Title
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Author
Linden, Greg

Publication Date
1998-06-01

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Greg Linden

Working Paper 126
July 1998

Prepared for the Kreisky Forum and BRIE Policy Conference: *Foreign Direct Investment and Trade in Eastern Europe: The Creation of a Unified European Economy*, Vienna, June 5-6, 1997.
Published jointly with the Center for German and European Studies, University of California, Berkeley.

Generous support for production of the BRIE Working Papers Series was provided by the Alfred P. Sloan Foundation.

Greg Linden is a Research Associate at BRIE and a PhD. Candidate in the Department of Economics at the University of California, Berkeley.

[1] I wish to thank Cynthia Berg, for excellent editorial assistance, and Dieter Ernst, under whose tutelage I discovered the fascinating complexities of global electronics production. Helpful comments on the paper have been provided by Andrew Schwartz and John Zysman. Any remaining errors are entirely my own responsibility.

Since the collapse of central planning in the former Soviet Union, multinational corporations (MNCs) have forged a range of production linkages in the three leading transition economies of Central Europe (CE) -- Hungary, Poland, and the Czech Republic.[2] The initial investments were by European firms, concentrated in automotive and electrical parts manufacturing, textiles, and agriculture. The last few years have witnessed the gradual build-up of foreign investment in more "high-tech" electronics activities, as a diverse group of multinationals expand their European production activities from West to East. While electronics production in CE pre-dates the arrival of foreign direct investment (FDI), the former state-owned firms are generally unable to compete with more advanced producers from the United States, Asia, and Europe. They are limited by relative weakness in marketing, product and process technology, organization and management, and capital resources. As a result, multinationals have become the principal actors in CE's export-oriented electronics sector.[3]

This paper examines FDI patterns in Central Europe and describes the nature of CE's multinational-led integration with the global electronics industry. Section One characterizes the international production networks that define the architecture of the global electronics industry, and explores the parallels between Asian and European regional production networks. Section Two portrays the emerging electronics networks in Poland, Hungary, and the Czech Republic.[4] The description is generated from two vantages: Local Capabilities -- which matter more in some sub-sectors than others -- and Production Organization -- which considers the emerging role of CE as a supply base. Section Three evaluates some of the local "supply" factors influencing MNC decisions including the Soviet-era industrial legacy, and post-Soviet policies toward foreign investment. A concluding section explores implications of CE's ascendance as a regional production platform, from both Western and Central European perspectives.

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[2] For brevity, these three countries will generally be referred to in this paper as "Central Europe" despite the corresponding lack of accuracy.

[3] In this paper, electronics is broadly defined to include electronic components, consumer electronics, computers, telecommunications equipment, electrical appliances, and electrical components for the automotive sector.

[4] The main source of information on which the study is based is the BRIE FDI Database, a compilation of news articles and other publicly available information about network activities in the electronics sector. Additional background information was provided by interviews conducted in Germany and the Czech Republic in 1994 and 1995 by Tim Sturgeon, formerly of BRIE, now at the Massachusetts Institute of Technology. His contribution is gratefully acknowledged.

I. International Production Networks

Today, global electronics manufacturing is organized by the international production networks (IPNs) of a few dozen multinational corporations, whose networks have been built up over the past four decades.[5] In East Asia, where IPNs have been a prominent feature of industrial development, Japanese firms initiated foreign investment in the 1960's to exploit the region's protected domestic markets. Throughout the 1970's, American and Japanese companies located production in Asia to capitalize on low wage costs for labor-intensive components production. As producers in Asia developed technical specializations and upgraded capabilities in the 1980's, American, European, and Japanese firms developed a more complex range of manufacturing linkages. What originally began as labor-intensive and export-oriented assembly developed into an elaborate regional division of labor.

The evolution of production activities in East Asia illustrates the changing terms of competition for electronics manufacturers. Whereas competition in high-technology has typically revolved around the level of the final product, firms now also compete on the efficiency and quality of the underlying production network they construct (Borrus and Zysman, 1997). The criteria for the location of production now extend beyond low factor costs (i.e. labor and land) to specialized product and/or process capabilities. The two motives are not mutually exclusive. In East Asia, direct investors appear to choose locations with the optimal combination of low factor costs and adroit technical abilities; with more mature technologies being deployed in lower-waged, lower-skilled locations, and higher-technology products produced where high technical capabilities are available, with less emphasis on labor costs.

A defining feature of production networks is their organization around geographic regions, with each lead firm establishing similar (but not identical) production organizations in Asia, Europe, and North America.[6] These regional networks typically consist of firms in high-cost locations coordinating activities in medium- and low-cost countries. As a simplified example, a

[5] "International production network," a concept developed by Dieter Ernst through a series of work at the OECD and BRIE, is used here to refer to the geographic distribution of the activities of the leading name-brand producers of electronic goods and components, particularly linkages both with their own affiliates and with non-affiliated suppliers. This reading of IPN is similar to the "vertical keiretsu" concept applied in Japan, but is less hierarchical and less exclusive -- suppliers can be part of numerous IPN and can potentially wield influence comparable to that of the lead firm (Borrus and Zysman, 1997).

regional network in Asia might have corporate headquarters in Japan, regional headquarters and high-value-added manufacturing in Singapore, and labor intensive production in Thailand and Indonesia. Similarly, American and Japanese investors in Central Europe will typically coordinate their regional activities from a previously-established (Western) European headquarters.

Multinationals tend to build up the densest network in their home region, which has been termed a "regional core network."[7] This form of organization allows the corporation to reduce costs by using off-shore production in the home region while maintaining close ties between design and production. Thus, the opening of Central Europe to investment offers European firms new opportunities to enhance their regional core networks, providing them a more diverse array of production costs and capabilities. In response, Europe's leading electronics companies -- such as Siemens and Philips -- have invested early and often in Central Europe.

A. The Asian Experience

In the electronics sector, the most elaborately articulated production networks have appeared in Asia, where electronics has long served as a driver for export-oriented growth. Over time, extensive cross-border complementarities have emerged. Japanese firms define product characteristics and produce the highest-value systems and components domestically. Korean firms have taken the role of "fast followers" for appliances and components with large scale economies. Taiwanese firms are prominent in the computer sector and also produce both low-value components and high-value niche products. Singapore is the administrative base for many of the networks in the region and acts as an assembly platform for high-value products. Malaysia is an intermediate-value assembly platform, while Thailand, the Philippines and Indonesia undertake mostly low-value assembly. As China integrates into the region and as various countries advance technically at different rates, the patterns of production will continue to evolve.

The rise of networked production in Asia occurred at the intersection of national industrial policies and the strategies of multinational corporations. Several countries in the region with minimal industrial heritage emerged from a period of import-substitution to strongly embrace export-oriented industrialization (EOI). As the industrializing countries of Northeast Asia (primarily Korea and Taiwan) instituted EOI policies, American firms were initiating low-cost

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[6] The global networks of different lead firms differ in the amount of cross-hauling between regions and in the amount of regional autonomy from home base -- see Ruigrok and van Tulder, 1995, esp. Chapter 8.

[7] United Nations, 1993, Chapter VII

offshore production to contend with Japanese competitors. Then, as the next cluster of countries (primarily from Southeast Asia) adopted export-led policies, the Japanese were moving offshore to defend their markets against low-cost rivals from Korea and Taiwan.

Malaysia's experience with production networks illustrates the interconnected forces of investment supply and demand, as national policy affects company strategies, which in turn influence policy. When Malaysia opened its first Free Trade Zone in the early 1970's, American semiconductor firms were expanding labor-intensive assembly operations overseas, while the Japanese began to ease their restrictions on outward investment. Within a few years, Malaysia was one of the world's leading exporters of integrated circuits, having garnered IC assembly investments by ten firms, which still employ thousands of Malaysian workers. In 1986, in response to a recession, the Malaysian government began a drive to attract new export-oriented investments. Once again, the timing was propitious. Japanese consumer electronics firms, facing a yen appreciation and domestic wage increases, were looking for low cost production sites for several lower-technology product segments. From 1986 to 1989, almost all of the major Japanese electronics producers established new Malaysian subsidiaries manufacturing TVs, VCRs and microwave ovens for export. European firms, including Grundig, Thomson, and Philips, also arrived or added new plants. Yet, even an established production location can miss out on foreign investment opportunities. For computer equipment, Malaysia's timing was less fortuitous. When American firms shifted assembly of computer and hard disk drives overseas in the mid-1980's, much of the investments bypassed Malaysia, and went to Singapore. Then as Japanese firms initiated offshore plants in this sector, they focused investments in the Philippines and Thailand.

B. The European Context

The opening of Central Europe created the possibility of its integration into Europe's regional production networks, similar to the integration of Southeast Asia as a "third tier" of production, supporting Japan and, more recently, Taiwan and Korea.[8] While certain parallels with the Asian region are apparent, the emerging production networks in the European region follow their own particular logic. Three factors, unique to Europe, will structure the development of production networks in CE.

[8] For a further description of the "tier analysis" of Asia's development, see Borrus and Zysman, 1997.

First, the United Kingdom has become the central node for the regional networks of non-European electronics firms, with investments covering the full gamut of electronics production. Since 1989, US- and Asia-based multinationals have concentrated their European investments in the established investment zones in Great Britain. Scotland, for example, which hosts computer plants belonging to Compaq and IBM, has even earned the name "Silicon Glen," with semiconductor manufacturing plants operated by companies like National Semiconductor and NEC. Wales is an important destination for consumer electronics, with large-scale plants established by Matsushita, Sharp, and Sony. The UK has garnered immense quantities of Japanese FDI, and continues to do so despite the low-cost skilled workers newly available in Central Europe. The 1995 Directory of Overseas Subsidiaries of the Electronic Industry Association of Japan shows that of 138 manufacturing subsidiaries in Europe as of mid-1995, 67 were established from 1986 to 1990 and only 19 during the following five years.[9] Of the 86 new Japanese investments just cited as occurring after 1985, 38 of them went to the United Kingdom, which offered investment incentives and relatively low wages in an intra-EU location -- in addition to English language and nearly two decades of previous Japanese electronics investment during which world-class manufacturing skills were localized.

The substantial electronics production in the UK region will most likely complement, and not compete with, the networks forming in CE. At least in the short to medium term, the UK region will continue to attract investments in more capital-intensive and cutting-edge production activities, while CE attracts investments in more mature, labor-intensive technologies. Over time, activities in CE affiliates will be upgraded, probably as new locations further eastward emerge to undertake the lower-skill assembly tasks in a more finely articulated regional division of labor.

Second, economic conditions in Europe have not been conducive to the rapid internationalization of production by European firms, thereby slowing their expansion into foreign locations. European companies were generally eager to tap into new supplies of both skilled and unskilled workers in a labor market unconstrained by the work rules prevalent in the west. However, Europe's leading economies in the 1990s have been coping with rising unemployment, making it politically difficult for Europe-based companies to engage in outward investments which appear to move more jobs abroad. By contrast, the strong yen and tight Japanese labor market in the 1980's lent support to extensive offshore investments in other parts of East Asia while a perpetual trade surplus with the region provided a political motivation to move production there.

[9] 1995 EIAJ Directory, Table 1.3.1

Third, unlike in Asia, there has been no "second tier" of European producers to threaten the leading firms, Siemens, Phillips, and Thomson. And whereas North American producers were forced to compete in their own domestic markets with Asian producers, European markets have been more protected from the brunt of foreign competition. This protection resulted from national political bargains which limited foreign access to European markets through quantitative restrictions, in effect, dampening cost pressures for European producers. The new political bargain being struck in Europe to eliminate protectionist measures has created an imperative for European companies to shift production to CE.[10]

The creation of networks in CE continues to be a gradual process, with levels of foreign electronics investments significantly lower than levels in Southeast Asia. During the period 1991 to 1994, Malaysia's average annual inflow in the electrical and electronics sector alone was $978 million[11] -- more than the Czech Republic received in all sectors during the same period.

C. Foreign Firm Strategies

Following the wrenching break up of the Soviet Union, Central Europe's state-owned electronics firms found themselves in poor shape to survive the new market economy. As such, foreign investment, and the accompanying capital, technology and marketing linkages, became essential to reinvigorating the industry's remnants and building anew.

One incomplete but telling measure of foreign involvement in the sector can be seen in trade numbers. In 1994, the share of electronics exports from the three transition countries to the European Union which was classified as "outward processing" (wherein imported inputs are assembled using labor-intensive techniques and then re-shipped) was 47%, up from 41% a year earlier. Basic assembly was clearly the primary mode of entry for most multinationals in CE's electronics sector. However, differences between the three countries were large, with Hungary at 67%, Poland at 44% and the Czech Republic at 19%.[12]

Foreign electronics investments in CE took place in two general phases. The first phase, roughly from 1989 to 1993, began with a brief and largely inconsequential rush of joint ventures by small foreign firms. The initial relationships were soon overshadowed by the more enduring direct privatization of various state assets to foreign multinationals, particularly in the

[10] See Borrus and Cohen, 1998.

[11] author's calculation from Malaysian Investment Development Authority data

telecommunications sector. From 1989 to 1991 in Hungary, and from 1991 to 1993 in Poland and the Czech Republic, multinationals entered into joint ventures with recently-spun-off divisions of state conglomerates. The second (and current) phase of foreign investment involves the establishment of major greenfield factories. Since its commencement in 1993 (earlier in Hungary), the pace of investment has been most frenetic in Hungary, but both Poland and the Czech Republic are beginning to attract their share of large-scale electronics plants (Table 6).[13]

[12] The data is from EUROSTAT, and were kindly provided to me by Tim Sturgeon.

[13] Tables are presented out of sequence so that tables 1 through 5 are harmonized with those in the shorter, published version of this paper.

TABLE 6: MAJOR* INVESTORS BY DATE IN THE ELECTRONIC AND ELECTRICAL SECTORS

(* -- total investment -- actual or anticipated -- greater than $20 million)

Year	Czech Republic	Hungary	Poland
1989		Siemens (telecom) $60m GE (lighting) $720m	
1990		Philips (VCR) $25m Samsung (TV assy.) $23m	Alcatel (telecom) $90m
1991		Electrolux (refrigerators) $120m United Technologies (auto parts) $25m Siemens (electrical parts) $20m	Curtis (TV assy.) $20m Thomson (CRTs) $90m Philips (lighting) $50m
1992		†Hantarex (monitors) $20m †Philips-Sanda [Flextronics] (plastic parts and CEM) $45m	Lucent (telecom) $50m
1993	Siemens (telecom) $37m Kyocera (components) $39m Siemens (electrical parts) $25m Ford (auto parts) $100m		Siemens (telecom) $50m †Fiat [Labinal] (auto parts) $20m
1994		ITT (auto parts) $40m	
1995		IBM (HDD) $100m Nokia (monitors) $30m	Philips (TV assy.) $25m Philips-Matsushita (batteries) $40m
1996		Philips (monitors) $30m Sony (audio equipment) $21m	
1997	Matsushita (TV assy.) $66m Motorola (semiconductors) $45m AMP (auto parts) $20m	Philips (audio equipment) $30m Nidec (HDD motors) $27m	
1998	FIC (PC assy.) $100m	Elcoteq (CEM) $30m	
?			Motorola (IC assy.) $150m Merloni (ovens) $50m

Source: Press reports, author's estimates; dollar amounts are either the accumulated actual investment at historical cost or projected total investment, whichever is greater.

Note: † -- affiliate was bought out by a subsequent investor, shown in brackets;
CEM = contract electronics manufacturing;
The last row is for investments that have been reported but not officially announced.

European firms have taken the lead in investments, motivated, initially, by geography and lower labor costs. German firms, in particular, have sought out investment opportunities in the region to escape stifling labor laws and the high cost of doing business at home. While Europe has a relatively small number of lead firms in electronics, they have made the earliest and most extensive investments in CE. Most notably, Philips of the Netherlands has built an extensive

network for consumer electronics in Hungary[14] and also made electrical-sector investments in Poland. Siemens of Germany has invested in all three countries in telecommunications equipment and electrical parts.

US firms are less in evidence, but have made a number of significant investments. Early investments were made in Hungary for automotive and lighting equipment production. In 1995, US investments began in microelectronics and final product assembly; IBM established a large-scale disk drive assembly plant in Hungary, while Motorola invested in an existing Czech wafer fabrication plant and later announced a new software center in Poland. More recently, several US-based contract manufacturers have expanded their European operations to Hungary.

Japanese electronics producers have been notably cautious. Several years of establishing sales and subcontracting networks preceded the first large-scale electronics investments. For the most part, Japanese firms did not participate in the direct privatization opportunities that constituted the first wave of investments, instead preferring greenfield plants. Kyocera invested in component production in the Czech Republic beginning in 1993, and Matsushita opened a large-scale TV assembly plant there in 1997. The Japanese pace of investing has picked up, especially in Hungary where a string of investments in audio-visual equipment and components began in 1995. Japanese investment in the Polish electronics sector has occurred mainly in cooperation with European partners, such as Matsushita's investment in dry cell batteries with Philips and Sumitomo's investment in automotive cable assemblies with Britain's Lucas.

Korean firms have moved fast in the region, looking to use CE as a production platform for the European market. Two of the three major Korean electronics producers have tied CE into their European networks. Samsung began building a Hungarian base as early as 1990, while Daewoo, which is better known in the region for its aggressive automotive investments, has also opened plants for the assembly of TV sets and washing machines in Poland.

[14] In 1998, Philips sold off some of its parts and sub-assemblies operation in Hungary and Austria to Flextronics, a U.S.-based contract manufacturer that will continue to supply Philips on an outsourcing basis. Such deals are currently widespread in the industry (Sturgeon, 1997).

II. Electronics Networks in Central Europe

The nature of foreign investments differ significantly by country. When Central Europe emerged from Communism, the **Czech Republic** had the most technologically advanced electronics sector, particularly in the "hard" know-how of precision engineering. At the apex of Czech electronics was Tesla's integrated circuit fabrication plant in Roznov, requiring some of the most demanding manufacturing know-how in electronics. Despite its technical proficiency, the country has not yet built significant foreign linkages through either subcontracting or direct investment.

Hungary, with historically strong ties with Western firms and production networks, is becoming a "supply base" for the regional electronics sector, attracting investments from suppliers of parts, components, and contract manufacturing services, as well as from final assemblers.

Poland has followed yet a different path. Trusted by neither the West nor the Soviets, Poland's political circumstances largely cut it off from new technology during the 1980s. Nonetheless, with the advantage of a substantially larger domestic market, it has attracted several producers of consumer products such as televisions and washing machines. Many of these firms have expanded their output to export to other European markets.

What follows is a detailed presentation at the sub-sector level of the electronics industry linkages that have formed over the last decade. The discussion is organized around two themes. First are **Local Capabilities**, in which a comparison of patterns at the high-end (microfabrication and software) and low-end (final assembly) will be used to suggest that the national capabilities make a difference in the ability to attract certain investments. Second is the **Organization of Production**, in which the Hungary-centered patterns for general-purpose components, parts, and sub-assemblies will be used to introduce the notion of a regional supply base.

A. Local Capabilities and FDI

Our first vantage examines the technological extremes of the electronics sector. At the upper end of the technology spectrum are microfabrication and software engineering, sub-sectors which require highly skilled workers. At the opposite extreme are product complexes for the assembly of consumer electronics, information equipment, and household appliances, which are dependent primarily on low-cost labor. While investments in assembly are spread roughly evenly

across the three countries,[15] more advanced technologies have initially concentrated where there is already an established capability. For example, foreign investment in wafer fabrication is limited to the Czech Republic, which was the only country to successfully produce integrated circuits under the Soviet production system.

High-End Sub-Sectors: Microelectronics and Software

Integrated circuit (IC) fabrication and software programming are both dependent on highly-skilled engineers, who can require years of training. The earliest foreign activities in these two sectors are concentrated where they already had an established domestic base: the Czech Republic for ICs and Hungary for software.

Microelectronics

The Czech Republic has the most developed microelectronics sector in CE, with major investments by Motorola. Motorola bought a controlling interest in the Tesla Sezam factory and its associated wafer supplier in 1997, following several years of subcontracting in which Motorola had helped upgrade the factory's operations. The company also opened a design center for analog ICs in 1994 near the Tesla factory. Total investment figures have not been disclosed, but are reported to exceed $45 million. As of 1990, the then-state-owned fab was primarily using 3-inch wafers and producing circuits with 4-micron line widths, well behind the six-inch wafers and sub-micron capabilities of Western producers. Nevertheless, a team from Motorola surveyed the sector in 1991 and declared the output of the Tesla fab to be comparable to if not better than that of its other subcontractors.

Poland's CEMI (part of the Unitra group) was also a producer of integrated circuits. Like Tesla, it used ten-year-old technology for MOS and bipolar chips. However, CEMI's reputation for quality was poor, and it was unable to produce output at a cost that could be competitive on world markets. In 1993, CEMI was declared bankrupt and offered for sale for the price of £1 to any buyer willing to take on its debt and its outdated production system. No takers were found, and production was eventually restarted in 1995 under ownership of Poland's Industrial Development Agency (ARP).

Hungary had even less success with integrated circuits in the Soviet Era. Hungarian IC production was initiated in 1985 under licenses from the Soviet Union and East Germany, but the

[15] As discussed below, the Czech Republic has notably fewer such investments, due in part to a less

factory burned down the following year, destroying all the equipment. Undaunted, a new Hungarian-Soviet joint venture, Intermos, was created to carry on, and began production in 1992. A second company, Interbip, was created with private funding to produce bipolar ICs for consumer electronics using technology from a small US partner, NCM. Intermos and Interbip were recently combined into a single firm called Melcom. The main products include switching diodes, power transistors and thin and thick hybrid circuits, primarily for export to customers such as Temic, Motorola, General Electric, and ABB.

Software

The underlying capabilities for software engineering are essential to a wide range of high level electronics activities from chip design to plant management. It is often noted that the poor quality of computers available in the Soviet bloc under Communism engendered a crop of unusually creative software developers who learned to overcome the limitations of their hardware.[16] Central European software engineers have had no shortage of contract work localizing software packages for the desktop PC and other markets.

As with IC fabrication, the pattern of foreign investment in software is very uneven, despite reportedly widespread software capabilities. The main investments in the sector are shown in Table 7.

TABLE 7: MAJOR INVESTORS IN THE SOFTWARE SECTOR
(total investment > $5 million and/or more than 100 workers)
(† indicates investments purchased by a subsequent investor)

Sub-sector	Czech Republic	Hungary	Poland
software	†Sevodata Sevelen [Cogema] (1990)	Siemens (1994) Ericsson (1994) CSK (1996) Nokia (1998)	ICL-Fujitsu (1993) Motorola (1998)

Source: News reports

One might expect investment patterns to correspond to levels of computer density, a key indicator of a country's information technology market. Yet, while Hungary and the Czech Republic have similar levels of PC penetration (see Table 1), foreign investment in software engineering has been highly concentrated in Hungary, a situation which suggests that "market pull"

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hospitable attitude toward foreign investors.

is only part of the draw for foreign investors, leaving differences in local capabilities as a possible explanatory factor.

TABLE 1: Personal Computers in Central Europe

Country	1993 PC Sales (units)	1995 PCs Per 1,000 Inhabitants
Czech Republic	122,000	14.2
Hungary	83,000	15.9
Poland	195,000	7.0

Source: Figyelo, December 21, 1994, Pg. 47; Euromoney, September 30, 1995, Pg.174

Hungary has a strong tradition in software and also some of the strongest foreign linkages. State-owned software house SzKI was performing commissioned work for Siemens as early as 1980. When SzKI was broken up during the transition, one of its spin-off companies, Recognita, received about a third of its start-up capital ($80,000) from Walters Europe in 1989. The company received later infusions from the Hungarian-American Enterprise Fund (HAEF) in 1992 ($380,000) and 1994 ($190,000), leaving HAEF with a 75% interest. Recognita produced optical character recognition (OCR) software for most European languages and was finally bought out by Caere, an American OCR firm seeking to expand its base in Europe, for $4.7 million in 1996.

Another strong local company, GraphiSoft -- a start-up dating from 1982 -- has carved out a niche in 3D drafting software for architects. As part of the company's global sales effort, a Japan sales office was opened in 1994. The following year, GraphiSoft licensed its 3D technology to a subsidiary of Japanese IT conglomerate CSK. In 1996, CSK and an investment subsidiary of Daiwa Securities purchased a 15.5% stake in GraphiSoft for $7.5 million. The funds went to help GraphiSoft with its plan to build an $18 million office building in Budapest which will become a privately operated software park.

Other direct investments have supported development of software for communications networks:

- In 1994, Siemens established Sysdata, engaged in software development for private telephone networks, employing 150 software engineers by 1995.

[16] see for example, Dyker, 1996.

- In 1994, Ericsson started a software support group in Budapest, one of 25 such centers worldwide. The number of programmers grew to 30 in 1995 and reached 90 in 1996 with further expansion planned. The company cited the country's "price to performance ratio" as the principal reason for the expansion, as the quality (number of bugs, development time) of the work doesn't quite match that at other centers in Finland, Norway and Ireland.
- Nokia, which won a contract to supply GSM equipment to a cellular operator in 1994, recently announced it will open two Hungarian research centers to develop switching software and applications. Total employment is projected at 330.

Poland and the Czech Republic have very capable software sectors, but they have not yet produced competitive companies like GraphiSoft, nor have they generated the same level of activity by foreign firms as Hungary.

In Poland, starting in 1989, ICL (the UK branch of Fujitsu) co-developed banking software for the local market with a Polish company called Softbank. ICL bought a 51% share of the 100-employee software and services company in 1993. Fujitsu itself recently announced that it would invest $350,000 to develop biotechnology software in Poland for the European pharmaceutical and food markets, starting with a staff of ten developers. In addition, Motorola recently committed to open a software center in the Krakow technology park that should eventually employ as many as 500 engineers.

In the Czech Republic, PragoData, a custom software house writes industrial management software. A Swiss firm, Sevodata Sevelen provided a third of its capital when it was established in 1990. The successful company was bought by Cogema of France in 1995. Siemens also has a software subsidiary in the Czech Republic, similar to that in Hungary but about one-third the size.

Product Complexes: Systems and Their Core Components

"Product complexes" are final products and their major subsystems, which must be assembled using some combination of automation and manual labor. Final products for which assembly has been started by multinationals in the transition economies of Central Europe include VCRs, personal computers, and television sets. These products encompass one or more core components such as VCR heads, computer "motherboards", and CRTs, respectively. The location of final assembly is not dependent on the local manufacture of core components, which are

typically the highest-value-added element of the system. However, local manufacture of the core component combined with final product assembly represents at least a potential vertical complex and signals the presence of local expertise in the overall product area. Basic assembly skills don't differ greatly across products, so it is often some historical quirk that makes one country the region's chief exporter for computers while another becomes the main exporter of monitors. Now that identifiable complexes have emerged (see Table 8), these patterns may persist indefinitely because product-specific technologies become localized.

TABLE 8: MAJOR INVESTORS IN SYSTEMS AND THEIR CORE COMPONENTS
(total investment > $5 million and/or more than 100 workers)
(† indicates investments purchased by a subsequent investor)

Sub-sector	Czech Republic	Hungary	Poland
PC assembly	FIC (1998)		
hard disk drives		IBM (1995)	
HDD parts		IBM (1997) Nidec (1997)	
monitors		†Hantarex (1992) Nokia (1995) Philips (1996)	
VCRs		Philips (1990)	
audio equipment		Philips (1992) Sony (1996) Bosch (1997) Clarion (1997) Philips (1997)	
televisions	Matsushita (1997)	Samsung (1990)	Curtis (1991) Daewoo (1994) Grundig (1995) HCM-Luks (1995) Philips (1995)
CRTs			Thomson (1991)
telecom	GEC-Marconi (1993) Siemens (1993) Velec [Sagem] (1993)	Siemens (1989) Ericsson (1990)	Alcatel (1990) Lucent (1992) Siemens (1993)
lighting equipment		GE (1989)	Philips (1991)
appliances		Electrolux (1991)	Daewoo (1995) Bosch-Siemens (1995)

Source: News reports

Personal computers

So far the only export-scale PC assembly investment has been made in the Czech Republic by a Taiwanese firm, First International Computer. Although not well known outside the industry,

FIC designs and assembles computers sold by better-known firms under their brand names, such as Compaq. Output began in 1998 at 10,000 units per month for export, and the total planned investment is $100 million.

Hard disk drives

Hungary has captured the lion's share of investment for the personal computer's major sub-systems: hard disk drives and monitors. The hard disk complex has some potential vertical integration, while the core component of the monitor -- the CRT -- must still be imported.

In 1994, IBM began subcontracting the production of hard disk drive head assemblies to the successfully-privatized Videoton, investing about $2.6 million and employing 150 workers. Subsequent investments of more than $20 million were made and equipment relocated from Germany so that in 1997, a new plant opened with 200 employees producing IBM's magneto-resistive heads. In 1995, IBM also decided to invest in assembly of complete drives in a factory leased from Videoton. By 1997, the total investment was about $110 million with 3,000 workers and a capacity of 3 million units a year. The plant's yield is claimed to be the highest of IBM's ten plants worldwide. A recent investment in support of hard disk drives was made by Nippon Densan (also known as Nidec), the leading producer of disk drive spindle motors. $27 million is being invested in a new factory that should eventually employ 800 workers.

Monitors

Like the hard disk drive, monitor production has been concentrated in Hungary, where the earliest investment was from Italy's Hantarex, which entered a majority-owned joint venture with the state-owned Mechanikai Laboratorium in 1991. The assembly venture expanded over the next couple years, then Hantarex was closed down in Italy under a cloud of scandal, bringing the Hungarian operation to a halt. In 1995, the Hantarex plant was taken over by Nokia, which made an initial investment of $30 million. In 1996, the factory employed 200 workers producing about 300,000 units per year for the West European market. The company has less than a dozen local suppliers, providing mostly packaging and plastic parts. Two Finnish suppliers, Ensto and Elcoteq, have recently arranged to build factories near Nokia's monitor factory to supply plastic parts and subcontracting services. Elcoteq's total investment -- encouraged by a three-year exemption from local taxes -- is expected to be more than $30 million. Philips also started a monitor factory in Hungary, in 1996. The $30 million factory employs over a thousand workers and capacity is one million units per year.

VCRs and audio equipment

Hungary is also the leading destination for investment in the assembly of VCRs and audio equipment. The story with Philips in VCRs is similar to that of IBM for disk drives, starting through a subcontracting arrangement with Videoton for parts and gradually expanding to become a major investment including final assembly. Recent investments by Sony and Clarion for audio equipment confirm Hungary's position as the preferred regional site for low-cost assembly of mature products.

Television sets and CRTs

Television assembly is one area in this sub-grouping where Hungary is not the leading investment location. Poland has attracted the most activity in this area, primarily because of its larger market. Several small-scale plants not reported in the table were opened to serve the local market, but these gave way to a series of larger investments by both European and Asian companies planning to use Poland as an export platform.

Poland's television complex is further shored up by local production of CRTs, the primary component of television sets. France's Thomson took a controlling stake in Polkolor, Poland's state-owned producer of CRTs, in 1991. By 1995, the company had invested over $90 million, raising capacity to 3 million units per year and employing over 5,000 workers. The factory supplies both local and West European markets with small and mid-size screens.

The Czech Republic also produces CRTs, although the former state-run factory is now locally owned and does not appear in the table. But the presence of this capability is indicative of a well-developed television complex, which may have helped convince Matsushita to commit to a $66 million operation in 1996 to serve the regional market. The company had begun evaluating local suppliers as early as 1994, and started sourcing TV tuners from Tesla Lanskroun (a passive components producer) and remote controls from Elitron Liberec (which used to make electronics for textile machinery) in 1995. However, in 1997, a spokesperson let it be known that the poor quality of local suppliers would make it difficult to meet informal targets for local content. The only local supplies to be used initially at the new plant will likely be cardboard boxes and printed materials.

The main foreign investment in Hungary's television sector came from Korea's Samsung, which started a 40%-owned joint venture in 1989 with a state-run producer, Orion. Hungarian engineers were sent to Korea to study production techniques. Output began in 1990 with a

100,000 set per year capacity and 125 employees. Local suppliers provided packaging, frames, and wiring for local content of about 15%. In 1991, Samsung bought out Orion's share and steadily raised capacity, which has now reached 500,000 sets a year, primarily for export. In 1995, the company became profitable, albeit with the help of a five-year tax holiday extension. Local supply of plastic parts has increased, raising local content to 25%. Less than 20% of parts come from Korea, with the rest from elsewhere in Europe, particularly CRTs, which are sourced from a Samsung brownfield plant in the former East Germany.

Telecommunications

The countries in this study all exited communism in dire need of upgrading their telephone systems, and were in a position to leapfrog from the era of mechanical switches to the latest voice and data networks. Each country saw the opportunity to impose investment requirements on suppliers of central office switches and network equipment. This bargaining naturally worked most to the benefit of Poland, which offers the largest market. Five electronics firms were directly privatized this way in Poland (including two each to Alcatel and Siemens) versus one each in Hungary and the Czech Republic.

As in the case of other electronics components, Czech firms offered multinationals attractive technology and quality, with the added incentive of market access spurring the ties to take an equity-based rather than contractual form. Siemens (which bought out a joint venture with Tesla Karlin) is the chosen supplier of switching systems, and also made a separate minority investment in Kabelovna for telecom cables. Additional Czech investments were made by GEC-Marconi (a joint venture with Tesla Telekomunikace for transmission systems), France's Velec[17] (a joint venture with Tesla Hloubetin for TV and radio transmitters), and AT&T[18] (a joint venture with Tesla Praha for optical transmission relays).

Lighting equipment

By far the most important investment in this sector is that of General Electric in Hungary. In 1989, GE took a majority share in state-owned Tungsram, with some 18,000 employees. After several years of careful management and training, the company is now GE's base for the greater

[17] Velec went bankrupt in 1996 and its assets were acquired by SAGEM.

[18] The operation -- now part of AT&T spin-off Lucent -- is of uncertain size and therefore not reported in the table.

European region. The total investment has reached over $700 million and employment is still over 10,000.

In Poland, Philips has bought several state-owned lighting firms, investing about $50 million.

Appliances

Another successful early privatization in Hungary was in the area of refrigerators. In 1991, Electrolux bought Lehel, a large (4,900 employee) state-owned refrigerator producer for about $65 million, subsequently turning the company into an important regional base. In 1995, a production line for box refrigerators was transferred from Spain, and the following year, one for chest freezers was transferred from Denmark. As of 1997, output was double its level prior to Electrolux's purchase, while employment is a little more than half (3,000). Electrolux has also introduced higher-value-added activities in Hungary. As early as 1992 it put a team of local engineers to work on refrigerator insulation technology. And in 1996, product development was transferred from Denmark along with the freezer production line.

Poland -- which boasts a successful local appliance company, Polar -- has attracted several investments related to washing machines. Daewoo opened a washing machine factory with an annual capacity of 100,000 units in 1995, primarily for the export market. Bosch-Siemens opened a $3.5 million washing machine plant in 1995 with a capacity of 25,000 units per year to serve the domestic market using parts imported from Spain; in early 1998, the company opened a new 200,000 unit per year plant built to develop export sales, employing 300 and costing roughly $30 million. And in 1996, Electrolux initiated a washing machine assembly joint venture with investment-fund-owned Swiatowit (a small producer of appliances and enamelware), with a 50,000 unit capacity aimed at the domestic market.

B. The Organization of Production: CE as a Regional Supply Base

"Supply base" activities, i.e., "the parts, components, subsystems, materials and equipment technologies available for new products and process development, as well as the structure of relations among the firms that supply and use these elements," are a primary entry

point to higher value-added activities.[19] In network terms, a country with a concentration of production of these intermediate products becomes central to other network nodes. Hungary's position as a nascent regional supply base will further encourage MNC's to upgrade their Hungarian activities, adding procurement offices, regional marketing, etc.

The presence of export-qualified activities in supply base products can serve to attract additional development. Although in many cases these inputs are manufactured in CE only to be exported for final assembly elsewhere (usually Western Europe), an increasing number of investments -- especially for plastic and metal parts -- are made to supply prior investors who assemble final products locally. The newly localized suppliers can then begin to broaden their customer base to other local and foreign customers. As part of the domestic supply base, they provide added attraction for future investors in final product assembly.

Table 2 shows the major investments in the sub-sector. The table entries, of which the most important are discussed below, demonstrate that Hungary is rapidly establishing a broad supply base for the electronics sector without equal in CE.

[19] This definition is from Michael Borrus in "Re-Organizing Asia: Japan's New Development Trajectory and the Regional Division of Labor," BRIE Working Paper #53, (1992).

TABLE 2: MAJOR INVESTORS IN
GENERAL-PURPOSE COMPONENTS AND SUB-ASSEMBLIES
(total investment > $5 million and/or more than 100 workers)
(† indicates investments purchased by a subsequent investor)

Sub-sector	Czech Republic	Hungary	Poland
electronic components	Kyocera (1993) Y.S./JAIDO/CAEF (1994) Schott (1996)	†Temic [Vishay] (1989) Philips (1995) Siemens- Matsushita (1995) Nokia (1995) Zytec [Artesyn] (1996) TDK (1996) BMC (1997) Hitachi Cable (1997) Sony (1997)	Philips (1996) AMP (1998)
plastic or metal parts		†Philips-Sanda [Flextronics] (1992) Pressmatic (1997) Daidong (1998) Flextronics (1998) Shinwa (1998)	
contract assembly		Philips-Sanda [Flextronics] (1994) SCI (1998) Elcoteq (1998) NatSteel (1999)	
electrical parts	Siemens (1993) ABB (1993) Matsushita Electric Works (1998)	Siemens (1991) InterLemo (1991) Legrand (1992) Leonische Drahtwerke (1998)	Philips-Matsushita (1995) Daewoo-Rocket (1997)
auto electrical parts and systems	Siemens (1992) EKM-Knobloch (1992) TRW (1992) Ford (1993) Hella (1994) AMP (1997)	General Motors (1990) Hirschmann (1991) Leonische Drahtwerke (1991) United Technologies (1991) AMP (1993) Alcoa-Fujikura (1994) ITT (1994) Lucas-Sumitomo (1996)	Delta Part (1991) †Fiat [Labinal] (1993) General Motors (1993) Siemens-Volkswagen (1993) Lucas-Sumitomo (1996) United Technologies (1996)

Source: News reports

Electronic components

The largest investment in electronic components was made in the Czech Republic, but Hungary has received a continuous stream of such investments. The large Czech investment was

made by Japan's Kyocera. Through the UK office of its US-based subsidiary AVX, Kyocera began subcontracting capacitor assembly to Tesla Lanskroun in 1992, involving about 400 workers. The following year, AVX set up its own subsidiary in a building leased from Lanskroun to produce tantalum capacitors, mainly for export -- the first Japanese direct investment in the Czech Republic. The company has invested an additional $40 million in the following years with 1,700 workers in Lanskroun and another 500 at a plant in a separate location. Some production was transferred from an existing operation in Germany where wages are ten times higher and work rules stricter. The Czech operation is being upgraded to add more of the intermediate steps of production, currently done in the UK, which necessitates cross-hauling of the work in progress.

Although none of the Hungarian investments in this sub-sector are on the same scale as that of Kyocera, they are still in the $10 million dollar range and cover a broad variety of component types for use in end products both in Hungary and elsewhere, primarily Western Europe. In two cases -- Temic (now owned by Vishay of the U.S.) and Siemens-Matsushita (a pre-existing joint venture) -- the initial investment was made in cooperation with local partners, but the local partners were eventually bought out as the operation was expanded.

At the opposite extreme, Poland has only recently received a few investments in this area, all in state-owned or recently-privatized companies.

Plastic and metal parts

Hungary has also received a fairly broad range of investments in the area of plastic and metal parts. While some of these operations were attracted by the prior investment of a particular customer (e.g. Korea's Daidong for Sony or Finland's Elcoteq for Nokia), these firms invariably seek to expand their customer base, so that Hungary is becoming a major supply node in regional networks.

Contract assembly

One of the most rapidly growing activities in the electronics sector is contract electronics manufacturing, which can range from "board stuffing" (placing components on circuit boards) to a much wider range of activities including procurement, design, and final product assembly and shipping -- all as outsourcing from a name-brand company (Sturgeon, 1997). Hungary has now attracted several of the leading firms in this field, including Flextronics (which purchased a previous investment from Philips and its Malaysian partner Sanda plastics), SCI, and NatSteel, which just recently began investing in a Hungarian base to serve the European region.

Electrical parts

The Czech Republic has received several major investments for electrical parts, primarily from European firms ABB and Siemens. In 1993, Siemens purchased the electromechanical component division (with 500 employees producing relays and switches) of the ZPA automation conglomerate from the National Property Fund. According to one report, the labor cost was 20% of that in Berlin, while productivity per worker was one-third. Siemens has invested nearly $20 million in the operation, expanding product lines to include telecom relays and fittings for optical cables. Most of the output is exported to Germany. Employment has risen to 1,000 and the plant is ISO 9002-certified.

In Hungary, Siemens is also active, having made a direct privatization purchase in 1991 of VIV, a maker of industrial switch gear. Employment has been maintained at about 1,700, and a new $8 million plant was opened in 1996 to assemble hybrid circuits and power modules. More recently Leonische Drahtwerke is investing $8 million for a highly-automated plant to produce cable bundles for supply to United Technologies for automobiles and to producers of consumer electronics. The plant will replace production previously done in Germany.

Poland's two investments in this category are both for batteries -- a joint venture plant of Philips and Matsushita representing an investment of nearly $40 million, and another by the Korean Daewoo and one of its suppliers worth some $15 million.

Automotive electrical parts and systems

In the automotive sector, activity is fairly even across the three countries. The majority of investments shown in the table are for cable harnesses, a low-technology, labor-intensive activity that firms are performing in Central Europe both for the domestic and export markets.

The major Czech investment for electrical auto parts was made by Ford, who bought the Czech Republic's Autopal with 2,600 employees in 1993. In this venture, Ford produces air conditioning and lighting equipment for Skoda and other East European producers, and has agreed to invest $65 million over five years. In 1997, a new $50 million investment was announced to produce lights for Ford plants in Germany and Spain. Autopal has also provided Ford a local technical development staff. In 1996, Ford invested $2 million in a lighting development center that will employ 50 engineers and technicians.

Hungary has also received investments for electrical auto parts other than cable assemblies. In 1994, ITT Automotive (through its German subsidiary) opened a new factory to make car electronic components, such as anti-lock brake system sensors, switches, and cables, for export to BMW, GM, Opel, Mercedes, and VW, replacing production formerly undertaken in Belgium. The investment is expected to rise to $40 million; a second plant was opened in 1995 producing motors for windshield wipers.

In Poland, the major non-cable investment was by Fiat subsidiary Magneti Marelli, which invested $20 million starting in 1993 to produce headlights, heating systems and dashboard instruments for supply to Fiat plants in Poland, Russia and Italy. The operation was purchased by France's Labinal as part of a larger deal in 1997.

Subcontracting: local firms in the supply base

Table 3 provides information for subcontracting relationships in the same sub-sectors, while Table 4 shows the subcontracting arrangements for systems assembly.[20] Each entry in the subcontracting table shows a foreign firm that has contracted for the supply of the indicated product from a locally-owned firm in one of the three countries.

Interestingly, Czech firms have the most such deals, showing that they are currently the most capable of directly meeting export market standards (although the television and computer assembly is mainly for the local market). However, the local subcontractors are still relatively small, suggesting that the Czech Republic has been unable to leverage its capabilities into growth, whereas Hungary has started from a somewhat weaker beginning and ended up with a central role in the Central European electronics industry.

TABLE 3: SUBCONTRACTING TO LOCAL FIRMS FOR GENERAL PURPOSE COMPONENTS AND SUB-ASSEMBLIES
(† indicates relationship that later added an equity component)

[20] The precise nature of a non-equity relationship between two firms can be extremely difficult to determine from news stories, hence, the term "subcontracting" is being used broadly here to describe any reported relationship in which it appeared that a Central European supplier was making products to specification for a foreign customer, without any claim for the degree of technology transfer involved. Experience suggests that most or all of these arrangements involve at least a minimal level of quality guidance, and several include direct, non-equity investments by the foreign partner in the local firm's operation.

Sub-sector	Czech Republic	Hungary	Poland
electronic components	Pacific Vista Systems - capacitors - (1991) Kyocera - capacitors (1992) Samsung - electron guns (1994) Optrex - LCD modules (1994) Elbaudo - potentiometers (1992) Raytheon - control modules (1993) Xerox - PCBs (1996)	Philips - VCR heads (1990) † Siemens-Matsushita - passives (1994) Texas Instr. - miscellaneous (1996)	IBM - crystals (1988) IBM - frames, cables (1992)
contract assembly	Nippon Columbia (1997)		Dassault - ticket dispensers (1994)

Source: News reports

TABLE 4: SUBCONTRACTING TO LOCAL FIRMS
FOR SYSTEMS AND THEIR CORE COMPONENTS
(† indicates relationship that later added an equity component)

PC assembly	IBM (1995) HP, Unisys (1996) Fujitsu (1998)	IBM (1992)	ICL (1988) IBM (1995)
peripherals and parts	IBM - printer cartridges (1993) Alps - keyboards (1993)	IBM - HDD heads (1994)	
telecom	GEC-Marconi - distribution eqpmt (1992) Siemens - distribution eqpmt (1992)		Telrad - exchanges (1991)
monitors		Upselect (1993)	
television	LG, Grundig (1991)	Thomson (1988)	†Philips (1991) Samsung (1993) Nokia (1994)
lighting eqpmt.	Siemens (1992)		Siemens (1994)
appliances and office eqpmt.	Philips - vacuums (1992) Bosch - fryers (1995)		Xerox - copiers (1988)
other consumer items	Avgad - security systems (1993) Matsushita - tuners, remote controls (1995)	Matsushita, Kenwood - audio equipment (1996)	

Source: News reports

The Hungarian subcontracting in electronics is accounted for mostly by one firm, Videoton, whose story demonstrates that a strong local supply base is a magnet for both equity and non-equity linkage formation, which in turn leads to further upgrading of local capabilities. The

company was a classic state-owned enterprise producing TVs, computers, and military equipment until it went bankrupt. With state support, it was taken over by local entrepreneurs, who decided from the outset to develop a skill set that would make the company a world-class subcontractor. It has entered into a long series of relationships with firms from Japan, Europe and the US, always with an eye to expanding its capabilities. Successful arrangements between Videoton and customers such as IBM and Philips led rapidly to direct investments (discussed earlier) by those firms, who also continued to employ Videoton's complementary subcontracting services.

III. The National Context of Foreign Investments

This section discusses the conditions and policies that have influenced foreign electronics investments in Central Europe. The starting point is a discussion of the influence on contemporary network formation of Soviet-era policies for the electronics sector through the medium of the inherited production structure. This is followed by a consideration of one of the key post-Soviet influences on network formation: receptivity to foreign investment. Those countries that are best able to establish a suitable investment environment, with some combination of secure property rights, investment incentives and political stability, will be more likely to lure foreign investments. But within these parameters, which roughly apply to all three countries here, significant differences have arisen.

These past and present industrial policies operate at different levels. While technical capabilities developed under Communism influence the sectors in investment is likely to occur (as shown earlier for software and integrated circuits), policies toward foreign investment act mostly on the aggregate level of FDI.

A. The Industrial Inheritance: Soviet Planning and CMEA Specialization Agreements

In the earlier section on the influence of pre-existing local capabilities, the importance of Soviet-era activities in software and microelectronics for shaping investment patterns in the 1990s was shown. This section looks at the relationship for the entire electronics complex.

Even though many state-owned companies (and thus the embodiment of experience in physical capital), have ceased to exist in their previous form, the underlying capabilities remain embodied in human capital, i.e., the workers. These cababilities are real and enduring, albeit

generally in need of updating. This is easiest to see where current electronics activities can be traced to past experiences. For example, it could be argued that Hungary's previous focus on system engineering has led to its current strength in system integration, and CRT production in Poland (now privatized to France's Thomson) provided a base for export-oriented TV assembly by local and foreign firms. However, it can be argued that Soviet-era specialization continues to affect activities throughout CE's electronics industry.

1. Soviet-era electronics in Central Europe: an overview

In the Soviet era, electronics production was primarily undertaken by a handful of large conglomerates, including Tesla and ZAVT in Czechoslovakia, Videoton in Hungary, and Mera and Unitra in Poland. Employment circa 1989 was roughly 100,000 each in Hungary and Czechoslovakia and nearly 200,000 in Poland.

Czechoslovakia had the most up-to-date infrastructure for the industry, having launched a ten-year program in the mid-1980s to develop the sector. The program focused on components, instruments, and automation controls.

Poland's electronics sector peaked in the 1970s as a producer of consumer electronics, electromechanical telephone switches, and computers. In the 1980s, under martial law, Poland's electronics sector stagnated for lack of both investment and technology as the country was isolated from the West. Russian distrust of the Polish regime also cut off access to the most sensitive Soviet technology.

Hungary presents yet another story. Its chief electronics-related role in the Soviet system was as a provider of low- and medium-range mass-produced products, and, in the IT sector, minicomputers. The country's "goulash communism" fostered a richer mix of public and private activities in the 1980s which was more conducive to absorption of new ideas from the West than the stricter Polish and Czech regimes. Hungarian high-tech firms were also more connected to the West through trade ties.

2. Specialization Agreements

One influence on the development of electronics under the Soviets was the specialization agreement. Although it enjoyed limited success as a policy instrument, it has left a useful trace that will help identify country capabilities at the sub-sector level.

Specialization agreements were necessitated by the Soviet system of trade. In the CMEA (Council of Mutual Economic Assistance) system, trade flows were negotiated and tended to be balanced for each sector (Crane and Skoller, 1988). An open trading system fosters specialization based on comparative advantage as revealed by response to price signals. Because trade flows were negotiated, the CMEA system worked against the emergence of sectoral differences between countries. The result was quasi-autarky, with the sectoral breakdown of output roughly similar across countries.[21]

The "specialization agreement" -- negotiated bilaterally or multilaterally -- was a CMEA policy instrument designed to mimic the benefits of free trade.[22] A specialization agreement basically permitted each signatory to focus on a set of components or final goods within a given industrial branch with the understanding that the resulting trade would still be balanced. The adjusted production pattern would theoretically improve scale economies for all covered products, although the non-specialized country was required only to import a certain amount from the specialized country, not to desist in production entirely. While the specialization agreement was devised early in the post-war period, such pacts became more widely used starting in the late 1960s with a series of agreements related to the automotive industry. In 1969, the first specialization agreement for the electronics sector -- the Multilateral Government Agreement on the Development, Production, and Application of Electronic Data Processing Equipment -- was signed. Under this agreement, computer systems were created based on the IBM S/360. The USSR produced large-scale machines, while Hungary made mini-computers and punch-card equipment. East Germany was given line printers, and Bulgaria, disk drives. The agreement rationalized a system in which some 30 different types of incompatible computers were being produced in CMEA countries.

During the 1970s about a third of intra-CMEA trade fell under specialization agreements and the share continued to rise in the 1980s. These agreements can serve as a rough guide to the areas of technical concentration in each country's electronics sector.

Crane and Skoller provide summary statistics from a RAND database of specialization agreements, believed to cover some nine-tenths of agreements through 1987. Table 5 shows the number of agreements for the electronics sub-sectors by country. The relative number of bilateral

[21] The remainder of the presentation of specialization agreements is based on Crane and Skoller. The author is also grateful to Dr. Steven Popper at RAND who provided internal RAND documents which further detailed the contents of some of the agreements.

agreements each country participated in gives at least a rough approximation of the importance of each sector in those countries. The figures which follow are believed to understate in the case of East Germany, but to be fairly indicative otherwise.

TABLE 5: COMECON SPECIALIZATION AGREEMENTS

	---------- **Bilateral and Trilateral Agreements (number)** ----------								
Sector	Total	Bul.	**CSSR**	GDR	**Hun.**	**Pol.**	Rom.	USSR	Yug.
Micro-electronics	8	1	**6**	3	**2**	**0**	0	4	0
Components	27	5	**11**	7	**7**	**13**	3	7	1
Optoelectr.	5	0	**0**	4	**2**	**0**	3	1	0
Computers	15	5	**2**	6	**2**	**4**	2	9	0
Telecom	12	3	**1**	2	**4**	**4**	0	10	0
TV sets	6	2	**4**	2	**2**	**2**	0	1	2
Refrigeration	4	0	**3**	0	**1**	**1**	0	2	1
Other appliances	15	1	**12**	7	**0**	**4**	0	0	6
TOTALS	92	17	**39**	31	**20**	**28**	8	34	10

Source: RAND Directory of CMEA specialization agreements, reported in Crane and Skoller 1988

These eight sub-sectors account for 92 of 888 bilateral agreements (compared with 66 for autos) logged in the RAND database. The table suggests the following:

- The Central European economies in our study were quite active in electronics, occupying a middle ground between the USSR and East Germany on the one hand, and Bulgaria, Yugoslavia, and Romania on the other.
- Czechoslovakia was involved in relatively more agreements for microelectronics and components, TV sets and appliances.
- Poland's agreements are dominated by electronic components, computers, and telecom.
- Hungary was part of more telecom and optoelectronics agreements than either Poland or Czechoslovakia.

3. Echoes of the past

These specializations do not deterministically map into current linkages, as other factors are also at play. For example, Bulgaria was Comecon's specialist in hard disk drives. After the

[22] The bilateral agreements were frequently the implementing mechanism for the multilateral accords.

fall of Communism, IBM briefly subcontracted some production to the Bulgarian producer, but ultimately turned to Hungary as its Eastern European disk drive base.

The majority of Central European electronics producers under Communism did not survive the transition in anything like their earlier form, if at all. The technologies used were generally out of date, and few managers were available to steer the firms around mountains of debt and rapid trade liberalization into full participation in the global economy. Many firms couldn't be sold at any price and have been liquidated. In such cases, only the intangibles -- such as electrical engineering, computer programming, and precision machining skills -- survive, and in many cases these have been successfully mobilized by both local entrepreneurs and multinationals.

Nevertheless, Soviet era activities often *do* find their echo in current electronics networks. For example, Soviet-era policy for the Hungarian computer industry fostered Hungary's contemporary prowess in software. Under the Computer Technology Central Development Program of 1969, Hungary was given responsibility for producing minicomputers. A Hungarian research institute, SzKI, designed an IBM-compatible unit while KFKI, another research institute, specialized in reverse-engineering DEC-compatibles. By contrast, the Polish and Czechoslovakian computer sectors were focused more on microcomputers, industrial control units, and peripherals (e.g., printers in Poland) for which system-level software skill was less important.

The Polish television industry is another case of the past contributing to the present. Poland's dominant television producer prior to 1990, Elemis, was established in 1955. The plant was highly vertically integrated, producing its own sub-assemblies and casings and most other components were sourced domestically. The core component -- the cathode ray tube -- was added to this complex in 1979 using technology licensed from RCA and Corning of the US. Although Elemis gradually lost its market and was recently liquidated, the CRT plant is now owned by France's Thomson and provides an anchor for Poland's growing position as an exporter of televisions. By contrast, Hungary's domestic production of CRTs was discontinued in the 1970s under a specialization agreement and was never restarted. Similarly, the Czechs had also stopped producing CRTs, but restarted production in the 1980s using know-how licensed from Japan's Toshiba and others, with this technology building naturally on local glass-making expertise; the Czech production continues and is now locally owned.

4. The fate of the state sector

Nevertheless, many Soviet-era investments have come to nothing in the present. State-owned companies capable of producing salable products were sold off to foreign or local buyers, and the rest languished. However, one finds important differences by country.

Hungary

Hungary, as described elsewhere, has probably had the greatest success in the reformation of its state-owned electronics sector. Foreign capital was called on for early transformations of viable enterprises. Tungsram, a huge lighting equipment firm, is now operated by General Electric of the US as its major European base.

Domestic capital was central to at least one notable success. Videoton, a diversified producer of consumer, industrial, and military electronics, was privatized to local entrepreneurs with prior experience running Muszertechnika, a computer company founded in 1985. The new owners had a very clear idea of how to rebuild and expand Videoton's capabilities[23] and have turned it into a leading regional subcontractor with a broad client base. Other state-owned firms, such as SzKI, were broken up, and several components became viable independent firms.

Poland

By contrast, the Polish offshoots of Unitra and Mera plus other independent state firms have had much less success. The state firms were saddled with enormous debts and uncompromising workers' councils in addition to outdated technologies and poor marketing skills. In many cases, this has meant bankruptcy or living death in the absence of assets which were sufficiently appealing to foreign buyers even at bargain prices. A notable exception is the state-owned Polar, which has succeeded in retaining a commanding position in the local appliances market.

Poland's most successful use of foreign capital was in telecommunications, where its relatively large market provided it some leverage. Using persuasion (and local content provisions in its procurement contracts), the government was able to privatize a total of five firms to designated suppliers versus only one or two each in Hungary and the Czech Republic.

[23] As of July 1998, the material at http://www.videoton.hu/ is very complete in this regard.

Fortunately, Communist Poland never outlawed small-scale private enterprise and appears to have harbored a number of capable entrepreneurs. The two leading vendors in Poland's personal computer market are local firms -- Optimus and JTT. Optimus was founded in 1988 and was so successful that it became the first private Polish company listed on the Warsaw Stock Exchange in 1994. However, these dynamic firms have – like most foreign firms – stayed away from state-owned assets.

Czech Republic

In the Czech Republic, the offshoots of Tesla and ZAVT have been relatively successful at surviving independently, although several eventually went through bankruptcy. However, these firms have generally been unable to leverage their capabilities to grow rapidly. A probable cause is the lack of access to foreign markets that is provided in Hungary by the numerous foreign firms populating the Hungarian electronics sector. Czech entrepreneurs have been mostly absent, possibly because the extreme repression of private activity under the orthodox Czechoslovakian Communist regime prevented the development of entrepreneurial skills.

B. The "Rules of the Game": FDI policies

While all three countries are at the forefront of Eastern Europe in their adoption of a market-oriented legal framework, which includes basic property, bankruptcy, and securities laws, each country has adopted slightly different "rules of the game," which affect their attractiveness to multinational electronics producers. In particular, the official attitudes in each country towards foreign investment seem to account for many of the differences in outcomes described above.

In general, Hungary, with its pro-FDI policies, has had great success in attracting foreign investors, whereas firms have been much more hesitant to invest in the Czech Republic. Poland, initially wary of foreign capital, has now opened its regime and is receiving a considerable flood of investment. Aggregate FDI figures confirm these impressions. As of the mid-1990s, Hungary had received, by far, the most foreign investment of the three, in both absolute and per-capita terms,

while Poland had received the second largest amount of FDI in levels but is third to the Czech Republic in per capita terms.[24]

Hungary's attractiveness to foreign investors clearly extends beyond the electronics sector. One factor which differentiates Hungary is a longer history of openness which has continued to be reflected in transition-era policies toward foreign investment. Cooperation between Soviet bloc and Western firms was not permitted at all during the 1950s. Limited interaction was eventually permitted, and soon minority foreign participation was allowed in a few selected industries, starting in Yugoslavia in 1967. Hungary adopted a similar scheme in 1972, Poland followed in 1976, and Czechoslovakia waited until much later -- 1986 (United Nations, 1992).

Hungary engaged in dozens of international joint ventures during the 1980s. By the time Czechoslovakia permitted its first joint venture with a firm from the West in 1986, Hungary had already formed 60. Thus as Communism ended, foreign firms probably knew Hungary better than most other countries in the region, and Hungary had the most extensive experience of the benefits of foreign linkages. This historical factor is often overlooked in discussion of Hungary's aggressive pro-foreign-investment stance in the 1990s.

Just as Hungary's history of openness appears to have carried over into the post-Communist era, the same can be said of the Czech Republic's tendency towards caution. As of January 1993, the newly-separate Czech Republic ended explicit incentives for foreign investors, switching to a policy of equal treatment for domestic and foreign investment. The Czech government made it a point to show that it could attract major investment without benefit of special tax incentives when it welcomed Kyocera in 1994 and Matsushita in 1996.

However, this hard-line stance recently collapsed in the face of economic reality. In Fall 1997, it became public knowledge that the Czech Republic was in competition with Egypt and Portugal for a $500 million investment by Intel in a plant for microprocessor assembly and test that would employ thousands of workers. Intel was demanding tax breaks and training subsidies, possibly in violation of the republic's own competition laws. In August, the government officially agreed on an undisclosed incentive package, only to see Intel put off its decision to the following year.

Poland lies in between the Hungarian and Czech extremes, falling closer to Hungarian openness. Poland had permitted some foreign investment starting in the 1970s, but foreign participation in the economy was stymied under martial law. The FDI regime was formally

[24] East-West Investment News, Winter 1996.

liberalized in 1991 (one year after Hungary) by a new law which simplified the approval process and lifted repatriation limits, but reduced tax rebates and replaced a recently-enacted automatic three-year tax holiday for new FDI with a more targeted tax break favoring investments which were rich in employment or exports. By comparison, Hungary kept automatic tax breaks for major investments in place until 1994 and even afterwards continued to offer tax holidays lasting up to ten years for selected cases. Among 18 companies receiving a five-year 100% tax holiday in a January 1995 determination were four electronics firms: Samsung, Videoton, IBM Storage, and Philips Monitors.

IV. Implications and Conclusion

The main findings of this chapter can be summarized as follows. All three countries are connected, in varying but increasing degrees, to international electronics production networks. Foreign investment is the primary vehicle for this integration, and Hungary has moved the furthest along this path, positioning itself as a major low-cost supply base in the region. Czech electronics firms, remaining independent, do not have the same degree of production linkages with foreign firms, despite a strong underlying skill base in precision engineering. Poland has been able to leverage its larger market to some extent, but has been slower than Hungary to attract export-oriented investment.

This process has been viewed with trepidation both externally and internally.

A. European Union: Fear of "Hollowing Out"

To some extent, growth in CE is based on the transfer of activities out of higher-wage countries in Western Europe as some companies literally move complete production lines. Such actions have raised the specter of "hollowing out" or de-industrialization in the West. However, Japan dealt with this successfully (prior to the bursting of its financial bubble) by upgrading its domestic production structure to higher-value-added goods even as offshore production mushroomed, eventually leading to a large share for imports from Japanese factories in Southeast Asia in the key consumer electronics sector.

The European Union should not doubt that it, too, can upgrade its electronics sector as lower-value processes are moved to peripheral locations. The ability to tap the skilled but relatively inexpensive labor in CE for more mature technologies will make European firms more

competitive on world markets. Furthermore, at least in the medium term, the relationship will be symbiotic -- as in the case of Japan and South-East Asia -- rather than competitive -- as in the case of Japan and Korea -- due to the lack of “local champions” in Central Europe.

B. Central Europe: Fear of Maquiladora Syndrome

Within CE, legitimate questions are asked about the emergence of "dual" or "enclave" economies with little generalized benefit to the country at large.[25] While this is a vast subject, it is worth noting here that the East Asia evidence shows that the outcome is at least as much a function of domestic policy as it is of the behavior of multinationals. Policies that encourage local firm creation and that equitably distribute the benefits of growth are likely to contribute to the broadest positive impact of foreign investment activity.

While it is true that multinationals bring along some suppliers when they invest abroad, most electronics products use hundreds of inputs, leaving plenty of room for local suppliers to participate.

Multinationals are frequently willing to provide technical assistance to local firms that demonstrate an ability and willingness to excel. An example in Hungary is PHT Print, a joint venture between Hiradastechnika, a private firm, and the Hungarian Bank for Investment and Development (MBFB). Philips provided production equipment worth $1 million to the joint venture, which will produce printed circuit boards for the Dutch multinational.

Furthermore, the East Asia experience shows that investments are upgraded in line with local capabilities. Malaysia continues to attract significant investments even as competing, lower-cost destination have emerged. The older affiliates in Malaysia have generally been upgraded to reflect the higher skills (and wages) that now exist there, by shifting production to higher-value-added products and introducing additional corporate functions such as product development and marketing. The international division of labor isn't fixed but rather constantly evolving, primarily through the movement offshore of additional activities from the home countries. In terms of local capabilities, the CE countries are in a more advantageous position than was Malaysia two decades ago and can expect to experience steady upgrading.

But the positive outcome of a strong locally-owned supply base is not guaranteed.

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[25] Ellingstad (1997) makes a tentative case for "Maquiladora syndrome" (i.e. foreign-owned activity occurring in enclaves and bringing little benefit to the broader host economy) in Hungary, based on the negligible growth of real wages, dualism between the foreign-owned and domestic production complexes, and concentration of foreign activity in a few dynamic enclaves.

Barriers to deepening of the linkages between foreign-owned and local firms do exist in CE, such as a limited number of qualified managers. Fortunately, one of the chief benefits of foreign investment may in fact be the management training that multinationals typically undertake. In East Asia, some of the best local companies in the electronics sector have been started by former managers at companies like Intel and Hewlett-Packard.

One of the most important policy recommendations that can be made based on the East Asian experience is the need to support the productive and innovative activities of local firms with appropriate fiscal incentives and financial institutions. This already appears to be an issue in Hungary, where several joint ventures were bought out by the foreign partner who expanded the venture's capital when the local partner was unable to pay its share of the expansion. Judging from both the East Asian experience and the nascent production linkages in CE, it appears that host countries can effectively determine the degree to which they benefit from the proliferation of network linkages with foreign electronics companies.

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TABLE 6: MAJOR* INVESTORS BY DATE IN THE ELECTRONIC AND ELECTRICAL SECTORS

(* -- total investment -- actual or anticipated -- greater than $20 million)

Year	Czech Republic	Hungary	Poland
1989		Siemens (telecom) $60m GE (lighting) $720m	
1990		Philips (VCR) $25m Samsung (TV assy.) $23m	Alcatel (telecom) $90m
1991		Electrolux (refrigerators) $120m United Technologies (auto parts) $25m Siemens (electrical parts) $20m	Curtis (TV assy.) $20m Thomson (CRTs) $90m Philips (lighting) $50m
1992		†Hantarex (monitors) $20m †Philips-Sanda [Flextronics] (plastic parts and CEM) $45m	Lucent (telecom) $50m
1993	Siemens (telecom) $37m Kyocera (components) $39m Siemens (electrical parts) $25m Ford (auto parts) $100m		Siemens (telecom) $50m †Fiat [Labinal] (auto parts) $20m
1994		ITT (auto parts) $40m	
1995		IBM (HDD) $100m Nokia (monitors) $30m	Philips (TV assy.) $25m Philips-Matsushita (batteries) $40m
1996		Philips (monitors) $30m Sony (audio equipment) $21m	
1997	Matsushita (TV assy.) $66m Motorola (semiconductors) $45m AMP (auto parts) $20m	Philips (audio equipment) $30m Nidec (HDD motors) $27m	
1998	FIC (PC assy.) $100m	Elcoteq (CEM) $30m	
?			Motorola (IC assy.) $150m Merloni (ovens) $50m

Source: Press reports, author's estimates; dollar amounts are either the accumulated actual investment at historical cost or projected total investment, whichever is greater.

Note: † -- affiliate was bought out by a subsequent investor, shown in brackets;
CEM = contract electronics manufacturing;
The last row is for investments that have been reported but not officially announced.

TABLE 1: Personal Computers in Central Europe

Country	1993 PC Sales (units)	1995 PCs Per 1,000 Inhabitants
Czech Republic	122,000	14.2
Hungary	83,000	15.9
Poland	195,000	7.0

Source: Figyelo, December 21, 1994, Pg. 47; Euromoney, September 30, 1995, Pg.174

TABLE 7: MAJOR INVESTORS IN THE SOFTWARE SECTOR
(total investment > $5 million and/or more than 100 workers)
(† indicates investments purchased by a subsequent investor)

Sub-sector	Czech Republic	Hungary	Poland
software	†Sevodata Sevelen [Cogema] (1990)	Siemens (1994) Ericsson (1994) CSK (1996) Nokia (1998)	ICL-Fujitsu (1993) Motorola (1998)

Source: News reports

TABLE 8: MAJOR INVESTORS IN SYSTEMS AND THEIR CORE COMPONENTS
(total investment > $5 million and/or more than 100 workers)
(† indicates investments purchased by a subsequent investor)

Sub-sector	Czech Republic	Hungary	Poland
PC assembly	FIC (1998)		
hard disk drives		IBM (1995)	
HDD parts		IBM (1997) Nidec (1997)	
monitors		†Hantarex (1992) Nokia (1995) Philips (1996)	
VCRs		Philips (1990)	
audio equipment		Philips (1992) Sony (1996) Bosch (1997) Clarion (1997) Philips (1997)	
televisions	Matsushita (1997)	Samsung (1990)	Curtis (1991) Daewoo (1994) Grundig (1995) HCM-Luks (1995) Philips (1995)
CRTs			Thomson (1991)
telecom	GEC-Marconi (1993) Siemens (1993) Velec [Sagem] (1993)	Siemens (1989) Ericsson (1990)	Alcatel (1990) Lucent (1992) Siemens (1993)
lighting equipment		GE (1989)	Philips (1991)
appliances		Electrolux (1991)	Daewoo (1995) Bosch-Siemens (1995)

Source: News reports

TABLE 2: MAJOR INVESTORS IN
GENERAL-PURPOSE COMPONENTS AND SUB-ASSEMBLIES
(total investment > $5 million and/or more than 100 workers)
(† indicates investments purchased by a subsequent investor)

Sub-sector	Czech Republic	Hungary	Poland
electronic components	Kyocera (1993) Y.S./JAIDO/CAEF (1994) Schott (1996)	†Temic [Vishay] (1989) Philips (1995) Siemens- Matsushita (1995) Nokia (1995) Zytec [Artesyn] (1996) TDK (1996) BMC (1997) Hitachi Cable (1997) Sony (1997)	Philips (1996) AMP (1998)
plastic or metal parts		†Philips-Sanda [Flextronics] (1992) Pressmatic (1997) Daidong (1998) Flextronics (1998) Shinwa (1998)	
contract assembly		Philips-Sanda [Flextronics] (1994) SCI (1998) Elcoteq (1998) NatSteel (1999)	
electrical parts	Siemens (1993) ABB (1993) Matsushita Electric Works (1998)	Siemens (1991) InterLemo (1991) Legrand (1992) Leonische Drahtwerke (1998)	Philips-Matsushita (1995) Daewoo-Rocket (1997)
auto electrical parts and systems	Siemens (1992) EKM-Knobloch (1992) TRW (1992) Ford (1993) Hella (1994) AMP (1997)	General Motors (1990) Hirschmann (1991) Leonische Drahtwerke (1991) United Technologies (1991) AMP (1993) Alcoa-Fujikura (1994) ITT (1994) Lucas-Sumitomo (1996)	Delta Part (1991) †Fiat [Labinal] (1993) General Motors (1993) Siemens-Volkswagen (1993) Lucas-Sumitomo (1996) United Technologies (1996)

Source: News reports

TABLE 3: SUBCONTRACTING TO LOCAL FIRMS FOR GENERAL PURPOSE COMPONENTS AND SUB-ASSEMBLIES

(† indicates relationship that later added an equity component)

Sub-sector	Czech Republic	Hungary	Poland
electronic components	Pacific Vista Systems - capacitors - (1991) Kyocera - capacitors (1992) Samsung - electron guns (1994) Optrex - LCD modules (1994) Elbaudo - potentiometers (1992) Raytheon - control modules (1993) Xerox - PCBs (1996)	Philips - VCR heads (1990) † Siemens-Matsushita - passives (1994) Texas Instr. - miscellaneous (1996)	IBM - crystals (1988) IBM - frames, cables (1992)
contract assembly	Nippon Columbia (1997)		Dassault - ticket dispensers (1994)

Source: News reports

TABLE 4: SUBCONTRACTING TO LOCAL FIRMS
FOR SYSTEMS AND THEIR CORE COMPONENTS
(† indicates relationship that later added an equity component)

PC assembly	IBM (1995) HP, Unisys (1996) Fujitsu (1998)	IBM (1992)	ICL (1988) IBM (1995)
peripherals and parts	IBM - printer cartridges (1993) Alps - keyboards (1993)	IBM - HDD heads (1994)	
telecom	GEC-Marconi - distribution eqpmt (1992) Siemens - distribution eqpmt (1992)		Telrad - exchanges (1991)
monitors		Upselect (1993)	
television	LG, Grundig (1991)	Thomson (1988)	†Philips (1991) Samsung (1993) Nokia (1994)
lighting eqpmt.	Siemens (1992)		Siemens (1994)
appliances and office eqpmt.	Philips - vacuums (1992) Bosch - fryers (1995)		Xerox - copiers (1988)
other consumer items	Avgad - security systems (1993) Matsushita - tuners, remote controls (1995)	Matsushita, Kenwood - audio equipment (1996)	

Source: News reports

TABLE 5: COMECON SPECIALIZATION AGREEMENTS

	---------- **Bilateral and Trilateral Agreements (number)** ----------								
Sector	Total	Bul.	**CSSR**	GDR	**Hun.**	**Pol.**	Rom.	USSR	Yug.
Micro-electronics	8	1	**6**	3	**2**	**0**	0	4	0
Components	27	5	**11**	7	**7**	**13**	3	7	1
Optoelectr.	5	0	**0**	4	**2**	**0**	3	1	0
Computers	15	5	**2**	6	**2**	**4**	2	9	0
Telecom	12	3	**1**	2	**4**	**4**	0	10	0
TV sets	6	2	**4**	2	**2**	**2**	0	1	2
Refrigeration	4	0	**3**	0	**1**	**1**	0	2	1
Other appliances	15	1	**12**	7	**0**	**4**	0	0	6
TOTALS	92	17	**39**	31	**20**	**28**	8	34	10

Source: RAND Directory of CMEA specialization agreements, reported in Crane and Skoller 1988