The Henderson Photolithography FIVE Data

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If you supplement the Henderson Photolithography FIVE Data, you must rename that variant of the original data with Henderson appearing first in the list of data set authors, along with the word FIVE. For example, if Joe Campus added product performance characteristics, the data set would be called the "Henderson-Campus Photolithography FIVE Data." If you merge two or more FIVE data sets, the new name of the data set must include the names of all of the original data set authors and the word FIVE.

2. Data Set Author

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3. Data Set Summary

This data set includes organizational and technical information and sales by product for product-development projects initiated by firms in the photolithographic alignment equipment industry between 1960 and 1986.

4. Authors' Research Using this Data Set

Henderson R. 1993. Underinvestment and incompetence as responses to radical innovation: Evidence from the photolithographic alignment equipment industry. *Rand Journal of Economics* 24: 248-271.

Henderson R. 1995. Of life cycles real and imaginary: the unexpectedly long old age of optical lithography. *Research Policy* 24: 631-643.

Henderson R. 1996. Maintaining leadership across product generations: the case of Canon in photolithographic alignment equipment. In *Managing product development*, Nishiguchi T, Ed, Oxford University Press.

Henderson R. 1997. On the dynamics of forecasting in technologically complex environments: the unexpectedly long old age of optical lithography. In *Technological innovation: oversights and foresights,* Garud R, Nayyar P, Shapira Z, Eds, Cambridge University Press, New York.

Henderson R, Clark K. 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly* 35: 9-31.

5. Additional References

Helfat, CE & Klepper, S. 2007. FIVE Project: Data Overview. http://papers.ssrn.com/paper=1028022.

Watts R, Einspruch N, eds. 1987. Lithography for VLSI. *VLSI electronics – microstructure science*. Academic Press, New York.

6. Data Set Sources

The data were derived from several sources. The first sources were publications in trade and scientific journals and internal documents from the firms in the industry. This information was cross-checked with published data from consulting firms that follow the industry and interviews with key individuals: generally the senior design engineer for each project and a senior marketing executive from each firm, along with other industry observers and participants.

7. Data Description

7.1 Product/Industry Definition

Photolithographic aligners are used to manufacture solid-state semiconductor devices. The production of semiconductors requires the transfer of small, intricate patterns to the surface of a wafer of semiconductor material such as silicon, and this process of transfer is known as lithography. The surface of the wafer is coated with a light-sensitive chemical, or "resist." The pattern that is to be transferred to the wafer surface is drawn onto a mask and the mask is used to block light as it falls onto the resist, so that only those portions of the resist defined by the mask are exposed to light. The light chemically transforms the resist so that it can be stripped away. The resulting pattern is then used as the basis for either the deposition of material onto the wafer surface or for the etching of the existing material on the surface of the wafer. The process may be repeated as many as twenty times during the manufacture of a semiconductor device and each layer must be located precisely with respect to the previous layer (Watts and Einspruch, 1987). A photolithographic aligner is used to position the mask relative to the wafer, to hold the two in place during exposure, and to expose the resist.

Optical photolithographic aligners are pieces of capital equipment sold directly to semiconductor device manufacturers. They usually represent at least 30% of the cost of a new semiconductor facility, and their performance is critical to its success.

The semiconductor photolithographic alignment equipment industry is characterized by small firms and a fast rate of technological innovation. This data set covers four waves of architectural innovation within the industry, corresponding to four different names for the photolithographic alignment equipment: Proximity aligner, Scanning projection, First-generation stepper, Second-generation stepper.

For additional information about the data, please see Henderson, 1993.

7.2 Excluded Fields

Although the original data set included research and development spending, that data is no longer available.

8. Variable List and Definitions: HendersonphotolithFIVEdata

The data are organized alphabetically by firm name, and within firm name by model number.

8.1 Firm Identifiers

Firm Name

[Variable name: *firmname*; string variable]: Name of company.

FIVE Firm ID (unique firm identifier for the FIVE Project)

[Variable name; *fivefirmID*; numeric variable]: Unique identifier for each Firm Name that appears in the FIVE data sets. Firm Names and FIVE Firm IDs may appear in more than one FIVE data set. If a firm's name changed over time, the FIVE Firm ID for the firm sometimes may change as well. In addition, different FIVE data set authors may have coded different firm names for the same company, which could result in different FIVE Firm IDs for the same firm in different data sets.

CUSIP Header ID (firm identifier assigned by Compustat)
[Variable name: *CUSIPheaderID*; numeric variable]: Unique identifier for each firm assigned by Compustat for 2007. For a given Firm Name, this ID is constant across all years in the data set. These IDs come from matching each Firm Name in the FIVE data sets to an identical or similar name in Compustat. ***There is no guarantee that these matches and IDs are accurate.*** There also are many Firm Names for which no match was found.

CUSIP Header Firm Name (company name assigned by Compustat)
[Variable name: *CUSIPheadername*; character variable]: Name of company given in Compustat for the CUSIP Header ID.

CUSIP Historical ID (firm identifier assigned by Compustat)
[Variable name: CUSIP*historyID*; numeric variable]: Unique identifier for each firm assigned by Compustat in their historical databases. For each Firm Name, the CUSIP Historical ID is that shown in Compustat for the year of observation in the FIVE data set. These IDs come from matching each Firm Name in the FIVE data sets to an identical or similar name in Compustat. ***There is no guarantee that these matches and IDs are accurate.*** There also are many Firm Names for which no match was found.

CUSIP Historical Firm Name (company name assigned by Computstat)
[Variable name: *CUSIPhistoryname*; character variable]: Name of company given in Compustat for the CUSIP Historical ID.

8.2 Product Characteristics

Model Number
[Variable name: *model*; character variable]: Model number assigned by each company, or type of model if no model number was assigned or available.

Type
[Variable name: *type*; character variable]: Type of photolithographic alignment equipment: cont (Contact printer), prox (Proximity printer), scan (Scanning projection aligner), s&r1 (First-generation step and repeat), s&r2 (Second-generation step and repeat).

Year R&D Begun
[Variable name: *yrR&D*; numeric variable]: Year in which company research and development began on the associated model number.

Resolution
[Variable name: *resolution*; numeric variable]: Resolution per model measured in microns. Resolution is provided for each model beginning with the year that R&D began on that model (*yrR&D*). Some models do not have resolution information.

Wafer Size

[Variable name: *wafersize*; numeric variable]: Wafer size per model measured in inches. Wafer size is provided for each model beginning with the year that R&D began on that model (*yrR&D*). Some models do not have wafer size information.

Speed

[Variable name: *speed*; numeric variable]: Throughput speed, most likely measured in wafers per hour. Speed is provided for each model beginning with the year that R&D began on that model (*yrR&D*). Some models do not have speed information.

Price

[Variable name: *price*; numeric variable]: Price in $000, nominal dollars. Price information is shown only for years in which sales of a given model occurred. Only one price is listed per model. Some models do not have price information.

8.3 Sales Information by Year

Sales Year

[Variable name: *salesyear*; numeric variable]: Year of observation for sales revenues, by firm and model number. All years covered in the data set (1960-1986) are listed for each firm and model number, although not all firms were in existence or sold equipment throughout the entire period.

Sales Revenue

[Variable name: *salesrevenue*; numeric variable]: Sales in $000, nominal dollars. Sales did not occur for all models in all years. Sales revenues are given only for years in which sales occurred. Some models were introduced but had no sales during the time period covered by these data.

