

WORKING PAPERS

EAST-WEST CENTER WORKING PAPERS



EAST-WEST CENTER

The U.S. Congress established the East-West Center in 1960 to foster mutual understanding and cooperation among the governments and peoples of the Asia Pacific region including the United States. Funding for the Center comes from the U.S. government with additional support provided by private agencies, individuals, corporations, and Asian and Pacific governments.

East-West Center Working Papers are circulated for comment and to inform interested colleagues about work in progress at the Center.

For more information about the Center or to order publications, contact:

Publication Sales Office
East-West Center
1601 East-West Road
Honolulu, Hawaii 96848-1601

Telephone: 808-944-7145

Facsimile: 808-944-7376

Email: ewcbooks@EastWestCenter.org

Website: www.EastWestCenter.org



Economics Series

No. 63, November 2003

Global Production Networks, Innovation, and Work: Why Chip and System Design in the IT Industry are Moving to Asia

Dieter Ernst and Boy Lüthje

Dieter Ernst is a Senior Fellow and Theme Leader for Economic Studies at the East-West Center. His previous affiliations include the OECD, Paris, as senior advisor, and the Berkeley Roundtable on the International Economy (BRIE), at the University of California at Berkeley as research director. Dr. Ernst co-chairs an advisory committee for the U.S. Social Science Research Council (SSRC) to develop a new program on Asia. He has served on the Committee on Information Technology and International Cooperation (ITIC) of the SSRC. He also serves as international advisor to a committee setting up a National Science Foundation for Malaysia. Recent books include *International Production Networks in Asia: Rivalry or Riches?*, and *Technological Capabilities and Export Success: Lessons from East Asia*.

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

This paper was prepared as an issue paper, to be discussed at the Planning Meeting of the SSRC on "Emerging Pathways to Innovation in Asia," September 12-13, 2003.

East-West Center Working Papers: Economics Series reports on research in progress. This paper has been peer-reviewed. The views expressed are those of the author and not necessarily those of the Center. Please direct orders and requests to the East-West Center's Publication Sales Office. The price for Working Papers is \$3.00 each plus postage. To destinations within the U.S. and its territories: for surface mail, add \$3.00 for the first paper plus \$0.75 for each additional title or copy sent in the same shipment; for airmail, add \$4.00 for the first paper plus \$1.25 for each additional title or copy sent in the same shipment. To destinations elsewhere: for surface mail, add \$6.00 for the first paper plus \$1.50 for each additional title or copy sent in the same shipment; for airmail, add \$7.50 for the first paper plus \$3.50 for each additional title or copy sent in the same shipment.

Global Production Networks, Innovation, and Work – Why Chip and System Design in the IT-Industry move to Asia

Issues and topics for future research

Dieter Ernst, East-West Center, Honolulu, Hawaii

Boy Lüthje, Institut für Sozialforschung, Frankfurt, Germany¹

September 2003

Draft – Please do not quote, comments welcome

In academic and policy debates on globalization, the issue of transnational production, technological innovation and restructuring of work has long been neglected. Recent research has pointed to the emergence of global production systems based on vertical specialization, such as in the electronics industry and in consumer-goods industries like textiles, garment and shoes (summarized in UNCTAD 2002). The electronics industry seems of particular importance here, since the relocation of productive functions to low-cost and low-wage regions entails important perspectives of technological development.

At the same time, the ongoing global recession in the information technology (IT-) industry calls for a more sober assessment of the promises of technological innovation and economic growth in the so-called “information society”. This includes growing concerns in industrialized countries over the relocation of highly-skilled jobs in IT-engineering and product design, as highlighted by recent warnings of a “Great tech jobs exodus” in the U.S. and Europe (Beckman 2003, Müller 2003). Moreover, the crisis points to the limits of the model of vertically specialized mass-production which has emerged in Silicon Valley and other centers of the “new economy” during the 1990s” as the basis for the resurgence of the U.S. as the dominant global power in high-tech.

Research at the Institut für Sozialforschung – carried out in collaboration with the East-West Center - has been analyzing these developments as related to the assembly sector of the electronics industry. Our studies of "electronics contract manufacturing" in the U.S., Western and Eastern Europe, Asia, and Latin America have extensively traced the development of this new industry model. Based on our empirical findings, the notion of *network-based mass-production* has been developed as a theoretical and analytical framework for the analysis of advanced global production systems (Lüthje/Schumm/Sproll 2002, Lüthje 2003).

The focus of this research has been on the manufacturing-side of the process of production, with special regard to the new forms of neo-Taylorist work organization and flexibilized labor relations resulting from industry-wide restructuring. This perspective reveals the contradictory and paradoxical character of capitalist

¹ Wilhelm Schumm at the Institut für Sozialforschung participated in the drafting of earlier versions of this paper in Frankfurt. Our thanks extend to him for his continuing comments and his vital support for the development of this project.

modernization in the information technology industry: the trend towards vertical specialization among product defining brand-name firms “at the top” of the global production chains on the one hand is matched by a massive vertical re-integration “at the bottom”, i.e. in manufacturing on the other.

In this context, the development of new networks of mass-production includes important features of industrial upgrading in developing countries, since there is a massive trend towards complex, vertically integrated production facilities in low-cost countries like Hungary, Malaysia, China, or Mexico. Our research highlights the importance of work in this scenario and the necessity of making the re-skilling of manufacturing work an essential part of industrial upgrading strategies – an issue often neglected in scholarly and policy debates. We have also pointed to the impediments of upgrading the labor process, which are embedded in the massive re-Taylorization of work within the contract manufacturing industry and the institutional framework of (sometimes oppressive) labor relations in the respective countries.

Beyond manufacturing: product innovation in vertically specialized production systems

An important question resulting from this research is how the rapid build-up of manufacturing-centered knowledge and skills in vertically specialized production systems is translating into the development of innovative capabilities in technology and product design.

Following successful role-models like Korea, Taiwan or Singapore, major low-cost manufacturing countries such as Malaysia, Hungary, Poland, Romania or China are

trying to follow similar pathways of technological learning by attracting engineering and development capabilities as for instance in micro-chips, telecommunications networks, Internet equipment, software, or automotive electronics, as well as in a host of non electronics-related industries like automobile manufacturing, chemicals and biotechnology, textile and garments, transportation systems etc. The most dramatic developments of this kind are currently taking place in China, with important implications for the transformation towards a capitalist market-economy and for the future role of the country in the global economic and political order.

These developments coincide with the accelerated crisis of older forms of industrial organization in the global IT-industry, leading to an ongoing shift towards forms of vertical specialization on the part of established vertically integrated electronics companies. Under vertically specialized models of market control and production – often referred to as “Wintelism” (Borras/Zysman 1997) – markets are “made” by segmentation of products and components, securing profits by rapid ramp-up of new technologies and products and subsequent monopoly or oligopoly in key technology markets. Tough control over Intellectual Property (IP) in product design and manufacturing processes is paramount. On the other hand, cost and flexibility considerations reinforce outsourcing and subcontracting, thereby creating new possibilities of entry for specialized companies, many of them in developing economies.

The perspectives and opportunities for industrial upgrading in this context are discussed by a growing body of research literature, mostly based on neo-Schumpeterian concepts of innovation and theories of flexible specialization.

However, most of the literature has not been looking at two important aspects of the dynamics of global systems of network-based mass-production:

- The *de-coupling of product development and manufacturing*, caused by the increasing separation of product design and development (performed by specialized brand-name firms without manufacturing assets of their-own) from physical production (organized by contract manufacturing firms);
- The *vertical specialization of research and development*. For complex systems such as computer chips, software systems, internet routers etc. product technology development is becoming more and more „modularized“, i.e. certain elements of the design process (mostly routine functions) are performed on a commodity base – available either as standardized routine procedure or as an external "service", performed by specialized subcontracting firms.

Both developments have wide-ranging implications for the organization of engineering work as well as for the relationship between product design and the development of new manufacturing processes. The de-coupling of design and manufacturing is fostering a new international division of labor between product design (usually in developed countries) and manufacturing locations (in developing countries). On the other hand, the modularization of design is making engineering work more easily transferable resulting in the relocation of important elements of the "chain of knowledge production" to low-cost locations.

As it seems, this dual process has profound implications for the organization of work, resulting in an accelerated fragmentation and oftentimes de-skilling of engineering

work, along with an increasing competition between low-cost engineering locations around the world (such as the Indian "software capital" of Bangalore or now the emerging software and chip design sectors in China). This restructuring is also closely related to the global migration of engineers and the emergence of "transnational communities" of high-tech specialists (Saxenian 2002). An important element in this scenario, though hardly understood, seems to be the resistance of engineers against relocation (as can be observed in Taiwan with the shift of engineering capacities to mainland China or in the U.S. and Europe in conflicts over the relocation of major production and engineering segments of high-tech development and service work to Asia).

Conceptual considerations

In a theoretical perspective, the problems outlined above call for an integrated perspective on the economics, organization, and politics of technology development in the context of vertically specialized global production systems. However, the relationship between global production networks on the one side and new forms of innovation and the social production of technology on the other has not been dealt with systematically in recent theoretical debates. Most literature on production networks is not discussing systematically problems of knowledge diffusion (see Ernst and Kim 2002) or knowledge generation (Schumm 2003). On the other hand, theories of innovation have not explored the impact of new forms of transnational production in an environment of vertical specialization.

We are intending to draw from three areas of social science and economics:

- Research on transnational production networks and the international division of labor, especially with relation to the problem of industrial upgrading in NIC.
- Theories of the social shaping of technology as developed in sociology, political sciences and certain areas of economics – particularly in relationship to national and regional systems of innovation.
- Industrial sociology of new systems of production in the context of transnational production networks.

Our research can take as a starting point the concept of global production networks and global flagship networks as developed by Ernst (2002a, 2002b, 2003) and his collaborators (Borrus e.a. 2000), referring to two dimensions of vertical specialization, i.e. *organization* (a move from integration to disintegration) and *location* (a move from geographic concentration to dispersion). This implies a critical view of existing network theories developed by sociologists, economic geographers and innovation theorists that focus on localized mostly inter-personal networks, leading to the proposition that network-based production systems operate in transnational rather than in local settings. In accordance with theories of global commodity chains (Gereffi and Korzeniewicz 1994), it can be stated that global production networks led by flagship firms are essentially hierarchichal in character. With regard to knowledge diffusion, these networks enhance and accelerate the transfer of technological know-how to developing countries but at the same time create new modes of unequal allocation of strategic knowledge (Ernst and Kim 2002).

An important theme – not broadly discussed in economic theories of innovation and sociology of technology and work – seems to be the increasing modularization of technological knowledge within global production networks. As more and more

elements of the design and development process are organized in complex market and/or network relationships between firms, even strategically important technological knowledge is assuming the character of standard commodities. Such knowledge is embodied in standard design rules or standard service packages for the design of software, chips or hardware components and can be traded independently from the respective end-products (Chang e.a. 1999).

The increasing organizational and geographical dispersion of design and development is also adding new dimensions to the relationship between the work of technologists and engineers in laboratories and design centers and the “market”, as theorized in concepts of tacit and codified knowledge or of the “de- and re-contextualization” of technological knowledge in the social shaping of new technological artifacts and systems (Schumm 2003, Esser e.a.1997, with regard to new models of software development: Konrad/Paul 1999). Modularization of technology design seems both to accelerate and to complicate the transformation of technological knowledge into new products, thereby essentially changing the position of specific types and groups of “knowledge workers” as bearers of strategic know-how in global design chains. The essential question would be to find the potentials of “upgrading” and “downgrading” of the skill and market value of engineering work in global design chains.

In theoretical terms, the challenge would be to transfer the rich body of empirical and theoretical research on the shifting paradigm of capitalist rationalization and the social production of technology to the field of vertically disintegrated production systems in developing countries. As to the restructuring of product development, a central implication would be the question whether and how a commodity-chain

approach (Gereffi/Korzeniewicz 1994) can be applied to engineering and design work. In general, this would also entail a shift in perspective from the focus of knowledge diffusion to the social production of technology and the complex questions of power and control (Noble 1984, Hack 1988).

Empirical topics and fields of interest

We start from a very broad concept of innovation, integrating the above mentioned dimensions of industrial restructuring, technology development and work. This implies three key assumptions:

(1) Vertical specialization does have both upgrading and downgrading potentials with regard to the particular work processes and locations involved. The outcome is determined by the economic, social and political conditions underlying the transformation of value chains in particular production networks, nations and regions.

(2) Restructuring of global design chains occurs within very complex network relationships with wide-spread cross-linkages and trade-offs between manufacturing-based innovation, product innovation and development of new standards and concepts in IT-infrastructure. The structure and location of particular elements and stages of the design and development “food chain” is shaped within this framework

(3) Equally, as can be learnt from a vast body of literature in recent industrial sociology, new production systems do have two-pronged and often contradictory effects on the character of work, i.e. upgrading and downgrading, de-skilling and re-professionalization (programmatically Kern and Schumann 1984). Again, the

resulting formation of work and work organization are shaped by complex social conditions and power relationships, as embodied in national, regional, and corporate labor systems, the role of trade unions and other forms of social organizations of workers, and ethnic, racial and sexual segmentation (including immigration policies) affecting the bargaining position of particular groups of the workforce (Lüthje 2003).

With regard to industries, the major fields of interest would be in core segments of the information electronics sector: chip design and manufacturing, telecommunications networks and standards, Internet switching equipment and software systems, and possibly some electronics-related fields in other manufacturing industries such as automobiles, advanced transportation systems, or banking and retail equipment. The field research would concentrate on networks lead by multinational flagship firms from the U.S. (Silicon Valley in particular), Europe, Japan and other Asian countries (primarily Korea and Taiwan), building on established research contacts with the particular firms and regions.

Given the complexity of global production networks in the particular industries, a strong focus on a small number of industry segments and their processes with their linkages to product markets and customers seems preferable. A most promising perspective would derive from a strategic concentration on the field of chip design in relationship with three major key industries:

- Telecommunications and computer networking infrastructure (representing infrastructure-based types of technology development, focused on complex technology systems and mostly by larger, integrated TNC and industry consortia with strong government participation).

- Mobile communications and handset devices (representing new types of consumer electronics goods in highly cyclical markets with ever shorter technology cycles).
- Automotive electronics (representing older mass-production industries with strong tradition in “Fordism” or “Toyotism” and a partial transition to vertically specialized production models).

The issue of standardization and “commodification” of engineering products, services, and work would have to be developed referring to key products in the respective industry segments. The question would have to be asked to which extent and how the modularization of technological knowledge in chip design may reduce the strategic importance of design know-how for the control of key end-product markets. To answer questions of this type would imply to disaggregate chip design into routine functions (design implementation, detailed design) and stages of design that center around conceptualization (reference designs, design rules, platforms). The latter is increasing in importance as a controlling stage, and as leverage point of innovation rents.

Geographically, the focal point for this work would be China and the East-Asian economies serving as a hub for China’s economic development (HongKong, Taiwan Singapore), and the connection of the “China Circle” with high-tech centers in the U.S., Europe, Japan, and possibly Korea. With the rapid economic development based on massive foreign investment during the recent decade, China has not only emerged as a primary location for new systems of network-based mass-production as in electronics or garment. It is also assuming a lead-role for newly industrializing countries as well as for industrially developed countries of the former socialist bloc.

Today, a growing number of strategic production segments as well as technology development is being shifted to China, also at the expense of other economies in East Asia and also Eastern Europe. From this perspective, a comparative perspective on Eastern Europe could also be of great interest.

Both the sectoral and the geographical scope of the studies would have to be selected according to case studies on global design chains for specific products. Apart from the aforementioned more detailed considerations, the lead question would be simple and straight forward: what is really happening in global design chains, as there is very few knowledge about this.

References

- Beckman, David (2003): The Great Tech Job Exodus ... How Microsoft and other U.S.-based tech employers are moving to offshore as many jobs as possible. *WashTech News*, January 24, 2003. www.washtech.org
- Borras, M./Ernst, D./Haggard, S. (eds) (2000): *International Production Networks in Asia. Rivalry or riches?* London: Routledge.
- Borras, Michael/Zysman John (1997): *Wintelism and the Changing Terms of Global Competition. Prototype of the Future? BRIE Working Paper 96B*. Berkeley, Ca.: Berkeley Roundtable on the International Economy.
- Chang, Henry e.a. (1999) *Surviving the SOC Revolution. A Guide to Platform-Based Design*. Norwell, Ma./Kluwer.
- Ernst, Dieter (2002a): "Global Production Networks and the Changing Geography of Innovation Systems. Implications for Developing Countries", *Journal of the Economics of Innovation and New Technologies* , Vol. XI, #6

- Ernst, Dieter (2002b): "The Economics of Electronics Industry: Competitive Dynamics and Industrial Organization", in: *The International Encyclopedia of Business and Management (IEBM), Handbook of Economics*,_editor: William Lazonick, International Thomson Business Press, London
- Ernst, Dieter (2003, forthcoming): The New Mobility of Knowledge: Digital Information Systems and Global Flagship Networks. Latham, R. Sassen S., eds. *Digital Connections in A Connected World*. Published for the Social Science Research Council. Princeton, NJ: Princeton University Press.
- Ernst, Dieter/ Kim, Linsu (2002): "Global Production Networks, Knowledge Diffusion and Local Capability Formation", *Research Policy*, special issue in honor of Richard Nelson and Sydney Winter, volume 31, no. 8/9
- Esser, Josef/Lüthje, Boy/Noppe, Ronald (1997): *Europäische Telekommunikation im Zeitalter der Deregulierung. Infrastruktur im Umbruch*. Münster: Westfälisches Dampfboot.
- Gereffi, Gary/Korzeniewicz Miguel (eds.) (1994): *Commodity Chains and Global Capitalism*. Westport, CT: Praeger.
- Hack, L. (1988): *Die Wirklichkeit, die Wissen schafft*. Frankfurt am Main: Fischer.
- Kern, Horst/Schumann, Michael (1984): *Das Ende der Arbeitsteilung?* München: Beck 1984.
- Konrad, Wilfried/Paul, Gerd (1999): *Innovation in der Softwareindustrie. Organisation und Entwicklungsarbeit*. Frankfurt/New York: Campus Verlag.
- Lüthje, Boy (2001): *Standort Silicon Valley: Ökonomie und Politik der vernetzten Massenproduktion*. Frankfurt/New York: Campus.

- Lüthje, Boy (2002): Electronics Contract Manufacturing: Global Production and the International Division of Labor in the Age of the Internet. *Industry and Innovation*. Special Issue: Global Production Networks. Editors Dieter Ernst and Linsu Kim. Vol. 9(No. 3):227-247.
- Lüthje, Boy/Schumm, Wilhelm/Sproll, Martina (2002): *Contract Manufacturing: Transnationale Produktion und Industriearbeit in der IT-Industrie*. Frankfurt/New York: Campus.
- Lüthje, Boy (2003): Fred Pollock in Silicon Valley: Automatisierung und Industriearbeit in der vernetzten Massenproduktion. In Demirovic, A. (Hg.): *Modelle kritischer Gesellschaftstheorie*, Stuttgart/Weimar 2003.
- Müller, Wolfgang (2003): Am Ganges und am Jangtse sprießen IT-Jobs. *Frankfurter Rundschau*, September 3, 2003.
- Noble, David (1984): *Forces of Production. A Social History of Automation*. Philadelphia: Temple University Press.
- Saxenian, A. (1994): *Regional Advantage. Culture and Competition in Silicon Valley and Route 128*. Cambridge, Ma./London: Harvard University Press.
- Saxenian, Annalee (2002): Transnational Communities and the Evolution and Global Production Networks: The Cases of Taiwan, India and China. *Industry and Innovation*. 9(3):183-202.
- Schumm, Wilhelm (2003): Technologiegeneseforschung und der Wandel des Rationalisierungsparadigmas. Buckel, Sonja/Dackweiler, Regina/Noppe, Ronald (eds.): *Formen und Felder politischer Intervention. Zur Relevanz von Staat und Steuerung*. Festschrift für Josef Esser. Münster: Westfälisches Dampfboot.
- Sturgeon, Tim (1997): *Turnkey production networks: a new American model of industrial organization?* BRIE Working Paper. Berkeley, Calif.: Berkeley Roundtable on the International Economy.
- Sturgeon, Tim J. (1999): *Turn-Key Production Networks: Industry Organization, Economic*

Development, and the Globalization of Electronics Contract Manufacturing. Ph. D.
dissertation, University of California Berkeley.

UNCTAD - United Nations Conference on Trade and Development (2002): *World Investment Report 2002. Transnational Corporations and Export Competitiveness*. New York/Geneva: UNCTAD.