The emergence of the outsourcing market and product technological performance

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A R T I C L E   I N F O

A B S T R A C T

This study is a novel empirical endeavor to analyze the impact of market demand and product technological performance on the growth of industry's outsourcing activities. Using the laptop computer industry as an example, this study examines the connection between the growth of outsourcing activities and product technological performance as well as market demand. The results suggest that, in addition to the relative efficiency assumed from transaction cost economies, the products' technological performance and market demand might also influence the growth of industry's outsourcing activities.

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1. Introduction

Jacobides [1] points out that the emergence of new intermediate markets that divide a previously integrated production process is relatively 'invisible' during the course of industry evolution. Many specialized firms surfaced from the once integrated production processes such as "fab-less" chip design companies in the semiconductor industry, specialized automotive part producers in the automotive industry, and specialized drug-testing firms in the biotech sector [1]. The emergence of these specialized firms breaks down the previously integrated production process such as was the case in the personal computer (PC) industry. Production process in the PC industry was once integrated in house, but now it is highly disintegrated with many firms specialized in a particular segment ranging from component production, PC assembly to distribution. The gradual transformation from integrated to disintegrated structure occurs when underlying products, services, and core technology remain the same [1]. For example, Taiwan Semiconductor Manufacturing Company (TSMC)

specialized in IC foundry. Fab-less chip design companies outsourced their production to TSMC. The gradual emergence of TSMC has disintegrated the conventional production process. This type of "invisible" transformation from integration to disintegration has a significant impact on the overall development of many industries such as automotive and semiconductor [1].

Williamson [2] suggests that the availability of an efficient market facilitates transactions and guides organizational governance mode selections. The emergence of TSMC provides a new intermediate market between IC production and IC design. The efficiency of TSMC allows fab-less chip design companies to abandon or bypass production. The transaction between TSMC and fab-less chip design companies reinforces each other's core capabilities. The transaction between TSMC and fab-less design companies forms a new intermediate market or outsourcing market between IC production and IC design. When such an intermediate market is available, the more efficient the market, the more active the outsourcing activities are. Market efficiency is relative to that of internal transactions. When such transaction between TSMC and fab-less design companies become more efficient, it is more likely that the firms will start to abandon internal production gradually. In addition to relative efficiency, firms often

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have to adjust their strategy based on the dynamics of their competitive environment [3]. Technological change constitutes a significant part of this competitive environment [4]. Firms adopt different organizational configurations in response to the gradual evolution of the technology life cycle [5,6]. The characteristics of each technology life cycle, such as demand [7,8], speed [4,9], product architecture [10], product complexity [11], and novelty [12] all influence a firm's integration [13] and outsourcing decisions. Novak and Stern [11] reveal that only a small body of research examines the impact of product performance on a firm's disintegration decision. The connection between industry's outsourcing activities and technology performance lacks empirical support [11]. The objective of this research is fill in this empirical gap by examining the gradual impact of laptop computer's technological improvement on the development of industry's outsourcing activities.

1.1. Outsource decision

Business strategy is often complex and must be appropriately examined from different angles [14]. Conventional discussion on outsourcing pays little attention to the variables affecting the growth of the outsourcing activities or the supply side of outsourcing services. Researchers have been interested in why firms choose to 'buy' instead of 'make' [15]. The buy side, the firm that contracts out, is often the point of attention rather than the supply side, where the firm provides the outsourcing service. From the buy side, the decision to outsource often involves a risk-and-benefit analysis [16]. The major outsourcing risk is the firm's loss of control over critical skills and suppliers. The benefits of outsourcing are more numerous and have received extensive attention [15–21], such as specialization, cost savings, time to market, and flexibility [22]. Although many scholars have examined the characteristics of outsourcing from various perspectives, relatively little empirical work has been conducted on connection between product technological improvement and outsourcing activities or the outsourcing supply side.

Resource-based view (RBV) and transactional cost economies (TCE) together provide the basis for the analysis of outsourcing. The decision to outsource implies a disintegration of firm activities [23]. At its basic element, outsourcing transfers a business process originally performed in-house to an external party [15,24]. The outsourcing market refers to the intermediate market that divided the business process between buyers and suppliers of a particular business task. The extent of disintegration can span various business processes, from producing a product component to the entire manufacturing process. Such outsourcing executed across a national boundary constitutes international outsourcing, or the relocation of business processes to a foreign subcontractor [24]. In addition, outsourcing can be divided into component and manufacturing forms: Component outsourcing entails subcontracting the manufacture of product components to a third party, whereas manufacturing outsourcing implies subcontracting the entire manufacturing process. Offshoring, on the other hand, refers to the disaggregation of the firm's value chain to a foreign location [25], which makes it a location strategy.

It has become increasingly common for firms to slice up their value chain activities through outsourcing to maintain their agility and keep up with the ever-changing competitive

landscape [26]. The decision to outsource depends upon the level of transaction cost involved in performing an activity internally versus sourcing it through an outside market. Accordingly, outsourcing is viewed as a natural continuance of Coase's and Williamson's work on contracting and transaction cost economics [15]. Following the idea of Coase [27], Williamson [28] suggests that the purpose of the firm is to economize transaction costs. The difference in transaction costs is the main deciding factor of the governance mode, but not the only one [29]. Williamson [29] summarizes the main aspects of TCE as follows: "align transactions, which differ in their attributes, with governance structures, which differ in their costs and competencies, in a discriminating way" [29]. TCE examines the connection between a governance mode and the costs associated with transactions [2]. Governance modes may take autonomous (market), cooperative (hierarchy), or hybrid forms [2], and by aligning these modes with the attributes of transactions, firms can improve their transaction efficiency [30]. The most common transaction attributes include asset specificity, uncertainty, and frequency [29]. In particular, asset specificity—the ease with which an asset can be redeployed to other uses without compromising product value—is key to analyzing the governance of contractual relations [29]. Market procurement offers a strong advantage when asset specificity is low, but high asset specificity favors internalization. The availability of an efficient market also facilitates transactions and guides institutional mode choices [2]. Williamson [14] further suggests that "a transaction occurs when a good or service is transferred between technologically separable stages" (Williamson, 1999: 1089). The non-separable activities will be conducted in-house. The independent nature of a modular system allows easier separation of production processes, which facilitates a firm's disintegration choice. The modular system gave rise to a group of specialized component providers in the automotive and semiconductor industries. Under a modular system, outsourcing became a common practice in these industries as companies contracted out parts of the value chain to specialized component providers [9]. Many scholars have revealed the impact of modularity on a firm's integration decision [6,10,23,31]. Embedded modularity significantly changes the relations among companies [22]. Modularity, consisting of units designed independently but still functioning as an integrated whole, alters industry structure and makes the best use of participating firms' abilities [22]. Modularity provides easier separation of activities.

On the other hand, TCE has been criticized for its narrow or single-minded focus on opportunism and bounded rationality while neglecting the role of value creation in governance decision [32]. Unlike TCE, though, outsourcing allows firms to concentrate on value-creating activities. The specialization that emerged in the modular system relates closely to the RBV, which states that firms should keep their core activities in-house and outsource noncore activities [16]. The RBV conceives of business organizations as unique bundles of heterogeneous resources, capabilities, and competencies [33], which implies that firm-specific resources are immobile, untradeable, and bound to the firm [34]. However, some resources are non-firm-specific, so others can imitate or replicate them. Thus, in the RBV, firms need to concentrate on their immobile core competencies and strategically outsource any noncore activities for which the firm has no critical strategic

need or special capabilities [16]. In this sense, outsourcing is a tool or strategy that enables firms to concentrate on their core competencies.

1.2. Modularity and outsourcing

A firm's organizational structure likely develops from an initial integral form into a modular form before returning to the integral mode, according to the evolution of its technology [6]. Component production tends to be vertically integrated in the early stage since components are mostly idiosyncratic [10]. Technical dialogue in this stage tends to be unstructured since customers cannot fully specify their requirements [6,23]. Hence, the cost of production is high. At the same time, firms attempting to compete on costs will try to standardize components [10]. Furthermore, as firms compete to establish industry standards, speed to market is a major strategic priority. Modularization facilitates such a strategy [23]. In addition, over-shooting, in terms of functionality, also encourages modularity and disintegration in order to improve speed to market [23]. If a dominant design emerges, with component standardization, firms tend to disintegrate as the product becomes more modular [10]. The elements within the product architecture will become more modular and codified with the emergence of the dominant design [6]. Codified information allows both better coordination in the market and technology integration, which lower the price and stimulate rapid technological advancement [6]. In addition, if firms were to outsource when the product architecture is integral, they risk being overly dependent on suppliers [12]; this risk is not salient when the product architecture is modular. Thus, modularity is an important facilitator of the firm's disintegration decision.

1.2.1. The conditions of an outsourcing market

The term "outsourcing market" refers to the transaction between outsourcing buyers and outsourcing suppliers in this research. Laptop computer brand owners are outsourcing buyers in this study and original equipment manufacturers (OEMs) are outsourcing suppliers. The presumption of TCE suggests that non-separable activities will be organized under unified ownership [14]. The emergence of an outsourcing market or the supply side of an outsourcing service is contingent upon the separability of business activities based on TCE. Modularity in the laptop computer industry allows easier separation of activities. Furthermore, Barney [33] believes that firms should concentrate on core business activities that are firm specific, immobile, and untradeable. Therefore, the outsourcing market is only possible when the buy side tries to disengage itself from the noncore activities.

Moreover, firms adjust their integration decisions in response to market demand. If they outsource, the firm's goal is usually driven by either capacity or knowledge [13]. Additionally, Jacobides [1] identifies specialization and trade as two key motivations. Stigler [35] found that many industries start off with a vertically integrated structure but increasingly become disintegrated as market demand increases. In the later stages of the life cycle, when demand declines, industries tend to reintegrate. Product life cycles influence firms' decisions to integrate or not [8,11]. Depending on the characteristics of their products' life cycles, firms might also need to make strategic trade-offs between control and flexibility (i.e., benefits and risks)

in a way that enables them to maintain their competitive and comparative advantages. If their internal capabilities do not match those of the best-in-world suppliers, and such a capability is integral to their business, firms can turn to an efficient market or supplier to find a strategic trade-off between their in-house production and outsourcing. A traditional, demand-driven argument suggests that the extent of integration evolves with changing market sizes [35,36], such that industries tend to integrate early on, shift toward disintegration as the market expands, and finally reintegrate as demand slows down [23]. Based on the above analysis, it is suggested that there is a possible connection between a firm's disintegration decision and market demand; namely, the former changes in accordance with the fluctuation in the latter. This assumption leads to the following hypothesis:

Hypothesis 1. (H1): There is a connection between the growth of industry's outsourcing activities and market demand.

1.3. Technological change and the firm's disintegration decision

The technology-driven point of view offers another perspective. RBV ignores the role of life cycles in its analysis. The firm's perception of its core activities is dynamic, contingent upon the evolution of the technologies involved. A firm's strategic needs change at different stages of the technological life cycle [37]. The firm's perception of core-activities is a reflection of the characteristics of the technological life cycle. Utterback and Abernathy [38] reveal that product innovation, production processes, and capabilities can be patterned as a life cycle. Specifically, the need to meet market requirements fuels initial product innovation [8]. As a dominant design emerges, competitive effort shifts from product innovation to process innovation and then to cost minimization [39]. The evolution in a technology's life cycle might, therefore, be driven by market requirements [7]; the performance of the technology also advances the life cycle from its premature stage to maturity [40,41]. Technological advancement propels firms to adjust their strategic focus from a product orientation to a process orientation. For companies focusing on different aspects of the technological life cycle, their strategic orientations will change, as well as their perceptions of what constitutes their core activities. It is then advantageous for a firm to adjust its disintegration decision according to the evolution of the technological life cycle. Characteristics of the technology life cycle influence the buyer's outsourcing decision, which would then affect the development of the supply side of outsourcing. A hypothesis is formulated based on the relationship between technology life cycle and the firm's disintegration decision.

Hypothesis 2. (H2): There is a connection between the growth of industry's outsourcing activities and product technological performance.

1.4. Decision to offshore

Offshoring enables firms to capture the benefits of skilled, relatively cheap labor abroad through business process relocation, which grants them both cost reductions and increased knowledge [25]. The process of offshoring follows an international product life cycle model, in which

capital intensive and technologically sophisticated innovations are typically developed in the USA for the domestic market. They then progress through various stages in which production shifts to other developed countries and finally to developing countries that become platforms for multinational corporations exporting to their home country and other developed markets [42].

Thus, offshoring tends to involve fewer technological value-added activities and rely more on product modularization and standardized activities [25]. It deals mainly with location, driven by comparative advantages, local market size, cultural distance, and institutional environments [26]; accordingly, its benefits include cost savings, flexibility, new revenue, repatriated earnings, and reemployment constraints [43]. However, a new wave of offshoring involves more sophisticated activities, such as product research and development [26], though the fundamental factors that drive offshoring remain the same: location and ownership of the business process. The above discussion suggests that there is a possible connection between the development of an offshoring market and technological performance.

Hypothesis 3. (H3): There is a connection between the growth of industry's offshoring activities and product technological performance.

The preceding discussion raises several potential routes for investigation. This research provides a novel empirical analysis that mainly examines the correlation between the laptop industry's outsourcing activities and product technological performance. Specifically, as an effective indicator of the shifts in the outsourcing buyer's production strategy, from in-house to outsourcing, this study considers changes in Taiwanese original equipment manufacturers' production output. This data helps overcome some limitations of survey-based research [12] and qualitative studies [1]. Furthermore, in this industrial setting, the value chain is highly segregated, with modular product architecture. In the laptop computer industry for example, product technological development is driven by component suppliers, such as Intel and Microsoft. No particular company has full control over the architecture, and the final product is a result of coordination by several firms. Examining outsourcing or offshoring at the firm level is insufficient; instead, this research takes an industry view of the course of the technology life cycle.

TCE stresses that the extent of the outsourcing activities depends on the relative efficiency in terms of business processes between internalization and externalization. It also depends on the attribute alignment of the governance mode. In light of the conditions proposed by TCE, each product's technological performance and market demand might also affect the overall development of outsourcing activities. The relationship between the growth of the outsourcing activities and the product's technological performance will be analyzed in this study as well as the correlation between market demand and the growth of the outsourcing activities. Furthermore, TCE also assumes separability in business activities as a crucial factor affecting outsourcing decisions from the buy side. RBV focuses on firms' comparative and competitive advantages from the buyer's perspective. Both theories provide the pre-conditions for the emergence of an outsourcing market. The business

activity has to be separable and noncore from the outsourcing buyer's side. Modularity facilitates business activities separation. A firm's perception of core activities evolves along with the technology life cycle. In addition, TCE also reveals the importance of outsourcing market availability in a firm's disintegration decision. The robustness of an outsourcing market affects the firm's disintegration decision. However, a question remains unanswered: Is there any empirical evidence that supports the connection between product technological performance and an industry's outsourcing activities?

2. Research methodology

This empirical study explicitly explores the connection between product performance and the growth of an outsourcing market. The sample consists of laptop computer manufacturers in Taiwan, working with the development of laptop computer product specifications. The architecture of laptop computers is highly modular, and most of the subsystems are independent, a situation that can be traced back to IBM's outsourcing strategy. In the early days of the development of the personal computer (PC), IBM created an open architecture platform and strategically outsourced production of all major components, as well as distribution, to third-party vendors, in its attempt to catch up with Apple [44]. Manufacturing was initially a core activity; later, IBM started to offshore its PC production facilities to Mexico and Scotland as suppliers of subsystems gained efficiency. By 2003, IBM had decided to outsource its manufacturing, and by 2005, it sold its PC unit to Lenovo.

The laptop computer industry thus uses an open architecture with a handful of subsystem producers. The value chain has been finely sliced into various units: component manufacturer, subcontractor, distribution, and so on. The modular nature of this industry corresponds to TCE's presumption that the process has to be separable in order for firms to outsource. This unique industry setting is an adequate basis for analysis, in which four major laptop computer manufacturers (Quanta, Inventec, Compal, and Wistron) provide the information used to measure outsourcing and offshoring strategies. These four Taiwanese original equipment manufacturers (OEM) do not have their own laptop brand, so the majority of their revenue comes from brand owners. They account for a combined market share of more than 90% of the global laptop market in 2010, according to the Taiwan Institute of Economic Research. Thus, the four OEMs provide an excellent sample, based on both the sheer size of their market share and their pure OEM-focused strategy. This study relies on production data from the four OEMs between 1994 and 2010, together with IBM's laptop product specification data for the corresponding period. Linear regression models analyze the connections between technological performance and the extent of outsourcing and offshoring in the global laptop computer industry.

3. Results

The production output of the four Taiwanese OEMs from 1995 to 2009 indicates the extensiveness of the outsourcing market in the global laptop industry. They may serve as such an indicator because their combined global market share during this time was more than 90%. For the measure of technology performance, this study uses laptop computer

product specification data from 1992 to 2010, including processor speed and hard drive size.

To measure the relationship between the growth of the outsourcing market and technological performance, this study starts by using processor speed as a technological indicator. The relationship between x and y reflects an exponential function. The logarithm of y ($y' = \ln y$) reveals a linear relationship between y' and x. Thus, for outsourcing activity and processor speed, the results are:

$$\text{Regression model}: \ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{log-likelihood}: \ln \hat{y}_i = b_0 + b_1 x_i = 14.95924 + 0.00138 x_i e^{b_1}$$
$$= e^{0.00138} \approx 1.001381.$$

These results indicate a significant connection between outsourcing activity and processor speed: For every unit of improvement in processor speed, there is a corresponding increase of $e^{b_1} = e^{0.00138} \approx 1.001381$ units in outsourcing activity, with an adjusted R-square of 0.93, as indicated in Table 1. In addition to output, market share was also applied to examine the relationship between the growth of outsourcing markets and technological improvements.

$$\text{Regression model}: \ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{log-likelihood}: \ln \hat{y}_i = b_0 + b_1 x_i = -1.1467275649$$
$$+ 0.0004497205 x_i \hat{y}_i \approx e^{-1.1467275649 + 0.0004497205 x_i}.$$

These results reveal the relationship between market share and processor $\vee$: For every unit of improvement in processor speed, there is a corresponding increase of $e^{b_1(x_1 - x_0)} = e^{0.0004497205(x_1 - x_0)}$ in market share, with an adjusted R-square of 0.93, as shown in Table 1.

The same process can be applied to measure the connection between offshore market growth and technological performance. The four Taiwanese OEMs started to offshore their production to China in 1997; this study therefore gathered data on domestic and Chinese production between 1997 and 2009. Growth in overseas production output provides the measure of the extent of offshoring. Thus, the relation between offshoring activity in terms of output and processor speed reveals:

$$\text{Regression model}: \ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{log-likelihood}: \ln \hat{y}_i = b_0 + b_1 x_i = 12.85661 + 0.002263 x_i e^{b_1}$$
$$= e^{0.002263} \approx 1.002266.$$

Table 1
Outsourcing/offshoring strategies and processor speed advancement.

Processor speed (MHz)			
	Coefficient/sig.		Adjusted R-square
	beta0	beta1	
Outsourcing activity (unit)	14.95924	0.00138	0.93
	<0.001	<0.001	
Outsourcing activity (market share)	−1.146728	0.00045	0.93
	<0.001	<0.001	
Offshoring activity (unit)	12.85661	0.002263	0.92
	<0.001	<0.001	
Offshoring activity (market share)	−3.348169	0.002057	0.95
	<0.001	<0.001	
Global demand (unit)	16.1	0.00093	0.9
	<0.001	<0.001	

Another significant connection is evident here between Taiwanese OEMs' offshoring activity and processor speed: For every unit of improvement in processor speed, there is a corresponding increase of $e^{b_1} = e^{0.002263} \approx 1.002266$ units in outsourcing activity, with an adjusted R-square of 0.92. In addition to absolute value, market share was also studied with respect to processor speed:

$$\text{Regression model}: \ln(-\ln(1 - y_i)) = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{log-likelihood}: \ln(-\ln(1 - \hat{y}_i)) = b_0 + b_1 x_i = -3.348168524$$
$$+ 0.002056661 x_i$$

The results indicate that as processor speed increases from x_0 to x_1, the proportion of offshoring also increases $\frac{1 - \exp\{-\exp(-3.348168524 + 0.002056661 x_1)\}}{1 - \exp\{-\exp(-3.348168524 + 0.002056661 x_0)\}}$, with an adjusted R-square of 0.95.

Data on global demand for laptop computers between 1995 and 2009 supports an analysis of the relationship between global demand and technological performance. Specifically, for global demand and processor speed, the results are:

$$\text{Regression model}: \ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{log-likelihood}: \ln \hat{y}_i = b_0 + b_1 x_i = 16.1$$
$$+ 0.00093 x_i e^{b_1} = e^{0.00093} \approx 1.00093.$$

The results reveal a significant relationship: For every unit of improvement in processor speed, there is a corresponding increase of $e^{b_1} = e^{0.00093} \approx 1.00093$ units in demand, with an adjusted R-square of 0.90.

Next, the same process applies to hard drive size, with the results summarized in Table 2:

Outsourcing activity in terms of output and hard drive size:

$$\text{Regression model}: y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{Log-likelihood}: \hat{y}_i = b_0 + b_1 x_i = 4411457.4 + 421.2 x_i$$
$$b_1 = 421.2 \text{ units.}$$

Outsourcing activity in terms of market share and hard drive size:

$$\text{Regression model}: \ln y_i = \beta_0 + \beta_1 \ln x_i + \varepsilon_i$$
$$\text{Log-likelihood}:$$
$$\ln \hat{y}_i = b_0 + b_1 \ln x_i = -2.9460770 + 0.2321896 \ln x_i.$$

The results indicate that as hard drive size increases from x_0 to x_1, the market share also increases $e^{0.2321896 * \ln\left(\frac{x_1}{x_0}\right)}$, with an adjusted R-square of 0.92.

Offshoring activity in terms of output and hard drive size:

$$\text{Regression model}: y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$
$$\text{Log-likelihood}: \hat{y}_i = b_0 + b_1 x_i = -2385492.1 + 442.6 x_i$$
$$b_1 = 442.6 \text{ units.}$$

Offshoring activity in terms of market share and hard drive size:

$$\text{Regression model}: \ln \frac{y_i}{1 - y_i} = \beta_0 + \beta_1 \ln x_i + \varepsilon_i$$
$$\text{Log-likelihood}:$$
$$\ln \frac{\hat{y}_i}{1 - y_i} = b_0 + b_1 \ln x_i = -28.209575 + 2.696555 \ln x_i.$$

The results indicate that as hard drive size increases from x_0 to x_1, the proportion of offshoring also increases

Table 2
Outsourcing/offshoring strategy and hard drive size advancement.

Hard drive size (MB)			
	Coefficient/sig.		Adjusted R-square
	beta0	beta1	
Outsourcing activity (unit)	4411457	421.2	0.95
	0.22	<0.001	
Outsourcing activity (market share)	−2.946077	0.23219	0.92
	<0.001	<0.001	
Offshoring activity (unit)	−2385492	442.6	0.93
	0.648	<0.001	
Offshoring activity (market share)	−28.2096	2.6966	0.88
	<0.001	<0.001	
Global demand (unit)	14160000	419.6	0.94
	0.00167	<0.001	

$\frac{\exp\{-28.209575 \ +2.696555 \ln x_1\}(1+\exp\{-28.209575 \ +2.696555 \ln x_0\})}{(1+\exp\{-28.209575 \ +2.696555 \ln x_1\})\exp\{-28.209575 \ +2.696555 \ln x_0\}}$,
with an adjusted R-square of 0.88.

Global demand and hard drive size:

Regression model: $y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$
Log-likelihood: $\hat{y}_i = b_0 + b_1 x_i = 14160000 + 419.6 x_i$
$b_1 = 419.6$ units.

Moreover, as Table 3 outlines, this study combined the two technological performance indicators, processor speed and hard drive size, to measure their relationship with outsourcing and offshoring using principal component analysis. The principal of the two variables takes a coefficient of 0.7071068. To overcome variations in the variables, the principal can be converted:

$$PRIN_1 = 0.7071068 \times \frac{MHz - mean(MHz)}{sd(MHz)}$$
$$+0.7071068 \times \frac{MB - mean(MB)}{sd(MB)}$$
$$PRIN_1 = constant + \frac{0.7071068}{sd(MHz)} \times MHz + \frac{0.7071068}{sd(MB)} \times MB,$$

where $\frac{0.7071068}{sd(MHz)} \times MHz + \frac{0.7071068}{sd(MB)} \times MB$ is the combined technological performance indicator. This indicator, used in conjunction with the outsourcing and offshoring data, reveals the following set of relationships: Outsourcing activity in terms of output and the combined technological performance indicator:

Regression model: $\ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$
Log-likelihood: $\ln \hat{y}_i = b_0 + b_1 x_i = 15.26321 + 1.12045 x_i$
$e^{b_1} = e^{1.12045} \approx 3.066234$.

Outsourcing activity in terms of market share and the combined technological performance indicator:

Regression model: $\ln y_i = \beta_0 + \beta_1 \ln x_i + \varepsilon_i$
Log-likelihood:
$\ln \hat{y}_i = b_0 + b_1 \ln x_i = -0.48138 + 0.34366 \ln x_i$.

The results indicate that as processor speed increases from x_0 to x_1, the market share also increases $e^{0.34366 * \ln\left(\frac{x_1}{x_0}\right)}$, with an adjusted R-square of 0.94.

Offshoring activity in terms of output and the combined technological performance indicator:

Table 3
Combined technological performance indicator.

	Coefficient/sig.		Adjusted R-square
	beta0	beta1	
Outsourcing activity (unit)	15.26321	1.12045	0.93
	<0.001	<0.001	
Outsourcing activity (market share)	−0.48138	0.34366	0.94
	<0.001	<0.001	
Offshoring activity (unit)	13.629	1.7012	0.86
	<0.001	<0.001	
Offshoring activity (market share)	−6.929	6.9212	0.94
	<0.001	<0.001	
Global demand (unit)	16.28394	0.77465	0.95
	<0.001	<0.001	

Regression model: $\ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$
Log-likelihood: $\ln \hat{y}_i = b_0 + b_1 x_i = 13.629 + 1.7012 x_i$
$e^{b_1} = e^{1.7012} \approx 5.48052$.

Offshoring activity in terms of market share and the combined technological performance indicator:

Regression model: $\ln y_i = \beta_0 + \beta_1 \Phi(x_i) + \varepsilon_i$
Log-likelihood:
$\ln \hat{y}_i = b_0 + b_1 \Phi(x_i) = -6.9290 + 6.9212 \Phi(x_i)$.

The results indicate that as processor speed increases from x_0 to x_1, the proportion of offshoring also increases $e^{6.9212(\Phi(x_1) - \Phi(x_0))}$, with an adjusted R-square of 0.94.

Global demand and the combined technological performance indicator:

Regression model: $\ln y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$
Log-likelihood: $\ln \hat{y}_i = b_0 + b_1 x_i = 16.28394 + 0.77465 x_i$
$e^{b_1} = e^{0.77465} \approx 2.169833$.

Finally, as indicated in Table 4, the connection between outsourcing and market demand is strong: With every unit of increase in market demand there is a corresponding increase in outsourcing activity of $b_1 = 0.9988$ units.

Regression model: $y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$
Log-likelihood: $\hat{y}_i = b_0 + b_1 x_i = -9556000 + 0.9988 x_i$
$b_1 = 0.9988$.

4. Discussion and conclusion

This research sets out to explore the variables affecting outsourcing markets. Three hypotheses (H1, H2, and H3) were formulated to examine such correlations. The results support the correlation between the growth of market demand and the growth in outsourcing markets (H1). In addition, the connection between technology performance and the growth

Table 4
The connection between outsourcing and market demand.

	Coefficient/sig.		Adjusted R-square
	beta0	beta1	
Outsourcing against market demand	−9556000	0.9988	0.99
	<0.001	<0.001	

of outsourcing markets is also strong (H2). Finally, the growth of offshoring markets and technology performance is correlated as well (H3).

TCE focuses on aligning transaction attributes with governance mode and stresses on relative transaction efficiency. In general, the vitality of an outsourcing market depends on the relative efficiency. The results of this research suggest that, in addition to relative efficiency, a product's technology performance and market demand might also influence the growth of outsourcing market.

Williamson [14] suggested that the ability to separate an activity is a crucial point in the governance mode selection. Non-separable activities tend to be executed within the organization. The modular nature of the laptop computer industry provides an appropriate example to examine the role of outsourcing under separability. The findings of this research suggest that, when business processes are separable, market demand is correlated with outsourcing activities. The preceding analyses, using production outputs of laptop computers, and proportional shares of outsourcing markets in the laptop computer market as outsourcing indicators, as well as processor speed and hard drive size as technological performance indicators, strongly support the connection between the growth of outsourcing activities and product technological performance. For every unit of improvement in processor speed and hard drive size, there is added outsourcing activity by four Taiwanese OEMs. The combined product technological indicators offer a similar pattern of results. Furthermore, the Taiwanese OEMs' offshoring activity increases along with product technological performance, whereas the brand owners' outsourcing activity intensifies as product technology progresses. At the same time, the OEMs' offshoring activity also escalates with product technology advancement.

The pace of expansion in global demand for laptop computers correlates with product technology improvements. Brand owners started to outsource around year 2000, and the volume of outsourcing increased significantly as technology developed. Thus, in-house manufacturing might have been perceived as a noncore activity, such that, as the product technology evolved, the benefits of outsourcing began to outweigh the risks. The role of outsourcing intensifies as technology develops, which is a reflection of how firms change their perception of core activities as the technology life cycle evolves.

The results supplement TCE's proposed conditions related to a firm's disintegration decision. The development of technology performance and market demand might also influence the growth of outsourcing activities based on the findings. The incorporation of technology life cycle as well market demand to the conventional TCE and RBV point of view might offer better insight to a firm's disintegration choice. Furthermore, TCE reveals market availability as a major pre-condition in governance mode choice. However, the conventional analysis of outsourcing mainly focuses on the buy side while ignoring that the outsourcing decision cannot be made without an available outsourcing market. The vibrancy of this outsourcing market is crucial to a firm's decision making process. This study explores the impact of technology performance on the growth of outsourcing activities.

These findings are of critical importance to industry practitioners planning their strategies. By carefully observing some key indicators of product technological performance and market demand, managers can allocate production strategies accordingly. In addition to relative efficiency and core activities, managers should also look at the overall evolution of technology and market life cycles when making the governance mode decision.

It should be noted, of course, that the findings and results of this research are based upon empirical evidence from a single industry. Further investigation into other industries would be beneficial to confirm these findings.

Acknowledgments

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