

## **Design for Location: The Impact of Manufacturing Offshore on Technology Competitiveness in the Optoelectronics Industry**

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Today only 28% of manufacturing value (MVA) added occurs within the U.S. (UNIDO, 2007). While this figure steadily declines, the percentage of MVA in South and East Asia continues to grow (2007). Over the past three decades there has been heated debate on how moving manufacturing offshore may impact economic development, jobs, and the distribution of wealth globally, nationally, and within individual nations (Rodrik, 1997; Berger, 1999; Bhagwati et al., 2004; Samuelson, 2004). Academics have likewise attempted to quantify the implications of moving manufacturing offshore to developing nations on host country and home country innovation (Cohen and Zysman, 1987; Grossman and Helpman, 1991; Kim, 1997). Despite the heated nature of these debates, and the extensive literature, academics continue to struggle with how to move past historical perspectives and forecast the future impact of offshore manufacturing on technological change (Macher et al., 2007). This paper, leveraging classical engineering and manufacturing simulation methods, quantifies for the first time how manufacturing location influences the relative economics of competing technologies, and thereby long-term technology development incentives for firms and the industries in which they reside.

This paper presents a case study of the impact of manufacturing offshore on technology competitiveness in the optoelectronics industry. It looks, in particular, at a critical design / facility location decision being faced by optoelectronic component manufacturers. The paper uses a combination of simulation modeling and empirical data to demonstrate the economic constraints facing these firms. The paper presents results based on detailed design and production data (over 150 process steps per design) collected from 10 optoelectronic component manufacturers in the U.S. and developing East Asia. This detailed empirical data shows how key process variables – not only wages, but yields, downtimes, material prices, and other plant operating parameters – change with manufacturing location. Using simulation modeling, the paper then demonstrates how these empirical differences in production impact the relative competitiveness of two design trajectories currently being debated in the industry.

The results show that production location changes the relative economics of the two competing designs – one emerging, one prevailing, which are perfect substitutes for each other on the telecom market. Specifically, if optoelectronic component firms shift production from the U.S. to countries in developing East Asia, the emerging designs that were developed in the U.S. no longer pay. Production characteristics are different abroad, and the prevailing design can be more cost-effective in developing country production environments. The emerging designs, however, have performance characteristics, which may be valuable in the long term to the larger computing market and to pushing forward Moore's Law.

Further, existing technology, market, and production constraints may be forcing firms to choose between the above two options. First, firms are currently unable produce integrated designs in their offshore production facilities due to a lack of local highly skilled design engineers and to problems transferring tacit backend assembly skills. Second, the constant attention of design engineers required on the production line makes it difficult to geographically separate design activities and production. Third, given the current market size and minimum efficient plant size for this technology, component manufacturers are unable to support two facilities (one in the U.S. producing the emerging technology and one in developing East Asia producing the prevailing technology) and, thus, two technologies without pricing under cost.

This creates a dilemma for firms. While the emerging designs and the prevailing designs are perfect substitutes on today's telecom market (thousands of units per year), in the long term, integrated designs may be critical to enabling the optoelectronic component manufacturers to access the much larger computing market (billions of units per year). More importantly, if the optoelectronic component manufacturers move offshore and, due to a lack of short-term economic incentives to do so, cease to push forward research and development in optoelectronic integration, there could be dire implications for long-term technology development in information technology (IT), due to a lack of advancement in technologies necessary for Moore's Law, and for applications throughout the IT industry.

In the case of the optoelectronics industry, seven of the eight component manufacturers with U.S. headquarters choose to relocate manufacturing offshore and manufacture there the prevailing technology. (The remaining two component manufacturers are contract manufacturers, and were from the start offshore.) Although in the short-term these firms are reducing production costs, according to this research they are also reducing cost incentives for research agendas in the U.S. focused on integration.

We conclude by suggesting that the optoelectronics case may be representative, more broadly, of small entrepreneurial start-ups with immature process technologies. We argue (1) that these start-ups if choosing to be born global must understand the implications of their location for their product and technology choices, (2) the option to manufacture offshore changes the critical core competencies for industry survival, and thus the relative competitiveness of the optoelectronic firms themselves, and (3) that the broader innovation ecosystem may need government support to keep manufacturing (whether hosted by small start-ups or other firms) in the U.S. long enough to meet longer-term technology development goals.

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