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TITLE: COMPUTER TECHNOLOGIES IN EASTERN EUROPE: THE IMPACT OF REFORM

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Computing Technologies in Eastern Europe: The Impact of Reform[1]

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1 Summary

Eastern Europe's poor performance in developing and applying computer technology – which acts as a drag on overall productivity and growth in the region – has for more than a decade fueled arguments for economic reform. Though they remain seriously deficient by Western standards, the computer industries of some East European countries are benefitting from national computerization programs, recent organizational changes, and greater involvement with the West. It is unlikely, however, that current reforms go far enough in addressing the systemic causes of the region's technological backwardness.

2 Introduction

"The gist of perestroika is to make Soviet society safe for the scientific-technological revolution."
–Silviu Brucan, former Romanian Ambassador to the United States and ex-editor of the Romanian Party newspaper.

Brucan, like a growing number of officials and intellectuals in Eastern Europe, recognizes that the success of economic reforms in the Soviet Bloc will hinge on their ability to develop and absorb modern technologies. Mikhail Gorbachev's strategy has gained a following, but it is by no means viewed as the sole path to a reformed economic system. In Romania, for example, Brucan was under house arrest when he endorsed perestroika.[1]

Nowhere is the failure to promote technological development more pronounced and its need for recovery strategies more acute than in the computing technologies. While most countries of the developed world are now economic beneficiaries of the information revolution, the six East European members of CMEA (CMEA-6) continue to struggle with basic innovation and application problems. The leaderships of Eastern Europe recognize that computing development is at the same time a prerequisite for international competitiveness and a fundamental challenge to the existing economic, political and even ideological orders in their countries. This dilemma has prompted differing assessments of the severity of economic crisis and the need to contemplate change. In this paper, we explore the approaches being employed in Eastern Europe to develop and apply computing, at the domestic level as well as through regional and international cooperation.[2]

[1] [Bruc88]

[2] This study builds on a decade-long research effort at the University of Arizona on Soviet and East European computer-related technologies. For background on CMEA integration efforts in computing technologies see [Mund81; Good82; Good85i; Good86c; Stap85b; Stap88]. For analyses of related issues in the Soviet context, see [Mche85; Good86i; Mche86i; Good87b; Stap88f].

3 Domestic Policies

3.1 Goals and Strategies

The CMEA-6 countries instituted a variety of national level programs, to promote innovation, production and use of the computer-related technologies. Since the early 1970s, different programs for computerization, electronization, robotization and informatization have been announced.[3] The East German leadership, for example, pursues a broad strategy of economic "intensification" – the progressive improvement of industrial efficiency and productivity – for which computing technologies are described as playing the key role. Fearing unreliable suppliers among its CMEA allies, and the effects of export controls in the West, East Germany has demonstrated an obsession with technological independence. Since the mid-1970s, it has invested more in the development of information technologies than any other East European country,[4] in an effort to build broad capabilities in microelectronics production, hardware manufacture and software development.

With virtually no technological tradition, Bulgaria has developed an electronics base that purportedly creates 18% of Bulgarian national income and 30% of all Bulgarian exports[5] – placing the country in third place globally in electronics production per capita.[6] Whether or not these claims are true, Bulgaria clearly has made the most progress in improving its electronics industry in the last 20 years. There are several reasons for this. Unlike other CMEA-6 countries, Bulgaria did not possess a strong heavy industry sector which might have lobbied against investment in the new technologies.[7] In addition, Bulgarian General Secretary Todor Zhivkov reportedly provided constant support to the country's budding computing industry as exemplified by the large microcomputer production complex in Zhivkov's native town of Pravets. Probably more than any other CMEA-6 country, Bulgaria also has benefited from CMEA integration, mainly through co-production arrangements with and market access to the USSR.[8]

Poland was once at the forefront of promoting computing in CMEA but its position has clearly deteriorated. In looking for a way to "fix" a malfunctioning economic system, Poland's leaders, in the early 1970s, decided to inject

[3] [See for example: Hyno88; Onic88; Pal87b; Neps86; Szen86b; Revi86b; Vyin85]

[4] In the current Five Year Plan, the GDR is devoting 9% of all state investments to the computing sector; significantly more, for example, than Czechoslovakia's 3.5% [Brat88b]

[5] [Przc86b]

[6] [Tryb87m]

[7] [Ivan88b]

[8] Over 80% of Bulgarian exports go to the Soviet Union [Klee88]. Of the TR25 billion planned for 1986-1990 CMEA trade in computing technologies [Ekon87], Bulgarian electronics exports to the Soviet Union are expected to account for TR7 billion [Alek88].

a large dose of computing technology. Grandiose projects were announced and the computing industry received large amounts of money (including hard currency) to finance systems-development projects that were to create a country-wide information system.[9] Most of these ambitious projects either never were completed or never gained the acceptance of their intended end-users. Following these disappointments, the computer industry in Poland went from riches to rags as investment capital dried up. Today, the state electronics industry constitutes only 3% of Polish industry, the same as 12 years ago.[10]

As in Poland, policymakers in Hungary recognized the potential of computing technologies early on. Unlike the Poles, however, the Hungarians have been more consistent and innovative in applying policies to promote those technologies. In addition to centrally administered programs, competitions have been announced to produce the most needed computing products – such as local area networks, teleprocessing services[11] and professional personal computers.[12] In response to these announcements, Hungarian firms submit descriptions of proposed projects and price bids for finished products. The most attractive bids receive state resources. Although the competitions sometimes are criticized for not being competitive enough and for fostering less-efficient domestic production when prices of the same products in the West have been declining,[13] they also are expected to regulate and standardize the private Hungarian computing markets. For example, the competition for professional personal computers is likely to shift the production of microcomputers from some 100 small producers of often incompatible equipment[14] to six firms selected for their best bids.

Romania and Czechoslovakia have been the least active in promoting computing technologies on the national level. The autarkic policies of President Nicolae Ceaucescu show no concern about the effects of falling behind. A Romanian initiative to promote computer-aided research and design (CAD) applications in industry is part of the program for the "Introduction of Technical Progress in the 1986-1990 Period," but seems to have made little progress.[15] In Czechoslovakia, policy makers apparently are beginning to appreciate the dangers of continuing on the rather lethargic course they have followed. In 1987, a high-technology production association called "Mikroelektronika" – a loose joining of some 120 enterprises involved in the research, manufacture or servicing of computer technology – was formed. The association has set high production targets for microcomputers and appears to be

[9] [Bozy83]
[10] [Tygo87b]
[11] [S85]
[12] This is a term used often in Eastern Europe to describe larger microcomputers suitable for engineering applications.
[13] [Vert87c]
[14] [Impu87]
[15] [Revi86; Revi86b]

moving fairly quickly to improve coordination among its constituent bureaucracies.[16]

3.2 Organizational Structures for Computer Production

Most of the CMEA-6 have shown a recent willingness to undertake organizational reforms in the pursuit of improved computer production. Only East Germany and Romania officially disavow a need for change.

East German computing enterprises are integrated into the country's combine system, developed in the 1970s to improve linkages between R&D organizations, manufacturers and foreign trade outlets in similar product categories. The GDR's Ministry for Electronics Technology oversees 17 combines. Those most prominently involved in computing production are Robotron, East Germany's principal computer hardware producer; Carl Zeiss Jena, which manufactures high-end microprocessors and microelectronics-production equipment, and Mikroelektronik, which produces 64K RAM chips and low-end microprocessors. Each of these combines consists of as many as 40 subsidiary firms with separate managements subordinate to the combine's general director. Research links between these subsidiaries and East Germany's major universities are common. Though benefiting from the economies of scale created by their size, East Germany's electronics combines suffer from the constraints on innovation and entrepreneurial management inherent in their hierarchical structures.[17] Only recently, for example, were combine general directors given limited authority to invest the hard currency earned by their exports. They still lack genuine control over state investment in their combines, product assortment and the setting of wages and prices.[18] Despite pressure from management ranks for greater decentralization, however, the East German Politburo clings to its attitude that the development of the combine system was all the "reform" needed in the country.

Similarly in Romania, the leadership has rejected any need for structural reform, arguing that it instituted major changes in 1978 by allowing enterprises to make their own production and sales decisions.[19] Computer production in Romania remains highly centralized in the Electronic Computer Enterprise, which was established in 1972 and produces the country's outdated "Felix" line of computers. The Computer Technology Research Center, which designs computers and does some software development, and the peripheral manufacturer Feper round out Romania's "Electronics and Computer Technology Industrial Center" near Bucharest.[20]

[16] [Bula88]
[17] [Klin87]
[18] [Bayl87]
[19] [Tagl87d]
[20] [Broc84]

The remaining East European countries recently have made at least some effort to improve on existing organizational structures. Czechoslovakia's computing production takes place in two large electronics concerns and numerous smaller-scale state enterprises–including more than 60 agricultural combines.[21] The Tesla organization, with plants throughout the country, designs and manufactures microprocessors, electronic consumer goods and telecommunications components, while the firm ZVT builds many of Czechoslovakia's finished computer systems. Though Tesla and ZVT remain highly centralized and hierarchical in structure, the country's new production organization, Mikroelektronika, operates under the oversight of the agricultural cooperative Agrokombinat Slusovice, which has earned a reputation for productivity with its profit-oriented management style and incentive systems for workers.[22] Formed in 1949 as an ordinary collective farm, Slusovice evolved into a quasi-capitalistic enterprise in which some 4,000 well-paid workers raise cattle, tend corn and assemble personal computers (PCs) almost side-by-side. Slusovice manufactured its first 40 PCs in 1982, and this year is expected to produce some 30,000, making it the largest microcomputer manufacturer in Czechoslovakia.

In contrast to Czechoslovakia where the Ministry of Electrotechnical Industry still issues directive plans, Hungary has eliminated direct state supervision of the electronics branch. However, national planning and coordination in computing technologies remains the responsibility of three central organizations: the Ministry of Industry, the National Technical Development Committee (OMFB) and the National Materials and Price Office. These three cooperate in formulating and administering the competition programs discussed above. Hungary's largest state producers of computing technologies are Videoton, Orion, MEV, Medicor, BGH, and MOM.[23] In addition, the Hungarian-West German joint venture "Selectronic" is the third largest Hungarian producer (after Videoton and Orion) of applied electronics.[24]

An innovative type of organization in both the Polish and Hungarian computing industries is the domestic joint venture. In Poland, the "Mikrokomputery" cooperative is a venture of fifteen state enterprises to produce microcomputers.[25] In Hungary, Ministry of Industry and OMFB have actively supported the creation of associations of key Hungarian computing enterprises to jointly take part in the competition programs. The PerComp Association, for example, created to take part in the competition for professional personal computers, is made up of six cooperatives and a trading firm.[26]

[21] [Cero87]
[22] [Prik88]
[23] [Szam87]
[24] [Male88]
[25] [Szac86]
[26] [Szte87c]

Poland and Bulgaria recently have reorganized the central bureaucracies supervising their electronics industries. Following the example of Hungary, Poland merged four industrial ministries – including the former electronics overseer, the Ministry of Metallurgy and Machine Industry – into one Ministry of Industry.[27] In Bulgaria, the new Ministry of Economics and Planning is responsible for strategic management of the whole industrial economy.[28] Below the ministerial level, in both countries, new organizations were created to coordinate electronics production – in Bulgaria the Electronics Association (EA), and in Poland the Elpol ("ELektronika POLska") cooperative.

The Bulgarian EA functions with a novel branch and inter-branch structure. The key organizations of the Bulgarian computing industry are regrouped into a number of economic trusts and combines responsible for different production tasks. To complete the research-production-marketing complex, a research institute and an investment organization are subordinated to EA as well.[29] Inter-branch coordination is accomplished through electronization centers that are to be members of both EA and of some other branch association.[30] This dual membership is intended to promote more effective utilization of new technologies in all branches of the economy.

Poland's Elpol is a cooperative of some 96 electronics organizations, most of which belong to one of the three electronics associations – "Mera", "Cemi" or "Telkom." Membership is voluntary and some of the heavyweights of Polish electronics thus far have refused to join.[31] Following the announcement of plans to set up Elpol, a heated debate ensued in Poland's media.[32] Critics fear that Elpol could become a giant monopoly, with the primary function of eliciting tax breaks and subsidies. Polish reforms of the early 1980s and more recent reforms were aimed at eliminating precisely such bastions of economic power that dictated conditions of operation to the central planning bodies. The backers of the cooperative claim that Elpol will not become a monopoly, because foreign firms will compete with it,[33] and argue that concentration of capital is essential to successful research and development in electronics.[34]

Many of the past reform attempts in CMEA were aimed at breaking up branch centers of economic power in order to improve innovation, product quality and the pricing mechanism, and to create at least a semblance

[27] [Zyci88g]

[28] [Durz88; Klee88; Cram88]

[29] [Vese88; Durz87]

[30] The whole Bulgarian economy has been reorganized into 10 associations of which EA is one [Vese88].

[31] [Jezi87] Despite lobbying by management, the workers' councils of Poznan's Unitra-Cemi and Wroclaw's Elwro voted down the proposals of management to enter Elpol.

[32] [Zuko88; Komp88c; Bacz87; Nowa87b; Kowa87c]

[33] [Zyci87v]

[34] [Zolk87; Sowi87]

of market-induced competition. These attempts were by and large unsuccessful in reaching their objectives. The recent organizational changes in the computing industries of CMEA point to a reemerging branch concentration, although not of a traditional, centralized, ministry-led nature. Even though in Poland and Bulgaria several industrial ministries were eliminated, new organizations emerged to coordinate the electronics branches in both countries. The creation of the Polish Elpol, the Bulgarian EA and also the Czechoslovak Mikroelektronika is indicative of industrial concentration in the computing branches. The supporters of EA and Elpol claim that that the new organizations will not reemerge as ministries under a different name because they will not have enough personnel to be involved in detailed supervision of their branches. EA, for example, is limited to 70 employees.[35] The Hungarian experience with decentralizing reforms, however, shows that the authority of the center does not disappear easily and in fact can reemerge if persistent decentralization pressure is not applied.[36]

The organizational changes in Poland and Hungary also imply that, at least in the electronics branches, the leaderships have for the time being given up on attempts to promote domestic competition within the state sector. The goal now seems to be to coordinate domestic production. Elpol and Mikroelektronika are likely to channel resources and to manage the supply chain for their branches. Coordination of production seems also to be the goal of the new Hungarian associations. In the strict sense, this strategy hinders a market-oriented economic interaction, because the newly formed organizations are likely to become monopolies. To keep such monopoly powers in check, the governments are likely to continue playing a major directive role in the economy.

3.3 The Private Sector

In Poland and Hungary at least, officials have encouraged private computing initiatives. Private or semi-private computing firms, cooperatives or work units have proliferated in both countries in the 1980s. There are no precise statistics on the numbers of such firms, but estimates suggest several hundred exist in Poland and a couple of thousand in Hungary.[37] The great majority of these firms are very small, with only two to five employees and with low capital bases. They are involved primarily in microcomputer trade, software development, and computer repair and services – all of which require small initial investments.

Private firms began appearing in the early 1980s in Poland, in the form of joint ventures using the capital of

[35] [Vese88]
[36] [Toke84; Mare86b]
[37] There may be as many as 500 of such firms in Poland and 2000 in Hungary.

Polish emigres ("Polonia" firms) and in Hungary as economic work associations (GMKs). The impetus was the very large profit margin that could be obtained on the resale of Western microcomputers. Liberal hard currency regulations, or habitual failure to enforce existing laws, made it possible for individuals to travel to the West to buy computer equipment or simply to order it via mail-order firms. With a general shortage of microcomputers and worsening economic conditions at home, both Polish and Hungarian authorities removed many of the traditional restrictions on private imports of computer equipment. As the number of suppliers grew, market economics began to take effect and prices declined substantially.[38]

The relationship of state organizations with the private computer firms thus far has been good. State enterprises have been the primary buyers of expensive microcomputer systems in Poland.[39] In Hungary, the economic work associations often obtain contracts from state organizations for software development or servicing.[40] Thus far, Poland and Hungary have not needed to protect domestic state-run microcomputer industries. This, however, may change in both countries as plans are realized to increase microcomputer production by state enterprises.

To date, the remaining CMEA-6 countries have not allowed significant private-sector involvement in computing development or manufacture, but signs of change are evident. Czechoslovakia's official media have begun to discuss the importance of "individual entrepreneurship"[41] and according to a Czechoslovak customs official, the country's recent removal of import duties on microcomputers is "unequivocally oriented toward as many of our people as possible getting their hands on computer technology."[42] Whether or not this stimulates private computing ventures will depend on changes in laws regulating the establishment of private firms.

In East Germany, though the country supports a small private service sector, we have found no evidence of computing enterprises not owned by the state. Despite the country's comparative success in computer manufacturing, personal ownership of computers in the GDR appears to be at one of the lowest levels in Eastern Europe – probably an indication of the current leadership's fear of the kinds of information access and free expression that would be made easier by widespread PC use. Outside of "showcase" stores in East Berlin, not even the simplest domestic PCs can be found for sale in substantial quantities and prices for Western-made machines such as the Commodore 64 exceed 10,000 Marks, the cost of a car in the GDR. East Germans are allowed to receive computers as gifts

[38] [Tomp87; Szau87]
[39] [Newm87]
[40] [Kocs85b; Vert87]
[41] [Rude88b]
[42] [Brat88c]

from abroad, but face severe fines and jail terms for attempting to resell such gifts.[43] Those East Germans who do gain access to computers as hobbyists, either privately or at one of the country's state-run computer clubs, are enthusiastic about their use; the country's relatively numerous computing journals have seen dramatic increases in their subscription rates. East German citizens who develop computer programs on their own time are free to share their work through a computer journal or through a central program archive in Dresden, but as yet they have no opportunities for financial gain.

Although Bulgaria has recently allowed private taxis, restaurants and hotels, and official pronouncements speak of equality between the different sectors of the economy,[44] a significant private market in computing technologies does not yet exist there. The private import of microcomputers is not profitable, because the state industry produces a large number of fairly respectable microcomputers and because the import duty on consumer goods is set at 100%.[45] The existing constraints notwithstanding, it is likely that in Czechoslovakia, East Germany and Bulgaria, some private activity, probably involving software development, eventually will be allowed. The potential benefits of such activity are too great to justify current restrictions.

3.4 Progress in Key Computing Technologies in the 1980s

Computing technologies have grown more complex and comprehensive in the 1980s. To examine, in a circumscribed way, the performance of the CMEA-6 we focus on three computing technologies that have come into prominence in the last decade: microcomputers, industrial automation and data communications.

Globally, the most notable computing hardware development in the 1980s has been the appearance of a broad range of microcomputers, ranging from low-end machines suitable only for simple electronic games to machines based on the powerful Intel 386 microprocessor that rival minicomputers in performance. This microcomputer revolution caught most CMEA countries by surprise.[46] Domestic production in the early 1980s was minuscule. Recently, production has picked up, but it still does not begin to approach the volumes common in the West or even in the newly industrialized countries of Asia.

The interest in applying computing technologies to industrial processes was greatly intensified in CMEA in

[43] [Dpa88]
[44] [Cram88; Klee88]
[45] [Zrob88]
[46] For an in-depth review of personal computing in CMEA see [Stap88].

Country	Production Total	Year
Bulgaria	24,863	1987
Czechoslovakia	less than 5000	1986
East Germany	33,505	1986
Hungary	4000-5000	1987
Poland	3000	1986
Romania	300	1985

Figure 1: Annual Domestic Microcomputer Production. Sources: [Pres86; Adn86c; Delo88b; Impu87; Komp87b; Stan87]

the 1970s, a likely result of the natural bias that Soviet-type economies have toward improving the "means of production." By 1985, some 200 robot models already were being manufactured in CMEA.[47] Several of the CMEA-6 countries have been somewhat successful in introducing various CAD/CAM systems and FMSs.[48] This is true particularly of East Germany and Bulgaria where automation efforts have been pursued most consistently.[49] However, serious problems have emerged that stem from broader systemic difficulties. Industrial automation is expensive and allows a positive return on investment only if labor is relatively expensive and gains from improved quality are significant. In CMEA, labor is fairly inexpensive putting into question many an automation project even if product quality is improved. On an even more basic level, the financial mechanisms in CMEA do not provide for viable methods of evaluating investment. Which factory should be automated often is a political decision, on some level, leading to inefficiencies.

Of the computing technologies that came into prominence in the 1980s, data communications has received the least attention in Eastern Europe. This lack of progress is analogous to the consistent neglect of telephone network development in the CMEA countries (Figure 2). Telephone lines are still of insufficient quality to support reliably even low-speed data transmission. Fiber optic lines, dedicated data networks and even local area networks are largely in experimental stages.[50]

The lack of innovation push, deficient trading arrangements and the absence of financial incentives all have contributed to the poor performance of the CMEA-6 computing industries. There is, however, another reason more

[47] [Sido85b]

[48] FMS – Flexible Manufacturing Systems; CAD/CAM – Computer-Aided Design/Computer-Aided Manufacturing.

[49] Bulgaria boasts of being fifth in the world in per-capita production of robots; East Germany claims that by the end of 1988 there will be 57,000 CAD/CAM workstations in operation in the country [Mitt88; Neue88b].

[50] Hungary has done the most in developing data communications technologies, as is evidenced by its packet-switched, data network called NEDIX [Geip88d] and several implementations of local area networks.

Country	1975	1980	1985
Bulgaria	8.9	14.1	20.0
Czechoslovakia	17.6	20.6	22.6
East Germany	15.2	18.9	21.1
Hungary	8.9	11.8	13.4
Poland	7.5	9.5	11.8
Romania	5.6	7.2	13.0
USSR	6.6	8.9	10.2
——			
USA	69.5	78.8	78.9
Japan	38.4	46.0	53.5

Figure 2: Number of Telephones per 100 inhabitants. Source: [Rutk88]

specific to the technologies of our focus. Computing technologies are increasingly more complex and "interdisciplinary" in their composition. The range of know-how incorporated in modern computers spans several fields, from chemicals through the intellectual output of systems analysts and programmers. In the West, the market mechanism forces producers of final products to establish horizontal links with producers of diverse inputs. In CMEA, industries are organized vertically and coordination among suppliers and manufacturers of final products has proven to be a a very difficult task.

4 Computing Technologies and CMEA Integration

CMEA integration in computer-related technologies in the 1970s was at least partially successful.[51] The presence of computers and peripheral equipment from different CMEA countries in the computer centers of Eastern Europe is proof that something was done right. That is not to say that all plans were actually realized, or that the current integration framework is satisfactory. Progress in computing integration has clearly decelerated in the last several years, exposing many weaknesses of the existing CMEA structures and underscoring the need for reform.

Although the ES and the SM[52] programs remain the backbone of CMEA ties in computing, new areas of cooperation have emerged. In this section we summarize existing CMEA arrangements and discuss new developments.

[51]For a comprehensive review of CMEA integration efforts through the early 1980s see [Good84]. This section extends part of that analysis to the present.

[52]ES stands for Unified System (Edinnaya Sistema) and SM for System of Small (Sistema Malykh) computers. Each of the CMEA-6 countries uses different acronyms for these two programs. We use the Russian acronyms, which are most commonly seen in the West.

4.1 Whither the ES and SM Programs?

In their initial stages, both the ES and the SM programs were modestly successful.[53] Throughout the 1970s and the early 1980s substantial numbers of ES mainframes and SM minicomputers were produced and distributed in Eastern Europe. One of the main reasons for this partial success was the decision to copy successful Western computer architectures. Most computers produced as part of both programs functionally duplicated or only slightly modified International Business Machines (IBM), Digital Equipment Corporation (DEC) or Hewlett-Packard (HP) architectures. Following the West in hardware not only saved development costs but also made it possible for Eastern Europe to use the large body of software available for the existing Western systems. Furthermore, adherence to Western standards made it easier to transfer technology within the Soviet Bloc and to produce compatible equipment and computers that could be traded as part of CMEA arrangements. Each East European country has focused on a subset of computing technologies, the products of which it sells to other CMEA countries. For example, Bulgaria specializes in disk memory devices; Poland in printers and teleprocessing equipment; Czechoslovakia in microelectronics components and upper-end SM computers; Hungary in monitors and printers; and East Germany in mid-range ES mainframes and microelectronics components.

After CMEA's initial successful functional duplication of IBM 360/370 architectures, the progression of the ES program toward subsequent IBM mainframe lines in the 1980s has been painfully slow. Several of the third-generation ES machines have some characteristics of the IBM 43xx line, but the vast majority of mainframes produced in CMEA is still based on technology that is around 10 years old. To be sure, some innovative developments have taken place,[54] but these were not world class innovations but for the most part corrections of existing problems.

Plagued by reliability problems, lack of peripheral devices and the slow pace of innovation, the SM program has been much less successful than its ES companion. The newest SM architectures appear to be based on the popular VAX architecture, developed by DEC. Three VAX-like machines already have been identified in CMEA[55] and their production is likely to be expanded. Still, even if series production of VAX-like computers is just under way in CMEA, that implies 8-10 year lag behind the introduction of those machines in the West.

[53] For comprehensive reviews of the two programs see [Davi78] and [Hamm84].

[54] For example, the operating system for the ES line has been expanded to drive a broader range of peripheral devices.

[55] The Soviet SM-1700, the Czech SM-52/12 and the East German K-1840. The K-1840 is clearly a VAX-like machine but has not been given an SM designation. See [Snyd88j] for more information on these machines.

The poor progress of both ES and SM integration continued with the development of microcomputers. Despite plans to develop 40 different types of PCs under the auspices of MPKVT,[56] no joint, integration program for this technology was ever articulated. All CMEA countries are producing their own, mostly IBM PC-compatible microcomputers and there is little cooperation or specialization.[57] Save for the Program to the Year 2000, an overall strategy for CMEA computing integration no longer seems to exist.

4.2 Program to the Year 2000

The Comprehensive Program for the Scientific and Technological Progress of the CMEA Countries until the Year 2000 (P-2000) attempts to address both the complexity and inter-branch nature of computing technologies. P-2000 consists of five priority areas, two of which – electronization and comprehensive automation of the national economies – encompass computing technologies and one of which – new materials and technologies of their production – is related to them.[58] The program is detailed and wide-ranging in its coverage. Virtually all worldwide trends in computing technologies are mentioned – supercomputing, artificial intelligence, electronic components, microcomputers, new telecommunications technologies (fiber optics, satellite communications, digital networks), robotics and flexible manufacturing systems, software, CAD and others. Although a few goals of the Program are specific,[59] most are broad and general. P-2000 is designed to focus attention on the new technologies, not to provide a full plan of action.

Specific tasks are to be designed and carried out through the established forms of CMEA cooperation and specialization – agreements, direct links and joint enterprises – and through the work of the leading organizations in each of the program's 93 "problem groups."[60] These organizations are supposed to not only coordinate work within the problem group but also to conclude contracts with CMEA firms or institutes to begin series production.[61]

[56]MPKVT stands for Inter-governmental Commission on Computer Technology, [Ekon87].

[57]In what could be a curious ploy to hide the shortcomings of integration in personal computers, some of the CEMA-6 PCs have, in addition to their domestic names, ES or SM designations [Stap88]. The ES microcomputers are all IBM-compatible clones, implying perhaps an extension of the IBM-based ES equipment to microcomputers.

[58][Majc86]

[59]An example of a precise task is the development of a supercomputer capable of more than ten billion operations per second (MOPS).

[60]All of the leading organizations are Soviet [Majc86].

[61][Svet86]

4.3 Results and Problems

The growing media openness in the Soviet Union and other East European countries has brought many of CMEA's problems to light. Although there are reports of successful developments of individual products,[62] the general assessment of progress on P-2000 is fairly negative. The director of research for the new materials priority area, for example, has complained that the leading organizations do not have any real means to influence manufacturers, even in the Soviet Union itself. Like many other CMEA officials, the director believes that reform is sorely needed in the organization.[63]

Real change, however, has been very slow in coming. The 44th CMEA Session, held in July 1988 in Prague, did not significantly modify the current operating mechanism, though it promised the much needed legal and currency reforms. Only organizational tinkering has taken place. For example, a new CMEA Committee on Electronization is supposed to coordinate all 34 electronization problem areas within P-2000.[64] The Committee will take over the P-2000 work of MPKVT, will replace the CMEA Permanent Committee for Radio Engineering and Electronic Industries and will oversee the work of the CMEA Committee on Scientific and Technical Cooperation.[65]

The central goal of the current reforms in CMEA is to eliminate layers of bureaucracy that coordinate economic relations among member countries. The hope is to directly link lower-level organizations and thereby improve communications and increase profitability and performance. Ministries and foreign trade organizations would be significantly scaled back or eliminated.

A significant number of CMEA enterprises involved in computing have established direct links such as inter-enterprise agreements, joint enterprises and international research and production associations (MNPOs). We have identified four joint enterprises dealing with some aspect of computing technologies: a Hungarian-Soviet joint enterprise called Intermos, to produce integrated circuits;[66] a Polish-Soviet joint enterprise called Polsib, to develop micro- and minicomputer systems and software;[67] a Hungarian-Soviet joint enterprise called Mikromed, to sell computer-based systems for medical applications;[68] and a Bulgarian-Soviet joint enterprise called Avtoelek, to

[62] [Prav87130] For example, a computer capable of 5 MOPS, personal computers, and a programmable robot reportedly have been introduced into series production as part of P-2000.

[63] [Manu87]

[64] [Przt88c]

[65] It is not clear whether the ES and SM programs will be transferred to the new Committee or will remain as part of MPKVT.

[66] [Varg87]

[67] [Alek88]

[68] [Neps87]

develop electronic systems for automobiles.[69]

Five MNPOs exist with a focus on computing technologies – four with an orientation toward robotics and computer-aided manufacturing and one specializing in software development. MNPOs differ from joint enterprises in that they share no common capital; their main function is to coordinate economic activity, technological development and foreign trade.[70] Three MNPOs are Soviet-Bulgarian, one is Soviet-Czechoslovak and one, Interrobot, is international (all European CMEA countries are members, except for the GDR and Romania).

It is still too early to pass judgment on these joint undertakings. However, some problems already are apparent. The lack of an exchangeable currency, which necessitates the continuation of bilateral barter trade, is a serious constraint. Another difficulty is structural. Most Soviet organizations with rights to conduct foreign trade (there are 76 of them) are large,[71] and prefer to deal with large East European firms such as Videoton or Robotron, which can usually command needed component supplies. Smaller producers suffer from such ongoing coalitions between the giants.

4.4 Computing Trade and Interdependence

CMEA trade in computing technologies follows the pattern for CMEA trade generally, in its focus on the Soviet market. Seventy-two percent of ES computer trade involves the Soviet Union,[72] which is not surprising given the size of the Soviet economy. The Soviet leadership has repeatedly pressed Eastern Europe to supply increasing quantities of high-technology products, in exchange for energy supplies the East Europeans need to survive. The Soviets eagerly purchase East European computing technologies, since similar purchases in the West or even from Asia would consume hard currency and are often limited by CoCom restrictions. East European computing firms have tried to oblige, particularly since exports to the Soviet market are often more profitable than sales at home, and since the low quality of East European computing products makes their sale in the West rare.

Intra-CMEA trade covers a broad range of computing products, from electronic components to mainframe computers. Poland chiefly sells monitors, printers, microcomputers, and teleprocessing equipment for the ES line, and its share in computing turnover within CMEA is 10%.[73] Hungary's CMEA portfolio is similar to Poland's,

[69] [Przt88f]
[70] [Przt88f]
[71] [Bacz88]
[72] [Racz86]
[73] [Alek88]

which is probably why Polish-Hungarian trade in computing products has dropped off considerably in the recent years.[74] Bulgaria trades primarily in disk memory devices, microcomputers and numerically controlled (N/C) machine tools. East Germany's strengths are the ES-105x mainframe line, microelectronic components and N/C machine tools. Czechoslovakia sells microelectronic components, minicomputers and teleprocessing equipment.

Signals on trends in computing interdependence within CMEA are mixed. On the one hand, intra-CMEA trade in computer-related equipment has been growing. The value of planned CMEA turnover in these technologies for 1986-1990 is TR25 billion – 15% larger than the turnover in 1981-1985.[75] On the other hand, particularly in the newer computing technologies, there seems to be an autarkic tendency for each country to develop its own capability. For example, despite past agreements on specialization and cooperation in the production of electronic components, most CMEA countries are trying to develop an indigenous capacity to produce what are often the same types of integrated circuits. As noted above, the same go-it-alone trend also has emerged in the production of microcomputers. Because of the defective CMEA trade mechanism and past experience with unfulfilled deliveries, the CMEA-6 countries apparently try not to rely too much on their partners in the Bloc.

The Soviet Union remains more interested in furthering CMEA interdependence in computing technologies than its East European partners. Figure 3 shows that the Soviets have participated in more bilateral specialization and cooperation agreements than any other East European country. All 93 leading organizations for the P-2000 problem areas are Soviet, and all of the joint enterprises and international research and production associations in computing technologies established thus far have a Soviet partner.

The dependence of the Soviets on Eastern Europe for computing technologies is more a matter of lagging production capacity than technological deficiency. Much of what is produced in Eastern Europe either is or could also be produced in the Soviet Union. Soviet industry simply has not been able to fill the country's demand for most computing technologies, and the quality of Soviet products, as compared for instance to East German products, is low. Many Soviet end-users prefer East European to Soviet-made equipment.[76]

The East European countries depend on Soviet-made computing products to a much lesser degree. The most important computing items that the Soviets sell to Eastern Europe are ES mainframes and microprocessors. While

[74] [Smul87]

[75] [Ekon87]

[76] Equipment service is also a factor. Sales of computer equipment now include service contracts, and most East European computer makers maintain service networks in the Soviet Union.

Product	Total	BU	CZ	GC	HU	PL	RO	UR	YU
Automated Production Systems and Robots Subtotals	9	1	4	3	1	2	2	7	0
Aut. Production Systems	2	0	0	1	0	1	1	1	0
Aut. Control Equipment	3	0	2	0	1	1	1	3	0
Robots	4	1	2	2	0	0	0	3	0
Electronics Subtotals	62	14	20	18	15	21	5	30	1
Microelectronics	8	1	6	3	2	0	0	4	0
Other electronics	27	5	11	7	7	13	3	7	1
Computers	15	5	2	6	2	4	2	9	0
Communications Equipment	12	3	1	2	4	4	0	10	0
Optoelectronics and optical equipment	5	0	0	4	2	0	3	1	0
Televisions	6	2	4	2	2	2	0	1	2

Figure 3: Computing Related Bilateral Specialization Agreements. Source: [Cran88] pp. 23-25

those are important in computerization efforts, there are indications that Soviet supplies of ES mainframes have leveled off and that the Soviets – themselves in the midst of a major push to produce microcomputers – have not been very willing to sell microprocessors.

5 Computing Technologies and East European Economic Relations with Non-CMEA Countries

5.1 Constraints on non-CMEA Economic Relations

Four factors exert the strongest influence on high-technology relations between the CMEA-6 and the non-socialist world. First, on the export side, an East European country's obligations to the Soviet Union may limit the goods it has available for sale to the West. For example, in East Germany more than 65% of Robotron's production is exported to other CMEA countries; even if the combine were to achieve greater competitiveness on Western markets, it would still face enormous Soviet demands in exchange for the raw materials the GDR depends on.[77] Second, the country's ability to produce needed technology domestically or obtain quality components from CMEA partners will influence its trade decisions. Third, the country's available stock of hard currency and its creditworthiness will

[77] [Krak87]

influence its ability to purchase significant quantities of computing technology in the West. Finally, Western export control restrictions sharply limit the types of products that a CMEA country can legally purchase.[78]

5.2 Computing Relations with the Developed Countries

Recent political developments have increased the likelihood of high-technology cooperation between Eastern Europe and the West. In June 1988, CMEA and the European Community established formal relations, following several years of negotiations. Soon thereafter, most of the East European countries moved to seek bilateral relations with the EC and have expressed the desire for what a Czech commentator called "systematic economic and scientific-technical cooperation" between CMEA and the EC, "as the foundation stone for the construction of a 'common European home'."[79]

The optimism notwithstanding, very little computing technology is traded between Eastern Europe and the developed Western countries. Only East Germany is making a concerted effort to develop a market in Western Europe for select information technology products. The hope of significant hard-currency revenues may have helped motivate East Germany's huge investments in computing production since the mid-1970s. Thus far, actual exports have been minimal. In IC chips, for example, the GDR typically manages to begin mass production only when Western and Asian manufacturers have already recouped their initial development costs for the same type of chip and are selling it at bargain prices. East Germany is left with the choice of running a subsidy business to generate some hard currency, or foregoing sales in the West due to its inability to compete. It has generally followed the second course.[80] A similar problem plagues sales in the West of finished systems by East Germany's Robotron. Even if the combine could divert a significant share of its production away from CMEA trade and domestic application, the price and quality of Robotron systems would render them largely uncompetitive in the West.

As a result of this recurrent lag in East German computing production, Robotron has managed to sell little more than computer printers and typewriters to the West on a regular basis. In 1987, those items accounted for most of Robotron's 25% increase in sales to West Germany, to about $22 million. Due in large part to the favorable conditions under which intra-German trade is conducted, about half of Robotron's trade with the West involves the

[78] For a review of issues in computing and export controls see [Nrc88].

[79] [Alst88]

[80] The example of the 64K RAM chip is telling. The Japanese introduced it in 1982 and sold it for $125 per chip. The East Germans developed it by 1986 at which time the price dropped to 30 cents [Maie86].

FRG.[81] Still, West German officials recently have begun to express concern that the overall growth of intra-German trade will stall unless East Germany institutes reforms and adopts less orthodox credit and investment policies to halt the growing disparity in the technological capacities of the two countries.[82]

Other East European countries have had some success in marketing software products in the West. Hungary sold a version of the Prolog programming language to the Japanese and reportedly earns more than $13 million per year in software sales mainly to Western Europe.[83] Recently, the Hungarians set up two software marketing firms in the West: Proper, based in Paris and selling to all of Western Europe; and VT Computer, a joint venture between Videoton and a British firm.

Most of the East European countries have shown a considerable interest in importing computing technology from the West, though this trade has been limited by Eastern Europe's hard- currency shortage and by Western export controls. Defined broadly to include electronic measurement and control instruments, Western sales of computing technology to all of Eastern Europe amounted only to about $410 million in 1986.[84] Nevertheless, the share of total Western exports to Eastern Europe accounted for by computing products has increased steadily, from 1.8% in 1980 to almost 3% in 1986. The chief Western exporters of high technology to Eastern Europe are West Germany, Switzerland, Japan, France and Britain. Though U.S. computing trade with Eastern Europe is not large overall, individual companies such as Honeywell, Atari and Commodore are finding CMEA markets.

5.3 Joint Ventures

Current interest in high-technology joint ventures with Western firms is unprecedented in most of East Europe. For example, Hungary has adopted and Poland is considering new laws eliminating the requirement that the state retain a 51% share of any joint venture. Both countries may grant tax advantages to such enterprises – especially in the high-technology sectors. In Poland, joint ventures soon may no longer need to have a Polish director, and may retain their earned capital.[85] Czechoslovakia is expected to approve legislation clarifying its joint-venture criteria in the near future as well.[86]

[81] It also regularly exports low-end computing items to France, Britain, the Benelux countries and Austria [Hand88; Busi87].
[82] [Wilm88; Info88]
[83] [Szak85; Tomp86; Worl88]
[84] The authors wish to thank Leyla Woods of the U.S. Department of Commerce for access to the trade figures cited in this paragraph.
[85] [Luky88; Tygo87j]
[86] [Stat88]

The West German government and business community are particularly interested in improving the conditions for joint ventures and trade with Eastern Europe. As a prime Western lender to Eastern Europe, the FRG has a vested interest in the region's economic health. Already Eastern Europe's largest Western trading partner by a significant margin, West Germany is moving toward even closer economic relationships. In 1987, for example, a West German bank and the Bulgarian Foreign Trade Bank established a "trade bank" to facilitate the setting up of joint ventures. The 1987 pact on scientific-technical cooperation between East and West Germany has improved the chances for significant intra-German computing ventures as well. A West Berlin-based research center already has received West German funding to design a finished Computer-Integrated Manufacturing (CIM) system, adapted to East German organizational structures, which will then be offered to firms in the FRG and GDR.

Examples of computing joint ventures with Western firms can be found in each of the East European countries, with the exception of East Germany. For example, Britain's ICL and Polish computer and furniture manufacturers have formed a firm that will sell Polish furniture for hard currency and use the earned money to buy ICL computers for resale to Polish customers in zloty.[87] In Bulgaria, the American firm Honeywell in 1984 created a firm called Systematics to train users and service personnel in the maintenance of Honeywell process control and automation equipment, both in Bulgaria and abroad.[88] More than 130 Hungarian-Western joint ventures exist in Hungary, including a software company with Britain and an agreement between the U.S. firm Dataproducts and Hungary's Videoton to produce line printers under license.[89] Recently, Hungary began a series of software R&D projects funded by the World Bank.[90] The Dutch corporation Philips set up a joint venture with the Czechoslovak Tesla to produce video recorders.[91] And in Romania, the U.S. firm Control Data has since 1974 held 45% ownership in a joint enterprise, called ROMCDC, that produces peripheral equipment such as printers and disk drives under license.

Thus far, despite its clear interest in gaining access to Western technology, East Germany has shown little willingness to enter into joint ventures with foreign firms. Fearing undue foreign influence over its economic decision-making that could result from joint ventures, the East German leadership simply has sought to improve its trade ties to Western countries in the computing field. East German resistance to joint ventures likely would soften under a younger leadership less fearful of economic dependence than the current Politburo.

[87] [Ples88b]

[88] [Male88b]

[89] [Loos88; Monk88; Busi88]

[90] [Worl88]

[91] Poland and Czechoslovakia had an agreement to cooperate on VCR production [Debi85] but reportedly abandoned it in favor of separate deals with Philips [Tryb86z].

Significant obstacles remain in the way of joint ventures between Western computing firms and East European enterprises. From the Western perspective, the absence of a unified market or even currency convertibility in Eastern Europe makes it difficult for firms to be assured of a CMEA-wide market for goods they might produce in any one country. From the East European perspective, the fact that Western firms generally prefer hard-currency payments rather than countertrade deals in exchange for licenses limits Eastern Europe's potential for significant profits on what for the most part already are outdated technologies.[92] That Western firms seek to maximize access to new markets in Eastern Europe while CMEA enterprises seek to maximize hard-currency earnings from sales in the West are opposing conceptions that can block joint-venture agreements from the start, or seriously disappoint their participants later.

Despite the difficulties, computing relations between the CMEA-6 and the West are likely to improve for two reasons. First, the results of CMEA integration efforts in computing, as described in Section IV, are falling well short of expectations – leading some East European countries to seek Western technology without waiting for it to be developed independently in the Soviet Bloc. Insofar as the reform efforts of individual East European countries are not uniform, they erode CMEA's ability to carry out long-term integration plans and contribute to disputes within the organization over currency convertibility and the assignment of specific development tasks.[93]

Second, most of the East European leaderships are realizing that their inability to obtain significant quantities of personal computers – either from domestic production or intra-bloc trade – is seriously hampering efforts to streamline other industries and develop the minimal popular computer literacy needed for economic modernization. They are turning increasingly to Western suppliers. Czechoslovakia's Kovo foreign trade enterprise has expressed its desire to import as many as 90,000 IBM-compatible PCs by the end of 1989. The U.S. firm Atari has already delivered some 100,000 8-bit PCs to Eastern Europe, and recently won an order from East Germany for an unspecified number of 16-bit PCs.[94] The Commodore firm is selling an estimated 15,000 PCs to East Germany this year, and perhaps twice that number if gifts to East German citizens by their West German relatives are counted.[95]

[92] [Geip88d]
[93] [Busi88]
[94] [Busi88b]
[95] [Econ88b]

5.4 Computing Relations with Newly Industrialized and Third World Countries

In an apparent attempt to obtain quality computing products without the constraint of export controls, the East European countries are showing an increasing interest in purchases from emerging exporters of computing products such as South Korea, Taiwan and Brazil. Despite the potential for political conflicts with North Korea and the People's Republic of China, several of the CMEA-6 countries were receptive in the past year to the opening of South Korean trade representations in their capitals and to a trade mission by the Taipei Computer Organization.[96] During a visit in 1988 to Brasilia, Czechoslovak Premier Lubomir Strougal discussed imports of computers from Brazil, which in recent years has developed an independent computing industry and has shown a growing interest in both the Soviet and East European markets.[97]

Eastern Europe's computing trade with the Third World remains minimal, since the CMEA countries generally do not have surpluses of high-technology goods that are not already allocated to intra-bloc trade or domestic modernization. Cuba purportedly sells IC chips to Eastern Europe – some 1 million to East Germany alone in the past several years – but it is not known to what use these circuits are put, other than to fuel rhetoric on socialist integration.[98] Several East European countries also have signed computing research pacts with Third World partners, though again their purpose is largely symbolic.

6 Trends and Prospects

The development and implementation of computing technologies is and will remain one of the highest economic priorities of the East European countries. Most of the CMEA-6 governments have focused large human and material investments on the computing sector, in an effort to secure the increased managerial efficiency and industrial productivity that automation can bring. Thus far, some results of these investments could be judged modestly successful, but most have missed the goal of catching up with the developed world or even of not falling further behind. The quality and quantity of CMEA computing devices lag Western levels by between five and 15 years, a condition that has not changed very much in the last decade.

Looking to the future, improvements in computing among the CMEA-6 will hinge on several key factors closely

[96] [Chin88]
[97] [Fuji86; Bras87]
[98] [Hava87]

linked to the process of reform. First, the success of the private computing sector in Poland and Hungary may have shown the rest of CMEA that private firms can contribute significantly to the technological performance of a country. Even though the private computing sector is likely to remain small in all of Eastern Europe for the foreseeable future, the appearance of private computing firms in other CMEA-6 countries can be viewed as a litmus test of reform intentions among policy makers in Eastern Europe.

Second, the recent organizational changes in the CMEA-6 point to a concentration of state-owned firms involved in computing. In Poland, Czechoslovakia and Hungary, the conclusion seems to have been reached that production quantity and quality can be improved more quickly through vertically integrated monopolies that command significant resources than through smaller firms that establish ad-hoc horizontal links among themselves. While the concentration of resources is also a tendency in international computing markets, the danger of monopoly excesses is probably greater in CMEA than in markets open to international competition. The extent to which governmental bodies of the CMEA-6 move to control the monopoly powers of new computing conglomerates, such as Poland's Elpol or Czechoslovakia's Mikroelektronika, will be an indication of how much power the state bureaucracies can still wield following the elimination of a number of industrial ministries.

And third, political and economic conditions in Europe as a whole will exert a strong influence on the technological development of the CMEA-6. The recent Common Market-CMEA pact, reduced perceptions in Western Europe of a Soviet military threat, and the passing in Eastern Europe of a generation of leaders that feared excessive economic ties to the West all bode well for more R&D ties, computing joint ventures and trade between two halves of Europe that increasingly view themselves as having common interests. Microcomputer trade has steadily increased between East and West Europe and is likely to expand to other technologies, such as data communications. Working against this trend, however, are the competing expectations that policymakers in Eastern and Western Europe continue to have regarding cooperation, ongoing Western export controls on high-technology transfers to CMEA, and the possibility that independent movement toward integration in the Common Market (the 1992 goals) and internal trade reform in CMEA could actually increase the insulation of the two Blocs from each other.

The effect of these factors on Eastern Europe's performance in computing will be evident in several areas, to which close attention should be paid in the West: 1) the development or lack thereof in the CMEA-6 countries of computing niches in which the quality and production levels begin to approach Western norms 2) the amount of East European computing technology that finds a market outside of CMEA, either as stand-alone products or as components in Western systems, and 3) the diffusion of computing technology in East European societies – not only to satisfy the demand for industrial automation and management information systems but also as a technology accessible to private citizens.

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