electricity Distribution and Control Apparatus
2720	Manufacture of Batteries and Accumulators
2732	Manufacture of Electronic and Electric Wires and Cables
2750	Manufacture of Domestic Appliances

Using this common definition, the first phase of our research consisted of analysing aggregate data such as the volume of output, exports, and value-added, as well as employment levels. This information is useful, as it provides a high-level picture of industry trends. However, this data does not allow us to determine the number or nationality of firms in the E&E sector or across its various

branches. Furthermore, national-level export data does not capture important interactions between firms within the domestic economy or the arrival of new types of firms that take over production functions from existing establishments. Also, while the availability of statistics for Singapore is good, the use of national-level data is less fitting for Johor and Batam, which are constituent territories of Malaysia and Indonesia, respectively.

A main component of our approach was the construction of a database of the total number of E&E firms in operation and by industry branch in Singapore, Johor and Batam. Given the availability of data, data-gathering in Singapore and the other two locations had to be carried out in different ways. For Singapore, a database was compiled using the *Singapore Electronics Manufacturers' Directory*, produced by a private publisher for the Economic Development Board and Association of Electronic Industries of Singapore. This directory is produced on a yearly basis, with individual company listings as well as listings of firms and affiliates by product category. Using these, a database was compiled for the period 1990-2013/14 – with the exception of a number of years (1994, 1996, 1997, 1999), where it was not possible to obtain copies of the Directory. Unlike the other two locations, this source did not contain systematic data on the nationality of firms, which had to be compiled through consulting other industry directories, government records, as well as company websites.

For Johor and Batam, time series were constructed based on data obtained from the relevant government authorities of Malaysia and Indonesia. These covered the 1993-2012 period for Johor and 1990-2012 period for Batam. With regard to Johor, information on company-level approval, closure, nationality, and industry branch was obtained from the Malaysian Investment Development Authority, which vets foreign investment applications and assesses their eligibility for incentives and rebates. Using the common ISIC-based classification outlined above, the total 'universe' of manufacturing industry-related approvals and closures was narrowed to those in the relevant E&E branches. This was cross-checked with: records from TPM Technopark (the firm with the largest industrial land bank in the state); various issues of the Johor Industry Guide, compiled by the Johor state government; and company websites.

For Batam, investment approvals and closure records from the Batam Indonesia Free Zone Authority (BIFZA) were consulted. This organization, formerly named the Batam Industrial Development Authority, was established in 1973 and tasked with: economic planning; building infrastructure such as industrial estates, ports, and highways; marketing and investor liaison; and

handling investment applications for the entirety of Batam Island. BIFZA is the first port of call for investors and has the most comprehensive records of investment applications. Based on archives of investment approvals maintained by the Authority, a database of firm entries, exits, nationality, and branch was constructed. This was cross-checked with data provided to us by BatamIndo Industrial Park, the largest and most-established industrial park on the island, as well as firm directories published by BIFZA and BatamIndo over the years.ⁱⁱⁱ Where necessary, additional information was gathered from company websites.

5. Revisiting the Electrical and Electronics Industry in Singapore, Johor, and Batam

Trends in Singapore

As mentioned, Singapore's E&E sector has undergone profound transformation over the last 25 years. The following paragraphs will review recent literature on developments in Singapore's E&E industry and analyse available statistics in order to shed light on two questions. First, is the industry marked by a conscious *dynamic* strategic coupling, where more competitive industry branches are developed and less competitive ones shed? Second, has there been progress up the value chain, with ever more sophisticated tasks carried out within the remaining branches?

Toh's (2013) 'mapping' of the recent evolution of the Singapore E&E industry reveals significant changes. Tables 2 and 3 show the main indicators he used, and are updated with recent data. He noted that trends of output, value-added and employment indicate movement towards greater value-added and sophistication. While declining in relative terms (representing 34 percent of output of the manufacturing sector as a whole in 2015, as opposed to 43 percent in the beginning) the value of E&E output increased three-fold over the same period. Value-added has also increased more than three times, while the number of employees decreased substantially over the same period. Although the E&E industry has come to represent a smaller proportion of the manufacturing sector in output and employment terms, its greater output and value-added produced by fewer workers indicate significant upgrading.

The trend towards 'moving up' is reinforced by the fact that the branch structure of the industry has changed significantly. Available literature shows that, during the 1980s, electronics production in the country diversified away from consumer electronics and components into industrial electronics,

particularly disk drives, computer peripherals, computer systems and integrated circuits, as well as supporting industries (McKendrick et al. 2000, Mathews and Cho 2000).

Table 2: Key Indicators for the Electrical and Electronics Industry, Singapore (million S\$)

	1990	1995	2000	2006	2010	2012	2015
E&E Output	30,599	62,495	86,397	78,547	98,181	89,361	90,814
<i>E&E Output (%)</i>	<i>42.5</i>	<i>54.8</i>	<i>54.2</i>	<i>34.0</i>	<i>37.6</i>	<i>31.1</i>	<i>33.9</i>
Total Manufacturing	71,923	113,974	159,404	230,766	261,364	286,976	267,866
E&E Value Added	5,888	11,960	18,834	19,774	23,141	19,666	21,851
<i>E&E V.A. (%)</i>	<i>36.2</i>	<i>44.7</i>	<i>48.3</i>	<i>40.3</i>	<i>38.4</i>	<i>31.6</i>	<i>31.0</i>
Total Manufacturing	16,245	26,783	39,030	49,043	60,225	62,189	70,417
E&E Employment	147,643	151,740	120,558	112,086	100,004	99,169	90,259
<i>E&E Emp. (%)</i>	<i>42.0</i>	<i>41.0</i>	<i>35.0</i>	<i>29.3</i>	<i>24.1</i>	<i>23.4</i>	<i>22.6</i>
Total Manufacturing	351,674	370,281	344,610	381,909	414,176	424,622	400,173

Sources: Singstat

An analysis of E&E exports shows that, during the 1990s and especially the 2000s, the sector became increasingly narrow, specialized, and more sophisticated (Table 3). It is also notable that the total value of domestic exports has fallen some 20 percent over the 1997-2015 period. When analysed against the increase in value-added and output, this means that a greater proportion of production is remaining in the domestic economy. With regard to industry branches, while consumer electronics contracted, other more technologically-sophisticated industry spaces such as semiconductors

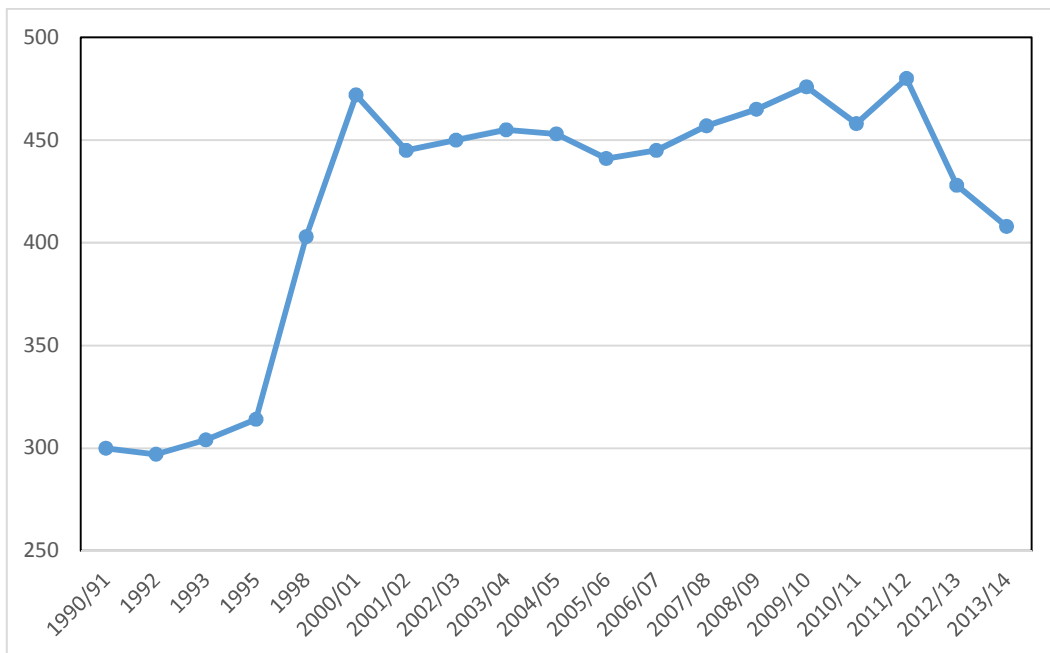
expanded significantly. Indeed, from a mere 16 percent in 1997, semiconductors now account for more than half of domestic E&E exports. Also of note is the important contraction in the disk drive/storage media branch. Exports of personal computers, components and boards, as well as telecommunication equipment have remained roughly static. Conversely, exports of electrical devices have increased noticeably.

Table 3: Domestic Exports in Current Prices (SGD Million)

Variables	1997	2000	2006	2010	2012	2015
Consumer Elect.	na	204,080	363,935	163,364	80,424	43,070
(%)	na	3.7	5.5	3.2	1.6	1.1
Integrated Circuits	839,480	1,485,099	2,322,260	2,314,178	2,461,257	2,153,095
(%)	16.4	27.2	35.1	44.6	49.7	52.9
Storage Media	1,505,155	1,109,188	834,036	559,732	241,430	137,837
(%)	29.3	20.3	12.6	10.8	4.9	3.4
Personal Computers	399,329	239,731	71,901	122,919	157,058	332,735
(%)	7.8	4.4	1.1	2.4	3.2	8.2
Telecommunications	166,890	247,891	566,791	86,258	218,139	128,718
(%)	3.3	4.5	8.6	1.7	4.4	3.2
Components/boards	931,389	1,173,391	1,657,355	1,237,076	1,078,820	716,202
(%)	18.2	21.5	25.1	23.9	21.8	17.6
Electrical Devices	na	60,998	348,390	219,214	485,098	270,670
(%)	na	1.1	5.3	4.2	9.8	6.6
Total	5,129,647	5,450,598	6,611,308	5,183,203	4,951,807	4,072,590
(%)	100.0	100.0	100.0	100.0	100.0	100.0

Source: Yearbook of Statistics Singapore, various years

Figure 2: E&E Firms (manufacturing establishments) in Singapore 1990-2014

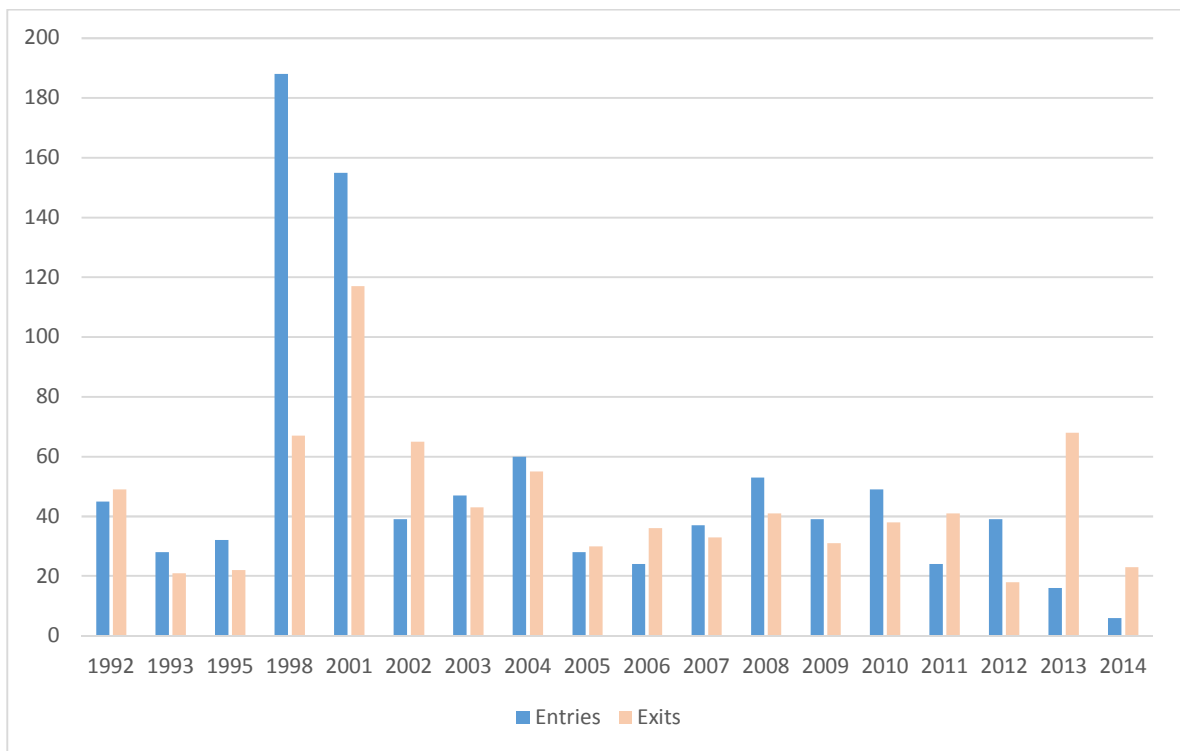


Source: Authors

Turning to our database, the trends revealed by an analysis of firm entries and exits match those shown by the abovementioned statistics – with some key differences. The first finding pertains to the number of E&E establishments in Singapore over the 1990-2014 period (Figure 2). The trend line shows that the city-state’s firm base experienced a substantial increase over the course of the 1990s, from 300 in 1990 to some 470 in 2001. Following this, the number of firms fell slightly – most likely influenced by the global industry downturn in this period – before remaining relatively constant over the next ten years. After 2012, the firm population dropped again, down to approximately 410 in 2014. The relatively stable number of firms after the year 2000 – along with rising levels of outputs, value-added, and exports simultaneous with decreasing employment levels – is consistent with generalized upgrading and rising productivity. The decrease in firm numbers after 2012 could be due to domestic policy changes, such as those set out in the Economic Strategies Committee, which advocated increasing the skill intensity of operations and phasing out of lower value-activities in Singapore (ESC 2010). This could have affected a number of smaller and less technologically-sophisticated firms.

Of the total population of 1195 firms that established manufacturing operations in the city-state during the 1990-2014 period, 406 were still in operation in 2014 – indicating a survival rate of 34 percent. The early 1990s were marked by a balance in firm establishment and closures (Figure 3). However, in the late 1990s, firm entries increased notably and were only partially offset by more frequent firm closures – resulting in a net gain in firm numbers. For the 2002-2012 period, firm entries and exits were in equilibrium. However, in 2013 and 2014, firm closures outweighed openings.

Figure 3: Singapore E&E firm Entries and Exits



Source: Authors

Table 4 sets out the number, proportion, and average tenure of all firms that have had a presence in Singapore over the 1990-2014 period. Singaporean firms constitute the largest group, accounting for 44.5 percent of the total. They are followed by American and Japanese firms, accounting for 18.2 and 16.3 percent respectively. European, particularly German, and Asian firms (Taiwan and PRC/Hong Kong) constitute the other significant populations. When analysed over time,

these proportions are relatively consistent, with a slight gain in the number of Singaporean firms vis-à-vis American and Japanese ones.

**Table 4: Breakdown of Firms Investing in Singapore
by Nationality and Tenure (1990/91-2013/14)**

Nationality	Number	Proportion	Average Tenure
Singapore	532	44.5	7.6
American	218	18.2	7.6
Japanese	195	16.3	10.2
German	45	3.8	7.1
Taiwanese	30	2.5	6.4
PRC/Hong Kong	30	2.5	6.4
French	23	1.9	5.6
Total	1195	100.0	7.9

Source: Authors

With regard to tenure, Japanese firms tend to stay the longest, an average of 10.2 years. Singaporean and American firms have shorter tenures of approximately 7.6 years, slightly under the average of the group as a whole. Taiwanese and PRC firms have noticeably shorter tenures, of 6.4 years. Interestingly, German and French firms have different average tenures, of 7.1 and 5.6 years, respectively. When compared to the two non-core locations, the survival rate and tenure of firms based in Singapore are lower and shorter, a potential indication of more dynamic environment with high levels of local firm creation and destruction on one hand, and the country's role as the first port of call in Asia for foreign firms on the other. In the recent wave of firm exits, Japanese and American firms have a significant share, indicating that E&E multinationals from these countries are no longer as committed to the city-state.

Table 5 sets out the proportion of firms by industry branch for the period 1990 to 2014.^{iv} There are a number of noticeable trends. First, the number of firms in the former dominant and relatively low value-added consumer electronics branch have decreased markedly. Component and computer-producing firms have also decreased somewhat, although the first group still remains the largest sub-population of firms. Storage media firms have also decreased notably, particularly relative to their levels in 2002-2003. Conversely, the number of semiconductor, communications equipment, and electrical device-producing firms have increased, the first by a factor of two, the second by about half, and the third by about a fifth.

Table 5: Singapore E&E Industry by Branch (1990/91-2013/14)

Group	1990-91	1995	1998	2002-03	2005-06	2009-10	2013-14
Consumer Electronics	14.7	12.4	7.9	4.5	4.8	4.8	4.8
Semiconductor Devices	7.8	10.5	10.0	13.6	14.8	15.5	15.8
Magnetic and Optical Media	2.5	3.1	2.9	4.5	4.4	4.0	2.7
Computer and Peripheral Equipment	10.6	11.8	10.4	8.8	7.0	8.1	7.1
Electronic Components and Boards	35.0	33.1	39.1	32.1	30.6	24.8	27.2
Communications Equipment	12.2	11.8	9.4	10.7	10.5	14.7	16.4
Electrical Devices & Equipment	11.9	12.7	14.6	16.9	17.5	16.3	15.8
CEM	0.3	0.3	2.1	7.0	8.1	9.5	8.4
Other	5.0	4.3	3.7	1.9	2.4	2.2	1.8
Number	360	323	481	472	458	496	438

Source: Authors.

While the picture that emerges is consistent with what is known from export data and industry documentation (EDB 2010, 2014, 2015), the focus on firm numbers yields some additional insights. First, comparing export levels with firm numbers can give a rough approximation of firm size. Thus, semiconductor firms represent only 16 percent of the total firm population, yet produce more than half of the industry's exports – indicating the presence of large-capacity and highly-productive firms in this branch. Conversely, large firm populations such as those in the electronic component and

electrical devices account for a smaller proportion of exports, indicating many smaller firms producing less value-added exports and/or producing inputs for other firms that are not exported. Furthermore, while the volume of exports from storage media-producing firms has plummeted, the number of firms has not decreased to the same extent, indicating a degree of resilience.

Second, the analysis of firm numbers by product category also allows the development of CEMs to be tracked. This is because these firms manufacture a wide range of products for third parties, and thus cannot be separately identified by output and export data. Our database indicates that the ranks of CEMs has increased from virtually nothing in the early 1990s to eight percent of the total in 2012. This growth could also potentially explain the decrease in overall firm numbers in recent years, as CEMs could take market share for intermediate products and sub-assembly work carried out by smaller firms.

Third, this exercise also demonstrates the importance of the electrical device & equipment branch, which provides basic inputs such as wires, harnesses, motors, batteries and accumulators to larger electronics-producing firms based in Singapore. Despite an overall shift to more technologically-intensive products, this relatively low-tech branch has remained relatively constant. While its exports have increased during the period under study, its relatively large number of firms could also indicate that much of its output remains within the domestic economy.

Thus, the data yielded from our compilation of firm data reinforces the finding that the Singapore E&E industry has transformed significantly over the past quarter-century. The industry branches that are expanding and contracting reflect a clear trend away from less value-added segments towards higher value-added ones, as well as a generalized narrowing and specialization. The increasing prominence of the semiconductor branch is in large part due to significant investments by the government in a dedicated high-technology infrastructure allowing foreign companies to enjoy spill-overs from an expanding integrated industry eco-system (van Grunsven 2013). To a lesser extent, this also goes for the data-storage media branch.

There is also some evidence that the city-state is hosting higher value-added operations that go beyond production, particularly in the areas of R&D and Innovation. Singapore's position in these branches has shifted from an exclusive production platform to an integrated value chain hub as companies have broadened their strategic coupling to hospitable locations (van Grunsven 2013).

However, information on R&D centres is less readily available in a form comparable to manufacturing units.

Singapore also was host to a growing number of Regional Headquarters. At one stage, during the regionalization push and when many E&E MNCs were still operating a substantial network of subsidiaries in the region, the city-state broadened its coupling strategy to include regional headquarters (Yeung, Poon, and Perry 2001; Edgington & Hayter 2013b). Verification of this – as well as identification of the dynamics of these units – is severely handicapped by the lack of data. From newspaper reports, it can be gauged that, at least in the E&E industry, Singapore is no longer as attractive for such operations outside the semiconductor and digital storage media branches. Larger E&E flagship firms in other branches have closed down their Singapore RHQs along with the substantial downsizing of their manufacturing and assembly operations.

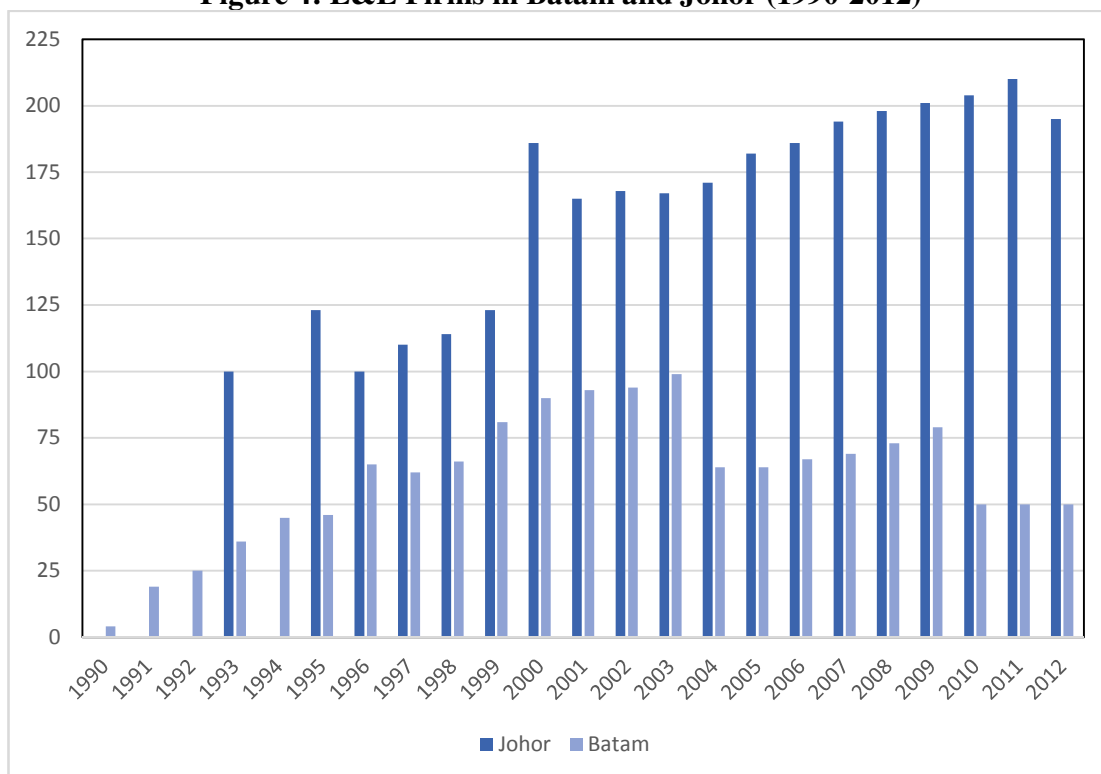
Trends in Johor and Batam

As to the non-core locations of Johor and Batam, the features that will be analysed include: the number of firms and their evolution over time; patterns in entries and exits; the origin of investments and their tenure; and the development of branch structures. With respect to the first aspect, an analysis of firm numbers in Johor indicates that the E&E industry has shown a somewhat positive growth path (Figure 4). While marked by years of significant increase and decline, the 2012 total was double that of the population in 1993. However, the improvement upon the size of the firm grouping in 2005 is small, indicating a levelling off of growth. Relative to Singapore, the size of the E&E firm population in Johor in 2012 is approximately half. As regards Batam, significant growth during the 1990s and early 2000s (associated with a liberalization of investment and relaxation of equity restrictions on the island in 1990), was followed by less-positive dynamics of the firm population from 2004. In 2004 alone, the number of E&E establishments declined by one-third to 64 firms. Over the next six years, it experienced a modest increase, only to be followed by significant loss after 2009. In 2012, there were only 50 E&E firms in operation on the island – half the number of eight years before, one quarter the number of firms in operation in Johor, and one-eighth those in Singapore.

Over the 1995-2012 period, 308 E&E firms have been operating in Johor, of which 198 were in operation in the last year – a survival rate of 64 percent. Looking at the overall trend, firm entries into Johor over this period remained generally higher than firm exits, leading to an increase in firm numbers (Figure 5). There was one notable jump in arrivals in 2000, when some 60 firms set up

operations. There were, however, three years where exits outnumbered entries: 1996; 2001; and 2012. On these occasions, firm departures were significant, with 30 firms leaving on the first two occasions, and 20 firms on the third. In all of these cases, the large number of departures was only partially mitigated by a lower number of arrivals.

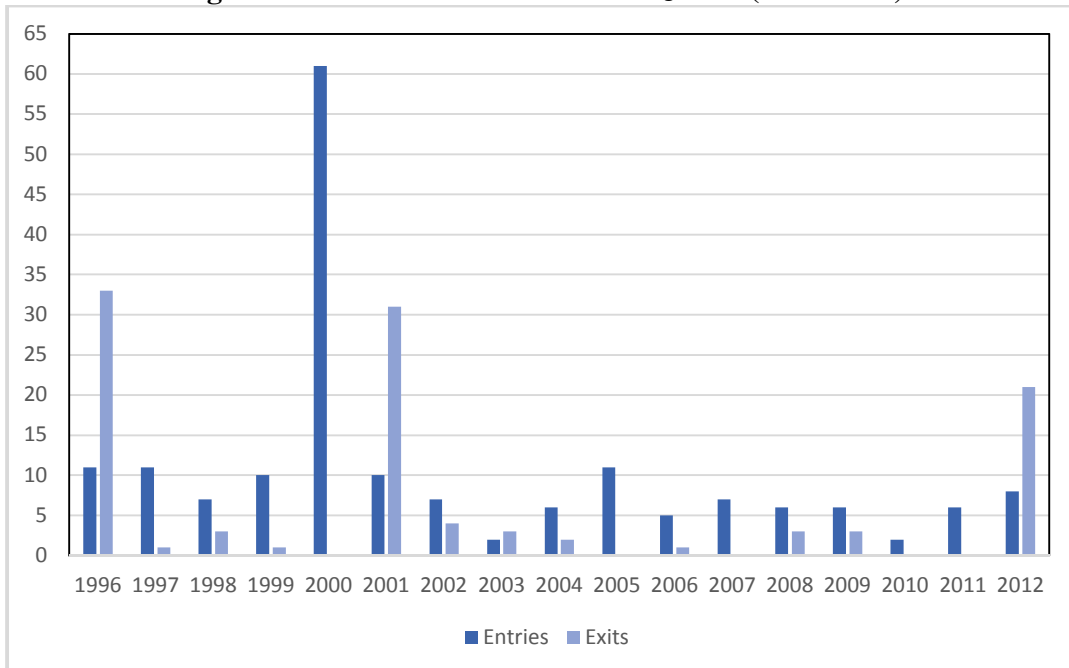
Figure 4: E&E Firms in Batam and Johor (1990-2012)



Source: Authors

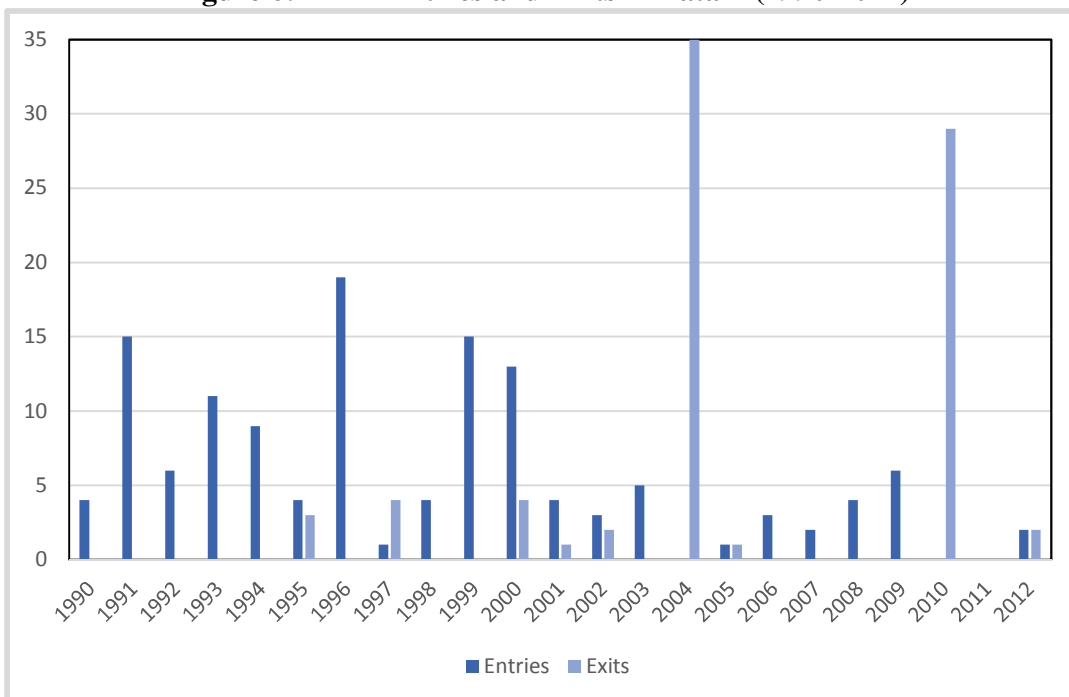
With regard to Batam, a total of 131 firms were in operation at some point during the 1990-2012 period. Of this, 50 were functioning in 2012 – indicating a survival rate of only 37.5 percent. In terms of patterns of entry and exit, firm entries were sustained from 1990 to 2003, with particularly significant increases in 1991, 1996, and 1999. Firm exits were relatively rare during this period. 2003 was a crucial year, as after this the level of firm entries was very low. Firm exits, for their part, were concentrated in two specific occasions, 2004 and 2010, with 35 and 29 exits each (Figure 6).

Figure 5: Firm Entries and Exits in Johor (1996-2012)



Source: Authors.

Figure 6: Firm Entries and Exits in Batam (1990-2012)



Source: Authors

Thus, across the three locations, the patterns of arrival and departure are broadly similar up until 2001, with all three nodes increasing their firm numbers. Following this date, however, their fortunes differ. Singapore and Johor have remained largely stable, and Batam has lost significant firm numbers.

With regard to breakdown by nationality and tenure, Johor displays a number of commonalities and differences with Singapore (Table 6). First, as with the city-state, Japanese, Singaporean, American, and European firms constitute the largest contingents. However, in this case, Japanese firms constitute the largest sub-group, and Singaporeans are the second-largest. In addition, the participation of domestic firms, in this case Malaysian companies, is much less important than in Singapore. Interestingly, firm tenures are noticeably longer, at 9.9 years. Given the production linkages to Singapore, it is most likely only the larger and more established firms venture across to Johor, thus contributing to their longer tenures. This is probably also accentuated by the lower participation of local firms. Regarding length of tenure and nationality, Japanese, Japanese/Malaysian, and Singaporean firms had longer than average tenures, with North American and Malaysian firms having relatively short tenures.

Table 6: Breakdown of E&E Firms Investing in Johor by Nationality and Tenure (1995-2012)

Nationality	Number	Proportion	Average Tenure (yrs)
Japan	81	26.2	12.2
Singapore	75	24.3	10.2
USA/Canada	38	12.3	8.5
Europe	35	11.4	7.7
Other East Asian	25	8.1	8.2
Malaysia	20	6.5	7.0
Japan/Malaysia	14	4.5	10.8
Total	308	100	9.9

Source: Authors, firms w/ incomplete data (10)

As to Batam, with regard to the nationality of E&E firms, Singaporean companies constitute the largest contingent, comprising just under one third of all firms (Table 7). Japanese affiliates follow, accounting for a little less than one quarter. Other significant nationalities include: American; Japanese/Singapore joint ventures; and Indonesian. Including joint ventures, Singaporean and Japanese firms account for almost 60 percent of firms in Batam. The average firm tenure in Batam is 10.3 years, with Japan, Japanese/Singaporean, and American firms having longer than average life-spans.

Table 7: Breakdown of All Firms Investing in Batam by Nationality and Tenure (1990/91-2012/13)

Nationality	Number	Proportion	Average Tenure (yrs)
Singapore	39	29.8	9.2
Japan	27	20.6	13.2
USA	12	9.2	10.8
Japan/Singapore	11	8.4	12.9
Indonesia	6	4.6	8.3
Total	131	100	10.3

Source: Authors, firms w/ incomplete data (21)

Thus, in the three locations, the largest firm populations are Singaporean, Japanese, and American firms. Johor differs in that Japanese firms are the most numerous, whereas in Singapore and Batam, Singaporean firms are the most prevalent. Batam differs in having very few European firms. And, the two non-core locations are marked by a very limited presence of local firms, in contrast to Singapore, where local firms constitute the largest group.

The fourth feature to be considered concerns branch composition. In Johor in 1995, the branches with the largest number of firms were: consumer electronics; electronic components and boards; and electrical devices (Table 8). In 2012, these three branches were still the largest. The only other notable firm group is CEMs, which expanded over the period under study. Thus, the Johor E&E industry has concentrated in branches with relatively low value-added, and this profile has not changed over time. It is also telling that these proportions did not change in response to developments

in Singapore, through an expansion in branches such as consumer electronics, computers and peripherals, or storage media.

Table 8: Johor E&E Industry by Branch (1995-2012)

	1995	2000	2005	2010	2012
Consumer Electronics	24.4	22.0	21.4	19.6	17.9
Semiconductor Devices	0.8	2.7	1.6	2.9	3.1
Data Storage	0.0	0.5	1.6	2.5	2.1
Computer and Computer Peripherals	5.7	7.0	5.5	5.9	6.2
Electronic Components and Boards	16.3	14.5	16.5	16.7	17.4
Communication Equipment	3.3	3.8	3.8	3.9	4.1
Electrical Devices	42.3	41.4	39.0	37.7	38.5
CEM	6.5	7.0	9.3	8.8	9.2
Other	0.8	1.1	1.1	2.0	1.5
Number of Firms	123	186	182	204	195

Source: Authors

As to the evolution of the branch composition of the E&E industry in Batam, it equally shows a continued specialization in the same relatively low-tech segments of the E&E industry, namely: consumer electronics; electronic components and boards; and electrical devices. And, as with Johor, the branch structure has evolved relatively little over time. The only other significant development was the expansion of the CEM segment, which doubled in size during the period under study. As with Johor, the branch structure indicates a high level of stasis and a lack of expansion of higher value-added branches. It must also be remembered that, in Batam, these proportions have remained stable in a generalized context of establishment withdrawal, meaning that these branches also experienced contraction after 2000. As for both non-core nodes it should also be added that the value chain activities in the E&E industry have not extended beyond production for a number of reasons. In both cases, companies have deemed the environment – *inter alia* human capital and technology –

insufficient to shift the coupling process. This observation clearly emerged from our scrutiny of *in situ* evolution of selected E&E establishments in both nodes (Camphenout & de Graaf 2013; van Oerle & Visch 2014; van Grunsven & Hutchinson 2014).

6. Discussion

Having laid out the trends in firm entries, exits, tenure, nationality, and branch structure, in this section we will refer back to the tools laid down in the conceptual section. We have identified a number of ‘drivers’ for a node to move along a pathway. These include: developments in endowments and competences; ‘micro-level’ developments in firms and MNC subsidiaries; and institutional commitment, on the part of government agencies, research institutes, and business associations.

The constituent nodes of the SIJORI cross-border region have evolved positively and negatively in terms of their endowments. Singapore’s substitution of the earlier cost-based manufacturing for more capital and skill-intensive production was a logical response to spiralling labour costs. Institutional commitment to a ‘high-road’ pathway produced substantial qualitative human capital development and technology infrastructure effective in enticing new multinational activity. With regard to the E&E sector, the data confirm that the industry in Singapore is marked by an active shedding of the less competitive industry spaces (‘moving out’), and at the same time industrial ‘moving up’ with a focus on technologically more sophisticated branches and activities. Consequently, we can see strategic coupling, with the aim of targeting more sophisticated industry branches such as semiconductors, as well as decoupling from less value-added segments such as consumer electronics. Furthermore, within industry branches, we see a collective commitment to value chain advancement.

With regard to the two non-core locations, the developments in Singapore present two opportunities for strategic coupling. First, either or both of the two non-core locations could mirror the city-state’s move away from mature industry branches towards newer, more sophisticated segments such as semiconductors. Second, Johor and/or Batam could move decisively into the branches being vacated by Singapore such as consumer electronics or storage media. In addition, value chain advancement along one or the other trajectory is also possible.

Provided that the two locations were to offer the same complementary production factors, institutional configurations, or local firm dynamics, either of these two strategic coupling possibilities

would be feasible. However, our data do not show any such positive industry dynamic in either non-core region. Indeed, the opposite is true for Batam, where we observe *de facto* gradual decoupling – particularly companies losing commitment to the island. While there is less evidence of the latter in Johor, the development pathway of the industry here has been flat at most. This is in line with observations for Malaysia as a whole (Rasiah 2010; Rasiah 2012; Yusuf and Nabeshima 2009).

What has accounted for this? In both cases, the institutional commitment to strategic coupling and value chain advancement has been seriously affected. With regard to Johor, the overall emphasis on attracting foreign direct investment has remained. However, since 2006 and the launch of the Iskandar Malaysia region in the southern part of the state, the focus has been largely on services, particularly healthcare, education, logistics, finance, and creative industries. The large number of new sectors and excessive focus on foreign expertise and know-how has meant that manufacturing has been, in relative terms, neglected. In particular, the E&E sector is perceived as ‘mature’, ‘risky’, and ‘competitive’ (Hutchinson 2012). When compounded with Malaysia’s structural challenges such as skill shortages, under-investment in research and development, and considerable levels of brain drain, the E&E sector faces formidable obstacles (World Bank 2011, 2013; Yusuf and Nabeshima 2009).

Batam’s ability to attract and retain investment has been affected by Indonesia’s far-reaching decentralization reforms. The increase in subnational governments and the autonomy afforded them has meant that the investment climate is now characterized by uncertainty, a lack of transparency, and a multitude of actors with veto power. Investment approvals, land zoning, and environmental approvals are no longer as efficient as in the past, and speculation has resulted in shortages of available land for investors. Current political priorities have shifted away from export-oriented sectors towards traditional economic pursuits such as farming and small-scale farming. Furthermore, Indonesia’s combustible industrial relations context has seen Batam’s workforce affected by periodic strife, affecting investor sentiment (Hutchinson 2015).

Thus, compared to Singapore, Johor and Batam have been far less successful attracting new firms and new operations. And, there is no evidence that they have been able to capture industry spaces vacated by the city-state. We observe that new firms or operations have been limited to Singapore. Furthermore, to a substantial extent, firms operating in Singapore are no longer following the logic of leveraging differential and dynamic comparative advantage of nodes/locations in close proximity.

While Johor has been able to maintain at least the basic requirements for participation in global and regional corporate networks in a production role for lowly-ranked affiliates in the E&E industry, this is not evident in the Batam case. This is supported by the recent investment patterns of Singapore-based E&E firms. As part of our study, an analysis of their subsidiary network and location trends over time was undertaken. The results clearly reveal the loss of appeal of Johor, let alone Batam, and the increasing prominence of locations further afield such as China (Fleuren and Janssen 2016). It has to be acknowledged that this also reflects market developments. However, this corresponds with another observation from our entry-exit data: recent exits from Singapore have been substantially larger than entries into Johor and Batam combined.

The above is also linked to evolving institutional attitudes and behaviour. In the process of shifting jurisdictions, Batam and Johor have shown less institutional interest in further growing the industry (Hutchinson 2015; van Grunsven and Hutchinson 2014). New development priorities have de-emphasized links with Singapore, and agendas in Batam have shifted towards traditional economic activities such as fishing and farming. In Johor, they have tilted towards services. In both cases, avenues for maximizing short term growth and generation of rents have started to dominate the agendas.

Upgrading the E&E industry is incompatible with this, as the acquisition of technological capabilities is a complex and time-consuming process, requiring the creation of substantial levels of social capital with firms, and with rewards showing only after some time (Doner 2007). This has led authorities to prioritise other goals and industries/sectors. The development of regional production factors and assets suitable to capturing new E&E industry spaces have taken a backseat in both locations, as authorities seek to diversify across multiple economic sectors, rather than pursuing depth in established ones (van Grunsven and Hutchinson 2016; van Grunsven and Hutchinson 2015). Due to a lack of institutional action, established companies have been left with conditions un conducive to new subsidiary establishment, and/or enhancement of subsidiary capabilities and mandates. As the disadvantages of the SIJORI Triangle have increasingly been weighed by MNCs and local firms against the comparative advantage of other locations, nodes such as Batam and Johor have been at the losing end.

7. Conclusions

This article's immediate aim has been to analyse and interpret the evolution of the E&E industry in the SIJORI cross-border region over the past 25 years. The analysis has been guided by the following research questions: how have the size, profile, and branch structure of the E&E industry in Singapore, Johor, and Batam evolved; have either of the two non-core territories captured industry spaces vacated by Singapore and, if so, which have these been; and what are the long-term implications of these developments?

From a theoretical perspective, this article has used the concepts of strategic coupling, value chain advancement, and industry branching to analyse how and to what extent regions or 'nodes' are able to successfully position themselves in global production networks.

The collection and analysis of comprehensive set of empirical data, specifically company entries, exits, nationality, and industry branch from all three locations has allowed the abovementioned questions to be explored.

As a node within a global production network, Singapore has demonstrated dynamic strategic coupling, as it has been able to move out of less value-added industry branches such as consumer electronics and storage media into more complex, sophisticated ones such as semiconductors. It has also demonstrated value chain advancement as MNC operations located in the city-state have been awarded higher-order mandates over time.

Johor and Batam have, for their part, shown markedly less strategic coupling. Neither location has accompanied Singapore in its migration towards the semiconductor industry branch. And, neither location has been able to garner a larger share of the industry branches such as computers and peripherals or consumer electronics that have left the city-state. Indeed, the branch structure of both locations in 2012 was almost identical to what it was in the early 1990s. Despite its lack of significant evolution, Johor has been able to grow its ranks of firms. Conversely, the number of E&E firms in Batam has shrunk, raising questions as to its long-term viability.

Relative to the initial core/non-core relationship between Singapore, Johor, and Batam, we find that, in the three component nodes, the E&E industry has developed in a way that reveals an increasing 'disconnect' between them, and SIJORI's significance as an integrated industrial cross-border region has been substantially reduced. Given the way institutional configurations have developed in both Johor and Batam, this conclusion appears to apply in more general sense. This only

corroborates the fact of a limited life span of the idea of Southeast Asian cross-border regions or 'Growth Triangles'. The silence that has surrounded the construct for the recent past will not be broken any time soon.

References

- Boschma, R. and K. Frenken. 2011. "Technological relatedness and regional branching". In *Dynamic geographies of knowledge creation and innovation*, edited by H. Barthelt, M.P. Feldman & D.F. Kogler. Abingdon: Routledge, Taylor and Francis.
- Campenhout, M. van and J.R. de Graaf. 2013. "In search for a silver lining: the evolution of the E&E industry of Batam, Indonesia". Master Thesis, Faculty of Geosciences, Utrecht University, The Netherlands.
- Coe, N.M., M. Hess, H.W-C Yeung, P. Dicken and J. Henderson. 2004. "Globalizing regional development: a global production networks perspective." *Transactions of the Institute of British Geographers* 29: 468-484.
- Coe, N.M. and H.W-C Yeung. 2015. *Global production networks: theorizing economic development in an interconnected world*. Oxford: Oxford University Press.
- Department of Statistics. Various years. *Yearbook of Statistics, Singapore*. Singapore: Department of Statistics.
- Doner, R. 2007. *The Politics of Uneven Development: Thailand's Economic Growth in Comparative Perspective*. Cambridge: Cambridge University Press.
- Economic Strategies Committee (ESC). 2010. *Report of the economic strategies committee: high skilled people, innovative economy, distinctive global city*. Singapore: Ministry of Finance.
- EDB. 2010. *Revolutionizing electronics: IC design in Singapore*. Singapore: Economic Development Board.
- EDB. 2014. *Industries – Electronics*. Singapore: Economic Development Board.
- EDB. 2015. *Singapore – global electronics hub, electronics factsheet*. Singapore: Economic Development Board.
- Edgington, D.W. and R. Hayter. 2013a. "The *in situ* upgrading of Japanese electronics firms in Malaysian industrial clusters". *Economic Geography* 89 (3): 227-259.
- Edgington, D.W. and R. Hayter. 2013b. "Glocalization" and regional headquarters: Japanese electronics firms in the ASEAN region". *Annals of the Association of American Geographers* 103 (3): 647-668.
- Ernst, D. 2002. "Global production networks in East Asia's electronics industry and upgrading perspectives in Malaysia". Economics Paper Series 44. Honolulu: East-West Center.

- Felker, G. 2009. "The political economy of Southeast Asia's techno-glocalism". *Cambridge Review of International Affairs* 22 (3): 469-491.
- Fleuren, B. and H. Janssen. 2016. "Changing lanes. The evolution of the E&E industry in Singapore". Master Thesis, Faculty of Geosciences, Utrecht University, The Netherlands.
- Henderson, J. 1989. *The Globalisation of High-Tech Production: Society, space, and semiconductors in the restructuring of the modern world*, Routledge: London, and New York.
- Hobday, M. 1995. "East Asian Latecomer Firms: Learning the Technology of Electronics", *World Development*, 23(7): 1171-93.
- Hutchinson, F.E. 2015. *Mirror Images in Different Frames? Johor, the Riau Islands and Competition for Investment from Singapore*. Singapore: Institute of Southeast Asian Studies.
- Johor Technopark. various. *Johor Industry Guide*. Johor: Johor Technopark.
- Lee Keun. 2010. "What makes more successful and less successful technological catch-up: analyzing 10 late-comer countries". Paper presented at the International Schumpeter Society Conference, Aalborg, June 2010.
- Lee Tsao Yuan. 1991. *Growth triangle. The Johor-Singapore-Riau experience*. Singapore: Institute of Southeast Asian Studies.
- MacKinnon, D. 2012. "Beyond strategic coupling: reassessing the firm-region nexus in global production networks". *Journal of Economic Geography* 12: 227–245.
- Marshall Cavendish Business Information. various. *Singapore Electronics Industry Directory*. Singapore: Times Directories.
- Mathews, J.A. and D.-S. Cho. 2000. *Tiger Technology: the Creation of a Semiconductor Industry in East Asia*. Cambridge: Cambridge University Press.
- McKendrick, D.G., R.F. Doner and S. Haggard. 2000. *From Silicon Valley to Singapore. Location and competitive advantage in the hard disk drive industry*. Stanford: Stanford University Press.
- OECD. 2013. *Interconnected Economies: Benefiting from Global Value Chains*. Paris: Organisation of Economic Cooperation and Development.
- Oerle, S. van and C. Visch. 2014. "Johor: future E&E gateway to the world? A study of the evolution of the E&E industry in Johor". Master Thesis, Faculty of Geosciences, Utrecht University, the Netherlands.

- Pangestu, M. 1991. "The Growth Triangle: An Indonesian Perspective". In *Growth Triangle: the Johor-Singapore-Riau Experience*, edited by Lee T.Y. Singapore: Institute of Southeast Asian Studies.
- Parsonage, J. "Southeast Asia's 'Growth Triangle': A subregional response to global transformation". *International Journal of Urban and Regional Research* 16, issue 2 (1992): 307-17.
- Pereira, A.A. 2004. "State entrepreneurship and regional development: Singapore's industrial parks in Batam and Suzhou". *Entrepreneurship & Regional Development: An International Journal* 16 (2): 129-144.
- Perkmann, M. and N. Sum. 2002. "Globalization, Regionalization, and Cross-Border Regions: Scales, Discourses, and Governance." In *Globalization, Regionalization, and Cross-Border Regions*, edited by M. Perkmann and N. Sum. Basingstoke: Palgrave Macmillan.
- Rasiah, R. 2009. "Expansion and slowdown in Southeast Asian electronics manufacturing". *Journal of the Asia Pacific Economy*, 14(2): 123-137.
- Rasiah, R. 2010. "Are electronics firms in Malaysia catching up in the technology ladder?". *Journal of Asia Pacific Economy*, 15(3): 301-319.
- Rasiah, R. 2012. "Is Malaysia's electronics industry moving up the value chain?". In *Malaysia's Development Challenges: Graduating from the Middle*, edited by Hal Hill, Tham Siew Yean and Ragayah Haji Mat Zin, 194-212. London: Routledge.
- Scalapino, R.A. 1991. "The United States and Asia: future prospects". *Foreign Affairs* 70 (5): 19-40.
- Singstat. 2016. *Statistics on the Singapore E&E industry*. Singapore: Department of Statistics.
- Sparke, M., J.D. Sidaway, T. Bunnell and C. Grundy-Warr. 2004. "Triangulating the borderless world: geographies of power in the Indonesia-Malaysia-Singapore Growth Triangle". *Transactions of the Institute of British Geographers (New Series)* 29: 485-498.
- Thant Myo, Min Tang and H. Kakazu, eds. 1994. *Growth Triangles in Asia: a New Approach to Regional Economic Cooperation*. Hong Kong: Oxford University Press.
- Toh, M.H. 2013. "The development of Singapore's electronics sector". In *Architects of growth? Sub-national governments and industrialization in Asia*, edited by F.E. Hutchinson. Singapore: ISEAS.
- Toh M.H. and L. Low. 1993. *Regional cooperation and growth triangles in ASEAN*. Singapore: Times Academic Press.
- UNCTAD 2013. *World Investment Report 2013: Global value chains: investment and trade for development*. Geneva: United Nations Centre for Trade and Development.

- UPEN Johor, 1989. *Pelan Ekonomi Negeri Johor, 1990-2005*, Johor: Kerajaan Negeri Johor Darul Ta'zim.
- Van Grunsven, L. 2013. "Singapore's ICT industry: an evolutionary perspective". In *The Economic Geography of the IT Industry in the Asia-Pacific Region*, edited by Cooke, P., G. Searle and K. O'Connor, 47-67. London: Routledge.
- Van Grunsven, L. and F.E. Hutchinson. 2016. "The evolution of the electronics industry in Johor (Malaysia): Strategic coupling, adaptiveness, adaptation, and the role of agency". *Geoforum* 74: 74-87.
- Van Grunsven, L. and F. E. Hutchinson. 2015. "The evolution of the electronics industry on Batam Island (Riau Islands Province, Indonesia): an evolutionary trajectory contributing to regional resilience?" *GeoJournal* 3(82): 475-492.
- Van Grunsven, L. and F.E. Hutchinson. 2014. "The Evolution of the Electronics Industry in the SIJORI Cross-Border Region". ISEAS Economics Working Paper No. 2014-2. Singapore: Institute of Southeast Asian Studies.
- World Bank. 2013. *Malaysia Economic Monitor: High-Performing Education, December 2013*. Washington D.C.: World Bank.
- World Bank. 2011. *Malaysia Economic Monitor: Smart Cities, November 2011*. Washington D.C.: World Bank.
- Yeoh, C., W. How and V. Sim. 2006. "Re-engineering economic space: the case of Singapore's transborder industrialization 'gambits' in Asia." *Journal of Asia Business Studies* 1(1): 34-45.
- Yeoh, C., K.C. Sin and C.C. Jialing. 2004. "Singapore's regionalization blueprint: a case of strategic management, state enterprise network and selective intervention". *Journal of Transnational Management Development* 9 (4): 13-36.
- Yeung, H.W.-C., J. Poon and M. Perry. 2001. "Towards a regional strategy: the role of regional headquarters of foreign firms in Singapore". *Urban Studies* 38(1): 157-183.
- Yeung, H.W.-C. 2014. "Governing the market in a globalizing era: developmental states, global production networks and inter-firm dynamics in East Asia". *Review of International Political Economy* 21(1): 70-101.
- Yeung, H.W.-C. 2015. "Regional development in the global economy: a dynamic perspective of strategic coupling in global production networks". *Regional Science, Policy and Practice* 71: 1-23.

- Yeung, H.W.-C. and N.M. Coe. 2015. "Toward a dynamic theory of global production networks". *Economic Geography* 91(1): 29-58.
- Yusuf, S. and K. Nabeshima, 2009. *Tiger Economies under Threat: A comparative analysis of Malaysia's industrial prospects and policy options*. Washington D.C.: The World Bank.
- Yusuf, S. 2004. "Competitiveness through Technological Advances under Global Production Networking", in S. Yusuf, M.A. Altaf, and K. Nabeshima (eds), *Global Production Networking and Technological Change in East Asia*. Washington D.C.: World Bank/Oxford University Press.

ENDNOTES

ⁱ A cross-border region (CBR) is defined as a territorial unit that comprises contiguous sub-national units from two or more nation-states (adapted from Perkmann and Sum 2002: 1). SIJORI is a special case - although it is not unique - in that one of the component units houses a capital city. This definition does not assume that: SIJORI constitutes a 'natural' economic territory; economic flows are 'triangular' in nature; borders are uniquely barriers to economic activity and trade; or that the interactions between the component units are solely economic in nature. Simply, the composite of three component territories is the unit of analysis. The term 'Growth Triangle' will be used when it refers to the specific trilateral government initiative or to the body of academic literature that uses this framework.

ⁱⁱ With some modifications, Singapore, Malaysia, and Indonesia base their industrial classification systems on the international standard (ISIC) and compile their statistics in analogous fashion. In Singapore, this is the Singapore Standard Industrial Classification System (SSIC); in Malaysia, it is the Malaysian Industrial Classification System (MISC), revision 3; and in Indonesia, it is the Indonesian Standard Classification of Industrial Activities (KBLI). This common classification allows effective comparison across the various countries.

ⁱⁱⁱ Given the two different methods of data collection, it is relevant to discuss the differing potential biases of each. The *Singapore Electronic Manufacturers' Directory* is compiled by a private firm, albeit with the imprimatur of the Singaporean government. It is the oldest and most established of its kind and inclusion is free for any company registered in the country. Firms are able to request to be removed if they wish. Given this, it is possible that a number of smaller firms who focus on business-to-business operations may have been omitted from the *Directory*. In addition, personal contact with a significant subset of firms (approximately 150) revealed that a small, but not insignificant, number of firms have closed down their production activities in Singapore, but have retained marketing offices – leading to the potential of over-reporting of manufacturing operations.

With regard to Johor and Batam, it is unlikely that firm numbers have been over- or under-reported due to the monopoly over investment approvals and granting of incentives held by MIDA and BIFZA, respectively. However, the product categories of the investing companies were recorded upon establishment, but then not updated in a systematic fashion. As a result, a standard protocol was followed. After consulting entries made by the investment authorities, industry guides and then individual company websites were checked to see if firms moved into other product categories over time. With the exception of CEMs, which are classified separately, this was not a common occurrence.

^{iv} These calculations are based on the product category listings. Firms can, and do, list in more than one product category within specific branches (eg consumer electronics). These listings have been cleaned within each branch, but there are some cases of firms listing in more than one branch (eg consumer electronics; communications equipment). As a result, the totals in this table are slightly higher than those in Figure 2.