Antidumping in supercomputers or supercomputing in antidumping?
The «Cray-NEC» Case

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Second draft, please do not quote. Comments are most welcome.

Abstract:

The U.S. antidumping case in vector supercomputers – the Cray-NEC case – resulted in the imposition of the highest antidumping duties in the entire U.S. antidumping history (454% for NEC, the main defendant). This, along with the considerable attention attracted by the dispute, would be sufficient ground for a closer examination of the case. Three additional aspects of the Cray-NEC case, however, render it particularly relevant to the economics and law of antidumping:

(1) the Cray-NEC case offers an opportunity to look at cases of dumping in the context of a product where antidumping could be a likely policy option – though such a policy is probably a second best option. There are, indeed, two situations where dumping could be considered as a serious source of concern and cause of policy intervention: predatory and strategic dumping. Predatory dumping is more likely to occur where only a few firms are involved, such as in the supercomputer industry. Strategic dumping requires static or dynamic scale economies which seem also likely in this case;

(2) the Cray-NEC case offers an opportunity to look at antidumping policy as a component of industrial policy. The supercomputer industry has so far been shaped by two other industrial policy tools: active subsidy through R&D funding and massive public procurement policies. The antidumping action could have been lodged as a substitute to these two instruments;

(3) the supercomputer case raises key issues about antidumping procedures *per se*, from the point of view of both determination and enforcement. Supercomputers as a product do not seem really subject to markets. The number of transactions, realized through auctioning, is very small, and the products sold are highly diversified. In these circumstances, is it meaningful to talk about a «market» for supercomputers – hence to apply GATT antidumping rules which presuppose that there is a market? Turning to enforcement, the Cray-NEC case offers an interesting development: if Japanese supercomputers cannot be sold in the U.S. market, they can be located in Japan, and their services sold to U.S. potential buyers from there (through appropriate telecommunications). In other words, the Cray-NEC case may offer the first clear example of trade in services as a substitute to trade in goods – raising a host of issues regarding antidumping procedures.

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Introduction

The U.S. antidumping case in vector supercomputers, often nicknamed the Cray-NEC case (Cray was the U.S. petitioning firm and NEC the most directly targeted defendant), has been lodged in July 1996, and was terminated in September 1997 with the imposition of the highest antidumping duties on manufacturing goods in the entire U.S. antidumping history (454%, 173.08% and 313.54% on NEC, Fujitsu and the other Japanese supercomputers, respectively). It has received considerable attention in the media owing to the nature of the targeted product and the identity of the contending parties: it is one of the very few antidumping cases involving non-commercial entities. It concerns the sale of a NEC vector supercomputer to an academic institution, the University Corporation National Center for Atmospheric Research (UCAR), funded by the National Sciences Foundation (NSF). And it has revealed huge pressures on all the parties involved: the case was close to being self-initiated by the Department of Commerce; an amendment to a bill proposed to withhold the salary of NSF executives who would allow academic institutions to buy dumped supercomputers; and lately, the U.S. Court of International Trade (CIT) has instructed that the International Trade Commission (ITC) reassess its final finding.

This context could already generate incentives to look more closely at the case. But there are three additional sets of reasons to examine the Cray-NEC case which are more directly related to the economics and law of antidumping.

First, the Cray-NEC case offers an opportunity to look at possible cases of dumping in the context of a product (supercomputers) which could make antidumping a conceivable policy option – though such a policy is likely to be only a second best, where "second best" may lay far below the first best policy. Following Willig (1999), there are two major situations where dumping could be considered as a serious source of concern: predatory and strategic dumping. Predatory dumping is more likely to occur if only a few firms are involved, such as in the supercomputer industry since 1993 (the first year with systematic data).[2] Strategic dumping requires static or dynamic economies of scale, which are, also a possibility in the supercomputer industry.

Second, the Cray-NEC case offers a new opportunity to look at antidumping policy as a component of industrial policy. Two other aspects of industrial policy have dominated the supercomputer industry: an active subsidy policy through R&D funding and a massive public procurement policy (a substantial portion of supercomputers is bought by public authorities, from defense to research agencies). It would be interesting to look at the extent to which the antidumping action has been lodged as a substitute to these two instruments (enlarging the possibilities of substitution for these policies to border instruments, such as tariffs or quotas).

Lastly, the supercomputer case raises key issues about antidumping procedures *per se*, from the point of view of both determination and enforcement. At a first glance, supercomputers do not look as a product really subject to markets. In the entire world, there are only a few hundreds of transactions a year which range from the mere upgrading of existing systems to full-scale new equipment. These transactions seem relatively loosely inter-related, and they involve supercomputer-based systems very different in power (by a factor of 500) and cost (by a factor of 1000). In these circumstances, is it meaningful to talk about a "market" for supercomputers –hence to apply GATT antidumping rules which are written on the basis that there is a market to consider in the importing (and exporting) country? Turning to enforcement, the Cray-NEC case offers an interesting development: if Japanese

[2]/Predatory pricing is also thought to be more probable in high technology, growing industries "where the temptation to discourage entry is large and the costs of curtailed entry even larger" (Milgrom [1987], as quoted in Flamm [1993]).

supercomputers cannot be sold in the U.S. market, they can be located in Japan, and their services sold to U.S. potential buyers from there (through appropriate telecommunications). In other words, the Cray-NEC case may offer the first clear example of trade in services as a substitute to trade in goods – raising a host of issues in terms of antidumping procedures.

The paper is organized as follows. Section 1 presents a summary of the complex history of the case. Section 2 provides the basic information about the "product" and its global "market." Section 3 looks at the likelihood that the supercomputer case would fit the various arguments justifying the existence of antidumping measures as a reaction to predatory dumping. Section 4 does the same for strategic dumping. Section 5 examines issues more closely related to antidumping procedures, that is, existence of dumping, injury and enforcement problems and the capacity to analyze antidumping policy as a strategic instrument.

1. The Cray-NEC case: a brief history

We review here briefly the main features of the antidumping case. A more detailed account is presented in annex 1. The antidumping investigation on Japanese vector supercomputers was triggered by the procurement of a system to an U.S. agency, the University Corporation National Center for Atmospheric Research. NEC, a Japanese supercomputer maker, was on the verge to win the $35.25 million bid when Cray, its main U.S. competitor, decided to file a LTFV complaint, in July 1996. This move is only the last in a series of trade frictions between Japanese and American supercomputer producers which trace back to the 1980s (see Tyson [1993] and Anchordoguy [1994]). The antidumping suit is exceptional for several reasons. First, the U.S. authorities nearly self-initiated the investigation, proceeding to a pre-investigation analysis of the dumping. Second, Cray lobbied hard in order to prevent the contract awarding to NEC, and an attempt was made in Congress to bypass the antidumping statutes and block the sale with a provision aimed at discouraging NSF's executives to award the contract to any of the Japanese producers. Third, the case ended up with the imposition of the highest antidumping duty ever in the U.S.: 454% for Cray.

Cray eventually filed the petition, in want of any more immediate solution. The proceeding was very confrontational, each actor adopting an aggressive strategy. The main Japanese producer concerned – NEC – refused to co-operate and alleged in the ITC preliminary hearings that Cray did not meet the bid requirements. Later, it challenged the right of the ITA to proceed with the LTFV calculation, alleging that the agency had prejudged the case by discussing and disclosing a pre-decisional memorandum. NEC chairman announced in the course of the investigation that his company was considering circumventing the antidumping ruling by providing supercomputer services over the Internet. Fujitsu, the other defendant in the case, stopped co-operating in the final stage of the investigation with the ITA and appealed to the Court of International Trade the ITA and ITC's final determinations, partly because of the way both agencies restricted the relevant market to vector supercomputers only. Cray tried to bring the issue of world-wide sales, arguing at first that Cray's winning of the bid would give a signal to other weather-research centers in the world to buy similar equipment (the so-called "lighthouse theory"). The American manufacturer tried also to reach an agreement with the Japanese producers on third-market pricing and called after reaching a positive outcome with the investigation for other antidumping complaints outside the U.S.

The petition finally reached its conclusion only very recently after the ITC remanded its decision in March 1999, re-affirming by a 3-1 vote its final determination of threat of injury following remand of the initial ruling by the Court of International Trade.

2. The supercomputer industry and marketplace

The section briefly describes the product "supercomputer" (and the services they provide), a presentation which sheds some useful preliminary light on the "relevant" market issue. The section then describes the global marketplace based on data available to us (as of June 1999).

Supercomputers: the product and its services

Supercomputers (invented by Seymour Cray, the founder of Cray Research, Inc., in 1972) are the high-end segment of the computer industry, with worldwide sales between $2 billion and $3 billion in 1996. They are designed to perform massive computations at high speed, primarily for research purposes, in order to investigate, among other, "areas that are physically impossible, too time-consuming, too dangerous or too expensive to study in any other way" [Cray's annual submission to the SEC, 10-K form, 12/31/1995]. Such areas typically include defense-related research; applications in aerospace, automotive, pharmaceuticals or petroleum; and weather forecasting.

Supercomputers come in different types of architecture, according to whether their memory is "shared" or "distributed" (Flynn's taxonomy) or whether they handle "vector" operations or not. Vector computers handle data in vectors: one instruction is needed to perform an operation on an array of numbers, whereas non-vector systems require as many instructions as there are numbers. Vector computing comes particularly handy when dealing with complex problems over time. Most vector computers use a shared memory structure (but not all like the Fujitsu VPP500 which work with a distributed memory structure) [ITC, Final, section I-C].

Supercomputers are often divided into three main categories based on the processor architecture (the key input of the machines): vector processors and parallel vector processors (PVPs), massively parallel processors (MPPs), and symmetric multiprocessor systems (SMPs). However, the distinction between these categories becomes less and less obvious.[3] For instance, some MPP systems may have "pseudo-vector" capabilities (such as the Hitachi SR2201), whereas some PVP systems use parallel architecture with vector processors (such as the Fujitsu VPP500 series). Other sources of difficulty in classifying supercomputers on a purely technological basis is that different architectures may be clustered together, or that the technology used for interconnecting processors varies greatly. As a result, a taxonomy of supercomputers based exclusively on technology is largely an open question. For instance, there has been a debate among experts building the Top500 list whether to classify the VPP500 series (and the following model, the VPP300/700) by Fujitsu in the MPP or the PVP category (Schnepf, 1996). They finally opted for the later category. As this is a matter subject to debate, we decided, for the purpose of our study, to put this series in the PVP category instead. Since its processor is a vector type one, and this classification is consistent with the criteria the ITC retained to define the relevant market, and since it highlights better the evolution of market shares between Fujitsu and NEC and their common competitor, SGI/Cray.

Historically, Cray as well as the Japanese producers started with vector systems which were the dominant system in the world until a few years ago. After a first inroad into the MPP market in 1991 (AP1000), Fujitsu opted in 1995 for an intermediary solution with its VPP500 line and its successor, the VPP300/700 series. In 1993, Cray diversified in MPPs (the T3D series). In 1994, Hitachi shifted to MPPs (SR2001). So far, NEC remains concentrated on the vector architecture, but it announced a new parallel line (the Cenju 3). In addition, interchangeability between systems, though

[3]/Indeed, we ignore several subtle sub-divisions, such as between MPPs and Scalable Parallel Processors (SPP). The most powerful supercomputers in terms of computation power are MPPs. Intel's ASCI Red, which broke the TeraFlop/s barrier in the Top500 benchmark test, is today's most powerful system. TeraFlop/s are trillions of floating operations per second (flop/s is the standard measure of the computing power for supercomputers). Intel's web site puts it this way: "if you used a hand calculator and took one second for each calculation, you would need 40,000 years to finish a trillion calculations – one second's work on the ASCI TFLOPS computer."

not complete, has been increasing over the years. In the beginning, Japanese vector were using proprietary operating systems (OS), before switching lately to Unix-flavored language, the most commonly used operating system in the supercomputer industry. Systems now share an increasing proportion of common codes and most third-party software can run on either system (ITC, Final, section I-C-II).

There is a vast price range for supercomputers –from \$100,000 to \$100 million. Vector computers (those specifically targeted by the U.S. antidumping action) show a narrower price range, in the low and medium end of the product –from \$300,000 to \$40 million [ITC, Final, section II-A]. The very high price of some systems mirrors the fact that some supercomputers may be designed for the end-user specific needs –hence for providing a given type of services. This feature raises the question of the "malleability" of the services provided by a supercomputer –a question of particular interest when defining the relevant market of supercomputers and when assessing the NEC effort to provide services from Japan-based supercomputers.

This brief description deserves two last remarks. First, the product life cycle of supercomputers is rather short, typically around five years, as shown by **figure 1** and **figure 2** for the leading product lines of SGI-Cray and the Japanese producers. This brevity mirrors an extremely fast pace of technological change. A common rule of thumb in the industry, also known as "Moore's law", asserts that the amount of "performance received per dollar spent" doubles every 18 months because of technical innovation. The cumulated power of the world's 500 fastest computers almost doubles every year (**figure 3**), and Intel's ASCI Red (the most powerful supercomputer installed since June 1997) has, in the last issue of the Top500, twice as much as computing power as all the Top500 supercomputers installed in June 1993. Such a constant and steady progression in raw computing power suggests that there are industry-wide economies of scale external to the firms, and maybe external to the supercomputer segment itself.

The second remark is particularly important when examining the possibility of strategic dumping. Supercomputers are built around one key input, namely the central processor units (CPUs) or "processors." The number of processors used in one supercomputer can range from 1 to as many as 65536. Nowadays, all supercomputer systems are more or less easily "scalable:" they have multiple processors, opening up the possibility of expanding the system's performance over time. Processors used in supercomputers can be divided in two categories: "off-the-shelf" processors and custom processors, a key distinction. Custom processors are used in PVPs: they are extremely powerful processors designed for a specific architecture. They are fragile, delicate to produce chips. A typical system houses 4 to 64 such processors. By contrast, off-the-shelf processors, which are commodity chips, are mainly used in SMPs and MPPs (this latter category using the largest number of processors) and they are produced in much greater quantities and by large semiconductor producers, not only for high-end supercomputer use, but also for lower segments of the industry, mainframes and servers. They come out much cheaper. Section 4 will come back to this issue.

The global marketplace

Our present description of the global marketplace for supercomputers relies exclusively (as of June 1999) on the annual record of the 500 most powerful supercomputers in the world, their producers, buyers, and technical performance. This record is provided by the "Top500" list (hereafter Top500) of the 500 most powerful supercomputers installed in the world, published biannually by Dongarra, Strohmeier and Meuer since 1993.[4] How reliable and exhaustive is the Top500? The regular use of Top500 by supercomputer-makers to voice their market supremacy in advertising and press

[4]/The lists are freely available on the web site http://www.top500.org

releases suggests a very acceptable level of reliability. The Top500 is build using the LINPACK benchmark to measure the speed of each system. The benchmark is considered as the best measure currently available to compare supercomputers' performance and the Top500 is regarded as the barometer of the industry.[5] There are however two problems with this list. The first one is that the list is not exhaustive of all sales in the market. New additions to the list every year account for roughly 200 to 300 units, which is only a fraction of the sales of supercomputers in a year (see **Table 1**).

Another point of contention is the fact that the Top500 is a list of the installed base of the most powerful supercomputers and not of market share of each vendor, thus overstating the importance of "old" systems (though old systems, tend to disappear quickly from the list because less powerful). This problem is the same as the one encountered by Greenstein (1994) in its study of the mainframe market. Following Greenstein, and what seems to be the usage in the industry, we take this as a reliable indication of the market share of each system family. Our reason is the same as Greenstein's: many systems are leased. Greenstein adds that mainframes are not subject to frequent mechanical breakdowns, which is also true for supercomputers (reliability is a key characteristic), so the services delivered (computing power) does not physically depreciate after sale. He also adds: "Sales data is not available, and it is not possible to estimate sales from the change in installed base from year to year, because it becomes an increasingly poor estimate of shipments of systems when systems become more than a few years old". Our analysis of the supercomputer market will thus rest on the Top500, as well as an estimate of sales from the change in Top500 from year to year. The Top500 counts the noticeable upgrading of existing supercomputers as "new" machines: we kept that approach.

There is another survey of the supercomputer market, which is done by International Data Corporation. The IDC survey (fee-based) presents the advantage of being comprehensive and providing data of prices. A drawback is that it categorizes computers differently, which seems less satisfactory to supercomputer makers. We could not have access to this data set.

Table 1 gives the main features of our estimate of supercomputer procurement at the world level based on two indicators: the number of supercomputers and the corresponding total maximum capacity of computation (labeled RMax in the Top500 and hereafter called MCC). Procurements are also split between PVP and non-PVP systems. It shows the skyrocketing average MCC (multiplied by a factor of 10 in five years) which again illustrates the fast and permanent technological progress, with particularly huge leaps between 1995 and 1997 for vector supercomputers and between 1995 and 1996 for MPPs/SMPs. This is an interesting point to be remembered in our context (the antidumping investigation lasted between July 1996 and August 1997, and the period under investigation was defined as July 1, 1995 to June 30, 1996). The rapid evolution during this period is attributable to two factors: first, the introduction of RISC technology for MPPs, and second, a new generation of powerful scalable parallel vector systems.

Since the U.S. antidumping authorities decided to consider the vector supercomputers as the "relevant" market for the determination of dumping and injury, **figure 4** illustrates the evolution of the total MCC share of the installed systems in the Top500 for this sub-group of supercomputers. **Table 1** provides similar figures for procurements. The most significant conclusion is that vector supercomputers cumulated power accounts for a dramatically diminishing portion of the supercomputer industry. Here again, we see an interesting change in trend after June 1996, with a significant acceleration of the decrease during the investigation period. Since that date, the decline has been constant.

The world market is characterized by a small number of competitors (around a dozen), with

[5]/An additional circumstantial evidence of our argumentation is the fact that Top500 listings were widely used in ITC briefs and hearings.

only a handful of significant players: Fujitsu, Hewlett-Packard (HP), Hitachi, IBM, NEC, Silicon Graphics/Cray (SGI/Cray) and Sun. All of the noticeable producers are from the U.S. or Japan: three European producers (MasPar, Meiko and Parsytec) withdrew from the market in 1995 and 1996, though they may be still "dormant" (like Meiko); however, Europeans kept a continued presence in the resale market and re-entered the Top500 in June 1999 (both with Siemens). The U.S. producers were the first to emerge, particularly with Cray Research. The industry is concentrating: some important manufacturers like Kendall Square Research (KSR) and Thinking Machines Corporation (TMC) exited the Top500 and there has been recently a series of mergers and acquisitions: Convex was absorbed by Hewlett-Packard, whereas Cray was bought by SGI and Digital by Compaq, two computer producers, but outsiders to the supercomputer market. It is interesting to note that all these absorbing firms are strong in "smaller" computer or electronic industries –hence echoing the shift from custom to off-the-shelf processors. This evolution is also visible in the recent and swift entry of chip-based companies operating in lower segments of the computer industry such as Sun, SGI and Intel, which made significant inroads in the market (**figure 5**).[6] To some extent, IBM can be considered as a new entrant also, since it was absent from the Top500 when it was first published. American producers IBM, Sun, Intel and Hewlett-Packard now share the bulk of the supercomputer market with the historical leader of the industry, Cray, now part of SGI. For Japanese producers, the history is different: since they producers entered the market in the early 1980s with Hitachi and Fujitsu, and NEC following a few years later, the Japanese supply of the supercomputer market has remained identical.

3. Predatory dumping as a rationale for antidumping

The first possible situation of dumping for which there is some conceivable justification for taking antidumping measures is predatory dumping. Predatory dumping occurs when foreign firms decrease prices in order to eliminate their competitors and to increase prices afterwards. The debate over the theoretical possibility of predatory behavior is not closed yet, especially regarding the question of how feasible is predatory behavior. Recent studies by Shin (1999) and Bourgeois and Messerlin (1999) for the American and European markets conclude to the very rarity of predatory motives in antidumping cases. It is not completely clear whether Cray's executives had in mind this precise definition of predatory behavior when they argued that "Japanese vendors of supercomputers are attempting to drive U.S. competition from the market by establishing unsustainably low prices for such systems" [SGI Press Release, August 27, 1997]. What follows looks at the predatory dumping issue in two contexts: the entire market and the market narrowed to vector supercomputers.

Predatory dumping in the entire market

Table 2 presents the procurements of the two groups of supercomputer-makers (the three Japanese producers and all the U.S. firms) in the different markets. First, large market shares in the U.S. would be a first indicator of the market power that Japanese firms could enjoy; on the contrary, small market shares are unlikely to provide the appropriate basis for a predatory behavior. We see that the Japanese share of the U.S. market is near negligible and even zero in November 1998.

Second, the possibility remains that the Japanese market share may be high in the rest of the world –making the Japanese producers powerful enough to "invade" rapidly the U.S. market. In such circumstances, Japanese firms could thus have adopted a predatory behavior –depending on the relative magnitude of the U.S. market and the market of the rest of the world. **Table 2** shows that the world market share of the Japanese firms (in number of systems sold) has reached a maximum of 15 % (but

[6]/As we aggregated SGI and Cray as a single entity over the period, SGI's entry on the market, prior to her takeover of Cray, with the Power Challenge series, is not visible on the figure.

41% in terms of MCC) for one year (1996). Moreover, the non-U.S. markets have roughly the same size than the U.S. market (though slightly smaller). The market share of the U.S. producers in markets outside the U.S. and Japan is 2.5 to 15 times larger than the Japanese market share.

Two additional conditions, moreover, would have to be met in order to suspect any possibility predatory behavior. The first one would be collusion among the three Japanese producers: no one is clearly dominant in any market. First, when we look in terms of installed systems, there is no clear leader: Hitachi, NEC and Fujitsu are roughly of equal size in terms of capacity installed over the years. Even though Japan has a history of strong monitoring of its industry at the government level, which may lead to collusive behavior, it is not obvious that Japanese producers could achieve full cooperation in foreign markets.[7] Hitachi has clearly chosen a different technology path, giving up the vector technology for MPPs and was not targeted by the dumping investigation. Fujitsu and NEC offer very different and competing solutions. Collusion, if not impossible, does not seem easy. A second condition necessary in order to make predation attractive would be the existence of significant barriers to entry in the industry. This is definitely not the case, as evidenced by the very successful inroads in the market in recent years by Sun and SGI.

These results do not leave much doubt about the unlikelihood of Japanese predatory behavior in the entire market. Two additional remarks are interesting. First, for the year 1996 (during which the antidumping complaint has been lodged), **Table 2** and **3** show a peak in Japanese market shares in both the U.S. and world market in terms of MCC, following the introduction of a new generation of products ahead of Cray. Second, **Table 2** raises as well the question of increasing risks of anti-competitive behavior in the U.S. after the imposition of antidumping duties, since U.S. producers are totally protected from foreign competition.

Predatory dumping in the vector supercomputer "market"

The antidumping case targets only the vector supercomputer, not the entire supercomputer industry. An examination of the vector market reveals a very strong increase of the Japanese share, to levels just below 90% in 1998. In Japan, the local producers' shares of the installed base have been constantly over 80%, opening the possibility of predatory dumping on the basis of this indicator alone. However, Cray's share displays the exact same predominance in the US market for vector computers, putting Cray in a virtual monopoly position there. This is a well-known situation in the vector supercomputer market, with Japan and U.S. being de facto reserved markets for their national champions. The "real" competition occurs in third markets, particularly in Europe, the third main market. There, Cray was dominating its Japanese competitors before starting loosing ground in 1995. At the time of the antidumping investigation, Japanese producers' share of the third important market, in Europe, was growing very rapidly, from 34% in 1995 to 86% one year later. These tendencies are confirmed by the examination of the evolution of the installed base.

It is doubtful, however, that such evolution should be the result of any predatory intent. Two reasons –in addition to the absence of evidence supporting collusion mentioned above– seem to support this conclusion. The first one is the dwindling of the PVP installed base, compared to other types of supercomputers, suggesting that the PVP is shrinking dramatically and rapidly. It does not seem economically logical for a predator to incur losses on a receding market with the perspective to have to recoup them on an even smaller market. As shown in **figure 3** and **figure 4**, the total maximum computing capacity installed of PVP is stagnant and the share of PVPs has decreased very sharply and was already below 40% at the time of the investigation. We can see that the decline of the PVP's share is not new and was already prevalent in the years preceding the investigation, hence Japanese producers

[7]/The obvious lack of cooperation between NEC and MITI during the investigation substantiates this conclusion.

could foresee that predating the market was financially not attractive. Second, along with this evolution, we witness what seems to be the gradual exit of SGI-Cray from the vector market to concentrate on the MPP segment.[8] The American producer's share of the total MCC has been constantly declining, including after the antidumping imposition of duties. We must remember, however, that SGI-Cray position on the supercomputer market as a whole has not deteriorated meanwhile, which casts further doubt on the likelihood of being predated by Japanese producers.[9]

Another fact leads us to think that predation is not worth trying in the vector market: the likely absence of inter-generation spillover. Several facts point to such a conclusion: first, a new generation of vector supercomputer can be extremely different from the previous one, including different architecture, processor technology; second, vector producers trade places in terms of installed capacity, as can be seen with Fujitsu and NEC; third, the first entrant from one generation to the other is not always the same, as witnesses the launching of Japanese series in 1995 before Cray. The last two points suggest the possibility of leap-frogging episodes in the vector market.

4. Strategic dumping as a rationale for antidumping

Strategic dumping requires three conditions: (a) substantial static economies of scale (for instance, based on R&D expenses); (b) substantial dynamic economies of scale (learning by doing); (c) that the domestic market of foreign producers is a protected "sanctuary," so that foreign producers can charge total (fixed and marginal) costs at home and marginal costs in their export markets without risking price-undercutting in their home market.

As always in international trade, all these conditions should not be expressed in absolute terms, but in "relative" terms. For instance, what matters is not the existence of a sanctuary market for foreign firms, but the existence of a substantially larger sanctuary market for foreign producers (compared to the sanctuary for domestic producers).

The static economies of scale issue

The production process is characterized by substantial fixed costs related to R&D expenditures: they account for 15-20 percent of Cray's sales (Cray fillings to the SEC, form 10-K, various years), and these figures can be considered typical for the industry. These R&D costs nevertheless do not seem big enough to deter a financially powerful undertaker: producers like IBM, Intel, SGI and Sun have made very significant inroads in the supercomputer market in a very short period of time in the past years. It is true, however, that these producers are not vector computer producers. One may wonder whether these entrants are proof that the source of economies of scale is moving from the supercomputer activity *per se* to its key input (processors) part. It means that, for MPPs and SMPs, a significant part of the economies of scale is realized outside the supercomputer industry, since the volumes of processor sold is much more important in lower segments of the computer market (mainframes or servers). This evolution does not concern as much the vector computing market, though there is an increasing degree of "parallelism" in vector-based systems. PVP's source of power remains the capability to manufacture very powerful CPUs (this question would deserve to be developed, but we lacked information on the matter). There may still be some economies of scale remaining in other key inputs. It seems, however, that they are not very substantial, as shows a very recent trend in the industry, with the increasing importance of cluster supercomputers and

[8]/This suspicion is confirmed in a recent SGI statement reported in section 5 and footnote 14.

[9]/SGI could indeed cross-subsidize her PVP line with her MPP business in the case of an aggression from the Japanese producers. This is all the more plausible that there is some overlap in the production process and that channels of distribution are the same for PVP and MPP lines (ICT, final, sections I-C-III & C-IV).

networks of workstations or even simpler PCs.[10] The networking of cheap computers or workstations enabled some supercomputer users to build “home-made” supercomputing power for low prices ($150,000-313,000). Three of such systems are now in the Top500.[11] The difficulty, here, is more in devising the programming and interconnection than in putting money on the production of big processors or other key inputs. This new direction in supercomputing is not yet adapted to every application, partly because of low input/output capacities, but it answers some needs.[12] Massive parallelism, which is one of the directions of research the U.S. government is pushing towards, is also confronted with a similar challenge: the progress and value added are more into how to run and connect the multiple parts of the system. Intel's ASCI Red –the most powerful computer in the world– architecture is based on 9,472 mere Pentium processors.

A non-negligible part of the fixed costs is financed by subsidies. Government intervention has been a constant in the supercomputer industry. Government support, both in the US and in Japan, has been channeled through subsidization of research programs and procurement of numerous systems. The ITC (final, section II-A) estimates that the scientific and engineering market mostly funded by the government, accounts for between one-third and one-half of the total vector computers market. “Domestic preference” policies in the U.S. and in Japan have restricted access to foreign producers in both countries. In the U.S., Cray developed its parallel line with two five-year funding from the ARPA. The five-year High Performance Computing and Communications Program (HPCC) ended in 1996 and was continued from 1997 on by the Computing Information and Communications (CIC) programs. The HCCP has helped to broaden the infrastructure for supercomputers and to give many institutions access to GigaFlop/s of computing power [Harms, 1997]. One of CIC’s components, the High End Computing and Computation (HECC) working group, with an annual funding of $450.8 million in 1996, deals specifically with supercomputing. From that sum, $270 million can be estimated to have gone directly to research directed at advancing the state of high performance computing and to the financing of acquisition of supercomputer facilities for government agencies.[13] The HECC’s aim is to provide “the foundation for U.S. leadership in high end computing and promote the use of high end computing and computation in government, academia, industry, and in broad societal applications”. Among the major accomplishment of the HECC, the 1999 Blue Book further states: “establishing scalable parallel processing as the commercial standard for high computing” (CICC, 1998: 9). Also under the HECC, the Department of Energy supports the Accelerated Strategic Computing Initiative (ASCI) program. The initiative goes along three different paths. Each option is implemented respectively by: IBM, with its Blue Pacific, a $96 million unit of 5,856 processors; SGI with the Blue Mountain, a $121.5 million cluster of 48 SGI Origin 2000 servers; and Intel with the Intel Red, a $46 million parallel system of 9,472 Pentium chips. From these figures, one can conclude that the level of subsidization of the U.S. supercomputing industry is very substantial.

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[10]/In the industry terminology, a cluster is an assembly of supercomputers with several processors, while a network refers generally to single-processor units.

[11]/The first of these computers is the Avalon, built by researchers at the Los Alamos National Laboratory in the U.S. is made out of 68 DEC Alpha processors and ranked 315th in the June 98 Top500. The system has been upgraded and links now together 140 processors and reaches the 160th spot in the list Two others systems, the Cplant, a cluster of DEC 5000a workstations, and the Parnass2, a cluster of 128 PentiumII PCs rank 129th and 362nd. The cost for the Parnass2 is $282,000.

[12]/As the biggest network of all, the Internet is a natural candidate for some applications. For instance, the newly launched SETI@home initiative (http://setiathome.ssl.berkeley.edu) is an example of loose parallelism with a huge computing power capacity enabled by the Internet (10 TeraFlop/s when we last checked their site on September 3). This initiative echoes the statements of NEC’s chairman on providing their supercomputer service over the Internet.

[13]/This figure is estimated from the figure calculated by CPMA (1995) for the year 1995. As the overall budget for HPCC programs for 1995 and 1996 are very similar in figures and allocation, we conclude that this figure is relevant for 1996 as well.

In Japan, the last generation of vector computers has also been developed in collaboration with governmental research institutes (See Anchordoguy [1994] for government support in Japan for earlier programs). The Numerical Wind Tunnel Project, delivered in 1995, is the prototype of Fujitsu's VPP series, and the CP-PACS project, a ¥1.5 billion (around $14 millions) project over five years, started in 1992, is the prototype of Hitachi's SR2201 series [Schnepf, 1996]. As a result of this massive public subsidy, both markets are heavily dominated by national producers.

A first look at public support can be based on the Top500 data on buyers, which may be split into five different types: government or classified (that is, military) research, academia, industry and vendor. Such a ranking follows the expected degree of explicit <u>and</u> implicit subsidization: complete for government, intermediate for research and academia, small (if any) for industry, and nil for vendor.

<u>Table 5</u> provides the breakdown of supercomputer sales in the U.S. and in Japan for all producers. Sales with a relatively low-subsidy content (industry and vendor) represent, on average, almost 32% in the U.S. and 26% in Japan, a difference which is not large.

The dynamic economies of scale issue

Dynamic economies of scale don't seem as important in the supercomputer industry as in other computer segments. One reason is simple: the low number of systems sold does not leave much room for learning by doing. For vector processors, the volume of sales for an entire life cycle is at most a couple of thousands of units, not a sufficient volume to reach significant dynamic economies of scale. A similar conclusion can be drawn for other customs components. For off-the-shelf components, like for static economies, the dynamic economies are external to the supercomputer segment: a few thousands units certainly do not account for much compared to the volumes attained in the servers or workstations' market segments. A second factor to take into account is the low level of standardization of the final product, which must be partly customized for each client which further reduces the scope for economies of scale earned from standardization. There remains, however, some learning by doing effects on the making of vector processor. The only estimate we have for such learning by doing effects is the one given in the Pre-decisional Memorandum (annex 2), which assumes a reduction in costs by one-third over 5 years. We do not know if this figure reflects accurately the reality, but it seems to confirm our initial suspicion that learning by doing is indeed small.

The "sanctuary" issue

<u>Table 4</u> gives a first indication of the relative size of the three major markets (EC, Japan and the U.S.) and of the rest of the world (comprising roughly a dozen of different countries, each year) for the entire supercomputer industry. It suggests that, even if well protected (see below), the Japanese market is of medium size –on (unweighted) average 15% of the world market between 1993 and 1996. It does not seem unreasonable to assume that the "sanctuary" market in the U.S. is more than 20% of the U.S. market: installed MCC –subject to buy American restriction– in classified institutions accounts already for almost 13% of the total on average over the period and a non-negligible share of the near 40% the MCC procured in research institutions must be financed by government funding (**<u>Table 5</u>**). In other words, the "sanctuary" market of the Japanese firms is likely to be substantially smaller than the "sanctuary" market of the U.S. firms.

Back to **<u>Table 2</u>** provides a first indication of the possible level of closure of the Japanese market (a long source of conflict between Japan and the U.S. –leading to several memorandum of understanding on public procurement, the latest dating back to 1990). First, for three years out of five, around half of the Japanese market is supplied by U.S. supercomputer-makers. Second, Japanese sales are relatively more important on the Japanese market than in the EC and the rest of the world. Lastly, the market share of Japanese producers is declining in Japan and in the EC (and stagnant in the rest of the world since 1996). This evolution may be the outcome of several factors, including the impact of the U.S. antidumping case. More importantly, this evolution may be indicative of the level of protection of the Japanese market: the narrowing of the gap between the market share of the Japanese producers in Japan and in the EC speaks in favor of the erosion of the level of protection in Japan. All these results reinforce the provisional conclusion that Japanese firms did not enjoy a substantial sanctuary market, in relative terms (compared to U.S. firms). On the other side, as seen in our discussion of the static economies of scale issue, American producers enjoy an important reserved market with all the procurement in the public sector or funded partly with public money. One final remark: which of the Japanese and American producers did enjoy the eventual sanctuary market? A piece of evidence is the attribution of government sponsored projects in the development of new generations of high power computing. This seems to point to an equitable sharing of the American and Japanese sanctuary market among the main local producers as seems to prove the attribution of the diverse government sponsored R&D programs described in the previous paragraph.

Strategic dumping in the vector market

When looking at the entire supercomputer market, strategic dumping does not seem a likely possibility. Can we draw the same conclusion for the PVP market alone? As already noticed in section 3, **Table 3** shows that the Japanese producers' hold of the Japan market is important: their share never fell under 80%. Likewise, the American producers enjoy a near monopoly situation on their own market. However, the Japanese PVP market is bigger than the American market for such systems, reflecting the preference in this country for vector systems and accounts on average for 50% of world sales over the period 1993-1996. All this raises the possibility of a Japanese "sanctuary" market for vector supercomputers. Could this be enough ground for strategic dumping?

The distribution of market shares, between American and Japanese producers across the world, is reminiscent of what was the situation in the Dram market: American and Japanese have a strong hold of their own market, while there is more competition on third-markets. This situation, as Irwin (1999) shows for the Dram market, can as well be consistent with the Japanese "unfair" trade practice hypothesis than other explanations, including the closure of the American market. In this case, the lack of evidence found by the ITC points out to the lack of strategic behavior from Japanese producers.

The evolution of the global market for vector computers, and the Japanese market in particular, casts a serious doubt on the possibility of any threat of strategic dumping behavior. From 1996 on, procurements, in terms of maximum capacity of computation sold, have stagnated, in 1997, then halved in 1998, which means a very significant decrease in "real" terms, taking into account the technological pace. In Japan, the decrease has even been more significant, procurements being reduced by 12-fold between 1996 and 1998. This evolution in Japan is quite understandable; given the high level of government funded procurements, and the economic crisis the country is experiencing. Is it really conceivable that with such a shrinking sanctuary market Japanese producers may engage in strategic dumping?

In addition, even though the American authorities opted for a market definition including the vector computers alone, we can not rule out the existence of substitutability between PVPs and MPPs. We have seen that the Japanese market is rather open to MPPs, thus eventually providing some ground for competition there.

5. The dumping case and its implications

We review in this section the most important issues raised during the course of the antidumping case, beginning with the aftermath of the case and some future implications. We then focus on several issues, which gave rise to heated debates during the examination of injury. We will discuss: the staggering level of dumping margin computed by the ITA; the market definition adopted by the ITC;

and the causality relationship between dumping and threat of injury.

The aftermath

As is clear from **Figure 2**, the antidumping investigation and measures have been very powerful, trimming substantially the life cycle of NEC's SX-4 and Fujitsu's VPP300/700 series. On the other hand, Cray's vector series, the T90, did not seem to benefit much from the ruling, with sales rebounding very slightly in the wake of the investigation. Overall, T90's sales have been dismal, as evidenced in **Figure 1**. This latter pattern raises the question of the motives which drove Cray to file an antidumping complaint. Indeed, in addition to the declining share of SGI/Cray in the vector market, other facts seem to point to at least a partial withdrawal of Cray from the market. In a filling to the SEC, SGI declared that it "found it necessary to downsize its vector supercomputer business" in fiscal year ending in June 1998.[14] SGI/Cray's interest in filing the antidumping complaint could well have been the parallel supercomputer market and not the vector market: the antidumping investigation and duties being a way to accelerate the decline of the vector market, favoring the MPP line and squeezing out potential future competitors (Japanese producers may switch to MPPs in the near future).

Another direct consequence of the case is more of a legal nature. By considering that the DOC didn't prejudge the case by drafting the pre-decisional memorandum and circulating it, the U.S. Courts allow the antidumping authorities to pre-investigate outside any statutory framework, which could constitute a potential harmful threat for foreign exporters.

Finally, this case underscores the incestuous relationships between the private and the public sphere in the supercomputer market. Cray reacted strongly because NEC nearly succeeded in winning a contract funded by public money.[15] The supercomputer industry is considered strategic from a military viewpoint and many interests call for a strong domestic high power computing capabilities. In addition, close ties between defense contractors and government is commonplace: this may explain why the case was nearly self-initiated.

The 454% margin

The disclosure of the pre-decisional memorandum (reproduced in annex) shows that the computation of a dumping margin was rather a crude exercise. In the pre-decisional memorandum, the dumping margin magnitude appears to be overwhelmingly determined by the assumption that was made on future sales. At $200 million, the R&D spending is very important, and accounts for the most of fixed costs, which, in the ITA calculation, themselves account for a major part of total costs. How important fixed costs are, as a share of total costs, depends on how many units the firm sells, and the ITA assumed low projected sales for NEC with 250 processors. Basically, this memorandum shows that any level of dumping could be calculated for NEC, since the calculation is so sensitive to the assumption on the projection of units sold.

As NEC refused to cooperate, the ITA could take the most unfavorable hypothesis for the Japanese producer. A small calculation reproduced in the annex let us believe that they retained the initial hypothesis of 250 processors sold for the entire generation of the SX-4 and Cray's allegation that NEC would only cash $15 millions out of the sale. In the absence of any further information on what hypotheses and how the ITA computed the dumping margin, we still can make two remarks. The first

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[14]/Filing to the SEC, Form 10-K, 28 September 1998. In the same document, SGI declares to be willing to merge its parallel and vector line and to see the decline of the vector market as a long-term trend.

[15]/In a email to Cray's employees following NCAR's announcement of NEC's selection, Robert Ewald, President and COO, writes: "Funding for this NCAR procurement is authorized by the U.S. Congress and as we understand the funds come principally from the National Science Foundation budget, the High Performance Computing and Communications Initiative which is intended to advance U.S. leadership in supercomputing, and from the U.S. Global Climate change program (another program that we have publically (sic) supported). You can imagine that it is particularly galling to see funds from programs that we have supported and are so close to our hearts, potentially expanded in an unfair manner".

one is that, among others, the assumption taken in the pre-decisional memorandum of 250 sales for processors is far from sincere. The number of SX-4 processors installed in the November Top500 list – an underestimate of the total sales over the life of the product– is already 236, not one year after the first shipping of such systems (it reached more than 700 installed units in June 1999, despite the antidumping ruling). Likewise the number of VPP500 processors, an older generation from Fujitsu is 564 at the same date (the later being, however, some 70% less fast than the SX-4).

The second fact is that such wide dumping margin stuck the Japanese producers in a corner solution. Its magnitude dissuaded the Japanese to try to bargain for a more advantageous outcome. It was not rational to try to discuss about the calculation; even if the ITA agreed on revising some of its hypotheses, the final rate would certainly still be at very high levels (see for instance Rosendorf [1996] for an enlightening presentation of the bargaining process in antidumping proceedings). This explains why the Japanese put all their energy in fighting the weak point of the investigation: the injury determination.

Finally, as this was the case with supercomputers, calculating below-cost dumping margins in the case of products with very high fixed costs, or dynamic economies of scale effects needs taking into account the worldwide sales of the defending firm. An investigation on such big markets as the U.S. is then likely to affect the firm not only in the American market alone, since it may react by adjusting its costs to comply to the antidumping ruling or its threat.

The market definition

Narrowing the issue to the vector supercomputer "market" raises a host of questions. First, is the argument according to which there is a small degree of substitutability between vector and non-vector supercomputers strong enough to legitimize the breakdown between vector and non-vector supercomputers? The question deserves to be raised all the more because UCAR issued a request for proposal to vector and non-vector supercomputer producers and, in the wake of the initiation of the case, decided to shift from the NEC vector supercomputer to a Hewlett-Packard MPP-supercomputer – not to the alternative offered by a new Cray vector supercomputer. The major argument supporting limited or non-substitutability is that shifting to a new type of system imposes "high costs." Leaving aside for a while the magnitude of the costs allows to focus on two points: (a) such an argument recognizes an advantage to the incumbent, that is, Cray in the U.S. market, over any entrant; (b) by the same token, it justifies some kind of dumping, as a rational signaling strategy by entrants challenging the incumbent firm. In sum, limiting the scope of the market on this ground leads inevitably to a justification of dumping. If one assumes that GATT law prohibits dumping by foreign firms –a wrong assumption (GATT does not require antidumping action) which is de facto taken by many WTO Members–, this approach leaves domestic firms as the only conceivable cause of dumping. Since, in the U.S., there is no domestic producer of vector supercomputers other than Cray (now SGI), the logical conclusion of combining non-substitutability and a no-dumping rule from foreign firms is the creation of a domestic monopoly in the "market" of vector supercomputers.

Second, looking at vector computers only facilitates the demonstration of the existence of dumping, but it makes the demonstration of the existence of injury harder –a point raised implicitly by Judge Pogue in his recent instruction that ITC should reassess its 1997 finding (CIT Consol. Court No 97-11-11967). Japanese market shares may be larger, but this is in the context of an increasingly smaller share of vector supercomputers in the entire industry. Such an evolution (measured in machines or in MCC) suggests the existence of powerful forces at work making harder the life of vector supercomputer-makers. These forces come from new technologies available on the supply side, in particular the already mentioned existence of off-the-shelf powerful processors. But they may also come from the demand side. Vector supercomputers are relatively rigid equipment: buyers buy machines which shall satisfy their needs for the next five years. Most of the buyers of supercomputers are at the forefront of science, such as academic or research institutions, or at the forefront of regulatory reforms such as airlines, telecom firms or banks, and are often government-supported institutions. In this context dominated by rapid technical progress for the users, the tendency among buyers is to be risk-averse: they tend to buy machines with adequate capacities for future expected "peak" periods of use, that is, with excessive capacities for most of the time. By no means (whether in private or in public practices), is this an optimal investment policy. The non-vector supercomputers (in particular, the scalable ones) offer enhanced flexibility and compatibility for the buyers –a much better management of the peak use of the machines.[16]/

The third question raised by limiting the antidumping investigation to vector supercomputers is the implicit aggregation of all the transactions into a "market." As is well known, there is a large number of transactions for which there is a single bidder or where competitive bids fall under the restrictive "Buy American" Act provisions. It would be interesting to examine the vector supercomputer market as a market divided in two segments: a competitive segment and a "sanctuary" segment –with all the implicit consequences for Cray who, as the largely dominant incumbent in vector supercomputers, is likely to be the major beneficiary of the "sanctuary" market (in terms of economies of scale). This point is close to the questions examined in previous sections.

Fourth, an intermediate option between the entire industry and the vector "niche" could have been considered: the definition of all the supercomputers within a price range of, say, $200,000 to $40 or 50 millions.

A last point deserves some attention: limiting the pertinent market to vector computers only does not preclude antidumping measures from having an effect on the whole supercomputer market. The five-criterion definition used by the ITC –even correctly and fairly applied, as Judge Pogue ruled out– does not rest on economics rationale and does not preclude some non-PVP supercomputers from being substitutable with PVP products. Several facts support this, and the ITC itself does not deny it (see for instance in ITC final's section II-A: "At the same time, the vector supercomputer industry is facing increasing competition from mid-range applications from non-vector supercomputers"). Hence, competitive bids in the U.S., for which vector and non-vector producers compete, may be affected by the disappearing of Japanese vector producers. A second reason may be the chilling effect generated by the antidumping measures, which affects also Japanese producers of non-vector supercomputers or any strategy of the existing Japanese producers to enter the MPP market. The only way to objectively analyze the degree of substitutability between PVPs and MPPs/SMPs would be to apply criteria similar to the one used in the horizontal merger guidelines in antitrust complaints. It is true, however, that the narrow conception of the market which is generally in use with the antidumping authorities is not necessarily prejudicial to the foreign firms, since a narrower scope of investigation means overall less harmful duties, if imposed.

The threat of material injury and the causality link

Examining once again the pre-decisional memorandum, one can wonder how causality works between the existence of sales at less than fair value and the threat of injury. Causality was a weak point in the ITC investigation, as Judge Pogue ruled out in his request that the ITC remand its determination, the agency failing to show that LTFV sales were a "material" cause of injury.

Our argument here is different from the CIT's criticism. Given that the size of the dumping margin is directly linked to the number of processors sold, the more processors sold, the less is the

[16]/In many respects, this issue is quite similar to what is observed in the energy sector, with the appropriate mix of nuclear and gas-based power plants.

dumping margin and *vice versa*. This is clearly incompatible with the ground on which the ITC ruled out the existence of a threat of injury, based on the existence of increased capacities and press statements in which Fujitsu and NEC "hoped to expand sales volumes by 100 percent and 63 percent (by number of orders), respectively, in fiscal year 1996, compared to fiscal year 1995" and press reports citing them "as hoping to increase exports to the United States and Europe" (ITC final, footnote 133, section V). Given the very low level of sales of Japanese producers in the American market, there is no doubt that any increase in sales will be indeed substantial. A sale of the importance of the UCAR procurement –3 systems totaling 96 processors–, would indeed be injurious for Cray, in terms of foregone sales, and would indeed represent a significant increase in import volume and market penetration meeting then part of the criteria laid out by antidumping authorities in their finding. Would such a sale occur (it did not), the number of processor sold would represent a significant amount compared to the ITA hypothesis.

Such a reasoning can still be held by the ITC, since it has to take the LTFV determination as given and doesn't have to "look behind" the margins set by Commerce, as Commissioner Crawford put it in the recent investigation on large newspaper printing press.[17]

6. Conclusion

The examination of the Cray-NEC case leaves little doubt about the absence of any predatory intent from the Japanese producers, should their product be dumped. The conclusion is in all probability the same regarding the strategic dumping possibility, despite some evidence of control of the local Japanese market. This case examination opens thus two questions: first was there some dumping pricing from the Japanese producers, and second, in this case, what was the motivation behind it? The ITA, by using the petitioner's submission to establish the dumping margin, did not investigate nor answer the first question. It would deserve to be examined more closely. Unfortunately, we had to leave the question aside, because of the lack of availability of information on prices and their evolution. High levels of discounting for the benefice of some buyers seem to be a common practice in the industry, therefore suggesting some possible episodes of "dumping". Such pricing could be the result of some economically sound behavior: a signaling strategy to win new customers, compensation for switching costs, the discounting of possible network externalities, the effect of some demand or supply cycle, or any other explanation. Another direction of research that needs to be explored is the impact of antidumping policy on auction markets and markets with few transactions. In a brief period of time, two cases have targeted such markets: the large newspaper printing press and the supercomputer industries.

One of the problems which arise when antidumping tackles with high-technology industries (see e.g. Flamm, 1996 and Irwin, 1999), is precisely the pace of the technological change, which seems very incompatible with the way injurious dumping is determined. We saw in the context of the supercomputer case that the calculation of the dumping margin and the determination of the injury do not have much economic sense. The supercomputer industry is obviously undergoing a dramatic technological evolution: even if there may a future for vector computers, new technologies developments <u>outside</u> the industry, in commodity processor computing power, in networking and software capability are certainly shaking out the vector supercomputer market. Cray seems to be the nearest to the exit, despite heavy subsidization of research and procurements for supercomputers. Or is it the reverse, precisely because of how subsidy policy is implemented. Parallel processing is indeed the

17/Large Newspaper Printing Presses and Components Thereof, Whether Assembled or Unassembled, from Germany and Japan, Inv. Nos. 731-TA-736&737 (final), USITC Pub. 2988.

industrial choice that has been decided by the U.S. authorities. From Cray's point of view, antidumping would then be a substitute to industrial policy, not a complement to it.

Annex 1: An account of the antidumping dispute

In March 1995, the University Corporation for Atmospheric Research (UCAR), an agency funded by the National Science Foundation (NSF), solicited bids to procure a supercomputer for an affiliate, the National Center for Atmospheric Research (NCAR). Potential vendors were offered to bid according to one of two scenarios: a $13.25 million three-year or a $35.25 million five-year contract. The bid was released to 14 vendors (that is, almost all the existing supercomputer-makers at the time), and three manufacturers offered final bids in the competitive range. Among them, were two Japanese makers, NEC and Fujitsu, though not a single U.S. public procurement on supercomputers had ever been awarded to a foreign supplier. When it became clear that NEC was on the verge of winning a bid of such magnitude, pressure began to mount from Cray, the leader in the market and principal contender in the procurement, and from the Department of Commerce.

U.S. monitoring of supercomputer sales in Japan and in the U.S.

Strong U.S. reactions in this sector were, as a matter of fact, nothing new. The US government had been monitoring closely supercomputer sales to the public and private sector for quite a while. In 1987, NEC was about to win (against Cray, Control Data and Amdahl) a bid to provide a system to the Massachusetts Institute of Technology (MIT). In order to block the procurement, the Department of Commerce sent a letter to MIT threatening with an antidumping investigation if the sale was to be at a price below cost: soon after, MIT withdrew its plan. The same year, the first supercomputer agreement was signed between the Japanese and the U.S. governments, requiring that governments give notice of their intention to procure a machine. In May 1989, disappointed with the results of the agreement, and the lack of access to the Japanese market, the United States put supercomputers under the Super 301 list of the Omnibus and Competitiveness Trade Act of 1988. These move led to the finalization and signing of a second supercomputer agreement, in June 1990. The agreement stated that real performance and not only peak performance should be used in procurements and that discount practices should be limited. In July 1992, Cray lost a bid to NEC for the National Institute for Fusion Sciences of Japan. The American manufacturer made a formal complaint to the Japanese government about several flaws in the procurement [Anchordoguy, 1994]. The Japanese government undertook an inquiry, and concluded to nothing reprehensible in the bid.

In February 1996, Cray complained again that NEC was undermining the supercomputer agreement. In 1995, Cray had lost a $40 million procurement with Japan’s Ministry of Education and a $7 million procurement with Japan’s Ministry of Health and Welfare. In a bilateral meeting with Japanese officials, the U.S. officials echoed Cray’s concerns and demanded a review of the two procurements, arguing that the Japanese agencies had made their decisions based on price only, ignoring the agreement requirement to examine also the performance of the system, the ability to meet the required specifications and the overall value of the machine. Another plea was to ensure that the “paper-machines” (that is, the supercomputers which are not yet developed) bid would be effectively delivered.

Building the antidumping case

U.S. officials affirmed that the U.S. complaint was not linked to UCAR’s pending procurement. However, when it became clear that NEC was about to win the contract, the DOC began the same maneuvers as in 1987. In the beginning of April 1996, the DOC assembled a team of Import Administration officials to analyze data from NEC’s bid and determine whether there had been tentative dumping. This pre-investigation analysis concluded to the existence of dumping, and subsequently the DOC informed the NSF about its findings. UCAR nevertheless announced that it intended to buy the supercomputer from NEC, and that it was entering in the final contract negotiations (showing that it was strongly in favor of the NEC procurement).

DOC's pre-decisional analysis concluded to dumping margins ranging between 163% and 280%.[18] At the NSF's request, UCAR had appointed a trade consultant to estimate the dumping, while Cray was building its own case –making it clear that it was considering filing an antidumping complaint [Inside U.S. Trade, May 24, 1996]. UCAR's analysis didn't show any dumping, whereas Cray concluded to a margin over 400%. It was not yet clear, though, who –of the DOC or Cray– would file under LTFV statutes. In a June 24 letter, the NSF asked Commerce Secretary Mickey Kantor whether the DOC intended to self-initiate an investigation –a move which would be quite exceptional since only once in the past had Commerce initiated a LTFV investigation on its own (in 1986, when DOC filed a complaint against imports of Dynamic Random Access Memories of 16Kb or above from Japan, for which NEC was one of the main Japanese exporters).

The "double" track

Meanwhile, Cray pursued simultaneously the political track. In April 1996, Rep. Martin Sabo (D-MN), the representative from the district where Cray's headquarters are located, urged the White House to back the US supercomputer industry.[19] Moreover, reacting to NSF's decision to buy from NEC, Rep. David Obey (D-WI), in whose district Cray Research has facilities, promised that he "will be studying the various options available to block the finalization of the agreement" [Inside U.S. Trade, May 24, 1996]. Indeed, Obey drafted an amendment to the Appropriations Bill, proposing to withhold the salaries of NSF's personnel who would approve contracts for supercomputer equipment that would later prove to have been dumped [Cong. Rec. H6905]. The "high-track", as it is called in the literature on U.S. trade policy [Finger, Hall & Nelson (1982)], is not a path often taken regarding dumping disputes. The fact that a government agency was involved in the procurement made it attractive this time. Should Cray succeed in getting Congress on its side, it would get a very substantial leverage on the NSF: as Weingast & Moran (1983) remind us, the Congress has the power to reorganize an agency, cut its appropriation, or even bluntly eliminate it. However, ultimately, the Senate dropped Obey's amendment and the House finally adopted the bill stripped of it.

This strong support from the political track, and its capacity to exert quite direct and extraordinary pressures on the <u>consumers</u> of the alleged goods (a very distinctive aspect of the Cray-NEC case) was only the first salvo of Cray's offensive. Only the exhaustion of this first strategy may have then led Cray to decide, on July 29, 1996, to file an antidumping petition charging NEC with a 454% dumping margin.

In the opening hearings of the ITC, NEC took an unexpected strong position: it charged Cray with not have been able to meet the bid requirements –casting a serious doubt on the existence of any injury. The potential buyer, UCAR, confirmed soon after in a hearing testimony the substance of NEC's accusation: Cray had not been able to meet the bid's long term requirements, whereas NEC did, and Cray's loss of the procurement was due to "technical deficiencies". While the ITC could not apparently resolve the matter, it decided nevertheless to rule a 3-1 affirmative preliminary determination of threat of injury on behalf of NEC and Fujitsu's idle capacities and their executives' statements (in the Japanese press) about their objectives to increase market penetration in the U.S. and Europe. Even more importantly, in early January 1997, UCAR begun to put into practice its policy

[18]/ on May 20, DOC, responding to NSF's request, sent a letter (the "Joffe letter") explaining DOC's findings. Attached to the letter was DOC's pre-decisional memorandum (reproduced in annex) detailing the dumping margin calculations. Both texts have been disclosed by the trade newsletter <u>Inside US Trade</u>, September 13, 1996.

[19]/Peter Passel, "A Supercomputer Deal Pits Buying American vs. Fair Trade", <u>New York Times</u>, 9th May 1996, p.D2.

taking the dumping case into account: it announced its decision to buy a small Hewlett-Packard scalable parallel supercomputer. The spending corresponding to this decision was not spectacular ($1.5 million). But, should the NEC system be unavailable, upgrading this Hewlett-Packard unit would have made UCAR eventually ready to switch to a supercomputer fully supplied by Hewlett-Packard.[20] The message was quite clear.

NEC also claimed that Cray was using the antidumping process to twist NCAR's arm into buying the equipment it was currently leasing to the agency [See Inside US Trade, 2 August 1996, p.15]. The UCAR procurement was, indeed, aimed at replacing old computing facilities (namely, a Cray system) by October 1996. The purchase option for the leased Cray equipment was valid until March 31, 1997. In short, NEC was accusing Cray of spurious LTFV charges aimed at reaping some rents. Staiger & Wolak (1994) have demonstrated the existence of such rents after filing a LTFV complaint in the U.S. antidumping procedure. The classical explanation for the existence of such rents lies in the harassment effects on the exports generated by the proceeding. The novelty in this case is that Cray harassed directly the consumer, not only the competitor. Cray indeed gained by delaying the bid: UCAR purchased more than $7 million dollars in equipment from Cray, an amount equivalent to one year of the five-year initial bid (or more than 50% of the three-year option, the option Cray was more likely to bid for [ITC final]).[21] The decision was motivated by its need to secure some computing capacity which would last until late 1998.

Cray, on its side, denied the harassment intent, saying that leased equipment was generally bought for "nothing". Indeed, the amount of $7 million is roughly 1 percent of Cray's 1996 sales, that is, not much. Moreover, as the investigation could well have ended at the ITC preliminary stage, that is at the end of September at the latest, the harassment intent is not obvious since UCAR had until March to take a decision regarding the leased equipment (though the investigation was bound to run until the LTFV final determination, well after March 1997).

The "third" track

Following the ITC ruling, NEC adopted an unusually high-profile strategy to counter the ongoing antidumping case: it submitted a suit in the Court of International Trade seeking to suspend DOC's investigation –requesting that an "unbiased body", in place of the DOC, rule the antidumping case. NEC also contended that DOC had prejudged the case before it went to trial, as seemed to indicate the "Joffe letter" and had disclosed the information in a political-level discussion. Informing Commerce Secretary Kantor of its filing, NEC also decided not to participate in the Commerce investigation. By retaliating against the U.S. agency and not Cray, NEC adopted an unprecedented strategy. Commerce reacted rather strongly to this unexpected rebuke and filed soon after, in vain, a motion to dismiss the case and later, in January 1997, two requests to the U.S. Court of Appeals. NEC's case was apparently so good that in February, Judge Donald Pogue, of the CIT decided to order the DOC to postpone for one month its preliminary determination and urge the two parties to try to settle the case.

Cray had actually already made an earlier offer for an out-of-the-Court settlement, under DOC supervision. According to the settlement scheme, NEC would have to agree to price according to the

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[20]/UCAR reaffirmed its position in the ITC's final hearings. Bill Buzbee (Director of the Scientific Computing Division for NCAR) stated that Cray had only been able to meet one out of four UCAR requirements, and only one of eight systems offered could have been tested, representing about 10% of the desired computing power in their final offer. For the remaining 90% Cray was bidding so-called "paper machines." UCAR concluded that NEC material "offered and demonstrated overwhelmingly superior technical performance and low risk relative to Cray Research" and that Cray "lost this procurement because of unacceptable technical risk" in their offer. See Bill Buzbee, "Comments on 'Technical Risk' from the UCAR post ITC Hearing Brief", September 12, 1997, a document accessible at http://www.scd.ucar.edu/info/additc.html .

[21]/This sum is to be compared with the $2-3 million that Cray is estimated to have spent in legal fees for the case.

results of the preliminary determination and to participate in the investigation. The two parties then met again, according to CIT's suggestion. In the course of talks, the balance of power changed: the CIT ruled out the injunction petition made by NEC, letting the DOC go on with the dumping determination.[22] As a result, the talks led to no agreement. Another blow to the Japanese supercomputer-maker, a week later, was the dumping preliminary determination, on March 31, which concluded to a 454% dumping margin.

From trade in goods to trade in services

In mid-April, NEC announced its intention to cooperate, offering to share some of its technology with Cray, but asking as a pre-requisite the withdrawal of the petition. On its side, Cray was demanding from its Japanese competitor to agree on pricing in "third" markets (third-market provisions are a well-known outcome of U.S. antidumping proceedings). Both sides felt they had a strong position. Cray had been comforted by the decisions of the CIT and Commerce. NEC surprised by adopting a new strategy. The Japanese producer showed a strong reluctance to cooperate in the antidumping investigation. NEC's chairman, Tadahiro Sekimoto, threatened: "If necessary, we will consider setting up a supercomputer center in Canada or somewhere else to provide services to users in the United States" [Japan Computer Industry Scan, April 15, 1997].[23] NEC had announced that it was waiting until the end of the investigation before putting the system into operation, which started effectively servicing customers in April 1998. The decision was finally made to install the server in Japan, a less risky place shielded from eventual "echoing" trade prosecutions [Maur, 1998]. In addition to the symbolic aspect of this move, NEC's decision may be an indication of where the future of supercomputing may lie (see section 4).

NEC-Cray talks continued in early May, without giving birth to any agreement, despite rumors that a settlement had been reached [Japan Computer Industry Scan, May 5, 1997]. At the end of the same month, Fujitsu withdrew in its turn from Commerce's investigation. The reason was one often heard: the heavy information requirements for the dumping determination and the little time given to answer to these demands.[24]

On August 20, 1997, the Court of International Trade finally rejected NEC's claims. Less than 24 hours later, the DOC rendered its final determination. The dumping margin was the same as Cray petitioned for: 454%. Fujitsu was assigned a 173.08% margin, exceeding by far the 27% provisional margin, and the remaining producers would be subject to the average duty of 313.54%. As a consequence, the NSF abandoned the idea of procuring the NEC material. Before ITC's final determination, Cray tried to push its advantage further: it was now considering going to the WTO to complain about Japanese manufacturers' pricing in world markets. "We plan to use the Commerce Department and ITC findings in the U.S. case to bring attention to their unfair practices in other markets worldwide" declared Irene Qualters, President of Cray Research [SGI Press Release, September 26 1997]. Another option considered was to "echo" the antidumping investigation against NEC on the European market, by inducing European authorities to examine NEC's dumping practices

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22/One of the statements of reasons why the "balance of hardship" did not favor NEC enough, was that no "likelihood of success" based on the merits of the case was demonstrated.

23/NEC hesitated between establishing this supercomputer server in Canada, in Latin American or in Japan. At first, the Canadian solution seemed to be favored, because of the proximity to the American market and also because the Japanese maker already had a small supercomputer business in Montreal, supporting its customer, the Canadian weather agency. Toronto also looked like an attractive place, because many MNE have offices there. It is questionable whether this announcement helped NEC's case. Fujitsu did not support NEC's declaration feeling it would alienate the American authorities. Moreover the servicing of supercomputing power through the Internet is not possible for all uses (because of the bottleneck that the Internet bandwith represents) and it is still not clear whether customers are ready to buy supercomputing power this way.

24/Especially since the DoC request arrived at the time of an important holliday in Japan, the Golden week.

there. This last solution confirms the high incentive of international firms to try to obtain antidumping relief in multiple markets, but it does not seem very likely: there is no significant European producer and Siemens, an important player in the electronics industry, is tied with Fujitsu by a selling agreement.

Annex 2: The pre-decisional memorandum FMV calculation[25]

- Bid price was $35.25 millions for a five-year lease for three SX-4/32. The net present discounted value using a yearly interest rate of 4% and assuming equal monthly payments is:

<u>US Price in millions of U.S. dollars (USP)</u>		**$31.393**
<u>Costs</u>		
material (hyp.: cost halved every 18 months)		$14.343
storage		$2.748
other services and software (18% of hardware costs)		$3.076
marketing costs (15% of revenues)	35.25*0.15 =	$5.288
subtotal		***$25.455***

- for R&D (Nonrecurring Engineering Expense, NRE), an estimated $200 million was supposed to be the development cost of the processor over 4 or 5 years. The cost of money adds $17.435 million. The per unit NRE are allocated over the number of processors which are projected to be shipped, the resulting figure is multiplied by a scaling factor of 0.666 reflecting the reduced NRE as systems increase to larger sizes like the 32-processor system. The hypothesis assumed in the memorandum is 250 processors shipped over the product's life.

R&D	(217.435/250)*0.666*32*3 =	$55.608
<u>Total Costs</u>		***$81.062***
Profits (based on the 2% earnings before tax)	0.02*total costs =	$1.622
<u>Fair Market Value (FMV)</u>		***$82.684***
<u>Dumping margin</u>	***1-(FMV//USP) =***	***163.38%***

- NEC claimed that it will ship 1754 processors. The R&D would be reduced to $7.926 million, and the FMV to $34.048 million. The dumping margin almost disappears to 8.46%.
- Cray claimed that only 500 processors would be shipped,[26] leading to a FMV of $54.324 million. Moreover, Cray assumed that NEC would get only (around) $14.9 million of revenue out of the transaction. The US price is then (around) $14.9 million and the dumping margin is 264.6%. Taking instead DOC's hypothesis on R&D, we obtain a margin of 454.9%.

25/ A copy of the pre-memorandum has been disclosed by Inside US Trade, September 13, 1996.

26/ Cf. note 25.

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Figure 1. Share of Top500 total computing power for SGI-Cray product lines (1993-1999)

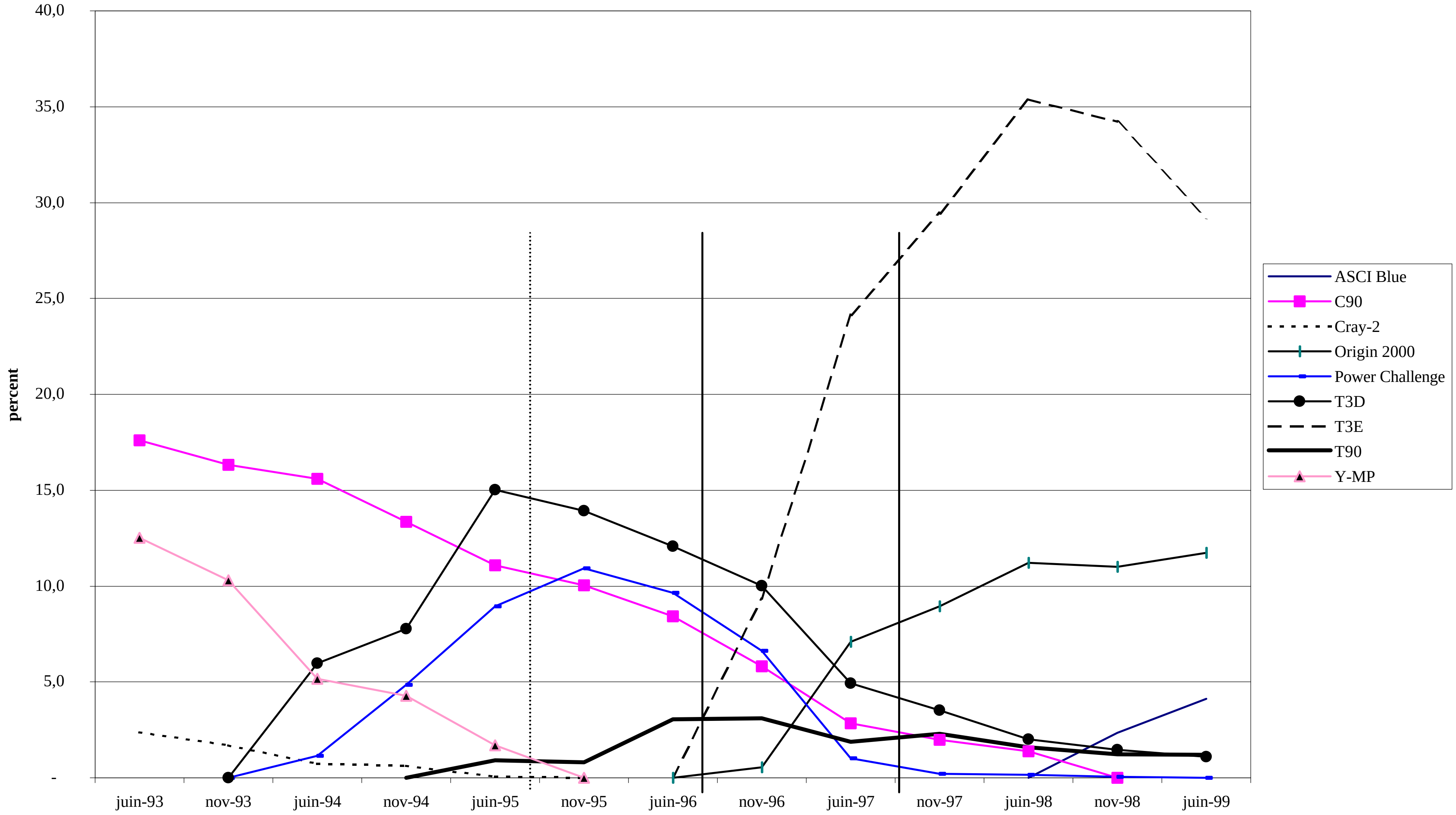

Figure 2. Share of Top500 total computing power for Japanese product lines (1993-1999)

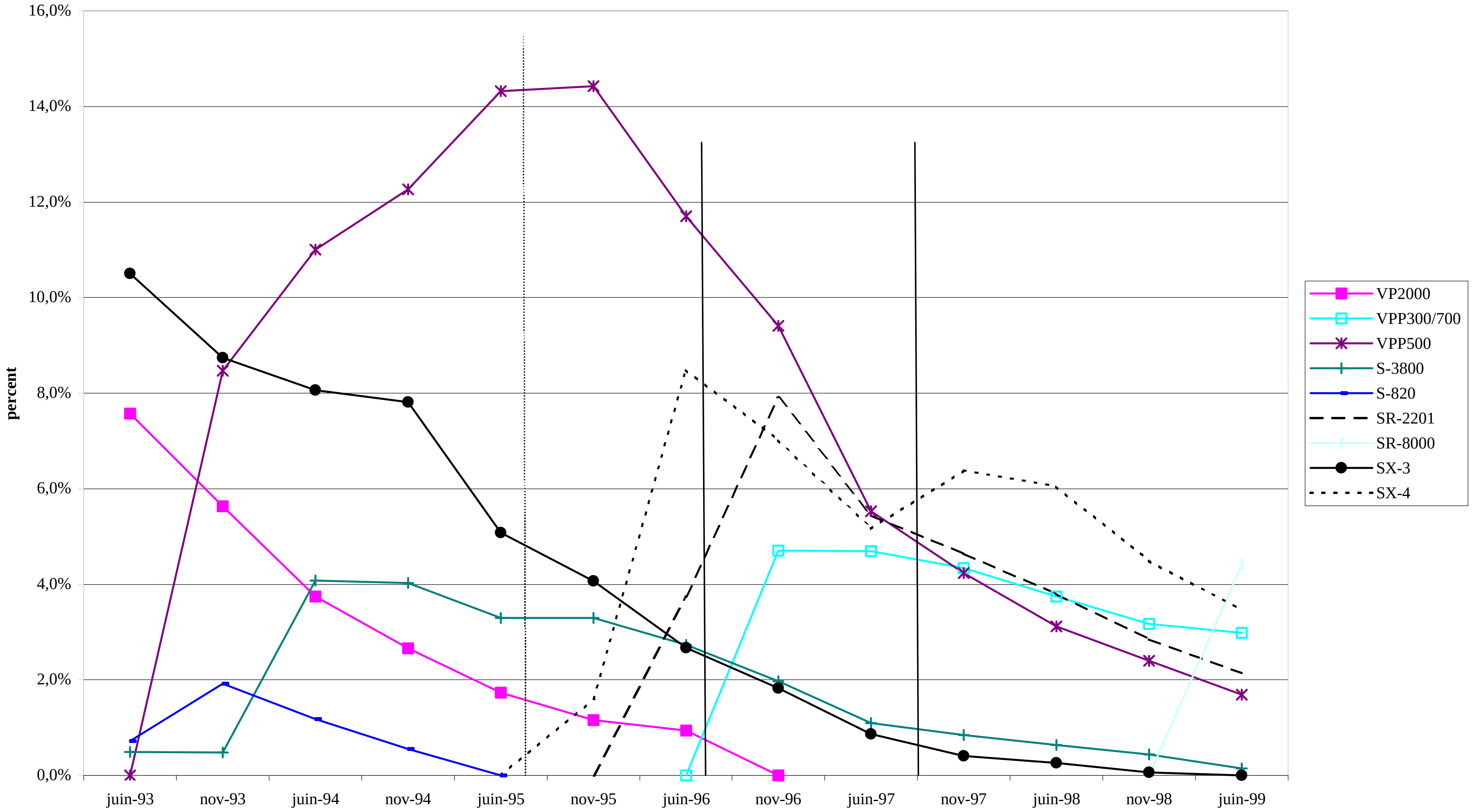

Figure 3. Total maximum computing power of the Top500 most powerful supercomputers

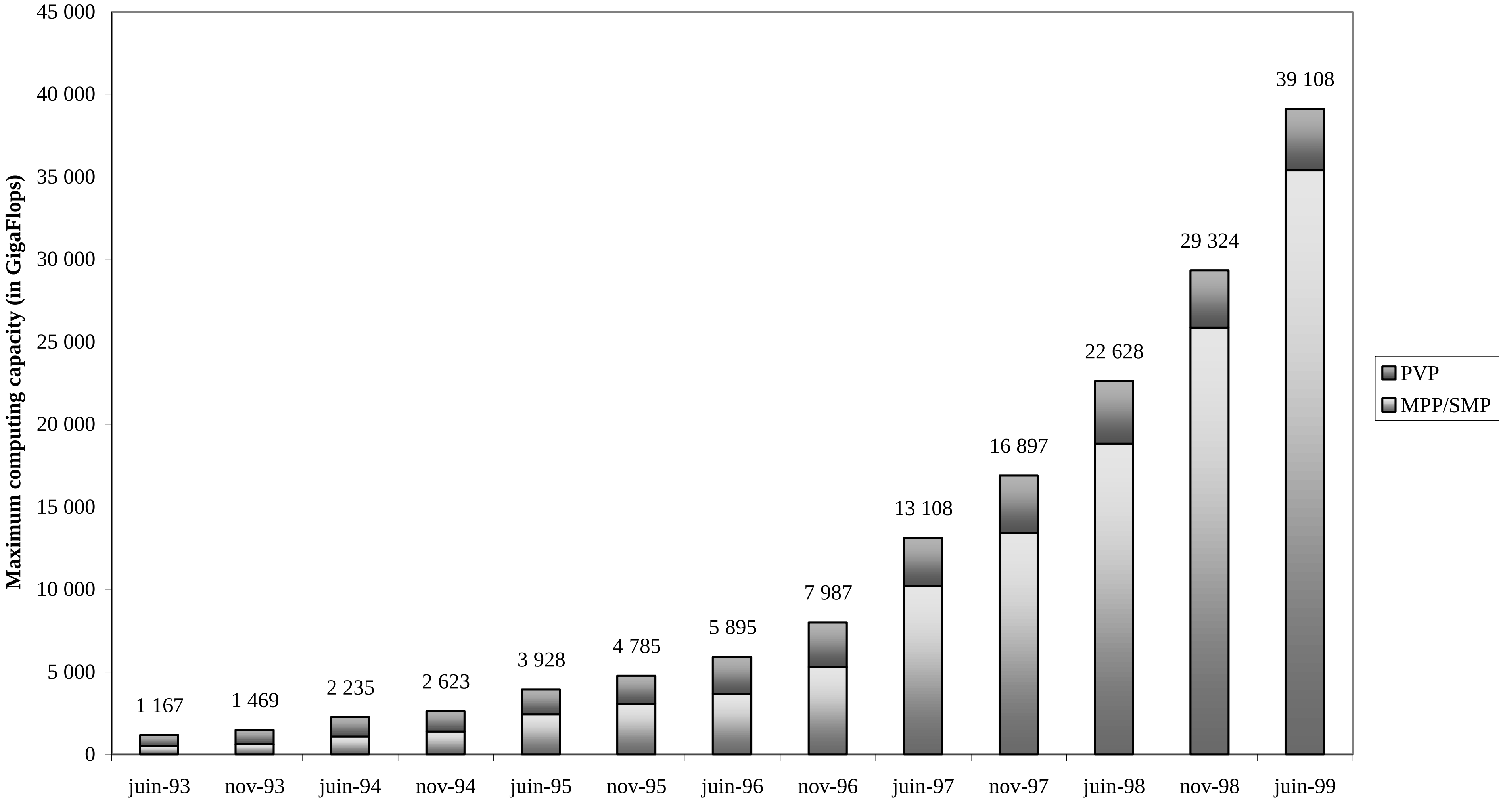

Figure 4. Share of Top500 for vector supercomputer manufacturers

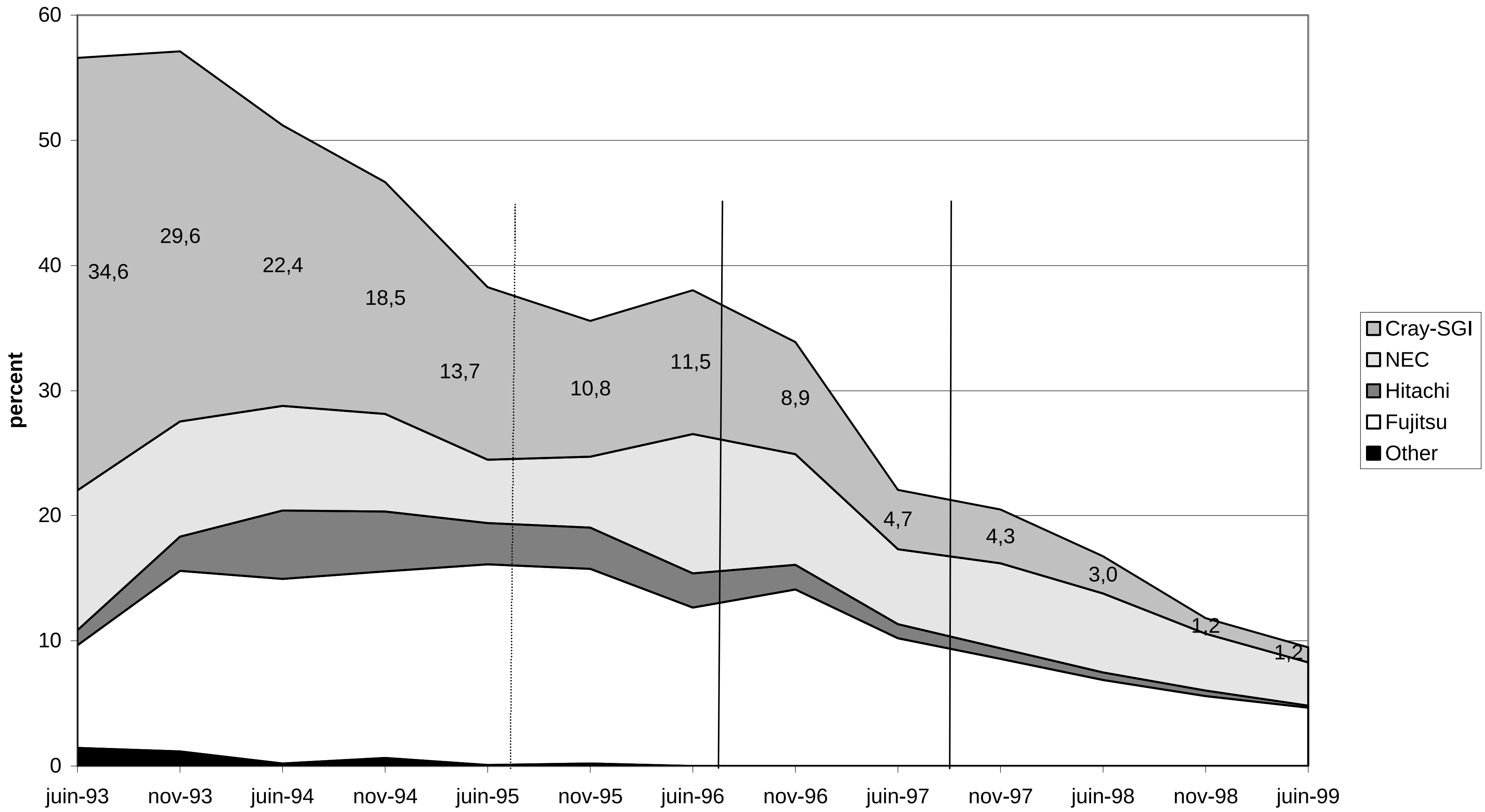

Figure 5. Share of the Top500 for supercomputer manufacturers

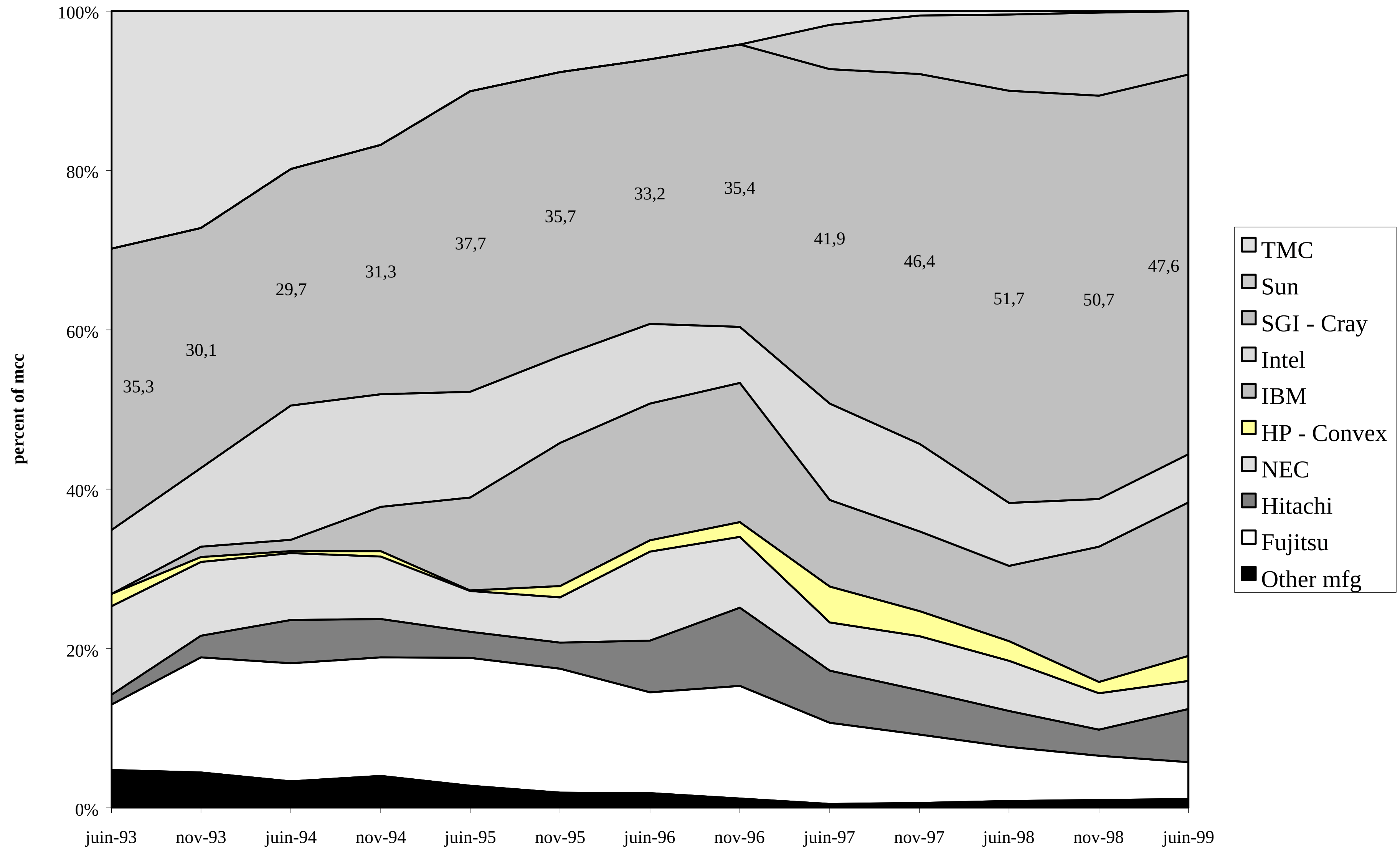

Table 1. Annual world sales of supercomputers (1993-98)

		1993	1994	1995	1996	1997	1998
Total number of machines	PVP	51	44	32	55	37	10
	MPP/SMP	61	162	211	198	282	277
Total maximum capacity of computation	PVP	312,9	270,0	368,9	1279,4	1394,9	644,8
	MPP/SMP	241,3	700,6	1406,8	2901,6	9607,8	13772,4
Average max. capacity of computation	PVP	6,1	6,1	11,5	23,3	37,7	64,5
	MPP/SMP	4,0	4,3	6,7	14,7	34,1	49,7

Source: Top500, various issues. Authors' computations.

Table 2. Breakdown of annual procurements of supercomputers in the main geographical markets, by producer's nationality

	1993	1994	1995	1996	1997	1998
Procurement in the U.S.						
Japan Co.						
nb of machines	1	-	1	3	1	-
max. capacity of computation (%)	0,3	0,0	0,6	2,0	0,3	0,0
avg. mcc (GigaFlops)	1,0	-	5,6	9,0	17,1	-
U.S. Co.						
nb of machines	58	86	126	122	181	182
max. capacity of computation (%)	99,7	100,0	99,4	98,0	99,7	100,0
avg. mcc (GigaFlops)	5,3	5,3	7,5	10,6	35,7	55,0
Procurement in Japan						
Japan Co.						
nb of machines	9	7	5	20	12	4
max. capacity of computation (%)	90,4	51,5	73,8	88,0	53,2	34,4
avg. mcc (GigaFlops)	17,3	10,4	39,9	65,7	50,0	43,6
U.S. Co.						
nb of machines	8	13	11	12	26	13
max. capacity of computation (%)	9,6	48,5	26,2	12,0	46,8	65,6
avg. Mcc (GigaFlops)	2,1	5,3	6,4	15,0	20,3	25,6
Procurement in Europe						
Japan Co.						
nb of machines	2	2	2	12	9	5
max. capacity of computation (%)	15,7	6,5	4,4	27,0	16,4	10,2
avg. mcc (GigaFlops)	4,0	8,6	8,6	26,5	52,1	65,2
U.S. Co.						
nb of machines	25	72	70	66	67	64
max. capacity of computation (%)	84,3	93,5	95,6	73,0	83,6	89,8
avg. Mcc (GigaFlops)	1,7	3,5	5,4	13,0	35,7	44,6
Procurement in the rest of the world						
Japan Co.						
nb of machines	1	4	1	3	2	1
max. capacity of computation (%)	12,5	36,1	10,0	36,3	29,0	34,1
avg. mcc (GigaFlops)	2,9	9,8	15,5	23,3	76,7	244,0
U.S. Co.						
nb of machines	8	22	27	15	21	18
max. capacity of computation (%)	87,5	63,9	90,0	63,7	71,0	65,9
avg. mcc (GigaFlops)	2,5	3,1	5,2	8,2	17,9	26,2
Total procurement in the world						
Japan Co.						
nb of machines	13	13	9	38	24	10
max. capacity of computation (%)	30,3	13,3	13,4	41,4	11,3	5,2
avg. mcc (GigaFlops)	12,9	9,9	26,4	45,5	51,6	74,5
U.S. Co.						
nb of machines	99	193	234	215	295	277
max. capacity of computation (%)	69,7	86,7	86,6	58,6	88,7	94,8
avg. mcc (GigaFlops)	3,9	4,4	6,6	11,4	33,1	49,4

Source: Top500, various issues. Author's computations.

Table 3. Breakdown of annual procurements of vector supercomputers in the main geographical markets, by producer's nationality

	1993	1994	1995	1996	1997	1998
Procurement in the U.S.						
Japan Co.						
nb of machines	1	-	1	3	1	-
max. capacity of computation (%)	1,1	-	7,4	17,6	9,5	-
avg. mcc (GigaFlops)	1,0	-	5,6	9,0	17,1	-
U.S. Co.						
nb of machines	18	12	11	15	10	2
max. capacity of computation (%)	98,9	100,0	92,6	82,4	90,5	100,0
avg. mcc (GigaFlops)	5,5	3,6	6,4	8,4	16,3	28,2
Procurement in Japan						
Japan Co.						
nb of machines	9	7	5	16	8	2
max. capacity of computation (%)	98,9	82,6	88,3	99,2	88,8	100,0
avg. mcc (GigaFlops)	17,3	10,4	39,9	43,6	62,1	28,6
U.S. Co.						
nb of machines	1	2	5	1	3	-
max. capacity of computation (%)	1,1	17,4	11,7	0,8	11,2	-
avg. Mcc (GigaFlops)	1,7	7,7	5,3	5,7	20,8	-
Procurement in Europe						
Japan Co.						
nb of machines	2	2	2	11	8	4
max. capacity of computation (%)	21,7	18,3	33,6	86,0	84,8	93,0
avg. mcc (GigaFlops)	4,0	8,6	8,6	27,6	52,2	66,8
U.S. Co.						
nb of machines	15	14	7	6	4	1
max. capacity of computation (%)	78,3	81,7	66,4	14,0	15,2	7,0
avg. Mcc (GigaFlops)	1,9	5,5	4,9	8,2	18,6	20,0
Procurement in the rest of the world						
Japan Co.						
nb of machines	1	4	1	3	2	1
max. capacity of computation (%)	15,1	89,4	100,0	100,0	93,4	100,0
avg. mcc (GigaFlops)	2,9	9,8	15,5	23,3	76,7	244,0
U.S. Co.						
nb of machines	4	3	-	-	1	-
max. capacity of computation (%)	84,9	10,6	-	-	6,6	-
avg. mcc (GigaFlops)	4,1	1,5	-	-	10,9	-
Total procurement in the world						
Japan Co.						
nb of machines	13	13	9	33	19	7
max. capacity of computation (%)	53,6	47,9	64,5	85,8	77,7	88,2
avg. mcc (GigaFlops)	12,9	9,9	26,4	33,3	57,1	81,2
U.S. Co.						
nb of machines	38	31	23	22	18	3
max. capacity of computation (%)	46,4	52,1	35,5	14,2	22,3	11,8
avg. mcc (GigaFlops)	3,8	4,5	5,7	8,2	17,3	25,4

Source: Top500, various issues. Author's computations.

Table 4. Breakdown of annual procurements of supercomputers by region

	1993	1994	1995	1996	1997	1998
Procurement in the U.S.						
PVP						
nb of machines	19	12	12	18	11	2
max. capacity of computation (%)	18,0	4,5	4,3	3,7	1,6	0,4
avg. mcc (GigaFlops)	5,2	3,6	6,3	8,5	16,3	28,2
MPP/SMP						
nb of machines	40	74	115	107	171	180
max. capacity of computation (%)	37,6	42,3	49,5	27,9	57,3	69,1
avg. mcc (GigaFlops)	5,2	5,5	7,7	10,9	36,9	55,3
Procurement in Japan						
PVP						
nb of machines	10	9	10	17	11	2
max. capacity of computation (%)	28,4	9,1	12,7	16,8	5,1	0,4
avg. mcc (GigaFlops)	15,8	9,8	22,6	41,4	50,8	28,6
MPP/SMP						
nb of machines	7	11	6	15	27	15
max. capacity of computation (%)	2,7	5,5	2,5	18,9	5,2	3,1
avg. Mcc (GigaFlops)	2,1	4,9	7,4	52,7	21,0	30,0
Procurement in Europe						
PVP						
nb of machines	17	16	9	17	12	5
max. capacity of computation (%)	6,6	9,7	2,9	8,4	4,5	2,0
avg. mcc (GigaFlops)	2,1	5,9	5,7	20,7	41,0	57,5
MPP/SMP						
nb of machines	10	58	63	61	64	64
max. capacity of computation (%)	2,5	17,8	19,3	19,7	21,5	20,1
avg. Mcc (GigaFlops)	1,4	3,0	5,4	13,5	37,0	45,2
Procurement in the rest of the world						
PVP						
nb of machines	5	7	1	3	3	1
max. capacity of computation (%)	3,5	4,5	0,9	1,7	1,5	1,7
avg. mcc (GigaFlops)	3,9	6,2	15,5	23,3	54,7	244,0
MPP/SMP						
nb of machines	4	19	27	15	20	18
max. capacity of computation (%)						
avg. mcc (GigaFlops)	1,0	3,4	5,2	8,2	18,2	26,2
Total procurement in the world						
PVP						
nb of machines	51	44	32	55	37	10
max. capacity of computation (GigaFlops)	312,9	270,0	368,9	1279,4	1394,9	644,8
avg. mcc (GigaFlops)	6,1	6,1	11,5	23,3	37,7	64,5
MPP/SMP						
nb of machines	61	162	211	198	282	277
max. capacity of computation (GigaFlops)	241,3	700,6	1406,8	2901,6	9607,7	13772,4
avg. mcc (GigaFlops)	4,0	4,3	6,7	14,7	34,1	49,7

Source: Top500, various issues. Author's computations.

Table 5. Breakdown of supercomputer sales in the world, by buyer, 1993-98

	1993	1994	1995	1996	1997	1998
USA						
Classified/Government	17,6	2,9	9,8	2,8	12,1	18,1
Research	42,5	26,9	32,6	46,4	49,1	38,6
Academic	21,7	41,9	16,7	9,8	11,1	4,3
Industry	10,3	10,1	22,6	34,5	18,7	23,4
Vendor	7,9	18,2	18,2	6,6	9,0	15,7
US market (GigaFlops)	308	454	956	1318	6486	10013
Japan						
Classified/Government	1,2	0,0	0,0	0,0	0,0	8,5
Research	82,3	44,0	32,9	36,0	28,8	19,2
Academic	10,5	17,4	32,9	59,4	56,3	11,6
Industry	3,6	11,1	9,6	3,1	14,9	54,0
Vendor	2,5	27,6	24,6	1,5	0,0	6,7
Japan market (GigaFlops)	172	142	271	1494	1127	507
European Union						
Classified/Government	0,0	5,1	0,0	1,2	0,0	2,0
Research	67,4	49,9	35,8	58,1	53,3	21,1
Academic	17,2	26,9	43,0	26,5	34,8	32,6
Industry	13,6	14,2	20,4	13,4	11,9	44,3
Vendor	1,8	3,8	0,8	0,7	0,0	0,0
EC market (GigaFlops)	50	267	394	1176	2860	3181
Other markets						
Classified/Government	0,0	0,0	0,0	3,0	9,7	0,0
Research	23,1	54,6	29,5	21,2	54,5	41,2
Academic	71,9	42,6	40,9	56,4	17,6	11,7
Industry	5,0	1,4	17,2	19,4	18,2	47,1
Vendor	0,0	1,4	12,4	0,0	0,0	0,0
Other markets (GigaFlops)	23	108	155	193	529	716

Source: Top500, various issues. Author's computation

Table 6. Cray financial performance, 1992-1996

	1992	*1993*	*1994*	*1995*	*1996*
revenues (USD mios)	797.6	894.9	921.6	676.2	677.6
- USA	450.8	563.9	491.5	291.8	…
- Europe	194.8	225.2	227.5	221.0	…
- Asia/Pacific	126.0	89.2	181.9	143.4	…
- Other	26.0	16.3	20.5	20.0	…
earnings (USD mios)	(14.9)	60.9	55.7	(226.4)	(130.0)
- % of revenues	-1.9	6.8	6.0	-33.5	-19.2
engineering & dvt expenditures (USD mios)	161.9	145.7	140.6	123.0	…
- % of revenues	20.3	16.3	15.3	18.2	…
revenue from US customers (percent)	57.0	63.0	53.3	43.1	…
revenue from US govt. (percent)	31.0	43.0	36.2	16.3	…
backlog (USD mios)	…	…	327	437	…
# installed systems	446	505	638	…	…
# installed PVP in the year	63	59	59	…	…

Source: SEC fillings, form 10-K, various years