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Electronics Contract Manufacturing: Transnational Production Networks, the Internet, and Knowledge Diffusion in Low-Cost Locations in Asia and Eastern Europe

Boy Lüethje

Boy Lüethje is a Professor with the Institut fuer Sozialforschung, Universitaet Frankfurt, Germany, and a specialist on telecommunications and electronics contract manufacturing.

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A serious assessment of the implications of the Internet for production networks in developing countries has to be related to the profound changes in the productive structure of global capitalism. In contrast to the general perception of "E-Commerce" and "Business-to-Business" (B2B)-marketplaces as a service phenomenon, it has to be stressed that in the "new economy" manufacturing matters probably more than ever (Cohen/Zysman 1987). In the electronics industry, a new model of outsourced manufacturing has emerged as a centerpiece of globalized production networks: Contract Manufacturing (CM) or Electronics Manufacturing Services (EMS).

Contract manufacturing can be characterized as a new system of transnational mass production serving different local and regional markets on the basis of highly flexibilized work arrangements. It is closely linked to the emergence of the “Wintelist” (Borrus/Zysman 1997) model of competition in key sectors of the information technology (IT) industry and the rise of “fabless” product design companies. Major CM-companies perform core functions of hardware manufacturing – printed circuit board assembly and systems assembly (“box build”) – for a growing spectrum of information technology and other electronics related brand-name producers (OEM). They also offer manufacturing related engineering and design capabilities, logistics, and after-sales services. Global networks of product introduction centers, volume plants, and distribution centers located in central “high-tech”-areas throughout North America, Europe, and Southeast Asia and in low-cost regions like Mexico, Eastern Europe, or China offer “one-stop shopping” solutions to multinational hardware vendors of various size and scope. The contract manufacturing industry is also a pioneer in the use of e-commerce- and B2B-technologies.

This paper will explore some possible implications of Internet-based manufacturing and procurement systems for electronics contract manufacturing in low-cost locations in Asia and Eastern Europe. It is based on current research at the Institut für Sozialforschung on the contract manufacturing industry and its work organization and labor policies in the United States and

Germany (Lüthje/Sproll/Schumm forthcoming). Our discussion is also related to a new research project on electronics contract manufacturing in Southeast Asia and Eastern Europe (Schumm 2000). The paper will summarize central findings and assumptions of this research and spell out some implications for the agenda of this workshop.

Our major points of interest are: (1) The variety of relationships between brand-name producers (OEM) and contract manufacturing firms emerging from different structures and traditions of firms and national economies; (2) the international division of labor within the contract manufacturing industry; (3) the shop-floor dimension, i.e. the impact of the Internet on manufacturing work within the context of differing national and regional production practices and cultures; (4) supply-chain-management and engineering; (5) telecommunications infrastructure development and its role for Internet-based manufacturing arrangements.

1.) Globalization and differentiation of the contract manufacturing industry

Contract Manufacturing is one of the fastest growing segments in the IT-industry. Growth rates are currently averaging 20-25% per year. According to industry consultants Technology Forecasters, the global market volume in the year 2000 has been 88bn $. The leading players of the industry, most of them former small subassembly companies, have hardly been known a decade ago. Today, the biggest firm has annual revenues of 20 bn $. Market concentration is developing rapidly with five companies of North American origin (Solectron, Flextronics, SCI, Celestica and Jabil Circuits) emerging as the key players. The name of these companies are unfamiliar even to many insiders. CM-providers have a policy of not posting their brand-name inside any product. The New York Times, therefore, called the EMS-industry a system of "stealth manufacturing" (for an in-depth history of the industry see Sturgeon 1999).

The growth of the industry has been closely linked to the "deconstruction" (Business Week) of the IT-industry into highly specialized subsegments of component, hardware, and soft-

ware manufacturing, as epitomized by the industry structure of California´s Silicon Valley. The emergence of contract manufacturing as a global industry is an important feature of the double-sided process of vertical disintegration and global centralization (Ernst/O'Connor 1992), which has become characteristic for the "post-fordist" segments of the IT-industry (for a theoretical interpretation based on French regulation theory Lüthje 1999/2001).

Today, contract manufacturing is being embraced by a growing number of vertically integrated OEMs in the U.S. and Europe like IBM, Texas Instruments, Lucent, Ericsson, Philips or Siemens. The large-scale outsourcing of entire product lines on the part of these companies, often achieved through the sale of established manufacturing plants to CM-companies, has become the main driving force for the expansion of the CM-industry.

The rapid expansion has brought about a highly differentiated spectrum of outsourcing relationships, emerging from various corporate strategies and traditions as well as from nation- and region-specific manufacturing practices. In the early phase of contract manufacturing, about a decade ago, the typical CM-customer was a high-growth start-up with very small or no manufacturing organization of its-own. Today there is a growing variety of outsourcing relationships, as summarized in the following table.

Types of OEM - CM - Integration

Fabless company - minimal final assembly and testing (Cisco, Sun ...)	**Full-scale manufacturing and supply-chain-managment (engineering – logistics)**
Full-scale outsourcing of product lines and/or plants (IBM, TI, Siemens ICM ...)	**Full-scale manufacturing and supply-chain-management – Plant conversion**
Large-scale final assemblers with high volume outsourcing of key-components (Dell, Compaq, HP CSD)	**Mass-production of key-components (dedicated lines)**
Customized final-assembly in key-markets (Compaq, Dell, HP PCD in Europe and Asia)	**Final assembly (box-build) (includes local CM-partners)**
Still open: keiretsu and chaebol-strategies	**e.g. Sony/Solectron, Acer/Solectron, Mitsubishi/Solectron**

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It should be noted that the major OEMs from Asia – Japanese keiretsu and Korean chaebol in particular – have been relatively reluctant to use contract manufacturing in their core region. Sales of major assembly operations to CM-companies mostly occurred in foreign markets (as Mitsubishi´s U.S. cell-phone assembly operation in Georgia, which was sold to Solectron). Only very recently, Sony handed over two assembly plants in Japan and Taiwan to a U.S. contract manufacturer - a move that some see as a major opener for the CM-model in Asia.

Only few companies have developed Internet-based integration of manufacturing and ERP-systems. Full-scale “virtual factory”-relationships seem most advanced between “fabless” OEMs and CMs. Cisco´s manufacturing organization can be considered a leading-edge model. The manufacturing of Cisco routers, switches etc. is integrated into an order and resource planning system, which is entirely based on Internet-standards. Major contract manufacturers are part of this arrangement. CMs also manage delivery and repair services, offering a seamless interface

to the Cisco customer. Flextronics, for example, is operating a manufacturing plant fully dedicated to major Cisco product lines. The virtual integration of this plant into the Cisco organization has to be secured by a sophisticated control system for manufacturing data on the part of Cisco and through a high degree of personal interaction between engineers of both companies, supported by the physical proximity of the respective operations in Silicon Valley.

The rapid growth of contract manufacturing is likely to produce more arrangements of this kind. From a broader perspective, the Internet seems ideal to manage the increasing variety and complexity of outsourcing relationships, supporting the role of contract manufacturers as "global supply-chain facilitators" (Solectron). Thus, Internet-based data-networking is likely to increase the variety of outsourcing arrangements, while it supports the standardization of interfaces and procedures within distributed value-chains (cf. Ernst 2000: 5). The option of customizing IT-networks makes it ideal to deal with different types of customer relations, production cultures, political and social regulations.

The role of Internet-based virtual factory models, however should not be over-estimated. Most OEMs are still far away from remodeling their own internal organization along the lines of fully distributed data-networking. Although the pace of internal change is considerable, it is more likely that vertically integrated OEMs will primarily use Internet-based E-commerce to manage external customer and supplier relations. This, however, will emphasize the role of E-marketplaces. The potential here is immense: Siemens, for example, is currently handling about 10% of its overall purchasing volume of 35 bn Euro through the Internet; the recently announced goal is to reach more than 50% in 2-3 years (FAZ, Oct. 10, 2000)

2.) A "New International Division of Labor"?

Contract manufacturing has been portrayed as a distinctively "American" model of manufacturing (Sturgeon 1997 and 1999), emerging from the specific context of the relatively frag-

mented structure of the U.S. IT-industry and the growth of subcontracting arrangements in Silicon Valley and other newer high-tech centers. The enormous expansion however has converted contract manufacturing into a global model of mass production. Contract manufacturers act as transnational "network builders", assembling a variety of plants with different manufacturing practices in specific national and global markets. Contract manufacturing therefore can be interpreted as a mode of integrating, coordinating, and regulating diverging conditions of production in global production systems (Lüthje/Schumm/Sproll forthcoming).

Large scale-manufacturing in low-cost locations around the Triad of industrialized capitalist nations has become an essential element of this system. Again, the growth speed is remarkable. In 1996, the leading contract manufacturer, Solectron, had about 10 locations world-wide, today there are almost 50. The first offshore plants were acquired as part of the take-over of manufacturing units from OEMs like IBM or TI who had plants in Southeast Asia, predominantly Malaysia. In the mid-1990s contract manufacturers acquired or built huge facilities in Mexico, most of them in the city of Guadalajara. Currently the most rapid expansion is underway in Europe. U.S. contract manufacturers are setting up large-scale facilities in Hungary, Poland, Czechia, and Romania, modeled after the Mexican model. Flextronics alone claims to have 10.000 employees in Hungary (see charts 2 and 3).

Manufacturing sites of the 5 leading CM in East Asia (09/2000)

Company	*Malaysia/Singapur*	*China/Hong Kong*	*Other countries*	*Product/Size (sqft)*
Solectron	Johor			PCBA 200.000
	Penang			PCBA 432,000
		Suzhou (Jiangsu)		PCBA 333.000
Flextronics	Johor			PCBA 210.000
		Beijing		PCBA 70.000
		Doumen (Guangdong)		Industrial Park with PCBA, PCB manuf., cleanroom, 900.000
SCI	Singapore			PCBA
	Penang			PCBA
		Kunshan (Jiangsu)		PCBA
			Thailand	PCBA
Celestica	Kulim			PCBA
		Hongkong		PCBA
		Dongguan (Guangdong)		PCBA
			Thailand	PCBA
Jabil	Penang			PC an peripherals; ca. 900 employees
		Hongkong		Telecom and networking, medical instruments, etc. Ca. 4300 employees
		Kanton (Guangdong)		
		Shenzhen (Guangdong)		
		Panyu (Guangdong)		

Source: Company Information (Internet)
PCBA = Printed Circuit Board Assembly

Manufacturing sites of the 5 leading CM in Eastern Europe (09/2000)

Company	Hungary	Czechia	Poland	Other	Products/Size /spft)
Solectron				Rumänien	PCBA 64.000
Flextronics	Zalaegerzeg				PCBA, system assembly 205.000
	Sárvár				PCBA, system assembly 385.000 Industrial park with suppliers
	Tab				PCBA, system assembly
		Brno			PCBA, system assembly 112.000
			Gdansk		PCBA, system assembly (under construction)
SCI	Tatabanya				PCBA
Celestica		Brno			PCBA
Jabil	Tiszaujvaros				PCBA

Source: Company information (Internet)
PCBA = Printed Circuit Board Assembly

Globalized just-in-time production is superseding traditional international divisions of labor in the electronics industry. The technology base and the manufacturing processes of CM operations in developed and in low-cost economies are very similar. The strategic goal is rapid interchangeability of manufacturing processes between plants around the globe. The drive towards global standardization of manufacturing processes, a core philosophy for major contract manufacturers, is accelerating the process of industrial upgrading towards "full package" production (Gereffi 1999) in low-cost locations. In Mexico, China, Hungary or Poland, some contract manufacturers are developing "industrial parks" with a full range of component suppliers and logistics firms, which mirror "modular factory" concepts of automobile or chemical manufacturers.

A certain hierarchy between locations, however, is defined through the lead position that Product Introduction Centers (PIC) in developed countries play in prototyping and in the ramp-up of new product lines towards volume manufacturing. This implies inequality in the distribution of engineering capacities and the access of plants in low-cost locations towards advanced engineering know-how within the global production system. It also implies a greater relative significance of skilled labor in strategic plants in developed economies.

Our research suggests, that there are differing types of hierarchies within Triad regions. In North America we have a more parallel development of mass production in low-cost regions of the United States and in Mexico. In the Pacific Rim context, contract manufacturing plants in low-cost locations in Asia have been integrated into this model. In Europe we have a more distinguished hierarchy between PIC-Type operations and more sophisticated product lines ("Führungsbetriebe", as they are called in German) in core EU-countries and volume production in Eastern Europe. The scenario in Asia seems still open: major contract manufacturing operations have been located in Penang and China's Guangdong province, with lead plants located in

Singapore and Hong Kong. The question is if a similar system of "Führungsbetriebe" will emerge in Taiwan and possibly Japan and South Korea.

For the future integration of volume manufacturing sites into the global production systems of the contract manufacturing industry, the Internet will be of great significance. As Mike McNamara of Flextronics International puts it:

"The driver of the Internet is the speed and the efficiency at which communication can occur for a lot of different items – anything from an order ready to ship all the way through to tracking a serial number on the shop-floor. .... The other driver is that information is immediately available when the CM is building on three or four continents. It is just as easy to get that data from the factory in San Jose to our customer in San Jose as it is to get it from Brazil to our customer in Europe." (quoted in Technology Forecasters 2000, p. 4)

All this, of course, implies increasing competition between low-cost regions. It is expected that the emergence of parallel networks of contract manufacturing around the Triad is mostly to the detriment of the existing networks of independent electronics component suppliers in Asia. Contract manufacturers are competing with smaller electronics component assemblers and design houses, especially in PC motherboards and other PCB-products. At the lower end of technology "industrial park"-type operations may have similar impact. U.S. contract manufacturers have been adding local contract manufacturers in Singapur, Malaysia, and China to their "portfolio". Solectron recently acquired Singapore´s NatSteel electronics, the No. 6 contract manufacturer in the world and the only Asian competitor of international scale. In this changing environment, the challenge for Asia, in the words of Far Eastern Economic Review, is "to create a dynamic open regional market that can keep local factories humming as more production for the North American and European markets moves away" (April 2, 2000).

3.) **The labor process and the integration of different manufacturing cultures**

From a shop-floor perspective, contract manufacturing is producing a new type of flexibilized manufacturing work in globalized networks. The new elements of the labor process are not

primarily technological or organizational. Basic work procedures – automated and manual PCB assembly, systems assembly ("box build"), and warehouse and logistics jobs – are standard and well-known throughout the electronics industry. The new elements of manufacturing work are resulting from the specific form of integration into the global value chains of the IT-industry.

The characteristic features of manufacturing labor practices in the CM industry can be summarized as follows:

- "Work without a product": as CM plants do not produce their "own" products, quality management and workplace control has to be refocused on "customer orientation".
- Relatively low wages with high variable proportions: as most CM-plants are located in low-cost areas, manufacturing wages and most benefits are rather modest, bonus oriented pay-systems (including stock ownership and options) have to ensure "customer orientation".
- Labor flexibility: The constant and very rapid change in production volumes is managed through an extensive use of "flexible" employment-schemes. In the U.S. and Europe, temporary labor has become a strategic resource of prime importance.
- Quality management based on restricted teamwork: in most plants there is an ideology of "team orientation", but no formal structure of work groups etc., as known from team concepts in other industries.
- A heavy reliance on women and minority workers: in U.S. plants particularly, an overwhelming part of the workforce is recruited from racial minorities in disadvantaged labor market positions.
- A strong trend toward non-union labor relations: most contract manufacturing plants have no or only weak union representation.

Different social and political contexts however produce different manufacturing practices. In the U.S., we clearly see a low-wage/high-flexibility model which meets most criteria of the term "management-by-stress" (Parker/Slaughter 1988). There is also a strong polarization between engineers and line workers – a characteristic feature of most manufacturing work in the U.S., which is reinforced through the widespread use of temporary labor in the contract manufacturing industry. In Western European plants there is a higher degree of work integration, more sophisticated automation practices, and also a stronger role for unions and legal employee representations (as "works councils" in Germany). Union wage standards are accepted even in non-union plants. However, there is a strong trend towards concessionary bargaining on the part of workers' representatives and unions, especially under the impact of competition from low-cost regions.

The differences in work practices seem to be closely related to the specific positions that American and European contract manufacturing plants have within the global division of labor. The greater role of manual work in U.S. plants (especially in non-programmable processes and in the rework of faulty products in PCB-assembly) can directly be attributed to the lower labor costs in traditional non-union areas like Texas, North Carolina, Alabama, or California´s Silicon Valley. In Europe, most manual assembly work is being relocated to low-cost regions in Eastern Europe or East Germany.

In some areas we can already see the impact of e-commerce-based direct sales on manufacturing work. The "Dell-model" of configuration-to-order (Dell/Magretta 1998) dramatically increases flexibility requirements in final assembly. As each computer product has to be configured to specific demands, manual assembly work is making a remarkable comeback in computer plants. Dell´s assembly operations in the U.S. almost entirely rely on manual labor with relatively low formal skill requirements. In Europe, some of the most successful indigenous contract manufacturers as well as high-end OEMs like Hewlett-Packard are using similar

facturers as well as high-end OEMs like Hewlett-Packard are using similar practices. One contract assembler for consumer PCs in Germany is operating almost entirely on the basis of manual labor (drawn from local a labor pool in an electronics industry center in East Germany with an average unemployment rate of 17%).

The impact of B2B-based supply-chain-management is, to our knowledge, not yet widely felt on the shop-floor. U.S. plants that are operating within an Internet-based "virtual factory" framework do not differ significantly in their work organization from more conventional plants. Given the high degree of control over manufacturing data that existing IT-networks offer to OEMs, tighter control of the shop-floor through Internet-based data networking does not seem very likely. As opposed to traditional subcontracting arrangements, OEMs clearly tend to leave the management of the labor process to their manufacturing partners. The most important impact of the Internet on shop-floor conditions, therefore, may probably be indirect: expansion of e-commerce related configured-to-order manufacturing is likely to increase the pressure to flexibilize work and employment.

The longer-term impact of the Internet, however, may emerge from the role of contract manufacturers as "global supply chain facilitators". The specific organizational know-how of transnational EMS-firms is in the integration and coordination of different work practices and production cultures within world-wide production systems. The management problems involved are very complex, superseding the traditional "path-dependency" vs. "best-practice" dichotomy. Internet-based manufacturing promises to facilitate the coordination of different conditions and cultures of production because it requires the definition of standardized interfaces between manufacturing procedures in different plants and locations. Work practices and manufacturing standards may become more comparable and, thereby, increase competition between individual plants and their workers.

4.) **Supply-chain-management and engineering**

One of the most difficult problems of supply-chain-management in the contract manufacturing industry is the procurement of electronics components and parts. Contract manufacturers have developed sophisticated know-how in managing this portion of the value-chain and exert considerable buying-power. Parts and components are either purchased by contract manufacturers on behalf of their customers or by OEMs themselves. Contract manufacturers have also relationships with global electronics parts distributors (like Arrows or Avnet). Local sourcing of parts and components, however, remains very limited. It is usually restricted to non-strategic items like cables, sheet metals, or plastic parts.

The calculation of prices, volumes, and availability of part-supply is essential to the CM industry. The problem is complicated by the cyclical nature of most component markets. Successful handling of market-cycles and pricing schemes bears considerable profit-potential. In this scenario, the Internet is producing two major changes: (1) the emergence of B2B-markets for electronics parts and components under the leadership of major OEMs; (2) new forms of supply-chain-management and engineering, which are related to the emergence of a new brand of application service providers (ASP) in electronics design and manufacturing.

Electronics parts markets are currently developed by two groups of OEMs, both including major contract manufacturers. One has been announced under the name of "The High Tech Exchange" and encompasses major computer and chip-manufacturers (among them HP, Compaq, Hitachi, Samsung, NEC, and, from the CM-side, Solectron; E-News May 8, 2000). The other one is called "e2open.com". It has strong participation from major players in the telecommunications and networking field (Ericsson, Hitachi, LG Electronics, Matsushita, Motorola, Nokia, Nortel, Philips, Seagate, Toshiba and, again, Solectron). Supported by technology from IBM, i2, and Ariba and with financing from major investment banks like Morgan Stanley it is representing a

combined parts purchasing volume of 200 bn $ per year (NYT May 30, 2000). The concept of both projects is mirroring large-scale e-market initiatives in other industries like Covisint in the auto industry or Chemplorer in the chemical industry, which include major manufacturers, e-commerce software companies, and telecom network operators. The promises are the usual ones: cost reduction at all stages of the value chain, reduction of time-to-market, and minimization of procurement costs (cf. Ernst 2000: 5).

Application Service Providers (ASP) in the electronics design field go beyond mere part-trading. They develop software, which integrates parts purchasing with the design process and product introduction at the assembly-line level. Start-up companies like Silicon Valley-based Spin Circuit are developing data-exchange systems for the design of printed circuit boards and hardware, bringing together OEMs, parts producers, distributors, and contract manufacturers. These "design gateways" promise seamless interfaces between product designers, manufacturing engineers, and parts suppliers who all will become part of a single internet-based exchange system. Design engineers may even be able to change their product lay-outs according to the cost and availability of parts tracked in online-databases. Some contract manufacturers are heavily supporting start-ups in this field because early participation seems to offer the opportunity to control crucial nodes in global Internet-based manufacturing networks.

The future impact on supplier networks as well as on manufacturing and engineering work is still difficult to assess. The suggestion seems plausible however, that the development of global electronics parts and component markets will foster the "de-localization" of sourcing relationships which is already characteristic for the contract manufacturing industry. On the labor side, we may expect substantial rationalization of engineering work, an increased separation of product and process engineering, and a diminished role for personalized cooperation between product and manufacturing engineers within local industry-networks. In qualitative terms, engineering work

will become much more oriented towards non-technical, "commercial" factors like cost and parts availability.

From an economic development perspective, this may imply a devaluation of the existing engineering skill-base in newly industrializing countries. It may also mean increased competition for engineers in developed countries from "long-distance outsourcing" of engineering work to low-cost regions, which up to now has been mostly limited to the software industry. The proliferation of the "Bangalore-model" into manufacturing may offset the negative quantitative impact on engineering jobs in developing countries. The problem however remains which kind of engineering work will be located in the offshore-design centers of the Internet-age.

5.) Infrastructure development

Our observations support the view that the emergent global e-business in electronics manufacturing will not have the spatially and economically homogenizing effects some pundits predict. As Geographers Neil Coe and Henry W. Yeung point out in their studies on e-commerce development in Singapore: "Instead, as with previous techno-economic systems, the world wide e-commerce will be characterized by distinctive and constantly evolving patterns of uneven development. Place, in the abstract sense, and cities, in their material form, will remain of the utmost importance, as there will be a need for centers of co-ordination and control, or hubs and nodes, in the intensifying world of electronic flows." (1999: 13).

Telecommunications infrastructure development is an essential part of this scenario. In the age of globalized e-commerce, the future position of low-cost manufacturing areas in the global manufacturing systems of the electronics industry as well as the potentials for knowledge transfer and economic development will more and more depend on infrastructural factors. Two major fields of concern can be identified: (1) Development of basic infrastructures, i.e. physical networks for standard telecommunications and data services. (2) Creation of an environment of ad-

vanced e-commerce services and the supporting infrastructure of service providers and software firms, especially in manufacturing-related fields.

The state of basic telecommunications networks highlights the general economic hierarchy between industrialized and developing countries. In developing Asia only the original "four tigers" have a fixed phone line penetration (the basic indicator for infrastructure development) comparable to the U.S., Western Europe, and Japan. The telecommunications infrastructure in major low-cost locations for the contract manufacturing industry in Asia (Malaysia and China) as well as in Europe (Hungary, Czechia, Poland, and Romania) clearly is in a state of underdevelopment. Eastern European countries suffer from the heritage of soviet-style socialism as well as from the more recent privatization shocks. China´s effort in telecommunications infrastructure development is one of the most ambitious in modern history.

In E-business related services, there is a similar hierarchy. In Asia, the more developed nations – Singapore and Hong Kong in particular – are in the position to become the regional nodes of advanced e-business service infrastructures. Some Asian hub economies have sector specific policy programs for the development of an advanced E-commerce environment. Singapore´s Electronics Commerce Masterplan, announced in 1998, links up a broad array of government agencies, e-commerce providers, software companies, and foreign and local electronics companies (like Dell, Compaq, or HP) in a public-private partnership effort to develop technologies, standards, and "best practice"-models for B2B-communication in local networks (Coe/Yeung 1999). The cooperation includes international manufacturing companies like Dell, Compaq or HP as well as local E-commerce software developers like Asia Manufacturing Online.

In Eastern Europe there are no regional hubs, it can be expected that the knodes of E-business development will remain within the central EU economies. The absence of regional hubs mirrors the more hierarchic international division of labor in the manufacturing field, as described

above. The most powerful players in Eastern European e-commerce infrastructures are potentially western telecommunications service companies with strong positions in the privatization process, Deutsche Telekom and some U.S. telcos in particular. The relationships between the hubs and the less developed countries will increasingly be regulated under EU telecommunications policy. Infrastructure development will be an important topic in the extension of the EU, although it hardly appears as a public issue.

Both the development of basic telecommunications networks and of advanced e-commerce services does not occur without heavy involvement of local, national, and (in the case of the EU) supranational government. The most successful economies in Asia demonstrate this clearly. The developmental state has a strong role both as builder and owner of telecommunications networks and as regulator, defining rates, technical standards, access conditions, and general policy goals. As in other fields, global electronics manufacturers have at least tacitly accepted this view by their participation in government-led development programs. The privatization of telecommunications monopolies is not likely to change this picture substantially, although there will be a greater role for private investment. In some countries, China in particular, participation of equipment vendors in network development is linked to the establishment of local manufacturing sites or technology transfer requirements.

For the development of future manufacturing networks in the electronics industry the relationship between national infrastructure development and global e-commerce consortia will be of great importance. The global e-commerce networks are producing new players in telecom infrastructure development, made-up of alliances of major OEM, contract manufacturers, parts distributors, software companies, and telecommunications network operators. The complexity and scope of future e-business networks favor “system integrators” with a wide variety of technical, organizational, and financial resources (for earlier experiences see BRIE/OECD/CEC 1989).

These consortia will have a central position in the definition of future standards for Internet-related manufacturing practices. Together with their local partners, they will also have to compete for market access to developing countries.

The challenge here seems to link infrastructure development and market access with broader goals of economic development and social sustainability. This question is not new. Our case, however, may offer insights and lessons of how to extend this notion into issues of work organization and workforce development, both on the shop-floor and within the networks. The increasing importance of infrastructure development for advanced manufacturing operations as well as the size and scope of investments of contract manufacturers into their plants, technology, and workforce development in low-cost locations seem to confirm the need and the opportunity for political intervention in this process. Even under the condition of increasing global competition between locations and regions for new manufacturing investments, infrastructure development offers an important opportunity to shape new manufacturing networks and practices, provided the relevant actors do not immediately join the neo-liberal privatization and deregulation chorus.

In a broader sense, this affects the whole set of development problems related to the implementation of new models of mass-production in low-cost regions, as pointed out above: the development of local sourcing relationships, social standards of work and workforce development, labor flexibility and its impact on skill-development, the location of engineering resources, and, as a relatively new question, the position of low-cost regions within the emerging international division in electronics engineering. As plant technology and manufacturing processes in developed and in developing countries are becoming more similar, there may be new chances of spelling out social standards and "best practices" in a truely global perspective.

6.) **Research problems and questions**

From the above reflections, a number of research questions emerges for a more precise assessment of the role of the Internet for electronics contract manufacturing in low-cost locations in Asia and Eastern Europe (see chart 4):

- Different types of OEM-CM integration: A first set of questions would be related to the scope and quality of Internet-based supply-chain-integration. How does the Internet fit into specific models of OEM-CM integration, emerging from the firm-, nation-, and region-specific conditions described above? For Europe, the main problem seems how and to which extent major OEMs in the European field will use Internet-based supply chain integration with their CM. For Asia, the open question is how major Asian OEMs will develop the use of contract manufacturers and enter Internet-based manufacturing arrangements? A possible outcome may be that there are indigenous types of network use developing, based on existing OEM-supplier relationships.

- International division of labor: Starting from the observation that there are different divisions of labor emerging across the Triad, we would have to take a closer look at the problem of how volume-manufacturing sites in low-cost areas are integrated into contract manufacturing networks in their regions. This question is closely related to the patterns of cooperation between CM "flagship" companies and their OEM-customers in the local arena. In Europe, we can expect a more limited scope of Internet-based re-organization of manufacturing practices which will correspond with the more hierarchic international division of labor between contract manufacturing operations in the central economies and their low-cost extensions in Eastern Europe. In Asia, we can expect a more complex scenario which is influenced by the existence of a well-developed regional base of electronics component suppliers. Contract manufacturing seems to reinforce the trend toward more centralized patterns of supplier

integration, which is driven by the emergence of global supplier markets in the electronics B2B-arena.

- The shop-floor dimension: Probably the most unknown factor in the development of Internet-based manufacturing arrangements is the labor process. One set of questions is related to the direct impact of new networking arrangements: to which extent will labor-related factors like wages, quality and customer satisfaction data, ramp-up- and delivery-schedules etc. become elements in the global trading of electronics parts, components, and possibly manufacturing services in e-marketplaces? A second set of questions would be directed to the indirect impact of e-commerce-related manufacturing practices on work, employment conditions, and workforce development at the shop-floor. As outlined above, increased flexibility requirements can be expected at all levels. An important question would be how the workforce effects are "distributed" along the manufacturing chain. In Europe, it can be expected that the balance will be more uneven between "West" and "East", with Eastern European sites bearing the risks of employment insecurity and other negative social effects. In the Pacific Rim context and within Asia the picture may be more differentiated.

- Supply-chain-management and engineering: Here we would have to take a closer look at the qualitative dimensions of Internet-based supply-integration. One topic is the impact of the global centralization of supply relationships through e-business marketplaces. A special question would be if there is a shift happening on the part of major OEMs and CMs from low-cost suppliers in Asia to more localized supplier infrastructures in Europe or North America. Another set of questions would have to explore the impact of new Internet-based design processes on the location of manufacturing related engineering functions (including the effect on knowledge transfer and skill formation).

- Infrastructure development: A last topic would be the identification of possible trade-offs between infrastructure development, manufacturing and work organization, and knowledge transfer in contract manufacturing locations (as outlined above). This would include the question which role transnational B2B-groups and new application service providers in supply-chain-integration and engineering will play in infrastructure development in low-cost regions, as well as problems of the regulation of B2B-transactions and marketplaces. We would also have to look at possible links between telecom infrastructure development and labor standards.

These problems could be explored in conjunction with the research currently planned at the Institut für Sozialforschung on the development of the contract manufacturing industry in Eastern Europe and Southeast Asia. The issues involved are complex. However, the drive towards global standardization of the production process in the CM industry seems to offer a chance to compare developments which not too long ago may have looked incomparable. The trend towards economic integration within both Asia and Europe as well as the transformation processes in Eastern Europe and China may be producing some interesting policy lessons for both regions.

This paper greatly benefited from discussions with my colleagues Martina Sproll, Hermann Kocyba, and Wilhelm Schumm

Research Topics: Contract Manufacturing – B2B/E-Commerce

Different Types of OEM-CM-Integration

- How does the Internet fit into specific models („fabless“ – vertical integration U.S./Europe – keiretsu/chaebol)?

International Division of Labor

- Integration of volume manufacturing sites in low-cost regions into Internet-based manufacturing arrangements?
- Potentials and patterns of local integration with OEM-customers and suppliers

Supply-chain-management and engineering

- Impact of electronics components ASP-models: Globalization of parts purchasing and markets
- Increased separation of product and process engineering?
- Systemic rationalization of engineering work: impact on jobs and local skill formation

The shop-floor

Increased labor flexibility through „direct sales“-strategies (contingent employment, manual labor as potential for flexibility)?

- Team-model without teamwork
- Further limits to manufacturing worker´s skill formation?

Infrastructure development

- Development of telecom infrastructure and labor standards?
- Role of E-business consortia and ASPs in B2B infrastructures
- Regulation of B2B transactions?

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