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GENERIC TECHNOLOGY, MODULAR DESIGN AND STRONG NETWORK GOVERNANCE AS A MARKET FOLLOWER'S EARLY STRATEGIES

Being a late mover in the wireless communication industry, MediaTek has developed itself as a world-class fabless IC provider. In emerging markets, MediaTek has been challenging Qualcomm's (the market leader) position. MediaTek's long history, large number, and detailed record of inter-firm cooperative R&D activities provide us a rare opportunity to deeply trail a fast market follower's strategies with regard to technology, product, architecture of product, form of strategic alliance, and performance. Based on the longitudinal, event-level, and quantitative analysis of MediaTek's case, we suggest: (1) to avoid market leader's retaliation, a market follower is prone to adopt a generic technology strategy, which will facilitate the application of a product line extension strategy; (2) to effectively and efficiently leverage R&D resources across the firm boundary, a market follower is very likely to choose modularity as its main product innovation approach; (3) to address the challenges of higher partner uncertainty associated with the network supporting the modular product innovation approach, a market follower will tend to select equity with higher ownership stake (over 50%) as its main network governance mode; (4) a market follower might achieve fast but not unlimited technological catch-up.

Keywords: *generic technology, product line extension, modularity, strong governance network.*

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ТИПОВІ ТЕХНОЛОГІЇ, МОДУЛЬНИЙ ДИЗАЙН І МЕРЕЖЕВЕ УПРАВЛІННЯ ПРИ ФОРМУВАННІ СТРАТЕГІЙ ПОСЛІДОВНИКА НА РИНКУ

У статті на прикладі корпорації "MediaTek" розглянуто формування стратегій послідовника на ринку. Вийшовши на ринок порівняно пізно, корпорація еволюціонувала в постачальника послуг найвищого класу і конкурує зі світовим лідером "Qualcomm" на ринках, що розвиваються. Дані по "MediaTek" дозволили проаналізувати стратегії послідовника відносно технологій, продуктів, архітектури продукту, форм стратегічного альянсу і продуктивності. На підставі часового, подієвого і кількісного аналізу зроблено висновки: 1) послідовник на ринку схильний прийняти стратегію типових технологій, які сприятимуть розширенню лінійки продуктів; 2) для ефективного і дієвого розподілу ресурсів на НДДКР вибирається модульність як основний підхід до інновацій; 3) для зменшення ризиків у співпраці фірми-послідовники схильні купувати акції для пайової участі (більше 50%) у фірмах-партнерах модульної інновації для управління мережею; 4) фірма-послідовник може дійсно швидко технологічно розвиватися, але так і не здогнати лідера.

Ключові слова: *типові технології, розширення продуктової лінійки, модульність, мережеве управління.*

Форм. 5. Табл. 1. Рис. 2. Літ. 27.

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ТИПОВЫЕ ТЕХНОЛОГИИ, МОДУЛЬНЫЙ ДИЗАЙН И СЕТЕВОЕ УПРАВЛЕНИЕ ПРИ ФОРМИРОВАНИИ СТРАТЕГИЙ ПОСЛЕДОВАТЕЛЯ НА РЫНКЕ

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В статье на примере корпорации "MediaTek" рассматривается формирование стратегий последователя на рынке. Выйдя на рынок сравнительно поздно, корпорация эволюционировала в поставщика услуг высшего класса и конкурирует с мировым лидером "Qualcomm" на развивающихся рынках. Данные по "MediaTek" позволили проанализировать стратегии последователя в отношении технологий, продуктов, архитектуры продукта, форм стратегического альянса и производительности. На основании временного, событийного и количественного анализа сделаны выводы: 1) последователь на рынке склонен принять стратегию типовых технологий, которые будут способствовать расширению линейки продуктов; 2) для эффективного и действенного распределения ресурсов на НИОКР выбирается модульность как основной подход к инновациям; 3) для меньшения рисков в сотрудничестве фирмы-последователи склонны приобретать акции для долевого участия (более 50%) в фирмах-партнерах по модульной инновации для управления сетью; 4) фирма-последователь может действительно быстро технологически развиваться, но так и не догнать лидера.
Ключевые слова: *типовые технологии, расширение продуктовой линейки, модульность, сетевое управление.*

1. Introduction. Many scholars have examined how a first mover becomes a successful leader at a new market, with far fewer considering how a late mover can catch up with or even overtake the first one. However, recent studies have started to focus on fast followers (Shankar, Carpenter and Krishnamurthi, 1998; Shamsie, Phelps and Kuperman, 2004; Kopel and Loffler, 2008; Shao, 2011), with the results indicating that fast followers need to actively adopt strategic choices in order to modify their organizational attributes and strategies to existing market conditions, such as adjusting their strategic positioning, strengthening their resource bases (Shamsie et al., 2004), imitating or improving the first mover's technologies, taking price cutting actions (Fernandez and Usero, 2009) etc. From another perspective, some researchers find that taking certain actions that have a greater competitive impact, greater average attack intensity, more visible attack, simpler attack, or less irreversible attack will evoke greater responses from competitors (Chen and Miller, 1994). Furthermore, an action provoking greater retaliation will lead to poorer performance (Chen and Miller, 1994).

Basing on these general ideas, this paper explores how a new market entrant is able to catch up with the existing leader that already had considerable advantages in terms of both technology and market position. We focus on the following specific questions. First, what product strategy does a new entrant adopt in order to avoid the leader's retaliation? Second, what technologies does the new entrant adopt to implement the chosen product strategy, and to provide strategic flexibility if the strategy fails? Third, with what product and organizational architecture can the new entrant leverage its partners' innovative capabilities and thus accelerate the catching up process? Fourth, what mode of governance is appropriate for the selected organizational architecture, especially in earlier periods? Finally, how do a technological gap between a market leader and a new entrant evolve over time?

A key point of this paper is that, to avoid direct confrontation with a market leader, a new entrant tends to choose and develop technologies with a broad range of applications, and the technological versatility thus accomplished will enable a new entrant to develop the products that are highly differentiated from the leader's existing products. Experience and strategic resources that accumulate with earlier success

can help enable a new entrant to further compete with a market leader in terms of technology, products and market position.

Another key point is that, to expedite the abovementioned process, a new entrant will fully utilize outside strategic resources, especially R&D and design skills, which usually come from small incumbents at the targeted market. If these outside resources are quite sufficient in both quality and quantity, then a certain degree of product modularity is feasible, even for a new entrant. A modular product innovation approach will make strategic alliances easier to build, run and adjust, and hence will greatly enhance the speed and flexibility of strategic actions.

Furthermore, this paper focuses on the governance mode (i.e., the type of ties) in an alliance network. Most of the related studies link product modularity to the loose coupling of strategic partners (Orton and Weick, 1990; Argyres and Bigelow, 2010; Press and Geipel, 2010), which means very weak ties between partner firms. In contrast, this paper suggests that, at the earlier stage of an alliance network strong ties are necessary for a new market entrant to exert appropriate control on partners and partners' tasks, although strong ties require quite a large amount of equity investments. This paper also discusses the technological impact of new entrant's actions in this regard.

This paper proceeds as follows: the second section discusses the related theories, the third presents the research methodologies used, the fourth reports the results of the MediaTek case study, and the final section contains conclusions and implications of this work.

2. Literature Review and Propositions.

Generic Technology and Line Extension Strategies. Based on the literature outline above (Chen and Miller, 1994), Schnaars (1994) and Robinson and Chiang (2002) indicated that, in order to avoid retaliation from a market leader, a follower, especially an early one, tends to employ line extensions, rather than product improvements, as its innovation strategy. It is natural that a new market entrant will adopt a line extension approach, since (1) this type of strategy does not require heavy investment in comparison to a strategy emphasizing major innovations; and (2) this type of strategy, in contrast to the one emphasizing product improvements, might reduce the likelihood of the market leader retaliating.

Moreover, even a minor innovation strategy (e.g., a line extension) is not an isolated occurrence, but requires long-term accumulation of technological capabilities. A new market entrant should thus start using generic technology, if available, as this efficient approach. Many scholars defined generic technology as the one that, when exploited will yield benefits across a wide range of economic sectors (Hagedoorn and Schakenraad, 1991; Bresnahan and Trajtenberg, 1995; Keenan, 2003). In spite of long tradition of broad definition, the understanding of generic technology in the literature is rather limited. Such technology is interesting because of its potential for value creation across a broad range of applications (Maine and Garnsey, 2006). Bresnahan and Trajtenberg (1995) considered that generic technology is not only associated with a wide range of uses but also with technological cumulativeness, dynamism and complementary innovations. Shane (2004) illustrated that a late mover can benefit from generic technology in 6 ways: (1) avoiding direct retaliation from the first mover; (2) strengthening flexibility; (3) having access to numerous

investment opportunities; (4) providing opportunities for future revenue; (5) diversifying risks and amortizing R&D costs; and (6) comparing target market applications in dissimilar sectors. Hence, we postulate that:

Proposition 1: When confronted with a market leader which already has significant technological and brand-name advantages, a new entrant will tend to adopt a strategy emphasizing deeper exploitations of generic technology, if possible.

Proposition 2: When confronted with a market leader which already has significant technological and brand-name advantages, a new entrant will tend to adopt a strategy emphasizing continuous product line extensions.

Modular Innovation. Besides generic technology, it is possible for an early follower to accelerate the catch-up process through modular product architecture, and increasing attention has been paid to modularity in the literature as a means of managing complexity and designing flexible technological and organizational systems (Thomke and Reinertsen, 1998; Ethiraj and Levinthal, 2004). Modularity in product design enables a firm to exploit technological opportunities and to react to evolving market opportunities through recombination, modular innovation and outsourcing (Thomke and Reinertsen, 1998). Product recombinations may either increase variety or leverage modules at new markets, enable a firm to satisfy diverse and fluid customer preferences, and minimize the need to predict which product traits will be most valuable (Sanchez, 1995; Sanderson and Uzumeri, 1995). A firm with a modular approach can also exploit technological opportunities that emerge late in the design cycle (Garud and Kumaraswamy, 1995; Thomke, 1997). Furthermore, modularity can expedite technological searches inside or even outside a product domain. Therefore, we postulate that:

Proposition 3: When confronted with a market leader which already has significant technological and brand-name advantages, an early follower is very likely to employ a strategy emphasizing both speed and diversity of innovation through product and organizational modularity.

Strong Governance When Building an Alliance Network. Besides the advantages discussed in the above, many researchers refer to low operating costs of a modular system, since in this type of framework the standardized interfaces and the black-box design rules make it unnecessary for participating organizations to make much effort in communication and coordination (e.g., Orton and Weick, 1990). Nevertheless, for a firm with a weak market position, the toughest challenge is to initiate a network of strategic alliances that will facilitate the modular product design approach. This means that a firm has to continuously search for appropriate potential partners, patiently persuade them to participate in an alliance and cospecialize their individual assets to alliance's needs, provide them with predetermined and acceptable modular interfaces, and then reconstruct the modular architecture when technology changes and conflicts among partners emerge. All these jobs are complex, uncertain, and time-consuming, especially at the early stages of a modular system. White and Lui (2005) argue that when alliance partners face either higher joint task complexity or higher interpartner diversity, cooperation costs (contracting, coordination, control costs etc.) will be higher, and in order to reduce them, a focal firm is more likely to select the hierarchical governance mode (the equity mode with a high ownership percentage) when forming an alliance network. In line with this, Santoro and McGill

(2005) show that assets cospecialization with high task and partner uncertainty requires more hierarchical governance. In sum, we postulate that:

Proposition 4: To form an alliance network that will facilitate the modular product design approach, an early and fast follower is more likely to select a strong governance mode, i.e. the equity mode with high shareholding percentage, as its initial strategy.

Limited Technological Convergence and Price Destruction. If a generic technology for multiple uses is available and a modular framework can be constructed in reasonable time and cost, then an early follower may quickly catch up with a pioneer. However, the technological convergence is not unlimited, especially in an environment in which patent (or copyright) protection has a strong impact. From time to time, a follower in a high-tech industry is blocked by pioneer's large and complicated web of patents (known as a "patent thicket"). Therefore, besides line extensions, the only feasible strategy for an early follower is to cut prices and penetrate lower tiers of the market. Furthermore, as many industrial histories have shown, the existence of a lower-tier-market "troll" may threaten the pioneer's position in the future. Confronted with a potential threat, market pioneer is motivated to cut its product prices, trying to squeeze the follower's profit, which may be used to fund the follower's R&D. This dynamics means that both follower and pioneer are affected by price cuts, with the former being more heavily affected. Summing up, we postulate:

Proposition 5: By applying appropriate strategies, an early follower can achieve technological convergence with a market leader in a rather short time, but under some limitations, which mainly arise from the excluding effect of the pioneer's large portfolio of keystone patents.

3. Research Methodology.

Plan of Case Analysis. In an attempt to indirectly track the case firm's development of relevant technologies, we apply the S-curve analysis to the cumulative numbers of inter-firm alliance events associated with each technology. Inspecting the differences between the resulting S-curves, we can learn the evolution of the case firm's technological priorities over time.

Furthermore, based on the analysis of the time pattern of technological development, we describe and discuss how the case firm, MediaTek, had made use of these technological bases to develop appropriate product architecture and strategies. It is interesting to examine whether the timing of technological developments affects the choice of technological alliance governance modes. To answer this question, we measure the propensity of each technology to choose various types of alliance governance. Linking the time pattern of technological development to the propensity measures, we might be able to learn the evolution of the case firm's alliance governance strategies.

We also examine whether and to what extent the case firm, as a market follower, has been able to catch-up technologically with a leader. To answer this, we compare the case firm's patent structure against a leader's. If the case firm's patent structure converges with the market leader's, then technological catch-up has occurred. In this, we assume that technological convergence, no matter whether it is qualitative or quantitative, will be revealed by the firms' patent structure. This assumption is quite reasonable, especially in the industry characterized by high technology and a strong patent regime. We apply the entropy analysis to this question, as elaborated below.

The data used in this paper include: (1) data on the case firm's technological alliances from the Material Information database on the Taiwan Stock Exchange Market Observation Post System; (2) experts' judgment with regard to the alliances' various technological area (generic technology, optical storage or wireless communication); (3) data on the case firm's product architecture and strategies from both the firm's annual reports and published journals and websites; and finally (4) the data on the case firm's and the market leader's patent structure from the United States Patent and Trademark Office (USPTO) database.

Curve Fitting and Variable Measurement. To fit the S-curves, we use the Pearl equation:

$$y = \frac{L}{1 + ae^{-bt}}, \tag{1}$$

where y – cumulative count of alliance events in time t; t – time in years; L – upper bound (saturation level) of y; a, b – characteristic coefficients.

Transforming the Pearl equation into a linear regression equation, we have:

$$\ln\frac{L-y}{y} = \ln a - bt. \tag{2}$$

We do not use the model derived from the Gompertz equation because of its much lower regression R^2. Examining the time pattern of the resulting curves, we might, although indirectly, identify the priorities the case firm put on its various technologies in different periods of time.

To measure the propensity of a technology to lead to the choice of a certain type of alliance governance, we define the revealed governance propensity of a technology as follows:

$$\mathrm{RSP}_{ij} = \frac{y_{ij} / \sum_i y_{ij}}{\sum_j y_{ij} / \sum_{ij} y_{ij}}, \tag{3}$$

where y_{ij} – cumulative count of alliance events through governance type i related to technology j in the last sample year.

In order to assess the technological gap between a market leader and a follower, a measure based on information theory is used. Theil (1969, 1972) and Frenken and Leydesdorff (2000) suggested the probabilistic entropy or information distance be measured as follows:

$$I = \sum q_j \left(q_i / p_j\right), \tag{4}$$

where (p_1, …, p_n) and (q_1, …, q_n) are *a priori* and *posteriori* distributions, respectively. To measure the technology distance between market leader and follower, p_j and q_j are measured as follows:

$$p_j = x_j / \sum x_j \text{ and } q_j = z_j / \sum z_j, \tag{5}$$

where x_j – count of the patents related to technology j owned by the market leader; z_j – the patents related to technology j owned by the market follower.

The lower the value of I, the more similar the market follower's technology structure to the leader's.

4. The Case of MediaTek.

Qualitative Analysis. MediaTek was established in 1997 as a spin-off of UMC's (United Microelectronics Corporation) IC design group. The broad and deep techno-

logical experience, covering nearly all of 3C products, which was developed in the world's second largest IC foundry firm (UMC) during the pre-spin-off period, constituted a very solid base for MediaTek to undertake a series of strategic actions in different stages of company development, and thus the new firm has been able to successfully penetrate every target market that it has sought to enter. MediaTek was listed at Taiwan Stock Exchange in 2001 and by 2007 was ranked the seventh largest IC design firm in the world. In 2010, it became the fourth largest, behind only Qualcomm, Broadcom and Marvell. As a wireless communication IC provider, MediaTek is the strongest competitor for Qualcomm, especially at emerging Asian markets.

Despite its wide-spread technological capabilities, MediaTek started its business by focusing on optical storage products, such as chips for CD-ROMs, VCD players, DVD-ROMs, DVD players, BD-ROMs and BD players, and did not produce chips for cellular phones and digital televisions until it had become a major supplier of the global optical storage market in 2004. Since 2004, MediaTek has greatly extended its product lines covering 2 main areas: (1) chips for digital music players, digital cameras and digital televisions; and (2) chips for wireless communication, WiFi and WiMax (wireless networking) and GPS (satellite communication) devices. A thorough inspection of the relevant technologies reveals that the former area was largely an extension of the firm's previous optical storage technologies, whereas the latter was relatively new, although MediaTek had had some relevant technological bases before being spun-off. The introduction of wireless communication products required MediaTek seriously consider its advantages with respect to the market leader, i.e. Qualcomm, and skillfully position itself to avoid strong responses from its rival. Strategic considerations lead to MediaTek's idea of a "multimedia phone", which did not emphasize state-of-the art communication technologies but rather the complete integration of communication and multimedia technologies, the latter of which was already one of MediaTek's strengths, due to its previous experience in optical storage. Furthermore, MediaTek brought this unique concept into reality by adopting the "system board" strategy, meaning the cross-tier integration of technologies (cross the tiers of hardware, middleware, and software). In addition to the effect of product differentiation, MediaTek's total solution strategy greatly reduced its customer's time and cost needed to develop new phones. As a consequence, MediaTek was able to deeply penetrate several less-developed but ever-growing markets, especially that in mainland China Market, in a very short time. Summing up MediaTek's technological and product strategies, we suggest the following postulation: a new but strongly motivated market entrant will tend to choose technologies with multiple applications as its starting technological bases, since this will enable the new entrant to differentiate its product lines as much as possible from the market leader's (Propositions 1 and 2). Moreover, the generic technologies that a firm adopts in its early years are likely to benefit later product strategies if the new entrant can combine the existing technologies with newly adopted ones in a sophisticated way, even though the firm's product strategies gradually become closer and closer to the market leader's (Proposition 1).

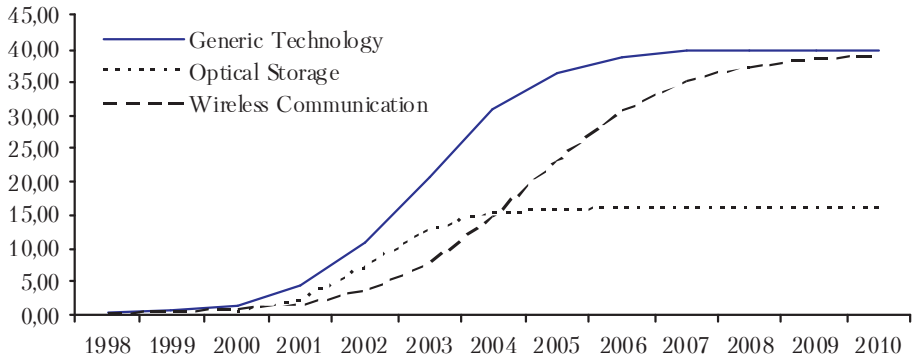
As both a global market follower and a local market leader, MediaTek has always been confronted with 2 challenges: (1) the continuous technological progress of larger direct or indirect competitors, e.g. Qualcomm, Nokia, Motorola, and Samsung; and (2) the ever-changing customer preferences in large emerging markets, e.g. mar-

kets in the BRIC countries. MediaTek's total solution strategy and the related challenges mean that the firm relies on both internal and external R&D resources. There have been many patent licensing, patent or company acquisitions, and R&D joint venture (equity or non-equity) since MediaTek was spun-off from UMC. Given the extreme complexity of identifying and assimilating outside innovations, it is imperative that MediaTek, for all its product lines, adopt a modular approach to product design, as this can enable the firm to reduce, as much as possible, the need to coordinate its R&D partners, thus speeding up the whole innovation process. We therefore propose the following postulation: for products with highly complex systems, a new and aggressive provider will tend to allocate necessary R&D efforts across the firm's boundaries if the R&D resources needed are abundant outside the company. Furthermore, to deal with extreme product and organizational complexity, the new provider will be inclined to adopt a modular product architecture (Proposition 3).

Quantitative Analysis. The large number and detailed record of R&D joint ventures provide us with a window for tracking MediaTek's path of technological development. Figure 1 divides all the relevant technologies into 3 categories and analyzes the growth patterns of joint ventures associated with these. Among the categories, generic technology is defined as technologies applied by both optical storage and wireless communication products. The results imply that before putting significant resources into the categories of optical storage and wireless communication, MediaTek had already heavily committed itself to the development of generic technology (Proposition 1).

Table 1 further analyzes the propensity of each category of joint ventures to choose one of the 4 alternative governance modes: (1) equity with over 50% ownership, (2) equity with 20–50% ownership, (3) equity with below 20% ownership, and (4) a non-equity or contractual agreement. The result shows that, in earlier years when generic technology was the main focus of resources, MediaTek was most likely to choose the strongest governance mode (equity with over 50% ownership) as the control mechanism in its joint ventures. In contrast, other weaker governance modes were more likely to be chosen in later times, when optical storage and wireless communication were the main targets of R&D efforts. A suggested reason for the earlier propensity is that, as a new market entrant, MediaTek was confronted with overwhelming partner uncertainty when trying to build a complete network of R&D partners, even though the partners were to be coordinated by the rules of modular systems, and the only way to resolve this challenge was to apply the strongest governance mode (Proposition 4).

Figure 2 evaluates MediaTek's technological distance from Qualcomm by the information-theoretical measure I, as defined in the preceding section. The roughly L-shaped curve shows that, in the view of patent structures, MediaTek achieved very limited convergence with the technological leader, except the first 5 years. Based on this empirical result and the history of competition between MediaTek and Qualcomm, we suggest the following general argument: in a high-tech industry, it is unlikely that a late comer will technologically overtake larger, early entrants owing to the following obstacles: (1) the extreme complexity of the product systems, (2) the gigantic and interwoven web of patents already owned by early entrants, and (3) the high frequency of technological changes brought about by larger early entrant (Proposition 5).



	Generic Technology	Optical Storage	Wireless Communication
L	40	16	39
ln a	6.46	5.21	6.85
b	1.09	1.65	0.90
R^2	0.63	0.85	0.92

Figure 1. **Growth of R&D joint ventures categorized by technological applications**

Table 1. **Propensity of R&D joint ventures to choose alternative governance modes**

Ownership Stake	Equity			Non-equity
	Over 50%	20–50%	Below 20%	None
Generic Technology	1.15	0.86	0.65	0.73
Optical Storage	0.69	0.54	2.70	1.37
Wireless Communication	0.97	1.33	0.66	1.12

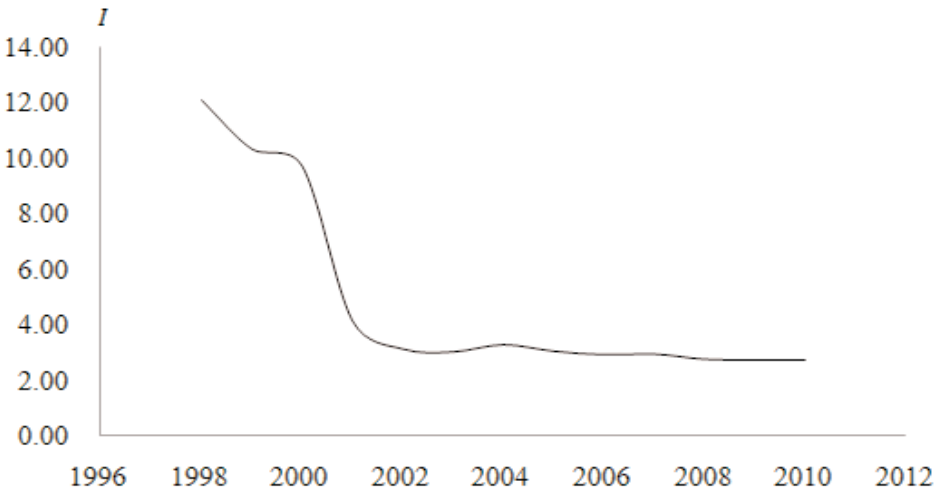


Figure 2. **Technological distance between MediaTek and Qualcomm Qualcomm**

5. Discussion and Implication. Our detailed case observation suggests 3 important ideas. First, when confronted with a market leader which already has insignificant technological and brand-name advantages, the only chance for a new entrant is to seek a sophisticated and unique "fabric of strategies". In the case of MediaTek, this fabric is basically woven with a series of decisions and actions regarding technologies,

product strategies, product architecture and design approach, organizational form and governance. It seems that the rich adopting a wide variety of strategies can provide a market follower, especially an early one, with more opportunities to effectively circumvent the leader's retaliation and to greatly improve the velocity and adaptability of their strategic actions.

Second, contrary to most of the relevant literature, our case analysis does not support the coexistence of organizational modularity and loose couplings (or weak ties) among strategic partners. This paper contends that this seemly paradoxical phenomenon is due to extremely high partner uncertainty, since a new market entrant might have no history of business success, and therefore cannot attract potential partners' participation, or, if they can, then the passion and effort exerted by partners can not be sustained. In other words, a modular design approach can resolve the problems that arise with inter-partner diversity, task complexity and task uncertainty, but not partner uncertainty (White and Lui, 2005; Santoro and McGill, 2005). The inherent lack of confidence in such situations will lead to a market follower's adoption of equity-type alliances, as long as the follower has enough capital to invest.

Finally, our analysis shows that a new market entrant that adopts the appropriate strategies can quickly narrow its technological disadvantages in earlier periods. However, this convergence can not last forever, and is, to certain extent, limited in the long run. It is suggested that this limitedness is due to the market leader's tremendous "thicket of patents," through which they can always deter or even block a follower's innovation efforts by claiming strict IP (intelligent property) rights, charging very high IP licensing fees or strategically cutting product prices if antitrust actions arise. Therefore, a follower's profitability is very likely to be suppressed and its power to threaten the leader will usually weaken in the long run.

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