Chapter 11

A Dynamic Model of Technological Growth

What Are the Fundamental Building-blocs of American Leadership?

Abstract: The firms might add value to a nation's economy by offering super-normal wages to the workforce, offering super-normal compensation to the local vendors, or diffusing super-normal purchasing power to the investors for further growth in consumption standards. If there emerge new opportunities for international exchange, then the workforce would be motivated to forego the super-normal wage compensation, and instead seek financing for supporting incremental trading from the global markets. The investors could consider such financing to be quite risky, in light of the super-normality of their existing rents, and demand exorbitant premiums. The social benefit cost ratio of the corporate focus on capitalists, when the human capital could generate increasing returns, is investigated using the American experiences. To facilitate effective appraisal of the global networking opportunities, a dynamic mathematical model of technological growth is presented.

Introduction

A scientific study of growth, and empirically quantifiable mathematical formulation for evaluating the unit of technological growth, is a theme of great topical interest. In a classic essay on the scientific methodology, Mill (1836: 322) elucidated, "When an effect depends upon a concurrence of causes, those causes must be studied one at a time, and their laws separately investigated, if we wish, through the causes, to obtain the power of either predicting or controlling the effect… With respect to those parts of human conduct of which wealth is not even the principal object, to these Political Economy does not pretend that its conclusions are applicable… This approximation is then to be corrected by making proper allowance for the effects of any impulses of a different description, which can be shown to interfere with the result in any particular case." Friedman (1953: 9) elaborated, "the only relevant test of the *validity* of a hypothesis is comparison of its predictions with experience. The hypothesis is rejected if its predictions are contradicted ('frequently' or more often than predictions from an alternative hypothesis); it is accepted if its predictions are not contradicted; great confidence is attached to it if it has survived many opportunities for contradictions. Factual evidence can never 'prove' a hypothesis; it can only fail to disprove it, which is what we generally mean when we say, somewhat inexactly, that the hypothesis has been 'confirmed' by experience."

On a more general note, Capra (1991: 318-319) highlights that the scientists, "construct a sequence of partial and approximate theories, each of them being more accurate than the previous one, but none of them representing a complete and previous one, but none of them representing a complete and final account of natural phenomena. Like these theories, all the 'laws of nature' they describe are mutable, destined to be replaced by more accurate laws when the theories are improved. The incomplete character of a theory is usually reflected in its arbitrary parameters or 'fundamental constants', that is, in quantities whose numerical values are not explained by the theory, but have to be inserted into it after they have been determined empirically… It is evident that the complete 'bootsrap' view of nature in which all phenomena in the universe are uniquely determined by mutual self-consistency, comes very close to the Eastern worldview."

The studies on the economic history of Europe show that in "1600 the English import from [non European] continents was practically nil. By 1660 in official values it was 24% of imports into London, by 1750 it was 46% of total English imports… Pepper, fine spices (nutmeg, mace, cloves and cinnamon), cotton textiles, tea and coffee in varying proportions constituted 80-90% of the imports from Asia throughout most of the period, sugar and tobacco accounted for 75-80% of the commodity imports from America… Cotton textiles were in the 16th and 17th century only imported in modest quantities, they only began their amazing career on the European market in earnest after the reconstruction of the English East India Company after 1660, when they accounted for 70-80% of the English imports from Asia. Even for the Dutch company, cotton textiles became the single most important import commodity after 1700." (Steensgaard, 1990: 46-48)

Table 1 presents the comparative average annual performance of the English and Dutch companies during 1740-1745, based on the previous research reported in Steensgaard (1990: 52).

Dutch company had limited exportable commodities, and could sustain payments only by digging deep into the local bullion reserves. Accordingly, it had a pre-dominant incentive for developing colonial stakes in Asia. The English company also recognized the prospects for increasing returns, and made visible commitments for rewarding the key principals who agreed to serve as dedicated agents in colonial development. The Dutch company offered countervailing services in exchange for the gifts from those who did not wish to be English agents. The Dutch services generated more than 10 percentage points higher returns on total investments, compared to the English ingenuity.

Table 1: Performance of the English and Dutch East India Companies
(Annual average for the period 1740-1745, in 1000 pesos)

	English Company	*Dutch Company*	*Total*
Current Payments			
1. Commodities	1,009	251	1,260
2. Bullion (treasure)	2,171	1,450	3,621
3. Colonial Service Earnings (bills of exchange)	620	609	1,229
Total	3,800	2,310	6,110
Current Costs			
1. Imported products	3,328	2,351	5,679
2. Colonial Servicing Costs (invisible gifts)	472	-41	431
Gross Profit on sale of imported products	4,227	2,969	7,196
1. Direct Investments	3,226	2,640	5,866
2. Dividends	1,001	329	1,330
Gross Profit as % of the Bullion Costs	194.7%	204.76%	198.73%

Contemporary wealth-effects were stupendous, "For centuries the peoples of Europe moved through their cities in a simple and effective manner as old as all mankind. They walked… The keeping of a coach and livery spread from royalty to nobility and then to wealthy bourgeoisie in the course of the late sixteenth and seventeenth centuries in the larger cities. London led the way, as it often did in the early modern period. By 1617 Fynes Morison could write, 'Sixty or seventy years ago coaches were very rare in England, but at this day pride is so increased, as there be few gentlemen of any account who have not their coaches, so as the streets of London are almost stopped up with them.' By the 1630s there were an estimated 6,000 coaches in the capital. In Paris the number of coaches grew from only three in 1530 to three hundred ten in 1658." (McKay, 1976: 3-4)

Based on the Postwar research in the US, Likert (1961: 9) explained, "The high-producing supervisors and managers make clear to their subordinates what the objectives are and what needs to be accomplished and then give them freedom to do the job. The subordinates can pace themselves and can use their own ideas and experience to do the job in the way they find works best. Supervisors in charge of low-producing units tend to spend more time with their subordinates than do the high-producing supervisors, but the time is broken into many short periods in which they give specific instructions, 'Do this, do that, do it this way, etc.'" Rogers and Larson (1984: 255) elaborate that "Office automation can also change the nature of supervision and control in the office. Computers capable of monitoring, for instance, employee lateness or absence records as well as daily productivity information could easily run a company more 'efficiently' than a softheaded human boss given to overlooking employee weaknesses."

On the whole, two unit forces in the international leadership position of the US over the 20th century might be highlighted: (1) assembly of the high quality self-organizing human capital networks, and (2) diffusion of the investment networks for improving the exchange proficiency. This work investigates the first force, and recommends the second for further academic research.

Rent-Generating Potential of the Network Assembly

Conventionally, the firms can enjoy super-normal rents only under inefficient market conditions, as are extant in the regions with poor information and communication infrastructure. Table 2 presents the international investment position of the US over the Post-war period. American firms have been the dominant long-term direct investors in the overseas affiliates and subsidiaries, and are far less prone to being owned by the overseas multinationals. Since the 1960s, the overseas firms rapidly recognized the strategic capability of the American networks and made dominant long-term portfolio investments in the US firms. American firms also gained an increasing cognizance of the option value inherent in the overseas portfolio stakes. By the 1980s their overseas investments were pre-dominantly targeted at the bonds, often supported through the US government credits. The foreign firms tried their best to diffuse the money invested in these bonds back to the US. The American firms substantially reduced the liquidity of their overseas investments over time, even as the foreign firms found diminishing opportunities for non-liquid stakes in the US. On the whole, American firms enjoyed a positive surplus in the cross-national financial service income. This translated into a substantially greater real market rate of interest in the US, than that in Japan.

Table 2: International Investment Position of the US in billions of $

	1950	1960	1970	1980	1990
Long Term Direct	11.8	31.9	78.1	396.2	623.6
Long Term Portfolio	5.7	12.6	26.6	62.5	241.7
Non-liquid short-term assets and US government credits	12.6	21.7	47.4	304.3	843.8
Liquid Assets	24.3	19.4	14.5	173.2	175.1
Total US Assets Overseas	54.4	85.6	166.6	936.3	1884.2
Long Term Direct	3.4	6.9	13.2	125.9	466.5
Long Term Portfolio	4.6	11.5	31.5	74.1	471.9
Non-Liquid short-term assets and US government debts	0.8	1.4	8.8	209.4	812.9
Liquid Assets	8.8	21.0	44.0	134.3	427.7
Total Overseas Assets in the US	17.6	40.8	97.5	543.7	2179.0

Source: Adapted from Survey of Current Business, Oct 1970, Oct 1971, June 1989, June 1992.

Despite super-normal incomes on overseas investments, the American financial services firms suffered considerable capital account losses on their dealings with the non-reputed clients. These losses were partly insured by the fact that the Japanese firms were seeking alternative international investment options, amidst diminishing returns on their American investments. Table 3 shows that this most evident in nations such as Venezuela and Mexico, where the governments invited new foreign investments around late 1980s. A similar situation developed in Brazil and Argentina, once privatization initiatives progressed to create a liquid market during the mid-1990s.

Table 3: Market Value of the Latin American Debt Bonds as Percentage of Par Value

	June 1985	June 1986	June 1987	March 1988	March 1989	January 1991
Argentina	60%	63%	58%	29%	18%	18%
Brazil	75%	73%	61%	48%	28%	22%
Mexico	80%	55%	57%	49%	33%	44%
Venezuela	81%	75%	71%	54%	33%	49%

Source: Robert Devlin (1989: 229) and Keith Pilbeam (1992: 428)

The American firms deployed a significant proportion of the funds received from the Japanese buyers into new foreign direct investments. Table 4 shows that the American ratio of foreign to domestic direct investments rapidly surged during the late 1980s.

Table 4: Overseas and Domestic Direct Investments of the American Firms

	American Direct Investment Overseas in Billion $ (Constant 1987 valuation)	Direct Investment Overseas/ Domestic Investments
1978	24.8	4.0%
1982	1.0	0.2%
1986	19.1	2.6%
1990	31.0	4.2%

Source: Computed from Business Statistics, 1963-91; US Department of Commerce

In the early Post-war era, as is evident from Table 5, the US firms broadened their direct investment networks from Latin American to European and other (primarily Asian) nations. But over the 1970s and 1980s, amidst an unexpected ascendancy of Japanese organizational networks, they focused their investment priorities pre-dominantly to the European region. Over the early Post-war era, the American overseas direct investments were targeted at the manufacturing sector. During the 1970s and 1980s, the US firms reduced the emphasis on the traditional material-intensive mining and petroleum sector. Instead an enhanced focus on other service-oriented operations was laid. Consequently, European technological trajectories became increasingly similar to that of the US. By the 1990s, European firms were moving rapidly to acquire substantial new as well as acquired direct investment stakes in the US. Japanese firms, facing escalating competitive pressures in the US market, sought to further their links with the distributors in other less reputed parts of the world.

Table 5: Composition of the US Overseas Direct Investment Position

	1929	1950	1970	1990
Total in Billion $	7.5	11.8	78.1	424.1
Canada	26.7%	30.5%	29.2%	15.8%
Latin America	46.7%	39.0%	18.8%	16.9%
Europe	18.7%	14.4%	31.4%	49.8%
Middle East/Africa	1.3%	8.5%	6.5%	2.1%
Others	6.6%	7.6%	14.1%	15.4%
Mining & Smelting	16.0%	9.3%	7.8%	2.3%
Petroleum	14.7%	28.8%	27.9%	10.6%
Manufacturing	24.0%	32.2%	41.2%	39.7%
Others	45.3%	29.7%	23.0%	47.4%

Source: Survey of Current Business, various issues

Japanese firms also tried to make best of the growing worldwide demand for the American services over the 1990s. They typically let the American firms decide where to invest the funds originally diffused from the Japanese market. Most of these funds were dominated in the US$, on account of a super-normal trade surplus of Japan with the US. In 1996, the net issues of international bonds and Euronotes surged from $313 billion in 1995 to $512.4 billion. The value of international loans disbursed rose from $310.8 billion in 1995 to $523.7 billion. The subscription of new international stocks grew $52.6 billion in 1995 to $81.4 billion. The relevant data on the disbursement of international loans to major national markets are available from the Bank for International Settlements (1997). A dominant shift in the international balance of payments paradigm took place in 1994, when the yen topped a market value of 80/$. Thereafter an increasing demand for the American services motivated a rapid appreciation in the value of the US$. Two forces in the value of international loans disbursed during the 1996 are investigated. (1) Constant **Japan-effect** measured as the value of international loans disbursed to a nation during the 1995. (2) Incremental **American-effect** measured as the (value of international loans disbursed to a nation during the 1995 – value of international loans disbursed to that nation during the 1994). The value of loans disbursed in 1996 is regressed on Japan-effect and American-effect. The t-values are in brackets. The results suggest that the Japanese firms rapidly expanded their loans into the pre-existing domains. The investment opportunities identified by the American firms foreclosed the Japanese loan option, and allowed the targeted clients to more than disproportionately service their historical debts. On the whole, the globalization of American financial services had a large negative impact on the demand for loans across all nations. The implied limitations on the network assembly might explain the unexpectedly poor performance of the Japanese economy over the 1997 and 1998.

Demand for Loans = -12.121 + 3.565 Japan-effect - 3.755 American-effect R sq.: 0.855
(-2.732) (12.762) (-4.406)

Hypothesis Formulation

Technological cost is an interactive function of the corporate- and local- effects. The catalyst forces that generate the technological cost may be classified as the cultural-effect. Irrespective of the technological cost, the firms might pursue technological trading because it enhances the quality of technological servicing (human-effect). Alternatively they might seek international reputation associated with the market-oriented firms (trading-effect). A greater corporate-effect limits the significance of human-effect in upgrading quality through technological servicing, especially at the national-level where there tends to be greater similarity in the material resources networked by the firms. Similarly, a greater local-effect limits the significance of trading-effect through technological exchange, especially at the international level where there tends to be substantial preference for the already developed markets. Under these conditions, organizational programs oriented towards trading from the emergent markets generate super-normal organizational profitability. The effectiveness of organizational learning, as a function of the corporate planning and local profitability forces, then guides the development of the organization at the international level. These factors may be summarized in form of the following mathematical definitions:

1. **Technological Cost** = Corporate-effect x Local-effect
2. **Technological Trading** = Human-effect x Trading-effect

Human-effect $\propto$ 1/Corporate-effect

Trading-effect $\propto$ 1/Local-effect

3. **Cultural-effect** $\propto$ Technological Cost
4. **Work-culture effect** $\propto$ Technological Trading
5. **Technological Servicing** = Cultural-effect x Work culture-effect
6. **Technological Exchange** = Technological Trading x Technological Servicing
7. **Technological Capability** = Technological Trading x Corporate-effect
8. **Technological Investment** = Technological Servicing x Corporate-effect
9. **Organizational Programming** = Technological Trading x Technological Investment
10. **Organizational Learning** = Organizational Programming x Local-effect
11. **Organizational Profitability** = Technological Exchange x National-effect

National-effect $\propto$ 1/Technological Cost

12. **Organizational Planning** = Organizational Learning x Organizational Profitability
13. **Organizational Development** = Organizational Planning x international-effect

International-effect $\propto$ 1/Technological Trading

14. **Workforce Proficiency** = Organizational learning x international-effect

15. **Networking Proficiency** = Organizational profitability x international-effect

16. **Exchange Proficiency** = Workforce Proficiency x Networking Proficiency

From Definition 1, the technological growth is a constant function of technological cost.

Technological Growth = f(Technological Cost) T 1

From Definition 2, technological growth can be boosted through technological trading.

Technological Growth = f(technological cost, technological trading) T 2

H 1: Technological Cost and Counter-trading

The greater the trading-effect in the organizational learning, the greater the competitive advantage.

From Definition 3 and Definition 4:

Technological Growth = f(cultural-effect, work-culture effect) T 3

T 2 suffers entropy, if cultural-effect > work culture effect:

H 2(a) Cultural Effect and Organizational Learning

The stronger the cultural effect, the greater the organizational learning.

H 2(b) Work-culture Effect and Technological Trading

The stronger the work-culture effect, the greater the technological trading.

Else, from Definition 5:

Technological Growth = f(technological servicing) T 4

From Definition 6:

Technological Growth = f(technological exchange) T 5

T 3 and T 4 suffer entropy, if technological exchange > technological servicing:

H 3(a) Technological Exchange and Marketing Creativity

The more leader-oriented the organizational learning, the greater the international reputation.

H 3(b) Technological Servicing and Manufacturing Creativity

The less vertically integrated a firm's development, the greater the competitive advantage.

Else, from Definition 7 and Definition 8:

Technological Growth = f(technological exchange, corporate-effect) T 6

Alternatively, T 1 - T 4 suffer entropy, if the correction factor for corporate-effect > 1, and Technological Capability > Technological Investment:

H 4(a) Technological Capability and Marketing Alliance

The more the firm interacts with non-reputed partners, the greater the technological investment.

H 4(b) Technological Investment and Manufacturing Alliance

The more focused a firm's rent generating behavior, the greater the technological investment.

The above implies two alternative criteria for boosting technological growth: (1) Corporate-effect > 1, and T 1 (technological cost) and T 4 (technological servicing) are the mechanisms for technological investment, and consequently technological growth, or (2) Corporate-effect < 1, and T 2 (technological trading) and T 3 (work-culture effect) are additional mechanisms for technological capability, and consequently technological exchange.

If Corporate-effect > 1 and local effect > 1, then the following alternative exists:

H 5 Technological Trading and Creative Linkages

The more a firm purchases from the outside vendors, the greater the productivity.

From Definitions 6 - 9, and T 6, if corporate effect < 1, then

Technological Growth = f(Organizational programming) T 7

From Definition 10, if corporate-effect < 1 and local-effect > 1:

Technological Growth = f(Organizational learning) T 8

T 6 and T 7 suffer entropy if the correction factor for local-effect > 1, and Organizational learning > Organizational programming:

H 6(a) Organizational Programming and Marketing Reactions

The greater the co-specialization of absorbed resources, the greater the technological investment.

H 6(b) Organizational Learning and Manufacturing Reactions

The less a firm owns the visible assets, the greater the technological investment.

Else, if the correction factor for national-effect > 1, then T 1- T 4 suffer entropy, and from Definition 11:

Technological Growth = f(Organizational profitability) T 9

If the correction factor for local-effect < 1 and for national-effect > 1, then T 5, T 8, and T 9 suffer entropy and from Definition 12:

Technological Growth = f(Organizational planning) T 10

T 1 - T 4 and T 10 suffer entropy if national-effect > 1, and Organizational profitability > Organizational planning:

<u>H 7(a) Organizational Profitability and Marketing Parity</u>

The lower the resources freed to the (institutional) market for corporate control, the better the quality of technological servicing.

<u>H 7(b) Organizational Planning and Manufacturing Parity</u>

The greater the resources freed to the (real) market for corporate control, the better the quality of technological servicing.

Else, if the correction factor for international-effect > 1, then also T 1 - T 4 and T 10 suffer entropy and from Definition 13:

Technological Growth = f(Organizational development) T 11

Alternatively if international-effect > 1 and T 5, T 8 and T 9 suffer entropy, and using Definitions 14 and 15, a corrected T 11 is needed:

Technological Growth = f(Organizational Development, International-effect) T 12

The above implies two alternative conditions when corporate-effect < 1, national-effect > 1 and international effect > 1: (1) local-effect < 1, and T 10 (organizational planning) is the appropriate approach for technological exchange, or (2) local-effect > 1, and T 10 (organizational planning) is the appropriate approach for organizational development.

Therefore the following alternative recommendation follows:

<u>H 8 Organizational Development and Network Assembly</u>

The greater the institutional activism, the greater the diffusion of Japanese investment networks overseas.

If corporate-effect < 1 and local-effect < 1, and national-effect > 1 and international-effect > 1, then using Definitions 10 and 11, Organizational Profitability > Organizational Learning

Using Definitions 14 and 15 => networking proficiency > workforce proficiency:

H 9(a) Workforce Proficiency and Organizational Profitability

The more focused a firm's discovery process, the greater the competitive advantage.

H 9(b) Networking Proficiency and Organizational Learning

The greater the absorptive capacity of an assembler, the greater the productivity.

If workforce proficiency < 1 and networking proficiency > 1, then using Definition 16 exchange proficiency < networking proficiency. Else if workforce proficiency > 1 and networking proficiency > 1, then using Definition 16 exchange proficiency > networking proficiency. Therefore the following implication is highlighted:

H 10 Exchange Proficiency and Innovative Linkages

The greater the productivity, the greater the competitive advantage.

The above has two alternative effects on technological growth: (1) if exchange proficiency > 1, then networking proficiency > 1, and Organizational profitability > Organizational learning; and (2) if exchange proficiency < 1, then networking proficiency < 1, and Organizational profitability < Organizational learning. The catalyst force in the exchange proficiency may be summarized as:

Hypothesis: Network Assembly and Technological Growth

The greater the human-effect in technological trading, the greater the international reputation.

Operational Measures

The normal value-added by technological capability may be termed as corporate-effect (α). The super-normal cost of technological investment may be termed as local-effect (β). A part of the differences in the competitive advantage may derive from the constant corporate- or varying local-effects. To evaluate the impact of productivity on competitive advantage, there is a need to quantify the correction factors for the significance of corporate-effect and local-effect. Unit competitive advantage yi is the sum of the organizational development variable $\alpha + \beta x$, and a marketbalancing productivity variable ε. The ordinary least square equation yields the unbiased unit estimate of the latent constant corporate-effect α and the latent unit local-effect β for each catalyst force x in the cost of technological investment. Each catalyst force x is independent of the productivity realization ε. If a catalyst force promotes a super-normal cost of the technological investment, then the inter-play of market forces compensates by limiting the realized productivity ε. The result is a significant variation in the unit local-effect β of the focal catalyst force, as measured by a near-zero t-value. Such a condition generates entropy in the power of the focal catalyst force. Competitive advantage then asymptotically approximates to the constant corporate-effect, subject to a correction for the counter-productive impact of the catalyst forces. The units supported by the catalyst forces suffer an escalating cost of technological investment. It becomes more productive for them to trade the technological services from the other more competitive units. The market might seek to offer super-normal resource endowments to these more competitive units. Under these conditions, if the cost of the acquired resource endowments exceeds the normal value-added by the technological capability of the competitive firms, then it is no longer productive for the less competitive firms to sustain the trading. In fact, through counter-trading of their firm-specific resources, these less competitive firms can realize an advantage par excellence. The overall trading-effect on competitive advantage is quantified as R sq., and the corrective human-effect as 1- R sq.

Test of the Hypothesis

From the first law of thermodynamics, productivity of manpower endowments 'a' in assembling the technological input 'h' is a function of two factors:

$$p(s_a^h)\ \alpha\ 1-(s_h)^{w_a^h}$$

$$p(s_a^h)\ \alpha\ (\delta_a^h)^{z_a^h}$$

where $p(s_a^h)$ is the significance of organizational learning in the targeted assembly, s_h is the targeted organizational profitability, w_a^h is the rate of organizational development, z_a^h is the opportunity cost of technological capability, and δ_a^h is the technological investment needed to assemble the targeted technological input.

From the second law of thermodynamics, the corrective effect of technological servicing on the competitive value of material endowments is guided by the following function:

$$s_a^h = s_a s_h p(s_a^h)$$

where s_a is the innovative value added by the technological servicing of the manpower endowment 'a' (termed human-effect), and s_a^h is the unit value created through the technological exchange of input 'h'. Taking a correction factor λ_a^h for the appreciation in national exchange rate (termed trading-effect), the overall technological growth may be measured as:

$$t_a^h = \lambda_a^h s_a^h \text{, or}$$

$$t_a^h = \lambda_a^h s_h s_a \{1-(s_h)^{w_a^h}\}\{(\delta_a^h)^{z_a^h}\} \qquad \text{---------} \quad (1)$$

Differentiating (1) with respect to s_h, and simplifying

$$1 - (1 + w_a^h)\ (s_h)^{w_a^h} = 0, \text{ or } s_h = \frac{1}{(1+w_a^h)^{\frac{1}{w_a^h}}}$$

➔ s_h is a monotonically ↑ function of z_a^h

i.e. *The greater the opportunity cost of technological capability, the greater the targeted organizatinal profitability.*

Further since (1) is an ↑ function of s_h,

The greater the targeted organizational profitability, the greater the technological growth.

<u>Forces Guiding the Targeted Organizational Profitability</u>

Technological growth per unit of material endowment 'b' owned by a firm is a function of:

$$t_b^h = \lambda_b^h s_h s_b \{1-(s_h)^{w_b^h}\}\{(\delta_b^h)^{z_b^h}\} \qquad \text{----------} \quad (2)$$

Differentiating (1) + (2) with respect to δ_a^h, market-effect t^h on technological growth is:

$$t^h = \frac{(\delta_b^h)^{1-z_b^h}}{(\delta_a^h)^{1-z_a^h}} = \frac{\frac{\lambda_b^h s_b}{w_b^h}\{1-(s_h)^{w_b^h}\}}{\frac{\lambda_a^h s_a}{w_a^h}\{1-(s_h)^{w_a^h}\}}$$

Implication 1: Catalyst Forces in Technological Growth

If $z_a^h = z_b^h < 1$, then trading-effect λ_a^h and human-effect s_a are monotonically ↑ function of δ_a^h

➔ *The greater the super-normal cost of technological investment over the normal value-added by the technological capability, the greater the trading-effect (or international reputation).*

➔ *The greater the super-normal cost of technological investment over the normal value-added by the technological capability, the greater the human-effect (or quality of technological servicing).*

Further since (1) is an ↑ function of λ_a^h and s_a,

➔ *The greater the trading-effect, the greater the technological growth.*

➔ *The greater the human-effect, the greater the technological growth.*

Implication 2: Correction Factor for Market-effect

If $z_a^h > 1$, $z_b^h > 1$, then as $(\delta_b^h) \to \infty, t^h \to 0$

If $z_a^h < 1$, $z_b^h < 1$, then $t^h \to \infty$ when $(\delta_b^h) \to \infty$ and $(\delta_a^h) = 0$

$$t^h \to 0 \text{ when } (\delta_a^h) \to \infty \text{ and } (\delta_b^h) = 0$$

➔ *The greater the super-normal cost of technological investment over the normal value-added by technological capability, the lower the market-effect (or competitive advantage).*

Therefore to investigate the overall effects of productivity on competitive advantage, there is a further need to correct the entropy effects of technological cost.

Investigating the Correction Factor for Technological Cost

If a firm enjoys an incremental term of exchange with the market, then there are strong incentives for it to assemble international networks. Without any exchange, the worker social benefit cost ratio of the firm is less than the social benefit cost ratio of the market. But as the firm harnesses its human capital for developing technological trading with the outside vendors, it can generate an incremental return. As such, the workforce proficiency grows, and the firm enjoys a positive growth in the productivity and sustained competitive advantage.

The above set of dynamic effects is best illustrated using the international experiences over the second millennium. At this time Europe was in a state of great intellectual as well as material stagnation. Church, with its orthodox tenets, dominated the intellectual realm. Jewish merchants, with their kinship ties, controlled the resource trading. In 1290, King Edward I of England expelled Jewish merchants from England, and extended direct state governance of the wool trade channels with the northern Belgium and Netherlands. The English national assembly rebuffed the pleas of Pope Boniface VIII (c. 1235-1303) for endowing the gains to the church, and brought clergy under the direct governance of the state. In 1306, Philip IV of France decided to follow the English, and expelled Jewish merchants. Soon, the French were engaged in a prolonged Hundred Years' War (1338-1453) with the English, and eventually prevailed in securing rights over the trading channels in the northwestern parts of the Continent. As the Jewish merchants sought to focus Eastward, Moslem Ottomans closed the trading links with Asia. Under Mohammed II the Conqueror, Ottomans took over the Greek capital Constantinople (Istanbul, Turkey) in 1453, and put an end to the millennium-old Byzantine Empire. They then negotiated a peace treaty with King János Hunyadi (c. 1387-1456) of Hungary, seeking support for military expansion into Asia. Matthias Corvinus (r. 1458-1490), the son of Hunyadi, patronized a revolutionary Renaissance in art and learning. The effects soon diffused further west through Lorenzo de' Medici (r. 1478-1492) at Florence (Italy).

John I (r. 1385-1433), whose mother was the English Philippa of Lancaster, initiated a new Aviz dynasty in Portugal in 1385. His son, Prince Henry the Navigator (r. 1433-1460) patronized the school of Sagres, where the ex- Jew and Arab teachers trained the mariners using tools such as Chinese compass for navigation. After the death of Prince, his nephew Duke Fernando of Beja took over as the director of the School of Sagres. Duke had an out-of-wedlock son, named Salvador

Fernandes Zarcos, whose mother was the daughter of an ex-Jew Zarco – who had colonized the island of Madeira and converted into Christianity in exchange for lifetime governance rights on the island from John I. King John II, who was married to the daughter of Duke Fernando, signed the Treaty of Toledo with Spain, whereby Portugal received monopoly over the sea routes to the East, and Spain over the sea routes to the West. In 1484, Salvador Zarco requested King John II to sponsor his proposal to "navigate directly towards the west in order to discover [a sea route to] the Indies, that is, Cipangu (Japan), Cathay (China), and India… [conditional on being appointed a] Viceroy of all the lands that he would discover, apart from a compensation of ten percent of all the business that ensued." (de Mello, 1998) King John II turned down the proposal. The alternative was to seek the support services of the Spanish Catholic Monarchs Ferdinand and Isabella (r. 1479-1516), who also ruled the Netherlands, Austria, and parts of Italy. These Monarchs had issued an expulsion indictment against the Jews. Therefore, Salvador Zarcos adopted an alternative Genoese Christian meaning of his signature, namely Cristofom Colon, or Christopher Columbus in popular parlance. He used a map that showed "Cipangu (Japan) in the middle of Atlantic, and further west Cathay (China) and India" to secure patronage from the Spanish court. On his westward voyage, he reached islands on the American continent in 1492, and then led 1500 mercenaries to colonize Americas over 1493-96. The Portuguese moved fast to negotiate rights on the eastern parts of Americas in 1494, and then dispatched Vasco da Gama to chart out the sea route to India over 1497-1499. Soon a new era of Scientific Revolution began, with the Polish astronomer Nicolas Copernicus (c. 1473-1543) promulgating that the planets revolve around the sun and refuting the entrenched Greek wisdom. In 1517, Martin Luther (c. 1483-1546) initiated the Protestant Reformation movement in Germany refuting the centrality of Church. Henry VII endorsed the movement in 1534 under an Act affirming supremacy of the King in England. The Spanish Emperor Philip II (r. 1556-1598) married the English Empress Mary Trudor (r. 1553-1558), assumed leadership of the Catholic Church, and extended his rule to the Portuguese empire in 1580 after the death of Portuguese King Cardinal Henry (r. 1578-1580). After the death of Mary Trudor, the English declared independence, and in

1600 formed the East India Company patterned after the United East India Company of Holland seeking profitable trading in India. They assisted the Dutch governors to topple the Spanish rule culminating into a victorious Treaty of Westphalia in 1648. The Dutch governor William III of Nassau (r. 1672-1702) married the English Princess Mary in 1689 and gained rule over the England. After six years of study in Holland over 1683-89, the English philosopher John Locke (c. 1632-1704) laid foundations of a new Enlightenment promoting Mercantile Liberalism. In a classic Two Treatises on Government (1690), he expounded a theory of colonialism founded on the natural property rights. These property rights were to be used to promote constant inflow of gold, through the super-normal export of domestic services for sustaining the domestic value of labor.

After carving out thirteen colonies in America by 1733, 1743 the English actively skirmished with the French in India beginning 1743. English Governor General Robert Clive (c. 1725-74) contested the city of Arcot from the French in 1751, and then fully vanquished them at the battle of Plassey in 1757. From 1756 onwards, the English went after the French and Spanish in North America, taking over nearly the whole region through 1763 Treaty of Paris. For the first time in their history, the English learnt revolutionary new scientific agricultural as well as industrial techniques at the threshold of First Industrial Revolution. In the meantime, the American colonies rebelled against the repressive British taxes, and organized collectively to declare independence in 1776. With French generously endorsing the cause, British were forced to surrender in 1781. Soon thereafter, the Americans appointed George Washington as the First President of the US in April 1789. Under these conditions, the French nobility became literally bankrupt, with the prices of basic necessities such as bread soaring several times in France during July 1789. The third estate declared a new 'National Assembly' as part of French Revolution, that led to the ascendancy of Napoleon Bonaparte (c. 1769-1821). Napoleon enthroned his brothers in Germany, Spain, and Holland, seeking to restore at least part of the international prestige for France. Seeking greater stability at home, in 1823, the US President James Monroe formulated a doctrine of non-interference in European affairs, and called for a reciprocal European non-interference in American hemisphere.

In an attempt to gain preferential alliance, King William IV (r. 1830-1837) of England extended the voting franchise in the First Reform Bill of 1832, limited the blatant exploitation of child labor through Factory Act of 1833, and updated the Poor Law in 1834. Soon his 18-year niece, Victoria (r. 1837-1901) initiated a liberal era of colonial expansion, seeking to diffuse the British learning internationally. From 1839, the British fought Opium War with China and in 1842 took control of Hong Kong, and in 1852 commissioned American help to force open the Japanese ports by 1858. In the meantime, the US abolished slavery after a successful Civil War (1861-65) in 1865, and introduced the 'due process clause' via the 14th Amendment in 1868 stipulating that no state shall "deprive any person of life, liberty, or property without due process of law." The subsequent century was the golden era of a broad-based American technological and economic leadership.

What Are the Fundamental Building-blocs of American Leadership?

Conventionally, it has been presumed that the American leadership fundamentally derived from the super-normal investments into the development of human capital. The recent studies of the American experiences seriously question the incremental value of human capital investments, under conditions where the constructive international linkages are missing. Goldin and Katz (1997: 16-17) report that, "In 1900 more than half of all public high-school students enrolled in Latin classes and virtually none took commercial classes. By 1935 only about 15 percent studied Latin, whereas 10 percent enrolled in bookkeeping, 17 percent in typing, and 9 percent in shorthand… the premium of high-school educated workers plummeted sometime during 1890 and the late 1920s, declining 30 to 40 percentage points most likely in the World War I period. Our best estimate of the rate of return to a year of high school for males was 22 percent before the decline and 12 percent after." Autor, Katz, and Krueger (1997: 57) found that the US industries evidencing, "large increases in the rate of skill upgrading in the 1970s and 1980s versus the 1960s are those with greater growth in employee computer usage, more computer capital per worker, and large shares of computer investment as a share of total investment. The result suggest that the spread of computer technology may 'explain' as much as 30 to 50 percent of the increase in the rate of growth of the relative demand for moreskilled workers since 1970." Nevertheless, the US economy possibly derived only limited benefits from the workforce skills. For instance, a study by Rajan, Volpin, and Zingales (1997: 27) highlighted that the "US manufacturers were preoccupied in the 1970s with the switch to radial tires, which the rest of the developed world had accomplished a decade earlier. In order to focus on the competitive domestic market and make the extraordinary investment required to switch to radials, they largely abandoned their international operations. This left them ill equipped to realize the economies of cross-border production in the 1980s. As a result, all the major U.S. tire manufacturers with the exception of Goodyear were acquired by foreign firms in the 1980s."

Sample and Data Source: The raw data on the economic growth of the US over a 120-year period, from 1870 to 1989, are available from Duménil and Lévy (1993). The forces in technological growth are analyzed over four thirty-year periods, 1870-1899, 1900-1929, 1930-1959, and 1960-89. **Trading Power** is measured as the (gross operating surplus in the US$/ total labor hours). Two forces in trading power of each period are evaluated: (1) Firm-specific resources, termed **Capability-effect**, measured as (Average gross capital stock during a year – Average net capital stock during a year). (2) Growth in firm-specific resources, termed **Investment-effect,** measured as (Average gross capital stock during a year – Average gross capital stock during the sample period). Table 6(a) presents the regressions of trading power on capability-effect and investment-effect, for each of the four periods. The intercepts yield the constant **international-effect**. The t-values are in brackets.

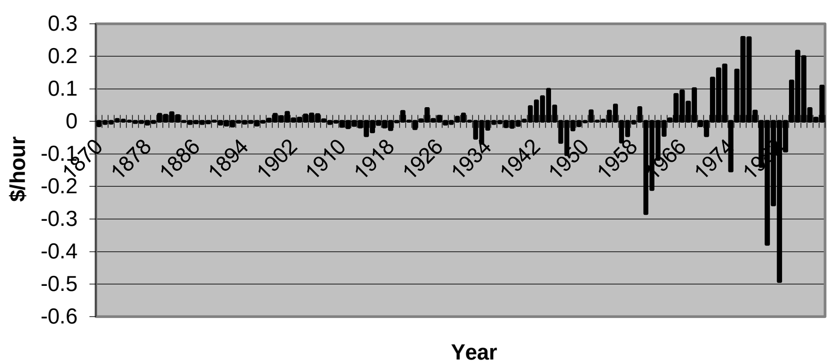
Constant international-effect was insignificant during the first three periods, but had strong positive impact on the trading power, after the stabilization of the US-led Post-war reconstruction, over 1960-89. Capability-effect was insignificant until the Great Depression. During the World War II and reconstruction era, capability had a significant positive impact on trading power. During the global era of 1960-89, a focus on capability was detrimental to trading power. Investment-effect was not significant during the first three periods, but had a constructive influence during the global era. On the whole, after the great merger era at the turn of the 20th century, trading power became a near perfect function of the technological servicing. Technological exchange dominated the 1870-99 period, when several new technologies such as electric and auto, and scientific methods for manufacturing and organization were rapidly diffused throughout the US economy.

Table 6(a): Trading Power of the US Economy

	1870-99	1900-29	1930-59	1960-89
International-effect	-19.075 (-1.69)	1.775 (0.91)	-0.307 (-1.34)	7.905 (15.74)
Capability-effect	1936 (1.70)	-31 (-0.80)	6.1 (4.51)	-2 (-5.88)
Investment-effect	-880 (-1.70)	16 (0.90)	-0.5 (-0.90)	2 (12.84)
R sq.	0.408	0.962	0.989	0.996

Figure 1 shows trading power from innovative technological exchange, quantified as the residuals of equations in Table 6(a). The innovative trading grew over the early 1880s and the early 1900s, but diminished during the war decades of 1910 and 1930. There was a renewed growth over the early 1940s period of war refugees, but benefits diffused during the late 1940s reconstruction. In the early 1960s, rapid diffusion of American investment networks into Europe hindered innovative trading power. Thereafter, the reverse inflows of European networks into the US increased the innovative trading power through the mid-1970s. The subsequent period until the early 1980s, involving the energy crises and hardware-intensive computerization, generated sharp entropy in innovative trading power. Since then the period of vendor-led software-oriented alternatives, and rapid diffusion of Japanese investment networks into the US, renewed the innovative trading growth.

Figure 1: Innovative Value of Trading Power



Human Power is measured as the '(wage compensation in the US$/total labor hours).' Table 6(b) presents the regression of human power on capability-effect and investment-effect. Constant international-effect had a significant positive impact on the human power over the 1870-

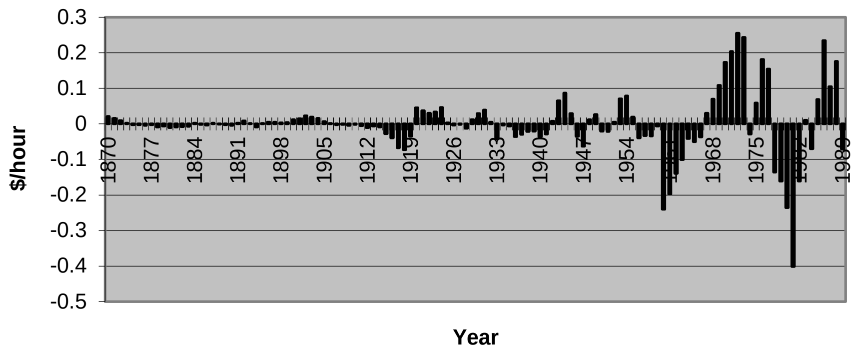
1899, the early formative years of American manufacturing technology and organizational design. The effects were not significant and near zero during the 1900-1959. Globalization era of 1960-89 again generated a positive international-effect on human power. Capability-effect was detrimental over the 1870-99, and was insignificant over the 1900-1929. Post-depression diffusion of American capital overseas sustained a positive capability-effect, but the super-normal growth of the targeted markets hindered the capability-effect over the 1960-89. The detrimental effect of capability over the 1870-99, and again over 1960-89, was compensated by an innovative positive investment-effect.

Table 6(b): Human Power of the US Economy

	1870-99	1900-29	1930-59	1960-89
International-effect	31.693 (4.38)	-0.815 (-0.29)	0.050 (0.25)	11.564 (25.96)
Capability-effect	-3190 (-4.36)	23.2 (0.41)	6.7 (5.83)	-2.9 (-9.50)
Investment-effect	1439 (4.36)	-7.8 (-0.31)	0.4 (0.76)	3.0 (21.13)
R sq.	0.480	0.968	0.997	0.998

Figure 2 presents the creative impact of technological exchange on human power, measured as the residuals of Table 6(b) equations. Creative value of the human power was positive over 1870-73, and again during 1895-1906, when the English capitalists generated new consumption power from the issues of Japanese government bonds on the London market. The super-normal capacity expansion over the 1914-19 period of World War I sharply limited the creative value of human power. The subsequent capacity realignment over 1920-24, and again during the Great Depression of 1929-32, added to the creative value. Consolidation and unionization of the dominant auto sector limited the creative value during 1933-41, but the refugee arrivals improved the situation over 1942-45. Great conglomeration period of late 1950s and early 1960s again limited the creative value. During 1967-77, the creative value of human power rose under a surging East Asian miracle. Over 1978-84, the creative value declined as the costs of energy crises loomed large, but thereafter energy-conserving empowerment options helped regenerate the creative human power.

Figure 2: Creative Value of Human Power



Networking proficiency is measured as 'percentage of capacity utilization during a year.' **Learning-effect** is measured as the 'residual of the trading power equation for the year.' **Development-effect** is measured as the 'residual of the human power equation for the year – residual of the trading power equation for the year.' Table 7 presents the regression of networking proficiency on the learning-effect and development-effect, for each period. The intercepts yield the constant **programming-effect** of projected demand. The t-values are in brackets.

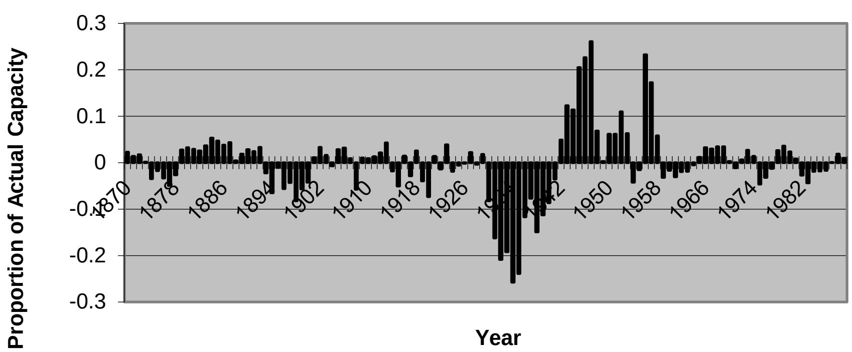
Actual capacity exceeded the programming-effect by 0.007% during 1870-99, lagged the programming-effect by 1.2% over 1900-29, again exceeded the programming-effect by 6.8% over 1930-59, and finally matched the programming-effect perfectly during 1960-89. Learning-effect was significant throughout the history. Organizational learning strongly added to the super-normal utilization of capacity over 1870-99, the effects attenuated during the vertically integrated multidivisional diversification era of 1900-29, but again strengthened over 1930-59. Learning was a fairly small force in capacity utilization during the conglomeration phase of 1960-89. Organizational development had a significantly negative impact on capacity utilization over 1900-29. On the whole, workforce proficiency dominated the capacity utilization only during 1900-29. After the War, there was a rising emphasis on the corrective organizational planning for supportive global links.

Table 7: Networking Proficiency of the US

	1870-99	1900-29	1930-59	1960-89
Programming-effect	0.993 (137.66)	1.012 (179.67)	0.932 (33.97)	1.000 (215.72)
Learning-effect	4.58 (2.77)	0.91 (3.10)	2.64 (3.57)	0.06 (2.13)
Development-effect	1.72 (1.48)	-0.99 (-3.95)	0.71 (0.75)	-0.00 (-0.74)
R sq.	0.353	0.518	0.359	0.188

Figure 3 presents the impact of global work-culture on the proficiency of American networking, measured as the residuals in Table 7. Networking value grew over the 1880s and early 1890s, and plummeted over the late 1890s and early 1900s. After some stability, a sharp decline occurred during the 1930s and early 1940s. The late 1940s to early 1960s colored a golden era in networking proficiency, with the US being actively involved in technical support and reconstruction of the international economy. Since then, the networking proficiency has been essentially stable, involving strengthening and maturity of the already discovered cultural links.

Figure 3: Networking Value of Global Work-culture



Conclusions and the Recommendations for Further Research

The foundations of the American system of technological growth were built on the devotion and dedication to work, and a fundamental appreciation for the universal parity in the value of human potential. These foundations became weak as the US transformed into a consumer society, with the labor becoming dominating and demanding in nature generating forces of entropy in the international leadership position of the US over time since the World War II. Japanese people, humbled by the American might as well as generosity, traded the worldwide organizational learning to realize a stellar rate of technological and economic growth. As for the recent and prospective potential over the forthcoming millennium, the true and essential implication of the dynamic model is that, "We are the makers of our mood, destiny, divinity, and eternity."

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