DIW Diskussionspapiere
Discussion Papers

Discussion Paper No. 148

The Computer Industry in East and West: Do Eastern European Countries Need a Specific Science and Technology Policy ?

by
Jürgen Bitzer*

*) Associate researcher at DIW

Berlin, May 1997

Deutsches Institut für Wirtschaftsforschung, Berlin
Königin-Luise-Str. 5, 14195 Berlin
Phone: +49-30-89789- 0
Fax: +49-30-89789- 200
Internet: http://www.diw-berlin.de

The Computer Industry in East and West:

Do Eastern European Countries Need a Specific Science and Technology Policy?

by Jürgen Bitzer[1]

[1] Associate researcher at DIW. Jürgen Bitzer c/o DIW, Königin-Luise-Str.5, D-14195 Berlin, Tel: +49-30-8 97 89 -328, Fax: +49-30-8 97 89 -200, e-mail "jbitzer@diw-berlin.de". This paper is an intermediary result of the project "Restructuring and Re-integration of Science & Technology Systems in Economies in Transition" financed by the European Commission, DG XII, within the Fourth Framework Program "Target Socio-Economic Research (TSER). The author thanks Christian von Hirschhausen for comments and Andrew Partington for proof-reading the paper. The usual disclaimer applies. Opinions expressed in this paper are those of the author and do not necessarily reflect views of the institute.

Abstract

National science and technology (S&T) systems are mentioned, in politics as well as in science, as a condition for the competitiveness of domestic high technology industries. An active S&T policy has, therefore, great importance for governments. Eastern European countries see, in an active S&T policy, the key for the creation of a new computer industry, which collapsed with socialism. With an industrial economic analysis of the market segments: PC, workstation, mini and mainframe computer and supercomputers this hypothesis is rejected for Eastern Europe. It is shown that the Eastern European computer manufacturers are present only in the PC segment. The analysis of production conditions, competition axes used and the computer market structure shows further that domestic computer manufacturers are well positioned in the PC business and have no need for a national S&T system. They have quickly built up global supplier networks which enable them to use foreign S&T systems. Therefore, with the current conditions on the computer markets in Eastern Europe, setting up national S&T systems for computer technology is not required.

JEL-classification: P51, L63, L11

Zusammenfassung

Das Nationale Innovationssystem wird häufig als Voraussetzung für die Wettbewerbsfähigkeit einheimischer Hochtechnologieindustrien angeführt. Aus diesem Grunde besitzt die Innovationspolitik einen hohen Stellenwert bei Regierungen. Mittel- und Osteuropäische Länder sehen in einer aktiven Innovationspolitik einen Schlüssel zum Aufbau einer neuen Computerindustrie, die mit dem Sozialismus zusammengebrochen ist. Mit Hilfe einer industrieökonomischen Analyse der Computermarktsegmente: PC, Workstations, Mini- und Mainframecomputer und Supercomputer, wird diese Hypothese für Mittel- und Osteuropa widerlegt. Durch Analyse der Produktionsbedingungen, der verwendeten Wettbewerbsachsen und der Computermarktstruktur kann weiterhin belegt werden, daß die einheimischen Computerhersteller im PC-Geschäft gut positioniert sind und keinen Bedarf für ein nationales Innovationssystem besitzen. Sie haben schnell globale Zulieferernetzwerke aufgebaut, die ihnen die Nutzung ausländischer Innovationssyteme ermöglichen. Aus diesem Grunde ist, bei den momentanen Marktstrukturen, der Aufbau nationaler Innovationssysteme in Mittel- und Osteuropa für Computertechnologie nicht notwendig.

Diagrams

1. Introduction

The importance of computer technology in industrial countries rises year on year. In nearly all parts of the economy humans use computer technology for their work. The development of computer technology in the last few centuries has enabled large increases in the productivity of industrial countries. Often special production processes were not possible before the introduction of modern computer technology. The application of computer modelling in industries like chemistry, aerospace, car manufacture also only became possible through modern computer technology. In western industrial economies the penetration of computers is well advanced. For the computer industry experts promise, corresponding to foreseeable developments in western economies (e.g. production processes, organisation types, etc.), above average growth rates into the next century.

In Central and Eastern Europe some years ago the experts also promised "glorious" prospects for the domestic computer industry. Today the expectations have to be revised and replaced by realistic estimations. Often a lack of money is cited as a reason for the disillusion development of the computer industry in Central and Eastern Europe. Governments in particular believe that a S&T policy with large financial means could repair the problems of domestic computer enterprises in the competition with large international computer manufacturers. A look at the international computer market structure and the competition axes used, will show that often the entry barriers, which have been developed over recent decades, are too high today for most of the potential computer enterprises in Central and Eastern Europe. Even if large financial means were available, they would not enable the competition disadvantages of the Central and Eastern European computer enterprises to be caught up in the medium term.

This paper therefore firstly analyses the competition on the European computer market. In the following chapter the computer market in Central and Eastern Europe, especially in Poland, Hungary, Czech Republic and Russia, will be analysed. From the results of the first two chapters an estimation of possible science and technology policies is drawn.

If we talk about computer industries we have to distinguish between three different segments which are closely linked but have their own tasks and conditions in the computer industry. The computer industry contains three parts: the computer hardware industry, the computer software industry and the computer service industry. The computer hardware industry produces the hardware needed to operate a data processing system (e.g. PCs, printers, monitors, modems, network devices etc.). In this paper only the computer manufacturing industry is to be analysed. This means that computer component producers will not be a subject of this paper. Nevertheless the connections between the component producers and the computer manufacturers will be analysed where it is required. The computer software industry, which is the subject of another discussion paper by the author, will also only be integrated where it is needed for the analysis of the computer manufacturing industry. The computer service industry contains services which are needed when enterprises operate data processing systems (e.g. training of employees, data maintenance services, etc.) The linkages between computer manufacture and the computer service industry will only be considered if it is needed for the analysis.

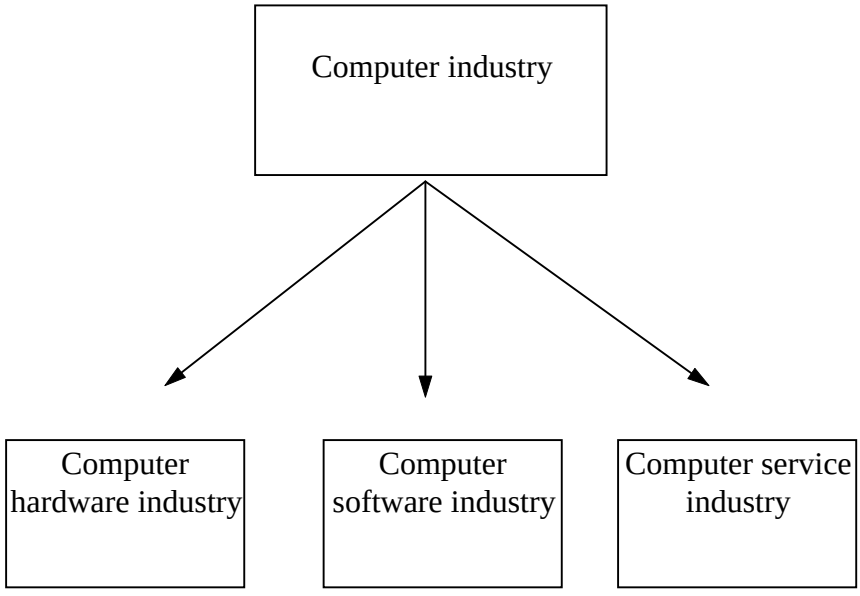

Diagram 1: The computer industry

2. The computer manufacturing industry

The history of the computer manufacturing industry reaches back to the year 1951 when the company Remington Rand installed the first electronic computer system named UNIVAC. Since this time the computer market has changed fundamentally. Today four different segments can be distinguished. The segment for PCs, the segment for workstations, the segment for mini- and mainframe computers and the segment for supercomputers. The computers in those segments differ in their calculating power, their price and their application fields.[2] Especially in the segment for PCs and the three other segments the market situation in terms of competition axes, potential customers, R&D intensity, market barriers etc. differ extremely. Because of this the PC market, the workstation, mini- and mainframe market and the supercomputer market will be examined separately in the following.

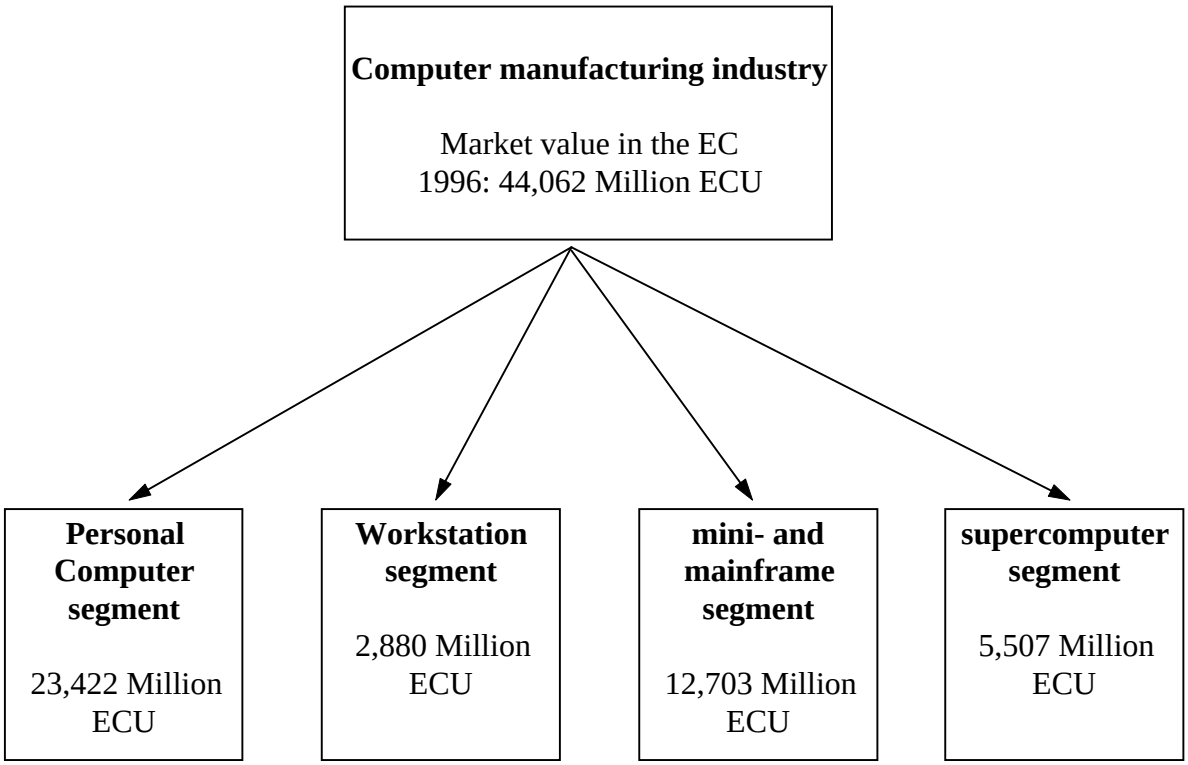

Diagram 2: The computer manufacturing industry

The following graphic shows the different market shares of the four market segments:

[2] Nevertheless the borders between the different segments start to disintegrate with the development of computer technology. The processing power of PCs today nearly reaches that of the workstations. The workstation are nearly as powerful as mainframe computers. So the differences between the four segments of the computer market become smaller.

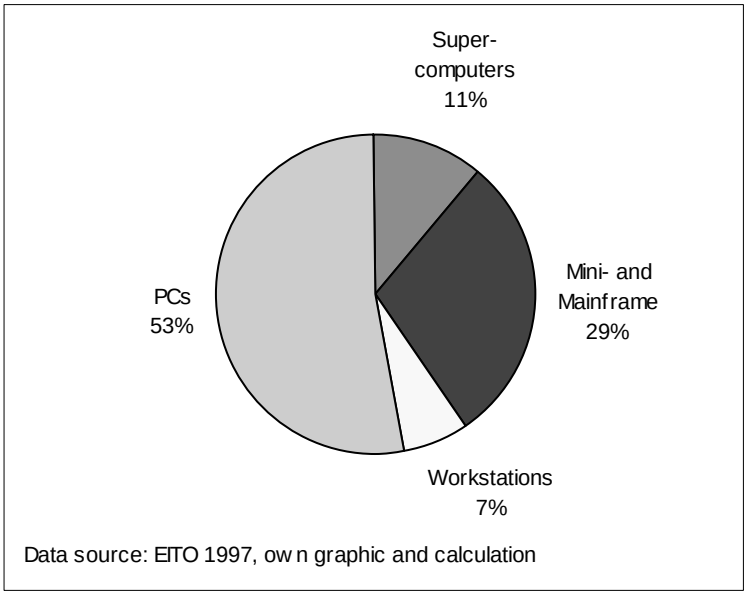

Diagram 3: Market shares in terms of value of the different computer classes in the EC 1996

2.1. The Personal Computer segment

Personal computers (PC) are the least powerful and least expensive computers of the four market segments. The processing speed of PCs lies between 20 and 50 Million Instructions Per Second (MIPS). The price for such systems is between $700 and $10,000. PCs are mostly applied in desktop applications like word-processing, spreadsheets and small data bases.[3]

In 1977 Apple introduced the first commercial PC. Until 1981, when IBM introduced its first PC, Apple held a monopoly based on proprietary technology. The birth of the PC-computer market as we know it today was 12th August 1981, when IBM put their first PC model on the market, which was designed as a open system. In contrast to using a proprietary technology they incorporated off-the-shelf components like Intel's microprocessor and Microsoft's operating system MS-DOS. So IBM's use of mass-produced components combined with widespread dissemination of its PC technology led to the emergence of IBM-compatible machines and clone makers.

In the European Union the market for PCs had a value of 23,422 Million ECU in 1996 (53% of the computer market in terms of value in the EC) and was the largest of the four segments

[3] U. S. International Trade Commission (1993), p. 68-71.

of the computer market.[4] In 1996 15,965,115 PCs were sold in the European Union; the growth rate from 1995 to 1996 was 17.4 %. [5]
Nevertheless in recent years a saturation of the PC market can be observed. Contrary to this the demand of private households has increased and partly compensates for the decrease in the professional market segment.[6]

The market conditions on the PC market differ fundamentally to the conditions on the other computer market segments. Because of the open PC technology the sources of innovation, the production, the competition axes used and the market structure in the PC market segment are completely different to the other computer segments.[7]

2.1.1. Production of PCs

The production of PCs is characterised by the openness of the PC technology. An open computer system is characterised by standardised hardware interfaces which ensure the mechanical connection as well as the data transfer.[8] This enables enterprises to produce components for PCs without a licence or a co-operating with a PC manufacturer. The result of this computer architecture is that a large number of highly specialised component producers exist which develop and produce such components independent from the PC manufacturer. Such enterprises produce the components in a mass production, at a high efficiency level and therefore cheaply. The result was a massive price drop for the main components in recent years (e. g. micro-processors, memory chips, graphic devices, hard drives etc.).[9] Examples for such components manufacturers are; Intel for its micro-processors, Microsoft for its operating system and application software, Diamond, Elsa, and Miro for graphic devices, Seagate, and Western Digital for hard drives etc.. Therefore only a few of the largest PC manufacturers continue to depend heavily on internal sources of components.

[4] EITO (1997), p. 279.
[5] EITO (1997), p. 289.
[6] Drüke (1993), p. 3.
[7] Kauffmann (1993), p. 5.
[8] Cf. Meffert (1993) for detailed discussion of computer standards.
[9] Drüke (1993), p. 3.

It is evident that this also has effects on the organisation of the production of PCs. Because several components are highly standardised, the assembling of PCs is, without a difference of size and location of the enterprise, typically carried out with simple conveyor belts and hand held screwdrivers.[10]

Compaq for example produce their PCs in a single conveyor belt production. This means that the complete PC is assembled in one location.[11]

From this follows, that large productivity differences in production do not exist in the PC manufacturing industry.

2.1.2. Sources of innovation

As a consequence of the architecture of the PC and the organisation of production, the main source of innovation in the PC market segment is the component suppliers. New processors, graphic devices, motherboards, disk drives etc. are mainly developed and produced by high specialised components suppliers. Only a few large PC producers still have internal capacities for the development and the production of components. For example, IBM still has large capacities for chip production but this is also the result of activities in other computer segments.

2.1.3. Competition in the PC market segment

In contrast to the segment where proprietary technologies dominate the market, the entry barriers to the PC market are low. The reason for this is that enterprises which want to enter the market do not have to build up any R&D facilities.[12] They can buy any component on the market. Furthermore the capital intensity for production is low, so that large financial means are not needed to enter the PC market. Competition intensity is therefore high; international enterprises must compete on regional markets with small regional clone makers who are

[10] U. S. International Trade Commission (1993), p. 113.
[11] U. S. International Trade Commission (1993), p. 113.
[12] Denger (1997), p. 26.

serious competitors especially in the home user market.[13] From this it is not astonishing that the 10 leading PC manufacturers in 1992 hold 61.5% of the world PC market in terms of value.[14]

The "time-to-market"[15] plays no important role in competition on the PC market, because the introduction of new technologies depends on the supplier so that all PC manufacturers have nearly the same time-to-market.[16]

The market segment for PCs is the only one out of the four examined segments where private households appear as an important part of demand. In 1993 2,722,000 PCs were sold to households (home users) with a value of 2,406 million ECU which corresponds to a market share of 15 % in terms of value of the whole PC market in the EC.[17] Home users use their PCs for their daily home work (like correspondence, on-line banking, etc.) and for their entertainment (computer games, encyclopaedia, etc.). Today the PC is becoming more and more a "commodity product".[18]

On the other hand there are the professional customers (mainly enterprises), which use PCs for their business. In 1993 6,026,000 PCs with a value of 13,213 million ECU were sold to professional users which corresponds to a market share of 85% in terms of value of all PCs sold in the EC.[19]

So PC customers should be distinguished into professional and home users because both groups have different demands in terms of attributes of the product PC and the support offered. From this the distribution channels of the manufacturers differ.

The market for home users

Downstream competition axes:

[13] Kauffmann (1993), p. 18.
[14] U. S. International Trade Commission (1993), p. 79.
[15] Time-to-market as the time required by manufacturers to assemble PCs, especially those incorporating new technologies (e. g. a new microprocessor) and deliver the finished product to the market.
[16] Kauffmann (1993), p. 11.
[17] EITO (1993), p. 233.
[18] Kauffmann (1993), p. 7.
[19] EITO (1993), p. 233.

- price
- offer to assemble individual PC
- advertising
- guarantee conditions

For the home user the price is the striking competition factor in the PC market and this can be proved exactly by figures. In 1993, 31% of units sold in the EC was to home users. But this corresponds to only 15% of the value of the complete PC market in the EC.[20] Therefore PC assemblers like Vobis, Atelco, Groupe Bull, Packard Bell, Gateway etc. dominate this market segment.[21] Because home users are mostly not dependent on their computer system quality and support is therefore of lower importance. The suppliers follow a "product-selling-strategy" and offer only a "bring-in-service"[22] for their products. But in recent times PC manufacturers are using the guarantee conditions , especially the duration, more and more as a competition axis. Because the quality and power of the PCs differ only slightly a brand loyalty by home users does not exist.[23] Therefore advertising becomes an important competition axis because the prices in this market segment are almost the same. So other strategies have to be used to separate themselves from other manufacturers.

A promising competition strategy is the offer to assemble individual PCs with the components inside which the customer has chosen. Today the customer can normally decide which components (micro-processor, graphic device, hard disk, monitor etc.) he wants in his PC. The open architecture of PCs enables this practice and it leads to a increasing number of PC models.

[20] Data source: EITO (1993), own calculations.
[21] Denger (1997), p. 27.
[22] The customer have to bring their faulty PC to the selling point where it will be repaired. Sometimes the repairs take 3 or more weeks because the PC is sent to the production location or the manufacturer for the repairs.
[23] Kauffmann (1993), p. 19.

The market for professional users

In the market for professional users the competition axes should be divided into passive and active competition axis. Active competition axes are actively used to separate oneself from other competitors. Active competition axes become passive when all competitors offer similar conditions on this axis, to their customers. With the change from an active to a passive competition axis, this competition axis becomes a condition for the participation in the competition and therefore an entry barrier for new enterprises. With an innovation, passive competition axes can also become active again.

Downstream competition axes:

Passive:

- quality/support
- integration/installation competence
- complete system supply

Active:

- price

The quality and the support, the existing computer system and the capacity for a complete system supply are passive competition axes, and therefore conditions for the participation in this market segment.

For professional users the quality and support have a greater importance because their business is often dependent on the functioning of the computer system. To get a high quality PC product and qualified and quick support for it, is an important buying assumption for customers on the professional market. For this enterprises are willing to pay a higher price. This can be proved with a comparison of the market shares in terms of units with those in terms of value. In 1993, 69% of units were sold to professional users but this corresponded to a value share of 85% of the complete PC market in the EC.[24] To guarantee this service the

[24] Data source: EITO (1993), own calculations.

supplier of PCs offer an "in-house-support"[25] for their customers. It should be added, that with the growing size of enterprises the use of PCs and the integration of them into an existing computer network grows as well. So small and medium enterprises often buy their PCs from suppliers who concentrate their activity in the home user market (system business).

Whether the customer still has an installed computer system or whether he demands a complete data processing system, he also wants integration[26] of the new PCs. The integration of PCs into an existing network with several different computer types or the installation of a complete computer network is an complex task for the installing enterprise. This shows that a supplying enterprise in the segment for professional users has to offer a problem-solving competence which is not needed in the market for home users.

Often customers want the installation of complete computer systems with PCs, workstations and mainframes. With computer systems with parts from different manufacturers the manufacturer responsible for a fault in the system can often not be found out without some doubt. Therefore the manufacturers have to offer knowledge and products in all of these computer classes. The proprietary computer technology used in the upper computer classes then leads to a brand loyalty of the customers. These proprietary technologies of large computers often enables only the manufacturer of the large computers to maintenance the complete computer system and to install additional components (e. g. new PCs) in the computer network. So the customers mostly order any extension or replacement from the enterprise which installed the current network, because only they can guarantee a faultless function of the complete system. This effect, which is typically for proprietary systems, leads to a dependence of the customer (locked-in user).[27] So mostly the complete data processing system and all supplements are ordered from one manufacturer. So IBM customers also buy their PCs from IBM.[28] So the smooth function of the urgently needed computer system is the reason for this brand loyalty.

[25] The manufacturer’s mechanics come to the customer’s location to solve their problems.
[26] Integration is the connection of single components to a system (cf. Meffert (1993) for detailed discussion of integration in the computer industry).
[27] Cf. Meffert (1993), p. 23ff for detailed discussion.
[28] Kauffmann (1993), p. 19.

It is not astonishing that all the leading enterprises in the professional PC market are mostly also established in the other computer market segments. Examples are IBM, Fujitsu, DEC, etc..

Because all large enterprises in this market segment fulfil the assumptions for the participation in this market segment, the price is the only active competition axis in the market segment for professional users.

Upstream Competition axes:

- Component supplier
- R&D

In contrast to downstream competition, the upstream competition axes do not differ between the manufacturers for the home and the professional market.

With the emergence of independent components suppliers and the reduction of internal capacities as a result of the open architecture increases importance of the relationship to the component manufacturers. So competition for the best buying conditions for the required components decides the price of the whole PC. So exclusive contracts were often carried out between component suppliers and large PC manufacturers to ensure good conditions. An example of this is the contract between Compaq, Intel and Microsoft. For Compaq the contract ensures the best conditions for the delivery of processors and operating systems. Intel and Microsoft on the other hand bind the largest PC manufacturer in the world to their products. Beneath such contracts economies of scale in the purchase play an important role. In particular large clone makers had reduced the component costs most aggressively.[29] Furthermore the delivery conditions, getting the required components in the right number, with good quality at the right time, decides the frictionless production.[30]
The relations to the component suppliers also decide the "time to market". For this it is crucial to get single units during the development period so that the manufacturer can test the new component with other components of his PC product. This helps to reduce the time to market.

[29] U. S. International Trade Commission (1993), p. 112-113.
[30] U. S. International Trade Commission (1993), p. 112-113.

R&D only plays a role in this case when the manufacturer produces some of the required components himself. So, some large enterprises still produce motherboards themselves. In this case the R&D activities were focused on increasing the processing and the speed of the complete computer system as well as cost reduction in the production of components.[31]

2.2. The workstation market segment

The workstation market segment is the newest of the four. It is characterised by high-performance micro-processors, high resolution monitors and sophisticated graphics capabilities. Their main application field is design and manufacturing operations as well as in development and administration which require large processing power and superior graphic applications.[32]
In the market segment for workstations we find computers with a processing power of 20-350 MIPS and a price of $5,000-$60,000.[33]

Workstations were introduced soon after PCs in the eighties. They close a niche in the market between the small PC and the large mini- and mainframe computers. Workstations were designed for engineers and other technical specialists who require larger amounts of processing power for their complex calculations and graphic imaging than PCs could offer. The workstation become quickly popular and closed the niche in the computer market because they offered more processing power then PCs and were significantly cheaper than mini- and mainframe computers.[34]
In contrast to the PC market, the workstation market is dominated by proprietary technologies of the manufacturers. Enterprises such as Sun Microsystems, Hewlett-Packard, IBM, DEC, etc. dominate this segment of the computer market.
In 1996 the market segment for client-workstations had a value of 2,880 million ECU.[35] It is the smallest of the four computer market segments and shows that the application of workstations is limited to very specialised tasks.

[31] U. S. International Trade Commission (1993), p. 112-113.
[32] Meffert (1993), p. 34.
[33] U. S. International Trade Commission (1993), p. 69-71.
[34] U. S. International Trade Commission (1993), p. 75.
[35] EITO (1997), p. 240-316.

2.2.1. Sources of innovation

The manufacturers of workstations did not outsource the research and development of the main components: processor and operating system. The expenditure on R&D is therefore larger than in the PC market. The focal point of R&D activities are the processor and operating system development. All predominant workstation manufacturers have developed proprietary RISC (Reduced Instruction Set Computer) microprocessors and UNIX operating systems.

Company	**Chip**
DEC	Alpha
Hewlett Packard	Precision Architecture RISC (PA-RISC)
IBM	PowerPC
Silicon Graphics	MIPS
Sun	Scaleable Processor Architecture (SPARC)

The same is true for proprietary variants for the UNIX operating system.[36]

Company	**Operating System**
DEC	ULTRIX
Hewlett Packard	HP-UNIX
IBM	AIX
Silicon Graphics	IRIX
Sun	Solaris
Siemens Nixdorf	Reliant UNIX

[36] Glanz (1994), p. 385-393.

2.2.2. Competition in the workstation market segment

In the workstation market only professional users play a role in the competition between the computer manufacturers. The main application fields are steering and control of production processes and graphic design but also application in the research and development departments. For small and medium enterprises the workstations are applied more and more as a server in computer networks. So all large suppliers of workstations offer workstations as island solution as well as server variant.

Downstream competition:

Passive:

- quality
- service/support/maintenance
- reputation of the enterprise
- knowledge and products of computer classes
- available software
- openness of the system
- processing power

Active:

- price

The quality, the available software and the still existing computer base work as passive competition axes in the workstation business.

The quality of a workstation includes two different aspects: faultless functioning and the quality of components used. The faultless functioning of the complete computer system, which means that the individual workstation as well as the connected computer system, is the assumption for the participation in the market for workstations. The reason for this is that such computers are mostly used in crucial areas of enterprises. For example in the steering and control of the production process. A failure of the computer system would lead to high

financial losses because in times of highly co-ordinated production if one production step is missed it will stop overall production. This leads us directly to the quality of the components used in the workstations. After all the components used decide the failure likelihood of the individual workstation but maybe also of overall production. Another aspect of quality is the efficiency of the different components. So high processing power can be useless if the data storage is not fast enough to handle the required tasks. This is true for all components used from data storage to network interfaces. So, a general design of the computer and the framework as well as quality control of the components is needed to guarantee a high quality of computer.

The quality leads us to the case of how the computer system is repaired if a fault appears. For the enterprises the maintenance offered, service and support play an important role in the decision of where to buy the computer system and therefore the reputation of an enterprise is an important competition factor. If the computer system break down it is very important that the system is repaired in the required time. The required time differs with the application field of the computer. So the break down of production has to be repaired as quickly as possible whereas the computer system of a small enterprise can possibly be shut down for a day or more. Closely connected to support is the maintenance of the computer system which should prevent the computer system breaking down. Only the manufacturer can offer such maintenance for the computer system because only he has the knowledge of the proprietary technology. The same is true of the service, and the training of personnel, etc..

The available software is another very important competition factor in the workstation computer segment because without the required software solution a computer is useless to the customers. So all manufacturers offer a large range of software products which are mostly own developments. Only in the case of the operating system UNIX do external software suppliers compete. The available software, in particular, could change to an active competition axis if a proprietary operating system is enforced to a industry standard.

The current computer base is often the decisive factor in the competition between computer manufacturers. The proprietary technology used for the current computer base often prevents the use of computers from another manufacturer. If technical aspects did not prevent the use of

computers from a competitor the costs of integration mostly do. Therefore activity in other computer classes is important to build up own lock-in effects.

Today the processing power of different workstations is of lower importance for customers because the different chip technologies today have comparable processing powers. Furthermore workstations are sometimes scaleable in their processing power (adding processors).

Today prices as active competition axis play an important part in the competition in the market segment for workstations. It should be added, that especially through innovations in chip and software technology, the available software and processing power could quickly be changed to active competition axes.

Upstream competition:

- R&D
- strategic alliances

The striking upstream competition axes are the R&D capacities and strategic alliances. Because the R&D on several components is not outsourced, all suppliers in this market segment have own R&D capacities. They are mostly home-based and only the manufacture of components is sometimes located in own factories in other countries. The R&D costs are high and therefore enterprises enter into strategic alliances. A recent example is HP and Intel who develop a new RISC-microprocessor called MERCED.[37]

The second reason for such strategic alliances is to enforce their proprietary technology as an industry standard. Two different types of strategic alliances can be found. Firstly, there are the strategic alliances on the RISC microchip technology, and secondly, there are strategic alliances on operating systems.

The reason for alliances in RISC technology is the improvement of the chip design and production. Therefore premier chip manufacturers form alliances. Examples are IBM and Motorola, Hewlett-Packard and Hitachi etc.. Furthermore the RISC chip manufacturers try to

[37] Web-Page of HP.

increase the penetration of the computer market with their proprietary technology. Therefore, strategic alliances are formed with workstation manufacturers who get the licence to produce the proprietary RISC chip technology. The following table shows the main players in the workstation market and their allies.

Main players	**DEC**	**Hewlett-Packard**	**IBM**	**Silicon Graphics**	**Sun Microsystems**
Allies	Cray	Convex	Apple	Acer	Amdahl
	Kubota	Hitachi	Groupe Bull	NEC	Control Data
	Mitsubishi	Mitsubishi	Motorola	Toshiba	Cray
		OKI			Fujitsu
		Prime			NEC
		Samsung			Solbourne
		Sequoia			Toshiba
					Unisys

Table 1: Main players in the workstation market and their allies[38]

As the table shows, Sun Microsystems and Hewlett-Packard in particular licence their RISC technology very aggressively. In 1992 Sun licensed their SPARC technology to over 40 clone makers.[39]

Also in the field of operation systems workstation manufacturers form strategic alliances to enforce the development of an standard operating system which is compatible with the own chip technology. The demand for open systems has grown in recent years. If one of the strategy alliance could establish a standard operating system on the base of their proprietary chip technology this would be a large competition factor. In particular, the penetration of the system software market increases if several chip manufacturers develop an operating system together which is compatible with their chip technology. The aim is an industry standard from which the owner will benefit mostly. Furthermore, the manufacturers with a broad range of computers will ensure, with their participation in such alliances, that the new developments

[38] U. S. International Trade Commission (1993), p. 121.
[39] U. S. International Trade Commission (1993), p. 120.

closely resemble their other operating systems for mainframe and mini-computers. Strategic alliances with the aim of developing a unified version of the UNIX operating system are: Advanced Computing Environment (ACE), Common Open Software Environment (COSE) and Open System Foundation (OSF).[40]

2.3. The mini- and mainframe computer segment

The market for mini- and mainframe computers is the mature market out of the four different segments. The market segment has a wide range in prices and processing power. So the processing power lies between 50 and 375 MIPS with prices between $25,000 and $1,000,000. The previously distinguished markets of mini- and mainframe computers had converged in recent years, because more and more customers use minicomputers and workstations as servers; a function once only performed by mainframes. Mini- and mainframe computers also face competition from networked workstations and personal computers which are cheaper and becoming more and more powerful. Today the main application fields for mini- and mainframe computers will be mission critical applications, which require high volume on-line processing capacities, security and reliability. Additional mini- and mainframe computers will be used more and more as file servers and data base managers in a file-server-relationship.[41]

In 1996 the value of the mini and mainframe computer segment was 12,703 million ECU. With 29% market share in terms of value it was the second largest out of the four computer market segments.[42]

[40] U. S. International Trade Commission (1993), p. 122.
[41] U. S. International Trade Commission (1993), p. 123
[42] EITO (1997), p. 240-316.

2.3.1. Sources of innovation in the mini- and mainframe computer segment

As with workstations the sources of innovation are normally internal R&D. Because most companies use a proprietary technology and the quality of the computers is the crucial competition factor, the manufacturers did not outsource the development and the production of components.

2.3.2. Competition in the mini- and mainframe computer market segment

Downstream competition axes:

Passive:

- quality
- maintenance/support
- network capabilities
- processing power
- availability of specialised components

Active:

- price
- available software

Passive competition axes in the market segment for mini and mainframe computers are the quality, the maintenance and support, network capabilities and the processing power.

Because of the mission-critical application fields where the mini- and mainframe computers are used, the quality, maintenance and support are the decisive competition factors in this market segment of the computer market. The breaking down of the server would mean the breaking down of the entire computer system and with it the business activity. Especially in banking and insurance, mainframes are used as servers for their large data bases. Mostly, the systems are

secured twice to prevent the break down of the entire computer system. After all, it is a question of the quality of the computers if they often have trouble or not. In the case of a breakdown of the entire computer system, quick and competent support is needed. So without professional support and maintenance, a mini and mainframe supplier has no chances of entering and being successful in this market segment.
Another important competition axis is the network capabilities of the product offered. Because almost all mini and mainframe computers still use proprietary technologies, the question after the network capabilities of the computer is a question of the offering enterprise. In contrast to the PC market where highly specialised components manufacturers guarantee the quality, performance and compatibility of the network components, in the mini and mainframe market it is still a question of the computer manufacturer and his knowledge of network technology.

Another passive competition axis is the availability of specialised peripherals. Because of the proprietary technology used the customer is, in questions of required peripherals, dependent on the supply of his computer manufacturer. So for example a bank must be sure that the supplier is able to deliver all needed peripherals for the banking business (e.g. statement of account printer, cash machines and so on). Because of the proprietary technology used, no other supplier for these peripherals generally exists or is able to guarantee that they work proper together with the central (e.g. mainframe) computer. So if the computer manufacturer did not manufacture such peripherals himself then he must guarantee that external peripherals work faultless together with the computer system offered. So, computer enterprises often focus their activity on the demands of a special branch for which they offer all the required peripherals.

The processing power as competition axis has lost its importance in recent years because more and more manufacturers use a parallel processing architecture based on RISC technology. This means that the processing power is scaleable through additional processors which can be added without a problem. So the exact desired processing power can be offered for every customer and his needs.

Because almost all mini and mainframe manufacturers fulfil the required conditions for a successful presence, in this market segment the price becomes more and more important competition axis. The price is therefore an active competition axis.

Another active competition axis is the available software. Because of the proprietary computer technology used in this market segment the manufacturer must guarantee the availability of software for his products. Mostly the manufacturers develop software themselves for their computers and external software houses only offer products for mini and mainframe computers sometimes.

Upstream competition axes:

- R&D
- public financed research and development programs

R&D is a crucial upstream competition axis in the mini and mainframe computer market segment. Because this market segment is not characterised by an open architecture, the development of own computer technology is the condition of entering this market segment. As an entry condition for this market segment every manufacturer must be able to offer a comparable computer technology, in terms of processing power and reliability, to their competitors. This leads to an innovation pressure because no enterprise can afford to lose the connection to the newest developments in computer technology. It should be stated again that this is only the condition for entry into this market segment. Later success depends on the downstream competition axes described above.

In the market segment for mini and mainframe computers, publicly financed R&D programs play a role. USA, Europe and Japan are largely involved in initiating and supporting R&D programs in computer technology. An example of such projects is the European Strategic Programme for Research and Development in Information Technology (ESPRIT) which advances the pre-competition research and economic integration in information processing, micro-electronics, office automation, software and flexible manufacturing. Mostly large computer manufacturers play a leading role in such projects.[43]

[43] Cf. U. S. International Trade Commission (1993), p.90-96, f or a detailed description of the different programs.

2.4. Supercomputer market

The first supercomputer was introduced in 1976 by Grey Research. Supercomputers incorporate the most sophisticated computer technology. The processing power of supercomputers reaches tens of billions of floating-point operations per second (gigaflop) and the prices are below $1,000,000. Because of the high prices the usage is limited to large industries or publicly financed research institutions (e. g. aerospace, automotive, chemical, environmental and petroleum industries as well as universities and governmental entities). For example SGI and Cray will deliver *a $110 million* supercomputer to Los Alamos National Laboratories in 1998 which will perform more than 3 teraflops or 3 trillion calculations per second.[44]

The application fields for supercomputers are applications which require the manipulation of vast quantities of data. They are used for computational modelling, complex simulations, and intricate scientific and industrial problem solving.[45] The demand for supercomputers fell in recent years immensely because with the end of the Cold War the government expenses for supercomputers were dramatically cut. So the governments did not spend any more whatever it took to get more speed for designing nuclear weapons or breaking codes.[46]

In 1996 the market segment for supercomputers had a value of 5,057 million ECU. With 11% market share in terms of value it is the third largest out of the four market segments.[47]

2.4.1. Sources of innovation in the market segment of supercomputers

Supercomputers are the fastest computers at any given time. Therefor the development is driven by the quest for higher speed. So, the sources of innovation are the internal R&D capacities. Only the capability of building one of the fastest computers in the world set an enterprise in the position to participate in the market segment for supercomputers. The working together of the several components by highest seed as possible require that all components stand the heavy demands of such a computer system. So to create a

[44] Browder (1996), p. 68.
[45] U. S. International Trade Commission (1993), p. 72-73.
[46] Browder (1996), p. 66.
[47] EITO (1997), p. 240-316.

supercomputer every component must be newly developed to correspond to the new computer technology.[48]

2.4.2. Competition in the supercomputer market segment

Downstream competition axes:

Active:

- processing power
- software writing assistance/support

In the market segment for supercomputers only active competition axes exist. The reason for this is that the manufacturers of supercomputers are just starting to find out what the demands of private enterprises in terms of supercomputing are. After the end of the Cold War, the manufacturers of supercomputers have to find new customers and to set up a business in this market segment. Therefore no established enterprises or competition axes exist.

The processing power and software writing assistance/support are used by the manufacturers of supercomputers as active competition axes. Because the application fields for supercomputers are the most complex today, the processing power is the most important competition factor. Mostly the available processing power decides if a project in the industry can be carried out or not. So complex molecular modelling in the chemistry industry is only possible with large capacities of computer processing power.

The second important competition axis is the available software for the supercomputers. In former times where mainly laboratories or universities used supercomputers the processing power was only used for experimental calculation programs. Such programs were mostly self programmed and run only one time. So the need for software writing assistance has no great importance. But since the eighties the supercomputers hold entry in the industry. The importance for application software is rising and is today a very important competition axis.[49] So, for example, Cray Research entered a consortium with pharmaceutical and chemical firms,

[48] Elzen/MacKenzie (1993), p. 119.
[49] Elzen/MacKenzie (1993), p. 119-120.

such as E.I. Du Pont de Nemours and Co. and Eli Lilly and Co. to develop molecular modelling software.[50]

So in conclusion we can say that processing power is no longer enough in the market segment for supercomputers.[51]

Upstream competition axes:

- R&D
- publicly financed R&D programs

R&D is the striking upstream competition factor in the supercomputer segment because of the importance of the processing power. Only with the most sophisticated computer technology is it possible to be successful in this market segment. R&D is traditionally focused on enhancing the processing speed of the computer. But this means that R&D is not only focused on the hardware but also on all components (e. g. software, hardware, components etc.) and the smooth working together of them. Cray Research, for example, invested 20% of their revenues on R&D in 1992.[52]

If manufacturers get public financial means for R&D in computer technology or if they get pre-competition research financed by the state this is a competition advantage if other enterprises are hindered from benefiting from such programs. But mostly it is not possible to hamper the participation of other enterprises in such projects. Nevertheless, such projects are attractive to lower the development costs of new computer technologies.

2.5. Conclusions

The computer market is still in its infant phase. The developments in computer technology lead to a quick penetration of the economy with computers of all segments. The development of computer technology also shifts the importance of the four computer market segments. The processing power of the PCs has risen immensely in recent years and therefore pushes into the

[50] U. S. International Trade Commission (1993), p. 133.
[51] Elzen/MacKenzie (1993), p. 145.
[52] U. S. International Trade Commission (1993), p. 131.

application fields formerly dominated by workstations. With the sharp drop in PCs prices, PCs became a cheap alternative to the workstations. In addition to this, the developments in network technology enable downsizing in data processing. Large computers like mini and mainframe computers are replaced by PC networks. The tasks of workstations and mini and mainframe computers shift more and more to server services like file and data storage. This development has led to the rising importance of the PC market segment in recent years. Today the PC market segment is the largest in the computer market (in 1996 in the EC the PC market had a 53% share in terms of value[53]).

In contrast to the other market segments the open PC architecture leads to great competition between large and small and medium PC manufacturers. The high standardisation of PC components leads to the disintegration of entry barriers to the PC market. So on regional markets small regional enterprises compete with large international manufacturers. Nevertheless, the entry barriers in the professional market are higher than in the home user market segment, because of existing passive competition axes which must be fulfilled by new entering enterprises.
PC clone makers but also PC brand name manufacturers benefit from the innovations of their highly specialised component suppliers. Only some large PC brand name manufacturers have their own R&D capacities for the development of PC components. The most important components in PC technology, the processor and the operating system, are dominated world-wide by the American enterprises Intel (about 85% market share) and Microsoft (90% market share). From which S&T system the PC manufacturers benefit depends on their supplier and the science and technology system (S&T system) they use. In the case of Intel it would be the American.

In the other market segments the situation is completely different. Proprietary technology dominates in these computer classes. A participation in those market segments is therefore only possible if enterprises develop a competitive computer technology themselves. Processors and operating systems are not freely available on the market so that an internal R&D capacity is needed. Furthermore, service, support and maintenance are of crucial importance in those market segments. With their proprietary technology the computer manufacturers ensure that only they can offer such demanded services. The customers in these market segments

[53] EITO (1997), p. 240-316.

furthermore demand problem solution capacities from their suppliers. This mean that the computer manufacturers must be able to handle large projects. They must be able to offer the hardware, the software, the required peripherals, the installation and the training of personnel of the customer. The competition is characterised by passive competition axes which work as high entry barriers. Therefore the market situation in these market segments is stable. Figures show that 15 of the top 20 firms in 1993 were also in the top 20 in 1985, and 7 of the top 10 in 1993 were in the top 10 in 1985 measured in terms of IT revenue.[54] The R&D capacities are mostly home-based and only the production of developed components is transferred to own production locations in other countries.

3. The computer manufacturing industry in Central and Eastern Europe

With the collapse of the socialist system the computer industry collapsed too. The opening of the formerly closed markets in Central and Eastern Europe smoothed the way for international computer manufacturers. The highly competitive, well organised and well financed computer vendors forced the regional obsolete computer industry into strong competition. As a result the local state-owned computer manufacturing organisations either collapsed or turned their activity to assembling low cost PCs. The collapse of obsolete capacities released personnel to the newly emerging private computer industry.[55] Entrepreneurs took over shut down facilities and started to assemble PCs, whereas the required components were imported from the Far East.

The market for larger computers collapsed totally because of the unstable financial situation of the potential demanding private customers. This lack of financial demand for larger computer systems leads to a large domination of PCs in the CEE and CIS computer market. The main customers remain government agencies and administrations, agricultural co-operatives and state enterprises which were supported financially by the World Bank, the European Bank for Reconstruction and Development (ERBD) and the European Community (EC).[56]

[54] Vickery (1996), p. 124.
[55] EITO (1993), p. 145.
[56] EITO (1993), p. 153.

After the initial stormy years when the economic situation became more stable, the strong competition had left only a few very successful private domestic assemblers in the PC market. In a further development the PC computer industry assimilated market structures similar to the West.[57]

In the higher market segments the domestic industry was shut down completely. The useful remnants of the industry were acquired by international manufacturers to serve as local distribution and support points. In the following years the major players in those segments opened wholly-owned subsidiaries in nearly all of the CEE and CIS countries.

3.1. Poland

In 1996 the Polish computer market had a value of 523 million ECU which is about 1% of the EC computer market. In comparison to Spain, the Polish computer market has a value of only 25% for the Spanish computer market.[58] The most important segment is the PC segment with a value share of 85%. It is followed by mini- and mainframe computers with 12%, workstations with 2 % and supercomputers with 1%.

[57] EITO (1993), p. 166-167.
[58] Data source: EITO (1997), p. 240-316.

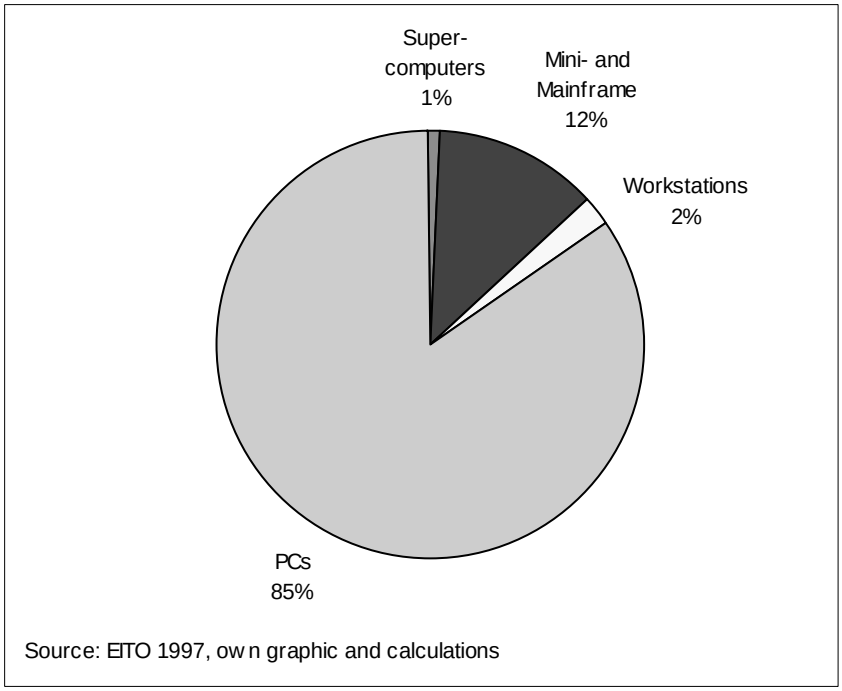

Diagram 4: Market shares of the different computer classes in Poland in 1996 in terms of value

The Polish government is the largest purchaser of information technology and therefore supports the penetration of the economy by information technology. In 1994 the Polish government spent 112 million ECU on hardware, software and professional services. Furthermore, the Polish government created several official organisations which are to support the computerisation of the public sector. Examples are the "Office for Information Technology" created in 1991 and the "Government Plenipotentiary Office for Informatics" created in 1994. Nevertheless, the penetration of the economy by computers is low as can be seen in that only 19 PCs were installed per 100 white collar workers. In comparison to this, in western Europe the number is 88 and in Spain 80.[59]

The PC market

In contrast to the western PC markets the home user market has no importance in Poland. In 1993 the home user market was only 2% of the complete PC market value in Poland. Because of the low entry barriers in the PC market, domestic enterprises are strong in this market segment. 5 polish PC manufacturers are in the top 10 of PC manufacturers in Poland. To

[59] EITO (1997), p. 62-63.

support this strong position of domestic PC manufacturers the Polish government has tried several times to protect them through an increase in the customs duties and the introduction of import quotas. But the increase of the customs duties for computer components in particular met with negative reactions among the domestic PC assemblers. As a result of this the government introduced import quotas for the import of information technologies.[60]

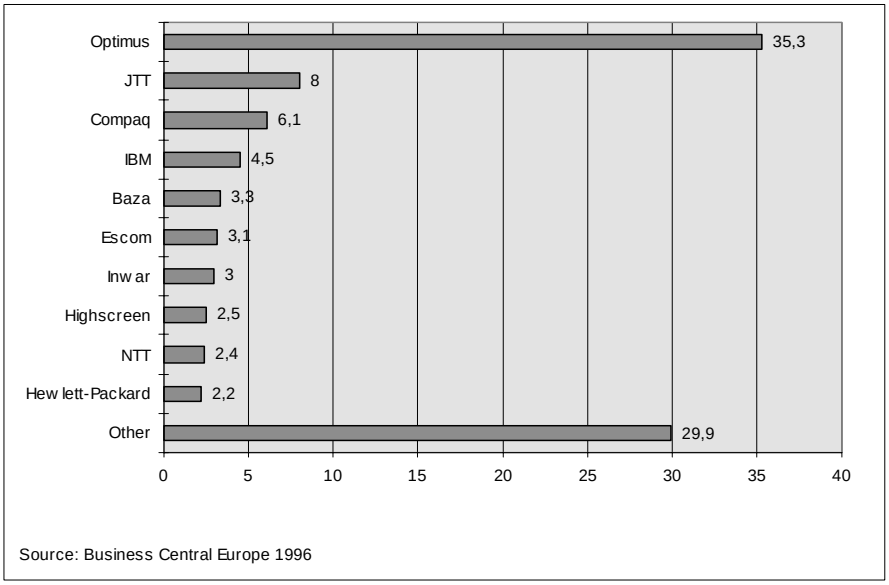

Diagram 5: Top 10 PC manufacturers in Poland Jan-Jun 1996

Nevertheless, the domestic manufacturers are losing shares in the Polish PC market. In 1995 only 3 western enterprises were in the top 10 of PC manufacturers in the Polish PC market, whereas in the beginning of 1996 there were 5 western manufacturers.[61] The market leader Optimus holds a share of 35.3% of the Polish computer market measured in units.[62] The top 10 manufacturers together hold about 70% of the Polish PC market. In 1995 they had 80%.

The other three computer market segments

The remaining three computer market segments are quickly summarised. After 1990 the semiconductor and mainframe industry collapsed completely. The once biggest mainframe manufacturer ELWRO switched to car alarms. Finally it was acquired by Siemens and it will be

[60] Cf. EITO (1994), p. 176-177, for a detailed description of the single governmental activities carried out to protect the domestic information industry.
[61] Computerworld (1996).
[62] O. V. (1996), p. 6.

shut down as computer factory.[63] The market segments for workstations, mini and mainframe as well as supercomputers are now fully under the control of the international market leaders in computer technology like IBM, HP, SUN, Siemens, etc..[64]

3.2. Hungary

In 1996 the Hungarian computer market had a value of 239 million ECU; this was 0.5% of the EC and 12% of the Spanish computer market. In Hungary the PC market segment has the largest importance of the four computer segments. 78% of the overall computer market fall to the PC segment. It is followed by mini- and mainframe computers (18%), workstations (3%) and supercomputers (1%).[65]

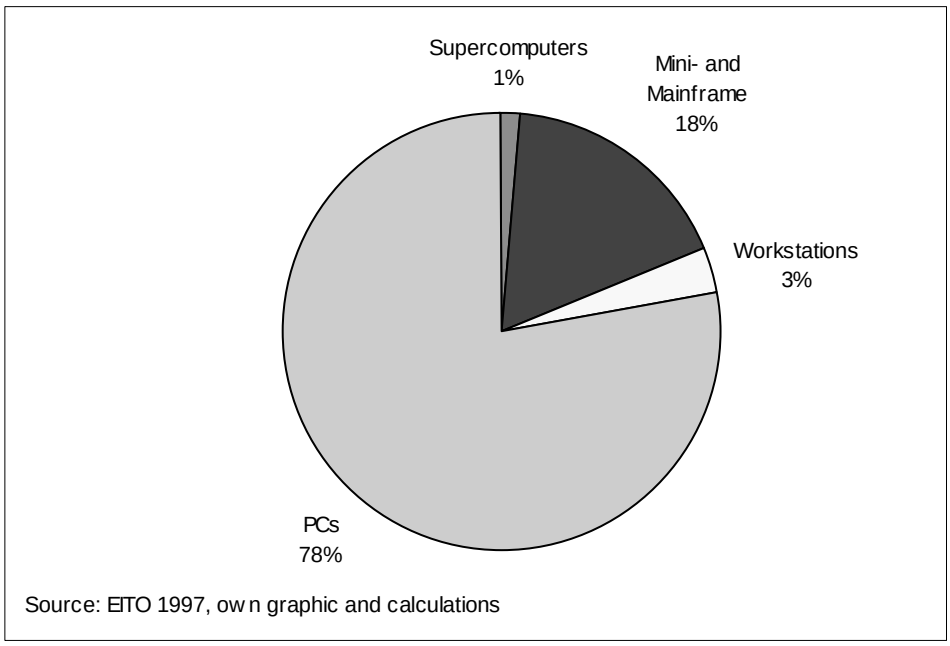

Diagram 6: Market shares of different computer classes in Hungary in 1996 in terms of value

The Hungarian government has become more active in recent years in supporting information technology development. The "Hungarian Co-ordination Office of Governmental Information

[63] Kubielas (1996), p. 24.
[64] Kubielas (1996), p. 24. EITO (1993), p. 153.
[65] EITO (1997), p. 240-316.

Systems" defined the computerisation strategy for the public sector. So, all installed equipment in public administrations has to support open system standards.[66]

With 34 PCs installed per 100 white collar workers Hungary has the largest penetration of the economy by PCs of all CEE and CIS countries. Nevertheless in comparison to western European countries it is a quite low penetration (Western Europe 88, Spain 80).[67]

The PC market segment

The PC market segment is dominated by domestic PC assemblers. Only 5 of the top 10 PC manufacturers in Hungary are western enterprises. The market leader ALBACOMP had a market share of 14.3% of all sold units in Jan-Jun 1996.[68] After the first rush of backlog demand is saturated, the price as the decisive factor is replaced by quality and support as the decisive factor of the customers in the PC market segment.[69]

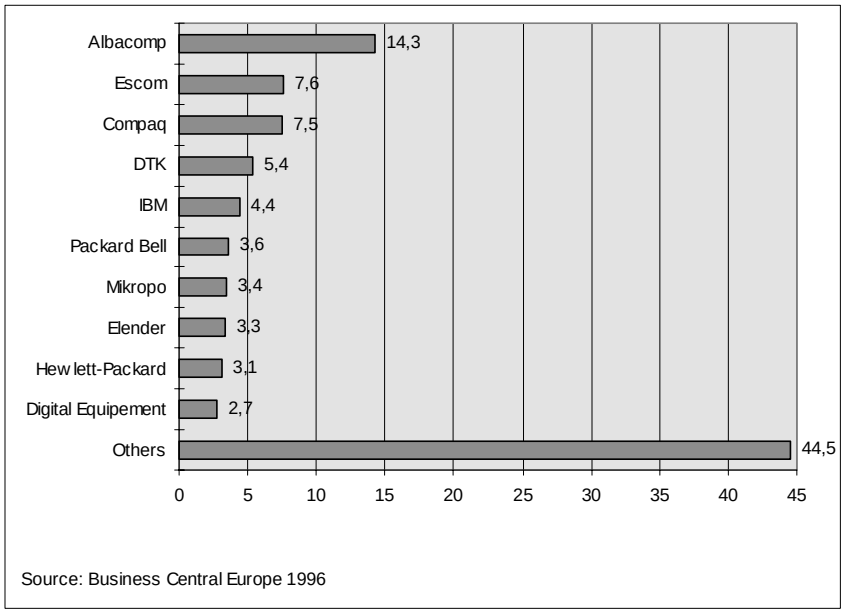

Diagram 7: Top 10 PC manufacturers in Hungary Jan-Jun 1996

The other three computer market segments

[66] EITO (1997), p. 60-61.
[67] EITO (1997), p. 63.
[68] O. V. (1996), p. 6.
[69] EITO (1994), p. 168.

As in Poland the remaining three computer market segments for workstations, mini and mainframe as well as supercomputers are controlled by the international market leaders in computer technology like IBM, HP, SUN, Siemens, etc..[70]

3.3. Czech Republic

In 1996 the Czech computer market had a value of 483 million ECU which corresponded to 1% of the EC and 25% of the Spanish computer market. As in the other eastern European countries the PC market segment is largely dominant with a share of 80% of the whole computer market value. Mini and mainframe computers have 16%, workstations 3% and supercomputers 1% of the overall computer market.[71]

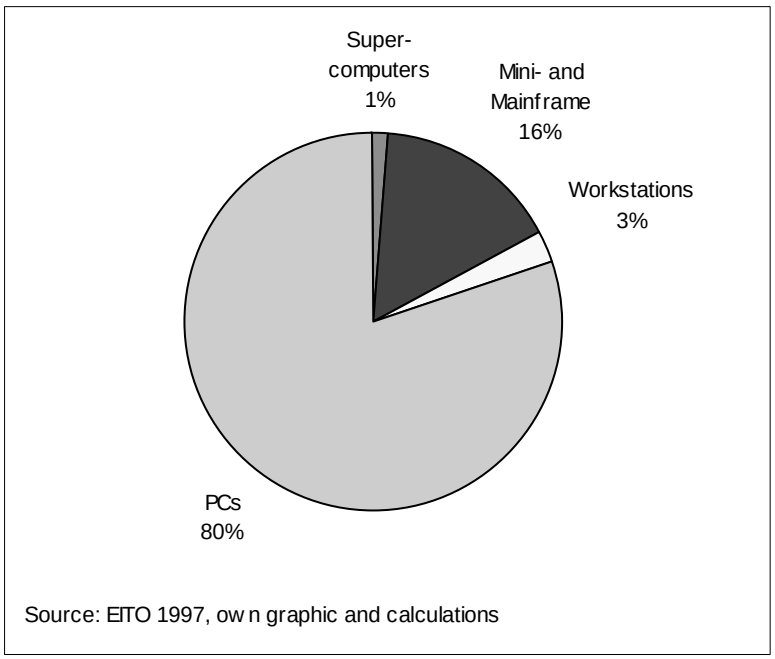

Diagram 8: Market shares of different computer classes in the Czech Republic in 1996 in terms of value

[70] EITO (1993), p. 153.
[71] EITO (1997), p. 240-316.

In the Czech Republic banking and financial services, government administration, insurance, industry and manufacturing, telecommunication, health services, transportation and small private firms will be the main customers of computer technology in the years to come.[72]

The PC market segment

In contrast to all other CEE and CIS countries in the Czech Republic a western enterprise is the market leader in the PC market segment. IBM leads with a market share of 10.4% of all sold units. The market position of the domestic enterprises is not as strong in the Czech Republic as in other CEE countries. Only 4 of the top 10 PC manufacturers are domestic enterprises. The market segment has the highest share of western penetration and the big western brands together hold about one-third of the PC market.[73] The market structure mirrors the trend in the Czech Republic that for customers in recent years the importance shifts more and more from price as decisive factor to quality and support.[74]
In the Czech Republic 26 PCs are installed per 100 white collar workers. This is the second highest penetration in the CEE and CIS countries.[75]

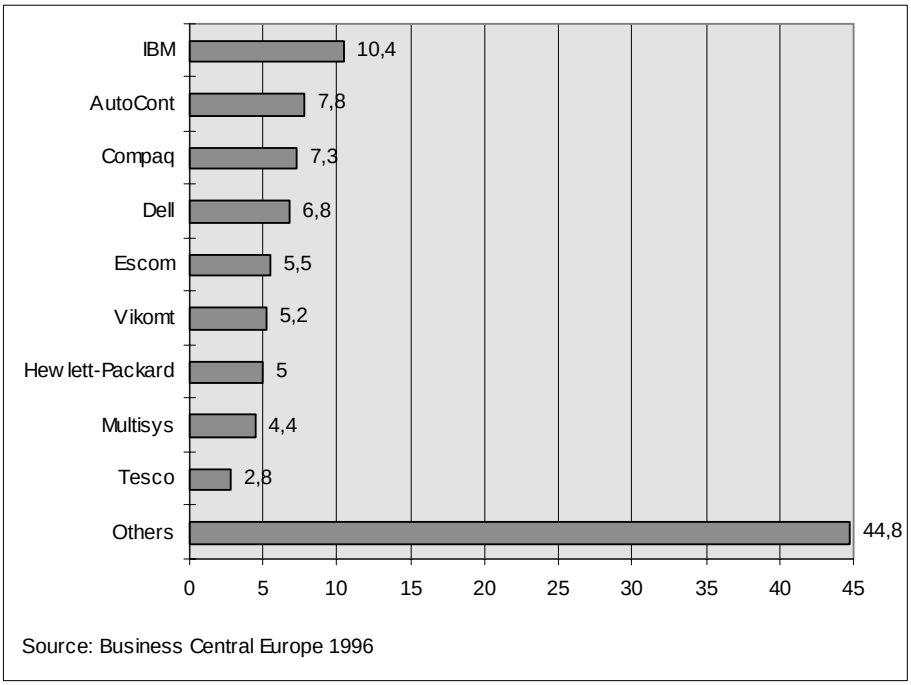

Diagram 9: Top 10 PC manufacturers in the Czech Republic Jan-Jun 1996

[72] EITO (1997), p. 59-60.
[73] O. V. (1996), p. 6.
[74] EITO (1994), p. 159.
[75] EITO (1997), p. 63.

The home user market plays no role in the Czech PC market. Only about 1% were sold to private home users. So the professional application of PCs dominate in the competition of PC manufacturers.[76]

The other three computer market segments

As in the other eastern European countries the three other market segments are completely controlled by the leading western enterprises in computer technology.

3.4. Russia

The computer market in Russia had a value of 1,489 million ECU in 1996 which corresponded to 3% of the EC and 76% of the Spanish computer market. In Russia the PC market segment is also the largest of the four analysed. The value of the PC market segment has 88% of the overall computer market. It is followed by mini and mainframe with 9%, workstations with 2% and supercomputers with 1%.[77]

[76] EITO (1993), p. 200-275.
[77] EITO (1997), p. 240-316.

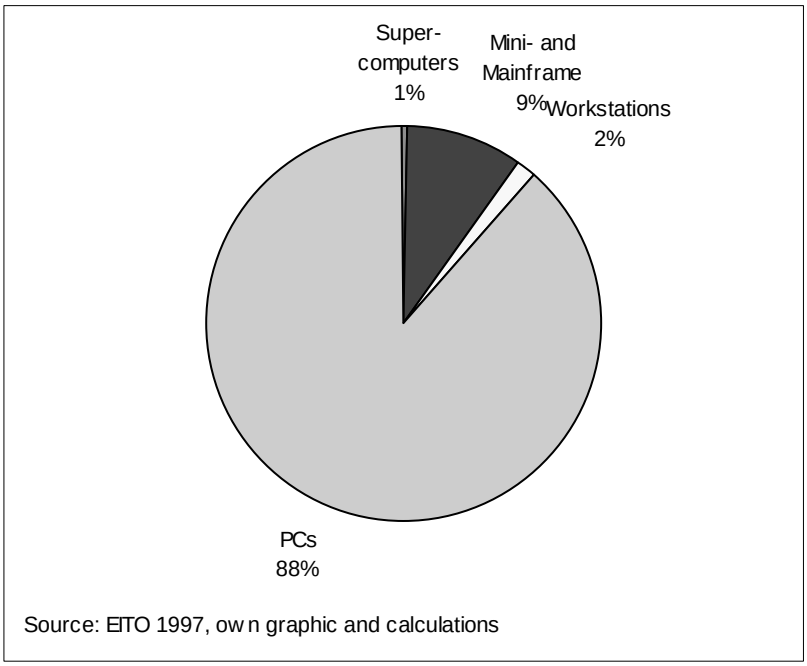

Diagram 10: Market shares of different computer classes in Russia in 1996 in terms of value

Although the Russian computer market is the largest (in terms of value) in Eastern Europe, the penetration of the economy measured in terms of installed PCs per 100 white collar workers is very low with 6, even in comparison to the other eastern European countries.[78]

The PC market segment

In Russia the domestic PC manufacturers are well positioned in the PC market segment. The market leader Vist is a Russian enterprise which has a market share of 14.6% of all sold units in Jan-Jun 1996. The two second ranked enterprises R+K and IBM both have a market share of 5.6%.[79]

[78] EITO (1997), p. 63.
[79] O. V. (1996), p. 6.

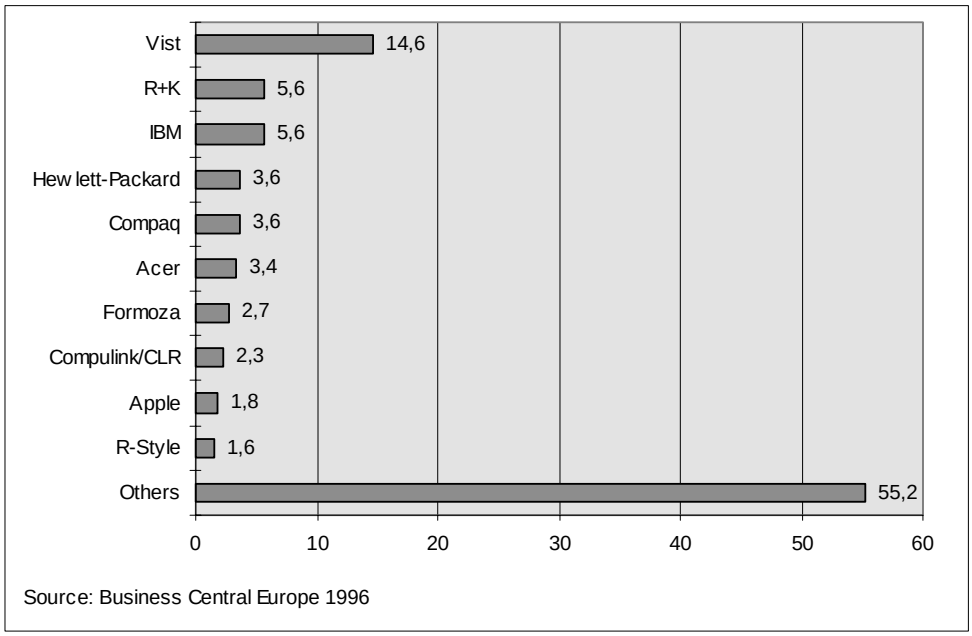

Diagram 11: Top 10 PC manufacturers in Russia Jan-Jun 1996

The home user market has no importance, as in all Eastern European countries. It had a value of about 1.25% of the complete PC market.

3.5. Conclusions

In Eastern European countries the PC market segment is by far the dominant one. At the same time it is the only segment where domestic enterprises were able to stand the competition of international computer enterprises. Often the market leader is a domestic PC manufacturer. All other computer market segments are controlled by the well-known large international computer companies. This market structure can be explained by the special production and competition conditions in the computer industry. In the PC market with its highly standardised products and components, the entry barriers for new entrants are low. Specialist knowledge for the production of PCs in not needed because the individual components required are highly standardised and assembling them is quite easy. The production process is not capital intensive and R&D capacities are not needed because all required components can be bought on the market. Because the computer market in Eastern European countries is in an early stage the main competition axes are the price and rapid availability. The home user market is

insignificant in all Eastern European countries. Competition axes, like quality and support, grow with the saturation of the backlog demand, in some countries a shift to quality and support as decisive buying factors can already be observed.

In the higher computer market segments (workstation, mini and mainframe and supercomputer) the situation is completely different. Here proprietary technology still dominates the computer products of the different manufacturers. The price is of lower importance here and knowledge is the condition for successful entry into the market segments. All Eastern European manufacturers collapsed because their obsolete technology was not able to stand the competition of the large international computer companies. In contrast to the PC market it was not possible to participate in this market segment without knowledge of modern computer technology and especially processor technology. The remaining parts of the former higher computer industry, and here in particular the employees, were acquired by international computer enterprises as distribution or support points. The development of the higher computer market segments is hampered by the poor financial condition of the potential customers for this market segment. Mainly the banking and finance services, manufacturing industry , insurance and state administrations lack the financial means to order large data processing systems. Instead of these large data processing systems, PC solutions were preferred because of their lower price.

The hardware spending in the region is still much lower than the average in western Europe, despite large financial programs to support the computerisation of those economies.

4. The computer industry and a science and technology policy in the CEE and CIS countries

4.1. The computer industry and its connections to the science and technology system in the CEE and CIS countries

The surprising result of the analysis is that the computer industry in Eastern European countries has no direct linkage to the S&T system and that a S&T system for computer technology in Eastern European countries is not needed corresponding to the computer market structure today.

In the PC market segment the sources of innovation are the suppliers of the components. The required components were mostly imported from the Far East, Japan or the USA. In Eastern European countries only the last step of the PC production, the assembly of the several highly standardised parts, is carried out. The domestic PC manufacturers use the S&T system of foreign countries for the production of the computers. They benefit from the S&T system to which their component suppliers are connected.

In the case of the three higher market segments the result is once again easier as in the PC market segment. Because no considerable production exist in Eastern Europe a S&T system is not needed for computer technology.

The maintenance of the obsolete R&D capacities or even the construction of new capacities would be a useless undertaking in respect to the technological lead, and with it the competition advantage, of the international computer manufacturers. The history of the development of the information technology industry shows that accumulated knowledge can only be caught up by new enterprises in this business with great difficulty. A historical comparison shows that 15 of the top 20 IT firms in 1993 in terms of revenue were also in the top 20 in 1985 and 7 of the top 10 were in the top 10 in 1985.[80]

[80] Vickery (1996), p. 124.

4.2. Possible starting points for a science & technology policy

Now the question arises of which S&T policy should be carried out to support the domestic computer industry. As the analysis has shown, only domestic PC-assembling enterprises are still active in the computer industry in Eastern Europe. For the production of PCs R&D capacities are not needed and it should be added that also in western countries the R&D capacities for PC technology are small and are still decreasing. So, the building up of R&D capacities for PC technology would be a waste of means, corresponding to the development in the PC production world-wide.

The former manufacturers of larger computer systems collapsed totally. The market is dominated by the large international computer enterprises. The required R&D capacities for participation in such market segments had to be built up from the scratch. Specialists in computer technology agree that computer technology developed in the former Eastern Bloc is obsolete and uncompetitive. An analysis of the market structure and the competitors show that high entry barriers exist in the markets for workstations, mini and mainframe and supercomputers. So it is not astonishing that in the top 20 enterprises in IT revenues, only one did not exist 1985.[81]
This shows that the prospects for a successful S&T policy in the computer segments for workstations, mini and mainframe computer and supercomputer are quite bad.

A protection of the domestic computer industry would only lead to a loss of the connection to modern computer technology. In particular, the domestic PC assemblers would lose the supply of necessary components and with it their sources of innovation.

[81] Vickery (1996), p. 124.

Bibliography

Adirim, Itzchock (1991): Current Development and Dissemination of Computer Technology in the Soviet Economy; in: Soviet Studies; Vol 43, No. 4; p. 651-667.

Aspray, William (1993): Technological Competitiveness: Comtemporary and Historical Perspectives on the Electrical, Electronics and Computer Industry; in: Institute of Electrical and Electronics Engineers;

Beyfuß, Jörg (1996): Erfahrungen deutscher Auslandsinvestoren in Reformländern Mittel- und Osteuropas; in: Institut der deutschen Wirtschaft; Beiträge zur Wirtschafts- und Sozialpolitik; Nr. 232, 7/1996; Deutscher Instituts Verlag; Köln.

Bradley, Stephen P.; Hausmann, Jerry A.; Nolan, Richard L. (1993): Globalisation, Technology and Competition: the Diffusion of Computers and Telekommunications in the 1990s; Boston.

Browder, Seanna (1996): Supercomputing: Tera's Brave Old World; in: Business Week; November 11, 1996; p. 66-68.

Corchón, Luis; Wilkie, Simon (1994): Computers, Productivity and Market Structure; in: Instituto Valenciano de Investigaciones Económicas; WP-AD 94-17.

Denger, Katharina S. (1997): Wettbewerbsstrategien und Innovationsprozesse in der Computerindustrie; in: Dortmunder Diskussionsbeiträge zur Wirtschaftspolitik; Nr. 81; Dortmund.

Drüke, Helmut (1993): Restructuring in the PC Industry: New Challenges, New Actors, New Strategies; a Study in Labor and Industrial Policy; in: WZB; Papers; FS 2, No. 93-201; Berlin.

EITO (1993): European Information Technology Observatory 93.

EITO (1994): European Information Technology Observatory 94.

EITO (1995): European Information Technology Observatory 95.

EITO (1996): European Information Technology Observatory 96.

EITO (1997): European Information Technology Observatory 97.

Elzen, Boelie; MacKenzie, Donald (1993): From Megaflops to Total Solutions: The Changing Dynamics of Competitiveness in Supercomputing; in: Aspray, William [Edit.]; Technological Competitiveness: Contemporary and Historical Perspectives on the Electrical, Electronic, and Computerindustries; IEEE Press; New York.

Europäische Kommission (1995): Panorama der EU-Industrie 95/96; Amt für amtliche Veröffentlichungen der Europaischen Gemeinschaften; Luxemburg.

Flamm, Kenneth (1989): The Computer Industry in Industrialized Economies: Lessons for the Newly Industrializing; in: The World Bank Industry and Energy Department; Industry Series Paper; No. 8.

Flamm, Kenneth (1993): The Computer Industry; in: Developing the Electronics Industry; Washington; p. 43-55.

Forge, Simon (1991): Why the Computer Industry is Restructuring Now; in: Futures; Vol. 23, No. 9; p. 960-977.

Forge, Simon (1993): Business Models for the Computer Industry for the next Decade: When Will the Fastest Eat the Largest?; in: Futures; Vol. 25, No. 9; p. 923-948.

Glanz, Axel (1994): Standardisierung in der Computerindustrie; in: Homo Oeconomicus; Vol. 11, No. 3; p. 349-417.

Greenstein, Shane M. (1994): From Superminis to Supercomputers: Estimating Surplus in the Computing Market; in: National Bureau of Economic Research, Inc.; Working Paper Series; No. 4899.

Heide, Jan B.; Weiss, Allen M. (1995): Vendor Consideration and Switching Behavior for Buyers in High-Technology Markets; in: Journal of Marketing; Vol. 59, No. 3; p. 30-43.

Hertweck, Friedrich (1989): Vektor- und Parallel-Rechner: Vergangenheit, Gegenwart, Zukunft; in: Informationstechnik; Vol. 31, No. 1; München; p. 5-22.

Jagoda, Fritz; Sinn, Dieter (1994): Supercomputing: Der Engpaß ist die Software; in: Diebold Management Report; No. 12, 1994; p. 5-9.

Kauffmann, Manfred (1993): Marketing Analysen: Konzepte und Strategien im PC-Markt; München.

Kubielas, Stanislaw (1996): International Co-operative Agreements in Poland in the mid 1990s: Evolution, Organisational Forms and Industry Characteristics, Part I: Country Industrial Report; in: Faculty of Economic Science Warsaw University; Warsaw.

Littler, Dale; Wilson, Dominic (1991): Strategic Alliancing in Computerized Business Systems; in: Technovation; Vol. 11, No. 8; p. 457-473.

Malerba, Franco; Torrisi, Salvatore (1996): The Dynamics of Market Structure and Innovation in the Western European Software Industry; in: Mowery, David C.; The International Computer Software Industry; Oxford University Press; New York, Oxford; p. 165-196.

Meffert, Jürgen P. (1993): Standards als Integrationsinstrument in der Computer- und Kommunikationsindustrie: Wettbewerbsstrategische Bedeutung und Durchsetzung; in: Internationales Management; Bd. 9; Univ.-Verlag Konstanz; Konstanz.

Nelte, Hans-Ulrich (1995): Host vor dem Platzverweis?, Verschiedene Alternativen zum Mainframe bieten sich an; in: Business Computing; No. 1, 1995; p. 28-31.

o. V. (1993): Umbruch: Windows NT ist SAPs neue Basis für das Downsizing; in: PC Magazin; Nr. 20, 12. Mai 1993; p. 8.

o. V. (1996): Special Supplement: Information Technology; in: Business Central Europe; November 1996; p. 1-15.

o. V. (1997): Außergewöhnlich preissensitiv: Rußland entwickelt sich zu eigenwilligem High-Tech-Markt; in: Markt&Technik; No. 12, 21.3.1997; p. 13-18.

Park, Siyoung; Lewis, Lawrence T. (1991): Devlopments in the Location of Selected Computer-related Industries in the United States; in: Growth and Change; Vol. 22, No. 2; p. 17-35.

Schäfer, Klaus (1994): Moderne Kommunikations- und Informationstechnologien (KIT): Zur Bedeutung der KIT in den Ländern Mittel- und Osteuropas; in: Nomos Universitätsschriften: Medien; Bd. 11; Nomos; Baden-Baden.

Somma, Ernesto (1994): Intra-industry Trade in the European Computer Industry; in: Weltwirtschatliches Archiv; Vol. 130, No. 4; p. 784-799.

Stavins, Joanna (1995): Firm Strategies in the Personal Computer Market: Are Established Brands Better off?; in: New England Economic Review; Nov.,Dec. 1995; p. 13-24.

Stavins, Joanna (1995): Estimating Demand Elasticities in a Differentiated Product Industry: The Personal Computer Market; in: Working Paper Series/Federal Reserve Bank of Boston; No. 95-9, July 1995.

Steffens, John (1994): Newgames: Strategic Competition in the PC Revolution;

The Economist (1996): A World Gone Soft: A Survey of the Software Industry; in: The Economist; May 25th 1996.

Thore, Sten (1996): Economies of Scale in the US Computer Industry: An Empirical Investigation Using Data Envelopment Analysis; in: Journal of Evolutionary Economics; Vol. 6, No. 2; p. 199-216.

US International Trade Commission (1993): Global Competitiveness of US Advanced-Technology Industries: Computers; in: World Trade and Arbitration Materials; Vol. 6, No. 2; p. 55-141.

Vickery, Graham (1996): Globalisation in the Computer industry; in: OECD; Globalisation of Industry: Overview and Sector Reports; 109-151.

Wendel, Dieter (1995): Systemsrchitektur: Corporate Server und die Zukunft des Mainframes; in: Diebold Management Report; No. 6, 1995; p. 12-16.

Wilson, Robert W., Warren-Boulton, Frederick R. (1995): Riding the Wave: Exclusionary Practices in Markets for Microprocessors used in IBM-Compatible Personal Computers; in: International Journal of the Economics of Business; Vol. 2, No. 2; p. 241-261.