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Foreign Participation in US-Funded R&D: the EUV Project as a New Model for a New Reality

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The "Who is Us" debate, launched almost 7 years ago by Robert Reich and Laura Tyson,¹ began to pose the fundamental question of whether and how long-established US policies should change to reflect the shifting American position in a globalizing world economy. For US-funded R&D projects, as for technology policy more broadly, the intervening years have provided few useful answers:² The old measures like production jobs created and exclusive participation by US-owned firms no longer provide reliable answers to the question of whether a given project will best advantage American interests. Instead, we need to ask what kinds of economic activities and jobs are likely to be created, in what business disciplines, across what economic sectors, with what overall impacts on the US economy's ability to generate broad technological advance. We need to understand whether and under what conditions potential foreign participants can contribute additional benefits to the domestic economy. The EUV LLC Project, described below, provides a welcome opportunity to reassess these issues, to describe a new model for US-funded R&D projects that better defines US interests in the global economy.

The EUV Project and American Interests

Lithography—the photographic process by which integrated circuit designs are transferred to silicon—is the most critical of the technologies comprising the production of silicon chips. Advances in lithography permit the design of ever more dense integrated circuits containing millions of circuit elements drawn with ever smaller line widths (now approaching 0.2 microns). For the last decade, the lithography business has been dominated by two suppliers, Nikon and Canon, both Japanese with essentially all of the technology development and production concentrated in Japan. In 1996, for example, the two firms together held an approximate 70% market share (with Nikon at 45-50% and Canon around 25%).³ Recently, two other players—one American, SVGL (Silicon Valley Group Lithography) and one European, ASML (ASM Lithography)—have gained important shares of the global market: With a 1996 share of under 5%, SVGL nevertheless was the leading supplier in the most advanced, deep-UV, portion of the market.⁴ With a share of about 20%, ASML has been gaining global share and may well have overtaken Canon in 1997.⁵ A fringe of other, smaller firms are concentrated in niches and are marginal players at the leading edge of process implementation.⁶

Twelve years ago the US government recognized the dilemma posed by US chip producers' increasing dependence for lithography on a small oligopoly of suppliers concentrated in Japan, with extensive, long-standing business ties to, and preferential relationships with, Japan's major chip-producers. One response was the creation of Sematech. At the time, it was widely acknowledged that if Sematech failed to preserve an American position in lithography tools, it would have failed in its core mission of leveling the playing field in chip manufacturing between the US and Japan. In the intervening years, Sematech did play an important role in keeping lithography know-how in the US. In particular, Sematech helped SVGL acquire its lithography business from Perkin-Elmer. But Sematech was never able to help US firms rebuild a market position in lithography that could seriously challenge the dominance of Nikon and Canon.

Today there is a new window of opportunity to accomplish that goal. As chip line widths shrink below 0.2 microns, radically new approaches are required to transfer the circuit designs into silicon. While there are several contending approaches, Extreme Ultraviolet Lithography (EUV) shows great promise and has been a significant focus of both public and private efforts.⁷ The EUV LLC, a collaboration of the National Labs with Intel, Motorola and AMD (three leading US chip-makers), is intended to accelerate the development and commercialization of EUV technology. The Project will license (for a negotiated fee) the underlying technologies (e.g., the light-source, optics, thin-film coatings, metrology) developed at the National Labs with USG R&D money; on-going support will be provided largely by the Project's private participants who will

invest about \$225 million (about 7X the associated USG funding).⁸ The project is structured to facilitate the participation of the crucial suppliers of the underlying tools and technologies that go into the chip-making process—including centrally, suppliers of lithography tools (indeed, roughly one-third of the project's funds are targeted to tool and technology suppliers). In return for funding development, Intel and the other EUV LLC partners will get purchase discounts and royalties on equipment sales that incorporate EUV LLC-licensed technologies.

As currently structured, the project is decidedly in US interests. If successful, it would

- ensure that the technical specifications—i.e., the crucial product standards—for the next generation of lithography tools are set in the US by the choices of US equipment producers and their customers (chip-makers)
- create a significant US player in next generation lithography tools while adding market competitors to the current duopoly that controls supply of lithography tools;
- provide first access for US chip-makers to next generation equipment;
- reinforce and amplify the US skill- and supplier-base in leading edge semiconductor production tools and technologies;
- perhaps even create access to the Japanese market by encouraging Japanese chip-making firms to adopt the American-sponsored technology standards.

These outcomes would provide significant benefit to the domestic US economy—creating jobs, developing skills and know-how, helping to make US-based producers more competitive in global markets.

Despite these obvious benefits, controversy has arisen over whether foreign firms should be permitted to participate in the EUV project.⁹ In particular, the concern is over whether ASML, a Dutch company, should be permitted to participate alongside SVGL as a second producer of lithography tools in the project. The participation of a second lithography tool-maker is being demanded by US chip-makers: They are global players, with global market presence, who do not want to be dependent upon a sole supplier for the critical lithography tool, even if that supplier is American. So long as firm-held intellectual property is protected and the playing field is level—i.e., each participant is competing fairly on implementation because each licenses similar Project technology on similar terms, complying with the appropriate commitments under US laws for each technology licensed—SVGL does not object to ASML participation. The hard issue, of course, which triggers opposition to ASML, is what the appropriate commitments attending ASML's participation ought to be: There is concern that ASML, as a European company with its principal operations in Europe, does not contribute enough to the domestic US economy to warrant participation in a

project whose underlying technology has been developed in significant part with taxpayers' money at the National Labs.

There are really two questions buried here. The first is whether foreign participation ought to be permitted in US-funded R&D projects—in the EUV context, this is a question of whether it is possible and desirable to achieve the benefits outlined above by excluding the participation of foreign firms. The second is whether the particular firm in question is the right partner for the project—in the EUV context, whether ASML and the commitments it is willing to undertake in return for participation make it the appropriate foreign participant. Our answers, elaborated below, are these: It is no longer possible or desirable to exclude foreign firms from US-funded R&D projects—they bring crucial know-how and are key players in causing US innovations to be adopted as global standards; both of these features provide enormous long-term benefits to the domestic economy. The long-term benefits expected to flow from the EUV project are, on balance, more likely to be accomplished with ASML's participation than without it—especially if ASML commits to produce products that incorporate the Project-licensed technologies in the US. Moreover, in general, we should prefer to include foreign firms who come from open economies, especially where their participation further reduces the market dominance of suppliers who are geographically concentrated in relatively closed economies. Under the conditions outlined below, ASML's participation should, in short, be permitted.

The New Reality

Up until the 1980s, when the absolute lead that US industry enjoyed in most high technology sectors began to evaporate, the federal government could be quite certain that the domestic economy would enjoy the lion's share of the broad social gains generated by its vast R&D budget. As the strongest and most advanced economy, the US was the launch market for the new technologies fostered by public spending. The major participants in US-funded R&D were American firms producing first and foremost for the domestic market. Thus, US industry typically commercialized and produced the innovations at home, and then exported abroad. Initial and leading customers—those who shaped the new technology's initial development and its path of diffusion—were also typically domestically-based. Local R&D, production, and advanced use meant that most of the spillovers that generated broad social benefits would occur within US borders.

During the past decade, however, several trends converged to challenge the easy identity between federal R&D and localized spillovers. Foreign competitors caught up and in some cases surpassed US producers. Foreign governments followed the US lead to sponsor high and rising levels of R&D spending. Foreign markets became effective launch markets for new technologies invented there, as Europe's Airbus proved in pioneering fly-by-wire and other aeronautical innovations (other examples include Europe's GSM standard for cell phones and Japan's market dominance of flat panel displays). Lead times for spill-over from

US defense spending collapsed as foreign producers caught up with US innovation. And as international competition intensified, so did the costs and risks of private R&D investment, so much so that even US firms chose to spread them across global markets by producing abroad and finding foreign partners. The trends identified above generated two significant consequences for the issue of foreign participation in US-funded R&D. The first is that more and more innovations now originate abroad and are often essential complements to US innovation (e.g., Taiwanese digital design capabilities are integral to some US PC assemblers' products). Indeed there is a broad pattern of increased international technological specialization now visible—new technical skills arising in new places around the globe, especially in Asia, and not readily duplicated back in the US, but essential to commercialization of innovation.¹⁰ Attempts to exclude foreign participation in US-funded R&D—motivated by the desire to confine the benefits to the US—thus risk excluding innovative capabilities originating abroad which the US economy and US firms need to prosper.

Even more significant, however, these trends also culminated in an unintended but important shift in the dynamic of competition in technology-intensive industries. By launching a new technology product in the US and then taking it global immediately through foreign presence and relationships, US choices about the underlying technical specifications in the new products could evolve into de facto global standards—as Microsoft and Intel accomplished respectively in PC operating systems and microprocessors (or Cisco Systems has now done with Internet routers or Cadence with chip design systems, or the Germans have done with SAP's corporate operations systems). Paradoxically, then, in this brave new world it is advantageous for technologies pioneered in the US to flow rapidly across the national borders, for the failure to do so means sacrificing the opportunity to set a global standard. The risk is that sometimes such technologies will be commercialized, produced, and exploited more effectively abroad than in the US. But the promise is that, by setting a global standard, the US will continue to be the source of the highest value-added in the chain of production and the related stream of follow-on innovations and technical spillovers associated with pioneering the new ideas and setting the standards. This has clearly been the case in information technology broadly.

In sum, we are now operating in a brave new world where technologies must flow rapidly across the US national border if global product standards are to be developed, while complementary technological capabilities developed abroad must be accessed quickly and effectively by US producers and the domestic economy if they are to remain competitive. We can thus no longer take for granted the easy identification between federal R&D spending and the generation of local spillovers that permit social benefits to be captured within US borders.

However, US-funded R&D programs can still maximize the likelihood of generating domestic benefits if they take account of the new constraints. Specifically:

- The innovations that result from public-funded R&D should be launched in the US (either before or simultaneous with a launch elsewhere) with domestic production linked to an infrastructure of locally present suppliers of the underlying technologies and production capabilities. This objective does not prevent production elsewhere, it simply requires that there also be US based production in order to preserve and enhance in the US precisely the research and production base from which future breakthroughs will result.
- Simultaneously, foreign participation should be explicitly included under three conditions:
 1. Where inclusion of foreign participants increases the likelihood of having the US-funded innovation adopted as a global standard because those participants will adopt and help to globalize it to the exclusion of foreign-developed alternatives or, relatedly, where such participation may preempt the establishment of a competing standard developed and launched abroad.
 2. Where the foreign participant brings complementary technical know-how and capabilities that are likely to be essential to the successful commercialization of the US-funded innovation.
 3. Where foreign participants agree to provide substantial US-value-added that will benefit the domestic economy's technology and production base in return for the right to participate.

Of course, not all foreign participants are equally good partners for purposes of accomplishing these objectives. How, then, should we evaluate foreign firms to determine whether they should be participants in US-funded R&D programs?

Foreign Participation in US funded R&D

The argument gets more complicated, both intellectually and legally, when we come down to which foreign firms should be involved. Some of the basic considerations are outlined below.[11](#)

We should admit upfront that, despite rhetorical arguments to the contrary (e.g., Former Secretary of Labor Reich's original "Who is us?" piece in the Harvard Business Review), there is, for the foreseeable future, a reasonable case to be made to treat the 'average' foreign-owned firm differently than the 'average' US-owned firm, in assessing whether they should participate in US-funded R&D.¹² Two-thirds to three-quarters of the assets, employment and sales of US MNCs (multinationals), and an overwhelming percentage of their best-compensated and highest-skilled jobs, are still in the US.¹³ The reverse is true for foreign-owned firms. Indeed, of the world's top 50 MNCs, of all national origins, who might be expected to be the most non-national of MNCs, almost all fall in the 60-90% range of assets within the home-country base.¹⁴ The major exceptions are oil companies (because oil fields tend to be located abroad) and small country multinationals like Nestle, Unilever and ABB (because their markets are located abroad)—and the latter would fall into the 60-90% range if we treated Europe as their home base. By that measure, the only real non-oil MNC is IBM, with about 50% of assets outside of the U.S.

The home-base bias of MNCs is reflected in their trade impacts as well. Despite extensive intra-firm trade, US MNCs have consistently run a positive trade surplus in the US. For example, in 1991, US firms exported \$115 billion to foreign affiliates and imported \$102 billion.¹⁵ By contrast, foreign affiliates in the US consistently run deficits (in 1991, Japan's US affiliates exported \$41 billion and imported \$89 billion; Germany's exported \$7 billion and imported \$17 billion). There are also, however, clear cases of foreign-owned firms that provide similar benefits to the US economy as those attributed to US-owned firms—at the moment, of course, they are mostly European, like Siemens, Philips, and the large European pharmaceutical/chemical companies (who actually spend a higher share of their US sales on US-based R&D than do most US chemical companies).¹⁶ Those particular firms can and should be treated differently than the 'average' foreign-owned firm—both rewarded and encouraged for their greater contribution to the US economy and armed with some incentives from the US that they can use at home to fend off political pressure aimed at reducing their contribution to the U.S.

Third, the foreign MNCs that contribute least to the US economy at the moment (based on the available empirical data), and are simultaneously most interested in accessing US R&D, are almost all Asian.¹⁷ We can anticipate with virtual certainty that we will have similar problems with mainland Chinese firms as they emerge into the world economy. It is this subset of foreign MNCs with which US policy should be most concerned (but obviously in a way that is even-handed and immune from political criticisms of "bashing").

Assuming, then that we want special criteria for foreign participation, what criteria should we use?

Referring to the analysis in part I, above, the first issue is whether they are already substantial contributors to the domestic economy—whether they can be expected to themselves generate local spillovers and other benefits. The best

indicator of contribution to the domestic economy would be US value-added throughout the business value-chain (i.e., from R&D through production, sales and service including sourcing from parts/services suppliers). However, domestic value-added is hard to measure and there are no systematic sources of the information.

If value-added data is too hard to come by, there are a collection of proxies that point at value-added indirectly. The geographic distribution of a firm's assets and employment is one such proxy (i.e., this would at least provide some indication of a firm's US-based manufacturing /R&D activities and jobs). Data on the geographic distribution of sourcing of parts/services is another complementary proxy. A third is corporate nationality for purposes of taxation and profit repatriation. Obviously, the least useful proxy is sales data . In all of these areas, we should be interested not just in current numbers but in the trends: is the firm trending toward a greater or lesser contribution to the US economy—i.e., we can imagine a situation in which it would be proper to exclude a current large contributor who is trending toward a reduction, in favor of a current small contributor who is trending toward a rapid increase. Also, in some specific cases, especially where the technology to be developed with US R&D funds is especially critical, we might consider requiring an explicit commitment to add value associated with the technology in the US (for example, by manufacturing here)—this is already done to some extent in the CRADA process with the National Labs. Whether or not a particular foreign firm generates significant domestic US-benefits, we still need to evaluate whether it fulfills the conditions identified earlier—whether it has unique technological capabilities, whether it can help to globalize US innovation as a de facto standard, and/or whether it may be necessary to preempt establishment of a competing standard. These issues can be directly evaluated both by US participants and by knowledgeable public and private experts on the industry and firm in question. But there are also a variety of related data sets that can contribute significantly to the evaluation process. Thus, one required data set is industry structure/conduct/performance information. We ought to be particularly wary wherever the potential participant is one of just a few dominant players in its industry segment who are geographically concentrated outside the US, particularly where the participant competes with its own customers (e.g., a maker of flat panel displays who also produces notebook computers). For example, imagine that Kyocera wanted to participate in a federal R&D program to spur the development of new ceramic materials for semiconductor packaging. Kyocera is the dominant supplier of ceramics for chip packages in the world. In that case we might want to exclude Kyocera even if it had unique know-how (it does) and made a major contribution to the US economy on the above indicators (in fact it does not)—on the grounds that further entrenching Kyocera's dominant position in the market is not good for the domestic economy. Or we might want to permit participation, but on tougher grounds than we would apply to other firms—e.g., only on the grounds

that it agrees to do all of the relevant manufacturing, R&D, and product/process engineering in the US.

We should also consider a firm's participation in cross-border collaborations like joint ventures, technology development alliances, equity investments, and the like, and its related intellectual property practices. While, as suggested above, alliances are inevitable and potentially very beneficial to the global position of US innovators, there are sometimes dramatic differences in the ways that similarly situated firms engage in cross-boarder collaborations: All other things being equal, we would want to favor a foreign firm known to engage in a two-way flow of technology (e.g., by granting flow-back licenses on improvements made to the US partner's technology) so that US partners (and the US economy) benefit, over a foreign firm that usually engages only in cross-border relationships that it can dominate, mostly absorbing technology from its American partner. All other things being equal, we should also favor a US firm that designs its cross-boarder collaborations to maximize benefits flowing back to the US economy over a US firm that mostly 'gives away the store' in its cross-border collaborations.

Beyond such firm-specific indicators, we would also want to consider country-specific factors. One important such indicator is foreign reciprocity in trade, investment, intellectual property protection and other forms of technology access. Asymmetries in technology access matter and directly affect how and how rapidly technology diffuses across national borders. It is appropriate to consider excluding *or placing more onerous requirements* upon foreign participants who otherwise qualify if they do not provide comparable access for US-owned producers, on the ground that the US-financed technology will diffuse rapidly back to the home country but technologies developed there with home-financing do not flow comparably back to benefit the US economy. Rather than outright exclusion, one might want to insist on the firm sharing an existing proprietary technology with one or more domestic producers in return for permission to participate. In essence, in some cases it would be useful to be able to use the preferences built into US R&D programs as part of a broad trade strategy, insisting on reciprocity to increase access to foreign markets and know-how.¹⁸

Another relevant indicator would be defense considerations. Obviously we might want to hold participants in defense-funded R&D to even higher standards—at the extreme, for example, an exclusive commitment to manufacture and source in the US or an explicit exchange of technology for participation. Similarly, where the R&D program in question involves dual-use rather than defense-specific technologies, we would want to favor the participation of foreign firms from close rather than distant allies. We would also want some assurance that technical improvements foreign participants make to US-funded dual-use technologies would be available to the US for defense spin-on.

As the foregoing suggests, no one set of criteria is useful by itself: Only by broadly assessing corporate behavior in a given context can we conclude whether participation is in the economy's best interests. Therefore, a flexible,

discretionary approach that broadly assesses current and long-term impact on the domestic US economy, bearing the above sets of indicators in mind, and which includes the discretion to make a given firm's participation conditional on providing certain reciprocal benefits, would appear to be the only realistic approach.

Foreign Participation in the EUV Project

A brief assessment of the participation of ASM Lithography in the Labs' EUV Project, using the criteria identified above, would look like this. ASM has little current domestic US value-added or production beyond sales and service. Given the importance of this industry and the underlying technology, we ought, therefore, to require that ASML provide additional reciprocal benefits if it is to benefit from US-funded R&D, namely that it commit to increase its domestic US value-added.¹⁹ To achieve this, there are four kinds of commitments it could make:

- to do all of the integration of the licensed technology (and substantial associated R&D and development) in the US
- to manufacture a reasonable portion of the resulting equipment in the US
- to procure a reasonable percentage of licensed sub-components from US-based suppliers for ASML's US-based production
- to license back improvements it makes to US-funded technologies

This typology is not exhaustive. Rather, it is meant to indicate the range of possibilities for ASML's participation to generate local economic benefits for the US, and to reflect the discretionary character of the necessary evaluation. Thus, doing all of the advanced R&D and integration in the US assures that those skills develop here; producing and/or procuring "reasonable" portions of equipment and licensed sub-components in the US assures additional benefits, as does licensing back improvements. What is 'reasonable' will vary from industry to industry and case to case.

In this case, in fact, ASML has reportedly offered to do its Project-related systems integration and associated R&D in the US and, assuming commercial acceptance of the tools that incorporate technology licensed from the Project, to set up US-based production to serve its US customers (which should include technically sophisticated tasks like on-going systems integration for commercial volumes, not just 'screw-driver' assembly and not just prototype production),). These will achieve significant benefits for the US. Of course, commitments to procure domestically at least some of the higher value-added components and to provide flow-back technology licensing would achieve more.²⁰ Overall, such concessions would go far to ensure local spillovers to the US technology and supply base from ASML's participation and would also create a range of good engineering, technical and production jobs in the US.

Turning to other benefits that can be expected to flow from ASML's participation, we might expect, first, that ASM will contribute unique know-how (e.g., it appears to have unique capabilities in, among other areas, achieving operational through-put in volume processing—so-called "staging" technology). Perhaps more significant, when we examine industry performance criteria, we note that the lithography industry is heavily concentrated—dominated over the last decade by two firms, Nikon and Canon, who are both Japanese and whose activities are geographically concentrated in Japan. Permitting ASM to participate in the EUV project thus adds the significant benefit to US users and the US economy of further deconcentrating the lithography industry and of relieving the threat of dependence on Nikon and Canon.

When we turn to country-specific factors, ASM, as a Dutch firm, originates in one of the world's most open trading economies.²¹ US firms fully participate in the Dutch market, dominating some segments, and there are no concerns with asymmetric technology access between the Netherlands and the US (or between Europe more broadly and the US). Moreover, industry conversations suggest that ASML's reputation and partnerships mirror that of its home economy for open, reciprocal, mutually beneficial practices. Moreover, to the extent that ASML has benefited from Dutch or European Union technology programs or other investments, its participation in the EUV LLC will permit the US, in turn, indirectly to reap some benefits from the European investment.

Perhaps most significant, as a European firm, ASM offers the dramatic benefit of bringing the relevant standards developed in the EUV project back to Europe and to ASML's global customer base—offering the prospect that the EUV standards will become de facto global standards or, at worst, that they will be the dominant standards in two of the three most developed regions of the world.

To be certain, ASML's participation would bring with it the risk of diminishing the likelihood that SVGL will emerge as a dominant player in lithography. Why help to create competition to SVGL? First, like it or not, Intel and other chip-makers demand a multiple vendor base—thus, SVGL by itself isn't a feasible alternative. Indeed, sole dependence on SVGL could backfire and endanger SVGL's own growing market position either by over-stressing its scarce production capabilities or by driving its customers to alternative technologies where there are multiple sources. Thus, the question is SVGL and who else, and on the analysis above, ASML is by far the preferable other.

Second, given SVGL's relatively small (though technically important) market position, it is far more likely that ASML and SVGL together can set a global standard than that SVGL could alone. Third, competition between the two should help to make each product better and to grow the overall available market between them. Moreover, with the commitments for local US production outlined above, the US economy should benefit even if only one of the two players survives as a significant force in the market. On balance, then, ASM's participation brings significant benefits with some risks to be sure, but few clear

drawbacks and ought to be permitted so long as ASML makes the kinds of commitments outlined above.

Finally, as noted before, the EUV project could complete the accomplishment started by Sematech—nurturing a leading-edge, US-based lithography supplier and, on a global basis, real alternatives to dependence on a few concentrated suppliers all in Japan. Moreover, if the program is successful, and if Japanese chip-producers are brought on board on the condition that they purchase from the project's participating lithography suppliers, it will also accomplish something entirely beneficial, unexpected and in recent years unprecedented: Developing Japanese customers for US and European suppliers who compete with Nikon and Canon. That, in turn, would ensure that the EUV standards do become true de facto global standards.

Endnotes

¹ Robert Reich, "Who is Us?" *Harvard Business Review*, (Jan.-Feb., 1990) and Laura Tyson, "They Are Not US," *The American Prospect*, (Winter, 1991).

² Indeed, current Congressional scrutiny attests to this. See, e.g., the comments of Senators Lieberman and Rockefeller, as reported in Mark Crawford, "Technology Oversight Lax Senate Democrats Warn," *New Technology Week*, 12:10, March 16, 1998, p.1ff

³ The source for these and the following market share numbers is VLSI Research. Conversation with VLSI Research's President, G. Dan Hutcheson, 2 April, 1998.

⁴ SVGL was the leader at 193nm, and a major presence at 248nm.

⁵ Reliable market share numbers for 1997 were not yet available as of this writing.

⁶ Some like Ultratech Stepper have important technical capabilities, but they are not a significant competitive presence at the commercial leading edge.

⁷ Other approaches include proximity x-ray lithography, SCALPEL (scattering with angular limitation projection electron beam lithography), Ion-beam projection lithography, and electron beam direct write. Like EUV, each of these approaches has significant technological and commercial hurdles associated with it that must be overcome (e.g., scaling the technology, achieving commercially-viable throughput). For a concise description of each approach, see the *Sematech Annual Report, 1997*, at p.10-11.

⁸ Figures supplied by the EUV LLC.

⁹ Two other concerns, whether the EUV LLC participants should receive royalties on technologies licensed to them by the US, and whether the participants have fairly treated all potential US tool and technology suppliers, are beyond the scope of this paper. For one take on these issues, see Jim Barnett, "Intel powers up research labs," *The Oregonian*, March 1, 1998.

¹⁰ For evidence, see e.g. Daniele Archibugi and Jonathan Michie, "The Globalization of Technology: Myths and Realities," *Cambridge Journal of Economics*, #19, 1995, and, Keith Pavitt and Parimal Patel, "The International Distribution and Determinants of Technological Activities," *Oxford Review of Economic Policy*, #4, 1988, p.35-55.

¹¹ A related issue is whether the approach suggested here is consistent with US obligations under the WTO. There are two concerns: 1)whether the approach violates national treatment, 2)whether it runs afoul of commitments on subsidies or government procurement. These issues are worthy of a more detailed discussion, but so long as the approach is applied consistently to similarly situated firms and with an eye on US obligations under relevant WTO agreements, it will not raise WTO concern. I am indebted on this point to my colleague Richard Steinberg.

¹² Reich, "Who is Us?" *supra*, at p.53ff.

¹³ See Tyson, "They Are Not US," *supra*, at p.37ff. See also, Yao-Su Hu, "Global Corporations Are National Firms with International Operations", *California Management Review*, Winter, 1992, p.107ff.

¹⁴ This and the following data from "A Survey of Multinationals" The Economist, March 27,1993, p.6-7, citing the United Nations.

¹⁵ Bureau of Economic Analysis and National Association of Manufacturers.

¹⁶ Gregory Tasse, Technology Infrastructure and Competitive Position, (Norwell, MA: Kluwer, 1992).

¹⁷ A BRIE database on Japanese FDI in electronics in the U.S. shows this is clearly true in that industry. See also, National Research Council, "Japanese Investment and Technology Transfer: An Exploration of its Impact," Report of a Workshop, (Washington DC: National Academy of Sciences, 1992), p.16-24. More generally, see Edward R. Graham and Paul Krugman, Foreign Direct Investment in the United States, (Washington DC: IIE, 1989). Graham and Krugman conclude that Japanese manufacturing affiliates in the U.S are much more likely to source off-shore than are European or US owned firms. Japanese affiliates may also invest less in R&D per capita.

¹⁸ Query whether we would want to do that for non-defense, social value issues -- i.e., would we want the discretion to exclude rampant polluters or violators of occupational safety/health rules from participation, whether US or foreign-owned? We might want to give, for example, a veto on environmental grounds to EPA-funded R&D projects.

¹⁹ It is true, of course, there will already be significant benefits from the Project in terms of US value-added and production because the project's other major lithography participant, SVGL, is a US-owned company committed to producing in the US. In many cases, by itself, this might be sufficient and we might not need to require that the foreign participant provide additional value-added locally. For example, that might be appropriate where the US participant is a dominant provider to the market and the foreign participant is not, or where the technology in question is not considered especially strategic from an economic or defense perspective. Neither is true here however.

²⁰ And the latter might be important to the extent that ASML improvements have dual-use implications. In fact, in this case, since ASML is primarily bringing systems integration and commercial staging know-how, it is less likely that ASML would come up with dual-use improvements that the American participants would not have.

²¹ Similarly, to the extent that the technologies in question have dual-use applications, the Dutch are obviously close allies