Papers in Evolutionary Economic Geography

06.11

New Industries in Southeast Asia's Late Industrialization: Evolution versus Creation
The Automation Industry in Penang (Malaysia) considered

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December 2006

Introduction

Much of the literature on the emergence of new industries in late industrializing countries in East and Southeast Asia recognizes the possibility of multiple modes of industry development. However, it appears to share a commonality in emphasizing the role of state intervention or involvement in industrial growth and restructuring (Clark & Kim 1995, Deyo et. al. 2001, Jomo & Wah 1999, Jomo 2001, Zysman & Doherty 1995). Thus the 'state versus market' discursive practice as part of the debate on late industrialization and industrial restructuring in East and Southeast Asia has been resolved to a large extent in favour of the former. In turn, this reflects ubiquitous industrial policy practice in Asian late industrializing countries that has emphasized industry development through guided selective government intervention (Masuyama et. al. 1997, 2001) A vision of the necessity to '*create*' industries for a number of reasons, either common to late industrializing countries or country-specific, has molded 'industrial policy' with a significant emphasis on selective state interventions. This emphasis has prevailed equally as to the linked question how (internationally competitive) export firms have developed in the past in the late industrializing countries of Southeast and East Asia (Ernst et. al. 1998, Jomo 2003). Especially in the second-generation Asian late industrializing countries this has engendered a circumscribed role and position afforded to (local) entrepreneurship.

As will be elaborated below, Malaysia is no exception to this discursive and actual policy practice (Jomo 1993; Jomo et. al. 1999, 2003; Kanapathy 2001; Rasiah 1993, 1999, 2001). At the current juncture, Southeast Asian (Malaysia included) late industrialization is confronted with the limits of sustaining the development/operation of specific export industries, i.e. the path pursued thus far (Rasiah 2001a). This in large part relates to the rise of China, resulting in increased competition in 'traditional' export industries. This is expressed in relocation processes and increasing difficulties in attracting foreign direct investment at the levels these countries have enjoyed earlier. A common response has been an emphasis on the necessity for upgrading (restructuring) towards industries that are complementary to rather than in competition with China's export industrial structure. Thus, devising new growth paths in industry, in the hope of catching a 'second wind' on the basis of new - particularly high tech - industries, is high on the agenda in Southeast Asian late industrializing countries. Second, greater indigenization of industry and technology development is also on the agenda.

Strikingly, a continuation of the 'government intervention practice' is clearly discernable in relation to the current question of the development of new competitive industries, specifically high tech industries, as well as indigenization. This is reflected in current views and practices as to industrial policy, continuing the significant role accorded to such policy in the predominant line of thinking (Bunnell 2004). Yet, doubts are also expressed as to whether this can and should be necessarily achieved through the modes that have prevailed earlier. Increasingly, there is also recognition of limits to 'East Asian models' of state intervention to achieve a 'remaking' of the industrial structure, as doubts are raised related to possible lock-in effects of modes of industry development (Breznitz 2005, Rasiah 2001a).

This leads to the intriguing question whether a state-orchestrated '*creation*' of new priority industries is the only possible route to new high tech industries in Southeast Asian late industrializing countries, given the existing industrial base? It can be argued that as a matter of fact the development of

industries may be conceptualized in differential ways, i.e. alternative modes of industry genesis and growth may be identified: besides institutional orchestration also market coordination. However, it is particularly interesting to refer here to an increasing amount of research into the evolution of industries, in terms of development path, composition/structure, and geography (at several scale levels), in evolutionary economics (e.g., Boschma & Wenting 2005, Cantner et al., 2004; Dahl et al., 2003; Klepper 2001a, 2001b, 2002) that is revealing pathways that deviate substantially from the 'create and grow' belief and practice. Among many other interesting aspects, it shows industry genesis and evolution as a more or less autonomous incremental process of the development of firms, incl. selection processes through entry and exit, from a range of seedbeds (some related to the existing industry base, some accidental) in particular locations (some equally accidental), and a linked similarly incremental process of capability development. Firms in new industries need in this view not be new firms. Conceptions of the dynamics of entrepreneurship have led to interesting elaborations of evolutionary 'models' of industry development.

Re-stating the above question, can successful industrial policies be based on an *evolutionary* 'birth and development' path with respect to the growth of high tech industry, be it nationally or in a specific regional/local complex? In this contribution, we argue that there is. The main argument put forward in this contribution holds that an evolutionary industrial policy is possible in industrializing countries, in particular in conjunction and following the establishment of multinational enterprises. With respect to the Malaysian case, as will be demonstrated later, industrial policy has accorded a role to the State that has gone much further than playing a catalytic role in the establishment of a range of export processing industries. However, in contrast to the state's role, we demonstrate the possibility of the development of new high tech industries as an *evolutionary process* of local firm development without much 'state involvement', at least directly. We do this on the basis of an analysis of the development of a recent growth industry in Malaysia, i.e. the manufacturing of automated equipment (or, automation industry, formally classified under machinery). More specifically, we report on the development of this industry and its constituent firms in the Penang region, a by now mature export production complex that in the initial and growth phases of its development was largely driven by foreign direct investment. As elsewhere in the country, there has been substantial state involvement in the initial establishment and growth of the complex, from the 1960s to the 1990s. Yet, more recent industry development has been propelled under a range of other impulses.

The discussion here addresses four questions:

1. First, what have been the forms and achievements of the predominant state-led model of industry 'creation' in late industrialization in Southeast Asian countries and what are the drawbacks in relation to the current agenda of high-tech industry development?
2. Second, how should an *evolutionary* 'birth and development' process and path with respect to the growth of high-tech industry be conceived?
3. Third, if the automation industry in Penang (and Malaysia at large) is marked by a different development 'mode', more in line with findings from evolutionary economic research into the evolution of industries, then how does this mode (and path) exactly look like?
4. Fourth, what are the implications for our thinking on 'remaking' late industrialization, specifically the prospects for greater indigenization of industry development, and to what extent can such policy be replicated elsewhere?

This paper will progress as follows. In the next section we briefly review the first question, focusing on the array of modes of state involvement in industry development. This is followed by a brief – and tentative – evolutionary economic account of industry development. In the subsequent section we direct the attention to Malaysia and first outline the rationale for and the different forms of state involvement in export industry development. Here we also show that – while the modes of operation of the state have substantially evolved – its role/involvement has hardly become less. The fourth section outlines Penang's industrial transformation and specifically deals with the development of the automation industry in the complex. A discussion on the questions raised in this introduction concludes this contribution.

Industrial policy in East and Southeast Asia

A review of the relevant discourse and literature reveals a significant - and wide array of modes of -

state involvement in industry development, driving home the pervasive idea of the '*creation*' of industries in a planned and coordinated manner (Masuyama et al. 1997, Masuyama et al. 2001; Jomo & Tan Kock Wah 1999, Jomo 2003). Interplaying with modes of involvement the role of the state is perceived to vary from direct participative (assuming a position as entrepreneur and/or investor) to catalytic in the background. While categorization of modes of involvement is in principle a fairly straightforward task, practice is highly complex in view of the often hybrid nature of state selective intervention. An illustration of the latter, and at the same time often-used mode of industry creation, is related to leveraging multinational companies. In his account of the emergence of Singapore as a 'Silicon Island of the East', Mathews (1999) demonstrates Singapore's dual strategy in its creation of a semiconductor industry. That is, not only to attract well-known MNCs in the industry to the city-state but also to leverage them in order to broaden their activities and to grow domestic firms, in part so-called Government Linked Companies (GLCs), specializing in segments of the industry or in support activities. This has *inter alia* meant inducing MNCs into technology transfer and learning assistance, as well as into linkages with local companies for procurement purposes. In this way not only the development of a sizeable industry cluster was achieved but also local industry upgrading. The same strategy was replicated in case of the Hard Disk Drive industry (Wong Poh Kam, 1999a, 2001).

Building an industry around foreign firms by attracting foreign direct investment has constituted one of the favored modes of export industry creation in the second-generation late industrializing countries. This has most of the time involved a substantial role of the state as seen in indicating priority or target industries, targeting specific companies, influencing the investment 'climate' and delivering specific needs of targeted industries and companies (in the form of e.g. specific infrastructure, labour, legal matters etc.), undertaking concrete procurement activities etc. Another mode deployed has been the building of new industries around large vertically integrated domestic companies whereby the role of the state revolved around targeting (appropriate) industries, picking strong winner firms or investing directly in (shared) ownership, nurturing these by providing them with technology (in part leveraged from abroad) and delivering markets (by limiting entrants), also setting of performance criteria etc. (Jomo & Tan Kok Wah 1999, Jomo, 2003). State leadership positions have been expressed *inter alia* in direct state investment in new firms in newly targeted industries (resembling 'picking winners'), through specialized institutional organizations or through large state-owned companies functioning as the investment arm of government, or in programmed processes of co-evolution, often with the direct aim to develop local support industries and local entrepreneurship. Direct government intervention of a leadership and followership kind has been largely absent in the mode whereby new industries have emerged from small firm based inter-firm networks and their linkage to public sector research and development institutes. Here, the role of the state has revolved more around feeding the network with the necessary technological knowledge, and promoting spinoff of new local firms from these institutes constituting new entrants in the industry, enhancing capabilities/competencies etc. (Jomo & Tan Kok Wah 1999, Jomo 2003). Interplaying the above modes is firm and industry formation building on 'environmental' factors and micro-level practices (of firms). Also here a role of government has been emphasized, although more catalytic influencing these factors and practices (not necessarily directly in the realm of industrial policy, but also technology and labour market policy etc.), with an emphasis on indirect forms of government-business coordination.

Local resources based industry creation/development has engendered substantial study of, and led to a wide-ranging discourse on, acquisition processes. These related to endowments in the form of micro- and meso-level technological capabilities, competencies, learning, technology networks and systems, innovation and innovation systems (e.g., Ernst, Ganiatsos & Mytelka 1998, Jomo 2001, Jomo 2003, Lall & Urata 2003, Mathews & Cho 1999, Koh Ai-Tee 1998, Kim 1998, Kim 1999, Kim & Nelson 2000, Kim 2001, Wong Poh Kam 1999b). This approach, focusing on the rise of domestic firms and industries from birth to becoming internationally competitive, highlights micro-economic determinants of economic performance. Most accounts of technological capability formation at several levels and of the accumulation of knowledge, competencies and capabilities in local firms (big and small) through learning acknowledge a substantial role of the state. From the perspective of industry creation and development the state is seen to operate here in related spheres, either direct interventionist or more catalytic. An interesting contribution to the literature in this vein, edited by Jomo (2003) and aptly subtitled 'How internationally competitive national firms and industries developed in East Asia', revolves around the role of relevant *institutional* characteristics in rapid growth, structural change and

industrial progress. In some cases the importance of private institutions that have emerged, such as business associations, to address collective action problems, is highlighted. However, the emphasis is clearly on state institutions at several levels. In the view of the editor, and most contributions in the book, a micro- and meso-oriented competencies view 'necessarily entails a greater appreciation of the role of industrial policy, in the sense of selective pro-active government interventions, as well as other institutional features, such as technological learning and information sharing arrangements, as well as other initiatives to overcome collective action problems' (Jomo, 2003, p.7). Forms of learning-oriented government-business coordination involve *inter alia* developing and maintaining close ties between state and individual businesses with direct transfer of incentives and privileges (foreign acquired technology) to these businesses; devising programs and playing a guiding role as to linkages between domestic firms and MNC establishments, or between domestic small firms and domestic lead firms (vendor development programs), with a view to develop local support industries and to equip them with the necessary technological knowledge through technology transfer.

While in this approach emphasis is put on rapid and successful technological learning and innovation, enhancing capabilities/competencies, and this remains a task of firms and industries themselves, their capacity to do so (mostly in a incremental and cumulative fashion) is seen to need a - at the least – catalytic or macro-entrepreneurial role of institutions [see also Tae Kyung Sung and Carlsson's (2003) reconstruction of the development of the CNC (computer numerically controlled) machine tools industry in Korea].

Much of the analysis of the role of the state in the creation and development of industries has departed from the assumption that this role is in principle beneficial by being a major impetus. More recently however, alternative critical views have emerged that point to limits of a 'developmental state' in its attempts to *create* new technological industries. For example, Breznitz (2005) in his analysis of two key sectors of Taiwanese IT industry argues that the division of labor between state and private industry at some stage limits the movement of the system to the technological frontier, hampering the further growth of the industry. Besides insufficiently addressing collective action problems, the interaction between institution and private industry has evolved into rivalry (unfair competition) rather than continuing along collective efficiency lines. Such emerging 'lock-in' situation compels a reconsideration and redefinition of the roles of the state. It can be suggested that the developmental state model is particularly useful in a first phase of industrial development as to attract foreign companies and to develop domestic industries. A second, follow-up stage, then, would benefit more from evolutionary policies based on indigenous entrepreneurship and a further broadening and deepening of local competences as a process of diversification and spinoff creation.

A brief evolutionary economic account: moving away from the State

The dynamics of industries is one of the key areas of study in evolutionary economics. Much of the recent work (summarized in Boschma and Frenken 2003, 2006) has focused on the Product Life Cycle model, or rather the Industry Life Cycle model, dealing with the longer-term evolution of industries after it has emerged. The model is frequently used to explain why industries typically transform from an initial situation marked by competition, entry and exit, to an end situation marked by an oligopoly in which only a few large companies dominate the market. The key concepts and 'events' in the model are entry, exit and shakeout, whereby the number of firms in the market, and the number of both entrants and exits follow a typical inverted U-shaped curve. Particularly interesting is the explanation offered by the model why shakeout takes place at an early stage after initial strong growth. This has to do with heterogeneity in the population in terms of characteristics and performance.

In the context of this paper it is most relevant to look at what an evolutionary economic perspective has to offer as to the process, or rather mechanisms, of *entry* of companies whereby a new industry is *born*. The work of Klepper (2001a, 2001b, 2002) identifies several mechanisms, and thus several types of companies: 1) preexisting firms diversifying from related industries, 2) new firms founded by people who headed firms in these same related industries, 3) new firms founded by employees of incumbent firms in the same industry. The first two categories involve experienced firms or entrepreneurs; the third category may be designated as spinoffs. A fourth type is also identified, namely a residual category of inexperienced *de novo* firms composed of firms founded by capitalists and by lower-level

employees in related industries. Klepper (2001a, p. 6) in modeling industry entry has the following to offer as to the sequence in which these different types of firms enter the arena: "It is assumed that at the start of the new industry, there are firms and experienced entrepreneurs in related industries with sufficiently high R&D productivities to enter profitably. As these firms enter, their ranks get depleted, causing the number of potential entrants in the experienced firm and experienced entrepreneur categories to decline over time. Spinoffs supposedly are linked to a 'birth and heredity' process. Employees of incumbent firms are assumed to learn from their experiences, which they can exploit in their own firms. Only employees with the requisite organizational skills, knowledge, and risk preferences start spinoffs. It is assumed that better-performing firms have superior learning environments that lead them to spawn more spinoffs, and spinoffs with higher R&D productivity. For simplicity, it is assumed that as the industry expands and more employees are hired, the number of potential spinoff entrants rises proportionally. The fourth category is composed primarily of two types of firms. One type are those founded by capitalists, who typically hire experienced employees of incumbents to direct their firms. It is assumed that the number of these potential entrants increases in proportion to the number of employees in the industry, comparable to potential spinoff entrants. The other type inexperienced firm is founded by lower-level employees in related industries. Comparable to the first two types of potential entrants, their number is assumed to decline over time as the ranks of employees in related industries willing and able to start their own firms gets depleted over time".

Incorporating geography, several researchers (e.g. Klepper 2001a, Boschma & Wenting 2005) have employed a similar 'model', combined with agglomeration economies, to explain the *spatial* formation of a new industry, i.e. *where* it is born and how it evolves geographically. According to these researchers evolutionary concepts such as those outlined above are very helpful in understanding (by theoretical prediction) e.g. the monopoly of an industry by a single region (concentration), why a specific industry has developed in a specific region/locale rather than another region/locale, or why during the life course a specific location associated with the birth of an industry remains prominent in its later geographical pattern. A finding of the work by Boschma and Wenting (2005, p. 16) is that the initial geography of a new industry is associated with particular regions being much more favourable than others during the first phase of development because of the pre-existence of, and therefore the endowment with, closely related activities, offering a local supply of potential entrepreneurs, knowledge externalities and skilled labour that could be readily exploited by entrants in the new industry. It may be noted that there might be a thin line between (explanation of) the *spatial* formation of a new industry and its initial development as such. In the current paper the analysis is less directed to this spatial aspect, although some notes will be made later on as to the aspect of location.

When we consider the (application of the) mechanisms outlined above in the context of second generation late industrializing countries or regions in Southeast Asia at the current juncture, it seems logical to account for earlier phases of FDI-driven and other processes of prior industrial growth under the aegis of government policy. In a somewhat modified form the mechanisms highlighted in an evolutionary account may then be identified as follows: first, diversification from related industries, second, entry by *de novo* companies as spinouts from hub firms in the base of MNC establishments that play a role on the demand side; third, spinoffs from incumbent firms in the same industry. Part of the analysis below of Penang's automation industry is directed to the occurrence of these mechanisms. We will now first consider Malaysia in general.

Malaysia and the development of new industries: the State and entrepreneurship

Malaysia's manufacturing sector can be divided in three relatively little-integrated segments, each the result of a different policy period and responding to a separate logic (van Grunsven & van Westen 2000, O'Brien 1993). Best known and most recent is the successful *export industry*, outward-looking and competitive, dominated by foreign firms and focused especially on the production of (consumer) electronics and electrical appliances, including assembly and a range of components. It functions according to global market forces and Malaysian policy responses designed accordingly. Second, there is the *import substituting* industry, grown since the 1970s thanks to a booming economy. It is dominated by joint ventures between local partners and foreign brands providing capital and technology. Its operations largely reflect a domestic policy framework, as these industries continue to be protected from foreign

competition, though less so than in the past. Further liberalization is envisaged both within a regional framework (ASEAN and its free trade area, AFTA) and more widely under international (GATT/WTO) provisions. Finally, there are the industries processing local *natural resources* for exports. This sub-sector, much of it in Malaysian hands, is a varied one.

The above segmentation can be associated with Malaysia's development policies, and specifically industrial policy, that by the mid 2000s had followed 5 distinct phases with alternating emphasis on import substitution and export orientation. In these five phases a number of new industries emerged in the manufacturing sector. The literature reveals a leading/initiating role of a confident and activist state, in spite of a strong reliance on market forces (Jomo 1993, Kanapathy 2001, van Grunsven & van Westen 2000, MITI 1996). As indeed in many East Asian 'developmental states', an economy based on private enterprises has never meant a *laissez-faire* policy. Bunnell (2004) in this context refers to the concept of industrial developmentalism. This is expressed in several modes of state intervention in the emergence of new industries being readily evident in Malaysia. In growing export industries, following the example of Singapore, Malaysia offered a production platform for international markets to international capital seeking to minimize production costs (especially labour and taxes). The main forms of intervention introduced to that effect included tax incentive packages for exports, administered under the Malaysia Industrial Development Authority (MIDA); amendments to labour legislation facilitating the supply of labour and controlling its cost; and the creation of Export Processing Zones (Free Trade Zones Act 1971). In growing import-substituting industries, the Malaysian government tried to emulate East-Asian models, especially South Korea's successful 'heavy and chemical industrialization' (HCI) drive of the 1970s. In the context of Malaysia's relatively small economy, heavy industrialization was translated into the creation of production capacity for iron and steel, petrochemicals, engines, and cement, as well as the showpiece of Malaysia's HCI sub-sector, the automotive industry and famous 'National Car Project', Proton. Faced with unfavourable market prospects for such plants (massive investment requirements, long gestation periods, as well as limited domestic markets and dim prospects of exporting to fiercely competitive international markets), these ventures required protected domestic markets, and led the state to take a lead role in their realization through the creation of a public enterprises system.

The logic of this developmentalism can be understood from a range of factors. The imperatives related to level of economic development, economic and industrial structure have been to some extent been 'overshadowed' by ethnic '*Bumiputeraist*' imperatives (Bunnell, 2004). Significantly, since 1970 industrial policy has been framed by the 'New Economic Policy' (NEP), setting out two major objectives which have since guided Malaysian policies, namely the reduction of poverty, and the de-linking of occupation with ethnic affiliation. A heavy reliance was placed on inducing foreign investment for the success of export-oriented industrialization. While recognizing the possibility of producing an economy in which foreign companies would play a pivotal role, more important was the creation of employment in urban-industrial sectors for Malay workers. There was a necessity to rectify unbalanced equity ownership and managerial/professional positioning in the economy of different domestic ethnic groups, again with an emphasis on increasing the stake of Malays in the economy. One way to do this was the creation of new industries through a direct state entrepreneurial role. The national car project and its lead firm Proton, should also be interpreted in this context, i.e. the development of a Malay class of managers and professionals. Linked vendor programmes provided an opportunity to create a support industry in which it was thought that *Bumiputera* entrepreneurship in the SMI sector could be fostered. It is relevant to note in this context that at this stage industrial developmentalism addressed the issue of ownership and management rather than technological capability. Policy reveals the main mechanism at this juncture for overcoming this constraint, namely foreign technological leverage through engaging in joint ventures with main foreign producers or (at a later stage) buying over foreign companies. It is obvious that this applied only to the lead companies; it appears that capability development in small firms remained rather vague and fragmented, casting doubts on the contribution of the ethnic imperative to economic welfare and leading some critical local scholars (Jomo K.S., Rajah Rasiah) at a later stage to emphasize its leakage effects. Leakage occurred through two mechanisms: for one, lack of attention for capabilities was reflected in a lack of performance standards and the absence of monitoring and appraisal devices; the second concerned opportunities for rent seeking and the sizeable actual rent dissipation that occurred.

As outlined by Bunnell (2004), for several reasons from the mid-1980s the climate for

'*Bumiputeraism*' changed giving an opportunity to Prime Minister Mahathir to follow his own convictions that were to some extent antithetical to what had become the mainstream. It is expressed in a shift in emphasis in the National Development Policy (NDP) that succeeded the NEP in 1990. While ownership and management objectives were moderated, entrepreneurial drive coupled with performance based on capabilities and competencies were made more prominent. Following the introduction of the NDP (and the associated 'Vision 2020' in which Mahathir himself had laid down the parameters of Malaysian economy and society into the next century) a set of - partly new partly familiar - core tenets came to the fore as the foundation for the country's progress. The new tenets involved a 'revolutionise to modernity' drive linking to a borderless global economy, the necessity to move beyond mere production into activities and areas where technological and innovative capability would become essential necessitating a technology and innovation push; also, an increasing 'indigenization' of industry and firm development. What remained was the conviction that going along a state planned road (a high degree of planning) would give the most guarantees for reaching the objectives and targets (related to *inter alia* Vision 2020). Rather than a gradual retreat of the state and less planning, this therefore implied the continuation of industrial developmentalism beyond the mid 1990s.

These tenets have taken on more concrete form first in the Second and Third Industrial Master Plan (IMP2 & 3). Emphasizing high tech industries, the centrepiece of which, the multimedia and IT industry and the associated Multimedia Super Corridor project, was launched in a big way in 1996, the modus operandi of the state took a major departure from earlier modes. In particular the creation of a public enterprises system to spearhead a new industry was no longer deployed as such. The government actually stepped up its involvement in the push for the development of technology-intensive industries (like IT and multimedia) but by a range of alternative means. These reflected the shift of its role towards catalyst and regulator, focusing on government-business coordination, promotion, solving collective action problems by collective efficiency based inter-firm networks, and acting on the 'environmental conditions'. The concrete choices and actions reflected the above-mentioned tenets of advancing 'modernity', indigenization etc.

Related to a range of existing and targeted industries, a 'macro-entrepreneurial' role was directed to developing a more comprehensive technological system (Jomo, Felker & Rasiah, 1999; Jomo & Felker 1999, Rasiah 2003). Here the state directed its efforts at reinforcing existing and establishing new public technology institutions, hoping to lure local business/entrepreneurship and the managerial and professional class (especially *Bumiputera*) into higher-risk high-tech areas. A similar aim gave rationale to the state directing its effort also at providing suitable physical and support infrastructure. The best illustration of the state influencing environmental conditions - in the prioritization of 'high-tech', modernity and indigenization - and thus the state's 'new' philosophy of its role, is the effort to create an *IT and multimedia industry*. As already noted, this became the centrepiece of Mahathir's vision of industrial upgrading and gave rise to the *Multimedia Super Corridor* project, launched in a big media blitz in 1996 (Bunnell 2004). The deeply planned nature of, and a leader role of the state in, industry development in this case is brought out clearly in: the development of a *de novo* physical site for the location of companies, hugh investment in its equipment with state of the art infrastructure, establishing new public institutions relating to the industry and locating them in the corridor, luring specific global lead companies to the corridor, regulation of entry into the industry for local companies by requiring listing as a MSC company involving a approval procedure based on explicit entry criteria; the granting of incentives once MSC-status has been obtained, imposing location in the Corridor as one of the conditions attached to MSC-status (thus a planned geography!!); development of an appropriate legal framework for the industry to operate; etc. Thus, while the MSC project expresses modes of operation of the state in new forms, at the same time its role/involvement is deeper than in any prior industry creation projects.

To conclude our discussion of industry development, state and entrepreneurship in the Malaysian case, something should be said about systemic coordination in the local 'embedding' of lead MNCs that had eluded Malaysian policy makers but had received some boost from stable industries (while at the same time being affected by relocating ones), This remained an uneasy affair, largely because of the ethnic factor. Existing firms in support industries linked to internationally driven clusters revolved mainly around Chinese entrepreneurship. Malay entrepreneurship was not so inclined to link itself to MNC-driven industries as they were constrained by lack of capability (an outcome of the lack of performance standards and monitoring systems). This was less an issue in domestic policy-driven clusters to which it therefore became more attached, aided in addition by institutional programs.

Less '*Bumiputeraism*' did not mean a wholesale move to multiculturalism and a level playing field where Chinese firms were treated on equal footing. There are some interesting exceptions however as to government-business coordination in Chinese dominated support industries still being fraught with difficulties. In some locations a more integrated production structure involving Chinese entrepreneurship emerged, with more local linkages and a larger part of the value chain concentrated within the locality, leading to further development of locally owned firms. Notably one such location was Penang. Rasiah (1999, 2001b, 2000c; 2002) points to the significant role of systemic coordination in this instance. In the particular setting this was made possible by ethnic convergence between local state (a Chinese dominated State government), foreign companies (with localized Chinese management) and local business (also Chinese). As we shall see later, this has been significant to the development of Penang's automation industry.

More important here, rhetoric (on 'free enterprise', economic competition, and 'standing on your own feet' through learning) and the performance of Chinese enterprise notwithstanding, private non-Bumiputera local firms are still rarely recognized as having the potential to move to a 'lead role'. The limits to 'extensive' growth and to the attraction of foreign capital in existing industries are increasingly recognized (becoming a too fiercely competitive undertaking), and there is an unmistakable indigenization effort. Well-informed observers (Jomo K.S., Rajah Rasiah) do agree that the role of the state has produced significant positive welfare effects. At the same time the state is also heavily criticized for unproductive use of state resources. Although policy initiatives have also started to take the form of public/private collaborative efforts and new Malaysian-owned businesses have been spawned from privatizing government corporations, the focus has been on Bumiputera entrepreneurship that had to be provided with the means to operate, not necessarily involving capabilities however. A main outcome, peculiar perhaps to the Malaysian domestic context, has been an enduring relationship of dependence between Malay enterprise and the state. Also, underperformance of this enterprise became endemic related to the lack of performance standards and of monitoring and appraisal mechanisms, In addition, substantial leakages have occurred because of opportunities for rent seeking and actual rent dissipation in large volume. Recently, performance improvements have occurred under an altered regime emanating from what has been outlined above already. Nonetheless, ambivalence has continued to prevail as to a significant role assigned to 'indigenous' or locally-owned firms of non-Bumiputera origin in Malaysia's economy, *other than as supporting industries*, which has been apparent in the identification by the Malaysian government of at least three major problems (MITI 1996, p. 9): conflicting with the redistributive aims of economic policy, the limited technological capabilities of such firms, hence a lack of local marketable R&D activities, and the difficulty these firms face in accessing international markets, seen as a precondition for further development in an era of globalization.

We may observe however that the perception of 'suppliers at best' and as a consequence little government attention has not hampered the development of such local enterprise to a level of being able to take the lead in the formation of new industries that had not been specifically targeted by government policy yet constitutes a useful segment in the industrial structure. The contrary seems to be the case. Going against some of the official assumptions, ironically, the other side of the state direction of new industrial development with specific targets coin is the 'state-less' evolution of new industry, with a degree of private sector direction that has obstructed heavy government involvement. Our account of the automation industry below reveals some of the mechanics behind the alternative development path.

The automation industry in the Penang Complex

Penang's Industrial Transformation

The rapid rise of Penang (figure 1) as 'Silicon Island' was closely related to the EOI-drive, especially in microelectronics, in the early 1980s (van Grunsven & van Westen, 2000). In the 1970s two Export Processing Zones were instituted by the local government to propel a FDI-driven export oriented industrialization process. In the following three decades the complex has rapidly expanded (table 1). Cooperating with the State government, the Penang Development Corporation (PDC) has played a vital role in attracting foreign investors (Haggard, Pao Li and Ong, 1998). The industrial history of the

complex can be divided into – it seems – three major stages, each of which shows differential characteristics, yet builds on the path followed earlier.

Figure 1 The Penang Export Manufacturing Complex

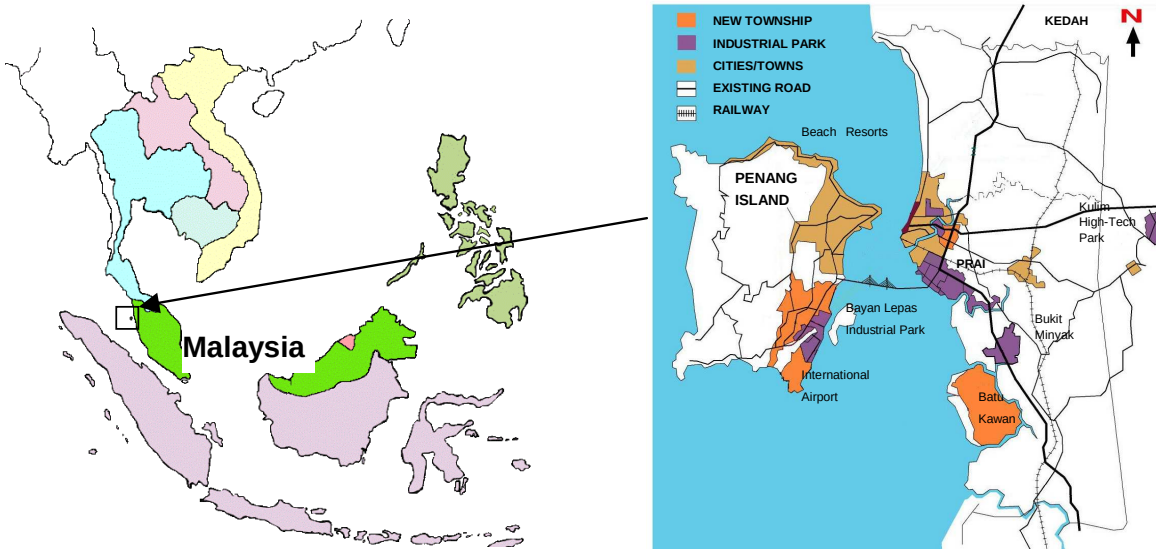


Table 1 Penang Industrial Growth

	1970	1990	2003	growth 1990-2003
(A) No. of Factories (in PDC Industrial Parks)	31	430	713	66%
(B) Employment	3,000	100,953	154,121	53%
(C) Paid-Up Capital (RM)	-	1.1B	7.7B	600%

Source: Invest Penang

During the first 'branch plant economy' stage in the 1970s, it developed into a satellite platform as multinational firms from all over the world (but in majority American and European) located in the region. The firms that were present at the first stage could be grouped into three major types of industries: textiles and garments, semiconductors and consumer electronics. All these were known for their labour-intensive character.

During the second stage, lasting from the mid-1980s till the late 1990s, the complex transformed into a more integrated production economy. Several developments coincided during this period. First, a human resources, capital and technological deepening in industries occurred. Second, the industrial structure underwent diversification with the insertion of new industries (although within the same techno-industrial path). One of the industries that played an important role during this stage was the hard disk drive industry (Haggard, Pao Li and Ong, 1998). Third, functional diversification took place to some extent. Fourth, a more extensive and sophisticated supply structure developed around key firms/industries. Not only a range of suppliers were attracted to the region in a co-location process, but also foreign investors build up fruitful relations with local Malaysian suppliers, part of the first stage of local spin-off. This contributed to a process in which new industries dominated by local firms started to flourish, aided by systemic coordination deeper and more extensive than elsewhere in Malaysia (Rasiah, 2001, 2002). One case is the machine tools industry. Thus the region developed into a mix of a satellite platform district and a hub-and-spoke district (Best 1999; Rasiah 2001, 2002; Haggard, Lim & Ong 1998; Doner & Ritchie 2002). As we will see in the subsequent discussion, the genesis of the

automation industry rests very much on the foundation of the local support industry.

Besides having been hit several times by a negative business cycle in its main industries, leading to substantial layoffs, in the post Asia Crisis period the complex appears to have become structurally more volatile. It seems to have entered a third phase as the competitiveness profile (Ong 2000) and new industry drivers have begun to alter what had been build up during the previous stage. In the area of human resources an increasing shortage and higher costs of both unskilled and skilled workers have combined with a short supply of knowledge workers of all kinds as skills formation has been based predominantly on the prevailing technological trajectory. Dynamism has been 'tested' by these factors. Turnover of establishments in the main industries has been on the increase. However, some of the key-industries developed in the first phase have maintained a remarkable local presence, in particular the semiconductor industry. Overall, the complex has kept its resilience. Corroborated by the analysis of the automation industry presented below, many of the local companies build up in the earlier supplier-oriented diversification process have survived new strategies of foreign lead firms. Also, there has been a further development of new variety through local initiative. Photonics, opto-electronics, computer and software development, and industrial automation are part of this new variety (SERI, 2002, 2004).

Development of the automation industry

There is now a rather substantial automation equipment industry in Malaysia in general and in Penang in particular. Still, until the research upon which the analysis below is based little was known about its genesis, its composition, characteristics etc. In discussions with local officials and academics in the framework of a project on the dynamics of the manufacturing complex frequently stories were heard about rapid growth of this industry (mostly based on hear-say though). This prompted us to initiate a pilot study aiming to uncover – some of – the development story of the industry. This study was carried out in the course of 2005[1]. A review of industrial policy in the initial phase revealed that not only the industry had not been targeted for 'state-guided' development, but also it got hardly any mention in the Second Industrial Master Plan. A chapter on machinery industry was conspicuously absent from the Plan, although it received some mention in the context of local support industries (as part of the foundation for developing targeted industry clusters).

A necessary step in the study was the identification and making an inventory of firms that could be considered part of the industry. A number of criteria (predominantly related to products manufactured) were applied to a range of sources (such as company lists available from the industry division of Penang Development Corporation, from the local Federation of machinery producers, resource persons etc.). This resulted in close to forty company names in the Penang region. These were subsequently all contacted by phone to verify their classification as (industrial) automation firm. A few had to be removed from the list; the remainder were approached for an interview. A good response rate resulted in 27 completed interviews. On the basis of these interviews an empirical database can be compiled on the large majority of the firms in the industry in the Penang complex. It should be noted however that the numbers mentioned above may not accurately reflect the size and dynamics of the industry (in the local context). For one, we may have overlooked some firms in the identification exercise; also, as no exit data could be uncovered, no insight exists as yet into firms that had entered the industry at some stage but had already exited before the listing was compiled.

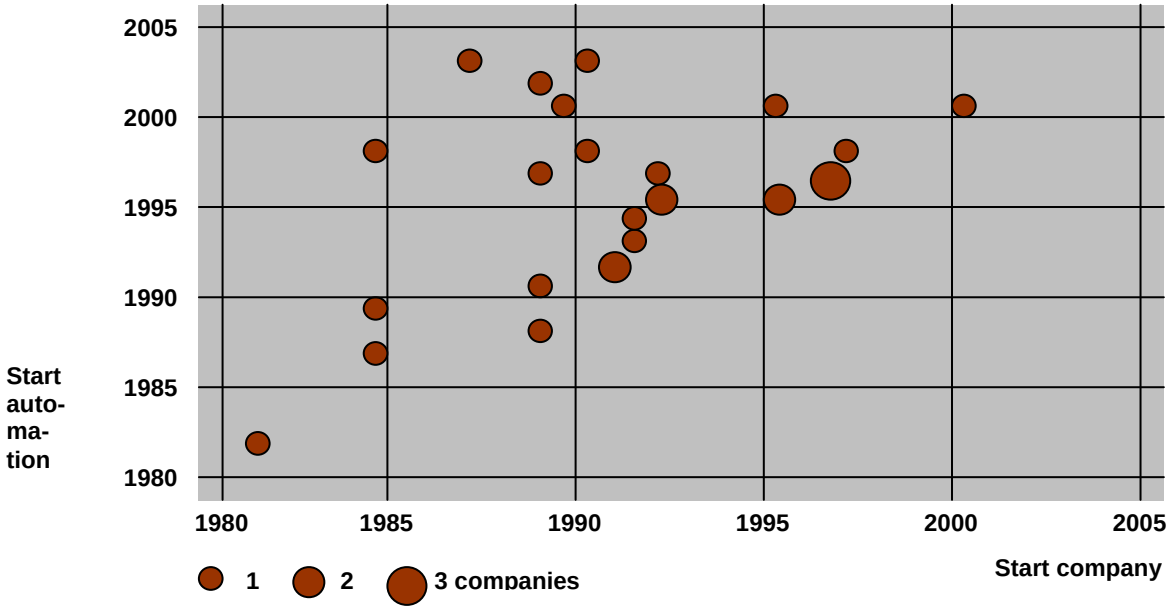
Below we present findings of the interviews conducted, relevant to the discussion here. Of the 27 interviewed firms only two proved to be of foreign origin, one from Japan and the other from Canada. Although both are subsidiaries of reputable international companies in the industry (Advantest and ATS Automation), the negligible number of MNC establishments demonstrates that the industry has neither been fuelled by a significant FDI inflow, let alone been built on that. Furthermore, operations of the two foreign firms in Penang are rather small scale.

A first analysis of local firms shows these to be a heterogeneous lot, in more than one way. Yet it unveals clearly the genesis and development of the industry as an evolutionary process with a decisive

[1] The research assistance of Ms. Marscha Aaldering, Masters student in the Faculty of Geosciences, Utrecht University, is gratefully acknowledged here, as well as local support provided by Prof. Goh Ban Lee of the School of Social Sciences, Universiti Sains Malaysia.

role played by local dynamic – Chinese – entrepreneurship in symbiosis with selected hub firms in the local base of MNCs which have maintained a significant presence in the complex until today. Significantly, in about two-thirds of the interviewed cases entry into the automation industry involved already existing companies for which automation was a *diversification* from the hitherto product-portfolio. The remainder (a minority) were *de novo* firms. As figure 2 demonstrates, the genesis of (industrial) automation activities in the firms interviewed may be situated in most cases during the 1990s; in a number of cases even more recently and in only three cases before 1990. But in a substantial number of cases the origin of the company dates (much) further back, i.e. there is a (substantial) time lapse between the (original) establishment of the company and the start of activities in (industrial) automation. It may be noted here that there is no clear pattern indicating that *de novo* firms were established more recently vis à vis the start of automation activities in the other set of firms.

Figure 2 *Automation firms in Penang: start of automation activities relative to start of the company*



Diversifying firms had almost invariably originated earlier through local Chinese entrepreneurship engaging in the production of machine tools, machine parts, metal components, precision components, jigs & fixtures, precision tooling etc. In a number of cases this is still the core business of the company, in other cases automation is now the core business but the other products are still part of the total product portfolio. In yet other cases the company has diversified further after having successfully gone into the industrial automation branch. Logically, most of the eight or so *de novo* firms had a less broad range of activities, although a few have grown rapidly and have started to diversify within and beyond automation. We encountered a range of organizational structures of companies. Given the practice of local Chinese firms to organize different or separate lines of business in individual corporate entities, only a minority of pre-existing diversifying firms still have a simple one-corporate entity structure. More common among these companies is a group structure. That is, companies consist of a varying number of subsidiaries with a holding company as the formal owner (e.g., LKT Industrial Berhad, which is among the largest and most well known local companies in the complex).

Three of the *de novo* companies have also assumed a group structure, reflecting either diversification *within* automation in the growth process, or diversification *beyond, but linked to* automation in rapid growth. An example of the former is ViTrox Corporation, one of the most recently established companies in the industry that has grown rapidly in large part specializing in high-speed machine vision inspection systems for the semiconductor industry. An example of the latter is PentaMaster, an often quoted success story in the industry, not only in Penang but in Malaysia as such.

We will return to these organizational structures when we discuss capability development in the companies.

Generally, the establishment of most companies, both diversifying and *de novo* ones, conforms very much to the mechanisms found in the 'evolutionary model'. As to the diversifying companies, the founder or founders of most of them had an employment history in one of the MNCs in the complex. Only a few outlined a different background (like founder has experience gained earlier in related activities) or stated that the history of the company went back to as far as the pre-MNC period (like been established in the 1950s as a foundry). Strikingly, the semiconductor industry was mentioned in many cases as where the founder(s) had been employed prior to setting up the company; even more strikingly, Intel Penang was mentioned very frequently in this context. Mostly, entrepreneurs were driven by the desire to set up an own company on the basis of the experience gained in the MNC and the market opportunities present (in which the former employer also played a role as our findings show).

The information obtained on the background of these companies and their founders/owners confirms that a substantial local support industry, consisting of local firms, has co-evolved with the operations of MNCs in a number of industries in the complex. Secondly, it reveals that employee start-ups have played a significant role here; that is, the background of founders/owners shows substantial spinout from MNCs to be a major mechanism. Thirdly, but not most relevant to the topic under discussion, it also reveals that probably only a small number of 'hub' firms are responsible for this. Intel Penang in particular is taking the position as the major spawning firm in this aspect. For the explanation of this, we may refer back to Rasiah's 1999 account of the development of a local supporting industry in Penang, the company Eng Teknologi in particular. As for the mechanisms underlying the establishment of firms that at a later stage diversified as described by Rasiah (1999, 2001b, 2001c), specifically a significant role that should be afforded to systemic coordination and thus to the (local) state, this is not really corroborated by the findings of our study. From the accounts given by the respondents as to how diversification came about (see below), it is apparent that systemic coordination did not play a significant role in this. In this context it may be observed that not until last year through private-public initiative a 'Penang Automation Cluster' (PAC) was established, aiming at collective action in addressing issues currently facing the industry. We will return to this development later.

Also in the more recent establishment of *de novo* firms hardly any evidence of a role played by systemic coordination was found. A similar process of spawning of spinouts from a set of MNCs operating in the complex accounts for most of these firms. Founders were mostly former employees of MNCs (frequently in the semiconductor industry) turned entrepreneur (for similar reasons as the founders of diversifying firms). They often possessed substantial engineering skills. Later we will address the question how they managed to jumpstart their own business. In some cases it took several steps to establish the current company. One example is Pentamaster. The current CEOs - and co-founders - had both served as automation engineers for National Semiconductor and Intel Technology Malaysia, both specializing in different fields. They left these companies to set up the company Penta-Electronics, with a third partner. After a few years it became apparent that the three founders had different ideas as to the direction of development of the company. It was then decided to discontinue the cooperation among the three. Two went on to establish Pentamaster; the third partner continued the original company with a different name, Pentatronics Technology System. The latter company until today has remained quite small, while Pentamaster became one of the leading companies in the local industry, earning the co-founders several times an award as Entrepreneur of the Year.

From the above account when seen in the light of an evolutionary economic perspective on the *spatial* formation of new industries it becomes clear why Penang has become a major location (in Malaysia) for the development of an automation industry. We asked the respondents of the companies whether they thought there were specific advantages of Penang (as a region) as to going into automation. Many mentioned the local labour market (availability of skilled labour, partly through inter-firm mobility) and the 'technology environment', derived from the general industrial profile of the region. Inter-firm networking is to some extent present, and appears also to play a role in the operation of firms. We will make a few more observations on this below. Agglomeration/localization economies have to some extent been at work. However, in the context of the topic under discussion, these are more notes on the side. As table 2 shows, varying origin of companies, of (the role of) automation activities and of the development of companies are reflected in substantial differences in the share of automation

in the total product portfolio, as well as in the share of employees in automation. The table also reveals substantial heterogeneity in terms of size (measured by number of workers).

While the above indicates the 'origin' of entrants into the industry we still have to deal with the 'conditions' governing entry. As to diversifying firms, the data suggest that moving into industrial automation was often client-driven. Reason for diversification was only to some extent declining profitability or uncertain market prospects of other lines of business, but most often specific demand from customers of these other lines of business (see table 2). This is reflected in the fact that many still operate on a custom basis. Not many focus fully on standard OEM/OBM production, being customer- rather than product-oriented. As MNC establishments in industries marked by rapid technological development of products (e.g. semiconductor, HDD) increasingly required *rapid* process adjustments, the tendency has in part been to look for opportunities for this locally and to extend local product procurement. This however at the same time led to the emergence of Penang and Malaysia at large as a significant market in its own right. This has been 'used' by at least a number of companies to develop the product portfolio from custom (only) to an increasing proportion of standard and own brand products. Most of the diversifying firms perceived that they could meet the challenges that their clients put in front of them, as with respect to the necessary capabilities/competences they already had a foundation to build on, acquired in related other lines of business. As capability extension rather than building a completely new set of capabilities was involved most companies perceived a rather short learning process.

It may be noted in this context, that in many cases engage in a discussion about capabilities and competencies was not so easy given varying interpretations. Asked in an open manner, many companies themselves often perceived their capabilities and competences as related to the range/nature/ quality/specifications of equipment on the production floor. This is also how many companies 'advertise' their capabilities in brochures and on their website. Such embodied capabilities obviously are only part of the picture. Only a few companies – in the capabilities section of their website for instance – referred to the ability to come up with effective *solutions* (be it design, technology, hardware tolerances, hardware-software integration etc.) in the context of projects awarded to them by clients, and related capabilities categorized in the literature. As to these, it was apparent from the interviews that clients assisted virtually all companies in the initial phase of going into full systems supply. This took the forms of design support, the opportunity to observe on the client's production floor, having their engineers stationed in the supplying company for the duration of the project, etc. Table 3 shows the main findings as to capabilities and technology development. Most companies felt that capability/competencies extension was primarily a matter of intra-firm learning (internal training offered to employees, learning by doing, etc.). In some cases, the solution to capability/knowledge deficiencies was sought in tapping into the local worker mobility process through which skilled workers previously employed in competing companies were brought in, or tapping into international skilled worker flows. Regular discussions with clients about product specifications, technical matters etc., was mentioned very often as an important component of the overall learning process. Strikingly, inter-firm collaborative networking or – simpler – inter-firm knowledge exchange was hardly mentioned as a mechanism for learning and extension of capabilities/competencies. Also strikingly, none of the interviewed companies in this category acknowledged a role of government (in the form of systemic coordination involving e.g. collective training programs, financial assistance, etc.) in the process of capability extension. We will come back to inter-firm networking after having briefly considered *de novo* companies.

As to *de novo* companies entrepreneurship by venturing out on their own was certainly not discouraged by the former employer; yet, the findings suggest that only in the case of a *small* number of such spinouts the former employer has constituted the initial node in a market network through which *inter alia* orders had to be secured (see table 2). As revealed in the interviews, in most cases the business did not develop through orders secured from the company where the founder(s) had worked previously (and the expectation that support in this form would continue for some time). Thus, founders of local *de novo* dedicated firms apparently could not always bank on incumbent firms as an initial market opportunity. This suggests that most such companies introduce new activities in the production system rather than being a division that is being outsourced but still fully dependent on the mother firm. Firms with new activities are the driving force behind an endogenous evolutionary development as they broaden and deepen the competencies available. Market and product opportunity were mentioned frequently as driver to venture out on their own, suggesting that *de novo* companies are more product-oriented and seek

out niche markets. The fact that custom products feature less prominently in the product portfolio of these companies and more often offer OBM might lend some support to such an interpretation. Likewise, the orientation of their product portfolio also does.

In the case of this set of companies, initial capabilities are very much based on the skills 'transferred' by the founding entrepreneur(s) from the company of the previous employer, or businesses the entrepreneur had been involved in earlier. While these companies do not show a significantly different pattern of learning it may be assumed that they are marked by a different learning process and curve, to the extent that they lacked the foundation of capabilities/competencies acquired in *related* business. Yet, it appears that the product and technological knowledge that entrepreneurs were able to 'transfer' to their own firm has provided sufficient compensation and the basis for product-oriented research and development, resulting in niche products. More detailed analysis of the findings indeed suggests that de novo firms do not perform significantly different compared to diversifying companies, perhaps even better. One characteristic that may be taken as an indicator of performance is export propensity. A independent samples t-test was carried out on this characteristic with diversifying/de novo as grouping variable. The resulting t-score (-.882, with α=0.05 and under the assumption of equal variance) remains well within the non-significance range (indicated by the upper and lower limits of value with 23 degrees of freedom; the two foreign subsidiaries were excluded from this analysis). Thus there is ni significant difference between the two groups as to the mean export propensity. It may be noted that de novo firms nonetheless have a lower mean export propensity compared to diversifying companies (45 versus 52%). Another characteristic that may be considered in this context is the company rating of capabilities. We asked companies to rate their capability on a 5-point scale on a number of aspects: market monitoring; marketing; design; custom/odm/obm production, low-/middle-/high-end; mechanical and system aspects; software integration and integration of new technology. As to non-production aspects the two groups do not differ to a substantial degree in terms of average rating score of capability. A simple cross-tabulation shows de novo firms to focus relatively more on production of standard machinery. This is translated in de novo firms engaging relatively more in odm and obm and less in custom production, especially lower-end. Again, similar t-tests were carried out with each of the aspects listed above as test variables and diversifying/de novo as grouping variable. The t-scores obtained on each of the aspects again lead to the conclusion that there are no significant differences between the two groups in capabilities (according to their own rating, whereby the element of subjectivity however may cause some distortion). Finally, on this subject it may be noted that a substantially larger proportion of de novo firms disagreed with the proposition that current capabilities are still rather shallow and narrow respectively.

We return briefly to the point of inter-firm relationships in the industry as a channel of knowledge transfer and learning/capability development. While the recently established Penang Automation Cluster to some extent functions as a platform for inter-firm collaboration, it is still in its infancy and rather circumscribed as to its aims (see later). Links between firms in the industry have developed and to some extent influence the functioning of the industry in the local context. Confronted with the question of heterogeneity in a dialogue between the author and some representatives of the industry[2], it was expressed that, while a distinction can be made between large and small operators, being small should not be interpreted as weak, or less strong with less growth potential. They see the structure of the industry as essentially tiered, with the first tier consisting the largest firms in terms of capitalization and market penetration. A second tier consists of not only strong local suppliers but also the smaller local automation houses. It was maintained that the latter are linked to the first tier in several ways, principally through outsourcing of work by first tier companies. Second tier companies thus have first tier companies in their market base. It was stated that the second tier principally carries out standardized work for the first tier. As the chairman of PAC expressed it: "Small firms fulfil a useful function in the industry, allowing us (the first tier) to shift the 'headache work' elsewhere, thus lowering costs" [3]. As there is no need for it, in the relationship between larger and smaller companies thus little knowledge is actually transferred, and learning by small companies from larger companies is minimal. In reverse, as outsourcing is not based on small firms possessing specialized knowledge/competences that is of use to the large companies, there is little learning by large companies from smaller ones. We will again address inter-firm collaboration when we consider market development below.

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2 Summer 2006, discussion with Chairman and governing council of the Penang Automation Cluster

3 Ibid

Table 2 Penang Automation firms: Selected Characteristics A (na = not available)

	Automation share product-portfolio	Custom/ Standard Products	Own brand	Export	Employees Company/ Group	Employees Automation	Reason introduction/diversification	First client(s) related to employment history?
Advantest Engineering Malaysia	100%	standard	yes	65%	30	30	Market	Na
ATS Automation Malaysia	100%	standard	yes	80%	50	50	Market	Na
Excel Precision	100%	both	yes	80%	90	90	market opportunity	Na
Polytool Integration	100%	both	yes	50%	300	na	market, demand from clients other business	no, to other activities
Greatech Automation	80%	standard	yes	60%	350	130	competition in parts market	no, to other activities
K.K.Choong Engineering	50%	custom	no	30%	60	20	market, demand from clients other business	no
Lis-Tec	35%	custom	no	40%	70	15	market, demand from clients other business	no, to other activities
Alpha Master (M)	15%	custom	no	0%	na	4	market opportunity	no, to other activities
Splendid Growth (M)	100%	custom	no	20%	15	15	market	partly, clients were earlier also clients of previous companies of founder
LKT Automation	100%	standard	yes	80%	na	175	market, demand from clients other business	no, to other activities
Pentatronics Technology System	80%	custom	no	30%	20	15	clients other business	no, to other activities
PentaMaster	80%	standard	yes	70%	300	200	market	no
ER Mekatron	100%	custom	no	50%	40	40	originally expansion from Singapore; later taken over	related to Singapore entrepreneur
Hillton Precision Engineering	60%	custom	no	40%	21	15	clients other business	yes
Gops Equipment Designer	50%	custom	no	10%	na	25	clients other business	no
JSI Systems	100%	custom	yes	50%	15	15	market	no
Vista Equipment Manufacturing	Na	custom	no	70%	100	10	market	no, to other activities group
Brusia Engineering	30%	custom	no	0%	na	na	market	yes
Micro Modular System	100%	both	yes	70%	60	60	market	no, to clients of sister company
UWC Automation	10%	standard	no	0%	na	35	market	no, to other activities group
AT Automation Technology	100%	both	no	30%	150	150	market	no
Wanjun Technology	30%	custom	no	20%	60	10	more value added; safety net	yes
Zoomic Automation	70%	custom	no	50%	60	40	clients	partly
ViTrox Corporation	100%	both	yes	40%	48	48	product opportunity	yes, were working in the same MNC
Prodelcon/Multimatic Systems	30%	both	yes	70%	240	15	clients	yes, but not previous employer; rather existing network
SRM Integration (M)	100%	both	yes	50%	60	60	na	yes
Epsilon Technology (M)	48%	custom	no	70%	70	20	clients	yes

Table3 Penang Automation Firms: Selected Characteristics B

	Capabilities			Acquired capabilities/learning					Role	Technology Development
	Custom	ODM	OBM	Intra-firm learning	workers other firms	workers abroad	clients discuss	obser-vation	govern-ment	
Advantest Engineering Malaysia	high	high	high	yes	yes	yes	yes	yes	no	from parent
ATS Automation Malaysia	high	high	high	yes	yes	yes	yes	yes	no	from parent
Excel Precision	good	good	good	yes	yes	no	yes	no	no	learning by doing
Polytool Integration	high	good	na	yes	no	no	yes	no	no	learning by doing, needs of clients, from abroad
Greatech Automation	high	good	good	yes	yes	yes	yes	no	no	learning by doing, needs of clients, from abroad
K.K.Choong Engineering	good	na	na	yes	no	no	yes	no	no	learning by doing
Lis-Tec	fair	na	na	yes	yes	no	yes	yes	no	learning by doing, networking
Alpha Master (M)	na	na	na	yes	no	no	yes	no	no	learning by doing, needs of clients, from abroad
Splendid Growth (M)	fair	na	na	yes	no	yes	yes	no	no	learning by doing, collaboration with local university
LKT Automation	high	high	high	yes	yes	yes	yes	yes	no	learning by doing, needs of clients, from abroad
Pentatronics Technology System	good	na	na	yes	no	no	yes	yes	no	learning by doing, networking
PentaMaster	high	high	high	yes	no	no	yes	no	no	learning by doing, needs of clients
ER Mekatron	good	na	na	yes	no	no	yes	yes	no	learning by doing, needs of clients
Hillton Precision Engineering	medium	na	na	yes	no	no	yes	yes	no	client specifications, tracking market developments
Gops Equipment Designer	medium	na	na	yes	yes	no	yes	yes	no	acquire skilled labour
JSI Systems	good	good	good	yes	no	yes	yes	no	no	learning by doing, needs of clients
Vista Equipment Manufacturing	good	na	na	yes	no	yes	yes	yes	no	learning by doing, needs of clients
Brusia Engineering	good	good	na	yes	yes	yes	yes	no	no	learning by doing
Micro Modular System	good	good	good	yes	no	yes	yes	no	no	work with MNCs, needs of clients
UWC Automation	medium	medium	na	yes	no	no	yes	no	no	client specifications, tracking market developments
AT Automation Technology	medium	good	na	yes	no	no	yes	no	no	learning by doing
Wanjun Technology	medium	na	na	yes	yes	yes	yes	no	no	acquire skilled labour
Zoomic Automation	high	na	na	yes	yes	yes	yes	yes	no	learning by doing
ViTrox Corporation	good	high	high	yes	no	no	yes	yes	no	learning by doing
Prodelcon/Multimatic Systems	high	high	high	yes	yes	yes	yes	yes	no	know how from clients
SRM Integration (M)	na	good	good	yes	yes	yes	yes	yes	no	client specifications, tracking market developments
Epsilon Technology (M)	high	na	na	yes	no	no	yes	yes	no	trial/error; discussions clients

n.a. not applicable

Notwithstanding the young age of the industry, dynamic trends have been occurring already. These concern (amongst others) the following: 1) technological composition of the product portfolio, 2) type of products, 3) type of markets, and 4) geography of markets. As to the first aspect, many companies indicated that they had started out with rather simple machines/systems in terms of technological content, design, systems integration etc.; but they had managed to move already to more complex machines/systems along with their learning trajectory and capability development. Over the past decade or so, companies were able to enhance capabilities in design; a number subsequently had expanded also into research and development to support the business partnerships with existing clients in the region and to be able to expand the client portfolio. This is reflected in a widening of the product portfolio from made to order only (on the basis of clients specifications) to a more diversified one, including own design and own brand manufacturing (table 2). However, most companies acknowledged that they do not yet have the ability to serve the high-end segment of markets. As noted earlier, *de novo* firms generally appear to be more specialized on a limited range of products for specific processes serving 'niche' markets. Nevertheless, also these companies stated that they still mostly served the low- and middle-end segments of markets.

The higher degree of specialization of *de novo* companies seems to limit them to a narrower range in terms of types of markets. From the findings it is quite apparent that the industry has already developed a significant export capability; for many companies the local market is still important – especially for the smaller ones – but only a few companies do not export part of their output. As the data show (table 2), export varies from as much as 80% to as low as only 10% of output. Export signals that already a significant geographical shift of markets is taking place. Many companies commented that the local market actually has limited growth opportunities. In part, this is associated with the relocation of MNC establishments in client industries from Malaysia to elsewhere in the region, especially China (for cost reasons). Thus far it appears that relocation has not (yet) affected the client base as on the one hand relocated MNCs still turn to Penang companies for automation services and on the other hand automation companies have followed MNC clients to the new location. Over half of the companies already have established operations in China, not only marketing/sales and service offices but in a number of cases also manufacturing units. Such overseas presence is used not only to serve existing clients but also to look for new opportunities in the growing market in China. Some companies foresee that in due time production is going to be shifted entirely to China, unless new markets in Malaysia (and elsewhere) can be tapped.

For another part local market perception reflects the initial focus of markets on two (local) industries: semiconductor and hard disk drives (focusing on machinery/systems for back-end rather than front-end processes). This is in line with the background of many of the founders. Gradually however, companies seek to diversify markets to different industries, like the medical devices industry, opto-electronics, photonics and others.

It is precisely for the purpose of further market development that the industry and the State government (in the form of Invest Penang) have recently joined hands to form the Penang Automation Cluster. At this point a few further observations may be offered about its establishment and functioning. Notwithstanding minimal attention in federal policy, the involvement of the State government testifies that locally the developments in the industry have not gone unnoticed in economic/industrial management circles. The establishment of the cluster on the one hand acknowledges the potential of the industry by the State government. From the perspective of the industry, it is driven mainly – as noted earlier – by collective efficiency considerations in addressing pressing issues concerning the future of the industry, especially markets and skills of the entrepreneurs in capturing new markets. An observation here is that the role of the State – rather than a steering one – appears to be limited to providing (logistical) support. Assistance in the penetration of international and new industry markets appears to be the main focus. There is no attempt at systemic coordination. Another observation is that broad collective action throughout the industry currently appears to be constrained. As it is, some autonomously developed 'realities' in the industry appear to have translated in the current (lack of) participation in the cluster. Typically, the industry 'elite' has been most active in advocating the establishment of the cluster and has taken a lead role since its establishment. Membership is thus far limited and biased towards the larger companies and a number of key suppliers. Apparently, the heterogeneity and perceived tiered structure of the industry currently militates against broader collectiveness. Broader participation is one

of the stated items on the development agenda of the cluster committee. In its perception, an important avenue for this is by offering positive spillovers, e.g. more knowledge transfer within the industry by organizing seminars to be conducted by the larger players (personal communication). In view of the current structure of inter-firm relations, it remains to be seen whether this will materialize. Unequal strength, also reflected and translated into divergent interests and orientations of players in the industry, may continue to obstruct the cluster agenda. It will be interesting to see what trajectory the industry will actually follow. If markets continue to change as they already have over the past five years or so, despite the role small companies fulfill in the industry, heterogeneity – if left unattended – may well result in the shakeout predicted in the evolutionary life cycle model. Leading to the interesting question which firms will be among the survivors and which will exit, and whether entry will continue nevertheless.

Conclusion

A basic premise inspiring this paper is that at the current stage of late industrialization in Southeast Asia alternative 'models' of development of new (especially high tech) industries are emerging. On the basis of the industrial automation industry in Penang we propose that a 'model' of autonomous evolution is gaining relevance vis-à-vis the idea of planned state-orchestrated, or – milder – state assisted industry development. In the introduction we posed some questions concerning the development of the automation industry in Penang according to a 'evolutionary model'. First, if the automation industry in Penang (and Malaysia at large) is marked by a different development 'mode', more in line with findings from evolutionary economic research into the evolution of industries, then how does this mode (and path) exactly look like? Second, what are the implications for our thinking on 'remaking' late industrialization, specifically the prospects for greater indigenization of industry development, and to what extent can such policy be replicated elsewhere?

Though wide-ranging, a 'limitation' of the discussion above is the focus on the 'birth' of the industry, necessary because of its 'infancy' stage of development. At the current juncture it is not possible (yet) to research the full richness of an evolutionary economic interpretation of new industry development. The findings of the current research, revealing 'evolutionary mechanisms' of initial development although in somewhat modified form compared to models, certainly encourage further longitudinal study of the industry. We have seen that new firm formation is indeed driven by spinout that introduces new activities in the local production system hereby diversifying and deepening the competencies available. The current state of the industry appears to be that many local automation companies now have the technical know-how in-house to export medium to increasingly more advanced technology equipment to MNCs in the rest of the region – and mature markets as well – given two major advantages. First, they have acquired the competencies to produce quality-automated equipment and therefore do less need transfer of technology from overseas. Second, the industry has the capability to produce good quality automated equipment at competitive prices. The industrial base that developed in Penang in subsequent phases of its development and the propensities of a set of MNC firms have done much to provide the necessary conditions for automation (companies) to develop and grow. However, this is not the same as saying that FDI is a necessary driver. Rather, one of the implications of the story told above appears to be that new high tech industries can develop without attracting investments by foreign companies in the industries concerned. Another implication appears to be that greater indigenization is possible without *planned* industry development employing selective interventions directed to targeted industries, firms or activities.

At the present juncture only some initial thoughts can be offered as to implications for industrial policy. The case study has revealed that the automation industry could emerge without any explicit industrial policy of systemic coordination. Following from our analysis we conceive the prospect of an 'evolutionary' industrial policy that moves away from 'creation' as dealt with in the earlier sections of this paper. This is a difficult message. A point to note here that within the framework of export oriented (originally FDI-driven) industrialization, governments still very often look at local firms only from the perspective of growing local support industries (seen as necessary to tie MNCs to the locale). So far, rarely policy circles have perceived localized hub and spoke systems as a potential breeding ground for new (high-tech) industries, i.e. the potential of evolution of new industries from the existing industrial

base through diversification and spinout.

An argument that governments at all levels should develop such awareness and should direct efforts at promoting a conducive environment would seems to bring us back directly to some of the government assisted models of industry development. Yet, some industrial policies are straightforward within an evolutionary model, in particular, policies facilitating entrepreneurship, in particular, the encouragement of spinout. As it is, there is a tendency in industrial policy to address competitiveness issues by radical change, i.e. to create new industries and activities that constitute new variety that does not build on the resource and knowledge base as it has developed. We argue industrial policy that – also – nurtures new variety that has sprung up on regional assets built up in the previous stage and therefore representing an *incremental* change within the predominant technological trajectory pursued, rather than a radical departure from it.

Arguably government intervention could be directed to the lack of homogeneity of firms in the early stage of a co-evolved industry, to the underlying causes and potential implications for the longer-term development of the industry. In the particular case under study we have so far been able to 'see' only evolution at the stage of infancy. Further study involving longitudinal tracking of the population of firms is necessary to identify the exact development path of the industry at large and (subsets) of its constituent companies. If heterogeneity conforms to the early stage of the life cycle model, it may be assumed that sooner or later selection will occur. As our case demonstrates, heterogeneity appears to defy a common policy, directed to industry at large. In particular it renders collective efficiency based courses of action problematic. Instead, more promising could be courses of action that 'listen' to life cycle interpretations. Also those that 'listen' to recent insight into inter-firm knowledge network patterns in clusters, that suggests that different subsets of companies are marked by highly divergent inter-firm networks impinging not only on their performance but also on their longer term chance of survival and interest in (local) collective efficiency based initiatives. However, any further elaboration on this is beyond the scope of the discussion here. What matters most here is that the policy implications might be that interventions seem most beneficial and productive if directed to specific subsets of companies, or specific aspects. The question of the possibility of replication elsewhere in the industrial structure should also be seen in this light.

As to the prospects of late industrialization in Southeast Asia in the light of increasing relocation and competition from other countries in the region, there seems to be a double answer emanating from the case studied. On the one hand the observations arrived at in this study leads one to conclude that there are still a range of opportunities to bank on. On the other hand the analysis also points towards a number of limitations, at the micro-level translating ultimately also to the meso-level. It will be interesting to see whether in future dealing with these will be entrepreneurship rather than state-initiated.

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