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Impact of cluster networks on exporting scope: importance of cognitive proximity and strategic fit with firm's upgrading innovation strategies and organisational capabilities

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Abstract: Distinguishing between intra-cluster ties (ICTs) and extra-cluster ties (ECTs), findings from the 110 semiconductor firms in Malaysia suggest that SMEs forming more ETCs tend to have higher exporting scope. The extent to which intra- and extra-cluster ties impacts SMEs' exporting scope further depends on the strategic fit with the firm's innovation upgrading strategies, and firm-specific capabilities in networking and realised absorptive capacity. In addition to networking capabilities, the positive interaction between extra cluster ties and realised absorptive capacity capability on export scope confirms the importance of reaching out to extra clusters with knowledge and capabilities that are similar enough to facilitate the understanding and internalisation of knowledge, but at the same time different enough to facilitate contributions of complementary knowledge. With respect to the moderating relationship between firms' innovation upgrading strategies and ETCs on exporting scope, we found a non-significant and positive finding for product and process innovation upgrading, respectively.

Keywords: extra clusters; intra clusters; exporting scope; cognitive proximity; networking capabilities; product and process innovation; realised absorptive capacity.

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1 Introduction

Cooke (2001, p.121) defined industrial clusters as "geographically proximate firms in vertical and horizontal relationships, competing and cooperating in a specific market field supported by a localized enterprise infrastructure with a shared developmental vision for business growth." As a construct, this theoretical perspective views industrial clusters encompassing both a geographical dimension (Crouch and Farrell, 2004) and a network dimension (Huggins, 2008). Accordingly, industrial clusters are understood to occur on the actor level (i.e., clustered firms' interactions), while also being embedded in specific geographical contexts. The dominance of small and medium-sized enterprises (SMEs) in emerging countries has also fuelled concurrent growing interest in how clustering can help promote internationalisation and competitiveness of these firms in the international marketplace (e.g., Gerke et al., 2023; Mugano, 2024). Their smaller size often limits SMEs to realise economies of scale and to take advantage of international market opportunities individually. However, by embedding themselves within clusters, SMEs can collectively benefit from agglomeration effects in a way that will help them gain scale advantages and access to resources for successful internationalisation.

While early research had tended to focus on clusters in developed economies, research on the influence of firm-level cluster relationships in emerging economies has been gaining traction. Recent examples include the textile cluster in India (Yadav and Rani, 2023), the software cluster in Bangalore (Turkina and Van Assche, 2019), and the agribusiness cluster in Egypt (El Kayaly, 2023). In response to calls for more studies on the sources and outcomes of cluster relationships on SMEs' innovation and internationalisation from emerging and transitional economies (Nikolić et al., 2019), this study focuses on how clustering facilitates internationalisation of SMEs within the semiconductor cluster in Malaysia. This cluster was targeted as a strategic cluster in 1986 when the country launched its first Industrial Master Plan (IMP) in the same year (Abad et al., 2015). Its evolution and transformation as one of the top 10 semiconductor manufacturers in the world serves as an excellent context to understand the effect of different network ties on the cluster's evolution. The choice of a Southeast Asian emerging economy for this study further stems from a desire to shift from traditional areas of research, i.e., industry clusters in more developed countries such as the US and Europe. According to the 2022 Milken Institute Global Opportunity Index, Malaysia ranks No. 1 in emerging Southeast Asia as the country with the most potential to attract foreign investors (Milken Institute, 2023).

To answer the study's research question, "how does a firm's external cluster relationships impact exporting scope and innovation activities among Malaysian SMEs in the semiconductor's cluster?", this study adopts the notion that to advance understanding on the role that inter-firm relationships play in cluster development, there is a need to first delineate their role in enabling firms to realise the benefits of clustering. All clusters do not grow and perform in the same trajectory. According to Menzel and Fornahl (2010), cluster dynamics follow distinct stages of development similar to that of the product life cycle which includes emergence, growth, sustainment, and decline. Geographical proximity is frequently highlighted in research regarding innovation and inter-organisational collaborations in clusters (e.g., Audretsch et al., 2023; Löfsten et al., 2023). While geographical proximity to key infrastructure, natural resources, and customers represents an important source of competitive advantage in the early stages of

cluster formation and growth, over the long run, they can potentially engender the phenomenon of 'proximity paradox' commonly described as a lock-in problem which hinders creativity and resulting in lower innovative output.

Recently, scholars of proximity dynamics distinguished between other dimensions of proximity from the geographic and argued that non-geographical proximity is more likely to affect interactive learning, the formation of knowledge cluster (Lazzeretti and Capone, 2016), and firms' innovation performance (Hansen, 2015). Notwithstanding the interest in the role of geographic proximity on inter-firm collaboration, there is limited understanding on how cognitive proximity affects SMEs' innovation strategy and internationalisation success. Cognitive proximity refers to the similarities of the knowledge bases of actors (Nooteboom, 2000). According to the co-opetition literature (Molina-Morales et al., 2014), success in collaborative R&D activities requires partners' knowledge bases to be similar enough to facilitate the understanding and internalisation of knowledge (i.e., geographic proximity to firms in the same sector), but different enough so that there are contributions of complementary knowledge. The heterogeneity in the technological and market knowledge bases across partners (i.e., geographic proximity to firms in different sectors) opens opportunities to access supplementary resources upon which to build innovation capabilities for internationalisation success.

Regarding the relationship between clustering and SME internationalisation, while the relationship between clustering has been examined with regards to different performance indicators such as internationalisation speed (e.g., Colovic and Lamotte, 2014; Francioni et al., 2017) and export intensity (e.g., Donbesuur et al., 2023), we argue that exporting scope also offers significant growth opportunities for SMEs. First, increasing export scope can provide a means for SMEs to spread risk. Second, by leveraging the knowledge gained through internationalisation, exporting scope exposes SMEs to new learning opportunities. Commonly expressed as the number of foreign markets in which an exporting firm is present, studies suggest differences in SMEs' exporting scope behaviour may occur due to the types of information and resources available to the firm from networks of relationships established between the SME and other connected players within and across clusters (Zimmerman et al., 2010).

In summary, to understand how cognitive and geographic proximity impacts SMEs' innovation strategy and internationalisation, this study addresses the impact of knowledge spillovers from relationships embedded in intra- and extra-clusters ties and their impact on SMEs to creatively exploit/explore acquired knowledge for successful exporting. More specifically, adopting a contingency perspective, this study attempts to explicate how an SME's internationalisation performance expressed in terms of exporting scope depends on the strategic fit between

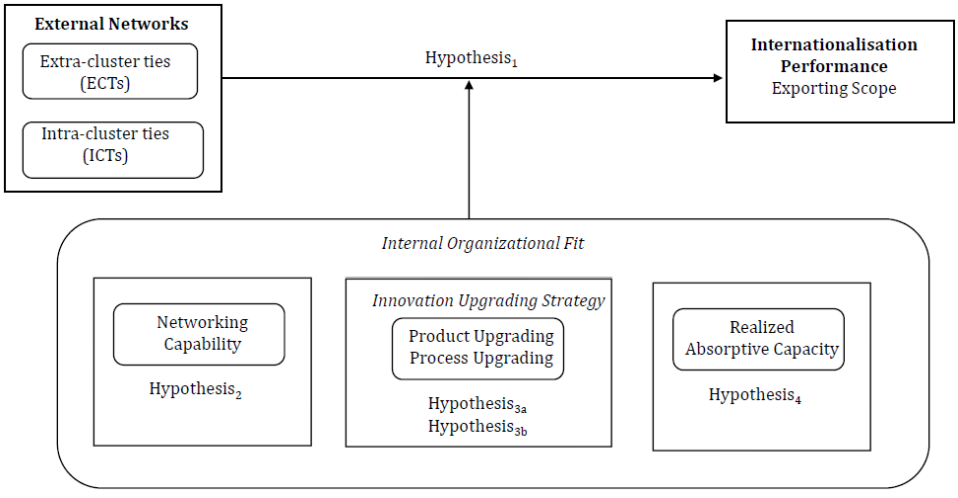
1 the firm's innovation upgrading strategy and participation in intra-cluster ties (ICTs) and extra-cluster ties (ECTs)

2 as well as its alignment with the firm's organisational capabilities, expressed in this study with respect to the SMEs' networking and realised absorptive capacity capabilities.

The theoretical framework for the study is captured in Figure 1. In the next section of the paper, we develop our arguments and hypotheses for our conceptual framework. We first discuss the impact of intra and extra cluster ties on a firm's exporting scope. Next, we examine the impact of fit among internal and external boundary conditions that may

affect firm performance. Specifically, we explore whether a firm's portfolio of cluster ties leads to stronger exporting scope when its resources are combined effectively with appropriate organisational characteristics (i.e., networking capabilities and absorptive capacity) and strategic orientations (i.e., innovation upgrading strategies). We then present the results of an empirical study that test our hypotheses among Malaysian SMEs in the semiconductor cluster. In the final section, we discuss the findings and their practical and theoretical implications, recommendations for future research, and conclusions.

Figure 1 Conceptual model



2 Hypotheses

2.1 Impact of intra- and ECTs on exporting scope

Regarding the link between industrial clustering and SME internationalisation, the literature remains ambiguous regarding the impact of these collaborative relationships. While a positive relationship was found (e.g., Carloni, 2021), others reveal a negative (e.g., Vissak et al., 2020) or a non-significant finding (e.g., Varma et al., 2016). Notwithstanding these conflicting findings, industrial clusters are often viewed positively as active promoters of firms' internationalisation (e.g., Boafo et al., 2023). However, we argue that the efficiency of interactive learning and knowledge spillover between collaboration partners in industrial clusters will be contingent on the level of interactions along the dimensions of geographic proximity and cognitive proximity.

The cluster literature suggests that clustered firms often use a mixture of intra- and extra cluster ties for successful innovation development (Chandrashekar and Mungali Hillemane, 2018). Adopting the framework proposed by Stam and Elfring (2008), inter-firm linkages within the cluster (ICTs) are viewed as geographically proximate relationships formed within the cluster while inter-firm linkages across the cluster (ECTs) derive not from geographical proximity, but from the purposeful cooperation that span

the boundary and geographic location of the cluster. As noted by Antonelli (2000, p.541), "proximity and co-localisation within a local system favor both the intrasectoral and intersectoral dissemination of technological knowledge." New technological knowledge generated in one industry, especially that of the semiconductor industry, often has considerable potential for applications in other industries. In this scenario, given the opportunities from shared access to distinctive knowledge bases within and across clusters, we argue that cluster participation in ICTs and ECTs allows SMEs to acquire different stocks of knowledge from which to develop competitive advantages for successful internationalisation.

The cognitive proximity perspective argues that the two primary knowledge types in collaborative innovation efforts involve technological knowledge and market knowledge (Langa et al., 2015). We expect ICTs and ECTs to have different impacts for companies with regards to the technological and market dimensions of cognitive proximity. When ICTs are high for the cluster firm and ECTs are low, the firm is deeply embedded in the cluster network, thus fostering the generation of trust with other cluster firms for successful internationalisation (Schmitz, 1999). SMEs with an emphasis on ICTs will primarily extend their investments close to their home country (Lisboa et al., 2013). Decisions regarding initial market selection are also often influenced by the location of SMEs' personal ties and ICTs may promote similar actions such as a particular geographical scope on which markets to enter and on which mode to use.

While an exploitation strategy via ICTs has the potential to impact SMEs exporting scope performance, they may become susceptible to cluster rigidity if they fail to broaden their networks with prospective partners or to identify potential business opportunities beyond their pre-defined export markets' periphery (Gunawan et al., 2016; Lisboa et al., 2013). In contrast, ECTs bring in knowledge elements that are different from those available within the cluster, allowing firms the ability to pursue exploration, side by side with exploitation through ICTs (Jacob et al., 2022). A major concern often expressed among SMEs is the need to spread internationalisation efforts across a broader portfolio of potential new markets to minimise financial exposure arising from economic crises in current exporting markets (Felzensztein et al., 2019). The cognitive diversity of extra-cluster partners' market knowledge offers SMEs the opportunity to gain economies of scope and synergies across different markets due to resource complementarity of partners' processes (Al-Tabbaa and Zahoor, 2024). From their selective linkages with external firms across different clusters, we argue that the extra-cluster knowledge increases the scope of the SME's access to new market information which encourages the firm to seek out and explore new opportunities into new unfamiliar markets. Altogether, we propose the following hypothesis:

H1 A higher ratio of ECTs (as opposed ICTs) in an SME's cluster portfolio will be positively associated with exporting scope.

2.2 Organisational fit: ICTs versus ECTs and networking capabilities

Being embedded in a cluster network may not be enough for firms; it is equally vital for a firm to successfully utilise and manage its networks. Among the varied firm-specific competencies important for overall internationalisation, the ability of the firm to develop and exploit intra and inter-organisational relationships, or networking capability, has been identified as a key resource for successful internationalisation (e.g., Bai et al., 2021;

Sedziniauskiene et al., 2019). Network relationships provide SMEs with credibility and resources, which subsequently enhance their international. participation and competitiveness in foreign markets (Zahoor et al., 2020). Research has also presented networking as an intangible asset to address obstacles such as institutional voids, lack of information or limited knowledge, and other circumstances inhibiting SMEs development in emerging markets (e.g., Dekel-Dachs et al., 2021).

Among the various definitions of network capability proposed in the literature, we adopt the definition offered by Kenny and Fahy (2011, p.237) at the SME level, that is, "the ability of an SME to initiate, coordinate, and learn from the activities of inter-firm collaborative relations to combine network resources in a trust-based relation that effectively translates success in international trade." Drawing on the dynamic capability argument which posits that inter-firm performance can often be explained by the capabilities in how firms' resources are acquired and deployed to match that of the market environment (Peng and Lin, 2021), we hypothesise that exporting scope will depend on the fit between a firm's cluster portfolio (firms' choice between ECTs and ICTs) and its networking capability. Specifically, SMEs with higher networking capability will benefit more from ECTs, while SMEs with lower networking capability will benefit more from ICTs in their cluster portfolio. Given that SMEs generally prefer to expand into countries closer to their home, firms with limited networking capabilities may rely more on ICTs for further exploitation of their international markets.

We expect SMEs with strong networking capabilities to proactively seek and build new contacts beyond their existing cluster with the intent of creating additional international growth opportunities from ECTs. This is important for SMEs with a focus on adapting their technologies to different applications and having to seek new markets for these applications. Collaborative firms in these ECTs may serve as useful instruments of overcoming geographical distance barriers and/or provide the necessary cultural knowledge when entering culturally (psychically) different markets (Styles and Ambler, 2000). Thus,

H2 Firms with higher networking capability will benefit more in exporting scope from a higher ratio of ECTs in their network portfolio

2.3 Strategic fit: ICTs versus ECTs and innovation upgrading strategies

It is generally accepted in the internationalisation literature that the development of innovative activities will enhance SMEs' internationalisation performance (e.g., Expósito and Sanchis-Llopis, 2019). While the distinction between 'innovation' and 'upgrading' has been drawn out by certain researchers (e.g., Matsuzaki et al., 2021), there is growing acceptance in the literature to view these two concepts interchangeably particularly in the context of firms from emerging market economies. Four types of upgrading are distinguished by Humphrey and Schmitz (2000):

a *Process upgrading* involves increasing the efficiency of production either through better organisation of the production process or the use of improved technology introducing changes in the organisation of production.

b *Product upgrading* is concerned with improving product quality and increasing value for consumers. This may be stimulated by changes in the end market, stemming from

changes in customer preferences, or the desire for higher value added, higher quality products.

c *Functional upgrading* involves the entry into a new, higher value-added function or level in the value chain.

d *Intersectoral upgrading* involves diversifying to a different sector based on competences acquiring in a specific activity.

Previous studies on value chain upgrading in the semiconductor sector argue that MNCs often provide support for process and product upgrading to local firms when expanding to emerging countries (e.g., Humphrey and Schmidt, 2000; Kotabe et al., 2023). For example, the study by Rasiah (2015) found significant upgrading in process and production technology among firms in Malaysia with respect to their linkages with foreign semiconductor multinationals. In contrast, functional and intersectoral upgrading occur less frequently as most of the global buyers at the top of the global value chains tend to confidentially retain the know-how of their skill-intensive operations, such as design, top research, and marketing in-house. While the provision of government grants has helped stimulated some functional upgrading among Malaysian semiconductor firms into chip design, wafer fabrication, and research and development, the number of firms engaging in functional and intersectoral upgrading remains relatively small. The exorbitant R&D and capital investment as well as the lack of sophisticated technological skills associated with functional and intersectoral upgrading further compel emerging market companies to focus on process and product upgrading as they do not require the firm to take on new tasks in the chain or to acquire additional diverse product and market knowledge.

Although studies recognise that the configuration of both product and process innovation networks is different from each other (e.g., Priyadarshini et al., 2024), the relationship between cognitive proximity and collaborative innovation in the context of clustering is seldom addressed in the literature. Based on the knowledge-based view of product and process innovations, knowledge associated with process innovations is difficult to comprehend and cannot be easily understood or copied by others (Gopalakrishnan et al., 1999). This is because knowledge affiliated with process innovations is less observable than knowledge affiliated with product innovations as process innovations are related to the production and delivery of outcomes and not the outcomes themselves. Furthermore, unlike product innovations, which are usually patented so the bulk of the knowledge of their functionality reside in the public domain, innovation knowledge related to manufacturing processes is often protected via trade secrets, where the details are highly confidential (Crass et al., 2019). Hence, the 'stickiness' associated with process innovations suggest that geographical proximity of firms in ICTs allows firms to acquire deeper knowledge and guarantee a certain closeness to the partner's cognitive base to facilitate the understanding and internalisation of process-related knowledge (Capaldo and Petruzzeli, 2015). As such, the following hypothesis is proposed:

H3a Firms with a focus on a process upgrading strategy will benefit more in exporting scope from a higher ratio of ICTs in their cluster portfolio.

Long-term viability of a cluster depends on increases in knowledge heterogeneity. One approach is to diversify into sectors or technologies where existing technologies are

adapted for different but related applications (Leten et al., 2007). Participating in extra cluster relationships enables firms to develop more exploratory innovative capabilities with respect to adapting their technology to new applications and growing market segments. Also known as technological proximity concept, studies have confirmed that cognitive proximity has more benefits for value creation purposes, as it allows for the recombination of heterogeneous knowledge inputs (Ehls et al., 2020). Furthermore, given the higher costs associated with the adoption of technologies to different applications, companies may seek export diversification to offset the R&D costs in technology development. In summary, we argue that firms that place priorities in applying related technologies to new products are likely to seek partnerships with extra-cluster firms. In this sense, the mutuality of knowledge bases provides opportunities for collective learning and knowledge combination that promote the innovation process (Leszczyńska and Khachlouf, 2018). They further provide the firm with the opportunity to differentiate their offerings and consequently enter new markets and meet customers' needs. Therefore,

H3b Firms with a focus on product upgrading will benefit more in exporting scope from a higher ratio of ECTs in their cluster portfolio.

2.4 Organisational fit: ICTs versus ECTs and absorptive capacity

The traditional literature on industrial cluster assumes that firms are homogeneous in terms of knowledge acquisition mechanisms. Recent studies from different industrial settings have begun to challenge this oversimplified view. This is due to variations in firms' absorptive capacity levels defined as "firms' ability to recognize the value of new information, assimilate it, and apply it to commercial ends" [Cohen and Levinthal, (1990), p.128]. Firms with high levels of absorptive capacity tend to acquire and assimilate knowledge as well as carry out transformation and exploitation to assist innovation activities (Müller et al., 2021). In their study of the Portuguese footwear cluster, Eiriz et al. (2013) came to this similar conclusion. However, not all firms possess similar absorptive capacity capabilities. Specific characteristics such as firm size and export intensity were strongly correlated with the capacity to acquire, assimilate, and transform acquired knowledge from the cluster. Finally, findings from Boschma and Ter Wal's (2007) study of the Barletta footwear cluster in Italy suggest that firms with high absorptive capacity were more connected non-locally and that firms with non-local knowledge relationships also performed better.

The multidimensional nature of absorptive capacity has been addressed in terms of potential absorptive capacity (PAC) and realised absorptive capacity (RAC). Knowledge acquisition and assimilation constitutes the former while knowledge transformation and application constitutes the RAC. Given that the objective of PAC is to acquire and integrate external knowledge internally, the characteristics of PAC are commonly discussed in the context of the external environment of the firm. In contrast, RAC is not often realised by companies because the building and accumulation of RAC usually require strong internal capabilities to transform and assimilate the various knowledge from different external sources to produce new ideas and innovative design (Müller et al., 2021). Indeed, studies contend that firms with stronger RAC are more likely to establish linkages with external sources of knowledge both within the cluster and across the cluster (e.g., Chandrashekar and Mungila Hillemane, 2018).

From the perspective of cognitive theory, low levels of cognitive distance have a positive effect on learning due to the ease of interactions among firms with different knowledge and perspectives. However, studies suggest that while larger distances in cognition have a negative effect on absorptive capacity, they can also engender a positive effect on the potential for novelty creation (Sánchez-García et al., 2023). While cognitive theory does not differentiate between PAC and RAC, the key argument of the theory is that once a certain level of cognitive distance is reached, further increases imply difficulties for the mutual understanding required to seize the opportunities of diverse knowledge unless the firm has strong RAC capabilities in transformation and exploitation of knowledge. As such, cognitive proximity encourages the development of knowledge absorption skills that allow for the effective application of new knowledge for innovation and the improvement of innovation performance. Knowledge and information about overseas markets such as customers and environmental changes need to be integrated with the firm's RAC to facilitate SME export diversification (Peng et al., 2019). As such, this study argues that SMEs with stronger RAC capabilities are more capable of combining extra-cluster knowledge with existing knowledge and resources for successful internationalisation. Therefore,

H4 Firms with stronger realised absorptive capacity will benefit more in exporting scope from a higher ratio of ECTs in their network portfolio.

3 Methodology

3.1 Sample

Researchers often describe the stage of a cluster life cycle with respect to the number of employees and the heterogeneity of 'accessible knowledge' (Menzel and Fornahl, 2010). Using these indicators, Malaysia's semiconductor industry can be characterised as in the expansionary/established stage of its cluster life cycle. The number of employees in Malaysia's semiconductor cluster increased from 577 to 322,000 to 575,000 in 1970, 2015, and 2019, respectively. Over the years, the semiconductor sector saw an increase in capital investments of 11%, 22%, and 30% during 1981–1990, 1991–2000, and 2001–2011, respectively. Malaysia also benefited from massive inward FDI by MNCs since the 1970s. The share of foreign firms' investment in the semiconductor sector rose from 39% to 56% and 85% during the same periods. Similarly, the growth of the semiconductor cluster saw a rise in exports from $2 b to $9.43 b in 1996 and 2021, respectively, making the country the 3rd largest exporter of semiconductor devices in the world (OEC, 2021).

The development and growth of the semiconductor industry in Malaysia started in the state of Penang (located in north-west Malaysia), initiated through the development of industrial estates (foreign trade zones) in 1970 by the Malaysian Government (Abad et al., 2015). Beyond hosting the greatest number of semiconductor firms and generating most of Malaysia's electronics exports, research consistently finds that Penang's manufacturing cluster has deeper capabilities and carries out more value-added operations than those elsewhere in the country (Mohamed et al., 2018). Indeed, some local firms have attained market leadership in very specific areas such as precision engineering and automated machinery and equipment, and in some cases, have

themselves become multinational corporations (MNCs) with operations overseas. Examples of these local companies and their market cap include Inari ($1.2 b), Vitrox ($850 m), and MPI ($555 m) (Regoma.com, 2012).

Our study's sampling frame consisted of 290 active semiconductor companies located in the northern Malaysian state of Penang. The following criteria were used in the sample selection process to ensure a representative sample. First, only independent, or privately-owned ventures which are established and managed by individual owners were considered since corporate ventures, subsidiaries, or business units of established companies often include shared joint responsibility for operations, decision-making, and resource provisions with the parent companies. Second, using the definition provided by the SME Corporation in Malaysia, only SMEs with fewer than 200 employees were considered. Third, the SME is currently engaged in international activities as verified by the Small and Medium Industries Corporation (SMIDEC) and Ministry of International Trade and Industry (MITI). Finally, using a five-year time period, 2012–2017, allowed for a dynamic assessment of the SME's exporting scope (Katsikeas et al., 2000). This time period also removes the potential extraneous impact of the COVID-19 pandemic which started in 2019.

Empirical data for the study was collected using in-depth interviews over a 5-month period in June 2018. The interview method is often encouraged in emerging markets as it engenders higher response rates and generates more valid information. On site interviews were scheduled with the SMEs' chief executive officers or top managers, since these key informants are often responsible for their organisations' strategic development with respect to innovation strategies and are more likely to be involved with decisions regarding firms' internationalisation strategies (Azari et al., 2017). While these face-to-face interviews potentially reduced the size of our sample, we believe the quality of the data collected through this method was more comprehensive, accurate, and reliable than what would have been possible through a mail survey. A pilot study involving ten companies was initially performed to fine tune the questionnaire. Malaysia is a bi-lingual country. Unless requested otherwise, interviews were conducted in English. Incomplete responses reduced the sample size to 230 responses. To control for the possibility that some of the sampled firms may have engaged in little or no technological innovation, a filter question was asked to ascertain if the firm had engaged in an innovative activity. Specifically, firms were regarded as active in innovations if they had introduced at least one of the following during the last five years:

1 a product design new to the business or a substantially improved product design (product innovation)

2 a new or substantially improved production process through new equipment or re-engineering (process innovation).

This resulted in a total of 110 innovative firms, representing a response rate of 48% (110/230).

Due to the on-site data collection, a test for response bias is not appropriate. Instead, comparing the respondents and non-respondent firms in terms of key firm characteristics, such as firm age ($t = 0.35$, $p > 0.05$), number of employees ($t = 0.39$, $p > 0.05$), and number of countries entered ($t = 0.20$, $p > 0.05$) revealed no significant differences. Therefore, we concluded that our sample of 230 firms represented the population from

which they were drawn. Detailed information about the sample characteristics is summarised in Table 1.

Table 1 Demographic profile of participating semiconductor firms

				Average	*Std. deviation*
Number of employees				89	54.9
Years in business				13	6.8
Countries selling to				10	9.5
Sub-sectors					
Consumer electronics			30%		
Electronic components			28%		
Industrial electronics			20%		
Electrical products			22%		
Respondents					
Position	CEO	65	54%		
	Director	20	17%		
	Manager	35	29%		
Ethnic background	Malay	25%			
	Chinese	64%			
	Indian	9%			
	Others	2%			
Family-owned	Yes	40%			
	No	60%			
Educational level	High-school	20%			
	Bachelor's degree	67%			
	Master's degree and higher	13%			

3.2 Measurement

All the measures came from previous studies, with some items adapted to the context of the study. The individual measurement items, factor loadings, composite reliability, and average variance extracted are summarised in Table 2. Unless specifically indicated, we measured all the items using a seven-point Likert scale (1 = 'strongly disagree', 7 = 'strongly agree'). Table 3 presents the correlation matrix and descriptive statistics of the measures.

- *Exporting scope:* Instead of a simple count measure of the number of destination countries (Benito-Osorio et al., 2016) or the Herfindahl-Hirschman Index (Patel et al., 2014), this study uses instead the standardised total geographic diversification (STGD) measure proposed by Boehe and Jiménez (2016) to capture an SME's 'diversity' in exporting scope. Earlier exporting scope measures tended to ignore unrelated and cross-regional diversification, thus biasing the measurement of geographic diversification, as countries within the same region may be strongly interconnected in terms of business cycles, markets, competitive, and institutional

characteristics. While later studies introduced the total geographic diversification entropy measure to address these concerns (Qian et al., 2010), its lack of standardisation makes the interpretation of diversification scores difficult across firms. As such, standardising the scores allows for a comparable examination of firms' geographic diversification by accounting for both the number of exporting countries within each region and the total number of regions.

The STGD index as shown below considers three distinctive characteristics of an SME's exporting scope: the distribution of the SME's sales across countries by attributing a weight to each destination country, unrelated (across world regions) and related geographic diversification (across countries within each world region).

$$STGD = \frac{\left[\sum_{r=1}^{R}\sum_{c=1}^{C} Prc * \ln\frac{1}{Prc}\right]}{\left[\ln(R) + \sum_{r=1}^{R} \Pr * \ln(Cr)\right]} \; such\ that\ Prc > 0$$

The STGD measure ranges from '0' (no geographic diversification) to '1' (fully geographically diversified) covering all possible countries and regions in similar proportions. *R* represents the maximum number of regions *r* considered, and *Cr* represents the maximum number of countries *c* in each region *r*. As for the regional breakdown, the four regions considered in this study were: South-East Asia, East Asia, North America (Canada, USA, and Mexico) and, Europe.

- *Extra cluster ties ratio:* The boundary of Penang' semiconductor cluster is clear, making it easy to identify ICTs and ECTs. According to the Malaysian Investment Development Authority (MIDA), semiconductor firms compete in four identifiable sub-sectors:
  1 consumer electronics
  2 electronic components
  3 industrial electronics
  4 electrical products.[1]
- We treated these as intra clusters in the semiconductor eco-space. Semiconductors are also an overarching technology that have applications in different industries, including automotive, medical, industrial, transportation, aerospace, and energy applications, just to name a few. We treated these industry clusters as ECTs. Instead of looking at the number of ECTs and ICTs an SME is involved with independently, we calculated a ratio that takes into consideration the number of ECTs over the total number of cluster ties formed by the SME in a given year. To ensure a positive value to indicate a greater ECT ratio (and a negative value to indicate a greater ICT ratio) for a given year, the following formula was used:

$$Extra\ cluster\ ties\ ratio = \frac{Total\ number\ of\ (ECTs - ICTs)\ formed\ by\ the\ SME\ in\ year_t}{Total\ number\ of\ cluster\ ties\ (ICTs + ETCs)\ formed\ by\ the\ SME in\ year_t}$$

- *Innovation upgrading strategies:* Measures for the *product upgrading innovation* construct were drawn from the secondary literature (e.g., Camisón and Villar-López, 2014; Menguc and Auh, 2010) as well as interviews to ensure the items captured the idiosyncrasies of the semiconductor sector. The four items assess
  1 the firm's ability to achieve economic efficiency by reusing existing design intellectual property in new products
  2 the level of engineers trained in software development and system design given their increasing importance as a source of differentiation for semiconductor companies
  3 the extent of external collaborations for new product design
  4 time to market which was defined as the period between the start of IC product design to the time when the product reaches mass production stage.

  This last item is not only a critical source of competitive advantage for semiconductor companies, but also an important metric used to allocate resources and make strategic commitments to product improvements.

  Items for *process innovation upgrading* drew on studies in the semiconductor industry by Hatch and Mowery (1998) and Macher and Mowery (2009) which found that that manufacturing performance improvements are driven in part by practices that improve the analysis of production volume, underscoring the contributions of R&D organisation and information technology practices to problem solving in new process development and introduction. With respect to process upgrading, yield optimisation has long been regarded as one of the most critical and at the same time, a difficult goal to attain in semiconductor operations. According to the Integrated Circuit Engineering Corporation, yield is "the single most important factor in overall wafer processing costs", as incremental increases in yield significantly reduce manufacturing costs (McKinsey and Company, 2018). In this regard, yield can be viewed as being closely tied to equipment performance (process capability), operator capability, and technological design and complexity.

- *Networking capability:* Incorporating the notion that strong- and weak-tie relationships have different benefits for a focal firm, the scales proposed by Thornton et al. (2014) were adapted for this study. Thornton et al. (2014) identified four underlying networking dimensions: namely information acquisition, opportunity enabling, strong-tie resource mobilisation, and weak-tie resource mobilisation. These four dimensions encapsulate "activities/routines/practices which enable firms to make sense of and capitalize on their networks of direct and indirect relationships" (p.954).

- *Realised absorptive capacity:* While traditional measures of absorptive capacity employed proxies such as R&D expenditures, patents, or the number of R&D employees, the focus on recent studies has been to move measurement of the construct to a broader dynamic firm capability perspective (e.g., Kotabe et al., 2014). Fundamentally, realised absorptive capacity includes developing novel insights and results from consolidating existing and newly acquired knowledge and transforming knowledge into business operations. With a focus on knowledge transformation and

exploitation, the realised absorptive capacity construct was measured with items proposed by Kotabe et al. (2014) and Flatten et al. (2011).

- *Control variables:* To account for the effects of extraneous variables, we included firm size, firm age, and industry growth as control variables as previous studies suggest their potential influence on firm innovativeness and internationalisation performance. The first two variables are useful proxies for resources available in the firm as well as the number of external ties and level of legitimacy possessed by the firm. These variables have been found to relate to export market diversification (e.g., López-Cózar-Navarro et al., 2017). The logarithm of the number of full-time employees was used as an indicator of firm size. Firm age was determined by the logarithm of the number of years the SME has been in operation. The level of industry growth which reflects the resource supply and opportunities of the firm's environment could also influence the choice of a firm's cluster ties. The industry growth construct was measured by having respondents indicate "the average annual growth rate of total sales in their served industry (consumer electronics, electronic components, industrial electronics, electrical products) over the past five years" ('1' = very low; '7' = very high) (Narver and Slater, 1990).

Table 2 Scale items used in survey

	Standardised factor loading
Dependent variable	
Exporting scope (Boehe and Jimenez, 2016)	
• Single measure ranging from '0', no geographic diversification, to '1', fully geographically diversified	
Independent variable	
Cluster portfolio	
• $\textit{Extra cluster ties ratio} = \dfrac{\textit{Total number of } (ECTs - ICTs) \textit{ formed by the SME in year}_t}{\textit{Total number of cluster ties } (ICTs + ETCs) \textit{ formed by the SME in year}_t}$	
Process upgrading (adapted from Hatch and Mowery, 1998; Macher and Mowery, 2009)	
$\alpha = 0.84$; AVE = 0.57; HSV = 0.30	
To improve end-to-end yields, our company in the past five years (2012–2017), …, (1 = strongly disagree; 7 = strongly agree)	
• Has put more emphasis on greater functional diversity within teams to improve learning and problem-solving performance.	0.76
• Deployed more IT resources for data collection and performance monitoring.	0.77
• Has stepped up skill upgrade programs for both operators and technicians in the areas of problem-identification, trouble-shooting, and preventive maintenance.	0.71

Notes: GFI = 0.92; RMSEA = 0.09; CFI = 0.86; IFI = 0.85.

Table 2 Scale items used in survey (continued)

	Standardised factor loading
Independent variable	
Product upgrading (adapted from Camisón and Villar-López, 2014; Menguc and Auh, 2010)	
$\alpha = 0.89$; AVE = 0.54; HSV = 0.27	
In the last five years, our firm (2012–2017), …, (1= strongly disagree; 7 = strongly agree)	
• Has achieved greater efficiency by reusing existing design intellectual property in new product design.	0.74
• Increased employment of engineers trained in software development and systems design.	0.77
• Has significantly improved our average time to market new product design with existing manufacturing process.	0.70
• Has increased the number of external collaborations with fabless companies for new product design.	0.65
Networking capability (adapted from Thornton et al., 2014)	
$\alpha = 0.74$; AVE = 0.52; HSV = 0.36	
Over the last five years (2012–2017), …, (1 = not satisfactory; 7 = very satisfactory)	
• Interactions with our business contacts allow us to obtain the information that is crucial to our company.	0.74
• We worked toward becoming an effective business partner for other companies in the market (e.g., potential customers or suppliers).	0.90
• Having good relationships with both suppliers and customers has enabled us to adapt to changes in the international marketplace.	0.81
• Identifying our competitors' major customers helps us to get to know the needs and requirements of potential customers around the world.	0.75
Realised absorptive capacity (adapted from and Flatten et al., 2011; Kotabe et al., 2014)	
$\alpha = 0.75$; AVE = 0.65; HSV = 0130	
For the past five years (2012–2017), how would you characterise your firm's ability to transform and exploit information? (1 = strongly disagree; 7 = strongly agree)	
Our company	
• Regularly considers the consequences of changing market demands in terms of new products.	0.73
• Has the ability to work more effective by adopting new technologies.	0.88
• Regularly reconsiders technologies and adapts them accordant to new knowledge.	0.90
• Face few hurdles to put technological knowledge into product and process patents.	0.89

Notes: GFI = 0.92; RMSEA = 0.09; CFI = 0.86; IFI = 0.85.

Table 2 Scale items used in survey (continued)

	Standardised factor loading
Independent variable	
Realised absorptive capacity (adapted from and Flatten et al., 2011; Kotabe et al., 2014)	
$\alpha = 0.75$; AVE = 0.65; HSV = 0130	
For the past five years (2012–2017), how would you characterise your firm's ability to transform and exploit information? (1 = strongly disagree; 7 = strongly agree)	
Our company	
• Has employees who can successfully link existing knowledge with new insights.	0.82
• Has employees who have the ability to fuse assimilated new knowledge with existing knowledge.	0.85
• Has employees who have the ability to structure and to use collected knowledge.	0.88
Control variables	
• Number of years in business _____	
• Number of full time employees _____	
• How would you perceive the average annual growth rate of total sales your industry over the past five years (2011–2016)? ('1' = very low, '7' = very strong)	

Notes: GFI = 0.92; RMSEA = 0.09; CFI = 0.86; IFI = 0.85.

Table 3 Correlation matrix

No.	*Variable*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	Exporting scope	1.00								
2	Firm age	0.09								
3	Firm size	0.10	0.18							
4	Industry growth	0.34	0.25*	–0.04						
5	Extra-cluster ties ratio	0.37	–0.09		0.05	–0.01				
6	Networking capability	0.43	0.07	–0.03	0.10	0.15				
7	Product innovation upgrading	0.02	–0.02	–0.03	–0.33**	0.10	–0.04			
8	Process innovation uprading	0.25	0.04	–0.04	–0.25*	0.21*	0.14	0.40**		
9	Realised absorptive capacity	0.41	–0.10	–0.05	–0.20*	0.14	0.04	0.55***	0.36**	1.00
Mean		0.44	0.44	1.11	1.95	3.98	0.37	3.78	4.03	4.70
Std. dev.		0.15	0.15	0.84	1.74	1.54	0.17	1.16	1.34	1.11

Notes: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

3.3 Method

3.3.1 Construct validity

To assess unidimensionality, the validation procedures proposed by Anderson and Gerbing (1988) were conducted. First, in support of internal consistency, all measures showed adequate reliability with composite reliability indices higher than 0.6 and average variance extracted higher than 0.5. Second, all factor loadings are highly significant ($p < 0.01$), and the composite reliabilities of all constructs (0.71–0.90) exceed the 0.70 benchmark, providing support for convergent validity for each construct. Third, the model also provided a satisfactory fit to the data [goodness-of-fit index (GFI) = 0.92; root mean square of approximation (RMSEA) = 0.09; confirmatory fit index (CFI) = 0.86; and incremental fit index (IFI) = 0.85]. Because the data was collected from one single respondent, common-method variance could be a potentially serious threat of bias that can artificially inflate the parameter estimations of the relationships between the different concepts (Podsakoff et al., 2003). To test for such a bias, we used Harman's one-factor test. Common-method variance is not present, as the unrotated factor solution showed the presence of multiple factors and no one accounted for the majority of the covariance.

Table 4 Regression of control and independent variables against exporting scope

	Model 1	*Model 2*	*Model 3*
Control variables			
Firm age (log)	0.242***	0.124***	0.100*
Firm size (log)	0.073^{ns}	0.086^{ns}	0.099*
Industry growth	0.021^{ns}	0.095*	0.094*
Main effects			
Extra cluster ties ratio		0.205**	0.524***
Networking capabilities		0.176***	–0.009^{ns}
Product innovation upgrading		0.346***	0.517***
Process innovation upgrading		0.012^{ns}	–0.243*
Realised absorptive capacity		0.139^{ns}	–0.103^{ns}
Interaction effects			
Networking capabilities × extra cluster ties ratio			0.279*
Product innovation upgrading × extra cluster ties ratio			–0.202^{ns}
Process innovation upgrading × extra cluster ties ratio			0.460**
Realised absorptive capacity × extra cluster ties ratio			0.434***
R^2	0.073	0.340	0.504
ΔR^2		0.267	0.164
F-value	7.093***	21.645***	23.352***

Notes: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; n.s = not significant.

The hypotheses proposed in this study were tested using hierarchical regression whereby the variables were entered sequentially. The regression results are summarised in Table 4. Model 1 only included the control variables. Model 2 added the main effects of the moderating variables: extra cluster ties ratio, product and process innovation upgrading,

networking and realised absorptive capacity capabilities. Model 3 added the interaction terms. To reduce the potential problem of multi-collinearity, the predictor and moderator variables were mean-centred prior to the creation of interaction terms.

4 Findings

As model 1 is a baseline model that includes only the control variables, the amount of variance explained significantly improved when including predictors in model 2. It is significant at the 0.001 level ($F = 21.645$; $R^2 = 0.340$) and explains an additional 27% of variance over the base model. Model 3 shows a moderate improvement ($\Delta R^2 = 16\%$) over model 2 ($F = 23.352$; $R^2 = 0.504$).

A greater participation in extra cluster ties (H1) increases the probability of the firm adopting an export diversification approach. According to model 3, the fully specified model, the relationship is significant at the 0.001 level and in the predicted direction ($b = 0.524$, $p < 0.001$). This validates our hypothesis, corroborating studies in the export information search literature that in a dynamic industry such as the semiconductor, embedding oneself in extra-local knowledge sources are important for identifying new export opportunities (e.g., Chabowski et al., 2018).

Our study also attempted to uncover the extent to which an SME's cluster portfolio may lead to greater exporting scope when combined appropriately with organisational characteristics. Hypothesis 2 examines the influence of networking capabilities on the relationship between firms' extra cluster ties and exporting. The positive interaction between ECTs and networking capabilities ($b = 0.279$, $p < 0.05$) is in line with studies which have shown that collaborative and cooperative networks outside one's clusters can enlarge the scope of a firm's international operations (Mitręga, 2023).

Hypotheses 3a and 3b explore the exporting scope implications of strategic fit between extra cluster ties and innovation upgrading strategy. The interaction between ECT cluster emphasis and product innovation upgrading is not significant, providing no support for H3a. The positive and significant relationship ($b = 0.460$, $p < 0.01$) for the interaction between ECT cluster emphasis and process upgrading contradicts H3b which argues that firms with a focus on a process upgrading strategy will benefit more in exporting scope from a higher ratio of ICTs in their cluster portfolio.

Hypothesis 4 proposes a positive relationship between extra cluster ties and exporting scope for SMEs with stronger realised absorptive capabilities. The results in model 3 suggest that the moderating effect is positive and significant ($b = 0.434$, $p < 0.001$), thus providing support for H4.

5 Contributions

Using the semiconductor cluster in Malaysia as the context for this study, we draw upon the relational view to provide new insights into the collaborative internationalisation of SMEs (Zahoor et al., 2020). Separately, the resource-based view regards networks as a strategic resource, bringing value to the firm in the form of international opportunity exploitation (e.g., Bai et al., 2021) while the network theory emphasises relational learning and network characteristics as key success factors for internationalisation

success (Stoian et al., 2017). By simultaneously considering these two perspectives within the context of SMEs, the relational view offers an interesting perspective on how and why resource-limited firms such as SMEs can achieve relational rent for internationalisation from their network ties within and across clusters.

5.1 Contributions to research on clusters and internationalisation of SMEs

The degree of 'openness' of cluster knowledge systems and their capacity to interconnect especially with extra-cluster sources of knowledge is viewed as particularly important in high-tech sectors such as the semiconductor cluster in Malaysia. As suggested by the positive relationship between ECTs and exporting scope, the collective efficiency via ECTs can generate opportunities for SMEs to enter new international markets beyond their existing clusters. Mobilising and committing internal resources to nurture these networks and increasing the diversity of a firm's knowledge base is vital as they can potentially raise awareness of growing market opportunities in other countries. The positive interaction between extra cluster ties and realised absorptive capacity capability on exporting scope confirms the importance of reaching out to extra cluster members with knowledge and capabilities that are similar enough to facilitate the understanding and internalisation of knowledge, but at the same time different enough so that there are contributions of complementary knowledge (Knoben and Oerlemans, 2006). Furthermore, if the capability to manage networks is heterogeneously distributed across firms and difficult to imitate, a firm's networking capability has the further potential to create a firm-level competitive advantage (Burt and Soda, 2021).

5.2 Contributions to research on geographical and cognitive proximity effects on innovation performance in SMEs

Findings suggest that proximity to the type of cluster is equally important for the type of firm innovation strategies. While a high degree of geographical proximity might be considered a prerequisite for successful clustering effect (Cassi and Plunket, 2015), our finding suggests that for successful knowledge spillovers, a certain threshold of similar technological competencies is required. This cognitive dimension was found to have a stronger impact on process innovation suggesting that firms pursuing this innovation strategy prefer to collaborate with cognitively proximate partners in their extra-cluster networks. Given that the knowledge underlying process innovation tends to be complex and tacit, this study supports the findings of Balland and Rigby (2017) which suggest that cognitive proximity play a more important role for the formation of process innovation knowledge for applications in new industries.

5.3 Managerial contributions

Although our study did not address whether cluster firms exchanged more knowledge through intra-cluster or extra-cluster relationships to confirm the existence of geographical proximity advantages, this paper has important implications for the debate about whether extra-cluster relationships carry knowledge more critical than intra-cluster ones or whether intra-cluster and extra-cluster knowledge are complementary. Semiconductors are a key enabling technology for many applications, including the internet of things (IoT), automotive, medical, industrial, transportation, aerospace, and

energy applications. To take advantage of the recombinatorial opportunities associated with these extra-technology clusters, firms must develop their capacity to identify and assimilate new external knowledge but must also integrate all this knowledge into the firms' knowledge base, transform it and apply it effectively for innovative purposes for successful internationalisation performance. The results of this empirical analysis indicate that the effect of cognitive proximity on the process of businesses' knowledge absorption capabilities on the firm's innovative and internationalisation strategy is a viable field for further study.

6 Limitations and future research

This study has several limitations. First, as the cross-sectional data in this study pertains to a single cluster, the results cannot be easily generalised to other countries and industrial clusters which may see different governance relationships between local and foreign firms and at different stages of the cluster life cycle.

Second, the cross-sectional analysis also inhibited us from understanding the dynamic interplay among the variables in the model. For example, compared to process upgrading, the realised tangible outcomes from product upgrading tend to take longer to realise. If the research had conducted the longitudinal study on the sample, the conclusion on the interaction impact of product innovation upgrading and extra cluster ties on exporting scope may have been more robust. Regarding the non-significant finding for the fit interaction between ECTs and product innovation upgrading and exporting scope, future research should address the role of buyer resistance, resource requirements, and in-house technological capabilities. Studies of firms in other emerging countries (e.g., China, India) found that local firms often encounter resistance from multinationals to share design and marketing competencies as they fear these higher-value chain activities may encroach on their core competence (Schmitz and Knorriga, 2000). Fearing the potential exit of their key buyers, local firms may also refrain from making investments in product upgrading which tend to be substantially more expensive and riskier compared to process upgrading. Lastly, whether firms in this study lack the necessary in-house capabilities to adapt their product-related technology to different applications deserves examination. Future studies should adopt a longitudinal approach to overcome these limitations that will allow for a fine-grain understanding on how intra- and ECTs as well as networking and realised absorptive capacity capabilities change in accordance with the SME's stage of the internationalisation process.

Third, the conceptual model proposed in this study does not claim to be completely representative of the perspective we aim to explicate. At the individual level, despite the prevailing consensus of the positive impact of entrepreneur's social network on the business performance of SMEs, activity, there is still room to improve the understanding of micro-actions and interactions of the entrepreneur and their effects in different domains (Song et al., 2017). For example, Zhao and Wang (2015) found that entrepreneurs with technical knowledge have an easier access to required resources from intra-industry ties while entrepreneurs with market knowledge can obtain more easily needed resources from extra-industry ties. How ICTs and ECTs moderate the relationship between entrepreneurs' market and technical knowledge and different types of resource acquisition can shed additional light on changes in SMEs' internationalisation over time.

Finally, performance was captured in this study with a single measure – exporting scope. We encourage future research to consider other objective and subjective measures of internationalisation performance as the extant SME literature has identified a positive relationship between networks and export intensity and satisfaction with export performance, respectively (Zou and Stan, 1998).

7 Conclusions

In summary, the extent to which ICTs or ECTs impact SMEs' exporting scope depends on the fit with the firm's innovation upgrading strategies, and firm-specific capabilities in networking and realised absorptive capacity. While local embeddedness within clusters promotes stability and closeness among participants, SMEs can become trapped in these relationships if firms in these intra-clusters have weak knowledge bases and low external openness. The evolution of the semiconductor cluster in Malaysia demonstrates that cluster internationalisation cannot be accommodated only within the role of agglomeration economies, but also depends on the strategic capabilities at the firm level to strengthen their research and innovation capabilities, and the capacity to seek and creatively exploit external knowledge within and across their clusters.

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Notes

1 The consumer electronics sub-sector includes the manufacture of LED television receivers, audio visual products such as blue-ray disc players/recorders, digital home theatre systems, mini disc, electronics games consoles, and digital cameras. Products/activities which fall under the electronic components sub-sector include semiconductor devices, passive components, and printed circuits and other components such as media, substrates, and connectors. The industrial electronics sub-sector consists of multimedia and information technology products such as computers, computer peripherals, telecommunication products, and office equipment. Finally, the major electrical products produced under this sub-sector are lightings, solar related products and, household appliances such as air-conditioners, refrigerators, washing machines and vacuum cleaners (Reogma.com, 2021).