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A Conceptual Methodology of “Industrial Engineering” for “the Industry as a Whole”: Semiconductor Industry as Illustration

Chen-Fu Chien

Department of Industrial Engineering and Engineering Management
National Tsing Hua University, Hsinchu 30013, Taiwan
Email: cfchien@mx.nthu.edu.tw

Abstract:

The discipline of industrial engineering has been declining in many countries in light of the changes of industry structures in developed countries, in which the competition is no longer among individual companies while the collaboration among horizontally specialized value providers are critical for the success of the individual companies as well as the whole supply chain. There should be a systematic methodology of “industrial engineering” that focuses on “industry as a whole” as the subject of study to differentiate our discipline from others such as electrical engineering or chemical engineering. Focusing on semiconductor industry as the specific subject, this study aims to propose a conceptual methodology of industrial engineering to investigate semiconductor industry. In particular, semiconductor industry is one of the most complicated and capital-intensive industries. Driven by Moore’s Law, semiconductor industry has a clock speed faster than other industries and thus can provide an important benchmark for other industries.

In the presentation, we propose a framework to explain the evolution of the semiconductor industry from the point of view of modularity and integration driven by technical and economical considerations to simplify complex production problems. Several case studies of the companies in different positions of the semiconductor value chain are illustrated to discuss some of the challenges and ongoing changes. TSMC established a pure wafer foundry business model in 1987 that assumes all the costs of capital expenditure and expenses in wafer fabrication never competes with its clients of fabless design houses and IDMs. The pure foundry can easily scale up or down its production capacity according to an individual customer’s needs, while maximizing fab utilization with a portfolio of various customers. Such a business model freed fabless and IDM designers from the burden of capital investment for advanced technology capacity. Thus, IC designers can concentrate on chip design for various applications including PC and consumer electronics. Meanwhile, the semiconductor industry is moving to more narrow specialization such as Ardentec that focuses on the middle layer of wafer sort between front-end of IC design and wafer fabrication and backend of IC packaging and final testing. Nevertheless, Global Unichip Corporation that positions itself as a design foundry focusing on SoC (System on a Chip) is trying to virtually integrate the supply chain to deal with technical challenges driven by Moore’s Law and technological inseparability involved in SoC and SiP (System in Package).

This talk will conclude with discussions of the implications of semiconductor industry evolution to computers and industrial engineering research.



Biography:

Chen-Fu Chien is a Professor of Industrial Engineering and Engineering Management and an EMBA Professor in National Tsing Hua University (NTHU). He is the Deputy Dean of R&D and CEO of University-Industry Collaborations Office in NTHU since 2008 and is also the Director of Science Park Sustainable Growth Project Promotion Office of National Science Council, since 2009. From 2005 to 2008, he has been on-leave to serve as the Deputy Director of Industrial Engineering Division in Taiwan Semiconductor Manufacturing Company (TSMC), which is the world largest semiconductor foundry. He received B.S. (with Phi Tao Phi Honor) with double majors in Industrial Engineering and Electrical Engineering from NTHU in 1990. He received M.S. of Industrial Engineering and Ph.D. of Operations Research and Decision Sciences from the University of Wisconsin-Madison in 1994 and 1996, respectively. He was a Fulbright Scholar in the Department of Industrial Engineering and Operations Research, UC Berkeley from 2002 to 2003 and also received the Executive Training of PCMPCL in Harvard Business School in 2007.

Since 2002, Dr. Chien has been a Steering Committee Member of Industrial Engineering Division in National Science Council, Taiwan. He is a Think Tank member for Government Science and Technology Projects in National Science Council and also on the Board of Directors of the Chinese Institute of Industrial Engineers (CIIE) and Chinese Institute of Decision Sciences in Taiwan. He had also been an Adjunct Professor of Tianjin University and Visiting Professor at the Cambridge University (sponsored by Royal Society), Tsinghua University (sponsored by Chinese Development Foundation), Waseda University (sponsored by Japan Interchange Association Young Scholar Fellowship). He is now an Associate Editor of *IEEE Transactions on Automation Science and Engineering*, Area Editor of *Flexible Services and Manufacturing Journal* and an Advisory Board Member of *OR Spectrum*.

His research and development efforts center on decision analysis, modeling and analysis for semiconductor manufacturing, manufacturing strategy, and data mining. Dr. Chien has received five invention patents on semiconductor manufacturing and published two books, more than 70 journal papers and a number of case studies in Harvard Business School. He has been invited to give keynote speech in conferences and leading universities including Harvard Business School, Cambridge University, Waseda University, IBM, and UC Berkeley. His keynote speech in IEEM 2006, Weihai, P.R. China was then invited by IIE to publish as a feature article in *Industrial Engineer* (2007 Feb, pp. 47-49). Dr. Chien received the Distinguished Research Award, Tier 1 Principal Investigator (Top 3%) and a number of Outstanding Research Awards from the National Science Council, Distinguished University-Industry Collaborative Research Award from the Ministry of Education, University Industrial Contribution Award from Ministry of Economics, Distinguished Young Industrial Engineer Award and Best IE Paper Award from CIIE, Distinguished Young Faculty Research Award, Distinguished University-Industry Collaborative Research Award from NTHU, TSMC Faculty Semiconductor Research Grant Award, Best Engineering Paper Award by Chinese Institute of Engineers in Taiwan. Dr. Chien has been invited to give keynotes and plenary talks in IEEM, APIEMS conferences, Cambridge University, Harvard University, and IBM Watson Research Center. His keynote in IEEM2006 was then invited by IIE to publish it in *Industrial Engineer* (2007 Feb., pp.47-49).