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EAST-WEST CENTER WORKING PAPERS

Economics Series

No. 47, May 2002

E-Business and the Semiconductor Industry Value Chain: Implications for Vertical Specialization and Integrated Semiconductor Manufacturers

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This paper will appear in *Industry and Innovation*, Vol. 9 No. 2 (August), Special Issue, "Global Production Networks, Information Technology and Local Capabilities." Dieter Ernst and Linsu Kim (guest editors).

1. Introduction

During the past 30 years, the global semiconductor industry has experienced rapid rates of technological change, rising costs for production capacity and declining prices for final products. Not coincidentally, this period also has witnessed an increase in vertical specialization in semiconductor design and manufacturing, illustrated by the growth of "fabless" design and marketing firms and their manufacturing counterparts, "foundries," that contract for the production of new product designs. During the past five years, increased vertical specialization has also been associated with an expanded role for equipment suppliers in developing new manufacturing process "modules" that integrate and complement the semiconductor manufacturing tools that they produce. Vertical separation of design and production of semiconductor components also has led to further specialization among design firms that create, license and trade "design modules" for use in integrated circuits (Linden and Somaya 2001).[1] In this paper, we examine the influence of Internet-based eBusiness applications on these trends and consider their effects on global production networks in the semiconductor industry. Although these trends began long before the development of Internet-related "eBusiness" applications, the Internet appears to be accelerating vertical specialization and may provide a fresh impetus to "design module" trading among firms. At the same time, however, Internet applications should enable integrated semiconductor manufacturers to increase their competitiveness and efficiency, and we briefly consider the effects of the Internet on these firms as well.

Although the widespread adoption of eBusiness applications within the semiconductor industry is likely to accelerate the long-term trend of increased specialization throughout the industry value chain, the Internet appears to be a catalyst, rather than primary cause, for such structural change. Ultimately, new Internet applications are likely to reinforce many of the underlying trends that have shaped the evolution of the semiconductor industry for the past three decades. These trends will influence the location of employment, design and production, and

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[1] Design firms are either the aforementioned "fabless" semiconductor firms or "chip-less" firms that do not sell any semiconductor products of their own, and instead rely on licensing revenue. Design modules represent a pre-designed function to be implemented in a semiconductor device. These functions include physical library functions, basic blocks and system-level macros. Design modules are also known in the industry as IP blocks, design cores and virtual components (Linden and Somaya 2001).

technology development in the semiconductor design, semiconductor manufacturing and equipment and materials industries.

2. Organization Of The Global Semiconductor Industry

Semiconductors in 2000 were a $204 billion global industry (SIA 2001), organized into a number of different product and geographic segments. But the basic sequence of operations required to fabricate semiconductor components is very similar across virtually all of these product segments (Figure 1 provides a schematic depiction). Individual semiconductor "chips" are designed with the aid of advanced software and computer workstations. Chemicals, gases, and materials are combined in an intricate series of operations that utilize complex manufacturing equipment to produce "wafers" containing a large number of "die," each of which (assuming that it does not suffer from fatal defects) forms the basis for a semiconductor chip. Individual die are cut from fabricated wafers, tested for defects, and assembled into complex "packages" that combine wire contacts with insulating material to form the finished semiconductor component.

Although semiconductor design activities are concentrated in specific regions of the United States (including such areas as Silicon Valley, CA; Austin, Texas and northwest Oregon), as well as in Europe and Japan, semiconductor manufacturing is more widely dispersed. Semiconductor chips are sold directly to end-users (e.g. DRAMs or embedded systems), but are more often used as intermediate inputs in electronic systems. The industries that provide manufacturing inputs—with the possible exception of product designs—and purchase finished semiconductor products are dominated by large, multinational organizations. Semiconductors are usually classified by technological sophistication (i.e., leading edge, trailing edge, etc.) and by product type (i.e., memory, logic, discrete devices, etc.).[2]

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[2] International SEMATECH' Global Economic Workshop classifies products into five specific groups: (1) Leading edge memory includes DRAMs; (2) Leading edge logic includes microprocessors and DSPs; (3) Other leading edge includes ASICs (PLDs and Standard cells), Flash memory, micro-peripherals and SRAMs. (4) Other ICs includes EPROMs, EEPROMs and other memory and gate arrays, standard logic and analog/linear circuits; and (5) Other semiconductor includes discrete circuits.

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