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‘The electronics industry in central and eastern Europe: an emerging production location in the alignment of networks perspective’

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THE ELECTRONICS INDUSTRY IN CENTRAL AND EASTERN EUROPE: AN EMERGING PRODUCTION LOCATION IN THE ALIGNMENT OF NETWORKS PERSPECTIVE[1]

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Abstract

This paper analyses the emergence of central Europe as a new location for the production of electronics. The main factors that drive integration in the region into global production networks are also analysed, as well as prospects for upgrading the industry by using network alignment perspectives.

Foreign investment is the primary vehicle of integration of CEE electronics firms into global production networks, and Hungary has moved furthest along this path, positioning itself as a major low-cost supply base in the region. Czech and Polish electronics industries are connected, in smaller, but increasing, degrees to international electronics production networks. Networks that are being built in CEE in electronics are usually confined to subsidiaries with still limited local subcontracting; they are export-oriented and are expanding.

Local subsidiaries have mastered production capabilities and several subsidiaries in Hungary are European mandate suppliers in their respective lines of business. EU demand is the main pull factor, which gives cohesion to the actions of MNCs as well as to the action of local and national governments in CEE. The layer of local firms is still very weak with very limited capabilities in core technologies. This is the key weakness which prevents further alignment of networks in CEE electronics. Local governments play an important role in working jointly with foreign investors in establishing industrial parks and new capacities

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INTRODUCTION

The electronics industry is central to today's industrial transformation. Its use in a wide range of sectors makes it the key technology for industrial growth and catch-up. The impact of electronics is no longer confined to its technological dimension but is now also important in terms of output and employment. In this respect, the electronics industry is now similar to the automotive industry. Given its importance, the study of the electronics industry in central and eastern Europe (CEE) should generate interesting insights into the nature of structural change and production integration in this region.

This is increasingly important as, during the socialist period, CEECs have been relatively backward in production, and especially in the diffusion of electronics technologies. However, after 10 years of post-socialist transformation and integration with EU economies, central Europe has emerged as an important new location for this industry.[1] In 1999, the overall value of electronics production in CEE was $26bn, of which $10.7bn was in exports.

In this paper we try to explain the emergence of a new production and export location in world electronics. Our main questions are, which factors can explain the emergence of CEE as a new production location? What is the role of local markets and local capabilities in this phenomenon? Is this growth merely a one-off adjustment that reflects the availability of cheap labour, or is there potential for further industrial upgrading? What is the conceptual framework that can help us understand this process in general terms? What are the policy lessons that can be drawn from the process of integration of CEE into global electronics networks, especially given the high unevenness of this process within the region?

Based on the successful east Asian experience in electronics, the growth of these economies has been framed within the state vs market argument. The dispute in the literature is whether the growth of east Asian economies, which was to a great extent based on electronics, can be ascribed to the role of market forces (which coupled with macroeconomic stability has played a key role), or to active government involvement. We do not want to dwell further on this debate as it has been discussed at great length elsewhere (for example, Krugman, 1994; World Bank, 1993; Wade, 1990; Amsden, 1989). Instead we want to build on Hobday *et al*, (2001) and Kim and von Tuznelmann (1998), which have shown the limits of state vs. market dichotomy in analysing east Asian electronics. Our main argument, which comes from the analysis of CEE electronics, is that the simplified framework, which reduces driving factors in one or two dimensions (be it states or markets), is masking rather than explaining the emergence of CEE as a production location. We explain the emergence of electronics in CEE through the alignment of networks framework, originally developed by Kim and von Tunzelmann (1998) in the analysis of the Taiwanese electronics industry. Within this framework, we explain the rise of CEE electronics production as a result of the interaction between several factors including MNC strategies, and the actions of local and national governments. EU demand is the dominant pull factor, but EU accession plays a secondary role in this process. This multi-level and multi-factor framework represents useful heuristics, which can accommodate the evolutionary character of changes taking place in this sector.

In the next section we describe briefly the state of socialist electronics and outline changes in the post-socialist period. The third section analyses the situation across individual

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[1] We distinguish between central Europe (Poland, Czech Republic, Hungary, Slovenia, Slovakia, Baltic Economies) and eastern Europe (Romania and Bulgaria). Unless it is not explicitly mentioned we include in the notion of CEE also Russia and Ukraine.

segments of the electronics industry. In the fourth section, we review activities of major companies in the industry. The fifth section explains the emergence of CEE as a production location in the context of structural changes in the sector, determining factors and the alignment of network elements. Section 6 discusses the prospects for further industrial upgrading. The conclusions summarise the major points and discuss some pertinent policy implications.

The paper is based on a combination of statistical data, business press evidence and academic sources, as well previous visits by the author to several electronics plants. As recent changes have taken place, and given the dearth of systematic case study evidence, the paper should be considered as an exploratory rather than an exhaustive account of industrial change in this sector.

2 THE DEMISE AND REBIRTH OF ELECTRONICS IN CENTRAL AND EASTERN EUROPE

Socialist economies of CEE were uncompetitive in computer production, relying on foreign technology for design and components. For example, their contribution to frontier technology development in electronics was relatively strong only until the mid-1970s.[2] Their high dependence on foreign technology meant that, in the early 1990s, CEECs were still using 1970s electronics technology. This was aggravated by the poor supply of components as a result of COCOM restrictions (Amman and Cooper, 1982; Hill, 1998). Also, electronics was greatly oriented towards military applications. Until the break-up of the Soviet Union, approximately 75-80% of the output of Soviet industry was for military and related purposes (Amman and Cooper, 1982).

The CMEA division of labour in electronics was developed to some extent. For example, Hungary was given responsibility for producing minicomputers while the Polish and Czechoslovakian computer sectors were focused more on microcomputers, industrial control units and peripherals. However, analysts think that, despite the division of labour within the CMEA, there was little specialisation of the countries in the region in electronics (Tilley and Hill, 1998).

Production was undertaken by several large electronics conglomerates, including the Tesla Group and ZAVT in Czechoslovakia; Videoton in Hungary; Mera and Unitra in Poland; VEF and Alfa in Latvia; Stara Zagora and Microelectronica in Bulgaria; and Iskra in Slovenia. Semiconductor production was comparatively more developed in the USSR than in central and eastern Europe. Hungary never had its own integrated circuits (IC) producer. Poland had its own IC producer, CEMI, but they were deprived of process equipment due to COCOM regulations. One factory within the Tesla concern in the Czech Republic had IC production. The leading Soviet firms were Mikron and Angstrem, both at Zelenograd; Integral in Minsk (Belarus Republic); and Vostok in Novosibirsk and Planeta in Novgorod (both in Siberia).

In 1989, electronics was suddenly exposed to imports from Asia, which domestic producers could not cope with and were subsequently squeezed out of the market. In addition, illegal imports further aggravated an already difficult situation. For example, in Poland, domestic companies' sales in the sector almost halved in a year, falling from \$725 million in 1990 to \$480 million in 1991.[3]

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[2] Analysis of technological capabilities of CEECs based on US patents data shows the technological profile of the region, with electronics having a negligible role after the mid-1970s (see Radosevic and Kutlaca, 1999).

[3] 'Cranking Up the Volume', *The Warsaw Voice – Business*, No 20 (395), 19 May 1996.

The majority of Central European electronics producers did not survive the transition in anything like their earlier form, if at all (see Table 1). Some of them operated as a network of small firms in different mutual relationships like Iskra and VEF. The Hungarian firm, Videoton, is the rare example of a successful turnaround of an ex-socialist conglomerate into a contract manufacturer (see Radosevic and Yoruk, 2000). In several cases, bad prospects for restructuring were further undermined by government privatisation policies. For example, Microelectronica, Botevgrad (Bulgaria) was a state-owned IC producer who was in critical condition in the early 1990s, losing markets and accumulating debts. However, its government owners refused to allow either to a joint venture or the selling of the company's clean room. When the company went bankrupt its clean room had not been used for 10 years and was worthless (Stanchev, 2002). Russian electronics, which we analyse here to a limited extent, has been rationalised and is trying to reorient itself towards low complex components. However, it suffers from a lack of investment and restructuring seems to be gradual (Hill, 1998).

Table 1: Ex-socialist electronics conglomerates in the post-socialist period

Tesla Group	Czech Republic	Association of firms based on ex-socialist conglomerate that have restructured with varying degrees of success
Tesla Ecimex	Czech Republic	TV colour pictures tubes. Toshiba licence
Tesla Sezam	Czech Republic	IC producer. Joint venture with ON Semiconductors
Terosil	Czech Republic	Silicon monocrystals for chip production. Joint venture with ON Semiconductors
Videoton	Hungary	The most successful case of turn-around of socialist electronic conglomerate into indigenous contract manufacturer
Iskra Group	Slovenia	Association of small and medium firms based on ex-socialist electronic company
VEF Group	Latvia	The largest telecom plant in the Baltics. Produces small digital electronic exchanges.
Alfa	Latvia	Seventh largest semiconductor producer in USSR. Now produces low complexity components. 600 employees.
Radiotechnika	Latvia	Audio equipment
Sigma	Lithuania	Ex-producer of mainframe computers which after closure and privatisation in 1997 switched to PC assembly under name of Sigmanta
Stara Zagora	Bulgaria	Ex-socialist conglomerate in restructuring stalemate. Part of group has been taken over by Videoton
Mikron	Russia (Zelenograd)	Analogue IC producer focused on low complex chips for lower end of Asian market (0.8-1.2 micron). Joint ventures. Part of industrial group.
Angstrem	Russia (Zelenograd)	IC producer (4" and 6" wafers). Part of industrial group.
Elektronika	Russia (Voronezh)	4" wafers IC plant
Krasanay Zarya	Russia (Voronezh)	Telecom equipment and ICs producer for Russian market
Integral	Belarus	Unrestructured state controlled conglomerate with 40,000 employees. Exports to Russia and Hong Kong analogue components

Source: Hill (1998), Radosevic and Yoruk (2002), Smith (2001), Latvian Development Agency (2002), Business Press.

The successful part of electronics during the 1990s was local PC assembly. Local assemblers based their success on the import of motherboards and other sub-assemblies from the Far East. It was successful because firms were close to customers, understood local needs including the low purchasing power of domestic consumers, who were concerned primarily with price (Bitzer, 1997). However, the advent of international producers, coupled with the increasing purchasing power in local markets, could make this success temporary.

The Government did not pay special attention to electronics. Technology gaps and limited purchasing power of the domestic market, compounded with the lack of finance, meant that governments did not hold any bargaining power in opening markets. For example, the Lithuanian government tried actively to support the restructuring of its computer industry. The main national producer was Sigma, which in 1991 sold only 141 of its mainframes from a capacity of 600 units. The production profile was then diversified so that the share of the computer business dropped from 80% to 12%. This was followed by attempts to develop a new PC in a joint venture with a US firm; this never entered production. In 1994, the Lithuanian government tried, with public support, to prevent the shutdown of the Sigma Computer Plant. The new state-private company, Sigmanta, was supported by the Ministry of Communication and Information Technology. In the 'National Programme for the Development of Communication and Informatics', Sigma's strategy concentrated on the production of workstations and servers, despite the fact that there was only an insignificant and slowly developing demand for computers in higher-end classes. Furthermore, the financing of Sigmanta was added to the Public Investment Program of Lithuania. Despite this, the situation of the company did not improve, and in 1997 it switched to PC assembly (Bitzer, 1997).

This case shows the failure of targeted industrial policy towards a sector in which, given weak domestic demand and the technology gap, industry did not have a chance to develop. Ultimately, policy attempts to support modernisation turned out to be secondary to a final outcome that seemed structurally predetermined.

Only in telecommunications were governments more strategic by giving opportunist investors stakes in national telecoms operators, or by conditioning privatisation by 'saving' national telecom equipment producers. This basically meant requesting that any joint ventures set up guaranteed to purchase telecoms equipment and parts from them. However, it seems that these attempts were not successful because of domestic producer's low bargaining power and producers who were technologically too far behind their competitors (Toth, 1994).

However, the demise of socialist electronics did not lead to the disappearance of this industry. After the mid-1990s, some CEECs, like Hungary, the Czech Republic and Poland, gradually became accepted into the supply base of large electronics companies. This was primarily because of available factors such as cheap skilled labour and their proximity to the EU market, and, in segments such as television, were based on local markets. This led to both local and export market-oriented production. For example, in 1990-91, 70% of all TVs sold in Poland were imported. However, with the arrival of foreign investors this has reversed and, currently, the import share of the TV market is less than 20% in terms of value. However, Poland has also become an important exporter of TV sets. In 1999, colour TV production in Poland amounted to five million units, of which four million were exported to the EU.[4]

[4] European Electronic Markets Forecast, September 2001.

3 THE EMERGENCE OF CENTRAL AND EASTERN EUROPE AS A NEW PRODUCTION LOCATION: REVIEW OF THE EVIDENCE

CEE has emerged as the new production location in world electronics. In 1999, total CEE electronics production reached $26.3bn, which is a little above the production level in Mexico ($25.2bn), the bulk of this growth being achieved in the last 4-5 years. However, this level is still low when compared to East Asian economies and China. Table 2 ranks selected countries according to their volume of electronics production in 1999.

Table 2: World electronics production in selected countries

	1996	1997	1998	1999	2000	2001	Average annual rate of growth	
							2001-1996 forecast	**1999-96 actual**
Austria	4162	3540	3722	3710	3986	4196	0.1	-2.7
Finland	5605	6467	8255	8818	10023	11061	16.2	14.3
France	36853	34822	36641	36657	38851	40327	1.6	-0.1
Germany	51407	47493	50067	50842	54801	57667	2.0	-0.3
Sweden	9193	10774	11499	13373	14922	16033	12.4	11.4
UK	39225	43525	48055	49190	51407	54211	6.4	6.4
Greece	432	453	495	545	604	668	9.1	6.5
Ireland	9808	11161	14016	16762	19586	21573	20.0	17.7
Portugal	2260	2117	2293	2470	2640	2799	4.0	2.3
Spain	7372	7214	7894	8007	8534	8981	3.6	2.2
Bulgaria	76	73	90	104	117	130	11.8	9.2
Croatia	191	198	208	205	241	273	7.2	1.8
Czech	1109	1157	1296	1541	1706	1814	10.6	9.7
Hungary	1780	3415	4988	6833	9178	11103	87.3	71.0
Poland	1975	2342	2697	2692	2743	2827	7.2	9.1
Romania	559	503	509	800	952	1120	16.7	10.8
Slovakia	324	380	599	726	869	1064	38.1	31.0
Slovenia	492	488	514	483	522	562	2.4	-0.5
CE	**6506**	**8556**	**10901**	**13384**	**16328**	**18893**	31.7	26.4
Russia	1748	1819	2231	2836	3224	3573	17.4	15.6
Ukraine	426	395	429	551	697	842	16.3	7.3
	2174	**2214**	**2660**	**3387**	**3921**	**4415**	17.2	13.9
CEE	**8680**	**10770**	**13561**	**16771**	**20249**	**23308**	28.1	23.3
China	34985	41929	52456	60818	71344	84127	23.4	18.5
Malaysia	29541	29827	29369	39211	49333	58092	16.1	8.2
Singapore	43652	43426	37851	40985	50875	58730	5.8	-1.5
S. Korea	48312	49136	41144	57857	67337	73993	8.9	4.9
Taiwan	32212	31731	33680	41209	46711	51198	9.8	7.0
Turkey	1829	2019	2390	2137	2280	2436	5.5	4.2
Mexico	15395	16862	23072	25260	27983	31111	17.0	16.0
Total	1067925	1082654	1077494	1179487	1328055	1432627	5.7	2.6

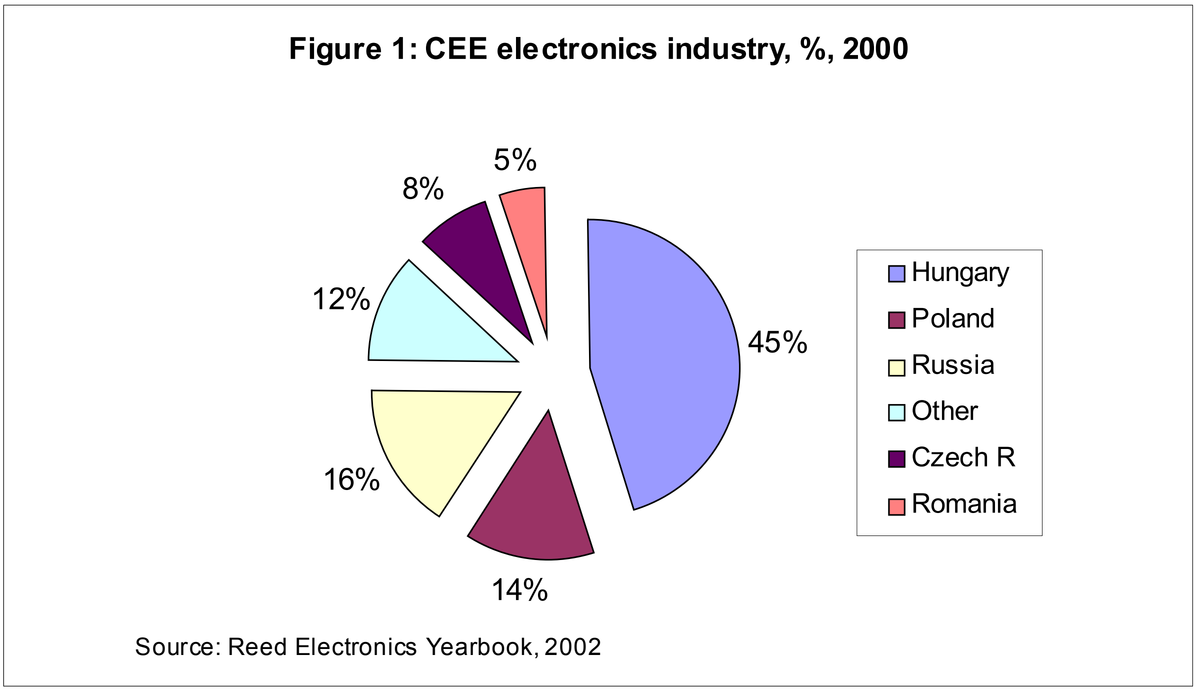
1 1996-1999 are current figures at current exchange rates

2 2000 and 2001 are forecasts at 1999 constant values and exchange rates (I.e inflation is not

Source: Reed Electronics Research, *The Yearbook of World Electronics Data, 2001/2 and 1999/2000*, Volume 4, East Europe and World Summary.

Growth in CEE has been mainly confined to a few countries, with Hungary having 45% of the share in 2000[5] (Figure 1). However, it seems that the process of expansion is set in where other countries are joining. Russia, because of its sheer size and following its 1998 recovery, is also likely to play an increasingly important role as a market as well as a production location.

5 Based on actual data.



Hungarian electronics production in 2000 was estimated to be half that of Ireland and a third of Mexico. This substantial rise follows the highest growth rates in Hungarian electronics production in the world in the last few years. Hungarian growth rates in 1996-1999, and estimates for 1999-2001, are the highest in the world. These are 87% and 71% respectively annually, which is far ahead of the rates for Chinese and East Asian economies. Volumes of Hungarian electronics production have reached levels of Finish production (Table 2).

The emergence of CEE electronics as a new production location is quite a recent phenomenon, with momentum gathering pace since the mid-1990s. Moreover, rates of most

CEECs are also in the top group. Among 13 selected countries with double-digit growth rates in the 1996-2001 period, there are 7 CEECs.

This rise in production has been accompanied by a subsequent rise in exports (Table 3). However, exports have been much more even, suggesting that only a few CEE countries could emerge as export locations. In only four years, Hungarian exports have increased from $0.9bn (1996) to $6bn (1999). Poland and the Czech Republic, as the two countries with the largest export level after Hungary, have rates of export growth which are much smaller. Also, they are lagging behind in exports with a total CEE share of 14.6% (Czech Republic) and 10.6% (Poland). Romania is emerging as a new potential location for labour-intensive assembly in electronics which did not exist a few years ago. A new facility by the US contract manufacturer, Solectron, is behind the sudden rise of its electronics exports. Croatian and Slovenian economies, which inherited relatively good capabilities in telecommunications, have not attracted any significant new investments in electronics.

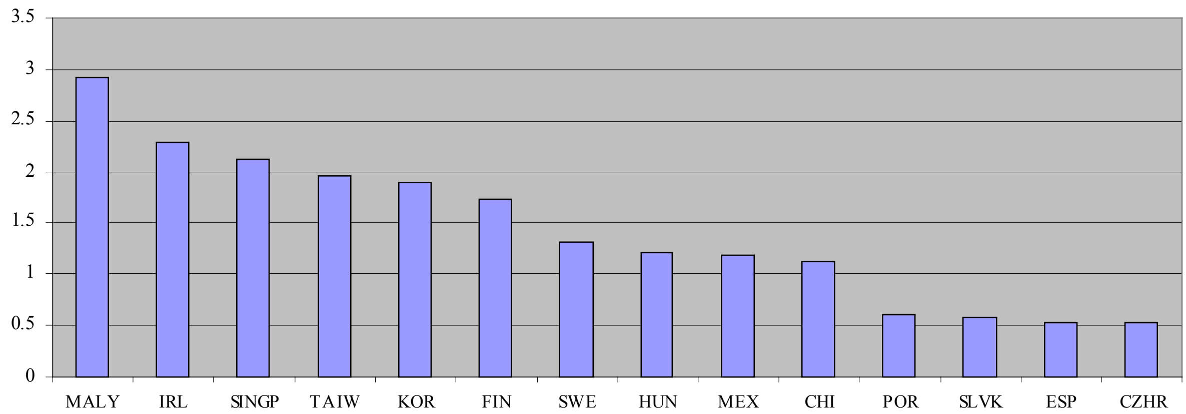
Table 3: Electronics export of the CEECs, millions current US$

	1996	1997	1998	1999	1999/96 Avg rate pa (%)
Hungary	932	3329	4737	6093	138.4
Romania	36	31	58	176	97.2
Slovakia	161	246	309	363	31.4
Poland	612	849	1142	1140	21.6
Ukraine	57	77	85	94	16.2
Czech	989	1176	1633	1572	14.7
Bulgaria	58	49	64	74	6.9
Russia	784	965	746	929	4.6
Croatia	123	160	164	124	0.2
Slovenia	298	284	276	228	-5.9
Total	4050	7166	9214	10793	41.6

Source: Reed Electronics Research, *The Yearbook of World Electronics Data, 2001/2 and 1999/2000*, Volume 4, East Europe and World Summary

Figure 2 shows the share of electronics production in apparent consumption (production + imports – exports) for selected number of countries. This should indicate the extent to which a country has become a production location relative to its market. The higher the share of production in relation to consumption the more there is scope for development of that country as a production location. Among CEE countries only the Hungarian share is above 100%. Hungary, which ranks very high in absolute and relative terms compared to other CEE countries, still has high potential for expanding as an export and production location in order to obtain shares similar to Ireland or Singapore. This suggests that, although Hungary's integration into the global electronics production network has been very fast, it is by no means extraordinary in global terms.

Figure 2: Electronics: share of production in apparent consumption, 1999



Source: Author based on Reed electronics Yearbook, 2001

3.1 An overview of individual segments of the electronics industry

The electronics industry is comprised of segments with a wide range of technological levels. At the upper end of the technology spectrum are microfabrication and software engineering, sub-sectors that require highly skilled workers and design capabilities. At the lower end is the assembly, which is dependent primarily on low-cost labour. In which segments of electronics do CEECs specialise?

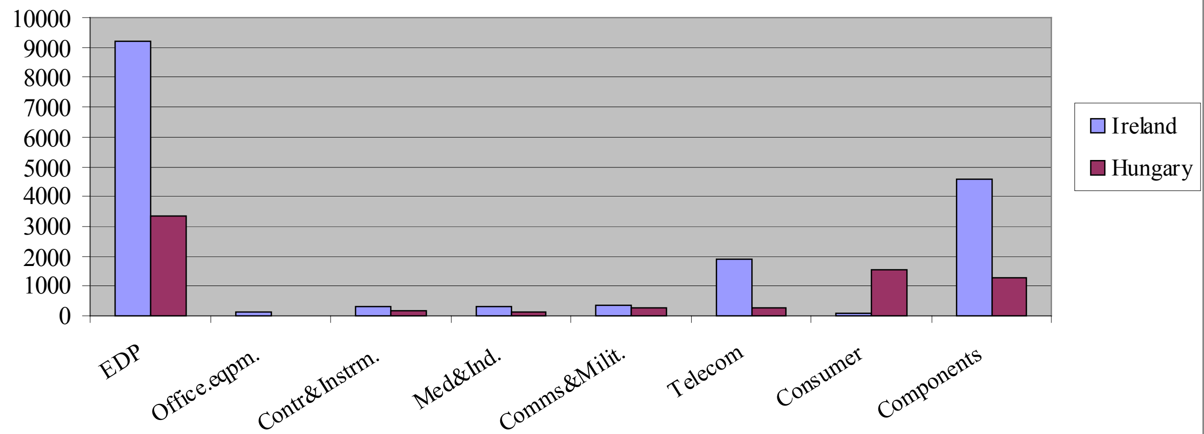
Table 4 shows that CEE has relatively diversified production across segments except to some degree in three countries (Hungary, Czech Republic and Poland). The correlation coefficient between the value of exports and the share of the top three segments in exports for 1999 is 0.51, which suggests that exports may be linked to increased specialisation. Hungarian electronics is strong in electronics data processing (EDP) which amounts to almost 50% of total production, or $3.3bn. Two other segments, consumer electronics ($1.5bn) and components ($1.2bn), are strong but clearly behind the production of parts for computers (hard disk drives, monitors, peripherals).

The majority of CEE exports (56%) come from Hungary and are in EDP, components and consumer electronics (Table 5). Exports in other segments (communications and military, telecoms, medical and industrial electronics) are much smaller, reflecting a relatively low technological level of electronics in CEE. In telecommunications no CEE is clearly specialised. This reflects poor technological capabilities in this area in the past, as well as a primarily domestic market orientation of foreign telecoms equipment operators.

Hungarian growth in electronics inevitably raises comparisons with Ireland, a country that is the main European location for several electronics segments. The profile of Irish specialisation in electronics is very similar to Hungary (see Figure 3). For example, correlation coefficient in shares of eight market segments between Hungary and Ireland is very high, 0.96. The areas of difference are a much larger consumer electronics segment in Hungary and a much larger telecom segment in Ireland. However, this is not surprising as segments reflect their importance in world electronics as well as relatively different entry barriers. Yet this high similarity suggests that Hungary is unlikely to be a complementary location to Ireland, more a competitive one.[6]

[6] Nevertheless, a sound conclusion would require detailed examination as Hungary is maybe producing in low value-added activities and Ireland in high value-added despite being in similar sectors of electronics. Hence, there is a strong case for exploring the extent to which Irish and Hungarian exports share features of vertical product differentiation (see Landesmann, 2000, for evidence in the case of the CEECs).

Figure 3: Electronics production by segements, 1999, $bn



Source: Reed Electronics Yearbook, 2001

Table 4: Electronics production by segments, 1999, $M (%)

	EDP	Office equipment	Control & Instrum.	Medical & Industrial	Comms & Military	Telecomm-unications	Consumer	Components	Total
Bulgaria	4.8	7.7	9.6	4.8	4.8	10.6	**32.7**	25.0	100.0
Croatia	2.9	2.4	17.1	12.7	6.8	**37.1**	0.5	20.5	100.0
Czech	10.4	1.9	13.0	7.1	11.2	11.0	15.6	**29.7**	100.0
Hungary	**48.9**	0.0	2.2	1.7	3.5	2.9	22.7	18.1	100.0
Poland	11.5	0.7	10.8	2.1	8.9	20.1	**26.6**	19.4	100.0
Romania	23.8	2.0	15.0	9.0	10.0	**26.3**	7.9	6.1	100.0
Slovakia	**27.5**	1.9	5.5	12.9	13.8	13.8	9.5	15.0	100.0
Slovenia	9.5	1.4	19.3	4.6	7.7	**22.8**	14.3	20.5	100.0
Russia	17.6	3.2	10.6	7.1	14.1	14.1	11.1	**22.2**	100.0
Ukraine	16.3	1.5	9.1	3.8	18.1	**23.6**	5.8	21.8	100.0
CEE	28.9	1.2	7.7	4.3	8.3	11.6	18.4	19.6	100.0

Source: Reed Electronics Research, *The Yearbook of World Electronics Data, 2001/2*, Volume 4, East Europe and World Summary

Table 5: Export of the CEE electronics industry, 1999

	EDP	Components	Consumer	Comms & Military	Telecomm-unications	Medical & Industrial	Total
CEE Export - total	4006.0	2923.0	2441.0	466.0	301.0	114.0	10793.0
Top exporter	Hungary	Hungary	Hungary	Russia	Poland	Czech	Hungary
% of CEE export	82.8	33.3	60.8	40.1	19.3	41.2	56.5
Second exporter		Czech		Hungary	Slovenia		
% of CEE exports		31.6		38.2	15.0		

Source: Reed Electronics Research, *The Yearbook of World Electronics Data, 2001/2 and 1999/2000*, Volume 4, East Europe and World Summary

Table 6: Shares of exports in production in sectors of electronics industry, 1999, in %

	EDP	Office Equipment	Control & Instrum.	Medical & Industrial	Comms & Military	Telecomm-unications	Consumer	Components	Average
Bulgaria	**80.0**	50.0	**90.0**	40.0	**80.0**	27.3	44.1	**126.9**	67.3
Croatia	**116.7**	0.0	65.7	3.8	14.3	43.4	0.0	**138.1**	47.8
Czech	**166.3**	26.7	39.5	42.7	20.8	13.5	**79.2**	**201.5**	**73.8**
Hungary	**99.3**	**100.0**	53.4	15.7	**74.2**	22.0	**95.7**	**78.5**	**67.3**
Poland	24.2	10.0	12.8	10.7	2.9	10.7	**76.6**	**78.1**	28.3
Romania	54.2	0.0	4.2	8.3	10.0	11.4	4.8	55.1	18.5
Russia	14.6	3.3	**79.0**	12.0	46.8	4.5	40.2	41.3	30.2
Slovakia	66.5	28.6	25.0	2.1	33.0	33.0	65.2	**94.5**	43.5
Slovenia	39.1	0.0	37.6	22.7	16.2	40.9	43.5	**89.9**	36.2
Ukraine	11.1	12.5	10.0	14.3	5.0	15.4	0.0	41.7	13.7
Average	**67.2**	23.1	41.7	17.2	30.3	22.2	44.9	**94.6**	

Table 7: Structure of CEE exports by segments and countries, 1999, in %

	EDP	Office equipment	Control & Instrum.	Medical & Industrial	Comms & Military	Telecomm-unications	Consumer	Components	Total
Bulgaria	0.1	17.4	1.7	1.8	0.9	1.0	0.6	1.1	0.7
Croatia	0.2	0.0	4.4	0.9	0.4	11.0	0.0	2.0	1.1
Czech	6.6	**34.8**	15.2	**41.2**	7.7	7.6	7.8	31.6	14.6
Hungary	**82.8**	4.3	15.2	15.8	38.2	14.6	**60.8**	**33.3**	**56.5**
Poland	1.9	8.7	7.1	5.3	1.5	19.3	22.4	13.9	10.6
Romania	2.6	0.0	1.0	5.3	1.7	8.0	0.1	0.9	1.6
Russia	1.8	13.0	**45.7**	21.1	**40.1**	6.0	5.2	8.9	8.6
Slovakia	3.3	17.4	1.9	1.8	7.1	11.0	1.8	3.5	3.4
Slovenia	0.4	0.0	6.7	4.4	1.3	15.0	1.2	3.0	2.1
Ukraine	0.2	4.3	1.0	2.6	1.1	6.6	0.0	1.7	0.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Electronic data processing
Electronic data processing equipment (computers, peripherals, parts, input and output units), consumer electronics and components are the most developed segments of CEE electronics. Their shares in overall CEE electronics production in 1999 were 29%, 18% and 20% respectively (Table 4). These three sectors are also those with the highest propensity to export[7] (see Table 6). A high propensity for the export of components suggests that the degree of intra-industry integration is very low.

The concentration of CEE countries in exports is somewhat larger than in production, which is understandable. The average share of the top three segments in production and export are 66% and 88% respectively. Hungary exports 83% of total CEE EDP export, 61% of consumer electronics and 56% of components' value. The Czech Republic has a somewhat distinctive position in the export of medical and industrial electronics and Russia has a similar position in the control and instrumentation segment (Table 7).

Hungary has captured the lion's share of investment for personal computers' major sub-systems: hard disk drives and monitors. IBM is the major investor and exporter of hard disk drives with annual exports of $1.5bn (see Table 8). Linden (1998) points out that the hard disk complex has some potential for vertical integration, while the core component of the monitor – the CRT – must still be imported. Nokia was the major producer of monitors until its Hungarian subsidiary was taken over by Elcoteq, the Finish based electronics contract manufacturer. Linden (1998) points out that the company has less than a dozen local suppliers, providing mostly packaging and plastic parts.

Table 8: Multinational electronics companies in Hungary

Company name	**Line of business**	Net sales ($m)	
		1998	**1997**
IBM Storage Products Kft	Disk drives	1514	1536
Philips Magyarország Kft	Monitors, videos, combi-videos, spare parts	1211	
Sony Hungária Kft	Audio devices	233	122
Nokia Display Products Kft	Monitors	20	145
Samsung Electr. Magyar Rt.	TV sets	158	91
Ericsson Magyarország Kft.	Telephone exchanges	131	144
Siemens telefongyár Kft	Telephone exchanges	126	127

Source: Converted into US$ based on Peter Clarke, *EE Times*, 2001, 26.04.

Consumer electronics
In consumer electronics, Central Europe has become an important exporting location for televisions and VCR. Hungary is the leading destination for investment in the assembly of VCRs and audio equipment. Its exports reached 3.6m video recorders in 1999 (see Table 9).

Television assembly is one of the few areas where Hungary is not the leading investment location. Poland has become the top exporter with the number of TV sets rising from 118,000 in 1994 to 4m in 1999. In 1991, France's Thomson took a controlling stake in Polkolor, Poland's state-owned producer of CRTs. By 1995, the company had invested over $90m, raising capacity to 3 million units per year and employing over 5,000 workers (Linden, 1998). South-Korean Samsung has chosen Hungary for one of its European manufacturing centres. The capacity of the plant in Jászfényszaru exceeds 1 million sets a year.

[7] High shares of re-exports in some countries are confusing the overall picture.

Within active components, CEE countries are producing mainly TV tubes. The Czech Republic also produces CRTs. Matsushita has invested in a $66m operation in 1996 to serve the regional market.

Table 9: Exports to EU: Consumer electronics: quantities (thousands units)

	1994	1995	1996	1997	1998	1999
Colour TV						
Czech R	4	1	2	35	295	474
Poland	118	264	490	2015	3319	4018
Hungary	85	290	441	1302	1845	2027
Slovenia	147	56	78	94	72	50
Video Recorders						
Bulgaria	0	0	0	9	41	59
Hungary	6	200	691	2450	3837	3595
Slovakia	52	13	11	-	10	32

Source: Reed Electronics Research, *The Yearbook of World Electronics Data, 2001/2 and 1999/2000*, Volume 4, East Europe and World Summary

Telecoms

Telecoms industries in all CEECs have changed radically since 1989. In this sector, technology and finance gaps were, on average, probably the biggest. Major European telecoms companies like Siemens, Ericsson and Alcatel have entered these new markets. In Hungary, Siemens and Ericsson started the final assembly of telephone exchanges. This was followed by Nokia's plant, the first mobile telephone plant in the region. Poland's most successful use of foreign capital was in telecommunications, where its relatively large market provided it some leverage. As Linden (1998) points out the Polish government was able to privatise a total of five firms to designated suppliers whereas Hungary and the Czech Republic could only privatise one or two each.

Integrated Circuits

Given the very poor state of supply of components and the technology gap during the socialist period, as well as the need for large investment in fabrication capacities after 1989, we do not find modern semiconductor labs in CEE. The biggest socialist era semiconductors producers are from Russia and they have shifted towards low-end electronics (Penn, 1996). Russian semiconductor manufacturers are addressing certain niche markets. One is power ICs, another is the so-called "pad-limited" low-end, low-cost chips. The huge volumes of watch, calculator and toy chips, made mostly in China and Hong Kong, fall into this category. Rather than compete for customers directly, the Russians are seeking alliances with manufacturers in Hong Kong, China, Taiwan, Singapore and other areas for these low-end markets. Major companies like Mikron, Angstrem and Integral have become active in exports and are engaging in joint venture activities with foreign partners (Table 1). Foreign investment has resulted in several joint ventures:[8] for example, the Korona venture between Mikron and Hua Ko Electronics Ltd (Hong Kong); International Rectifier Corp (US) with Electronica

[8] Robert A Sanford (2000): 'The Russian Bear Begins to Roar. Semiconductor business has adjusted better to radical change than other industries', *Semiconductor Magazine*, November, Vol 1, No 11,.

(Voronezh); Ericsson with Kvant (Zelenograd); and Hitachi with Svetlana (St Petersburg). Exports are also making progress though absolute amounts are still very small (Smith, 2001).

In Central Europe, foreign activity in fabrication (IC) and software programming are concentrated where they already have an established domestic base: the Czech Republic for ICs and Hungary for software. The Czech Republic has the most developed microelectronics sector in Central Europe, with major investment 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 centre for analogue ICs in 1994 near the Tesla factory (Table 10). Tesla Sezam's 800-strong workforce make semi-conductor chips in a joint venture with ON Semiconductors, formerly part of Motorola.[9] Another ON Semiconductors joint venture, Terosil, makes silicon mono-crystals for chip production.

Some offshoots of Tesla, the large ex-socialist conglomerate, have been relatively successful at surviving independently, although several eventually went into liquidation. Linden (1998) points out that these firms have generally been unable to increase their capabilities to grow rapidly. Poland's CEMI 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 after bankruptcy it was re-established in 1995 under the ownership of Poland's Industrial Development Agency (*ibid*).

Electronic components

The largest investment in electronic components was made in the Czech Republic, but Hungary has also received a continuous stream of such investments. Both countries export similar values of components. Japan's Kyocera made a large investment in the Czech Republic. A subsidiary of Kyocera, AVX, makes one-fifth of the 16 billion annual global output of tantalum chip capacitors, a vital passive component in telecoms and computer applications, which it exports worldwide direct to OEMs. In 1998, impressed by the low fault rates in its Czech plant, AVX began expanding its workforce to nearly 3,000. AVX is particularly happy with the expertise of the cluster of engineering supplier companies in central Moravia.[10] Other components produced in the Czech Republic are chips and silicon crystals (ON Semiconductors), ceramic substrates (YS Corp), YV picture tubes (Schott), solar panels (Linet), video optical parts (Philips), LCDs (Optrex), resistors/condensers (Vishay), resistors (Matshushita), etc.

To sum up, a review of the position of CEE countries across electronics segments suggests that they are present in technically less demanding areas such as passive components, audio equipment, and technically less complicated computer parts, except hard disks. However, a true assessment of technological sophistication of foreign investments in electronics would require detailed case studies of several major segments. It is difficult to generalise based on only aggregated data. In fact, when these data are complemented with case study evidence, it seems that CEE occupies a somewhat diverse range of positions in electronics, which vary from low cost assembly and the production of non-electronics parts, to more demanding R&D activities, mainly in telecoms software. In the rest of this section we review the situation in PC assembly, as this is the only area of electronics where domestic producers during the 1990s have not been inferior to international companies. In addition, we review foreign investments in R&D and software.

[9] Czech A.M. 23 August 2000.
[10] CzechInvest www.

PC assembly

CEE is a relatively immature and fragmented market. The CEE PC market is forecast to increase its share of European shipments from 15% in 2000 to 17% in 2004.[11] None of the leading local manufacturers in the region has captured a significant proportion of the total regional PC market. Local assemblers that appear in the top 10 of PC manufacturers operate only in one country, generally Russia and Poland. The only export-scale PC assembly investment has been made in the Czech Republic by a Taiwanese firm, First International Computer, which has set up a production plant in Rudno near Prague. Currently they are expanding to produce over 200,000 PCs per month. In contrast, shipments for all international manufacturers are spread across the whole region. According to Gartner Dataquest (2000) over the past three years international manufacturers have significantly strengthened their position, mainly at the expense of local companies. Compaq is the market leader, with 5% of the shipment share, aggressively improving its position and outperforming its competitors in major country markets. Toshiba has also experienced high growth rates in the region but is a player only in the mobile PC market.

CEE local PC manufacturers have emerged as cheaper alternatives to international PC manufacturers' products. Initially, their lower prices went hand-in-hand with inferior quality and support. However, over the years quality has improved, but customers still expect local manufacturers' products to be cheaper than those of international manufacturers. To meet this challenge, most local manufacturers (who began with very simple value propositions and only a few products), now offer full product ranges to address various customer segments, from small consumers to large businesses.

However, international PC manufacturers are gradually starting to oust established local manufacturers, because the former have developed strategies to cater for the price-sensitive CEE PC market. This is usually done through promotions to their dealers and end users, launching special ranges for CEE, for which they offer cut-down versions of existing ranges.[12] Local manufacturers operate on thin profit margins and many will not survive in the medium term, whereas international manufacturers are committed to this market for the long term.[13]

Price differences between local manufacturers' and international manufacturers' products remain sizeable. However, with competition increasing, this may change in the next two or three years. Gartner Dataquest estimates that, on average, local manufacturers' prices are 10-20% lower than those of international manufacturers. Currently, the average price of a deskbound PC in the region is about US$1,000, so the price difference is, according to Dataquest, between US$100 and US$200.[14] Because prices are falling on a regular basis, there will come a point when a 10% difference will be so slight that even the most cost-conscious buyer will be prepared to pay the higher price if there is a perceived reason to do so. Therefore, local manufacturers will have to make increasing efforts to improve the quality of their products and services.

In any event, most players in the market have now realised that a long-term strategy cannot rely solely upon hardware, but that hardware should be the "bait" that locks customers

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[11] Natalie Spitz, Annette Jump (2000): 'Eastern Europe: A Bright Future?', *Dataquest Perspective*, 20 October.

[12] Annette Jump (2001), 'Is Strong PC Market Growth Sustainable?', *Dataquest Perspective, Eastern Europe*, 7 March.

[13] Annette Jump (2000): Eastern Europe: Land of Opportunity for International Manufacturers', *Dataquest* Perspective, 31 August.

[14] Natalie Spitz and Annette Jump (2001): 'PCs in Eastern Europe: What's Included in the Price?', *Dataquest Perspective*, 28 March.

into further services.[15] For example, in Hungary international manufacturers occupy all of the top five places, and the largest local assembler, Albacomp, continues to slip further down the list of top manufacturers. International companies have already appeared in this field as well. For example, Siemens has commissioned Muszertechnika, a local PC company, with the assembly of personal computers under the Siemens trademark.[16] However, this pattern may not be followed in Russia and Poland where local assemblers may be able to compete successfully against international manufacturers. The two leading vendors in Poland's personal computer market are local firms – Optimus and JTT. Since 1993, the characteristic feature of the Polish PC market has been persistent dominance of these two domestic assemblers – over 70% of all PCs sold – that has not been matched anywhere else in Europe (Kubielas, 2002).

R&D and Software

R&D and software skills have also attracted investors into CEE (see Table 10). In 1994 in Hungary, Siemens established Sysdata to engage in software development for private telephone networks, employing 150 software engineers by 1995. Also in 1994, Ericsson started a software support group in Budapest, one of 25 such centres worldwide. The number of programmers grew to 30 in 1995 and reached 90 by 1996 with further expansion planned. Poland and the Czech Republic have capable software engineers, but they have not yet produced competitive niche segments companies like the Hungarian GraphiSoft[17] and Recognita[18], nor have they generated the same level of activity by foreign firms as Hungary.

In the Czech Republic, PragoData is the most well known custom software house which writes industrial management software. ON Semiconductors, formerly the Semiconductor Components Corp of Motorola, has a 25-person analogue IC design unit while Motorola operates a 30-person R&D centre which is researching micro-controller and digital signal processor reference platforms. Rockwell Automation operates one of its four global Independent Advanced Technical Laboratories in Prague. The only one outside the USA, it specialises in intelligent diagnostic software. Honeywell also runs a specialist R&D centre in Prague developing control software and tools.

It is difficult to judge the significance of R&D/SW centres for foreign investors. In several cases, CEE R&D centres are part of company R&D network, ie, they are not performing adaptive R&D.

[15] Natalie Spitz and Annette Jump (2001): 'PCs in Eastern Europe: What's Included in the Price?', *Dataquest Perspective*, 28 March.

[16] Annette Jump (2001): 'Eastern Europe: Is Strong PC Market Growth Sustainable?' *Dataquest Perspective*, 7 March.

[17]GraphiSoft is a start-up company dating from 1982 which has become a known niche producer in 3D drafting software for architects. The company has developed an integrated software module known as ArchiCAD, still the company's best-selling product: it is marketed in 80 countries and used by over 65,000 architects worldwide. In 1999 Graphisoft and Pricewaterhouse Coopers entered into a joint venture to launch ArchiFM, Graphisoft's property management software.

[18]Recognita is one of a number of spin-off companies from SzKI, the state research institute. It produces optical character recognition (OCR) software for most European languages and was bought out by Caere, an American OCR firm seeking to expand its base in Europe, for $4.7 million in 1996 (Linden, 1998). Its main product, optical character recognition software, has earned the company international renown. Recognita became market leader in this sector with 90% of its business being for export, and its products are sold in 25 countries.

Table 10: Foreign R&D and Software centres in Central Europe

Company	*Year*	*Activity*	*Employment*
POLAND			
Motorola	2000	SW development	500 (plan 2002)
Olicon (Denmark)		SW development	
Lucen Technologies		SW development	
HUNGARY			
Nokia		2 R&D centres for switching SW and applications	330 (plan)
Erricson	1994	R&D centre	90
Siemens (Sysdata)	1994	SW development for telephone networks	150
Motorola	Plan		
IBM			
CZECH REPUBLIC			
ON Semiconductors	1994	Design centre	25
Motorola	1994	R&D centre	30
Rockwell Automation	1993	Technical Lab	18
Honeywell	1995	Technology Centre	14
Logica	1995	Development Centre	100
Siemens		SW development for telephone networks	50
Erricson	2000	R&D centre in co-operation with Czech Technical University in Prague	

Source: Business Press and company sources

3.2 Major companies in CEE electronics

As Linden (1998) and Ernst (2000) point out, a defining feature of production networks in electronics is their organisation around geographic regions, with each lead firm establishing similar production organisations in Asia, Europe and North America. The opening of CEE as a production location enabled EU MNCs in electronics to expand regional core networks. This enabled them access to a diverse array of production costs and capabilities in close proximity.

Philips and Siemens have taken the lead in investments, motivated, initially, by geography and lower labour costs. Philips has built an extensive network for consumer electronics in Hungary and made electrical sector investments in Poland. Siemens has invested in all three countries in telecommunications equipment and electrical parts. Korean firms (Samsung and Daewoo) have also moved into the region early, looking to use central Europe as a production platform for the European market. By the mid-1990s, US firms had also joined. 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 centre in Poland. More recently, several US-based contract manufacturers have expanded their European operations to Hungary. By the end of the 1990s, Japanese firms had joined, some of which relocated their facilities from the EU, in particular from the UK. Kyocera invested in component production in the Czech Republic and Matsushita opened a large-scale TV assembly plant there in 1997 (Linden, 1998).

There are three groups of companies that make up the electronics landscape in CEE: OEM electronics producers, contract manufacturers and local electronics firms.

Table 11: Major foreign direct investments in electronics in CEE

Company	Year	Activity	Mode of entry	Location	Employ-ment	Value, $m
HUNGARY						
Philips, 17 plants of which					9500	134
Philips Hungary	1990	Consumer electronics, lightning, components, semicond, comm systems, medic systems, domestic appliances, personal care products		Budapest		
Philips Assembly Centre	1990	TV video combis, VCR, CD-R, DVD		Szekesfehervar		25
Philips	1995	assembly of colour monitors for PCs		Szombathely		
Philips Monitor Manufacturing	1996	PC monitors, PCB’s		Szombathely	1000	30
Philips Components	1997	Car stereo components, CD-RW, reading heads		Gyor		30
Philips	2001	Distribution centre for CEE	Greenfield	Szekesfehervar		10
Philips Payer Industries		Hair clippers and foil shaver parts		Ajka		
IBM Storage Products	1995	hard disk drives		Szekesfehervar	1000	100
Flextronics	1997	Manufacturing services (production of parts, assembly of finished parts)	Takover of “Neutronics”, a European contract manufacturer	Tab, Sárvár, Zalaegerszeg	5600 (1999)	137
Flextronics	2000	Manufacturing services		Nyíregyháza	700 (plan 3000)	75
Samsung, Korea	1991	TV sets		Jászfényszaru		20
Siemens	1991	telecom				3
Nokia	1995	monitors			200	30
TDK	1995	transformer/ processes ferrite		Rétság	700	15
Nidec	1997	HDD motors				27
Elcoteq, Finland	1997	Manufacturing services, GSM repairs	Two greenfield plants	Pecs		1400

Company	**Year**	**Activity**	**Mode of entry**	**Location**	**Employ-ment**	**Value, $m**
Siemens/Matsushita	1997	ceramic chips/microwave elements	Acquisition from Siemens	Szombathely	1514	10
Sony	1998	home electronics	Brownfield	Gödöllô	1200	21
Elcoteq, Finland	1998	Manufacturing services, monitors	Acquisition from Nokia	Pecs	2400	30
DDD, Bosch	1998	automotive electronics		Kecskemet	500	
JIT Electronics, Singapore	1999	GSM mobiles, peripherals	In 2000, taken over by Flextronics	Budapest	300 (500 plan)	30
Clarion, Japan	1999	CD players/audio equipment		Nagykáta	350 (700 plan)	12
Bosch	1999	Automotive electronics		Hatvan	300	
KeyTec BV, Netherland	2000			Zalaegerszeg	40 (80 plan)	
Artesyn Tech., US	2000	Telecom power supply units	Expansion	Tatabayna	700 currently	20
Jabil, US	2000	Printed circuits and components		Tiszaujvaros	500 (2500plan)	80
Rafi - BBP, Germany	2000			Mezotur	100	
Nokia	2000	Cellular phones	Greenfield	Komarom		
DBTel, Taiwan	2000	Mobile phones		Debrecen		
Zollner, Germany	2001	Electronic equipment	Greenfield	Szugi	300	Ft3.2bn
Nat.Steel/Solectron				Budapest		
Shinwa, Japan		Car radios				22.5
Yageo, Taiwan	2002	Multi-layer ceramic capacitors	Greenfield	Szombathely		
Tyco Electronics Corp	1993	connectors and electronic modules	Greenfield, 3 plants		2,200	
Vishay		Back-end work on diodes, sensors, and transistors			1,200	
SCI		Contract manufacturer		Tatabanya		

Company	**Year**	**Activity**	**Mode of entry**	**Location**	**Employ-ment**	**Value, $m**
CZECH REPUBLIC						
Matsushita	1997	TVs	Greenfield	Plzen		66
Matsushita	1999	Electrial resistor plant	Greenfield	Plzen		79
Matsushita	1999	Electromagnetic relays	Greenfield	Plana		100
Epcos (Matsushita , Siemens AG, …)	1999	Ferrites				27
Philips	2000	TV picture tube factory	Greenfield	Hranice	570	192 (600 plan)
Philips	2000	Components plant	Greenfield		3000 plan	624
Philips	2000	Electronic microscopes		2 plants		
FIC, Taiwan	2000	PC & peripherals assembly	Greenfield		plan	
Fist International, Taiwan	1997	Computers				100
Asea Brown Boveri (ABB)			Joint venture			
Celestica, Canada	2000	Manufacturing services	Acquisition from Gossen-Metrawatt	Brno	800	
Celestica	2000	Manufacturing services	Greenfield	Brno	300 plan	50
Celestica	2001	Assembly/repairing mobiles	Acquisition from Sagem	Kladno		
Flextronics	2000	Manufacturing services	Greenfield	Brno	3000 plan	20 (100 plan)
Flextronics	1992	Plastic parts and CEM	Acquisition from Philips-Sanda			45
Dovatron, DII, Ireland	2000	Manufacturing services	Acquisition of domestic electronic company	Brno		
AVX, Kyocera	1998	Tantalum chip capacitors			3000	66
CIS Electronics, Germany	2001	Communications		Nove Mesto	260 plan	2mDEM
Siemens	1993	Telecoms				37

Company	Year	Activity	Mode of entry	Location	Employ-ment	Value, $m
Siemens	1994	Automotive electronics, Telecom cables,				
Siemens	1998	Electromechanical components				
Vishay, US	1993-98	Electronic components	6 plants			22
Mitsubishi , Koyo Seiko	2001-05					26
ON Semiconductors & Motorola, US	1997	Semi-conductor chips	Takeover of Tesla Sezam		800	45
ON Semiconductors & Motorola, US	1997	Silicon mono-crystals for chip production.	Joint venture with Terosil			
Trimex Tesla (Linet), Switzerland		Photovoltaic cut wafers				
Foxconn (Hon Hai), Taiwan	2000	Joint venture with Tesla Pardubice				50
Télémécanique, France	1993	Telecom equipment				22
Schneider Electric (Groupe Schneider)	1993-98	Electronic components				17
YS Japan	1994		Takover of Tesla plant			16
Punch International, Belgium						17
Cherry Corporation, US	1993	Elec components (computer keyboards)				14.5
Infineon Technologies AG, Germany	2000					4.8
Deltec, Germany	1993					4
JPM, US	2000			Bělá nad Radbuzou		2.4
SCG Holding Corp., US	1999	Electronic components	JV with Tesla Sezam and Terosil			
POLAND						
Yageo (Taiwan)	2000	Manufacturing services	Acquisition from Philips			
Elcoteq		Manufacturing services	Greenfield	Wroclaw	200	
Elcoteq	2001	Manufacturing services	Greenfield	Wroclaw	1000 plan	

Company	Year	Activity	Mode of entry	Location	Employ-ment	Value, $m
Curtis (USA)	1990	TV sets				100
Alcatel (FRA)	1990	Telecoms	Takeover	Poznan		150
Thomson (FR)	1991	TV sets		several locations		301
Philips	1991	Lighting				50
Lucent (NL)	1992	Telecom equipment				139
Siemens (GER)	1993	Telecoms	Takeover	Warsaw		150
Philips/Matshushita	1995	Batteries				40
Philips	1995	TV sets/components		Kwidzyn		25
Daewoo		TV sets/components				
Motorola		IC assembly	Greenfield	Cracow	(500 plan)	150
APW	2001	Global provisioning centre	Acquisition from Lucent	Bydgoszcz	300	
Tohoku Pioneer (JPN)		Loud speakers	Stake in local company	Wrzsenia		35.7
ICL (UK)		Computing equipment and SW	Majority stake in Softbank	Warsaw		12.1
Unysis (USA)		Computer technology		Warsaw		6
Flextronic		Contract manufacturing	Greenfield	SEZ Tczew		2
Flextronic		Contract manufacturing		Gdansk		
Qcom AB, Sweden	1993	Contract manufacturing	Takeover by Flextronics in 2000		70	
ESTONIA						
Elcoteq		Mobile phone plant	2 greenfield plants	Tallin	2600	
Elcoteq		Engineering centre		Tallin	800	
SLOVAKIA						
Sony		Home electronics		Trnava		

Source: Business Press; Czech and Hungarian investment agencies; Polish Agency for Foreign Investment, Linden, 1998.

OEM electronics producers

Philips

Phillips is the 15th largest enterprise group in Europe, the largest in the electronics sector with €27.6bn turnover and 238,000 employees. It is also the first mover into CEE electronics. As was seen with ABB (see Radosevic, 2002) it has built up an extensive network of plants across the region, in Hungary, the Czech Republic and Poland. In Hungary, Philips is a major player in the electronics market where, by the end of 1999, it had invested €140m in 17 plants. The company plays a major role in Hungarian exports where it is the third largest exporter, fifth largest group and second largest electronics exporter (Table 8). Its exports from Hungary in 2000 amounted to €2.2bn and its domestic sales were €2.2bn. The company had 9,500 employees in 1999 and 7,200 in 2000. Most of this reduction took place through sales of plants to contract manufacturers. The largest of Philips Hungarian subsidiaries manufactures TV sets and VCRs, car systems, PC monitors, car stereo systems, electronic parts, medical equipment, and re-writeable CD-drives[19] (see Table 11). In addition to its wholly owned subsidiaries, Philips has minority shares in two Hungarian firms (Atos-Origin, an IT services provider and Hungarian speakers systems). It uses Elcoteq, Flextronics and SCI as contract manufacturers for GSM repairs, production of parts, and the assembly of finished parts. In Hungary, Philips has a network of seven subcontracting firms (see Table 12).

Table 12: Subcontractors of Philips in Hungary

Company	Location	Activity
Jetech	Gyor	Fax production
Lux Electro	Kecskemet	Assembly and production of plastics
Magyar Kepcso Ltd	Szombathely	Matching of monitor picture tubes
Mediagnost Ltd	Budapest	Production of medical systems
Phycomp	Sarvar	Production of passive components
PLA	Balatonlelle	Production of PCB's
Videoton MBKE Ltd	Kaposvar	Production of kitchen applicances, iron and haircare

Source: Philips

The move to CEE came as a result of efforts to adjust its strategy to changing conditions in the electronics sector. Pressure to reduce the cost of the integral supply chain ranked as the most prominent driver for relocation to CEE.[20] The move to CEE is part of Philips' broader strategic shift to reduce the number of production sites in order to achieve greater volume and of the shift to lower wage regions (Table 13).

In October 2000, Philips merged its Hungarian subsidiaries and operated as Philips Industries Kft. They moved to the Czech Republic in 1999 and set up new regional CEE headquarters in Prague. Philips has invested $192m in the Czech Republic in a television picture tube plant marking the company's biggest investment in central and eastern Europe.[21] Total investment could reach around €600m over six years, making it the second largest picture tube plant in the world. The plant will supply TV manufacturers locating in the region

[19] Hungary A.M., 16 October 2000.

[20] 'Philips made a good start, says Boonstra', *Financial Times*, London, 26 March 1999.

[21] Anderson, Robert (2002): 'Philips in Czech TV-tube deal', *Financial Times*, London, 30 March, p11.

and would enable the company to maintain its number one position as the manufacturer of colour picture tubes.

Table 13: Philips: changes in production location sites

Philips Lightning:		
Number of production sites		
1990	136	
2000	80	
Move to low wage countries		
	High wage	Low wage
1990	77%	23%
2000	49%	51%
Philips Consumer electronics		
	Focus	**Number of factories**
1980s	Local	100>
1990s	Regional	36
2000	Global	14

Source: www Philips

Siemens

As with Philips, Siemens also entered CEE very early. For a company whose strong position continues to be international operations, the move to CEE was 'natural'.[22] Siemens has established subsidiaries in all CEECs of which the most important are Hungarian, Polish and Czech.

In electronics, its most important acquisitions have been in telecommunications equipment. A Hungarian subsidiary was acquired in 1991. Siemens Telefongyár develops, manufactures and markets EWSD telephone exchanges, produces text and data transmission equipment, and installs and assembles telecommunications networks and cables. Its main customer is the Hungarian telecommunications company, MATÁV. The operation units are imported, but the exchanges are assembled in Hungary. Through its subsidiary, Infeon Technologies, Siemens also owns a plant in Trutnov (Czech Republic) producing optical fibre connectors and converters.

IBM

IBM is active in Hungary. IBM Storage Products Ltd is a wholly owned subsidiary of IBM Deutschland GmbH that began manufacturing high-capacity hard disks in 1995. This factory has the latest technology and an annual output of over 1 million units, almost all of which are exported to Europe. Videoton Holding Rt built the factory to IBM specifications and standards. IBM leases both the building and its energy supply system from Videoton. Two-thirds of the company's employees are involved in the production of hard disk drives for Videoton Mechanics Ltd, a subsidiary of IBM Storage.[23] Videoton and IBM are located in the same industrial park, which bears Videoton's name. Under a long-standing co-operation

[22] Siemens total employment is 447 thousands (1999) of which 267 thousands employees work outside of Germany in 190 countries.

[23] IBM Storage began manufacturing 2.6-inch hard disks for laptops after investing $35 million investment. Full annual capacity will reach 3 million units and should create 900 new jobs.

agreement, the two companies lend each other workers to cope with fluctuations in demand characteristic of the global electronics market.[24]

Nokia

Nokia first came to Hungary in 1995 where it established production of computer monitors. Almost all the 15", 17" and 19" monitors assembled in the Pécs factory are exported. The primary end users are either in Europe or the US. In early 2000, the Elcoteq Company from Finland acquired Nokia's monitor assembly plant in Pécs. Nokia currently manufactures portable phones in Komárom in Hungary and operates R&D centres in Budapest and Debrecen.

Ericsson

Ericsson is an important supplier to several telecom operators in all CEECs. Its manufacturing is outsourced to contract manufacturers so its CEE subsidiaries are mainly involved in services. For example, in Poland the contract manufacturer Flextronics is making 3G products for Ericsson in the Industrial Park Gdansk.

In Hungary, Ericsson supplies mobile switching exchanges and radio stations, and operates, maintains and provides system support for them. Ericsson also markets and distributes mobile phones and has an approximate 30% share in this market.

Ericsson came to Hungary in 1990. To being with, most components were imported. In 1992 the Hungarian content began increasing until, by late 1993, most of the equipment was manufactured domestically. A downturn in the local telephone exchange market forced Ericsson to move into software development and mobile telephony, a field in which it has entered a long-term strategic agreement with Westel 900 GSM, a local mobile phone operator (Linden, 1998).

The company also operates one of the largest software development centres in Hungary. The centre, which was founded in 1991 and merged with the research laboratory in 1997, develops, among other things, mobile telecommunications, Internet, and ATM data transmission technologies. The company's regional centre, which was founded in Budapest, also provides technical assistance to mobile operators in other countries in Central Europe.

In Croatia, Ericsson has taken over Nikola Tesla, a local telephone exchange company and its former licensee, and turned it into a training and service centre for its network. In Poland, Ericsson has a 10% market share and a local company with 470 employees (1998).[25]

Motorola

Motorola is present in the Czech Republic, Hungary and recently in Poland. In the Czech Republic, Motorola took advantage of its great experience with former Tesla Roznov engineers and entered its two significant semiconductor successors – Tesla Sezam and Tesla Terosil. The joint takeover with ON Semiconductors in 1997 followed several years of subcontracting in which Motorola had helped to upgrade the factory's operations. The Motorola locality in Roznov pod Radhostem became an important centre for designing and manufacturing semiconductors for the whole CEE and entered the new world markets. Later, Motorola also entered the former Tesla Piestany (Slovakia). In 1994, Motorola opened a design centre for analogue ICs near the Tesla factory. This centre focuses on the motor control area, wire and wireless communications, telecommunications and multimedia.

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[24] Dan Nashaat and Robert Smyth (2001): 'IBM cuts temporary staff at Székesfehérvár plant', *Budapest Business Journal*, 9 July.

[25] Contact – Ericsson Internal Publication, No 09, 1998.

In 2000, Motorola opened a software centre in Poland in the Krakow Technology Park where it employs 500 engineers.[26] This is one of its 19 software engineering and production facilities worldwide. The Krakow Technological Park, with an increased area and operation time of 20 years, has been expanded to encourage Motorola to invest more.[27]

In Hungary, Motorola has three local manufacturing facilities run by contract manufacturers – JIT Electronics (Budapest), Flextronics (Zalaegerszeg) and DBTel (Debrecen). They are producing parts for mobile phones, which comprise one-third of Motorola's total European portable phone output.

Sony

Sony is present in Hungary and Slovakia. In 1997, it invested $21 million in Hungary where it has 1,200 employees and exports 80% of its audio products to the EU. Sony also produces home electronics products in Trnava. From Central Europe Sony now supplies half of its home electronics products sold in Europe. In 1998, additional major investments were implemented, among them a new IT system for the audio-visual products division. Additional production lines were also installed.

Matshushita

Matshushita (Panasonic) has been present in the Czech Republic since 1997 where it produces TV sets. The Matsushita project was the first major Japanese greenfield investment in the Czech Republic and a major success for CzechInvest, the Czech foreign investment agency which brokered the deal with the city of Plzen. In January 1999 the Matsushita group opened a second plant in the Czech Republic, in the town of Plana in west Bohemia, which produces electromagnetic relays. The firm employs 100 people. The next-generation digital Panasonic TV will be also produced in Plzen with doubled output. As part of the expansion plan Matsushita is transferring R&D and SW development from the UK to Plzen.[28]

Samsung

Samsung Electronics entered Hungary in 1989 through a joint venture involving the Hungarian Orion. In 1991, Samsung established production of TVs. Output began at 100,000 TVs annually, with the majority being sold to the domestic market. The factory currently exports close to 2 million colour TVs annually and is Samsung's third-largest TV plant worldwide[29] (Table 9). Ninety per cent of its output is exported, but Samsung is also the market leader in the Hungarian TV market.

Hewlet Packard

HP does not own production facilities in CEE but is present through a contract manufacturer. In 1998, Hewlett-Packard selected Flextronics to be its primary manufacturer in Europe for inkjet printers, starting with the HP DeskJet 720C printer.

Flextronics is responsible for building both printed circuit board assemblies (PCBA) and complete box assembly. Production is at the Flextronics Sarvar site in Hungary. Printers produced for HP by Flextronics incorporate components produced by suppliers operating from the Sarvar site, including EcoPlast, the wholly owned plastic injection molding subsidiary of Flextronics.

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[26] Roseanne Gerin (2001): 'Christmas go ahead for Motorola plant', *Warsaw Business Journal*, 24 August.
[27] Andrzej Ratajczyk (2001): *The Warsaw Voice – Business*, No. 3 (639), 21 January.
[28] www.CzechInvest.
[29] Drew Wilson (2001): 'Privatization Keys Hungary's Turnaround', *Ebn, Manhasset*, 29 Jan, p50.

Contract manufacturers

Contract manufacturers, or electronics manufacturing service companies, have emerged as an important new player in world electronics. These companies assemble a wide array of electronics products in whole or in part for OEM producers. Initially, contract manufacturers were doing only “board stuffing” or putting IC on motherboard and serving OEMs on an overflow basis. However, they gradually shifted towards full turnkey manufacturing services serving as a primary supplier of Electronics Manufacturing Services.

By utilising these services, OEMs are able to focus on new product innovation and concentrate more on their core competencies – such as research and development, sales, marketing and branding – and less on manufacturing and distribution. In surveys, OEM purchasers say their companies save about 25% of manufacturing costs by outsourcing production to contract manufacturers. In some cases contract manufacturers are designing complete systems for lower-end products.[30] As contract manufacturers improve their design capabilities, they are beginning to compete with original design manufacturers (ODMs).[31] Contract manufacturers are able to offer time-to-market advantage, collaborate with customers to complete product development ahead of schedule and consult on design, manufacturability, and reliability issues to ensure that products are introduced quickly without sacrificing quality.

The preconditions for contract manufacturing were put in place because of the increased codification and standardisation of technological processes in electronics (Sturgeon, 1997). International standard setting bodies (eg, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC)) have developed industry-wide classification and specifications for components and processes. These preconditions have been followed by pressures to reduce costs, achieve flexibility and innovation opportunities, which all create pressure on OEMs to focus on new products development rather than on manufacturing.[32] In addition, the Internet may have also fuelled the trend towards outsourcing as it makes it easier for companies to share information and move it around. Therefore, even European companies like Siemens, which until recently were very vertically integrated, have increasingly turned to contract manufacturers when it offers them a strategic advantage. This is the case especially if products are in the latter-half of their life cycle, and volume levels do not keep plants at full capacity.

It is estimated that in the electronics industry today, about 15% of all manufacturing is outsourced and forecasts are that this share may rise rapidly towards 60-80% over the next five to ten years.[33] The move to outsourcing production is forecast to continue and will lead to further expansion of the contract electronics manufacturing (CEM) industry. For example, European contract manufacturing has grown from $11.1bn in 1999 to $23.6bn in 2001.[34] Market value of publicly traded contract manufacturers was $120bn in 1999.[35] It has been estimated that the OEM market was $705bn in 2000, while CEMS was $103bn and forecast to grow to $250bn in 2005.[36]

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[30] Jim Carbone (2002): ‘Design moves into EMS spotlight’, *Purchasing Magazine Online*, 17 January.
[31] ODMs are design houses that have manufacturing capacity. ODMs will design products and then build them for customers. Solectron and other contract manufacturers are offering ODM capability in certain product areas such as cell phones and servers.
[32] Lyell, December 1999 issue (pp84-88) of SMT.
[33] December 1999 issue (pp84-88) of SMT.
[34] Richard Ball (2002): ‘Market watchers look for shoots of growth’, *Electronics Weekly*, 20 February.
[35] www.smtmag.com
[36] *Electronics Weekly*, 17 November 2001

Contract manufacturing is developing at a high rate in CEE. From 1993 to 2000 the value of contract manufacturing services in CEE rose from $0.5bn to $4bn, a rate similar to other European regions (see Table 14). However, most of this growth took place in the period from 1996 onwards. It is estimated that by 2003 CEE will become the major European location for contract manufacturing and will lead both Ireland and the UK.[37]

Table 14: Electronics contract manufacturing in Europe

	(bnUS$)		
	1993	**2000**	**2003 (est)**
CEE	0.519	3.94	12.923
UK & Ireland	1.468	5.341	6.436
Germany, Austria & Switzerland	0.907	2.515	5.21
France & Benelux	0.983	3.231	5.127
Scandinavia	0.302	3.933	4.979
Spain	0.228	0.694	1.698

Source: CzechInvest Study on Electronics based on data of Enterprise Ireland, 2000.

CEEC have now attracted several of the leading firms in this field, including Flextronics, Celestica, Solectron, SCI, and NatSteel (later taken over by Solectron).[38] Sturgeon (1997) argues that in comparison with North America and Asia, the contract manufacturing sector in continental Europe has been very slow to develop. However, developments in the last five years suggests that situation in Europe has changed, especially with the arrival of US and Asian contract manufacturers, and the emergence of indigenous European contract manufacturers. In addition, we observe a new trend where OEM producers in CEE are selling their plants to contract manufacturers, as with the sale of Nokia’s plant to Elcoteq.

Flextronics

Flextronics is a Singapore-registered company run from California.[39] It is top of the rankings of the leading 40 European CEMs with combined European sales of $2bn. Flextronics has plants in Malaysia, China, Mexico and CEE[40] (Table 11).

Flextronics was the first company to see the huge potential of CEE in contract manufacturing at a time when this trend was taking root in other regions. Competitive pressures have forced European brands such as Bosch, Ericsson, Nokia, and Siemens to outsource more, and Flextronics saw this opportunity. As the first mover in this area it controls roughly twice the manufacturing capacity of its six largest competitors combined.[41] Flextronics’ European operations are growing by 50% a year and already generate about 40% of its global revenue (*ibid*).

[37] CzechInvest 2001 study on electronics industry based on data of Enterprise Ireland.

[38] Timothy Sturgeon: *Turnkey production networks in electronics: new opportunities for cross-border integration and economic development in eastern Europe*, Briefing paper No 19, BRIE, University of California.

[39] Flextronics is the first American manufacturer, which in 1981 went offshore, setting up the Flextronics Singapore facility.

[40] Flextronics is one of the world’s electronic manufacturing services providers building complete products that range from complex printed circuit board assemblies for computer workstations to personal digital assistants. It has shown steady growth from $93 million in FY 1993 to annualised revenues of $13.8 billion. It employs over 70,000 employees worldwide in 28 countries.

[41] William Echikson (2000): ‘Contract manufacturer Flextronics dominates Europe from its old industrial heartland’, *Business Week*, 23 October, Issue: 3704, pp148B-148F, Tab, Hungary.

In Hungary, Flextronics has renovated the facility in Tab, which now employs 1,500 workers, and created two new facilities in industrial parks in Zalaegerszeg and Sarvar, which combine Flextronics' assembly operations with those of component suppliers and distribution partners.

The company has also established a new plant in Nyíregyháza in eastern Hungary. Three out of four Flextronics locations in Hungary are operating in Industrial Parks.

Annual sales targets are in the region of $500 million. Revenue at Flextronics' Hungarian facilities has risen 100% annually for the last five years, and it is expected to continue rising as OEMs outsource more of their manufacturing worldwide. Flextronics currently employs around 10,000 people in its Hungarian factories, making it the fourth largest employer in the country.[42]

The Flextronics Central European facilities, originally purchased by Flextronics in 1997, manufactures plastic components, PCBs, electronic modules and complete products for consumer, telecommunications and industrial applications for both European and international markets. Flextronics operates as contract manufacturer for all major European OEMs. In 2000, Flextronics signed an agreement with Siemens to manufacture approximately 33 million mobile telephones by the end of 2003.

In Hungary, Flextronics has its Industrial Park in Zalaegerszeg which is focused on printed circuit board and systems assembly, and produces motherboards for personal computers, CD rewritables, ink jet printers, laser printers and DECT phones (cordless phones) for OEM customers. In 2001, Flextronics moved into full scale production of Microsoft's Xbox games console at its factory in Sarvar, Hungary. This is claimed to be the first games console factory located in Europe.[43] Flextronics has also facilities in the Czech Republic (Table 11).

Celestica

Celestica is the third largest electronics contract manufacturer in the world with a revenue of $9.8 billion in 2000. The company has three plants in the Czech Republic, and invested $70m in 1999 in PCB and MST production plant in Rajecko. The company expanded the facility in 2000 and took over the Czech subsidiary of the French SAGEM,[44] which operates in Kladno, Czech Republic. The deal places Celestica as SAGEM's primary contractor and includes a three-year supply agreement. This is worth approximately US$500 million in total revenue over the course of the three years associated with the manufacture, repair and related supply chain services for mobile handsets and other communications products.

Celestica has also acquired the Czech operation of the German test and measurement firm Gossen-Metrawatt near Brno, and has also build greenfield facilities.[45] Under the terms of the arrangement, Celestica is in strategic long-term supply and cooperation agreement with Gossen-Metrawatt.

In addition to CEE, Celestica has six other European operations in the UK and Ireland. However, the global downturn in the electronics industry forced Celestica to close plants with the loss of 1,100 jobs in the Midlands and northern England; a circuit board factory in Ashton-under-Lyne near Manchester with the loss of 570 jobs, and 450 jobs at an assembly

[42] Daniel Nashaat (2001): 'A quest for low wages takes U.S. contract manufacturer from Nyiregyhaza to Ukraine', *Budapest Business Journal*, 26 February.

[43] Melanie Reynolds (2001): 'Flextronics makes one Xbox every 30 seconds in Hungary', Electronics Weekly, 5 December, p1.

[44] SAGEM is the second largest French group in the field of telecommunications and the third largest European Company in electronics for defence and security.

[45] 'Celestica to Employ 3,000 at Rajecko Plant', *Czech A.M.*, 18 September 2000.

plant in Kidsgrove, Stoke-on-Trent.[46] Assembly carried out at the Manchester site is being transferred to a lower-cost factory in the Czech Republic leaving Celestica still with 1,300 employees in the UK, its European base.

Jabil Circuit

Jabil is a US-based contract manufacturer, which established one plant in Hungary as its sole manufacturing and distribution centre for CEE, and 95-100% of its output is exported to European markets. Domestic content is expected to reach 20% of the total production value.

Solectron

Solectron has plants in Hungary and Romania. It bought Nat Steel, the Singaporean contract manufacturer, which also has plants in Mexico and Hungary.[47]

JIT Electronics

JIT Electronics of Singapore has invested $30 million in Hungary in a production facility in Budapest. The company is producing GSM mobile phones, computer peripheral devices and other electronic products.

Elcoteq

Elcoteq Network Corporation is the biggest indigenous European electronic manufacturing services company. The group's principal customers are ABB, Ericsson, Kone, Nokia and Philips. The company manufactures electronics sub-assemblies, mainly terminal products for Nokia, and end-products for the telecommunications industry.

Elcoteq also provides manufacturing services for digital mobile phones and their accessories. Mobile phones, accessories and components accounted for 75% of revenues in 2000, the remaining 25% being in engineering services and other.

The company currently employs 11,400 people. With sales of €2.21billion (US$2.04 billion), this equates to sales of US$179,000 per employee. Elcoteq Network Oyj has its headquarters in Finland, but derives most of its sales outside of its home market. Elcoteq's sales in Finland are only 31.5% of total sales.

Elcoteq has manufacturing services plants in Finland, Estonia, Russia, Hungary, Poland, Germany, Mexico and China, as well as customer service centres in Denmark, Switzerland, the USA, Japan and Hong Kong.

In December 1997 it opened a factory in Hungary, in Pécs Industrial Park. This plant produces electronic consumer products, electronic components, and electronic data processing and components of consumer electronic products for telecommunication companies. The company has also acquired the Nokia computer monitor assembly plant in Pécs. The initial investment was $30 million.

In Estonia (Tallinn) the company operates a mobile phone plant and an Engineering Services Center, which altogether employs 3,400 people. In Wroclaw, Poland, Elcoteq has 200 employees manufacturing, among other things, heat cost allocators for buildings based on wireless data transfer. The new plant in Wroclaw will be built on a new greenfield site and, when operating at full capacity, will have about 1,000 employees.

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[46] Sheila Jones (2001): 'Celestica to cut 1,000 jobs in favour of cheaper Czech plant', *Financial Times*, 6 September.

[47] Claire Serant (2000): 'Solectron to buy Singapore's NatSteel', *Electronic Buyers' News*, Issue 1236, Manhasset, 6 November, p10.

Endogenous electronics manufacturers

Videoton: endogenous contract manufacturer[48]

Videoton is the main indigenous contracting manufacturing company in the electronics industry in central Europe. It is Hungary's fifth biggest employer with more than 16,000 employees in Hungary, plus a further 1,000 in a newly acquired company in Bulgaria. It is a holding company with 34 business units located across 11 sites.

Over the past 6-7 years, Videoton has more than doubled its output with an annual increase of 20%. This has been achieved through 30 contract-manufacturing projects for the MNC supply network. Some of the subcontracting arrangements have been in place since the end of the 1970s, especially those with AKAI.

Before 1989, Videoton was a producer of numerous final products in the electronics area. When faced with threats to its survival, it had to close most of its lines and following privatisation continued only with the manufacture of loudspeaker systems, colour TVs and defence equipment. However, it has begun production of CDs. The major strategic shift though, is the expansion of contract manufacturing which today forms the majority of Videoton's revenues. Exports based on contract manufacturing arrangements represent 80% of total sales. Videoton's main areas are electronics, electrical appliances and automotive supplies.

The main change introduced by the new management was to abandon the manufacture of complex end-products and to become a subcontractor in several areas, especially in electronics assembly (Szalavetz, 1997). Videoton's 'engine of development' is the strategic development of contract manufacturing through the creation of new projects and businesses, from initial contract through to technical analysis and feasibility studies (Videoton, 1999). Videoton operates as a facilitator of foreign projects by lowering transfer costs, especially management costs of transfer projects.

Videoton labels its strategy as 'integrated manufacturing services'. This is a combination of its own parts and component suppliers (background industries) and manufacturing related services to its foreign partners under contract relationships. The company has been successful in using the Industry Park as the backbone for its expansion of contract manufacturing activities.

The important factor in the emergence and then growth of Videoton is that the company was not broken up before privatisation. Videoton continued to operate as a holding company which enabled it to develop a strategy based on building diverse production activities and synergies among its company units.

Tesla Ecimex

Tesla Ecimex is, together with Videoton, an example of successful indigenous modernisation and restructuring. Tesla Ecimex is a wholly Czech-owned producer of TV colour picture tubes using Toshiba technology under licence. Since beginning production in 1980 it has produced five million tubes. After being privatised and sold to its management in 1994 it has expanded production and shipped nearly two million tubes including newly introduced 28-inch tubes. The firm ships directly to OEMs across Europe.

[48] Based on Radosevic and Yoruk (2000).

Others

Table 1 shows the situation of the ex-socialist electronic conglomerates as of today. In addition to these firms we find a number of small firms, often spin offs of these companies or R&D institutes.

4 CEE ELECTRONICS: HOW TO EXPLAIN THE EMERGING PRODUCTION LOCATION?

The emergence of Central Europe as a new production location in electronics cannot be explained only by looking at the available resources or factor endowments. While some factors such as labour costs and proximity carry significant weight, it is difficult to understand country differences in the penetration of FDI by looking only at country resources.

In order to understand the dynamics of CEE electronics modernisation, we need to introduce a governance aspect or organisational aspects of the international integration of this sector. We assume that resources such as human capital, proximity or labour costs are only potential advantages which, in order to be realised, require matching sectoral governance. Sectoral governance in this case is a complex set of relationships between different firms (foreign and domestic), local and national governments, which must match each other for the sector to grow.

We interpret the emergence of a new location as a multi-dimensional phenomena, which requires the simultaneous existence of several factors and complementarities among these factors. Whether complementarities will be realised depends on the governance dimension of international production integration.

This problem has been approached in the literature as a dichotomy whether it is markets or states that are most important in generating growth through integration in international production networks. In the case of CEECs, market perspective has been dominant through transition economics, which argues that the progress in transition or convergence towards a market economy is essential for growth.

Hobday *et al* (2001) point out that underlying both perspectives is the acceptance of a continuum of government-industry relations, typically running through from state-led, to corporatist, to market-driven (p210). The state vs market account is unable to account for the strategies of firms and the differences between them. Hobday *et al* (2001) take a significant step forward by bringing company strategies into the state-market debate, both local and foreign, which significantly changes our understanding of industry dynamics.

Although this framework is a step towards a more realistic understanding of the drivers in the process of sectoral modernisation, it still omits a variety of other factors, factors which also play quite an important role in CEECs, such as local governments, EU accession and EU demand. Second, a variety of actors and networks that have to align at the same time to bring about industrial change requires a conceptual framework that explicitly brings this interaction into focus. We think that the alignment of a network framework as developed in Kim and von Tunzelmann (1998) offers new opportunities for understanding the successes or failures in industrial modernisation through international production networks.

In accordance with Hobday *et al* (2001) our argument, which comes from the analysis of the CEE electronics, is that the simplified framework which reduces driving factors on one or few dimensions, be it states or markets, is masking rather than explaining the emergence of CEE as a production location. Our extension is based on the fact that in the case of CEE electronics, it is not only states and markets whose impacts are mediated via firms, but also local governments. The EU are also actors that mediate in this process. The multiplicity of actors and their related networks requires that we explicitly introduce the problem of network alignment or misalignment. In this perspective the formation of globally integrated industrial networks is seen as an outcome of the alignment of various networks.

Ernst (1999) also recognises this issue by pointing to ‘co-evolution of international and domestic knowledge linkages that explains Korea’s extraordinary success in information industries’ (p32). Kim and von Tunzelmann (1998) point to the alignment of networks as an explanation for the Taiwanese success in IT. Network alignment comes because of effective coupling between the evolution of national specific systems and the global (regional) production networks. The issue is not only ‘the question of developing networks but of integrating locally and nationally emerging networks with global network structures’ (Kim and von Tunzelmann, 1998, p1). From this perspective the issue is the way in which markets, firms, CEE states and EU actions bring about the ‘alignment’ of these networks in CEE electronics.

A variety or multiplicity of networks is what drives the process of integrating CEE into global production systems. By plugging themselves into global supply networks, domestic firms externalise their disadvantages in accessing markets, technology and finance by surrendering control to foreign owners. Foreign investors then operate as ‘compensatory mechanisms’ for weakened domestic firms. The alternative – growth through generic expansion and detachment from global networks – is not a viable option.

However, whether an alignment of networks will take place depends not only on their mutual linkages but also on the nature of each individual network. The more national and local networks are developed, the more sustainable will be their alignment with foreign firms and their networks, provided that their interests are complementary. If local production networks are weak then undeveloped domestic firms can only enter dominant alliances, ie, alliances where local firms are dependent on the foreign partner. In such situations MNCs dominate network alignment, which eventually produces a weak alignment of networks and thus a weak economic position in global production networks.

Before we analyse integration of CEE electronics through the network alignment framework we should take two elements into account. First, technological opportunities and structural change in electronics determine prospects for network alignment in CEE. Second, network alignment takes place with given resources (physical, human, technological and organisational), which, through network alignment, are mobilised, shared and recombined. Hence, the nature and quality of resources strongly affect prospects for network alignment. In conceptual terms our analysis of CEE electronics is based on the following three layers of analysis and aims to answer on the following three questions:

Level of analysis	**Main question**
National, supranational, global and local governance and their interaction	Whether network alignment or misalignment takes places in CEE and why?
Regional and country specific resources/factor endowments	Whether resources favour network alignment or misalignment in CEE?
Structural change in world electronics	How structural change in electronics affects prospects for integration of CEE electronics into production networks?

In the rest of this paper we, first, outline how the main structural changes in electronics industry have affected prospects for integration of CEE into international production networks in electronics (Section 4.1). In Section 4.2, we discuss the major factors or endowments, which operate as resources for network alignment. In Section 4.3, we analyse elements of network alignment and try to understand their interaction. Since our focus is on the governance aspects of the integration of electronics our analysis in 4.1 and 4.2 is sketchy.

4.1 Structural change in electronics industry: context for network alignment in central and eastern Europe

From a location perspective the main feature of structural change in electronics is the secular trend towards a dispersed supply base or away from exclusive concentration on east Asia. Globalisation, which once seemed to mean that most of the world's manufacturing jobs would move to Asia, is now forcing Asian companies to expand outside the region.[49] The emergence of CEE as a production location in electronics parallels the emergence of Mexico as another important emerging location.[50] This led some analysts to argue that Asia's position as electronics workshop to the world is under threat from countries such as Mexico and Hungary.[51] This is still an exaggerated claim but one which nevertheless points to the need to analyse the extent to which this may be true or false.

This location aspect of structural change in electronics is very favourable for CEE. However, the location aspect is related to several other aspects of structural change in electronics, which we highlight in the remainder of this section.

First, there is a long term trend in electronics of moving from a highly localised to a highly globalised production pattern. An example is Philips consumer electronics, which has gone from more than 100 factories 20 years ago, to having 12 main production sites today (of which two are in Hungary in Szombathely and in Szhekesferhvar) (Table 11).

This reduced number of factories not only increases volume and efficiency, but also makes plants more focused with many functions outsourced to contract manufacturers or subcontractors. The reduction in the number of plants is accompanied by, as Ernst (2000, p6) put it, by 'the outsourcing of external capabilities that reside within a network of interacting firms'. The network of suppliers and subcontractors is co-ordinated by flagship firms which have now become a new organisational form appropriate to a globalised economy (Rugman and D'Cruz, 2001; Ernst, 2000).

Second, an important feature of this new model of industrial organisation is the decoupling of manufacturing from product development and their dispersion across firms and national boundaries (Ernst, 2000). The rise of electronics manufacturing services is a clear indication of this trend. However, as Ernst (2000) point out geographic dispersion is heavily concentrated in a few specialised local clusters. This paradox of joint globalisation – dispersion accompanied by concentration – is resolved if we take into account the changing industrial organisation that underpins the structural change in electronics.

Third, in order to resolve the paradox between increased dispersion and concentration, companies are focused on reducing costs of the integral supply chain through outsourcing, relocation to low cost sites, reduction in the number of suppliers, common standards to improve flexibility and a global product range.

Fourth, competitive pressures are forcing electronics companies not only to move production from expensive to cheaper areas, but also to locate close to main markets in order to achieve flexibility. These drivers generate the need for flexible-manufacturing structures,

[49] For example, Singaporean NatSteel (which has been taken over by Solectron) now employs 2,750 Mexicans and half of its plant space is outside Asia. Its second-largest plant is in Hungary.
[50] Electronics products and components make up about three-quarters of Mexico's exports. Mexico as a whole has nearly doubled its exports in the past five years, to $117.3 billion in 1998 from $60.6 billion in 1994.
[51] G Pierre Goad (1999): 'Mexican wave', *Far Eastern Economic Review*, 11 November, Volume 162, Issue 4: pp10-13.

which requires common standards, which are in turn a great incentive to transfer process technologies in order to attain these standards. Hence, CEECs are well placed to acquire production capabilities given their skill levels.

In summary, company responses to structural changes in industry are operating in favour of CEE as an emerging location. Delocalisation from east Asia, decoupling of manufacturing and design, coupling of concentration and proximity, pressure to reduce costs of the integral supply chain, are all important drivers which increase the attractiveness of CEE as production location in electronics. For example, even the EU companies, which have been traditionally organised as vertically integrated companies, have moved very quickly to the region pursuing outsourcing and low cost strategies. The emergence of contract manufacturers who have become much more actively involved in the further localisation of the supply industry also contributes to this. For example, as part of its strategy in Hungary Flextronics has established Industrial Parks which are hosting and supporting all potential suppliers to the electronics industry. These parks co-locate suppliers on the same campus where manufacturing takes place, resulting in greater operational flexibility and responsiveness to customer needs. Products can be produced on site and shipped directly from the Industrial Park to the OEM's end users, greatly reducing freight costs of incoming components and outgoing products.

4.2 Factor endowments and their relevance for electronics industry

Network (mis)alignment is a problem of inter-organisational relationships or networks that cut across several networks. This governance problem does not operate in abstract or unrelated to factor endowment or resources. Hence, the application of network alignment as a framework to understand the emergence of the electronics industry in CEE, requires that we clearly distinguish between factors and organisational capabilities.

By factors, we mean the available physical, geographical and human factors or resources, which in the international economy operate as attractors for foreign investors.

What makes the concept of network alignment distinctive is an implicit assumption that network alignment depends on the organisational capabilities of actors and networks, and on complementarities among different networks within which actors operate. We can think of factors as the resources, which networks and actors can mobilise in order to generate capabilities. Only when networks are developed and complement each other may we expect that growth in the globalised economy will take place.

Any regional (national) comparative advantage or disadvantage as expressed in factors or resources is conditional upon the (non)existence of networks and network organisers. It is only them who may or may not turn this conditional advantage into a real absolute advantage. While this may be obvious in a local, regional context, the alignment of network perspectives suggest that this problem is also endemic to a globalised economy whose growth is dependent on MNCs strategies interacting with local and national networks. Favourable factors for growth are only conditional advantages, which can operate only when network organisers and alignment of different networks (local, national, MNCs) are in place. Advantageous determinants may be converted from conditional into real advantages only through network mobilisation and alignment of different networks.[52]

In the case of CEE, research on FDI suggests that there are several factors which operate as points of attraction for foreign investors, and which represent basis for decisions of MNCs. The local market, proximity to the EU, and low labour costs are usually the major motives for FDI found in surveys and econometric research (for overview see Holland *et al*, 2000).

[52] For a further extended discussion on the regional context of CEE, see Radosevic, 2002.

Table 15 summarises the assessment of the quality of different factors, which are of relevance for electronics, and we discuss briefly each of these elements.

Table 15: Quality of factors of relevance for electronics industry

Factor	Quality of factors
Local market	Limited and unsophisticated local demand
Labour	Large pool of skilled labour with the second level education
Education and skills	Generally favourable with varying emerging constraints in sector specific skills
R&D and engineering	Quite favourable
IT infrastructure	Varies greatly across region
Proximity to EU	Important attractor

Local market in electronics

CEECs are small as markets in electronics, in both population and purchasing power terms. The total market of CEECs in 1999 was $19.5bn, similar in size to the Singapore market. If we add Russia and Ukraine, with $6.7bn, then the total market value is $26.2bn, still $4bn below the Korean market. In addition, most of the CEECs are small countries. Countries that are large in terms of population (Russia, Ukraine, Poland and Romania) have relatively low GDP per capita when compared to small countries.

However, Central European economies compare much better as a production location than as a market location. In that respect, Central Europe has overcome the socialist legacy remarkably well and the share of the ICT sector in GDP in these economies has already matched the share of Southern EU.[53] Moreover, the share of the ICT sector in the Czech Republic and Hungary is at the EU average or above (Mickiewicz and Radosevic, 2001). However, in terms of IT expenditure per capita Central Europe is substantially lagging behind the EU average. The per capita gap in IT is much bigger than income per capita gap.

Labour cost

FDI surveys often highlight labour costs as an important motivation for locating in CEE. However, a more analytical approach would suggest that it is not nominal wages that attract investors, but efficiency wages or nominal wages in relation to labour productivity. An analysis of Rojec and Jaklic (2002) supports this view but also gives a more subtle understanding of wages as determinant of FDI. Their argument is that investors are concerned with increasing the value-added per labour cost. Hence, they are looking for locations where the labour force is able 'to produce the expected amount of value added per employee with given production technique, but at lower labour cost per employee' (p26). Within this framework, quality as a motive for relocation goes together with wages that are lower than at the existing location. This suggests that investment/relocation decisions are made not only on the basis of labour cost per employee but also whether there are conditions available which will enable the firm to achieve the required level of productivity. On that basis Rojec and

[53] Information technology (IT) refers to the combined industries of hardware for office machines, data processing equipment, data communications equipment and of software and services. Information and communication technology (ICT) refers to IT plus teclecommunications equipment and services.

Jaklic (2002) show that value-added per labour cost in foreign investment enterprises in Slovenia is higher than in Germany, Austria and other EU countries.

Table 16 shows that Hungarian productivity in electronics is far ahead of other CEE countries. However, this may not have to do solely with the quality of available factors. In fact, the skills levels and education structure of the Hungarian labour force compared to, for example, the Czech Republic can explain very little of these differences. Therefore, data on productivity do not explain differences in the presence of FDI but actually their effects.

Table 16 suggests that resources by themselves (in this case labour costs) cannot explain differences in the degree of integration into international production networks within CEECs. Once the critical mass of FDI enters into the economy, labour productivity will increase which in turn will increase the value of resources, which were initially similar to other economies. This will lead to further regional polarisation in the presence of FDI as long as value-added remains competitive in relation to labour costs. As labour costs rise so should value-added. However, value-added may not rise fast enough given the slower pace of upgrading of a country's skill base. For the time being central Europe has been able to generate similar value-added with much lower labour costs when compared to other European locations. This led to the relocation of electronics facilities to CEE from EU. Table 17 shows some examples of relocations in electronics from the UK to CEE.

Table 16: Labour productivity in the electronics industry, in $ 000

	Based on PPP exchange rates		**Based on nominal exchange rates**	
Hungary 1996	121.86	100.00%	57.94	100.00%
Czech 1997	70.56	57.90%	27.13	46.83%
Poland 1997	46.99	38.56%	21.83	37.67%
Croatia, 1999	46.29	37.98%	27.99	48.30%
Slovakia 1997	21.72	17.83%	8.23	14.20%
Romania1998	19.99	16.40%	5.72	9.87%
Bulgaria 1997	14.22	11.67%	3.64	6.29%
Russia 1996	13.50	11.08%	5.83	10.06%

Source: Own calculations based on Reed Electronics Research, *The Yearbook of World Electronics Data, 2001/2 and 1999/2000*, Volume 4, East Europe and World Summary. WIIW, Handbook of Statistics, Countries in Transition, 1999 and 2000.

Table 17: Examples of relocations in European electronics in 200/2001

RELOCATIONS FROM UK TO CEE						
Company	**From**	**Status**	**To**	**Year**	**Activity**	**Number of lay offs**
SMK, Japan	UK	closure	Hungary	2000	Mobile phone batteries	
Sony	Wales, UK	closure	Hungary	2000	TV sets and monitors	
Panasonic, Japan	Wales, UK	closure	Czech R	2000		2000
Alps Electric	England, UK	downsizing	Czech R	2001		400
Alps Electric	Scotland, UK	closure	Czech R	2001	PCB assembly	120
Celestica	England, UK	closure	Czech R	2001	PCB assembly	570
Celestica	England, UK	closure	Czech R	2001	PCB assembly	450
					est.	**4000**
ELECTRONICS: RELOCATIONS FROM CEE						
Mannesmann	Hungary	closure	China	2000	Car audio plant	1000
Ericsson/ Elcoteq	Hungary	discontinued	China	2000	mobile phones	
Ericsson/ Elcoteq	Estonia	discontinued	China	2000	mobile phones	
Flextronics	Hungary	downsizing	Ukraine	2001	subcontracting sub-assembly work	
Lexmark	Czech R	closure		2001	Printed Circuit boards	121
					est.	**1500**

Source: Business press

The UK is the central node for non-European electronics firms in Europe. Hence, Japanese affiliates in the UK started to move to Hungary or the Czech Republic, especially after a critical mass of investors came to the region. It is very difficult to get an idea of the magnitude of these relocations. Table 17 shows only those relocations reported in the business press in a one-year period. These cases suggest that companies are moving mass production manufacturing to factories in the Czech Republic, leaving sales and marketing and low-volume prototyping in the UK. Linden (1998) assumes that relocations from the UK will most likely complement, not compete with, the networks forming in Central Europe. However, individual cases suggest that relocations are leading to loss of exports from the UK rather than to complementary specialisations, which would ensure UK export to new locations.

These trends have revealed weaknesses in the UK supplier base and the need to move to higher value-added segments. It seems that the UK is no longer a competitive manufacturing environment for commoditised goods. For example, the large-scale assembly and manufacturing operations that have characterised the Scottish electronics industry for the last 20 years are no longer competitive with CEE and Asian firms (Yeates, 2001). It is estimated that, in 2001 the Scottish electronics industry lost 10,000 jobs (Yeates, 2001b). However, upgrading may not be easy, especially as it was not foreseen. For example, Scotland is not ready in the short-to-medium term to move to a higher value-added level and will have to import labour to fill the thousands of vacancies that exist in information technology and software companies.

However, in some electronics segments Central Europe is not able to produce at low enough labour costs given the value-added level that it generates. As a result, rising costs, including unit labour cost, in some Central European countries are forcing the shift of low assembly jobs to China[54] (Table 17). Also, some cases suggest that we may expect relocation to the east of CEE, ie, more to Ukraine and Romania. For example, Flextronics is subcontracting some production to the Ukraine, where labour costs are less than one-quarter that of Hungary's. Since March 2001 the company has been sending some of its most labour-intensive production work from Nyiregyhaza (where wages are about GBP1.40 an hour), to Beregovo (Ukraine) where they are about a quarter of that.[55] A tentative co-operation agreement with the Radiozavod factory in Beregovo will involve jobs such as the joining of larger components to printed circuit boards. More automated jobs, such as contact assembly (the soldering of integrated circuits, diodes and other small components), will stay in the recently built Nyiregyhaza factory for the time being.[56] For contract manufacturers such as Flextronics, the search for greater efficiency will not stop at the Hungarian border and it will be only a matter of time before we see further expansion of electronic assembly to Ukraine and Romania.

R&D and design capacities

Until the mid-1990s, overall expenditure on R&D in CEECs had been decreasing sharply. Since then expenditure has stabilised or even started to grow again (Radosevic and Auriol, 1999). However, R&D intensity in the ICT sector (R&D/Value Added) in CEE is very low. For example, R&D intensity in the Finnish ICT sector is 15.7% and in Hungary less than 1%. This low R&D intensity is not peculiar to the ICT sector but reflects a generally low R&D intensity in Hungarian industry. Similar conclusions apply to the Czech Republic and Poland whose share of exports in low price/quality segments (downmarket) is very high. Data for 1996 show that the Hungarian, Czech Republic and Polish export share of downmarket segments was 45%, 66% and 66% respectively, by far the highest in the OECD, similar to Turkey (66%), and above Greece (41%) (Mickiewicz and Radosevic, 2001).

From among the big investors in the electronics industry, firms primarily interested in telecommunications have invested in Central European R&D (Table 10). Their activities centre around software, which seems to be abundant in CEE. In Central Europe, in particular in Hungary, the Czech Republic and Poland, software engineers have not moved to other countries.[57] It is estimated that Hungary has around 10,000 software engineers, and only 500 have left the country. In Hungary, Nokia opened three R&D centres specialising in mobile switching and wireless software. The Hungarian R&D hub is second only to the hub at the

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[54] Peter Serenyi (February 2001): *Business: China's cheaper, Why Mannesmann and Shinwa have defected east*

[55] Robert Wright (2001): 'A new chip off Hungary's old bloc: Electronics: Western standards are bringing success to a Ukrainian factory', *Financial Times*, London, 1 June, p13.

[56] Daniel Nashaat (2001): 'A quest for low wages takes US contract manufacturer from Nyiregyhaza to Ukraine', *Budapest Business Journal*, 26 February.

[57] A significant number of engineers from the region are employed in several R&D labs and software centres owned by foreign firms in the Czech Republic.

corporate home in Finland. Ericsson runs a software centre developing ATM data transmission technologies and wireless applications.

However, in other sectors of electronics we do not find much R&D activity. The impression is that "there is some design work going on but not much. On the other hand, the global shortage of engineers and the high level of education means it will come. Hungary is ahead, and the Czech Republic is not far behind." **(ref???)** For example, Elcoteq plans to increase the flow of new products and eventually create an engineering centre, adding value to the operation. Although Elcoteq's more established plants in Finland handle most challenging new products, Hungary has begun to take on some small industrial products fresh from the R&D lab. Flextronics has Hungarian engineers developing and laying out circuits in support of its Austrian-based R&D centre.

The research and development base, organised around electronics manufacturing, and financed by multinational companies, was able to absorb some of those researchers dismissed from state-financed research institutes. Hungary is the only CEE country that has introduced incentives to support R&D by foreign investors. Research projects which employ a development team consisting of at least 30 people, have an investment value of at least HUF 500 million, and are connected to high-tech, can be granted support of up to 25% of the investment value.

Information and Telecommunication Infrastructure

Information and telecommunication infrastructure is both an important economic activity by itself as well as an essential prerequisite for the growth of electronics. The gap in diffusion of IT and telecommunications between Central Europe and the EU was huge in the early 1990s. Due to privatisation and liberalisation in this area (both policies still being gradually implemented), and rising demand, which is also partly driven by foreign investments, this gap has decreased but is still substantial. In terms of the number of telephone mainlines per capita, Central Europe is clearly at the bottom of the European ranking (Mickiewicz and Radosevic, 2001).

The sophistication of the telecoms infrastructure varies greatly among the Central European economies when indicated by the share of ISDN lines. This reflects not only past lags but also some latecomer advantages in replacing rather obsolete technologies with the latest developments. As development of knowledge-based services increasingly depends on the Internet, the diffusion of Internet hosts is important to this process. With the exception of Estonia, the number of Internet hosts in Central Europe is similar to those of Southern EU countries (see Mickiewicz and Radosevic, 2001, for further details).

Education and skills

Expenditure on education has not been substantially reduced in relation to GDP during the transition period in Central Europe, except in the case of Hungary (see Mickiewicz and Radosevic, 2001, for further details). Levels of investment in education are generally either around the EU average or, as in the case of Estonia, above 6% of GDP – among the highest.

When compared to EU economies, Central Europe, with exception of Poland, has a very low share of population with a first level of education and lower ranging from 0.3% in the Czech Republic to 2.9% in Slovenia. This share is similar or better than in the high-income EU economies and greatly below the share in low-income (South) EU economies.

There is a very high share of an economically active population with second stage secondary education in Central Europe. It ranges from 46.3% in Estonia to 79% in the Czech Republic. With the exception of Estonia, CE has a low share of population with third level education.

This suggests that the structure of education in Central Europe is compressed on the edges, with low shares of both least educated and people with higher education. The low share of economically active population with third level education (with the exception of Estonia) may represent difficulties in absorption and diffusion of new IT-based technologies in services and industry, especially in the adoption of IT. On the other hand, the large share of second level education may guarantee sufficient capacity in use of well-established IT.

A high proportion of the population with secondary level education in Central Europe has undergone vocational education, ie, their skills are relatively specialised which may present problems in economy-wide restructuring. The favourable structure of the general level of education in Central Europe is a necessary but not sufficient condition from the point of view of the absorption and diffusion of IT. It has to be accompanied by training and retraining programmes.

In contrast to foreign investors, domestic enterprises and public institutions have not been able so far to promote retraining activities to the extent required by the scale of restructuring challenges. For further growth of electronics in CEE it will be essential to develop technology specific skills in cooperation with MNCs. While for the first stage of penetration into electronics, electro-mechanical and software skills may suffice, this may not be sufficient for the next stage where design skills should play an important role. For example, IC fabrication requires a large pool of skilled engineering in IC technology. It is unlikely that CEE can embark on these activities as long as their educational systems are not tuned to this change.

Proximity to EU vs flexibility as factor in electronics industry

The proximity of Central Europe to the EU is often highlighted as an advantage for locating electronics activities. The business press suggests that producers are pressed to build factories close to markets.[58] On the other hand, proximity does not seem to be so important in electronics as in automobiles. Electronic enterprises appear to adopt a more global approach and to buy on a much more international basis. Instead, it seems that flexibility is much more important. For example, a survey of EU contractors (EU, 1997) in electronics cites one of the main reasons for subcontracting as being flexibility in terms of volume supplied. Geographical proximity comes as the least important factor in a subcontracting relationship. The predominance for flexibility arises from the need for speed or time-to-market. This explains the rise of contract manufacturing, which can improve delivery times and reduce costs.

It is possible that proximity in electronics is not the essential sectorally, but is a firm-specific feature.[59] In addition, business locations decisions are conditioned by a variety of interrelated factors. Costs can be related not only to quality but also to proximity, especially for parts for which transport costs are high. For example, Philips' subcontractors do not produce electronics products; they produce bulky goods, such as plastic boxes, packaging and

[58] For example, statements like this suggest the importance of proximity: "Our decisions are very much driven by asking ourselves, 'Where is the final consumption?' And wherever the final consumption is, we try to establish the manufacturing, as long as labor costs are not too different," (….)" Regionalization of production is important to be close to the market you're selling to."

[59] For example, Flextronics, which also has plants in south east Asia, has no particular policy about what types of equipment or levels of equipment get made where. As Flextronics executive put it "It's related to our customers' preferences, (…) Some like us to have manufacturing close to their selling point. So if you have equipment going on sale in Europe, then it makes sense to manufacture it here in Hungary. For North America it would be Mexico, and for southeast Asia it would be China."

metal components, for which transport costs are high.[60] Central Europe can combine opportunities for flexibility with proximity and low labour costs.

4.3 Network alignment elements

Although structural changes in electronics work in favour of the CEE as an emerging location, by themselves the can explain neither the scale nor scope of this phenomenon. Also, factors or resources operate only as potential advantages, which require network organisers

Table 18: Assessing the potential for network alignment in Central and East European electronics

Network alignment elements	Quality of networks and actors	Complementarities for network alignment
MNCs	First movers (ex Philips, Samsung), Contract manufacturers (ex Flextronics)	Low cost strategies Pressure for flexibility
Domestic enterprises: ex-socialist electronics conglomerates	With the exception of *Videoton* and few others very weak restructuring agents	Privatisation and inherited gaps have prevented their active engagement
SMEs	No clear picture emerged	Potentially the weakest actor in generating complementarities
State administrative capability	Capability for strategic FDI or subcontracting policy varies greatly	Only Hungary and Czech R governments have engaged in complementary actions
Government incentives (upfront advantages)	General and specific incentives are favourable	Favourable impacts clear in the case of tailor-made incentive packages for strategic investors clearly
Local governments	Entrepreneurial actor	Strong interest in maintaining employment and increasing incomes
EU demand	Important attractor	Will continue to operate as important attractor
EU accession	Secondary factor	May hinder growth of free economic zones
Overall assessment	Varies greatly across countries	Operate favourably in Hungary and the Czech Republic

and complementary interests between global, national, supranational and local networks to be realised. In order to understand the pattern of integration of CEECs into international electronics networks we have to introduce the governance dimension of the problem.

The alignment of network frameworks explicitly takes into account the governance dimension. Table 18 summarises the main state of the different elements of this framework and assesses the potential for their alignment or complementarities.

[60] The nature of their products explains their proximity to their customers and for them subcontracting is an essential part of their activities. Their links to Philips are very loose; no participation in the design of the products, no provision of financial assistance, no staff training, etc, only exceptionally is there any provision of equipment. They generally do not have second tier subcontractors. So, the electronics content of Philips is almost nonexistent; what they subcontract are non electronic parts (EU, 1997, p54).

Multinational Companies

Structural changes in the electronics industry induced companies to respond strategically by outsourcing to achieve flexibility and faster time-to-market. On the EU market, EU companies have become increasingly exposed to Japanese competition via their subsidiaries, which forced them to shift production to CEE in order to remain competitive.

The EU companies Phillips, Siemens, Alactel and Ericsson, followed by the Korean firm Samsung, first responded to strategic opportunities offered by the opening of CEE. In just a few years, Philips has managed to establish a network of 17 subsidiaries in Hungary. Korean Samsung established a TV sets plant, while Siemens established subsidiaries in all CEECs.

A truly entrepreneurial response was the entry of the Flextronics US contract manufacturer, which opened the way for other contract manufacturers, both from the US and the EU. In the mid-1990s, the structural factors working in favour of central Europe in electronics became obvious and provoked relocations of several Japanese plants from the UK to Hungary and the Czech Republic.

As Linden (1998) pointed out, economic conditions in Europe have hindered speedy and large relocation of production by European firms to CEE. Although leading EU electronics companies reacted to new market opportunities, especially in telecoms, or immediately tapped new supplies of skilled labour, as in consumer electronics, this response did not involve medium and small sized electronics firms. This may have to do with rising unemployment during the 1990s, which made it difficult to engage in outward relocations given the relatively inflexible EU labour market.

Companies' strategies that deepen linkages with the local economy are essential for network alignment. Unfortunately, case study evidence in electronics is still very poor at indicating the exact extent of local sourcing. A much less pyramidal structure in electronics, when compared to the car industry, limits the extent of local subcontracting. The business press suggests that networking is mainly confined to subsidiaries and parent firms, or on subsidiaries in other countries. This may not only be the result of weaknesses of the CEE supply base but also a feature of partial subcontracting in electronics. There is patchy evidence that local sourcing is confined to low costs components like plastic and mechanical parts.

Domestic enterprises

Local enterprises are not strong actors in the complementing strategies of MNCs and meeting opportunities, which arise from integration into EU markets. This is the most serious handicap of CEE for deeper industry integration, and reflects largely differences in historical heritage across CEE. Large ex-socialist electronics conglomerates were lagging behind in many respects in technology, finance and market access. Deficiencies in resources were often compounded with protracted privatisation procedures, which led to strategic stalemate that further deepened their crisis. A few cases of successful restructuring like some parts of the Tesla concern in the Czech Republic, Iskra in Slovenia and a very successful turnaround of Videoton in Hungary, are difficult to generalise. Factors important in their success include the simultaneous existence of a variety of elements along a network of alignment approach whose combination is difficult to replicate (Radosevic and Yoruk, 2001).

The case of Videoton, which is the only indigenous company that has managed to turn itself into a network organiser, clearly shows the advantages of this position in terms of bargaining power. Given the absence of large domestic firms, which would operate as network organisers, it is foreign firms that have taken that role in the region. Domestic companies that are successful are, as a rule, those that have Western companies as partners.

However, it is unlikely that ‘local champions’ or ‘blue chips’ will emerge for quite some time in electronics. Domestic firms are likely, with few exceptions, to play a dependent role in global production networks. This by itself may not be a problem since very efficient branch plants have been established in CEE. Possibly, driven by contract manufacturers (turnkey suppliers) we may see some clustering of different sized local firms.

CEE has comparatively more developed resources (especially human capital), than organisational capabilities at the firm level and government level. Where they exist at the firm level, as in the case of Videoton, or at government level, as in the Czech Agency for FDI, outcomes are visible. To have a strong local supply base a country must also have local network organisers, ie, companies capable of organising local supply chains.

Small and Medium Size Enterprises (SMEs)

Local sourcing in which SMEs would play an important role usually takes time to develop. Unfortunately, we do not have systematic evidence of the extent of local sourcing in CEE electronics. Local sourcing beyond local subsidiaries is limited but has nevertheless started. Case study evidence suggests that electronics manufacturers typically use only 10-20% of local supplies and services. Flextronics, which has increased local sourcing in Hungary to 50%, is, probably, an exception.

An important reason for limited local sourcing is that the quality of local SMEs has not yet reached the required level. Most SMEs were established in the last decade and are too new to have the necessary experience. The dynamic layer of SMEs is essential in order to generate a culture of electronics industry and innovation. If innovation surveys can serve as a guide, they show that the share of innovative SMEs in CEECs are extremely small when compared to the EU.

In CEE, the segment of technologically dynamic small firms is marginal. Compared to the European Economic Area[61] where the share of innovative small firms is 40%, in Poland and Slovenia their share is 4.1% and 16.9% respectively (see Mickiewicz and Radosevic, 2001). Moreover, the innovative activity of small firms has substantially decreased in the last 10 years. For example, in Poland, the share of innovative SMEs went down from 40% in 1992 to 16% in 1994-96 and further to 4% in 1998. A very small share of innovative SMEs in Poland suggests that their dynamism is confined to mainstream business and much less to technical entrepreneurship. In more general terms, it seems that the problems of innovation in Central Europe are, to a great extent located in the small firms sector and its weak links with large firms. All this suggests that the SME layer is, together with large domestic firms, the weakest actor in generating complementarities with MNCs.

Government policies

Although it is difficult to measure effects of government policies the history of CEE electronics during the 1990s shows that policies do matter. In the Czech Republic and Hungary, which are leading locations in electronics, government policies have been important in understanding the patterns and timing of investments.

[61] EU and Norway.

Table 19: Measures for the support of the inflow of foreign direct investment in four CEECs, as of early 2001

	Hungary	Czech Republic	Poland
Taxes	- 18% corporate tax - 20% dividend tax	- 31% corporate tax	- 32% corporate tax
Incentives	-100% tax relief for 10 years if over $33m is invested - 100% corporate tax relief for 10 years if over $10 million invested in an underdeveloped area - 50% tax relief for 5 years if over $3.3m is invested - 100% tax allowance for R&D costs	- 100% corporate tax relief for up to 10 years - Criteria – investment of USD 10 million, at least 50% goes to production sector, 40% of the investment goes to new machinery - In areas with above average unemployment (9%) threshold for tax relief is $5m	- Tax deduction up to 30% of investment amount from the tax base: conditions e.g. revenue from export is over 50%, buying patents, ISO 9000, pharmaceutical industry
Special incentives (grants)	- Grants of up to 20% of the total investment - Grant up to 15% of the cost of the establishment of European regional corporate centre - Grant up to 50% of costs of introduction and certification of quality and environment monitoring systems - Subsidy of up to 50% in connection with the establishment of cluster management - Grants up to 33% of to promote innovation-oriented industrial parks and development of their services - Subsidies to promote establishment of logistic centres and the development of logistic services	- Location in a customs-free zone - Job-creation grants (up to $ 5500 per each new job) - Training grants (up to 35% of the total training costs) - Provision of low-cost building land and/or infrastructure (government assistance up to 60% of preparing land and infrastructure)	- Full tax allowances in selected regions for investment projects of at least ECU 0.4 million

	Hungary	Czech Republic	Poland
	- Subsides for the development of regional electronic markets - Subsidy to promote the establishment of technological incubator houses and innovation transfer centres - Subsidy for creating new jobs of up to Ft1mn per new job		
Customs regime, **Free trade zones**	- Customs-free zone status for export-oriented companies	- Duty-free imports of new machinery related to projects exceeding CZK 10 million - Customs clearance – drawback system	- Duty-free import of machinery under OECD list 84 and 85 - Duty-free import of the fixed assets as a contribution to the share capital - Duty-free special zones

Source: Hungarian Ministry of Economic Affairs and ITDH, Investors' Booklets. Government incentives, 2001, Hunya 2000, Czech Invest

For understanding the actions of Central European governments it is useful to classify policies into three categories: general incentives, specific incentives and strategic FDI policies.

Electronics, as other sectors, benefited from general incentives offered to foreign investors in CEECs. Preferential tax rates are being introduced in all CEECs. (Table 19 shows general and some specific incentives in Hungary, Poland and the Czech Republic.)

The more specific support polices are in place, the greater potential they have to influence decisions of investors. Two models of specific support are present in Central European electronics: special economic zones and industrial parks.

The Hungarian government was the first to offer tax holidays and to set up free-trade zones, which meant that exporting companies paid no duties on either the components they imported or on the finished goods they shipped abroad. Many companies are set up in customs-free zones, meaning no tax on the import of supplies and equipment from any destination. In Poland, 15 special economic zones (SEZ) are the main incentives for foreign investors. SEZ are not compatible with EU competition policy and the government has modified the principles of their functioning to make them compatible with EU laws.

The Polish Parliament created an act on Special Economic Zones in 1990. The state defines or issues permits – on the basis of the argument provided by local government – for the operation of separate industrial and service zones, within the borders of which economic activities can be performed only if they are permitted by local government. The permit entitles companies to a partial or total tax allowance. During the initial 15 years of the SEZ's life cycle, an investor may be fully exempt from income tax for a period of up to 10 years. After these 10 years of income tax free operations, an investor is entitled to 50% of income tax relief for a period of up to 10 years, not to exceed the zone's life cycle. The investor has to meet either a minimum investment or employment level within the zone in order to qualify for these benefits.

Each SEZ sets its own minimum investment and employment levels necessary to obtain tax preferences and relief.[62] Income tax relief as a result of meeting minimum employment criteria is measured on a per month basis and provides only partial income tax exemption. All Special Economic Zones are controlled and managed by joint stock companies owned by the State Treasury, except two that are managed by the Industrial Development Agency.

Industrial park policies are specific FDI policies, which have a big impact on the development of networks in electronics. The Hungarian government funded the development of 112 industrial parks spread across the country, which has proved attractive to electronics companies such as Flextronics, IBM, Jabil Circuit, and Philips. Of all industrial parks in Hungary, 15% are in free economic zones (FEZ).

The Ministry began inviting bids for the building of industrial parks in 1997. Thus far 28, 47 and 37 parks have been awarded that status in the three years 1997, 1998 and 1999, respectively. In 1998, industrial parks employed 8% of the manufacturing workforce (60,000 people) which accounted for nearly 13% of all sales in the Hungarian manufacturing sector, of which an average of 74% was exported.

Hungarian municipalities own most of the industrial parks. In order to ensure efficient management of the facilities, most cities set up a business entity to run them. However, industrial parks are businesses in themselves and several foreign investors have declared interest in investing in them. For example, Mitsubishi Corporation and its German subsidiary

[62] For example, in the Suwalki Special Economic Zone it is enough to invest a minimum of €350,000 to obtain full income tax exemption. The minimum investment level for the Slupsk SEZ is €700,000; for Kostrzyn-Slubice SEZ – €1 million, and for Katowice, Lodz and Tarnobrzeg SEZs – €2 million.

are jointly financing the Újhartyán Industrial Park in order to attract electronics and car parts suppliers.[63] The biggest investment in industrial parks in CEE will be a planned joint venture between the municipality of Nagykanizsa, southwest Hungary, and Italian property giant Redilco Real Estate spa. According to the *Budapest Business News* Redilco intends to invest around $700 million into the project over the next seven years, in addition to investments made by companies locating to the park.[64] The attractions of the park include a four-year national corporate tax holiday offered to companies moving in. This is because the town is considered as an area of severe unemployment.

Flextronics has an Industrial Park in Gdansk (Poland), which is its sixth park, with the others being located in Hungary, Mexico, Brazil and China. The company has distributed these Industrial Parks throughout the world to reduce production and freight costs of incoming components and outgoing products.[65] In the Czech Republic, Flextronics is to build a technology park that will create 3,000 jobs over five years.[66] The city of Brno has let out a 50 ha piece of land to Flextronics for a symbolic price of one Czech crown. In the park, seven of the firms' factories and their suppliers will be built amounting to $100 million.

In addition to general and specific policies Central European electronics, as with the automotive industry, abounds with cases of individual incentive packages or arrangements with investors that are considered to be of strategic importance for national governments. Again, Hungary has until recently been the leading country in this respect, when Czech investment agency took very active approach to FDI in electronics. In comparison to Hungary, the Czech Republic was late in introducing incentives and was perceived by potential investors as uncompetitive. With the change of Government in 1996, CzechInvest, the foreign investment promotion agency, managed to raise the incentives. Moreover, the agency has established six overseas offices with the latest office being opened in California's Silicon Valley to attract high-tech, electronics and IT investors to the CR.[67]

Effective government policy should balance its support between general incentives, specific incentives and strategic FDI policies. Only the general incentives seem to be insufficient and may not match what individual investors expect or need. On the other hand, putting the emphasis only on strategic incentive packages may not by itself guarantee positive effects. For example, there is an opinion that too much UK government money has been aimed at high-profile inward investment opportunities through individualised incentive packages which, with exceptions, do little to raise the skill levels of workforce (Deans, 2002).

Some CEE governments have become aware that using incentives only as a means of attracting FDI may not be sufficient to ensure a positive effect on the local economy and generate linkages with local firms. Therefore, they have embarked recently on programmes whose aim is to increase local sourcing. The Hungarian government launched the supplier programme called the "Integrator programme" in order to assist small and medium sized companies that supply multinational companies operating within Hungary. CzechInvest has launched the Czech Supplier Development Programme, which is designed to help manufacturers increase their local content, and is focused on the electronics sector as its number one priority. The aim of the programme, with $2.5m in funding from EU and the state

[63] At present, Mitsubishi offers a service that helps to relocate manufacturing facilities. Through this part of its global activity, Mitsubishi hopes to promote overseas expansion of small- and medium-size Japanese manufacturers.

[64] Dan Nashaat (2001): 'Land sale key to Redilco project', *Budapest Business Journal*, 14 November.

[65] Flextronics, Press release, 18 April 2000.

[66] Anderson, Robert (2000): 'Flextronics builds park', *Financial Times*, 4 July, p7.

[67] 'CzechInvest Arrives in Silicon Valley', *Czech A.M.*, 6 December 2000.

budget, is to raise the percentage of parts foreign investors purchase from Czech firms from the current 5% to 25%-30%.[68,69]

Local governments

Local governments in CEE, jointly with MNCs, have become the most active agent for integrating FDI into the local economy. General and specific incentives cannot prompt MNCs to set up in CEE, but the favourable attitude of local governments willing to receive the manufacturing business can. Involvement of local government is the essential ingredient in strategic FDI policy.

The example of the Videoton industrial park shows that local government played one of the key roles in its success (Radosevic and Yoruk, 2000). Entrepreneurial local government is essential in reducing red tape, bureaucracy, and can greatly reduce investment time. For example, in 1992, when Philips showed interest in investing in Hungary, its representative commented that 'the support of the local council was an important factor in the company's decision to build a greenfield television and VCR plant in Szekesfehervar. The council helped Philips to find and buy location for the plant and to secure state subsidies to pay for its infrastructure. It also administered the deal and issued the necessary paperwork and permits as quickly as possible' (Marsh, 1995, p27). This was in line with local government strategy which was to do all they could to attract foreign investors, to help provide land and utilities and to promote retraining for the people.

This phenomenon is not confined to Hungary but seems to be very strong in Poland as well. Dunin *et al* (2002) argue that the actions of national government did little to create favourable conditions for the development of new, internationally competitive industry. One of the most significant exceptions has been the extensive investment in infrastructure carried out by Polish local government throughout the past decade (p20). They cite data by which Polish local government typically spent more than 20% of their budgets on investment in the 1990s, thereby accounting for 50% of all public investment spending.

Arrangements between Nokia and the government of the Hungarian town Komárom could serve as an example of such behaviour. In a competition with several big towns, this Northern Transdanubian town won the opportunity for a mobile telephone factory to be built in the framework of a capital investment of $115m by Nokia. In addition to tax exemptions, Komárom has also undertaken to improve some of the public utilities at its own expense.[70]

EU policies and network alignment

European policy in electronics has been to trade imports for foreign direct investment, ie, Europe discouraged imports but tolerated and often "directed" FDI (Linden, 1998). Therefore, both US and Japanese electronics firms made substantial direct investments to establish themselves as local producers in Europe. CEECs that signed European Agreements have been affected by these local content rules in many sectors, especially in the automotive industry. However, it seems that, due to the partial nature of subcontracting in electronics the local content policy did not present an obstacle to non-EU foreign investors to export to the EU from CEE.

The proximity to the EU market, as well as its sheer size, operates as a strong attractor to locate in CEE. While MNCs were the key organisers or pushers of this process, EU demand during the 1990s determined the strength of the pull force. The overwhelming orientation of CEE electronics firms on the EU makes the entire electronics sector very vulnerable to

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[68] 'New fund to help small electronics suppliers', *Czech A.M.*, 20 March 2001.
[69] For details see www.czechcinvest.org/ci.
[70] Peter Clarke (2001): *EE Times*, 26 April.

changes in EU demand. In that respect, growth in Russia may be seen as a necessary balance. However, once it happens it will very likely force CEE companies to move up the value chain as some of its assembly operations may one day move to Ukraine and to Russia.

EU accession is usually perceived as an important factor in motivating investors into CEE. Moreover, there is econometric evidence which suggests that the EU announcements on accession have had an important effect on investment decisions (Beavan and Estrin, 2000). Even so, case study evidence suggests that the part of the accession process plays a secondary role as the effective obstacles to trade and FDI have already been eliminated. In addition, the concentration of electronics on only three central European countries suggests that the effects of accession are either different across different candidate countries or are unrelated to the expansion of FDI in electronics. In cases of special or free economic zones, accession may slow down the process of investments as governments would lose an instrument which seemed to play an important role in the development of electronics in the CEEC, so far.

4.4 Morphology of networks and network organisers

As pointed out earlier, factors or resources by themselves are not sufficient to explain the network alignment. Favourable factors are only a conditional advantage, which operate only when network organisers and the alignment of different networks is in place. Advantageous resources or factors may be transformed from conditional into real advantages only through network mobilisation and the alignment of different networks. The alignment of network framework helps us to understand who are the actors and networks involved and how their interactions influence international production integration in a specific sector.

However, Table 18 with network alignment elements still does not tell us who is the major actor or the dominant network. It assumes that all nodes of the framework are equally important. Yet, in reality this is far from true. In order to understand the potential for network alignment, and to support complementarities between different networks and actors, the power structure of local networks should be recognised and these networks evaluated as to what their objectives are. As Benett and Krebs (1994) point out, a given network does not imply that all agents are equally important; often only one agent is the key animator of development (p132). The structure of power and control within networks is important in order to understand who the important network organisers are.

Although stated in much of the available literature on networks, the problem of the logistics of networks should not be minimised. The content of the networking, or in our case strategies of actors, needs to be addressed as identical networks can function positively or negatively for economic or other performance reasons according to what is communicated (Fine, 1999, p7). A great deal of change that occurs in networks arises from single actors functioning as change agents or network organisers. Strategies of key actors will strongly shape the morphology of networks.

In Radosevic (1999) we concluded that network organisers in the post-socialist era could be any actor with the necessary capability and resources – a user or supplier firm, a bank, a holding company or a financial-industrial group, a foreign trade organisation, a design institute, a foreign firm or, in some cases, even the state or regional administration. However, given the managerial, financial and technology gaps in CEE it is foreign companies that, for the time being, are the most active network organisers in CEE.

In the electronics industry the main driver for the network alignment are MNCs. However, their role seems to be much less dominant when compared to sectors like the car industry, where industry architecture is much more pyramidal. MNCs have to overcome negative legacies of the socialist system and not only turn around the firm but also change the local environment as well.

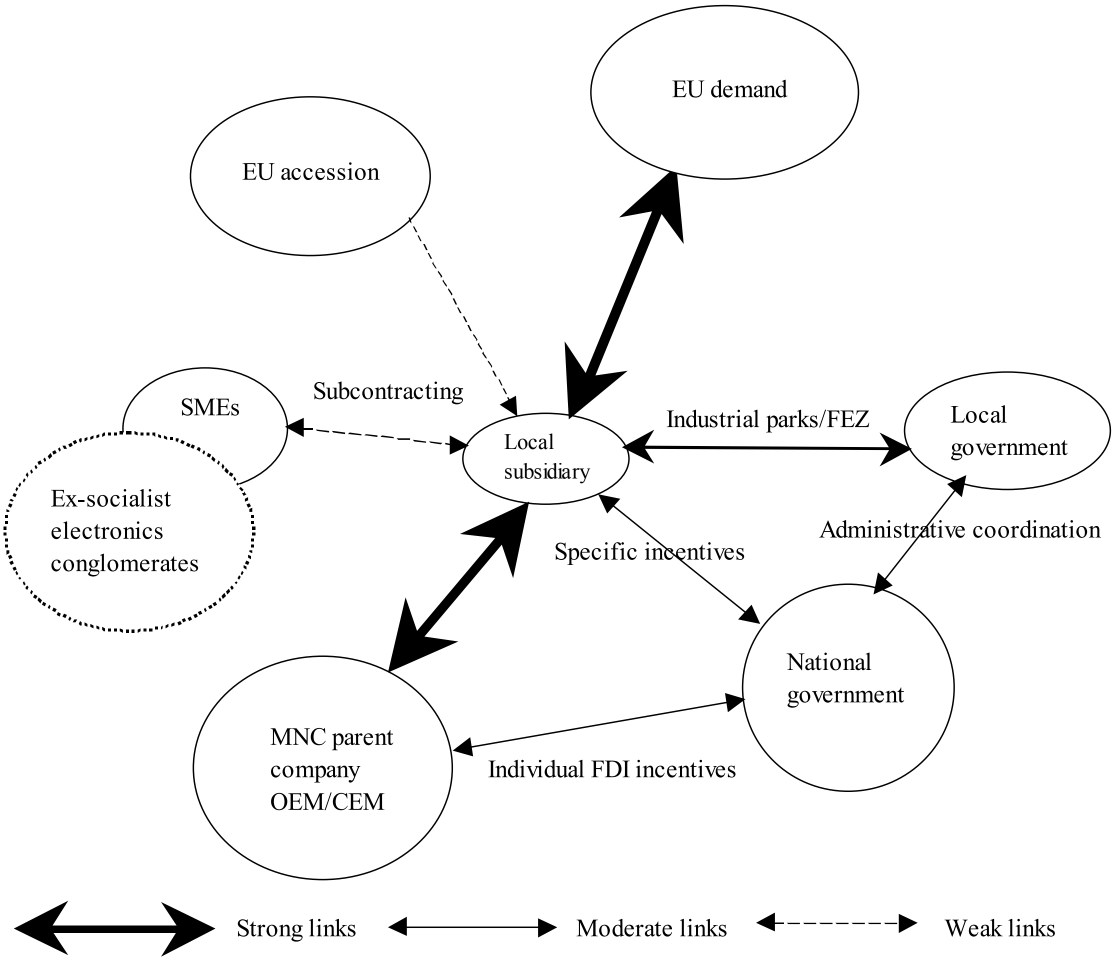

Figure 4: Stylised relationship and strength of network alignment elements in Central European electronics

MNCs play a major role in shaping the way CEE integrates into global networks in electronics. However, EU demand is crucial in pulling MNCs towards further integration of CEE into their production networks.

Two other important factors for network alignment are the actions of local governments, specific incentives and actions of national government. When compared to other regions, local industry networks, including large and small firms in CEE, do not play an important role; they are on average weak and undeveloped as network organisers. Also, the accession process does not seem to bring about a closer alignment of networks. Figure 4 tries graphically to summarise the power of individual actors/networks and the intensity of linkages in network alignment.

Figure 4 shows the situation which can be considered as 'typical' for the region. It does not convey significant country differences, in particular coupling of national and local government policies in Hungary, compared to other countries. The figure depicts the situation in which the network alignment is driven by MNCs, is pulled by EU demand and confined to local subsidiaries of MNCs. In Hungary and the Czech Republic (after 1996) local and national governments played an important role through subsidies and industrial park policies. As in the east Asian story of electronics dynamics (Hobday *et al*, 2001) the key finding is the critical role of foreign capital.

5 INDUSTRIAL UPGRADING IN CENTRAL AND EAST EUROPEAN ELECTRONICS

In this section we discuss the prospects for further upgrading of the CEE electronics industry. During the 1990s, we have observed an intensive building of manufacturing capabilities in Central European electronics, in particular in Hungary, the Czech Republic and to some extent in Poland. The penetration of electronics into the region is highly uneven and reflects national differences, which we analysed within the alignment of network frameworks. However, before we try to speculate analytically on the prospects for further upgrading we want briefly to describe the patterns of upgrading that took place during the 1990s.

5.1 Patterns of upgrading during the 1990s

Expansion of the existing facilities in manufacturing in terms of increased investment, employment and exports has been pronounced during the 1990s. This has involved extensive upgrading of production capabilities. The following few examples should give an idea of the most frequent pattern of upgrading, though a fair understanding would require case studies.

For example, Tyco Electronics Corp, which came to Hungary, went from 13 employees in 1993 to 2,200 in three factories today. The company makes connectors and electronic modules for domestic and EU customers. It has started assembly-engineering operations and now undertakes some simple customer-required design changes. Tyco is investing further $11 million to expand capacity by 50%, add a plating department, and bring in additional molding and stamping machines for a fully integrated connector plant.

Linden (1998) describes a path of expansion which seems to be quite characteristic for the most successful cases of FDI. Korea's Samsung started production of TV sets in 1989 in Hungary. Hungarian engineers were sent to Korea to study production techniques. Output began in 1990 with a 100,000 set per year capacity and has today reached 500,000. Local suppliers provided packaging, frames, and wiring for local content of about 15% which has now increased to 25% with the local supply of plastic parts.

Matshuita's investment in the Czech Republic has been praised as a plant that has achieved high quality and production records. Within four months of the start of production, the in-process rejection rate was below 3% and production levels topped 1,000 sets per day. According to the Executive Director, Matsushita Television Central Europe, this was the shortest construction period in its 26 television factories in the world.[71]

According to the 1998 Czech Investment Agency survey of foreign investors, 68% intend to expand manufacturing operations in the Czech Republic.[72] This confirms that there is still scope for expansion of FDI in electronics of a similar type to that already undertaken.

In general, a review of the business press suggests that mastery of production capability has been quite extensive in the region. This is in line with figures on productivity of foreign investment enterprises in CEE, which are much higher when compared to domestic firms (Hunya, 2000).

However, it seems that cases of functional upgrading or moving from manufacturing to engineering within the same firm are rare. Although we find several examples of foreign controlled R&D, software and design centres in electronics, they are mainly in the telecommunications area, not in core areas of electronics. This, together with the strong

[71] *Financial Times*, 02.12.97.
[72] www.czechinvest.

product specialisation of foreign plants, suggests that the mastery of technology has been confined to process improvement technology.

In terms of modes of entry, the frequent pattern is a shift from subcontracting to FDI. A precondition for this shift is the mastery of production capability by subcontractors. A few examples should give an idea of the pattern. Motorola, which is present in the Czech Republic, 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. Linden, (1998) describes this pattern as the example of IBM, which in 1994 began subcontracting the production of hard disk drive head assemblies to Videoton, investing about $2.6 million and employing 150 workers. 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 in IBM's ten plants worldwide (*ibid*). The story of Philips in VCRs is similar to that of IBM for disk drives, started through a subcontracting arrangement with Videoton for parts and gradually expanding to become a major investment including final assembly. AVX Kyocera began subcontracting capacitor assembly to Tesla Lanskroun (Czech Republic) in 1992. The following year, AVX set up its own subsidiary in a building leased from Lanskroun to produce tantalum capacitors. By the following year, the company had invested an additional $40 million with 1,700 workers in Lanskroun and another 500 at a plant in a separate location (Linden, 1998).

To sum up, we find indications of the mastery of production capability but relatively limited functional upgrading. As local companies prove themselves to be competent subcontractors, they are then taken over by foreign partners. Most often they operate as product specialist plants or rationalised operators, which explains the limited possibilities for functional upgrading. Also, the limited autonomy of subsidiaries indirectly confirms this impression. However, given our sparse evidence we may be wrong and further case study work along the analysis of Polish and Romanian clothing sectors would be needed (see Yoruk, 2001).

Critical mass and endogenous spillovers

In the previous section we highlighted the fact that the dominant pattern of upgrading is in terms of improved production capability, with very limited or no functional upgrading. This would suggest that we will see an extension of the existing trajectory of expansion of investment across the region confined to product specialist plants or rationalised operators.

A further expansion of similar types of FDI may generate a critical mass of investments, which in the second stage may lead to differentiation of types of plants with different product mandates. For example, some analysts think that the presence of so many assembly factories in Mexico (Guadalajara) has created the critical mass necessary to develop a local supply network. This is seen as a threat to Asia's electronics companies. A similar potential for endogenous spillovers seems likely in the Czech Republic, but in the automotive industry after the recent entry of Peugeot-Toyota, which comes in addition to the already developed production network of WV-Skoda. However, except in Hungary none of the other CEECs has reached such a critical mass in electronics.

An important new development noticed in Hungary is the emergence of clustering or companies which enter to meet the demands of other investors. In a globalised economy, where flagship firms operate as the centre of a network, this is not surprising.[73] Flagships are bringing their suppliers. For example, in 2000, Sanyo was negotiating with two of its foreign

[73] Rugman and D-Cruz (2000) define a flagship firm as a firm that 'provides leadership to a vertically integrated chain of businesses with which it has established key relationships' (p8).

suppliers to move into the Dorog Industrial Park (Hungary), where the electronics manufacturer produces dry cells for mobile phones made by Nokia.[74] The Germany-based Zollner Group, will build a second Hungarian factory in Szügy, north Hungary, principally to produce electronic equipment, mainly for multinationals. Zollner clients include Toshiba, for which it makes laptops, and Renault, for which it manufactures global positioning systems.[75] The bulk of Flextronics output, as well as of other contract manufacturers, is marketed to other foreign companies in the electronics industry in Hungary. The main motive for Elcoteq to enter Hungary was to supply plastic parts and subcontracting services for the Nokia factory that produces monitors (Linden, 1998).

These examples suggest that increased sourcing among foreign investors may generate clustering and spillovers. However, clustering and spillovers may not emerge between local and domestic firms but between foreign firms. This may partly explain the absence of spillovers in CEECs which comes from econometric studies. In an economy, such as the Hungarian, which is so heavily dominated by foreign investment enterprises this is to be expected. However, the Irish experience shows that even in a small economy there are limits to foreign-led modernisation and that, eventually, long-term growth is more sustainable if domestic firms are able to integrate with foreign firms.

Alternatively, we could argue that critical mass by itself is not sufficient to bring anything new in terms of industrial upgrading but simply more of the same, ie, a mass of specialist or rationalised operator plants which may be in a country as long as labour costs for the same value-added are lower than in other economies. In this case, we will not see the expansion of investment followed by the diversification of types of plants like factories with enhanced mandates or strategically independent with expanded functions, especially design.

In reality, industrial upgrading is always a dynamic process with countries moving up or down industry ladders. Hence, whether a country will become an important global location in electronics will depend on the technological diversity of plants and their functional upgrading. Table 17 shows that although UK some plants are being relocated to Hungary and the Czech Republic, some plants have also moved to China from Hungary.[76] Also, we are seeing the beginning of the relocation of labour intensive operations from Hungary to Ukraine (Flextronics) and their emergence in Romania (Solectron). So, in the medium-term Hungary has to find something else other than cheap labour as a cost advantage. Most industry sources believe that, over time, manufacturing will continue moving east into Russia in the endless search for a lower cost work force. In the long-term this may threaten the position of Hungary and the Czech Republic which could be squeezed between cheap eastern locations (Ukraine, Romania) and technologically sophisticated Western European firms.

In the medium-term we may see the emergence of regional architecture in electronics characterised by the inclusion of a few more countries into production networks (Ukraine, Romania) and possibly the tiering of countries with Hungary and the Czech Republic occupying higher value-added positions. There is already a trend of positioning some companies in Hungary as European mandate plants. For instance, one of the largest is IBM's plant in Székesfehérvár, which supplies the whole European market with hard disk drives manufactured there. The video and television/video manufacturing plant realised by Philips,

[74] Daniel Nashaat (2000): 'Sanyo brings suppliers', *Budapest Business Journal*, 13 November.
[75] *Hungary A.M.*, 13 July 2001.
[76] Labour costs were the reason two electronics manufacturers shifted some production out of Hungary, suggesting that shakeout in low-end assembly work has begun. Germany's Mannesmann AG has relocated a car audio plant to China just three years after opening it in Hungary, resulting in a loss of more than 1,000 jobs. A division of Japan's Shinwa followed, moving its car radio assembly plant to China for a 25% savings on labour costs.

also in the industrial park in Székesfehérvár, has also become a central manufacturer for Europe. The Székesfehérvár factory became the sole Philips VCR and combined TV/VCR production facility in Europe**.** The Finnish firm Nokia has also transferred its complete European monitor production capacity into its monitor plant in Pécs. The Jászfenyszáru plant is Samsung's only TV manufacturing plant in Europe. If Hungary managed to establish itself in higher value-added activities, then we may expect that the electronics industry network will spread further to the East or South East. Hungarian Videoton, which has taken over part of the Bulgarian ex-socialist electronics conglomerate Stara Zagora, shows that this path is a real option (Radosevic and Yoruk, 2001). However, this scenario is based on significant improvements in the Hungarian national system of innovation, in particular in assistance for vocational training.[77]

Case study evidence shows that contractors have been willing to provide assistance to bring their subcontractors up to the level of quality suppliers. However, the problems involved in climbing up the value-added ladder through subcontracting are not trivial. From a sample of 90 Hungarian subcontractors, Szalavetz (1997) showed that close cooperation with foreign partners brings considerable productivity improvements. In her sample, all processing firms received a transfer of technology or equipment, and half the firms benefited from investment or working capital finance provided by the foreign partner. However, after the initial push the learning process gradually slowed and finally stopped completely. Szalavetz (1997, p5) points out: "Once the Hungarian company had undergone sufficient restructuring to ensure that cooperation can go smoothly, foreign partners abandon any further developmental effort". This occurred even in those cases where foreign partners had decided to increase their equity in the Hungarian company (*ibid*, p53).

This example illustrates the difficulties involved in deepening production integration. It also points to the discontinuous character of technological integration and the emerging structural barriers for CEE firms after initial productivity improvements (see Radosevic, 1999b, chapter 5).

The majority of the EU subcontractors do not receive financial assistance from their main contractors, and so investments are financed by bank loans, leasing, or from equity. Subcontractors are required to hold significant levels of stock. At present, subcontractors usually pay storage costs, which in the past were mainly borne wholly by the main contractors (EU, 1997, p53). Central European subcontractors may face the same or even bigger problems.

This, together with a high dependence on contractors, suggests that the sheer critical mass of investors and plants does not guarantee industrial upgrading through functional upgrading or changing the technological position of factories.

6 CONCLUSIONS

1 This paper analysed the electronics industry in CEE as an emerging production location. The analysis was framed within the alignment of network frameworks. This framework represents the bridge between the literature on business networks and MNC which have remained largely separate.[78] The literature on commodity chains tries also to tackle this problem but its framework is reduced on commodities as clearly identifiable objects, with little or no attention to the broader context. Problems of product convergence vs technology

[77] According to a survey of EU electronics subcontractors, this should be provided at national level, and in cooperation with trade associations (EU, 1997, p52).

[78] In a regional context this problem has been recently tackled through the literature on 'developmental subsidiaries'.

convergence in electronics make this perspective irrelevant for the electronics industry. The network alignment perspective is quite relevant in the context of state vs market debate. It shows that the issue cannot be reduced to state vs market, but that it has to include not only firm strategies (Hobday *et al*, 2001) but also local governments and EU.

2 Given the relatively developed production and R&D capabilities of CEECs they are in a potentially favourable position to build manufacturing capacities in electronics via FDI. The alignment of network approach is useful to show which factors play a role in the emergence of positive or negative outcomes. The positive outcome of a strong locally-owned supply base is not guaranteed. Factors by themselves are not the sole determinants of positive outcomes. This is because their use is dependent on a variety of inter-organisational linkages and organisational capabilities. As suggested by the resource-based theory of the firm, it is not resources by themselves but their productive use which depends on variety of capabilities and institutions. The alignment of networks approach can be used as a useful heuristic to identify the main issues involved in linking the different actors and networks involved in the process of building sectoral capabilities.

3 The alignment of network approach argues that the intersection between different networks is firm, country and region specific and involves a variety of the governance factors that hinder or enable alignment of different networks. Differences in types and qualities of national, global and local networks influence how this alignment will take place. When the alignment of networks is successful, it involves close links not only within a specific network, but also across several networks. However, networks can also be undeveloped or misaligned. Networks fail when different networks (global, national and local) do not couple or align. This network failure should be distinguished from a failure to develop networks. The asymmetries in quality and development of local, national and global networks and actors, rather than the mistakes in the process of alignment, can often explain why networks fail, ie, do not align.

4 The application of this framework to explain the emergence and sustainability of upgrading CEE electronics has generated several conclusions:

4.1 Foreign investment is the primary vehicle of integration of CEE electronics firms into global production networks and Hungary has moved furthest along this path, positioning itself as a major low-cost supply base in the region. Czech and Polish electronics industries are connected, in smaller but increasing degrees, to international electronics production networks. Other countries have much less integrated industries though this situation may change in the medium term, primarily through the activities of contract manufacturers.

4.2 The EU operates as the main source of demand for CEE electronics industries. This is the main pull factor which gives cohesion to the actions of MNCs and of local and national governments in CEE. However, this also means that CEE electronics firms mirror to a great extent the strengths and weaknesses of EU electronics firms in terms of market segments and dynamics of growth.

4.3 Networks that are being built in CEE reflect the strategy of the dominant actor – the MNC. They are usually confined to subsidiaries with still limited local subcontracting, are export oriented and are expanding. Local subsidiaries have mastered production capabilities and several subsidiaries in Hungary are European mandate suppliers in their respective lines of business.

4.4 Ex-socialist electronics conglomerates have substantially decreased in size and most are operating as loose associations of medium- and small-sized firms. Videoton Hungary is a notable exception to this pattern in terms of successful domestic-led restructuring. The layer of local firms in electronics is still very weak with very limited capabilities in core technologies. This is the key weakness for further alignment of networks in CEE electronics. CEE still seems far from the situation in East Asia where former managers at companies like Intel and Hewlett-Packard have started some of the best local companies in the electronics sector. The weak financial systems of CEECs, and still undeveloped capabilities in electronics technologies and lack of experience in competition in this sector, means that the local networks will remain very much dependent on foreign investors.

The mastering of process technologies has primarily taken place within the foreign firms and in some successful domestic firms. In some respects, the situation in Central Europe in electronics is similar to the situation in Malaysia and Thailand (but not Korea and Taiwan), where the overwhelming dominance of MNC investment is matched by the absence of major local exporting firms (Hobday *et al*, 2001).

4.5 Local governments in Hungary and Poland played an important role in working jointly with foreign investors on establishing industrial parks and new capacities. In Hungary, and after 1996 in the Czech Republic, national government played an important role in attracting FDI to electronics. In agreement with Dunnin *et al* (2002) we can conclude that local governments, as the least powerful actor, have made the greatest efforts in relation to their capacities to reconcile their interests with those of MNCs.

5 Linden (1998) suggests that 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. Our analysis clearly shows the need to support the weakest node in the alignment of networks frame, which are domestic small and large electronics firms. The East Asian experience shows that host countries can effectively determine the degree to which they benefit from the proliferation of network linkages with foreign electronics companies (Linden, 1998).[79] However, CEECs today have much less possibility of determining the degree to which they can benefit from international production integration.

Given a significantly changed international political economy through GATT liberalisation and EU accession, the room for independent decision-making is for them very much reduced. It is true that national policies do still matter. However, the CEEC states today had to shift much more toward a regulatory role. EU accession will further remove prerogatives for decision making, especially instruments like free economic zones and fiscal support. CEE states will have to learn how to influence industrial development on their territory and this will have to be done in cooperation with the EU.

[79] Hobday *et al* (2001) argue that this is much less the case as government strategies appear to be much less effective than the initial accounts of electronics development in east Asia have suggested.

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