

論 文 摘 要

本論文採用實地實證研究，以一家專業晶圓代工廠商為研究對象，詳細分析在晶圓代工的製造環境下，產品多樣性及製造彈性對生產品質、生產週期時間、設備生產力與生產成本之影響。不同於過去研究，以外部彈性(例如：產品組合彈性、新產品彈性等)為研究重心，本論文以內部彈性為研究範疇，涵蓋機器彈性與路徑彈性兩種彈性型態，據以彌補現存製造彈性文獻的缺口。

關於產品多樣性與製造彈性對生產績效與生產成本之直接影響，本論文首先以等候理論與整數規劃模型為基礎，加入實地環境特性的考量，推導研究假說與實證模型；繼而，蒐集來自個案公司 6 個月的詳細生產資料，包括兩類資料型態：機台水準(machine-level)與生產批量水準(lot-level)進行實證分析。綜合理論模型與實證分析結果，本論文發現：在晶圓代工的製造環境中，由於製程高度自動化之故，產品多樣性對生產績效的直接影響並不顯著，但因研發與工程實驗所產生的環境變異性則對生產績效具有顯著的負面影響；在製造彈性方面，吾人則發現路徑彈性不僅有助於生產週期時間的縮短，也對品質與成本績效具有顯著的正向影響，而機器彈性雖有助於設備生產力的提昇與生產成本的降低，但對生產品質則有顯著的負面影響，此外，本研究也發現：製造彈性與設備生產力、生產週期時間及生產成本之間存在非線性關係，並呈現報酬遞減的趨勢，隱含：極大化製造彈性並非最佳，有限的彈性水準即可達到最大的彈性利益。

考慮製造彈性的價值高低與環境不確定性密切相關，本研究進一步採用路徑分析檢視產品多樣性、製造彈性、環境不確定性與生產績效之間的關聯性，基於本研究以內部彈性為研究範疇，並以製造環境為研究客體，依據生產管理文獻，由製程時間變異性、到達時間變異性及產品需求變異性三項指標定義製造環境的不確定性。實證結果顯示：產品多樣性主要係透過環境不確定性間接影響生產績效，而機器彈性與路徑彈性則有助於調和內部不確定性對生產績效的負面影響，進而達成生產績效的提昇。本論文之分析結果隱含：過去管理會計研究認為產品多樣性對生產績效的影響主要來自於批量作業活動(batch-level activities)與產品支援活動(product-sustaining activities)的增加，而忽略產品多樣性對環境不確定性的影響，可能低估產品多樣性的攸關成本，尤其在一高利用率與高度動態的生產環境中，產品多樣性透過環境不確定性對生產績效的間接影響可能大於產品多樣性對生產績效的直接影響；另一方面，本研究指出：在一動態環境中，廠商可透過製造彈性的提昇，降低環境不確定性對生產績效的負面影響，但最適彈性水準的決定則須取決於製造彈性與其他生產績效衡量之間的函數關係。

關鍵詞：產品多樣性、路徑彈性、機器彈性、環境不確定性、晶圓代工。

Thesis Abstract

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Title: Impact of Product Variety and Manufacturing Flexibility on Production Performance and Production Cost: A Field Empirical Analysis of a Semiconductor Wafer Fabrication Plant

This thesis reports the results of a field empirical study examining the impact of product variety and manufacturing flexibility on production quality, cycle time, equipment productivity, and production cost within the context of semiconductor wafer fabrication facilities. To fill the gap in existing research, I attempt to study internal flexibility, rather than external flexibility (e.g., product flexibility, mix flexibility). Two types of internal flexibility are selected, which are machine flexibility and routing flexibility.

Using both machine-level and lot-level production data from one dedicated wafer fabrication plant, this thesis examines the direct impact of product variety and manufacturing flexibility on production performance and production cost. Empirical results suggest that greater product variety does not have a significant impact on equipment productivity but does have a significant adverse impact on production quality. Moreover, I find support for the hypotheses that greater routing flexibility has a significant positive impact on quality, time, and cost performance. As for machine flexibility, it has a significant positive impact on equipment productivity and cost performance, but has a significant negative impact on production quality. Furthermore, I also find a non-linear relation between manufacturing flexibility and equipment productivity, cycle time, and production cost. This implies that maximizing the level of manufacturing flexibility is not necessarily optimal for firms. Limiting the flexibility level may actually have the greatest benefit.

To further clarify the mechanisms through which variety and flexibility impacts performance, I move beyond the direct effects and investigate the linkage between product variety, manufacturing flexibility, environmental uncertainty and production performance. Based on the operations research, environmental uncertainty is operationally defined as the process time variation, inter-arrival time variation, and output variation. Results from path analysis indicate that product variety negatively affects production performance through environmental uncertainty. This finding

stands in direct contrast to the general belief in management accounting research that greater product variety leads to an increase in the number of batch-level activities and product-sustaining activities, which thus increase the production cost. In other words, the reported cost of product variety may be underestimated, because we do not consider the impact of product variety on environmental uncertainty. The magnitude of the underestimation is especially greater in a highly congested and stochastic environment. Empirical results also show that machine flexibility and routing flexibility mitigate the adverse impact of environmental uncertainty on production performance.

Keywords: Product variety; Routing flexibility; Machine flexibility; Environmental uncertainty; Wafer fabrication.