

Industry dynamics in Growth Triangles: the E&E industry in SIJORI 25 years on

Francis E. Hutchinson  and Leo van Grunsven *

Launched in 1989 and encompassing Singapore, the Malaysian state of Johor, and Batam Island in Indonesia, the SIJORI Growth Triangle sought to market these territories as a 'single investment destination' offering differing factor endowments in close proximity. Singapore was the 'core' of the region; Johor and Batam occupied 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 scrutinising 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 Growth Triangle. We document an increasing disconnect between the three nodes that has substantially reduced SIJORI's significance as an integrated industrial cross-border region.

Introduction

In the early 1990s, cross-border regions gained popularity as a way of understanding and promoting regional industrial development in Asia. 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 because of complementary comparative advantages at close distance. Other terms such as cross-national growth zone and subregional economic zone

also referred to the same phenomenon (Thant et al. 1994).

For many, the Singapore, Johor, and Riau Islands (SIJORI) Growth Triangle was, along with the Hong Kong-Shenzhen manufacturing complex, an exemplar of this phenomenon in Asia.¹ Driven by institutional and corporate responses to cost advantages and proximity, the cross-border movement of industrial production began to link Singapore with the Malaysian state of Johor to the north and the Riau Islands in Indonesia to the south. Launched in 1989 and initially encompassing Singapore, Johor, and the island of Batam, the Growth Triangle was used to market the three

* Francis E. Hutchinson, Senior Fellow, ISEAS-Yusof Ishak Institute, Singapore (Corresponding Author, E-mail: fhutchinson@iseas.edu.sg) and Leo van Grunsven, Associate Professor, Department of Human Geography and Planning, Faculty of Geosciences, Utrecht University, Utrecht, the Netherlands. This work was supported by the ISEAS-Yusof Ishak Institute Research Fund and the Department of Human Geography and Planning, Faculty of Geosciences, University of Utrecht.

1 SIJORI is a special case—although not unique—in that one of the component units houses a capital city. It does not imply that economic flows are 'triangular' in nature. The term 'Growth Triangle' is used when it refers to the specific trilateral government initiative or to the body of academic literature that uses this framework.

territories as a 'single investment destination' offering: a high level of connectivity, different cost structures, and a significant degree of political capital. Over the next decade, Singapore-based multinationals and Singaporean firms were enticed to relocate labour-intensive functions to Johor and Batam, while retaining or establishing more capital- and skill-intensive functions in the city-state.

The electrical and electronics (E&E) industry was very prominent in this regionalisation. 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 assumed the position of 'regional core' of the region.

Similar to other cross-border regions,² and following a period of high visibility, the SIJORI Growth Triangle gradually moved out of the limelight after the late 1990s. In tandem, academic attention on the three locations and their linkages has dwindled. While new segments in Singapore's E&E industry have continued to attract academic attention (Mathews and Cho 2000; McKendrick et al. 2000; Rasiah 2009; Toh 2013), almost no research has been carried out on developments in the two non-core locations. Consequently, very little is known about: the development of the E&E industry in Johor and Batam; how connections between Singapore and these two locations have evolved; and the extent to which the institutional contexts in the core and non-core territories have developed in a way that might encourage other cross-border production networks.

Research on this topic is timely for several reasons. In the 1990s, Singapore was seen as the core and source of investment for the development of the two non-core regions.

Conversely, the regionalisation of production from the city-state to Johor and Batam was conceived as a condition for and channel of Singapore's industrial upgrading process. While the Triangle has moved out of the limelight, this does not mean that cross-border production networks have disappeared. Indeed, they may continue to be a defining characteristic of the SIJORI cross-border region. That said, while the region's attributes at that time may have successfully encouraged cross-border linkages, subsequent institutional developments in one or more component territories may have altered or negated these initial conditions.

Framed by a global production network (GPN) and agency approach, and utilising a unique database containing information on the establishment, closure, nationality and industry branch of E&E firms in Singapore, Johor, and Batam, this article addresses three research questions. First, have the institutional contexts in all three territories retained conditions conducive for the continued development of E&E industry branches in the two non-core regions? Second, how have the size, profile, and branch structure of the E&E industry in Johor and Batam evolved since the early 1990s in relation to Singapore? Third, what are the implications of the trends observed for other cross-border regions, particularly with regard to the development and maintenance of appropriate institutional contexts?

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. Subsequent sections discuss the analytical approach, the development of industry in Southeast Asia, and the initial phase of the SIJORI Growth Triangle. Following this, we set out the necessary enduring conditions for the evolution of the E&E industry in the two non-core SIJORI territories, namely: the manner in

2 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, p. 1). This definition does not assume that: it constitutes a 'natural' economic territory; 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 the component territories is the unit of analysis.

which Singapore's E&E industry develops; and institutional and corporate arrangements in Batam and Johor. In the penultimate section, we present findings gleaned from our database as to the evolution of the E&E industry in Batam and Johor. A final section discusses the implications of the empirical findings.

GPN, dynamic strategic coupling, and cross-border regions

As argued by Felker (2009), one hallmark of Southeast Asia's industrialisation process is its reliance on FDI as a driver of development—as opposed to domestic technological capabilities. 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, 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 different 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 levels and sources of comparative advantage are not static, and corporate responses to them are in flux. Over time, specific nodes change in regard to branches and operations in a *dynamic strategic coupling* process (Yeung 2015; Yeung and Coe 2015).

In relation to this process, the concept of *branching* can be understood as an inter- and

intra-industry and firm-level process where an industry's configuration changes as some of the existing varieties of products dwindle and new ones are introduced. This change occurs when: corporations and institutions introduce a new segment or industry to a territory (and others leave); firms 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). In the conceptualisations offered by MacKinnon (2012) and Yeung (2015), branching entails decoupling and recoupling.

Given that the development of an industry in a given location is an evolving amalgam of comparative advantage, government policy frameworks, industrial trends, and corporate decisions, actor agency and differing or shifting levels of commitment (of places to specific industries and branches within them, and of branches to places) 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 upgrade its industrial structure. This can be achieved in two ways, at industry and firm levels. First, local branching, whereby a technologically unsophisticated variety of products or product categories is augmented (initially) and/or gradually replaced by more sophisticated varieties that may be related (belonging to the same product and technology family) or unrelated (embodying different technology from existing product groups). 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 region-targeting and firm-allocating of new activities that are either technologically more sophisticated or functionally higher-order (OECD 2013; UNCTAD 2013).

Besides moving up, other obvious pathways for a country or region are: stability or stagnation (relative to 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, into and out of networks, as new locations or regions enter production networks by attracting investment, and/or established regions are excluded (Ernst 2002, 2009; Coe et al. 2004; OECD 2013; UNCTAD 2013; Edgington and Hayter 2013a, 2013b).

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, skills 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 upgraded production roles and/or from mere production to an additional role in product adjustment and development (Edgington and Hayter 2013a, 2013b). 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).

These drivers indicate the role of agency by public and private actors. Over time, regions that do not maintain or advance as to capabilities and assets but rather neglect or lose them, that act opportunistically rather than strategically, may find themselves stuck in a value-added position and an increasingly precarious situation as other nodes increase competitiveness. Decoupling is a distinct possibility. From an institutional perspective, disengagement 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 (for example, assembly). For firms, it means that they lose commitment to a node (Edgington and Hayter 2013a, 2013b).

Specific attributes of cross-border regions include economic complementarity; proximity; and connectivity (Lee 1991; Thant et al. 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 et al. 1994). Thus, such regions can be important 'nodes' in GPNs by combining several positions or functions in the network.

In dynamic terms, as the core-region provides new opportunities for the non-core regions, shifts in the territorial division of labour across the constituent territories can result. Institutional and corporate agency in tandem render the constituent parts of cross-border regions open to changes in (strategic) coupling and differential pathways. Besides, the evolution of institutional configurations may reshape predispositions, attitudes, and behaviour, as well as the endowments of the constituent subregions (positively and/or negatively). Corporate agency is manifested in firms operating in them continuing or discontinuing to follow the logic of leveraging differential and dynamic comparative advantage of nodes/locations in close proximity. It is manifested also in new firms or operations being attracted or discouraged by dynamic comparative advantage. At one extreme, one possibility (or pathway) is the non-core regions capturing new opportunities and co-evolving in tandem with the core region, as the latter upgrades its industrial variety and functions. At the other extreme, non-core regions become less attractive and their linkages and networks dwindle.

Industry evolution in the core region, evolution of the institutional context, and associated policy evolution in non-core regions combined, allow certain prediction of the level of co-evolution of the non-core regions through dynamic strategic coupling. Before analysing these, in the next sections we outline the research methodology and offer a brief account of the E&E industry in Southeast Asia, as well as of its early manifestation in the SIJORI Growth Triangle.

Analytical framework

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 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 (Table 1).³

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 grouping is complemented by two additional categories: ‘contract electronics manufacturers’ (CEMs), 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.

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. While providing a high-level picture of industry trends, this data does not

Table 1
The E&E 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

Source: Singapore Standard Industrial Classification Code.

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

3 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.

ways. For Singapore, a database was compiled using the yearly *Singapore Electronics Manufacturers' Directory*, produced by Marshall Cavendish Business Information (1990–93, 1995, 1998, 2000–2014) for the Economic Development Board (EDB) and Association of Electronic Industries of Singapore. Using individual company listings as well as listings of firms and affiliates by product category, 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, and 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 and establishment, closure, nationality, and industry branch was obtained from the Malaysian Investment Development Authority. 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 industry and investment guides compiled by Johor state government agencies (Johor

Corporation 1992, 1993; Johor Technopark 1996); and company websites.

For Batam, investment approvals and closure records from the Batam Indonesia Free Zone Authority (BIFZA) were consulted. This organisation, formerly named the Batam Industrial Development Authority, was established in 1973 and is tasked with among others 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.⁴ Where necessary, additional information was gathered from company websites.

Lastly, in-depth surveys were conducted with 40 firms in Johor and Batam to gain insight into the institutional contexts as well as *in situ* firm-level upgrading in the two non-core locations.

The E&E Industry in Southeast Asia and the emergence of SIJORI

In the 1960s, Singapore and Penang in Malaysia began to assemble light manufactures such as radio components and semiconductors for the American and Japanese markets. In the 1980s and 1990s, as FDI continued to flow in, Singapore became the 'core' of the region.

4 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 that 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 their production activities in Singapore but have retained marketing offices—leading to the potential for 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.

Assisted by its financial, technological, and managerial resources, the city-state began to move into more technologically complex and skill-intensive areas of manufacturing. After 2000, Singapore also began to host procurement centres, and subsequently regional headquarters and research and development facilities.

Leveraging on their macroeconomic policies and investment frameworks, Southeast Asian countries such as Malaysia, Thailand, the Philippines, and Indonesia began to move into more labour-intensive production. 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 remain the leaders in terms of technology and production processes.

Over time, MNCs have created an intricate set of production networks across countries, seeking to leverage different capabilities. In this process, firms were seeking to exploit the comparative advantage of different territories. This allowed them to match technological level with environment and competences on the one hand, and to develop regional production chains through networking on the other.

As regards SIJORI, Johor and Batam began to grow rapidly as 'satellite' developments of Singapore. The latter's industrial restructuring 'push' of targeting higher value-added and more sophisticated activities was accompanied by a regionalisation 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 relocation was assisted by the creation of new economic spaces beyond its territory, through the establishment of industrial parks and other infrastructure by government-linked corporations (Pereira 2004; Yeoh et al. 2006).

Entering the E&E industry later than Singapore, Johor and Batam managed to establish and 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. Similarly, Indonesian authorities liberalised 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). Indonesia-Singapore joint ventures establishing industrial parks in Batam were a clear manifestation of this.

These developments resulted in substantial resource flows into the two non-core locations. From 1990 to 1997, Johor received an average US\$800 million of foreign manufacturing investment per year—an almost fourfold increase relative to the previous decade. Similarly, FDI into Batam increased from negligible levels in the 1980s to average US\$230 million per year from 1990 to 1996 (Hutchinson 2015). While authorities in both Malaysia and Indonesia voiced concerns about the labour-intensive nature of the investment, these worries 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: (1) a regionalised integrated manufacturing complex; (2) an industry and corporate construct based on the complementarity of production factors located in close proximity; (3) a strategic construct from Singapore's perspective that allowed the retention of industries and firms in the region while 'moving up' the value chain; (4) increased production linkages as well as a core/non-core division of labour linking the three territories, and (5) a space where non-core parts have assumed a subordinate position (Grundy-Warr et al. 1999; How and Yeoh 2007; Lee 1991; Pereira 2004; Smith 1997; Sparke et al. 2004; Toh and Low

Table 2
Key indicators for the electrical and electronics industry, Singapore, 1990–2015 (S\$ million)

	1990	1995	2000	2006	2010	2012	2015
E&E output	30,599	62,495	86,397	78,547	98,181	89,361	90,814
%	42.5	54.8	54.2	34.0	37.6	31.1	33.9
Total manufacturing	71,923	113,974	159,404	230,766	261,364	286,976	267,866
E&E value added	5888	11,960	18,834	19,774	23,141	19,666	21,851
%	36.2	44.7	48.3	40.3	38.4	31.6	31.0
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
%	42.0	41.0	35.0	29.3	24.1	23.4	22.6
Total manufacturing	351,674	370,281	344,610	381,909	414,176	424,622	400,173

Source: Singstat (2016).

1993; Yeoh and Wong 2005; Yeoh et al. 2000, 2004a, 2004b, 2006).

The evolution of the E&E industry in SIJORI

Singapore

Using *Singstat* aggregate statistics, Toh's 'mapping' (2013) 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 in output, value-added and employment indicate movement towards greater value-added and sophistication. While declining in relative terms (representing 34 per cent of output of the manufacturing sector in 2015, as opposed to 43 per cent in the beginning) the value of E&E output increased threefold over the same period. Value-added has also increased more than three times, while the number of employees decreased substantially over the

Table 3
Domestic exports in current prices, Singapore, 1997–2015 (S\$ 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*, 1998, 2001, 2007, 2011, 2013, 2016.

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.

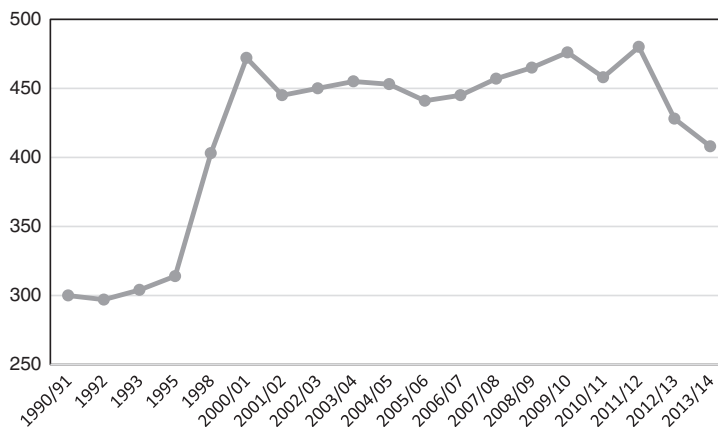
The trend towards 'moving up' is reinforced by the fact that the branch structure of the industry has changed significantly. Available literature shows that, during the 1980s, electronics production diversified from consumer electronics and components into industrial electronics, particularly disk drives, computer peripherals, computer systems and integrated circuits, as well as supporting industries (Mathews and Cho 2000; McKendrick et al. 2000).

An analysis of E&E exports shows that, during the 1990s and especially the 2000s, the sector became increasingly specialised and more sophisticated (Table 3). It is also notable that the total value of domestic exports has fallen some 20 per cent 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 per cent in 1997, semiconductors now account for more than half of domestic E&E exports. Also of note is the large 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.

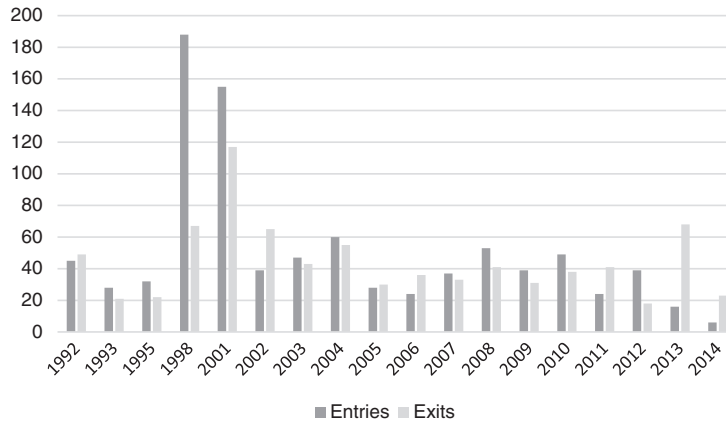
Turning to our database, the trends in firm entries and exits match those shown by the abovementioned statistics, with some key differences. During the 1990–2014 period (Figure 1), the number of E&E establishments initially increased substantially, from 300 in 1990 to some 470 in 2001. Following this, the number of firms fell slightly—most likely influenced by the global industry downturn in this period—before remaining constant over the next ten years. After 2012, the firm population fell again, down to approximately 410 in 2014. The picture is consistent with generalised upgrading and rising productivity. The fall 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 advice

Figure 1
E&E firms (manufacturing establishments) in Singapore, 1990–2014



Source: Authors' compilation.

Figure 2
Singapore E&E firm entries and exits



Source: Authors' compilation.

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—a survival rate of 34 per cent. The early 1990s were marked by a balance in firm establishment and closures (Figure 2). 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 2002–12 period, firm entries and exits were in equilibrium. However, in 2013 and 2014, firm closures outweighed openings.

Table 4 sets out the origin and average tenure of all firms that had a presence in Singapore over the 1990–2014 period. Leaving Singaporean firms (the largest group) aside, USA and Japanese firms (accounting for 18.2 and 16.3 per cent respectively) as well as European (particularly German) and Asian firms (Taiwan and PRC/Hong Kong) have constituted significant populations. Their

proportions have stayed rather constant over time.

With regard to tenure, Japanese firms tend to stay the longest, an average of 10.2 years. Singaporean and US firms follow. Compared to the two non-core locations, the survival rate and tenure of firms based in Singapore are lower and shorter, potentially reflecting a 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 US firms were a significant share, indicating that E&E multinationals from these countries are no longer as committed to the city-state. At the end of this section, more observations are made on this development.

Setting out the proportion of firms by industry branch for the period 1990–2014,⁵ Table 5 shows that the number of firms in the former dominant and relatively low value-added consumer electronics branch have declined markedly. Component and computer-producing firms have also fallen

5 These calculations are based on the product category listings. Firms can, and do, list in more than one product category within specific branches (for example, consumer electronics). These listings have been cleaned within each branch, but there are some cases of firms listing in more than one branch (for example, consumer electronics; communications equipment). As a result, the totals in this table are slightly higher than those in Figure 1.

Table 4
Breakdown of firms investing in Singapore, by nationality and tenure (1990/91–2013/14)

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

Source: Authors' compilation.

somewhat, although the first group remains the largest subpopulation of firms. Storage media firms have also declined sharply, particularly relative to their levels in 2002–03. Conversely, the number of semiconductor, communications equipment, and electrical device-producing firms has significantly increased.

While consistent with what is known from export data and industry documentation (EDB 2010, 2014, 2015), firm numbers yield some additional insights. Semiconductor firms represent only 16 per cent 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 in electronic components and electrical devices accounting for a smaller proportion of exports, indicate many smaller firms producing less value-added exports and/or producing inputs for other firms that are not exported. While exports from storage media-production establishments have plummeted, their number has not decreased to the same extent, indicating a degree of resilience.

The analysis of firm numbers by product category also allows the development of CEMs to be tracked. As these firms manufacture a wide range of products for third parties, they cannot be separately identified by output and export data. Our database indicates that the ranks of CEMs have increased from virtually nothing in the early 1990s to eight per cent of the total in 2012. This growth could also potentially explain the reduction in overall firm numbers in recent years, as CEMs could take market share for intermediate products and subassembly work carried out by smaller firms.

Furthermore, this exercise also demonstrates the importance of the electrical device and 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 fairly stable. While its exports

Table 5
Share of 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 and 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' compilation.

have increased, its relatively large number of firms could also indicate that much of its output remains within the domestic economy.

Thus, our compilation of firm data reinforces the observation 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 generalised specialisation. Moving beyond production, while information, for instance, R&D centres is less readily available in a form comparable to manufacturing units, there is sufficient documentary evidence that in the main E&E branches the city-state has captured higher value-added operations in the areas of R&D, design and innovation. Singapore's position in the semiconductor branch has evolved from a production platform to an integrated value chain hub as strategic coupling has broadened to wafer fabrication, circuit design and innovation, whereby companies collaborate with government-funded research institutes (van Grunsvan 2013).

While documentation is scant, as both authorities and firms have been reluctant to disclose the status of these establishments, in the 2000s Singapore has become host to a growing number of regional headquarters of electronics multinationals. This growth reflects the city-state broadening its coupling strategy to include such functions—during the regionalisation push and when many E&E MNCs were still operating a substantial network of subsidiaries in the Southeast Asian region (Yeung et al. 2001; Edgington and Hayter 2013b).

The latter is another illustration of the large role of institutional agency with regard to the pattern of evolution outlined above. Indeed, a range of government statutory boards, ministries and dedicated agencies has been instrumental in forging the E&E industry pathway. Prime among these is the EDB, widely regarded as the architect of Singapore's economic strategies. It has operated in close liaison with several ministries such as the Ministry of International Trade and Industry

(MITI) and the Ministry of Manpower Agencies. The increasing prominence of the semiconductor branch is in large part due to significant investment by the government in a dedicated, high-technology infrastructure allowing foreign companies to enjoy spillovers from an expanding integrated industry eco-system (van Grunsvan 2013). To a lesser extent, this also goes for the data-storage media branch.

Well into the 2000s, institutional commitment to a 'high-road' pathway, producing substantial qualitative human capital development and technology infrastructure, proved effective in enticing new multinational activity. However, more recently the logic of corporate agency following institutional agency appears to have suffered from changing circumstances, as market crises in some branches have forced re-organisation and consolidation. The so-called 'middle-income trap' bears testimony to the capabilities and technology constraints in Southeast Asian countries. With the exception of Vietnam, flagship firms in Southeast Asia have started to downsize operations as a result, in favour of further expansion in China.

As in the earlier period, Singapore operations in part hinged on a substantial Southeast Asian network, and its contraction has rendered Singapore less attractive. From newspaper reports, it can be gauged that prominent MNCs in the E&E industry outside the high-technology branches have substantially downsized Singapore operations. Many have closed their Singapore regional HQs along with substantial downsizing of manufacturing and assembly operations in other parts of the region. Philips Electronics is a case in point. Headquartered in the Netherlands, the MNC has had a long-established presence in Singapore, at one time maintaining a network of production facilities in the city-state making television sets and components. During the 1990s, part of the production process was offshored to a plant in Batam but supervised from Singapore. Now, while Philips maintains a footprint in the city-state, its consumer electronics production facilities there have closed. At present, the corporation's Batam facility assembles hair dryers and irons and is

managed from their office in Jakarta (van Grunsven and Hutchinson 2014).

The above signals three points relevant to cross-border dynamics and opportunities for non-core regions in the E&E industry:

- Concurrent with industrial 'moving up', with a focus on technologically more sophisticated branches and activities, the industry in Singapore has continued to shed the less competitive industry spaces ('moving out'). Furthermore, within industry branches, we see a substantial period of collective commitment to value chain advancement and specialisation. For the non-core regions, these have provided opportunities to move into new E&E industry spaces.
- Recently, networks across Southeast Asian centred in Singapore have started to shrink, altering regionalisation patterns. This has reduced the commitment of MNCs to Singapore. Non-core regions may be negatively affected by the lesser potential for or prevalence of distribution of value chain operations.
- The segment of local SME firms active in ancillary branches has continued to be sizeable. These firms have experienced increasing pressure on their production operations in Singapore due to continuously rising costs. Due to their limited internationalisation experience, the SIJORI cross-border region may constitute an attractive option for regionalisation.

Non-core regions could 'co-evolve' with Singapore in its transformation process, through deepening capabilities and capturing less sophisticated operations in the same branches—notably the production of semiconductors and associated products. This would constitute strategic coupling through targeting less value-added operations. 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. The likelihood of capturing these can be gauged from the institutional evolution that is discussed below.

Johor and Batam

In the late 1990s, the attraction of the Growth Triangle concept began to fade, for several reasons. 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. Furthermore, political changes in Malaysia and Indonesia altered the ability and inclination of Johor and the Riau Islands to court FDI in manufacturing (Hutchinson 2015).

In Malaysia, the central government has devised a new regional governance construct that has substantially increased its influence in Johor. As part of a new regional development paradigm, the Iskandar Malaysia economic corridor was established in the southern part of the state. Sitting in between the federal and state governments, the corridor management agency constitutes a third layer of bureaucracy—with delegated authority but little legal wherewithal to enforce compliance (Hutchinson 2016).

While the overall emphasis on attracting FDI has remained, under central government auspices the focus has shifted to services, particularly health care, 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 became perceived as 'mature', 'risky', and 'competitive' (Hutchinson 2014). Given Malaysia's structural challenges such as skill shortages, under-investment in R&D, and considerable 'brain drain', the E&E sector has faced formidable obstacles at the local level in Johor (Yusuf and Nabeshima 2009; Rasiah 2010, 2012).

The firm interviews conducted with E&E MNCs in Johor support these conclusions. When asked their opinions regarding the local institutional context and its amenability to continued operations or upgrading, a majority indicated experiencing difficulties finding or retaining appropriately skilled labour. Johor's technology infrastructure in terms of training institutes, universities, and research institutes, as well as its local supply base were also given mediocre evaluations. In contrast, the state's physical infrastructure was more positively rated. In terms of interaction with federal and state governments, respondents rated the country's political stability highly, but were less enthusiastic about the efficiency, proactiveness, or potential for interaction in their dealings with the two layers of bureaucracy. With regard to Iskandar Malaysia, the provision that was most highly valued was the ability to import foreign workers with greater ease, which was seen as key to sidestepping the shortage of appropriately qualified local labour.

With regards to Indonesia, in the postcrisis period the country's administration has undertaken major reforms towards decentralisation and democratisation. On the one hand, these have increased the number, power, and autonomy of subnational governments, complicating the business context for international firms (International Crisis Group 2012). On the other hand, democratisation has pressed accountability upon local administration, engendering electoral opportunism in local affairs. The increase in subnational governments and the autonomy afforded them has meant that the investment climate has become characterised by uncertainty, a lack of transparency, and a multitude of actors with veto power.

In the Riau Islands and Batam, political priorities have shifted away from export-oriented sectors such as E&E towards traditional economic pursuits such as small-scale farming and fishing (Provinsi Kepulauan Riau 2013). Furthermore, Indonesia's industrial relations context has become increasingly combustible, as evidenced by more frequent strife. Batam's, largely migrant, workforce has

started to regularly engage in industrial action, demanding better pay and working conditions. The local government's response to substantially increase the minimum wage means that, following Jakarta, the island now has the highest minimum wage in the country (BPS 2016).

Efficiency of investment approvals, land zoning, and environmental approvals has suffered, and speculation has resulted in shortages of available land for investors (Hutchinson 2017). Coupled with generalised improvement in the business environment elsewhere in the country, this means that Batam's business case is no longer so compelling. Indeed, out of a subset of 20 urban locations in Indonesia, Batam ranked 15th, 10th, and last in ease of starting a business, obtaining construction permits, and registering a property, respectively (World Bank 2012).

As with Johor, the picture emerging from the interviews of E&E firms in Batam is congruent. While respondents acknowledged the availability and low cost of labour, real concerns were raised about the island's skill base. The firms also signalled that the local technology infrastructure was of limited relevance to their production activities, and its quality was low. The local supplier base was evaluated slightly more positively, but most respondents signalled that the diversity of skills and focus of these firms was limited. When asked about the efficiency, proactivity, and potential for interaction with the national and provincial governments, the majority of firms were neutral in their evaluations.

In the process of shifting jurisdictions, and evolving institutional agendas and behaviour, in both Johor and Batam new development priorities have de-emphasised links with Singapore, in favour of more endogenously propelled avenues for maximising short-term growth and generation of rents. Thus, Johor and Batam have begun to show less interest in growing the E&E industry (van Grunsvan and Hutchinson 2014; Hutchinson 2015). In both cases, the reduced institutional commitment to strategic coupling and value chain advancement in the E&E industry has meant that the development of regional production

factors and assets that are attractive in capturing new E&E industry spaces have taken a back seat (van Grunsven and Hutchinson 2015, 2016).

As the shifts in comparative advantage of the SIJORI Growth Triangle have been weighed by MNCs against the comparative advantage of other locations, the logic of leveraging the differential and dynamic comparative advantage of locations in close proximity may have significantly lost appeal. By implication, nodes such as Batam and Johor may have been at the losing end. Considering the different drivers discussed above, we surmise that, in the interplay of opportunities and constraints, cross-border industrial shifts may not have died but have dwindled and shifted in direction, with MNCs becoming less prominent and Singapore firms more prominent. The empirical analysis that follows seeks to verify this postulation.

Revisiting the E&E industry in Johor and Batam: empirics

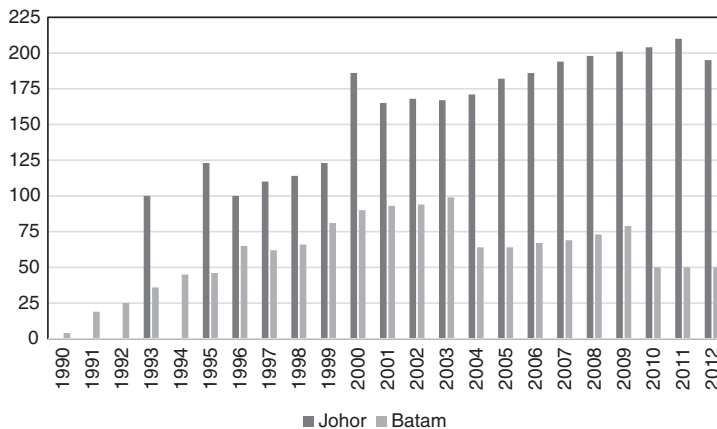
As to the non-core locations of Johor and Batam, the features that are analysed include: the number of firms and their evolution over

time; patterns in entries and exits; the origin of investments and their tenure; and the development of branch structures. With respect to the first issue, an analysis of firm numbers in Johor indicates that the E&E industry has a somewhat positive growth path (Figure 3). While marked by years of significant increase and decline, the 2012 total was double that 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 liberalisation of investment and relaxation of equity restrictions on the island in 1990), was followed by less-positive growth 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.

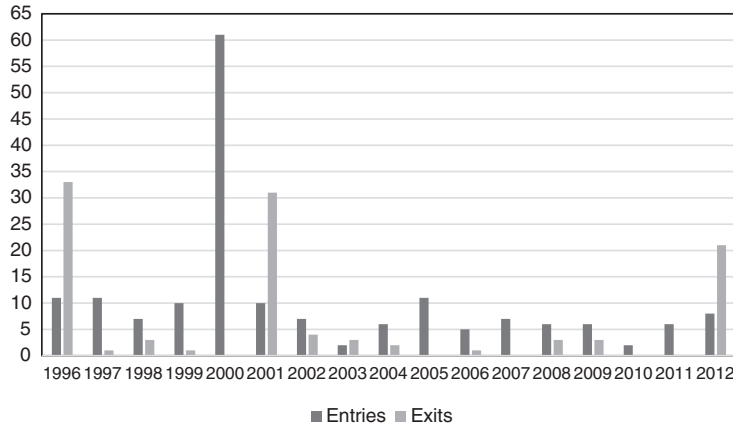
Over the 1995–2012 period, 308 E&E firms have been operating in Johor, of which 198 were

Figure 3
E&E firms in Batam and Johor, 1990–2012



Source: Authors' compilation.

Figure 4
Firm entries and exits in Johor, 1996–2012

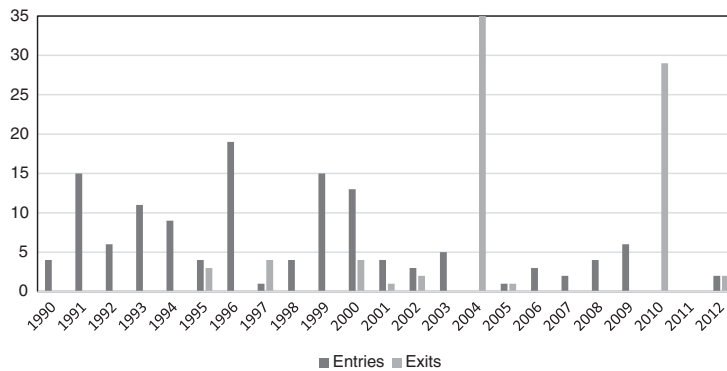


Source: Authors' compilation.

in operation in the last year—a survival rate of 64 per cent. 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 4). 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 cases, the large number of departures was only partially mitigated by a lower number of arrivals.

With regard to Batam, a total of 131 firms were in operation at some point during the 1990–2012 period. Of these, 50 were functioning in 2012—indicating a survival rate of only 37.5 per cent. With respect to 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 were concentrated in two occasions, 2004 and 2010, with 35 and 29 exits each (Figure 5).

Figure 5
Firm entries and exits in Batam, 1990–2012



Source: Authors' compilation.

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 commonalities with and differences from Singapore (Table 6). First, as with the city-state, Japanese, Singaporean, USA, and European firms constitute the largest contingents. However, Japanese firms constitute the largest subgroup, and Singaporeans 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.

With regard to the nationality of E&E firms in Batam, Singaporean companies constitute

the largest contingent, comprising just under one-third (Table 7). Japanese affiliates follow, accounting for a little less than one-quarter. Other significant nationalities include: USA, Japanese/Singapore joint ventures, and Indonesian. Including joint ventures, Singaporean and Japanese firms account for almost 60 per cent of firms in Batam. The average firm tenure in Batam is 10.3 years, with Japan, Japanese/Singaporean, and US firms having longer than average life-spans.

Thus, in the three locations, the largest firm populations are Singaporean, Japanese, and USA. 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 the 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

Table 6
Breakdown of E&E firms investing in Johor, by nationality and tenure, 1995–2012

Nationality	Number	Proportion (%)	Average tenure (years)
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: Own data, firms w/ incomplete data (10).

Table 7
Breakdown of all firms investing in Batam by nationality and tenure (1990/91–2012/13)

Nationality	Number	Proportion	Average tenure (years)
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: Own data, firms w/ incomplete data (21).

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: Own data.

has not changed. 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.

As to the evolution of the branch composition of the E&E industry in Batam, it equally shows a continued specialisation 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 changed little. 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 generalised context of establishment withdrawal; meaning that these branches also experienced contraction after 2000 (Table 9).

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 several reasons. In both cases, companies have deemed the environment—*inter alia* human capital and technology—insufficient to shift the coupling process. This observation clearly emerges from our scrutiny of *in situ*

Table 9
Batam E&E industry by branch (1990/91–2012/13)

Branch	1990	1995	2000	2005	2010	2012
Consumer electronics	0.0	19.6	15.6	12.5	10.0	12.0
Semiconductor devices	0.0	6.5	3.3	4.7	4.0	4.0
Data storage	0.0	4.3	2.2	3.1	4.0	4.0
Computer and computer peripherals	0.0	4.3	2.2	3.1	2.0	2.0
Electronic components and boards	25.0	28.3	40.0	35.9	26.0	26.0
Communication equipment	0.0	2.2	1.1	0.0	0.0	0.0
Electrical devices	25.0	26.1	28.9	29.7	38.0	36.0
CEM	50.0	8.7	6.7	10.9	16.0	16.0
Other	0.0	0.0	0.0	0.0	0.0	0.0
Number of firms	4	46	90	64	50	50

Source: Authors' compilation.

evolution of selected E&E establishments in both nodes. This evolution is not marked in any way by upgrading of any significance (van Campenhout and de Graaf 2013; van Grunsven and Hutchinson 2014; van Oerle and Visch 2014).

Finally, the recent investment patterns of Singapore-based E&E firms are briefly considered. 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 these events also reflect market developments. However, this conclusion corresponds with another observation from our entry-exit data: recent exits from Singapore have been substantially larger than entries into Johor and Batam combined.

Conclusion

Having laid out the empirical findings on trends in firm entries, exits, tenure, nationality, and branch structure, we return to the research questions in the introduction. We have identified a number of 'drivers' for a node to move along an industry pathway. These include: developments in endowments and competences; institutional commitment on the part of government agencies, institutes, and business associations; and corporate commitment as revealed in 'micro-level' developments in firms and MNC subsidiaries. As to non-core parts of a cross-border region, opportunities provided by the core are in part ingrained in these drivers as they shape the trajectory of the core.

Several concluding observations can be offered as to our first two research questions. As a node within a GPN, Singapore has pursued dynamic strategic coupling, moving out of less value-added industry branches such as consumer electronics into more complex, sophisticated ones such as semiconductors. It has also successfully pursued value chain

advancement as MNC operations located in the city-state have been tasked with higher-order mandates. Its institutional capacity to grow factor endowments and entice new MNCs has been extraordinary. Combined with its regionalisation drive, a virtuous dynamic could propel the E&E industry further in the non-core parts of the SIJORI Growth Triangle, after their initial development stage. However, the potential for this appears to have declined more recently. Preceding this, significant alteration of institutional arrangements has shifted development priorities in both non-core regions, as well as breaking the complementarities in and appeal of their production factors.

On the basis of the latter, we surmise that the E&E industry pathway in both non-core regions would be less virtuous than could be expected on the basis of opportunities provided by the core. In addition, in recent years, circumstances in Singapore would further dampen the possibility of leveraging MNCs in the industry through cross-border operations. This would shift the focus decidedly to Singapore firms in the industry. Our empirical findings in large part confirm the postulations made. The pathway of the E&E industry has shifted in both non-core locations. In Johor it has turned flat; this is in line with observations for Malaysia as a whole (Yusuf and Nabeshima 2009; Rasiyah 2010; Rasiyah 2012). Outright industry decline is revealed in the case of Batam. While Johor has been able to maintain at least some basic requirements for participation in international corporate networks, this is less evident in Batam. In the latter case, we observe *de facto* gradual corporate decoupling—companies losing commitment to the island. Neither non-core region has captured the production spaces abandoned by Singapore.

Confined to the case at hand and focusing on the non-core regions, some implications and lessons of these developments can be indicated. First, to expect conditions to remain unaltered over a span of 25 years is not very realistic. Second, under the dynamic conditions seen in SIJORI, cross-border networks have dwindled after a while. Third, to maintain such

networks and growing the E&E industry would require acquisition of technological capabilities, which is a complex and time-consuming process (Doner 2007). On the one hand, national conditions have not been conducive for this. On the other hand, it has shown to be incompatible with altered institutional configurations whose prime concern is achieving short-term growth and reaping rents from diversity, thus neglecting depth, no matter how undeliberate and unintended. Fourth, especially in the case of Batam, the long-term viability of the industry is at stake.

Beyond this, an increasing ‘disconnect’ between the three nodes of the region is revealed, and SIJORI’s significance as an integrated industrial cross-border region has been substantially reduced. This outcome only corroborates the fact of a limited life span of the Growth Triangle concept as a cross-border region seen from the perspective of actual connections. To the extent that this concept can be generalised to other cases in the East Asian region, it is believed that the silence that has surrounded the construct in the recent past will not be broken any time soon.

References

- Boschma, R. and Frenken, K., 2011. ‘Technological relatedness and regional branching’, in H. Barthelt, M.P. Feldman and D.F. Kogler (eds.), *Dynamic geographies of knowledge creation and innovation*, Abingdon, Routledge, Taylor and Francis.
- BPS, Indikator Utama Kepulauan Riau Semester 1-2016. Badan Pusat Statistik: Provinsi Kepulauan Riau, Tanjungpinang.
- van, Campenhout, M. and de, Graaf, J.R., 2013. *In search for a silver lining: the evolution of the E&E industry of Batam, Indonesia*, Master Thesis, Faculty of Geosciences, Utrecht University, Utrecht, The Netherlands.
- Coe, N.M., Hess, M., Yeung, H.W.-C., Dicken, P. and Henderson, J., 2004. ‘Globalizing regional development: a global production networks perspective’, *Transactions of the Institute of British Geographers*, 29:468–84.
- Coe, N.M. and Yeung, H.W.-C., 2015. *Global Production Networks: Theorizing Economic Development in an Interconnected World*, Oxford University Press, Oxford.
- Department of Statistics, 1998, 2001, 2007, 2011, 2013, 2016. *Yearbook of Statistics, Singapore*, Department of Statistics, Singapore.
- Doner, R., 2007. *The Politics of Uneven Development: Thailand’s Economic Growth in Comparative Perspective*, Cambridge University Press, Cambridge.
- Economic Development Board (EDB), 2010. *Revolutionizing Electronics: IC Design in Singapore*, Economic Development Board, Singapore.
- 2014. *Industries—Electronics*, Economic Development Board, Singapore.
- 2015. *Singapore—Global Electronics Hub, Electronics Factsheet*, Economic Development Board, Singapore.
- Economic Strategies Committee (ESC), 2010. *Report of the Economic Strategies Committee: High Skilled People, Innovative Economy, Distinctive Global City*, Ministry of Finance, Singapore.
- Edgington, D.W. and Hayter, R., 2013a. ‘The *in situ* upgrading of Japanese electronics firms in Malaysian industrial clusters’, *Economic Geography*, 89(3):227–59.
- 2013b. ‘Glocalization’ and regional headquarters: Japanese electronics firms in the ASEAN region’, *Annals of the Association of American Geographers*, 103(3):647–68.
- Ernst, D., 2002. *Global production networks in East Asia’s electronics industry and upgrading perspectives in Malaysia*, Economics Paper Series 44, East-West Center, Honolulu.
- 2009. *The new geography of knowledge in the electronics industry? Asia’s role in global innovation networks*, Policy Studies Papers 54, East-West Center, Honolulu.
- Felker, G., 2009. ‘The political economy of Southeast Asia’s techno-glocalism’, *Cambridge Review of International Affairs*, 22(3):469–91.
- Fleuren, B. and Janssen, H., 2016. *Changing lanes. the evolution of the E&E industry in Singapore*, Master Thesis, Faculty of Geosciences, Utrecht University, Utrecht, The Netherlands.
- Grundy-Warr, C., Peachey, K. and Perry, M., 1999. ‘Fragmented integration in the Singapore-Indonesian border zone: Southeast Asia’s ‘Growth Triangle’ against the global economy’, *International Journal of Urban and Regional Research*, 23(2):304–28.
- How, W. and Yeoh, C., 2007. ‘The internationalization of Singapore’s state-enterprise networks in the context of Asia’s transborder

- industrialization: further evidence from Indonesia, Vietnam and China', *Journal of Asian Business*, 23(1):1–25.
- Hutchinson, F.E., 2014. 'One priority among many? The state government and electronics sector in Johor, Malaysia', in F.E. Hutchinson (ed.), *Architects of growth? Sub-national governments and industrialization Asia*, Singapore, Institute of Southeast Asian Studies:87–120.
- 2015. *Mirror Images in Different Frames? Johor, the Riau Islands and Competition for Investment from Singapore*, Institute of Southeast Asian Studies, Singapore.
- 2016. *Evolving paradigms in regional development in Malaysia*', ISEAS Economics Working Paper, 2016–5, Institute of Southeast Asian Studies, Singapore.
- 2017. *Rowing against the tide? Batam's economic fortunes in today's Indonesia*', Trends in Southeast Asia 8, ISEAS Yusof Ishak Institute, Singapore.
- International Crisis Group, 2012. 'Indonesia: Defying the state'. Asia Briefing 138. Jakarta/Brussels: International Crisis Group, 30 August.
- Johor Corporation, 1992, 1993. *Johor Investment Guide*, Johor Corporation, Johor Bahru.
- Johor Technopark, 1996. *Johor Industry Guide*, Johor Technopark, Johor.
- Lee, K., 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, T.Y., 1991. *Growth Triangle: The Johor-Singapore-Riau Experience*, Institute of Southeast Asian Studies, Singapore.
- MacKinnon, D., 2012. 'Beyond strategic coupling: reassessing the firm-region nexus in global production networks', *Journal of Economic Geography*, 12:227–45.
- Marshall Cavendish Business Information, 1990–93, 1995, 1998, 2000–2014. *Singapore Electronics Industry Directory*, Times Directories, Singapore.
- Mathews, J.A. and Cho, D.-S., 2000. *Tiger Technology: The Creation of a Semiconductor Industry in East Asia*, Cambridge University Press, Cambridge.
- McKendrick, D.G., Doner, R.F. and Haggard, S., 2000. *From Silicon Valley to Singapore. Location and Competitive Advantage in the Hard Disk Drive Industry*, Stanford University Press, Stanford.
- OECD, 2013. *Interconnected Economies: Benefiting from Global Value Chains*, Organisation of Economic Cooperation and Development, Paris.
- van, Oerle, S. and Visch, C., 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, Utrecht, The Netherlands.
- Pangestu, M., 1991. 'The Growth Triangle: an Indonesian perspective', in T.Y. Lee (ed.), *Growth Triangle: The Johor-Singapore-Riau experience*, Institute of Southeast Asian Studies, Singapore:77–115.
- Parsonage, J., 1992. 'Southeast Asia's 'Growth Triangle': a sub-regional response to global transformation', *International Journal of Urban and Regional Research*, 16(2):307–17.
- Pereira, A.A., 2004. 'State entrepreneurship and regional development: Singapore's industrial parks in Batam and Suzhou', *Entrepreneurship and Regional Development: An International Journal*, 16(2):129–44.
- Provinsi Kepulauan Riau, 2013. Rencana Kerja Pembangunan Daerah Provinsi Kepulauan Riau Tahun 2013. Tanjungpinang: Pemerintah Provinsi Riau, 2013.
- Perkmann, M. and Sum, N., 2002. 'Globalization, Regionalization, and Cross-border Regions: Scales, Discourses, and Governance', in M. Perkmann and N. Sum (eds.), *Globalization, Regionalization, and Cross-border Regions*, Basingstoke: Palgrave Macmillan.
- Rasiah, R., 2009. 'Expansion and slowdown in southeast Asian electronics manufacturing', *Journal of the Asia Pacific Economy*, 14(2):123–37.
- 2010. 'Are electronics firms in Malaysia catching up in the technology ladder?', *Journal of Asia Pacific Economy*, 15(3):301–19.
- 2012. 'Is Malaysia's electronics industry moving up the value chain?', in H. Hill, T.S. Yean and R.H.M. Zin (eds.), *Malaysia's development challenges: graduating from the middle*, Routledge, London:194–212.
- 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*, Department of Statistics, Singapore.
- Smith, S.L., 1997. 'The Indonesia–Malaysia–Singapore Growth Triangle: a political and economic equation', *Australian Journal of International Affairs*, 51(3):369–82.
- Sparke, M., Sidaway, J.D., Bunnell, T. and Grundy-Warr, C., 2004. 'Triangulating the borderless world: geographies of power in the Indonesia–Malaysia–Singapore Growth Triangle', *Transactions of the Institute of British Geographers, (New Series)*, 29:485–98.
- Thant, M., Tang, M. and Kakazu, H. (eds.), 1994. *Growth Triangles in Asia: A New Approach to Regional Economic Cooperation*, Oxford University Press, Hong Kong.
- Toh, M.H., 2013. 'The development of Singapore's electronics sector', in F.E. Hutchinson (ed.),

- Architects of growth? Sub-national governments and industrialization in Asia*, Singapore, ISEAS.
- Toh, M.H. and Low, L., 1993. *Regional Cooperation and Growth Triangles in ASEAN*, Times Academic Press, Singapore.
- UNCTAD, 2013. *World Investment Report 2013: Global Value Chains: Investment and Trade for Development*, United Nations Centre for Trade and Development, Geneva.
- van, Grunsvan, L., 2013. 'Singapore's ICT industry: an evolutionary perspective', in P. Cooke, G. Searle and K. O'Connor (eds.), *The economic geography of the IT industry in the Asia-Pacific Region*, Routledge, London:47–67.
- van, Grunsvan, L. and Hutchinson, F.E., 2016. 'The evolution of the electronics industry in Johor (Malaysia): strategic coupling, adaptiveness, adaptation, and the role of agency', *Geoforum*, 74:74–87.
- 2015. 'The evolution of the electronics industry on Batam Island (Riau Islands Province, Indonesia): an evolutionary trajectory contributing to regional resilience?', *GeoJournal*, 82:475–92.
- 2014. *The evolution of the electronics industry in the SIJORI cross-border region*, ISEAS Economics Working Paper No. 2014-2, Institute of South-east Asian Studies, Singapore.
- World Bank, *Doing Business in Indonesia 2012*. World Bank, Washington DC.
- Yeoh, C., Perry, M. and Lim, M.L., 2000. 'Profile of a low-cost manufacturing enclave: the case of Batamindo industrial park, Indonesia', in R. Edwards, C. Nyland and M. Coulthard (eds.), *Readings in international business*, Sydney, Prentice Hall:193–212.
- Yeoh, C., Lim, D. and Kwan, A., 2004a. 'Regional cooperation and low-cost investment enclaves: an empirical study of Singapore's industrial parks in Riau, Indonesia', *Journal of Asia-Pacific Business*, 5(4):43–65.
- Yeoh, C., Sin, K.C. and Jialing, C.C., 2004b. 'Singapore's regionalization blueprint: a case of strategic management, state enterprise network and selective intervention', *Journal of Transnational Management Development*, 9(4):13–36.
- Yeoh, C. and Wong, D.S.Y., 2005. 'Created' enclaves for enterprise: an empirical study of Singapore's industrial parks in Indonesia, Vietnam and China', *Entrepreneurship and Regional Development*, 11(17):479–99.
- Yeoh, C., How, W. and Sim, V., 2006. 'Re-engineering economic space: the case of Singapore's transborder industrialization 'gambits' in Asia', *Journal of Asia Business Studies*, 1(1): 34–45.
- Yeung, H.W.-C., Poon, J. and Perry, M., 2001. 'Towards a regional strategy: the role of regional headquarters of foreign firms in Singapore', *Urban Studies*, 38(1):157–83.
- 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 Coe, N.M., 2015. 'Toward a dynamic theory of global production networks', *Economic Geography*, 91(1):29–58.
- Yusuf, S. and Nabeshima, K., 2009. *Tiger Economies under Threat: A Comparative Analysis of Malaysia's Industrial Prospects and Policy Options*, The World Bank, Washington.