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Aligning internal and external networks: Taiwan's specialization in IT

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Summary

This paper combines the approaches of political governance scholars and the national systems of innovation perspectives, to reassess the emergence of Taiwan's successful IT hardware industry. Reductionist views of seeing this as the result of either the pull of free market forces or the push of the state are rejected. The alternative of emphasising the role of governance through networks is accepted, but we stress the multiplicity of networks: global, national and local. The key to success is then seen as the stronger alignment among these various networks. Markets, firms and the state all played their part in this intensified alignment. The role of the state, which was particularly important in linking demand networks to supply ones, is seen as operating through indirect rather than direct links to firms and markets, and especially by encouraging human capital formation and spin-offs of people. In theoretical terms, we conclude there is an need to link political and evolutionary approaches.

1 INTRODUCTION

Our objective in this paper is to help explain the particularly successful performance of Taiwan in segments of the information technology (IT) industry. We present the successful specialization in IT by Taiwanese firms as the effective coupling and close alignment between the evolution of their national system, with its distinct network features and local network dimensions, and the global IT production networks of leading foreign computer firms. We thus perceive the basic ingredient in Taiwan's success in this area not just as a question of developing networks but of integrating locally and nationally emerging networks with global network structures. Instead of applying the prevalent state vs. market framework of analysis, a rather blunt instrument to capture the basic nature of Taiwanese development process, we shall examine the ways in which markets, firms and the state brought about the 'alignment' of these networks. In particular, we shall study the interactions between world market dynamics (ie, the demand network side) and the national structural context (ie, the supply network side).

2 THEORETICAL FRAMEWORKS

The analysis is guided partly by the political governance approach and partly by evolutionary theories of technical change. These two perspectives are amalgamated through the concept of governance, which we take to comprise both 'control' and 'structure'.

On the side of 'control', and from the vantage point of political and sectoral governance scholars, there exists a fundamental distinctiveness of 'industrial order' (Herrigel 1994) among the capitalist economies of countries. In this view there are fundamentally differing ways of organizing economies, with the major sources of such differences

usually being non-economic variables such as politics and culture.[i] It is a presumption of the political governance school that there should be some relationship between 'political governance' and responses of 'corporate governance'. Kitschelt (1991) describes this as 'translation', here it is a part of what we mean by 'alignment'.

Governance modes are conventionally divided into markets, hierarchies (both corporate and governmental) and networks (eg, Thompson *et al* 1992), which differ in the centralization or dispersion of 'control'. While attention has shifted in recent years to networks, not enough attention in our view has been given to the *multiplicity* of networks. Economic theories of governance, for their part, emphasize the boundaries of the firm, and the decision to 'make or buy'. The 'make or buy' decision may however be amalgamated with the political governance perspective, and the decision seen as one that may take place variously in firms, networks, or countries.

From the evolutionary perspective, the 'structure' of economic and technological systems and their relationship to produce growth can be assessed. Of particular relevance is the recent emphasis given to 'co-evolution' as between systems (Nelson 1994). This paper makes use of the 'national systems of innovation' approach (eg, Freeman 1987; Lundvall 1988; Nelson 1993), which emphasizes the diversity of institutions and their interlinkages to constitute an innovation system in a particular national or regional environment.

3 EXISTING APPLICATIONS OF THEORY TO TAIWANESE NETWORKS

Reductionist theories see the success of IT in Taiwan, and many other instances of catching up, as stemming from single factors such as 'state leadership' or 'free-market forces'. For reasons brought out in our subsequent analysis, we find these excessively simplistic. The strengths and limitations of existing approaches can be better assessed by

focusing upon the less reductionist perspectives, which do make considerable effort to include the network dimensions of the Taiwanese case. However, each tends to emphasize one kind of network dimension.

3.1 The global network dimension

The explanations here place the world market at the center of the analyses. They look at the ties existing between the production networks of the East Asian and advanced countries (especially the United States), and their effects upon East Asian technological and economic growth. Thus Hobday (1995), for example, analyses how world market integration through subcontracting acted as a training school for Taiwanese firms, enabling them to overcome technology and market entry barriers and to assimilate manufacturing and design technology. While Hobday focuses on the learning process taking place inside the subcontracting firms in East Asian NICs, Zysman *et al* (1997) explore the nature of the global production networks more from the perspective of the sourcing strategies of the US firms, analyzing East Asian and Taiwanese incorporation as a supply base into their production strategies and networks.

3.2 The national network dimension

It is the domestic structural dimension that political economy explanations of the Taiwanese industrial development process, such as those by Amsden (1985), Chu (1989), Cheng (1990), and Wade (1990), place right at the center of the analysis. Here the primary focus and unit of analysis is the state-firm relationship and the domestic political-institutional arrangement. Thus, for example, Amsden's state-centered approach historically analyses the political-institutional source of the Taiwanese 'developmental state' and its important contribution to Taiwan's development process. Others focus on the

broader relationship and interaction between the state and society (above all, firms) in terms of distinctive political regimes and institutional links, and the resulting effects on the industrial growth. In particular, Wade looks at the way in which the different sub-sectors of the electronics industry are organized and politically governed, arguing that the Taiwanese government's leadership of the market and the contribution of its public R&D institutes have been critical for the development process in Taiwan's electronics. The 'national innovation system' approach referred to above, which explores the efficiency of 'home bases' of firms in view of the relevant institutional interactions and as connected with countries' distinct patterns of technological innovation and specialization can be seen as emphasizing the national network in a different guise (for an analysis of the Taiwanese system of innovation, see Hou and Gee 1993).

3.3 The local network dimension

The familiar concept of local networks and clusters usually places the nature, depth and quality of regionally clustered inter-firm relations and the role of supporting networking institutions at the center of the analysis. Much emphasis is placed upon culture (eg, trust), geography, and the attainment of Marshallian 'external economies' (Harrison 1991). In the practical case of IT in Taiwan, the relevance relates to the much-acclaimed Hsinchu Science-Based Industrial Park (HSIP) for the IT development process.

3.4 Alignment of network dimensions

In our view, a truly comprehensive explanation of Taiwan's IT success entails an analysis of networks in all three dimensions - global, national, and local -as well as an examination of their complex interactions. By contrast, existing explanations of the Taiwanese (electronics) development process - each emphasizing differently the three

dimensions and the associated key factors like world market, technology, politics and institutions, geography and culture - remain partial explanations. Since each level has considerable plausibility *a priori*, the major challenge for us is then how to combine and integrate systematically all three network dimensions. We shall take them in the order just described.

For this purpose, we shall emphasize the historical dynamics and *alignment* of networks. Global, national, and local networks each critically mattered for Taiwan's electronics development process. Attention must be paid to both demand-oriented networks (the global IT production network as a form of market-pull dynamics) and supply-oriented networks (the Taiwanese system of innovation, including its manifestation in locally concentrated networks), as well as their dynamic and co-evolutionary interactions. Taiwanese IT performance turns out to have given rise to an unusually positive historical conjunction between the demand network and supply network sides. By using the concept of alignment, we shall be able to pay due attention to the co-evolutionary dynamics and mutually reinforcing supply- and demand-side driving forces behind Taiwan's IT development process.

4 GLOBAL NETWORKS: THE DEMAND SIDE

As is well known, Taiwan's industrial structure is organized predominantly around small- and medium-sized family enterprises (SMEs) and a few large firms and business groups, where even the latter are small by international standards. SME-based systems of production are frequently regarded as being potentially flexible but often constrained by deficiencies in one or other functional respect - sometimes in finance, sometimes in technology, sometimes in marketing, and so on. Yet Taiwan's success equals that of South Korea, whose industrial growth was built almost entirely on large, horizontally

diversified and vertically integrated business conglomerates (*chaebols*). One explanation for this has been the export-orientation of Taiwanese SMEs and their responsiveness to global markets and requirements.[ii]

4.1 The role of OEM production

In just under 20 years, Taiwan has emerged as the world's third largest producer of IT hardware products after the USA and Japan, and well ahead of Germany, France, Italy and Korea. The largest bulk of Taiwan's IT production is made up of monitors, notebooks, desktop personal computers (PCs) and motherboards, the combined value of which accounted for over 81% of Taiwan's PC hardware production in 1996 (*Asia IT Report*, December 1996, p4). Taiwan now produces one-third of the world's notebook computers and one-quarter of its desktops, and is also the world's largest maker of monitors, motherboards, keyboards, and image scanners.

This impressive performance is achieved mainly by Taiwan being tightly integrated into global subcontracting networks of the leading computer firms and its role as a major source of their original equipment manufacturing (OEM) and original design manufacturing (ODM). The Taiwanese IT industry is heavily dependent on OEM and ODM (which henceforth we combine and treat simply as OEM). Contrary to some earlier views about the dynamics of industry in such economies, the OEM proportion has been rising and that of own-brand manufacture (OBM) falling over time (Kraemer *et al* 1996, pp236-7; *Asia IT Report*, January 1997, p2). OEM-based export is now the predominant form of production and sales, even for Taiwan's largest IT business groups. Taiwan's IT firms are also overwhelmingly export market-oriented.

In spite of their awareness of the inherent disadvantages of OEM, as pointed out by Hobday (1997), this development trend is welcomed by the Taiwanese government organization, the Market Intelligence Center (MIC) at the Institute for Information Industry (III). It is also intended as Taiwan's current strategy to integrate itself more tightly into the global IT production network and thus to move up the value-added chain (*ibid*). To see why, we need to examine why Taiwan was well-fitted to entering the fray of the very demanding global IT markets.

4.2 World market opportunities

In the electronics and computer industry, much of Taiwan's export-oriented industrialization had benefited at first from early foreign direct investment (FDI), as the existence of TNCs and subcontracting opportunities induced the emergence of a large number of small- and medium-sized firms and traders. This induced the initial process of largely demand-pulled, buyer-oriented development of Taiwanese electronics and computer industries (Hobday 1995; Kraemer *et al* 1996; Chen and Sewell 1996). In the early 1980s, PC production was thus led by TNCs, as foreign computer makers invested in production facilities (Hobday 1995, p143). The global oligopolistic IT production networks which then emerged in earnest in the mid-1980s permitted the Taiwanese IT producers' full-scale breakthrough into the world market.

This followed from the change in the global IT business environment and technological property since the mid-1980s, that now rewards many of the key strengths of Taiwanese network system. Most of all, a technological 'window of opportunity' emerged out of the shift to open, non-proprietary computer systems (Bresnahan and Greenstein 1997), very much a *market-mediated* technical change. This allowed Taiwanese producers to build cheap IBM-compatible PCs, by making effective use of their networked production

system. This came about somewhat fortuitously, because the IBM PC, which became the dominant personal computer platform in the 1980s, had vertically disintegrated innovation and an 'open architecture', as IBM abandoned the vertically-integrated strategy it had used in other IT segments. The architecture was open in the sense that any firm could add hardware or software components to an IBM-compatible PC, which could be sourced externally through global production networks.

The resulting lowered entry barriers and the new horizontally-segmented industry structure created by the PC revolution meant that many Taiwanese companies were able to compete in fast-growing market niches throughout the production chain (Ernst and O'Conner 1992, p58; Kraemer *et al* 1996, p216). A company could build a better or cheaper component, based on openly available technical standards, and find a buyer for it (*ibid*, pp244-5). The PC industry's attributes of (i) a complex knowledge base (requiring technology-product design and commercialization), (ii) high opportunity conditions (encouraging external network developments), and (iii) low appropriability conditions (encouraging entry) (Malerba and Orsenigo 1993) much suited the Taiwanese firms' fast followership strategy of imitation and production differentiation.

Their success in turn generated global IT market change, above all by becoming the 'Krupps of the computer wars' - a reference to the German arms maker who supplied all the combatants in World War I (Kraemer *et al* 1996, p237). This positive transformation of Taiwanese firms - away from being junior and subordinate subcontractors subject to leading computer firms to becoming important partners - is also evidenced today by their ambition to become 'full-service OEM suppliers'. Here they intend to 'lock' the leading foreign firms into their manufacturing services, and pursue a more interdependent relationship with the global IT production network; instead of their simple dependence on the globally sourcing computer firms.[iii]

Important in their rise as "key links in computerdom’s world value chain" (*Fortune* 8 August 1994, p51) has been not only the cheap price of their goods, but also the extensive technological improvement and specialization of Taiwanese firms, in particular in the product design area (Levy and Kuo 1991; Hobday 1995). Taiwan's competitive base and core competencies evolved quickly and progressively from low-cost competition and simple assembly activity at the beginning of the 1980s to the stronger design-capability based ODM system in the mid-1980s. Taiwan's closer integration of its exportable products into global production systems has therefore been facilitated, not by increased subservience to the leading-edge global companies, but by increased reliance on its own capabilities to design products that meet fast-moving needs of worldwide markets. We thus turn next to the internal production systems of governance that brought this situation about.

5 NATIONAL NETWORKS IN TAIWAN

The national foundation of Taiwanese firms' IT success derives from the distinctive network features of Taiwan's system of innovation and production, which are very much politically and culturally shaped. It is characterized by a combination of in-house experience, learning and development, with a wide variety of external sources of information and advice available through formal and informal networking.

5.1 Foreign influences and entrepreneurs in the IT sector

The apparently external influence of FDI described above worked through specific cultural factors within Taiwan. The system could have not expanded so quickly had it not been for Taiwan's typical Chinese entrepreneurial culture. Taiwan, once labelled as 'Boss Island' (Shieh 1992), where everybody's ultimate career goal appears to be entrepreneurship and becoming his own boss, was a particularly fertile ground in which dense subcontracting and trading networks could take root.

Locally owned subcontracting firms were created, as typically entrepreneurial Taiwanese managers formerly from the subsidiaries of foreign multinationals opened their own businesses, worked at the assembly operations, and quickly saw subcontracting opportunities to exploit with relatively little start-up capital. In the early 1960s, investments in consumer electronics assembly by large foreign-based TNCs, like General Instrument, Texas Instruments and Sanyo, led to the establishment of many local suppliers and subcontractors in Taiwan, many of whom later switched into becoming computer firms and traders (Lam 1992; Kraemer *et al* 1996, p236; CIER 1997, pp3-10).

These powerful TNCs were thus quickly surrounded by a large number of small, locally-owned subcontractors, who inundated them with offers of manufacturing services (Hobday 1995, p119). The new firms were usually undercapitalized, so instead of starting production as integrated manufacturers of computer products like keyboards, as in Korea (Levy and Kuo 1991, p365), they bought an absolute minimum of specialized equipment and relied on outside sources for other services they needed. This relatively small-scale production system gave Taiwanese computer-related product manufacturers tremendous flexibility in *what* they manufactured, to be able to respond swiftly to newly emerging profit opportunities and also to move on quickly to other products, once the market

reached satiation (Lam 1992). In this context, it is helpful to note that they are better seen as 'generic' manufacturers, keen to move into any other industry where they can make money, than as being specialized in one industry; as seen for example in the shift from consumer electronics to PC production (*ibid*, p315; Hsing 1996, p12).

On the technology side, the sophistication of these subcontracting firms so greatly improved that the initial TNC motivation of low-cost labor was transformed, as they augmented their engineering process and product design skills (Hobday 1995, p144). Technological upgrading came first from the 'trickle-down effect' from TNCs (Lam 1992, p321), ie, the diffusion of market and technology knowledge from them. The presence of the TNCs thus became "a university for future local entrepreneurs" (*ibid*, p368; CIER 1997, pp3-11). The quick upgrading of design capability by Taiwanese firms may also have much to do with this factor.

This process of both 'trickle-down' and active transfer of knowledge from leading foreign TNCs then allied with Taiwanese networks abroad, especially in the USA and Silicon Valley area, which provided valuable direct links with the markets of the US and an infusion of technology and modern management skills into Taiwan's economy. The Taiwanese and Chinese expatriates abroad have played such major roles both as overseas networks and returnees to Taiwan, crucial for connecting Taiwan's production system tightly with advanced market knowledge and technology, that they have been called "human resources on deposit".[iv] According to Dahlman and Sananikone (1990, p127), approximately 25% of Silicon Valley scientists and engineers are reputed to be of Chinese origin, working with some leading high-tech firms such as IBM and acquiring advanced technical expertise.

5.2 Political origins of the Taiwanese network system

One may then ask about the Taiwanese state's role in this process, as it may at first blush appear as if all this happened just through entrepreneurial activities and TNC-led market dynamics. The underpinnings of this Taiwanese network system are in large part political, in terms of both specific state policy actions and the dynamics of political regimes. These fostered a decentralized, predominantly SME-based industry structure, the strengthening of ties and networks through subsidizing public R&D and network organizations, and ultimately the 'linchpin' role of the Taiwanese state and parastatal institutions in the diffusion process in the national system.

The origins of this system go back to the political regime dynamics of the 1950s and 1960s and to subsequent state policy actions in the following decades, which helped create a dispersed, SME-predominant industry structure throughout the economy and tended to discourage the creation of large private firms. The latter have been suppressed in Taiwan by political regimes, whose dynamics stem from unique Taiwanese ethnic politics and the ruling Kuomintang party's ideological views on restraining private capital (Haggard 1988; Cheng 1990; Gereffi 1990; Amsden 1991).

The political leadership in Taiwan was determined to prevent the concentration of resources in private hands, believing that a small group of powerful businessmen who controlled a large share of private resources and the financial system had caused its downfall on the Mainland (Park 1990, p119). This bias against big private business firms in Taiwan was exacerbated by the ethnic differences between the Taiwanese business community and the Mandarin-dominated Kuomintang political elite (Cheng 1990; Amsden 1991). These ethnic politics and the determination of the leadership were then manifested in the proliferation of an extensive state enterprise sector in Taiwan (see

Wade 1990; Park 1990), as public enterprise has served to consolidate the power of the Mainlander bureaucracy from the beginning (Amsden 1985), making the state itself "the major capitalist in Taiwan" (Cheng 1990, p151; Chu 1989, pp666-7).

It is also within this context of Taiwanese political economy that state leadership for industry came to be vested mainly in public research organizations and enterprise offshoots from these organizations rather than with existing large private firms as in Korea.[v] The proportionately large national R&D burden shouldered by the state[vi] can be accounted for by the distinctively Taiwanese relationship between the industrial 'structure' and policy 'strategy'. Thus in Taiwan, economic officials have been constrained by the lack of an extensive web of channels to the private sector, because of the lack of a true coalition relationship between the state-based Mainlander minority elite and the Taiwanese industrial capitalists (Chu 1989, p666). Furthermore, nurturing large-scale capital in Taiwan would also have endangered the fragile but broad distributive coalition encompassing SMEs, farmers, state-sector employees, labor, and broadly defined consumer and household savers that the ideologues within the state endeavor to maintain (Chu 1989; Cheng 1990).

Unlike in Korea, the state was thus led to favor SMEs in its industrial policy-making. It created a large number of extra-firm, industry-wide support organizations and infrastructure, as well as substantial public organizations that conduct research and disseminate technology and provide market intelligence to the private sector, hence investing in linkages and network organizations so as to compensate for the liabilities caused by the small size of companies (Kraemer *et al* 1996, p217; for details of the institutions, see Lall 1996, pp35-6).

5.3 Role of the Taiwanese state: strengthening and supplementing networks

Prior to 1980, planning and policy for the electronics and computer industries consisted of, at best, a series of relatively limited *ad-hoc* measures, and these amounted to little in substance (Lam 1992, pp158, 240). The Taiwanese state cannot be granted a guiding-state type of foresight into the growth potential of computer industry as Taiwan's major export industry, either.[vii] Until the late 1970s, its emphasis lay on heavy industry. Only when the industry was already well established, with little governmental help, did planners and government bureaucrats wake up to the development of a dynamic electronics and computer industry as more than just an Export Processing Zone or 'low technology' industry. By the 1980s the boost given was rather more positive, eg, through official research efforts (*ibid*, pp215-19).

For the computer industry, with its special inputs and skills, expansion in size and effectiveness is always strongly conditioned by how rapidly and effectively a support structure that provides these grows up. The most important role of the Taiwanese state was to accommodate this need.

5.3.1 Direct intervention to coordinate technological development and diffusion in computer-related areas

Taiwanese policy-makers were already confronted by dense and dynamic subcontracting networks of SMEs and traders when they launched their high-technology ventures in the IT area; through the Industrial Technology Research Institute (ITRI), by building R&D consortia, and in creating the Hsinchu Park. The Taiwanese state therefore strongly subsidized public R&D institutions like ITRI, to provide market intelligence and channel technology to private firms (Kraemer *et al* 1996, p217).

ITRI, founded in 1973 by the Ministry of Economic Affairs (MOEA) as a non-profit R&D organization, now focuses principally on the area of electronics and information (ITRI 1996, p28; Kraemer *et al* 1996, pp221-3). In particular, the government-sponsored Electronics Research and Service Organization (ERSO) and later the Computer and Communications Research Laboratory (CCL) of ITRI[viii] became the major instrument of Taiwanese state policy in the industry. ERSO's and CCL's major mission has been to diffuse their mainly applied research project results to the private sector (MOEA 1995, p173).

However, the importance of technology transfer from ITRI can be debated (Gee and Kuo, pp40-1). Its contribution to the technological upgrading of Taiwanese firms looks far from clear, at least as far as the small- and medium-sized firms are concerned. Although ITRI's various laboratories were primarily intended to serve SMEs, it has been rather the large Taiwanese electronic firms who have actively used and benefited more directly from ITRI's services. According to MOEA's (1995) survey of electronic firms, it is mainly large firms who have frequent interactions with government R&D institutions, and have better success in utilizing ITRI than smaller electronics firms. Hou and Gee's (1993) survey confirms that large Taiwanese firms, by virtue of their better contact with domestic research institutions and in forming alliances with foreign corporations, conduct more joint research projects with domestic research institutions and engage more in technology cooperation with foreign partners than do the SMEs, who depend almost entirely on their own efforts, eg, through reverse engineering activities (*ibid*).[ix]

Some authors, like Mathews and Poon (1995), therefore instead consider ITRI's role as a 'consortium organizer' as crucial to the technological upgrading of Taiwanese SMEs. They argue that, for example, the New PC Consortium formed by ITRI/CCL in 1993, which brought a vertical alliance of PC manufacturers, component and peripheral

suppliers, as well as software producers, was successful. They conclude that, thanks to ITRI's *direct* intervention to coordinate technological development and diffusion, Taiwan's high-tech SMEs were collectively able to achieve the innovation 'economies of scale' that are normally enjoyed only by much larger firms.

MOEA, however, acknowledges on the basis of its firm survey that ITRI/CCL's role as a consortium organizer was at least an *organizational* 'failure' (MOEA 1995, pp39ff, 174ff). The notebook PC project alliance to develop a prototype 386-SX notebook personal computer in 1991 proved to be quite successful when judged from the *technical* side, but the project received much criticism from the participating firms, as the product's common design reduced the ways in which alliance members could compete with each other, and resulted in a price war, hence leading to the collapse of the alliance after just two years (*ibid*, p175). As for the new PC consortium formed by ITRI in 1993, it then reports that the price war problem also destroyed this supposedly improved 'second generation' alliance, and the subsequent alliances trying to overcome the deficiencies of the first project have yet to succeed (*ibid*, p177).

Nevertheless, these ITRI-initiated consortia and alliances helped usher in the trend towards more network-building and joint R&D development in the Taiwanese computer industry, for example to formulate specifications for palmtop computers (Lee *et al* 1996). More than one year after the termination of the second-generation notebook alliance, various alliances such as those for computer assembly technologies and development of electronic connectors had mushroomed. So ITRI's direct intervention measures through the organization of development consortia may have failed, but it has strengthened some already existing network co-ordination and co-operation mechanisms of firms within the Taiwanese IT industry; hence in the end turning the Taiwanese parastatal actors into a kind of 'network-facilitator'.

5.3.2 Indirectly facilitating technology diffusion

The more potent contribution of the Taiwanese state thereby lay in an 'indirect' role of supporting the entrepreneurial efforts of a dynamic private sector, by making use of the typically Chinese entrepreneurial culture and by actively encouraging *spin-offs of people*; hence promoting the knowledge diffusion 'indirectly' but probably more effectively. This way, the Taiwanese state and parastatal institutions took on the crucial 'linchpin' role in the whole diffusion process. It appears to be this 'indirect' contribution that has really mattered for Taiwan's SMEs, whilst larger Taiwanese electronics firms also seem to have benefited from ITRI's more 'direct' technology transfer and diffusion services. The former was achieved mainly by educating R&D people and managers, especially by transferring these 'human technology-carriers' to private SMEs, who then became highly effective conduits for diffusing technology to the private sector.[x]

ITRI, as a non-profit organization, has been deliberately allowing and encouraging its people to go into industry, as it considers the 'spin-off of people' as one effective way of carrying out technology dissemination and transfer. ITRI's president, Shintay Shih, reveals this position in an interview as follows:

> "We [ITRI] are not a private company, we are a non-profit organization... And we see that people are the best source of technology transfer. So ... let the people flow around, it's the best way of disseminating information, and to train the industry to become more R&D-conscious. So we encourage our people to go to the industry." (*Electronics Business Asia*, January 1996, p48)

According to his estimate, close to 10,000 people have left ITRI over the past 20 years and 73% of them joined industry, while ITRI has been able to replace them by recruiting new graduates from universities and expatriates from the United States. Personnel trained by ITRI make up the backbone of the Taiwanese R&D and engineering force in the IT industry on an on-going basis, together with the overseas Chinese returning (with technical and managerial experience from leading-edge US companies and universities) to Taiwan.

Unlike its direct intervention measures of technology transfer and other technological upgrading activities (eg, through consortium promotion), ITRI's more indirect contribution to technological upgrading by both large and small firms remains largely undisputed, though hard to quantify. Sometimes this may have been inadvertent. Gee and Kuo ({UNCTAD!!}, p41), for example, report that, with the setting up of Hsinchu Park located very close to ITRI, most of their interviewed firms located in the Science Park acknowledged luring away qualified and experienced engineers from ITRI.

Important in this context has certainly been the parastatal institutions' ability to 'glue' these informal linkages more strongly together, through their sponsorship or active allowance of these spin-offs. The positive role of the Taiwanese government thus lies in its contribution to intensifying all the available webs of personal connections as well as the networks of public and private actors in the national system.

But it is noteworthy that this expansion process was nonetheless crucially facilitated by the above-mentioned entrepreneurial culture in Taiwan; hence culture was just as important a form of 'glue'. The speed of diffusion of market and technological knowledge from government-sponsored research institutions to private firms, as well as in inter-firm networks, was greatly enhanced by the high turnover of the entrepreneurial Taiwanese

engineers and managers, who left the research institutions or large private firms to set up new companies. The migration of people is evident from state enterprises to private business and especially to SMEs, with recycling among the lower end of the firm-size distribution (Shieh 1992; Hou and Gee 1993; Kraemer and Dedrick 1996). As Amsden (1991, pp1127-8) argued, there has been a considerable coming and going of people among firms of different sizes and ownership structures in Taiwan, creating informal inter-firm linkages.[xi]

The result is then a strong diffusion-orientation and networkedness of the Taiwanese system, in which constant spin-offs are going on from public R&D institutions, from major private firms, and also from leading-edge US companies and universities.

5.3.3 Investing in training

Thirdly, the Taiwanese state made an effective investment in the human infrastructure, shouldering the major burdens associated with investment in training. It is commonly accepted that ITRI has been the most important source of human capital for the Taiwanese electronics and computer industries over the past twenty years, including many who moved into private industry (Gee and Kuo, {UNCTAD!!}, pp40-1).

The government also greatly contributed to the progress of the IT industry by mass-producing engineers, in a university education system for engineers that is considered to be highly effective (*Fortune*, 8 August 1994; Gee and Kuo {UNCTAD!}, p39). Stan Shih, Acer's president, thus considers the 'low cost of brainpower', ie, well-educated and relatively cheap engineers, as one major strength of being based in Taiwan (*Upside*, March 1994). He makes it clear that the government's effective support of university engineering departments and training of the people have produced much more of an impact than the technologies that have been developed so far (Shih 1994, pp50-54). Hou

and Gee's survey (1993) also found that governmental policies geared toward human infrastructure investment are considered as one of the most useful policies to firms' technology improvement.

Taiwan has no cheap factory labor, but thrives on engineers who are lightning fast at exploiting technology obtained from abroad, and who typically earn $15,000 a year, only about one-third as much as their US counterparts. It is their work that enables Taiwan to claim the middle ground between low-end labor-intensive economies like mainland China and the high-tech domains of the US and Japan (*Fortune*, 8 August 1994).

Taiwan's one major endowment for IT success is thus the abundant human capital, provided both by government education programs and the reverse brain drain, supplying the country with many tens of thousands of well-trained college and vocational school graduates from electrical engineering departments as well as experienced engineers. This highly-qualified labor force has greatly improved the absorption capabilities of the electronics industry and also helped to attract many foreign direct investment projects to Taiwan. This has especially been the case in the design area (Kraemer and Dedrick 1996, p21), thus consolidating the particular innovational strengths of the Taiwanese PC industry (see below).

6 LOCAL NETWORKS: HSINCHU PARK

This ability of the state to tap into personal and overseas connections is also evidenced by its creation of Hsinchu Park. The Taiwanese government was highly successful in attracting US-trained expatriate engineers back to the homeland, especially from Silicon Valley. Many of these engineers settled in Hsinchu Park, which played a key role in the government's successful plan to bring back overseas engineers (*Electronics Business*

Asia, December 1997, pp46, 49). Hsinchu Park thus turned out to be a unique vehicle to help Taiwan's local production network to ally effectively with the valuable overseas Chinese network of information and knowledge sources. It was built in 1980 to tap overseas Chinese/Taiwanese networks for high-level scientific and managerial talents, who bring not only technology or 'know-how', but also market knowledge or 'know what' (ie, what to invest in) to the Park (Kraemer and Dedrick 1996, p29; Hou and Gee 1993, p40); thus virtually spinning high-tech companies off from leading-edge US companies and universities. The connections with Taiwanese engineers still working abroad helped the country to link up with the global computer production network and enhanced the competitive power of Taiwan's IT industry. The Taiwanese state wooed many of them back and helped them to set up their own companies in the park, hence enhancing the reverse brain drain.[xiixiii]

A very high proportion of Taiwan's IT product output comes from Hsinchu; examples include terminals (56%), desktop computers (52%), image scanners (50%), portable computers (42%) and network adapters (SIPA 1995, pp14-15). In both production and governance respects, Hsinchu is more comparable to the hyper-entrepreneurial Silicon Valley network, and indeed built on this model through a top-down approach by the Taiwanese government, than to the Northern Italian type of 'flexible specialization'. Hsinchu however also differs from the Silicon Valley model, as its inter-firm and inter-organizational network is geared more to production; with a closer coupling of innovation and production than in Silicon Valley's innovation network. So, unlike the Silicon Valley model, Hsinchu does not suffer from a systemic neglect from manufacturing and an extreme separation of the sites of innovation and production (compare Florida and Kenney 1991, pp34-5). This is considered as a major advantage by entrepreneurs in Hsinchu who returned from Silicon Valley.[xiv]

Apart from its important function of spinning off high-tech firms from abroad, Hsinchu is also an important organizational value-creating device, like ITRI. It has so far successfully encouraged its Park-based firms to do more R&D by providing various incentives (like R&D grants). Compared with a somewhat lagging level of R&D relative to sales of about 1% for Taiwanese companies overall, companies inside the Park spend more, with their average R&D intensity about 5% (SIPA 1996). On the whole, its mission to attract high-tech firms to the Park and facilitate them to take roots in Taiwan has been successfully fulfilled, and its vital function as Taiwan's 'incubator of high-tech companies' is much heralded (Chang *et al* 1997, p27.5.2).

In addition to the geographical concentration of the firms and supporting institutional structure within Hsinchu Park, there is an intensive geographical concentration of Taiwan's extensive supply infrastructure within the narrow confines of the corridor between Hsinchu and Taipei. About 90% of Taiwan's supply infrastructure - with multiple sources for any required upstream product category - for its computer industry is located within the 60-km range from Taipei to Hsinchu (Kraemer *et al* 1996, p225). This intervening area is even more concentrated in printed circuit boards (PCBs), hence being complementary to and mutually supportive with the more IC-concentrated Hsinchu Park area.

ITRI's frequent contact with firms was facilitated by its location very close to Hsinchu Park (Gee and Kuo {UNCTAD!!}, p41). Hsinchu Park-based firms took also advantage of talent pools provided by the nearby major technical universities - National Chia Tung University and National Tsing Hua university - as well as of SIPA's institutional infrastructure which provides various support and networking services. With all these steady sources of researchers at hand and constant knowledge flows, Hsinchu helped

create a conducive intellectual climate and to expand Hsinchu-based firms' technological prowess at relatively low cost (Chang *et al* 1997, p27.5.6).

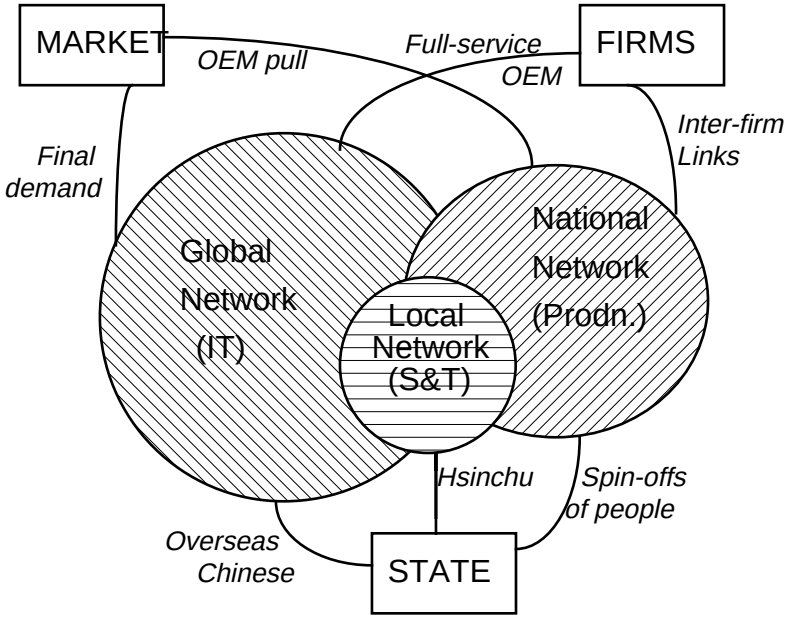
7 ALIGNING THE NETWORKS

These different levels at which networks operated were aligned through the governance mechanisms exerted from each 'vertex' of the overall structure: markets, firms and the state. Alignment was not the result of one particular actor's activities but through their intersection. Their effect was to bring the networks into more extensive contact.

7.1 Alignment through markets

World markets provide the demand-pull, without which Taiwan could not have propelled its export-led development in IT. This has developed primarily, and as we have seen increasingly, through OEM production. Our stress lies on how these world market pull influences have been re-created at the national market level.

FIGURE 1: Networks and their alignment in Taiwan's IT development



The geographically concentrated networks of component suppliers enabled a 'virtual just-in-time system' of supplier relations to emerge.[xv] Compared with the well-known Japanese just-in-time system, the Taiwanese system is characterized more by arm's-length and constantly shifting 'spot contracting' supplier relationships, quickly entering and exiting firm networks.[xvi] This rather loosely integrated network enabled Taiwanese firms and business corporations to *externalize* supply transactions, and thus cope with the volatile PC industry and its extremely rapid product life-cycle.

Flexible compensation gains, *external* to the individual firm but *internal* to the whole IT industry, were thus generated as the result of the inter-firm ties and the division of labor within the network structure. These compensate for the usually fragmenting competitive forces of pure markets. Otherwise, Taiwan's system might easily have 'drowned' in its hyper-competitive and hyper-entrepreneurial system. Thus it is important to note that the

Taiwanese IT industry is not solely governed by market mechanisms, but complemented by inter-firm network collaboration and coordination.

Equally important is the fact that, despite its inherent virtue, a cooperative network arrangement alone does not always entail success. The Taiwanese network production system functions so well because the exchange of information about needs, techniques, and technology among buyers, suppliers, and related industries has occurred at the same time as active rivalry was being maintained in the industry (Porter 1990, p152). Taiwanese IT success is therefore based on a combination of tough inter-firm competition and collaboration. The competitive aspect is apparent not only in the 'Darwinian environment' (*Fortune* 8 August 1994, pp52-3), where some 50 to 100 companies die each month and a like number of new ones spring up in their place, but also in the constant breaking and re-forming of supplier relations.

7.2 Alignment through firms

For the current IT industry, this kind of Taiwanese network form of production is particularly well-suited, as it allows firms to pursue new markets with small investments and enhances the capacity to respond flexibly and rapidly to shifts in demand. Taiwanese manufacturers are said to operate with overhead costs of less than 10% of sales, compared to 25-30% for foreign competitors, thanks to the presence of many small flexible suppliers allowing for quick delivery of parts necessary to achieve fast production ramp-up and turnaround and also to the limited levels of R&D and marketing they carry out themselves (Kraemer *et al* 1996, p239). Because of such cost reduction capability, combined with Taiwan's strong (re-)design capability (Wade 1990; Hobday 1995), a lead time from order to shipment is possible within one month, delivery operation within one week, new engineering design with three months (H-C Chang

1997). In addition, Taiwanese firms are able to undertake virtually simultaneous product development. In such fashion, they have continued to 'push' into world markets, especially in areas like PCs where time-to-market is so crucial.

Both large and small IT firms were encouraged continually to seek new product market segments in which they could make a profit, permitting them to concentrate more on small-volume market segments and hence on the *product* innovation side rather than on manufacturing prowess. Taiwanese firms became 'product innovators', whilst Koreans are more 'manufacturers' and process innovators (Levy and Kuo 1991). This derives from their respective political economies. Without the cheap credit subsidies available through the government-controlled banks of Korea's vertically integrated *chaebols*, Taiwan's niche-seeking small firms had to become responsive to new product market opportunities. Even large Taiwanese firms usually lack the economies of scale or scope, so they too were forced to shift constantly to new products once the products became standardized and mature (*ibid*; Gee and Kuo 1993). Taiwan's production network structure allows even the largest firms to avoid extensive vertical integration to coordinate the production chain, and to gain from being part of the network. Owners of Taiwanese firms typically prefer subcontracting to expansion or integration.

Taiwan's business groups resemble loosely-knit agglomerations in which firms tend to be organizationally separate from other firms, with no unified management structure (Gereffi 1990, p15). Instead of a formal system of command, there exists a highly flexible management arrangement in each business group that relies on networks generated by personal relationships. Typical of this kind of corporate governance is the Acer Group which adopts a client-server management organization structure similar to computer networking models.[xvii] This allows Acer to source valuable high-tech components and peripherals internally and externally, lowering costs and raising

efficiency, while supplying leading-edge products to a strong worldwide distribution network at competitive prices (Shih 1994, pp102-103; *Fortune*, 8 August 1994). Through methods such as modular manufacturing, inventory turnover is very rapid, which gives firms like Acer a substantial advantage for market competition in the PC industry, where time-to-market speed and cost-competitiveness count for so much. In a way, the very basis of competition has been shifted here to a new level, with Taiwanese firms competing on the *collective* basis of the industry network, whereas (say) Korean *chaebols* compete merely on the basis of their individual *chaebol* structural capability.

7.3 Alignment through the state

The role of the state was essential to aligning demand-side (global) networks with supply-side (national and regional) networks. In Figure 1 and in our preceding discussion, the state is seen as linking networks at all three levels (though the *direct* links to firms are rather weak). While Taiwan's political regime dynamics over time appear to have generally interfered with the rise of a *chaebol*-type hierarchical governance structure, those government policies had positive bearings on this IT governance structure; by contributing to the ease with which collaborative arrangements and networks were formed and sustained among the Taiwanese PC producers themselves, as well as with other major networks like the overseas Chinese.

The state helped align regional networks with sectoral networks. The existence of the Taiwanese state and parastatal institutions facilitated the flow of technological and market information and provided the Taiwanese SMEs with access to key external resources and advantages. Given the Taiwanese firms' usual practice of shifting from one product to another without much investment for sustained quality improvement, Mody (1990) warns that the Taiwanese structure has 'excess flexibility'. Thus it is to the credit

of the Taiwanese state that it has so far effectively compensated for the lack of capability-building investments at the individual-firm level by its provision of an externally available and stable pool of value-creating and diffusing activities through public organizations such as ITRI.

8 CONCLUSIONS

The driving force of this successful alignment is therefore too complex and dialectical to be reduced to one single variable such as state-leadership or free-market dynamics, as in some simplistic arguments of state vs. market. In reality, what brought about the successful alignment, and hence Taiwan's successful IT specialization, were historically specific, highly complex and evolutionary interactions and dynamics of all the relevant factors such as politics, culture, markets and technology.

There are a number of conclusions to be drawn from this case study, which touch on many currently controversial debates.

1 *Global vs national controversies*: One conclusion is that the foundations of the 'global' economy are actually 'national'; as many BRIE-based authors like Zysman *et al* (1997) and national innovation system scholars like Patel and Pavitt (1994) emphasize the enduring, distinctive national roots of the global economy. Taiwan's IT case confirms the importance of its distinctive national network organization, which has profoundly shaped the way in which Taiwanese firms have been integrated into global IT production networks.

2 *Evolutionary perspectives*: The concept of 'alignment' has proved particularly useful for revealing the evolutionary dynamics and driving forces as well as for drawing

attention to the specific configuration of both global IT networks and Taiwanese national networks and their interconnections. Evolutionary studies emphasize 'co-evolution', but in this study we draw attention to the governance factors making co-evolution feasible. While the successful alignment was due to somewhat *fortuitous* historically favorable evolutionary dynamics of the global IT industry since the mid-1980s, it is the *path-dependent* elements, ie, the accumulated managerial and technological capability of Taiwanese actors in the process, which have shaped Taiwan's further successful development path in the 1990s.

3 *State vs. market controversies*: The role of the Taiwanese state in this kind of evolutionary alignment process has been crucial. If it were not for the parallel governmental efforts and human infrastructure investments to improve skills, the alignment of Taiwanese national networks with the global PC production network could scarcely have taken place so effectively. In this respect, the Taiwanese state's role as an important catalyst and 'facilitator' of the already rapidly evolving IT industry's expansion process should not be underestimated.

The Taiwanese case demonstrates that governmental support for the technological change-generating activities of firms goes beyond the simple provision of codified information that is stressed in mainstream economic analysis, to include training for researchers and engineers who go on to work in business firms. By the same token, the role of the Taiwanese state has been more complex than a simple industrial targeting policy, as often advocated by the proponents of state-leadership and policy activism. In these respects, the existing state vs. market dichotomy is too blunt an instrument to analyse different sub-sectors and industries.

4 *Macro-level vs. micro-level controversies*: It was the national network environment which shaped Taiwan's relatively small-scale, flexible production system, with its structural ability to compensate for market risks and to cut down the inventory- and logistics-related costs and to generate rapid product innovations. In this respect the national innovation system approach is validated, but we would underline the inadequacy of treatment of political factors in such work. It makes little sense to look at firm strategy and structure alone while separating their organizational behavior from its political and historical context.

A strong complementary analysis is needed of the political and institutional as well as cultural dynamics, which underlie the national systems. The political governance approach is thus adopted in this paper as a means of analyzing the key issue of how various network dimensions were aligned to effect Taiwan's success in IT hardware.

[1]See eg, Streeck and Schmitter (1985), Hollingsworth *et al* (1994).

[1]The Taiwanese system is built more around networks of around 700,000 SMEs, accounting for 70% of employment, 55% of GNP and 62% of total manufactured exports (Lall 1996, pp. 35-6).

[1]Interview with H-C Chang at III. All interviews referred to in this paper were conducted in May 1997.

[1]Miin Wu, president of Macronix: interview.

[1]Recently, however, the Taiwan government has begun to fund private-sector R&D directly by individual companies or by industry-research institute partnerships.

[1]In 1994, the government's contribution to R&D funding in Taiwan was 48.2%, as compared with 36.9% in the USA, 32.3% in the UK, 19.2% in Japan and just 16.0% in South Korea (National Science Council 1996, p16).

[1]Taiwan's export-orientation in computer and electronics industries has little to do with the state's deliberate export promotion policy of the industries, in that they 'only incidentally' fitted with the government's officially proclaimed strategy of export-led growth (for details and evidence, see Lam 1992, pp217-20).

[1]In 1990, on the creation of CCL, ERSO was restructured and its computer and communication industry responsibilities were transferred to CCL (Hobday 1996, p124).

[1]However, ITRI's overall contribution to national patenting activities is quite large (Choung 1995, pp38-9).
[1]Thus Taiwanese firms see the role of ERSO as critical, but primarily through educating R&D personnel (Hou and Gee 1993, p397).

[1]Examples, of which there are many, include the Elitegroup, a $300-million-a-year maker of motherboards being founded mainly by engineering veterans of Acer, and UMAX, the highly successful scanner producer, which was also initially set up by former engineers at another major scanner producer (interview with Jeffrey M Wun at UMAX).

[1]Among the incentives provided for start-ups by the overseas Chinese, the most important are tax incentives, including a five-year exemption of corporation income tax for newly established firms (Wu and Tseng 1997). In addition, low-interest loans are available as well as R&D grants (SIPA 1996).

[1]The success of Hsinchu Park led to the decision to establish a second park, the Tainan Science-Based Industrial Park, in the south of Taiwan, which will start operation in 1998 (SIPA 1996).

[1]Examples include Mr Miin Wu, president of the highly successful IC company Macronix International, and also L-S Tung of SIPA, according to interviews with both, May 1997.

[1]Interview with Chen at CIER.

[1]Interview with W-J Kuo at CIER.

[1]See Mathews (1997, pp33-4) for a detailed explanation of how the 'client-server' organizational architecture works in practice, generating maximum flexibility and autonomy within a global organizational coherence.

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