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Learning and assimilation vs. M&A and innovation: Japan at the crossroads

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ABSTRACT

Historically, Japan constructed its socio-cultural system so that it introduced, adopted, assimilated, and developed Western technology selectively without spoiling its own indigenous culture. And until recently, Japan learned and assimilated global best practices without being dependent on mergers and acquisitions (M&A). M&As in Japan were the lowest in the world until 2000, suggesting a low dependence on acquiring technology in this way. Recently, the number of M&As has increased dramatically among certain Japanese manufacturing firms. Prior to 2004, these firms were less profitable than their counterparts that did not depend on M&A. Today Japan's corporate technology and innovation strategy is at a crucial inflection point of maintaining the indigenous learning/assimilation function while also becoming more dependent on M&As. This paper explores the changing role of M&As in Japanese firms, and also considers the role of Web 2.0 and Enterprise 2.0 in the innovation process. Using an empirical analysis of the trajectories of Japan's leading electrical machinery firms, this paper explores the changing role of M&A in the context of business innovation in Japan, and the ongoing dialectic between indigenous strengths and global best practices.

1. Introduction

Historically, Japan has utilized an explicit function for assimilating best practice into its business model, which subsequently led to rapid productivity improvement. The OECD [1] points out that it is important for a nation's R&D to use not only its indigenous technology but also learning and assimilated spillover technology, which the OECD calls "acquired R&D." The OECD compared dependence on acquired R&D to gross R&D (i.e., indigenous R&D plus acquired R&D) in member countries. Fig. 1 illustrates the results of this analysis, which demonstrates that Japan dramatically increased its acquired technology in the 1970s and 1980s, leading to higher dependence compared to other nations. The OECD concluded that Japan's rapid productivity improvement in the 1970s and 1980s could be attributed to this higher dependence on acquired technology.

In contrast, Japan's dependence on mergers and acquisitions (M&A) remained the lowest in the world, as shown in Fig. 2.

Japan's indigenous industry organization and performance were cultivated and developed within the country's institutional systems [3]. Both organization and performance show trans-generational improvement and do not necessarily indicate that Japan's businesses always adapt well to external systems. Therefore, M&A can result in a deterioration of indigenous organization and performance, particularly manufacturing [4]. This is usually the result of corporate acquisitions that do not take advantage of the opportunity to learn and assimilate. Our research suggests that Japan accomplished its technological

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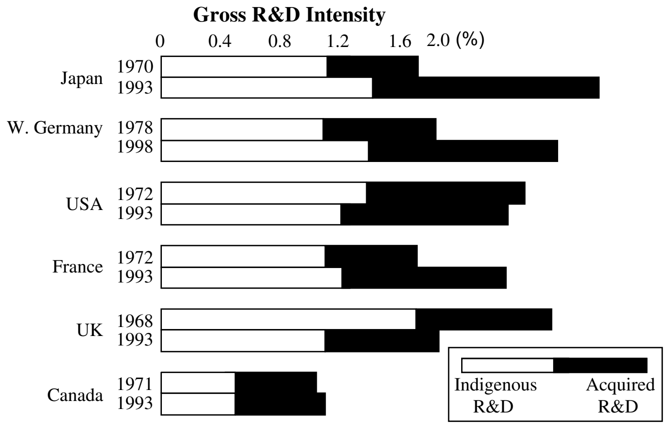


Fig. 1. Gross R&D intensity in 6 countries. Note: R&D intensity = R&D expenditure (indigenous or equivalent acquired R&D) per GDP. Source: [1].

advancement by increasing its indigenous strengths and incorporating learning from global best practices. Until the early 2000s, this was accomplished while maintaining the world's lowest dependence on M&As.

However, as a consequence of the heady successes of the 1980s followed by the bursting of the so-called "bubble economy," learning dramatically declined in the 1990s, followed by prolonged economic stagnation [5]. Despite these circumstances, some firms have continued to fuse global best practices into traditional institutional constructs; other firms have failed to do this. This has led to a bi-polarization of Japan's high-technology firms. Firms that have seized every opportunity to learn have accomplished a high level of profit; firms that focused solely on indigenous strengths realized lower profits [6].

Paradoxically, our research will show that firms that did not depend on learning and assimilation prior to 2004 are the ones that engaged in M&As. Firms found M&As to be a "shortcut" that brought a quick financial remedy, enhancing shareholder value without the need to incorporate learning into traditional Japanese institutional constructs. From the perspective of technological innovation, these firms did not depend on learning and assimilation. In contrast, firms that focused on learning and assimilation demonstrated substantial synergy effects by increasing marginal productivity of technology and increasing profitability. Fig. 3 demonstrates the number of M&A in Japanese corporations which shows that the number has increased dramatically since 2004. This demonstrates the dramatic increasing trend toward dependence on M&As in Japanese corporations.

This trend points to a crucial inflection point for Japan's institutional management of technology: should companies shift from their traditional strength of learning and assimilation and depend largely on in-house development? Or can firms successfully meld M&A and institutional innovation to achieve higher profitability? New technological advances are having an impact on the way firms address this question. For example, the advancement of network technology has dramatically changed the world's institutional systems. The impact of recent innovations for Web 2.0, which emerged in 2004 bringing structural changes in firms' business operations and strategy, could now play a key role in Japan's institutional evolution [7].

It is widely postulated that the new paradigm of Web 2.0 and Enterprise 2.0 have induced open innovation [8], which may help to relax the barriers to implementing exotic systems [9]. Furthermore, the emergence of Web 2.0 corresponds to the

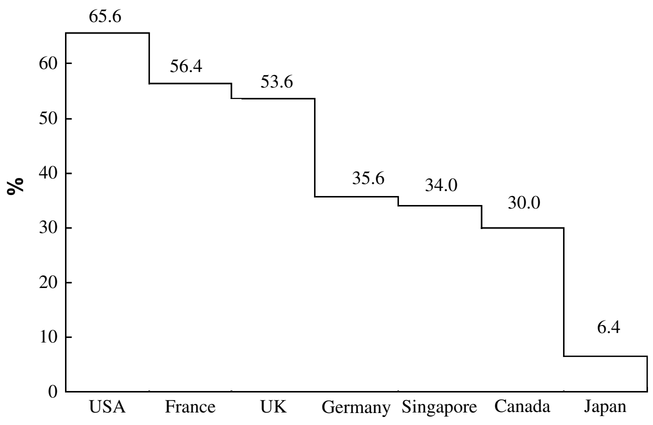


Fig. 2. Dependence on M&A in major countries (1990–1999). Note: Dependence on M&A = number of M&A firms/ total number of IPO firms. Source: [2], adapted by the authors.

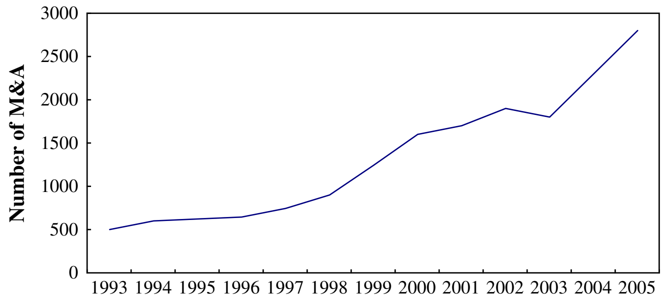


Fig. 3. Growing M&A trend among Japanese corporations (1993–2005). Source: MARR (RECOF Corporation).

dramatic growth of M&As in Japanese firms (suggested in Fig. 4). It is apparent that success in leveraging M&As with learning and assimilation leads to more profitable corporate growth.

Web 2.0 is the name given to a new generation of websites that allows users to share content and create networks in online public forums. It is dramatically changing not only lifestyles but also business practices in Japan and elsewhere [7]. The transformations in the way firms do business has led to a new concept called Enterprise 2.0, which was originally defined as "effective utilization of social platforms within and between firms, as well as between firms and the customers" [9]. This has now moved into a next-generation, IT-driven business model that evolves in a self-propagating way driven by advances in Web 2.0 technology [11].

One important Enterprise 2.0 concept is the notion of collective knowledge. Knowledge generated by firms, which is invaluable for its innovation and competitiveness, increases as user involvement increases. This occurs via the following functions:

- the autonomous participation of users, and
- growing richness of system content as user involvement increases.

Although there has been increased attention on these issues, to date no attempt has been made to analyze the relationship between a possible shift from technology acquired by learning/assimilation to technology acquired by M&As, and the impact of Web 2.0 and Enterprise 2.0 on this shift.

Using an empirical analysis that compares Japan's leading electrical machinery firms' use of M&As and their effect on learning and assimilation, this paper provides new insights into the entrepreneurial trajectories of Japanese firms making use of Web 2.0 and Enterprise 2.0. The critical choice facing these firms is whether to maintain learning and assimilation or to depend on M&As for technology learning. And in the business environment since 2004, a third possibility is to leverage Web 2.0 in order to successfully create learning and assimilation following M&As.

This papers is organized as follows: Section 2 reviews Japan's explicit learning and assimilation function; Section 3 analyzes the hubris of business successes in the 1980s followed by the economic crash of the 1990s. The recent dramatic increase in M&As and new business dynamics since 2004 resulting from Web 2.0, are highlighted in Section 4. Section 5 summarizes new findings, policy implications, and suggestions for further research.

2. Japan's learning and assimilation function

Historically, Japan has introduced, adopted, assimilated, and developed Western technology into its economic, social, and cultural systems in a selective way without impairing its own indigenous culture [12]. During the Edo period (1603–1867) in

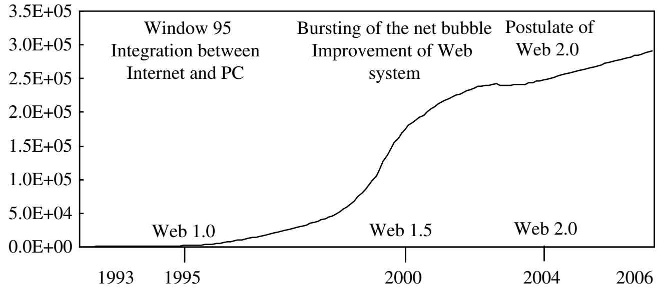


Fig. 4. Trend in cumulative number of co.jp domains (May 1993–June 2006). Source: [10].

particular, the *Sankin Kotai* system, which required federal lords (*daimyo*) to periodically appear at the capital city of Edo (now Tokyo), resulting in considerable information exchange among regions.

The unexpected appearance of American ships in 1853 triggered an influx of Western civilization and culture, which the Japanese adopted selectively. Thereafter, the Meiji government (1868–1912) focused on strengthening Japan's wealth, military might, and industrial production, while intensively promoting Western learning and cultivating Japan's indigenous spirit by establishing education systems encouraging moral ethics. These efforts greatly contributed to technological developments in Japan before, during, and after World War II. In the 1980s, remarkable improvements in high technology were viewed as a crystallization of these earlier efforts. Fig. 5 illustrates the institutional system that enabled Japan to maintain this high elasticity.

Based on this institutionalized system, Japanese management, up to the end of the 1980s, actively introduced advanced technologies and management systems from the U.S. and Europe, and evolved these systems within Japan's own institutional systems. Seeing Japan's increasing technological advancements, the U.S. and Europe undertook similar efforts. As Japan learned and assimilated new technologies and practices, their accomplishments led to a self-propagating cycle (illustrated in Fig. 6). For example, based on R&D and technology developments accomplished by the UK's Engineering Research Association

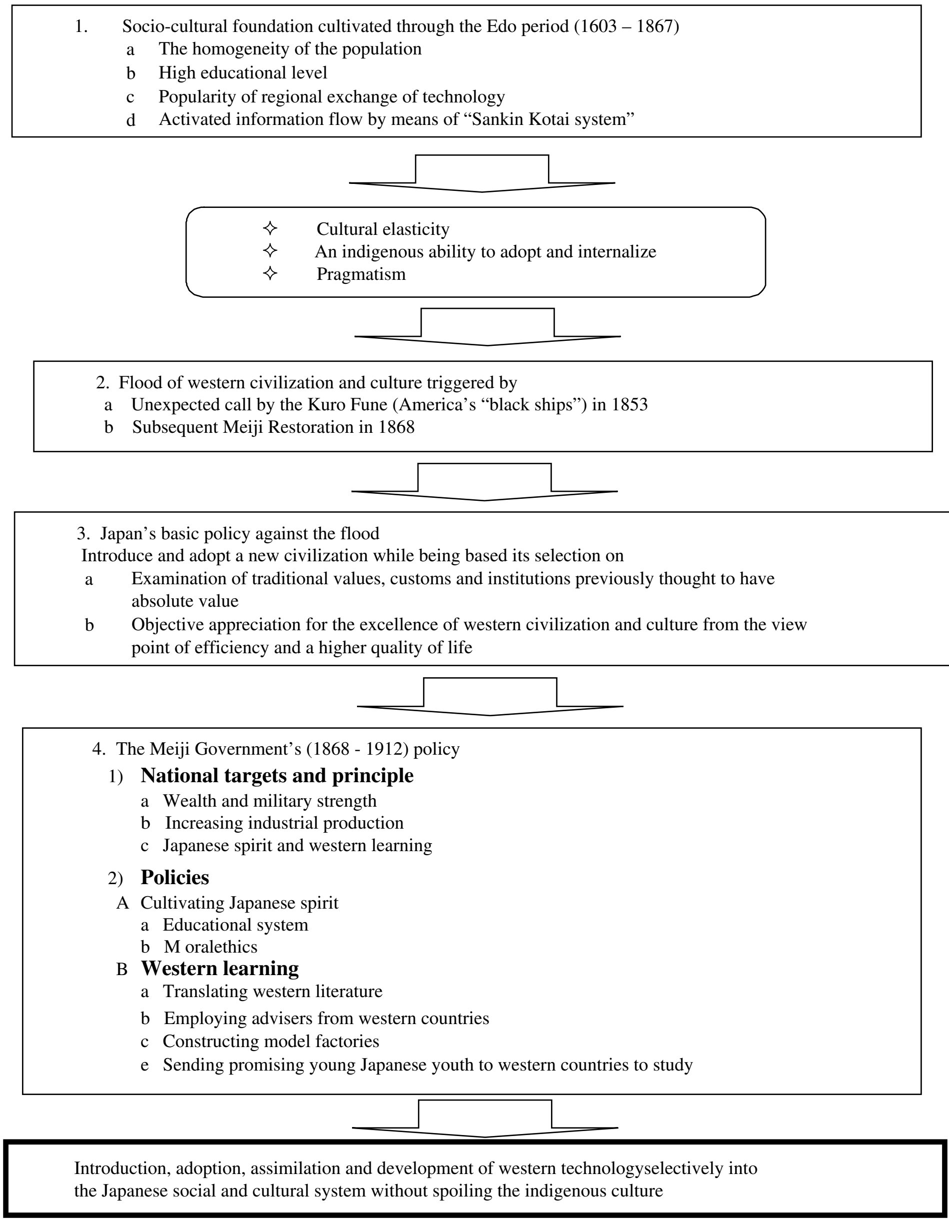


Fig. 5. Socio-cultural systems enabled Japan to smoothly and effectively assimilate imported technologies. Source: [13].

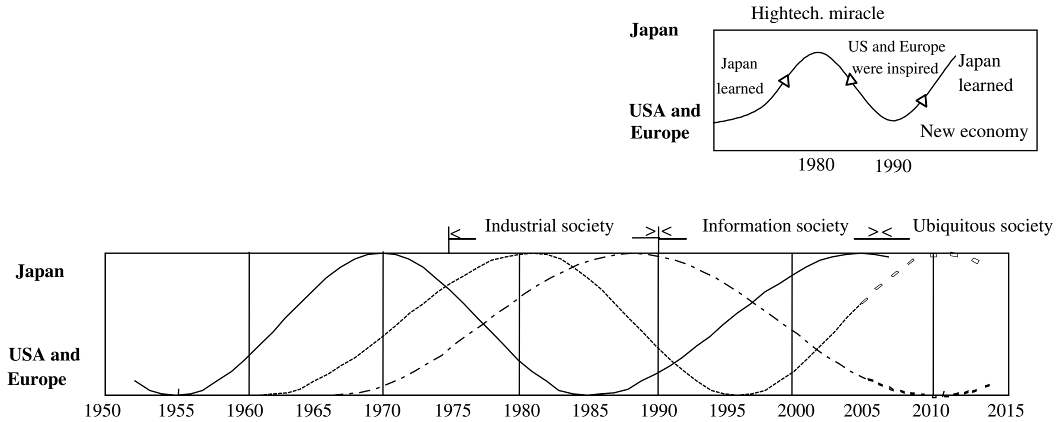


Fig. 6. Co-evolutionary development cycle of Japan's MOT system. Source: [14].

in the 1950s, Japan developed its own R&D consortium by enacting the Law of Engineering Research Association in 1961, which contributed to Japan's high-technology successes in the 1980s. In turn, the U.S. enacted the National Cooperative Research Act in 1984 to leverage joint research between university and industry, which led to further advantages in the digital economy of the 1990s. This in turn inspired Japan to engage in its own joint projects between university and industry in the beginning of the 2000s [14].

Table 1 compares trends in GDP and TFP (total factor productivity) growth rates and their composition in Japan over the last four decades. It demonstrates Japan's notable TFP growth until the end of the 1980s, which can be attributed largely to the effects of learning and assimilated spillover technology [14]. This is a classic example of Japan's indigenous learning and assimilation function.

Fig. 7 further illustrates this function.

This learning and assimilation function can be attributed to the following unique Japanese characteristics:

- distrust of strangers, coupled with a strong desire for homogeneity
- cumulative learning that stimulates assimilation of spillover knowledge
- strong curiosity, smart in assimilation, thorough in learning and absorption.

These factors underlay the historical development shown in Fig. 5 and made a strong contribution to rebuilding the institutional foundations of Japan's economic development after World War II [15]. The characteristics of Japan's post World War II economic environment included:

- strong, but productively focused, competition
- heavy demand from users and consumers (in terms of quality, function, design)
- active inter-industry stimulation
- mutual stimulation between dynamic changes in industry structure and advancements in R&D activities.

This economic environment corresponded to the following social and cultural foundations:

- high levels of education
- diligence and commitment among workers and managers
- highly organized systems and customs
- enlightened management strategies with dependence on government policy.

Table 1
Trend in GDP and TFP Growth Rate and its composition in Japan (1960–2001) – % p.a.[a]

		1960–1973	1975–1985	1985–1990	1990–1995	1995–2001
	GDP (TFP)	9.7 (6.2)	2.2 (1.4)	3.4 (2.8)	2.0 (−0.3)	1.8 (0.2)
Japan's TFP composition	Direct effect of R&D investment	1.0	0.2	0.5	0.2	0.3
	Indirect effect of R&D investment	2.0	0.4	1.0	0.4	0.5
	Learning and spillover effects	3.0	0.8	1.3	−0.9	−0.6

Source: Watanabe (2005).
[a] See Appendix 1 equation the decomposition of TFP.

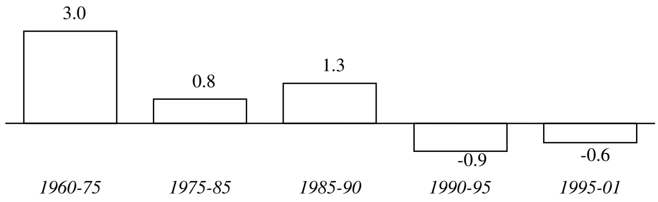


Fig. 7. Trend in contribution of learning and assimilation to GDP Growth Rate in Japan (1960–2001, % p.a.).

It is quickly apparent how these factors interact: a high level of education is a fundamental requirement for a society with a competitive nature that demands high-quality, innovative goods. Commitment on the part of workers and managers is a key element, and well-organized systems and customs function in active inter-industry stimulation and respond to dynamic changes in industrial structure. Through well-planned management strategies, long-term considerations and R&D investment are made, which take into account structural change in industry sectors.

Japan's economic environment and social and cultural foundations coincided with the factors that contributed to its economic development after World War II, as illustrated in Fig. 8. Domestic factors fostered the economic environment while international factors stimulated growth through critical situations such as energy crises and currency appreciation, which distorted the favorable factors but did in fact force innovation and change.

As a result of these factors and their outcomes, a systematic mechanism that induces industry vitality in Japan was developed as illustrated in Fig. 9. Based on a strong economic environment and corresponding social and cultural foundation,

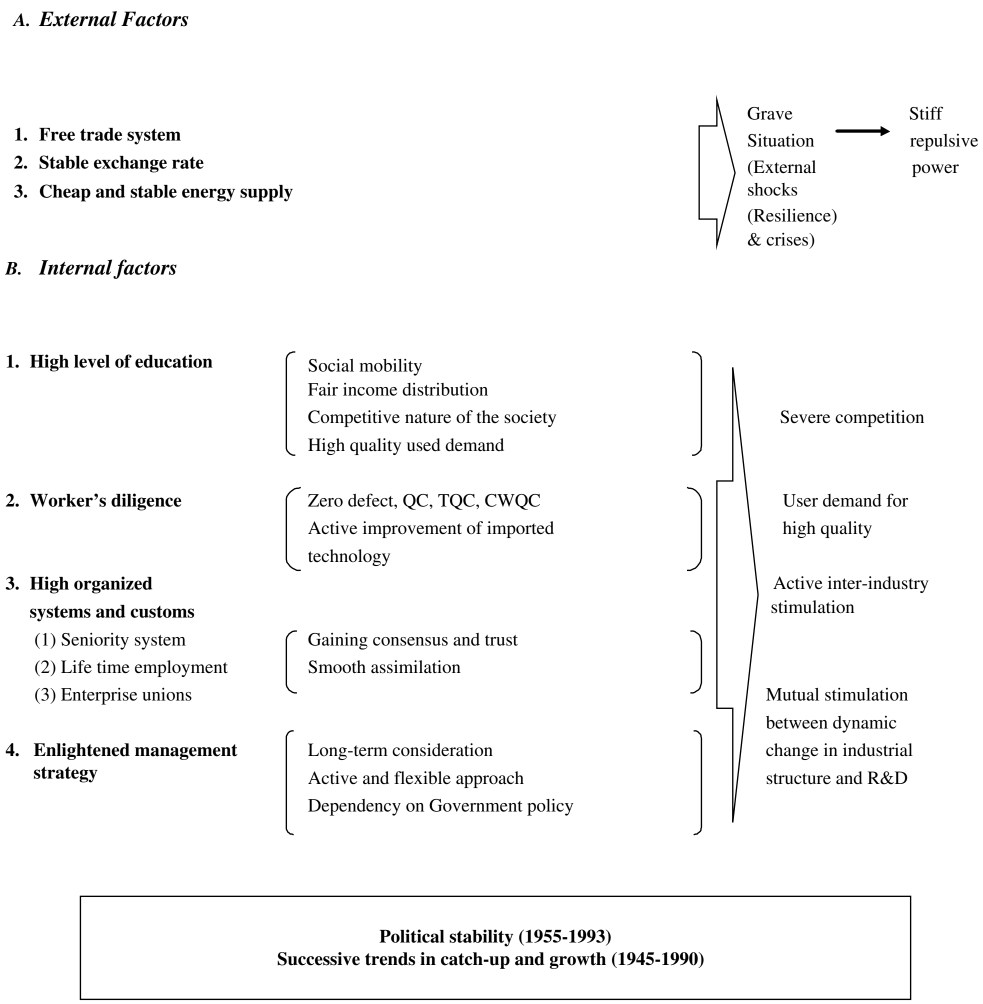


Fig. 8. Foundation of Japan's economic development after World War II. Source: [15].

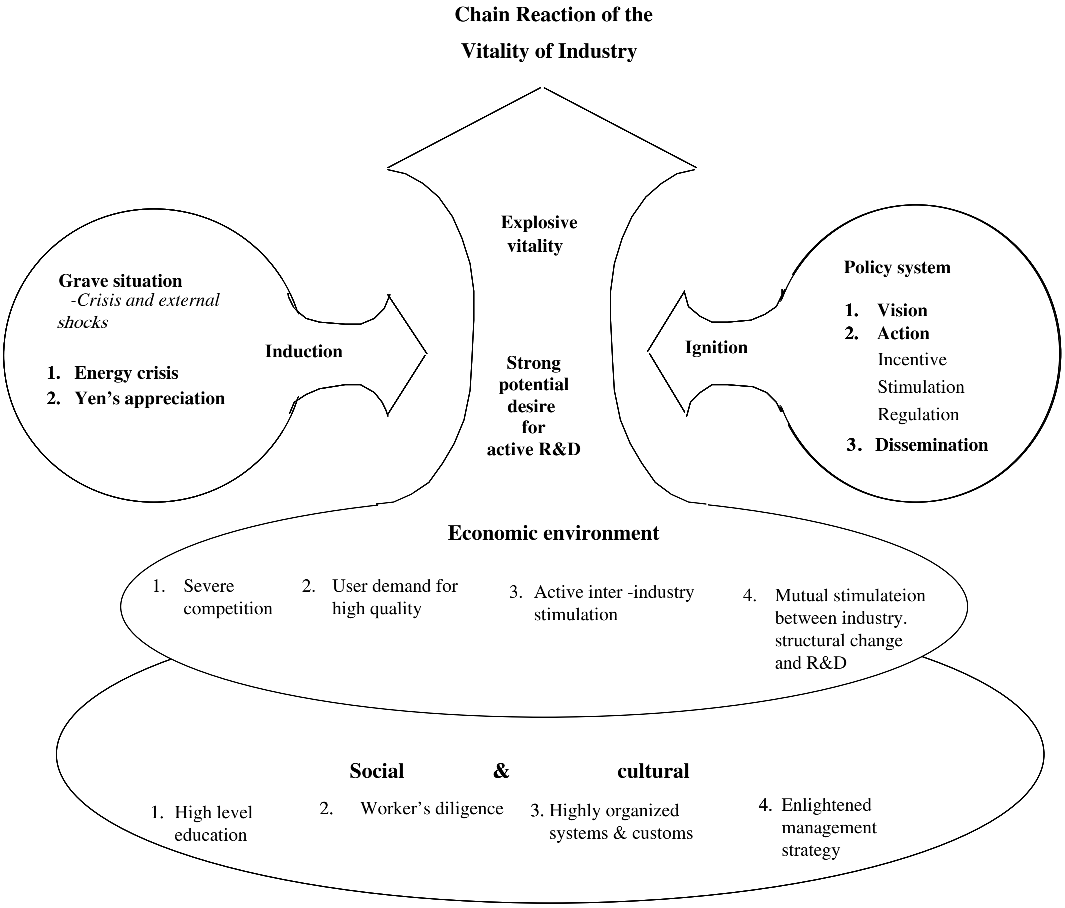


Fig. 9. Scheme for inducing vigorous industry R&D activity in Japan. Source: [15].

a strong desire for active R&D has involved. This is further supported by the role of government policy which leads to a chain reaction of industry vitality [16].

Among these factors contributing to constructing Japan's unique institutional systems, active inter-industry stimulation functioned well in maximizing learning and assimilation effects. This stimulation was typically observed in the mutual stimulation between the automobile industry and iron and steel industry in the initial development of the Japanese automobile industry in the 1960s. Another noteworthy inter-industry stimulation was seen in the technology spillover from electrical machinery and transportation equipment to iron and steel and chemicals (see Fig. 10), leading to energy efficiency improvements in energy-dependent industry in Japan, as illustrated in Fig. 11.

Electrical machinery and transport equipment are not necessarily energy dependent. They conducted intense energy R&D, which contributed to energy efficiency improvements in iron/steel and chemicals. This in turn provided technology spillover from such core technologies as sensors, monitors, and controllers, which are essential to improving energy efficiency in energy-dependent industries. Likewise, this benefited suppliers who depended on qualified materials essential for improving their competitiveness.

3. Stagnation follows the hubris of the 1980s resulting in bi-polarization

Japan's cumulative learning style tends to minimize the impediments of organizational inertia that impede the introduction and adoption of exotic technologies and systems; it also accelerated the assimilation of spillover technology. Japan's economic growth through the 1980s can be attributed to notable technological progress (i.e., TFP increase), which was enabled by the country's socio-cultural system (X-efficiency) and its techno-economic contributions. The contribution of X-efficiency (R&D investment plus learning and spillover effects) contributed more than 80% of Japan's TFP growth rate during the 1980s [14].

The learning efforts became negative in the 1990s, however, due to (a) X-inefficiency because of the hubris of the 1980s, and (b) organizational inertia which impeded flexible adaptation to a new paradigm of the information society and mature

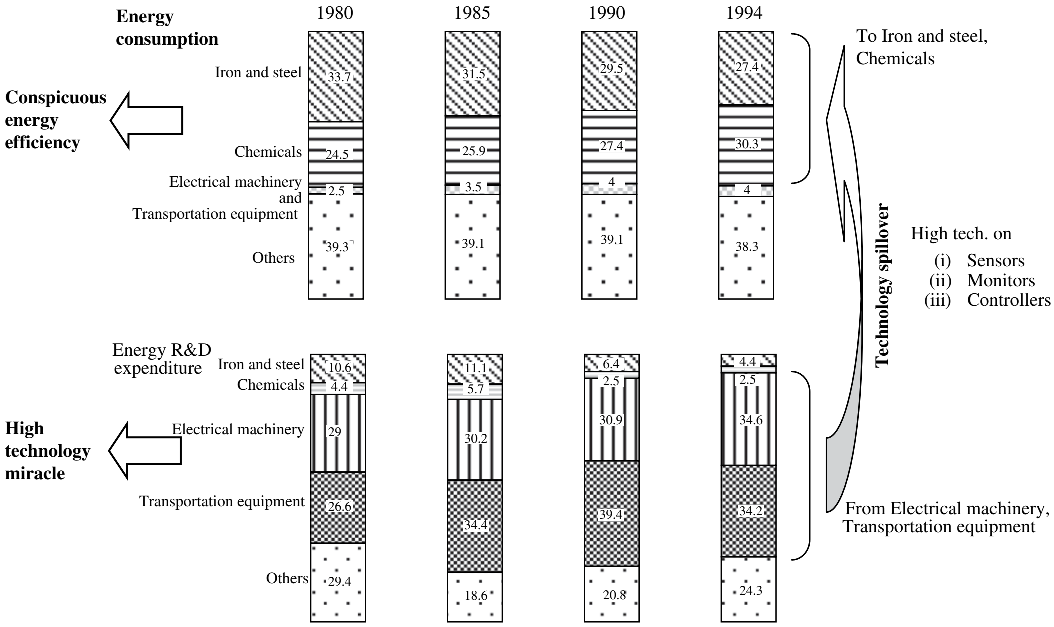


Fig. 10. Technology spillover from electrical machinery and transportation equipment to iron and steel and chemicals in Japan (1980–1994).

economy. Fig. 12 illustrates the trends in learning coefficients in Japan's leading electrical machinery firms over the period 1980-2004.

Fig. 12 also demonstrates that learning coefficients in the leading electrical machinery firms continued to decline in the 1980s and 1990s. Notwithstanding these trends, Canon and Sharp demonstrated a notable upward trend from 1992 and 1997, respectively. This can be attributed to their intense learning efforts and subsequent assimilation of spillover technologies.

Fig. 13 compares dependence on assimilated spillover technology in Japan's leading electrical machinery firms. It shows the contrast between Canon and Sharp's higher dependence and the lower dependence of Matsushita and Hitachi, which corresponds to the contrasting learning coefficient in Fig. 12 [17].

These analyses demonstrate a contrast between firms that pursue intense learning and assimilation, such as Canon and Sharp, and firms that are unwilling to change or learn, such as Matsushita and Hitachi, which relied on the "not invented here" syndrome and did not focus on learning and assimilation.

Fig. 14 demonstrates trends in operating income to sales (OIS) in leading electrical machinery firms from 1980 to 2005. The figure also highlights the contrast between Canon and Sharp (a higher OIS) and Matsushita and Hitachi (a lower OIS), corresponding to the contrast between firms that embrace learning and assimilation and those that did not.

These analyses suggest that leading high-technology firms in Japan, which previously shared a homogenous techno-entrepreneurial trajectory, now have bifurcated trajectories due to differences in their efforts to fuse indigenous strength with learning and assimilation of best practices, which competitors have done. With this in mind, Fig. 15 analyzes the techno-entrepreneurial situation of Japan's leading 13 electrical machinery firms that share a higher market value of equity than the average level in the sector. Fig. 15 correlates OIS and marginal productivity of technology to demonstrate a clear contrast

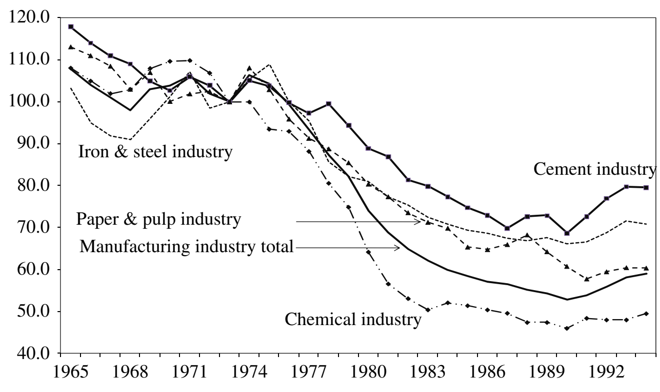
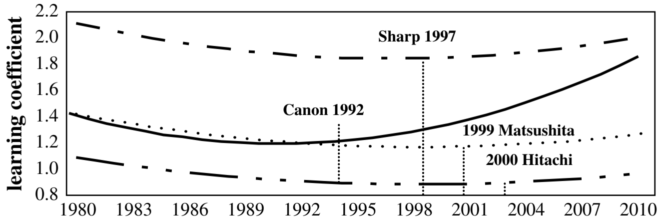


Fig. 11. Trends in unit energy consumption in the Japanese manufacturing industry (1965–1994) – Index: 1973 = 100.



	Infection year	learning coefficient ratio (2004 - 1990)
Canon	1992	1.25
Sharp	1997	1.01
Matsushita	1999	0.97
Hitachi	2000	0.94

Fig. 12. Learning coefficients in 4 electrical machinery firms (1980–2004). Note: see Appendix 2 for a correlation between price of technology and governing factors of learning coefficients.

between Group A firms (including Canon and Sharp), and Group B firms (including Matsushita and Hitachi). Group A firms are learning/assimilation firms and demonstrate a virtuous cycle between OIS and marginal productivity of technology. Contrary to this cycle, group B firms represent "old style" firms that are unwilling to incorporate change, and thus experience a vicious cycle between OIS and marginal productivity of technology as they decrease their marginal productivity of technology level and increase OIS. This trajectory demonstrates a bi-polarization trend between learning/assimilation firms and firms that do not assimilate technology and learn from external sources, even those they acquire.

4. Increase in M&A and New Reaction

Fig. 16 shows trends in the number of M&As and the R&D intensity (R&D expenditure per sales) in Japan's manufacturing industry over the period 1990–2005. The figure also shows that while R&D intensity remains substantial with no increase in this period, the number of M&As has increased from the beginning of the 2000s, with a dramatic increase after 2004. These trends suggest that M&As have taken the place of the R&D that previously stimulated learning and assimilation.

Following this hypothesis, Fig. 17 analyzes the trend in marginal productivity of technology by comparing both M&A and non-M&A firms. While the majority of M&A firms did not change (including Matsushita and Hitachi), non-M&A firms (such as Canon and Sharp) are the leading learning/assimilation firms. Fig. 17 demonstrates that while non-M&A firms continued to increase their marginal productivity of technology, M&A firms experienced the reverse trend, showing a decrease in their marginal productivity of technology until the end of the 1990s. This trend is in line with the general understanding that M&As are a shortcut with no institutional change undertaken beyond the acquisition of a corporate asset. These firms did poorly in terms of profitability because they were unable or unwilling to adapt or change. In this regard, M&As replaced R&D, which was previously used as a key mechanism for learning, assimilation, and technological innovation. Fig. 17 demonstrates this surprising trend, showing that the change started in the beginning of the 2000s, resulting in a dramatic increase from the earlier analysis period of 2003–2005.

It is interesting to note that there was a reversal in 2004, where M&A firms became more profitable. This suggests that, contrary to past performance, M&As can increase a firm's productivity through synergy effects. The question is: What happened in this time period that enabled these firms to better leverage M&As to achieve corporate growth and to incorporate the learning effects? Since this phenomenon occurred just as Web 2.0 and Enterprise 2.0 were emerging, this emergence could help to explain the change.

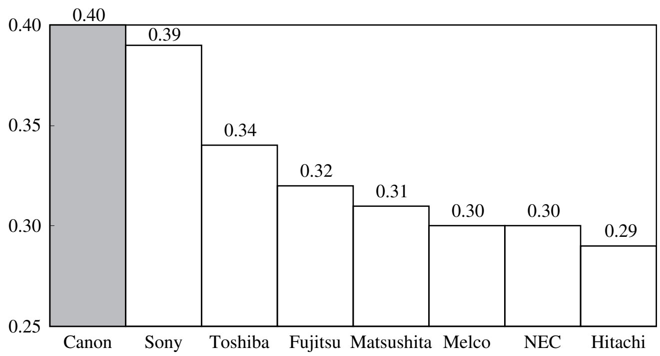


Fig. 13. Dependence on assimilated spillover technology in Japan's electric machinery firms (1998) Source: [17]. Note: see equation in Appendix 3 which measures assimilation capacity.

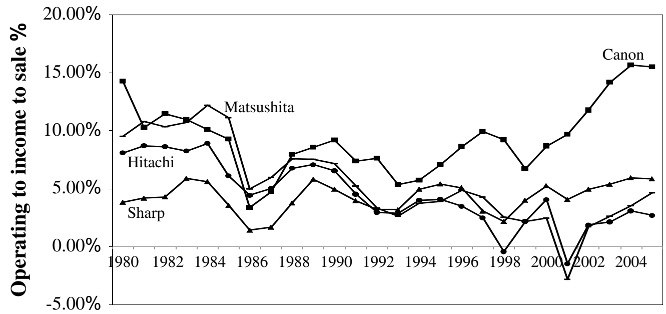


Fig. 14. Trends in Operating Income to Sales in 10 Leading Electrical Machinery Firms (1980–2005).

To explore this possibility, the impact of the emergence of Web 2.0 as a factor that induces M&As by creating positive synergies is analyzed. First, the diffusion trajectory of Japanese corporations, and the degree of effective utilization of the Internet's inherent capabilities,[1] including the transition from Web 1.0 to Web 2.0, was identified. Second, a comparative empirical analysis was undertaken of the monthly diffusion in the number of corporate (co.jp) domains from May 1993 to June 2006 utilizing the Bass model [18], which depicts the diffusion trajectories of innovator and imitator. As suggested by the concept of the bi-logistic growth model [19], a comparison between a single Bass model and a bi-Bass model was conducted. While the former estimates the aggregated trend in the corporate (co.jp) domains, the latter estimates each trend in Web 1.0 and Web 2.0 (see Appendix 5 for the estimation results). Fig. 18 illustrates the trend shown by the bi-Bass model, which was statistically more significant than that of the single Bass model.

According to these results, the transition from Web 1.0 to Web 2.0 had a significant impact on the firms' behavior. This can be linked with Enterprise 2.0, which has taken full advantage of Web 2.0, especially compelled by economic circumstances, to transform corporate culture. Some of the institutional policies that have been transformed include reconsideration of lifetime employment and an organizational climate that encourages openness to open source innovation [20]. As global competition increased over the 1990s, corporations accelerated their alliances in order to survive, leading to improvements in their capacity to assimilate not only technology innovation but also new trends in organization and culture, often driven by M&As.

One of the key drivers is the growth of Web 2.0, which is a major step in the evolution of Internet-based tools. In the years ahead, it will undoubtedly have a significant impact on the way information is managed and distributed within corporations [21].

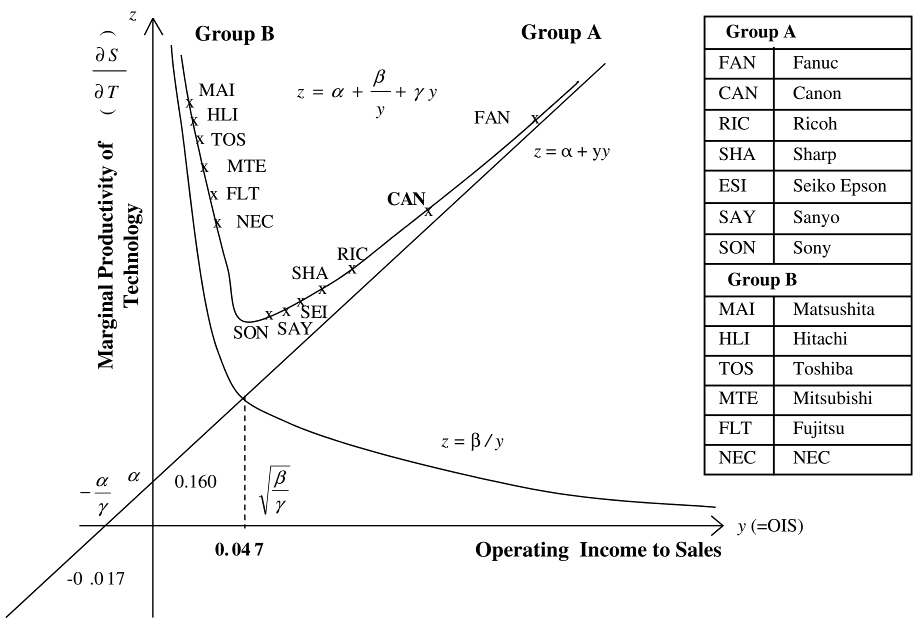


Fig. 15. Techno-entrepreneurial situation of Japan's leading 13 electrical machinery firms (2001–2004). Notes: (a) Vertical axis indicates the order, not absolute value, of marginal productivity of technology within the group of A and B, respectively. (b) In order to avoid irregular OIS change after 2001, Sony's OIS is based on the average between 1984 and 2004. Sanyo's OIS excludes 2002. (c) See Appendix 4 equations that identify the techno-entrepreneurial situation.

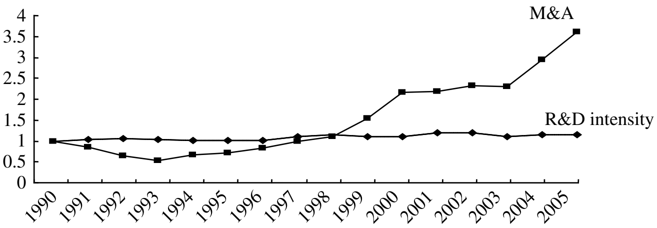


Fig. 16. Trends in M&A and R&D intensity in Japan's manufacturing industry (1990–2005) – Index: 1990 = 1.

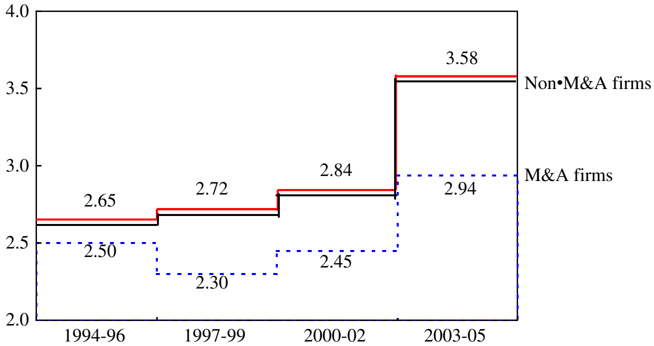


Fig. 17. Comparison of marginal productivity of technology between M&A and non-M&A firms in Japan's electrical machinery firms (1994–2005). Notes: (a) M&A firms include NEC, Hitachi, Toshiba, MELCO and Matsushita. Non-M&A firms include Canon and Sharp. (b) Marginal productivity is the average of the firm's values measured by the diffusion trajectory of sales in each respective firms over the period 1980–2005.

Its impact will encourage the breaking of bureaucracy, alterations in the entrepreneurial culture, greater openness in corporate structures, and consumer information sharing, collaboration, and participation—each of which changes the nature of M&As.

Given the shifting characteristics of Web 2.0 from innovator to imitator, this transition may have had a strong impact on the dramatic increase in M&As among Japanese corporation in terms of their ability to adapt and incorporate global best practice. To test this possibility, we conducted a comparative correlation between the impacts of the transition from Web 1.0 to Web 2.0 and the number of M&As in Japanese corporations during the period 1993 to 2005 (see Appendix 6 for the result of the correlation analysis). By dividing the timeline into two waves corresponding to Web 1.0 and Web 2.0, the analysis demonstrated with statistical significance that there is a seven times higher value of coefficient for Web 2.0. While further in-depth analysis is required to substantiate this relationship, it does indicate that Web 2.0 played a role in the increased performance of Japanese firms involved in M&As.

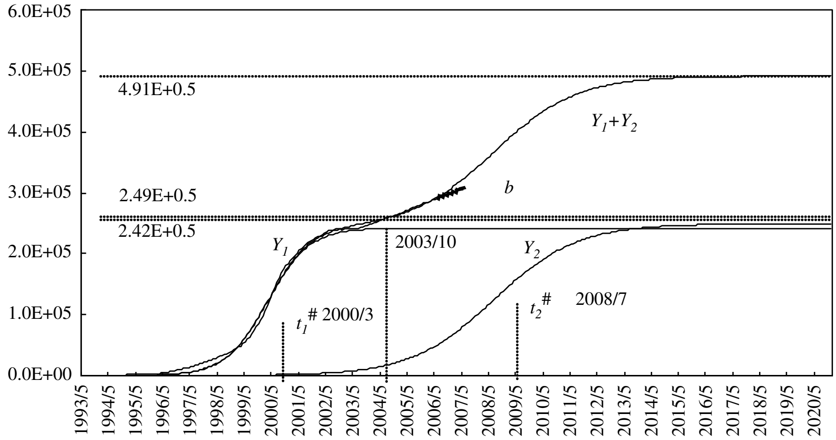


Fig. 18. Trend in the co.jp domains as illustrated by the Bi-Bass model (May 1993–Dec 2020). Notes: (a) May 1993–Jun 2006: actual, and Jul 2006–Dec 2020: extended estimates by the model using May 1993–Jun 2006 data. (b) Jul 2006–Jun 2007: preliminary estimates.

5. Conclusion

There has been an increasing amount of M&A activity in Japan since 2000. Furthermore, firms that were involved in M&As before 2004 suffered in terms of performance whereas those involved in M&As after 2004 have become more profitable. We reviewed contrasting options between learning and assimilation, and M&As in the techno-entrepreneurial trajectory in Japanese industry. On the basis of an empirical analysis focused on Japan's electrical machinery firms, two trajectories were identified that contrasted learning and assimilation and M&As.

Important findings include:

- Historically, Japan constructed a unique socio-cultural system that introduced, adopted, assimilated, and developed Western technology selectively into Japan's socio-cultural system without spoiling its indigenous culture.
- This system incorporates Japan's explicit function for learning and assimilating global best practice, which enabled Japan to realize rapid productivity increases.
- However, following the hubris of the 1980s, learning coefficients dramatically declined in the 1990s in some Japanese firms, resulting in a bi-polarized structure among its high-technology firms.
- While firms endeavoring to maintain learning effects have successfully fused their indigenous strengths with global best practices to create high levels of profit, firms that did not change experienced lower profit. One explanation for this is that these firms used M&As as a shortcut, and these firms were unable or unwilling to "learn" because of cultural and institutional impediments.
- A dramatic increase in the number of M&As has been observed recently, particularly in firms that struggled earlier. Closer investigation revealed that this indicated some system logic had changed, and now these firms were reaping the assimilation and learning benefits from M&As.
- Despite previous performances, the synergy effects of M&As have been observed in these firms, demonstrating an increase in the marginal productivity of technology—just the opposite prior to 2004.
- This phenomenon can be partly attributed to the emergence of Web 2.0 and Enterprise 2.0. It is suspected that embracing and using Web 2.0 and Enterprise 2.0 required fundamental institutional changes that reduced or eliminated previous barriers to learning and assimilation.

These findings offer the following important policy implications to support Japanese firms' effort to manage technology as a result of the emergence of Enterprise 2.0:

- While the Japanese policy system, and firm business models, have been shaped by the homogeneity of Japan's institutional systems, the bi-polarization trend in high-technology firms offers a warning that the reorganization of policy systems based on heterogeneity is essential.
- M&As in a Web 2.0 and Enterprise 2.0 environment in which open innovation is vital. A reconsideration of the possibilities for maximizing the synergy effects of M&As should be undertaken.
- A comprehensive comparative assessment between the fusing effects of learning/assimilation and M&A should be conducted.
- Furthermore, a new learning/assimilation and M&A strategy should be pursued in order to maximize synergy effects.
- Since Japan's traditional policies are based mainly on inducing effective learning and assimilation and not necessarily inducing synergies via M&As, a new policy framework should be constructed that corresponds to Enterprise 2.0 and the subsequent synergy effects as a result of M&As.

Finally, further research could focus on elucidating the dynamism that enables the synergy effects in M&As. Also a comprehensive comparative assessment between learning/assimilation and M&As within the new Enterprise 2.0 stream. Given the profound institutional implications of these new technologies, understanding their effects on Japanese firms would provide useful insight into the technological transformation of business practices.

Appendix 1. Decomposition of TFP

TFP and its components are estimated by the following equation:

$$\frac{\Delta TFP}{TFP} = \dot{TFP} = \underbrace{k^{-1}\eta \cdot \frac{\partial V}{\partial T} \cdot \frac{T}{V} \cdot \dot{T}}_{\text{Direct effect of R\&D investment}} + \underbrace{(1-k^{-1}\eta)\eta^2(\psi-1)k^{-1} \cdot \frac{\partial V}{\partial T} \cdot \frac{T}{V} \cdot \dot{T}}_{\text{Indirect effect}} + \underbrace{(1-k^{-1}\eta)\dot{F}_d - (1-k^{-1}\eta)\psi\eta \sum_i s_i \dot{p}_i}_{\text{Learning/spillover effects}}$$

where V: GDP; F_d: Final demand; T: technology stock; P: factor's price; s_i: $(P_iX_i)/(PV)$; X_i: factor i'squantity; : production elasticity to cost; ηe: elasticity to production; $\psi = e/(1-e(1-\eta))$, k: profit ratio (=PV/C); and C: total cost.

Appendix 2. Correlation between price of technology and governing factors of learning coefficients

Correlation between price of technology and governing factors of learning coefficients in Japan's leading machinery firms (1980–2004) is summarized as follows:

$$\ln P = \ln B - \left[(\alpha-\beta) + \beta \cdot b_1 \cdot t + \beta \cdot b_2 \cdot t^2 + \beta \cdot b_3 \cdot t^3\right] \ln T$$

	ln B	$(\alpha-\beta)$	$\beta \cdot b_1$	$\beta \cdot b_2$	$\beta \cdot b_3$	adj. R^2	DW	$1980 - b_1/2 \cdot b_2$
Matsushita	−9.94 (−5.61)	1.45 (4.92)	−0.030 (−5.01)	0.0008 (4.66)	-4.2×10^{-6} (−1.13)	0.994	2.81	1999
Hitachi	−7.47 (−3.43)	1.11 (2.99)	0.024 (−2.73)	0.0006 (3.64)	7.9×10^{-6} (2.13)	0.997	2.34	2000
Canon	−7.95 (−3.00)	1.47 (2.31)	−0.045 (−2.05)	0.0019 (2.62)	-3.4×10^{-5} (−3.37)	0.989	1.98	1992
Sharp	−11.80 (−2.53)	2.15 (−2.07)	−0.034 (−11.42)	0.0010 (10.95)	-2.5×10^{-5} (−2.57)	0.989	2.01	1997

Learning coefficient $\lambda = \frac{\partial \ln P}{\partial \ln T} = (\alpha-\beta) + \beta \cdot b_1 \cdot t + \beta \cdot b_2 \cdot t^2 + \beta \cdot b_3 \cdot t^3 \approx (\alpha-\beta) + \beta \cdot b_1 \cdot t + \beta \cdot b_2 \cdot t^2$
Learning coefficient of the leading firms follow concave trend with minimum level at time $t = -\frac{b_1}{2b_2}$

Appendix 3. Equation for measuring assimilation capacity

Assimilation capacity z is depicted as follows:

$$z = \frac{1}{1 + \frac{\Delta T_s}{T_s} / \frac{\Delta T_i}{T_i}} \cdot \frac{T_i}{T_s}$$

where T_i: indigenous technology stock, and T_s: technology spillover pool.

Appendix 4. Equations for identifying techno-entrepreneurial situation

Technology progress in firms can be depicted as follows:

$$W = (X, Y)$$

where X: ratio of R&D (R) to Operating Income (OI) and Y: OI to sales (S).
Taylor expansion to the secondary term: $\ln W = a + b \ln X + c \ln Y + d \ln X^* \ln Y$
When ln W, ln X and ln Y are TFP growth rate, R/OI (R&D per OI) and OI/S (operating income to sales),

$$\frac{\Delta TFP}{TFP} = a + b\frac{R}{OI} + c\frac{OI}{S} + d\frac{R}{OI} \cdot \frac{OI}{S} = a + b\frac{1}{OI/R} + c\frac{OI}{R} \cdot \frac{R}{S} + d\frac{R}{S}$$

Since $\frac{\Delta \mathrm{TFP}}{\mathrm{TFP}} = \frac{\partial S}{\partial T} \cdot \frac{R}{S}$, marginal productivity of technology can be developed as follows:

$$\frac{\partial S}{\partial T} = \alpha + \frac{\beta}{OI/S} + \gamma \frac{OI}{S}$$

Appendix 5. Comparison between the Single Bass Model and Bi-Bass Model

(1) Estimation of the co.jp domains by the Bass Model (May 1993–June 2006)

$$Model: \ Y(t) = \frac{N\left(1 - e^{-(p+q)t}\right)}{1 + \frac{q}{p} e^{-(p+q)t}}$$

Parameter	Estimate	t-value	adj. R^2	AIC
N (carrying capacity)	2.67×10^5	191.81	0.998	18.09
P (innovator)	4.1×10^{-5}	5.74		
q (imitator)	0.89×10^{-1}	36.51		

(2) Estimation of the co.jp Domains by the Bi-Bass Model (May 1993–June 2006)

$$Model: \ Y(t) = Y_1(t) + Y_2(t) = \frac{N_1\left(1 - e^{-(p_1+q_1)t}\right)}{1 + \frac{q_1}{p_1} e^{-(p_1+q_1)t}} + \frac{N_2\left(1 - e^{-(p_2+q_2)t}\right)}{1 + \frac{q_2}{p_2} e^{-(p_2+q_2)t}}$$

Parameter	Estimate	t-value	adj. R^2	AIC
N_1 (carrying capacity in Y_1)	2.42×10^5	145.87	0.999	17.08
N_2 (carrying capacity in Y_2)	2.49×10^5	75.66		
p_1 (innovator in Y_1)	1.3×10^{-5}	8.35		
q_1 (innovator in Y_2)	1.08×10^{-1}	58.33		
p_1 (imitator in Y_2)	0.25×10^{-5}	2.60		
q_2 (imitator in Y_2)	0.55×10^{-1}	22.74		

Appendix 6. Results of the correlation analysis

Correlation between the transition from Web 1.0 to Web 2.0, and the number of M&A in Japanese corporations (1993–2005)

$$M\&A = 1965.2 + 0.3\times10^{-2}Y_1 + 2.1\times10^{-2}Y_2 \qquad \text{adj. } R^2 = 0.978$$
$$(6.10) \quad (10.82) \quad (7.06)$$

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