The Changing Keiretsu: Is the Japanese Mode Still Efficient in the New Japan?

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Abstract

This paper applies an evolutionary model to characterize the structure of Japanese business groups since the 1990s. The simulation results of the dynamic model suggest the destabilization of the 1980s equilibrium. The equilibrium that Keiretsu system dominates in Japan and the traditional American system dominates in the US no longer exists. This model predicts an interior equilibrium, i.e., the co-existence of both systems in the US and Japan. Moreover, this interior equilibrium is reached only by a combination of very weak network effects, an expansion of demand in the US market, and the lower trade barriers in the capital and labor markets.

Keywords: Japanese Keiretsu, Evolutionary Games

JEL Classification: C73; C92; D23; F12; L22

1 Introduction

The characteristics of Japanese business groups (*Keiretsu*) and comparisons with their western counterparts have been widely discussed in diverse disciplines since the 1980s. Aoki (1986, 1988) discusses the non-hierarchical mechanism of operational coordinations; Hashimoto and Raisian (1985) study the lifetime employment system; Milgrom and Roberts (1990), Holmstrom and Milgrom (1994), and Taylor and Wiggins (1997) focus on the differences between the competitive bidding system and the "just-in-time" system; Fung (1991) and Lawrence (1991) look at links between the characteristics of *Keiretsu* and the nation's overall trade competitiveness and bilateral trade balance with the US. Many authors in the 1980s argued that the US and other western countries should learn from the Japanese system and adopt its characteristics to enhance the efficiency of their firms and the national economy.

However, bank reform, changes in the structure of the workforce, the foreign direct investment and the emergence of e-commerce challenge the effectiveness of the *Keiretsu* system. The *Keiretsu* system has become a costly relationship in the new economy. More and more Japanese business groups have begun to learn from the American experience. The co-existence of both systems is observed. But the adjustment process is slower than it should be.

This paper applies an evolutionary model to characterize how *Keiretsu* have adapted themselves to macroeconomic changes in the Japanese economy since the 1990s. The simulation exercise looks for the conditions under which both the American and Japanese styles of organizational modes would prevail in Japan and the US in the long run, and why the adjustment process is taking so long.

In the case of autarky, the shrinking of demand in Japan itself will not have any impact on the choices of organizational modes, and the weak network effects will decrease the basins of attraction of the corner equilibrium. However, neither the shrinking of demand nor the weakening of network effects leads to an interior evolutionary equilibrium in autarky.

The parameters characterizing the demand, the network effects, and the trade barriers in the input markets are discussed separately in the two-country model. Similarly, the change in demand and the lower trade barriers in the input markets do not have any significant impact on the evolutionary equilibria. Weaker network effects in Japan will decrease the basins of attraction of the corner equilibrium. All American firms using the American mode and all Japanese firms using the Japanese mode are less likely to be observed in the long run when the network effects are weaker. The same is true in the autarky model; none of these changes alone can lead to an interior equilibrium in the long run.

The last part of this paper discusses the simultaneous changes in these parameters. Only with a combination of very weak network effects, an expansion of the demand in the US market, and the lower trade barriers in the input markets can we observe both the American mode and the Japanese mode prevailing in both countries. Overall, the simulation results of this model predict an interior equilibrium in which the *Keiretsu* system and the traditional system co-exist. The conditions required to achieve this interior equilibrium also provide an answer for the sluggish adjustment process.

This paper is organized as follows: Section 2 gives an overview of the Japanese economy. Section 3 lays out the basic parametric model. Section 4.1 studies the choices of the organizational modes in Japan based on different demand and network effects in the absence of trade. Section 4.2 simulates the choices of organizational modes in Japan when trade is open. Section 4.3 examines the interactions between the simultaneous macroeconomic changes and the choice of organizational modes. Concluding remarks are provided in the last section.

2 The Japanese Economy

The Japanese economy has been in the process of adjustment since the early 1990s. The recent changes in the Japanese economy include sluggish economic growth, financial reform, an increase of FDI, the emergence of e-commerce, and changes in the lifetime employment system. An overview of these changes is provided here. How these changes relate to the restructuring of the *Keiretsu* will be discussed in Section 4. The first significant change is the low growth rate, or alternatively, the drop in demand. Compared with the remarkably high growth in the 1960s,[1] the Japanese economy has been in a slow growth period since 1975. In the slow growth period (1975-1989), the growth rate in Japan was around 4 percent, which is still the highest among the G7. However, the growth rate in the 1990s fell abruptly. The average growth rate from 1992 to 1998 was 1.1 percent, which is the lowest among the G7.

The main banks associated with the *Keiretsu* groups control most shares of the market.[2] To get a soft loan from their main banks is one important factor in the consolidation of the *Keiretsu* relationship. Following the recession, the massive bad-loan problems reached an intolerable level in the mid-1990s. The small banks went bankrupt, and the big banks also suffered a lot from "nonperforming loans". To cure the ailing financial system, Japan has committed itself to creating a competitive banking industry. Banks are not willing or not able to provide soft loans to the industry as before.

The lifetime employment system is a well-known characteristic of the *Keiretsu*. Employees are hired by the company when they graduate from school and stay with the company until their retirement. Wages usually rise with the length of service or with the worker's age. When young workers are the main body of the workforce, firms following the seniority-related wage structure can keep the wage cost relatively low, even though they have to pay higher wages to the senior workers. However, with the aging of the population, there are more older workers and fewer younger workers. The lifetime employment structure is not as easily maintained, and the seniority-related wage system must change. As the current downturn has beaten deeper into profits, companies have begun to use cheaper

[1]Throughout the 1960s, the average growth rate stayed about 10 percent.

[2]As of December 1995, the total number of domestically licensed banks was 171. The eleven city banks hold 46 percent of the domestically licensed banks' total assets.

part-time workers to replace full-time workers.[3] Besides, some companies, such as Matsushita Electric Industrial and Fujitsu Electronics, have started to offer managers the choice of performance-related pay or the usual seniority scale.

In addition to the bank reform and the change in the employment system, foreign investment has also sped up the change in Japan. The mergers and joint projects between the Japanese firms and foreign firms inevitably lead to the restructuring of the Japanese industries.[4] The emergence of e-commerce loosens *Keiretsu* links further as the network among producers and distributors spreads all over the world.

3 The Model

The theoretical framework of this paper depends on the parametric model described in Friedman and Fung's (1996) work. The analysis starts from a simple one-country model with a single industry. There are fixed numbers of identical firms in the isolated country. Each firm chooses between two alternative organizational modes. The short-run Cournot-Nash equilibrium is determined by firms simultaneously choosing the output quantity. The two-country model with trade will also be described in this section. The long-run steady-state (evolutionary equilibrium) is achieved when no firm can increase its short-run profit by unilaterally switching modes. The evolutionary equilibria will be discussed in Section 4.

3.1 Organizational Modes

Before starting the formal model, we first define the two alternative organizational modes, A and B. Mode A is popularly identified with American firms. In A

[3]Nissan Motor cut 21,000 jobs to stave off bankruptcy, Sony got rid of 17,000 jobs, and NEC cut 15,000 jobs during the recession.

[4]For example, Sumitomo Rubber, Japan's second-biggest tire maker announced a joint venture with America's Goodyear; a series of joint ventures was announced by an American chemicals and plastic firm, Dupont, with Teijin, and Japan's troubled second-biggest car maker, Nissan, put itself up for sale.

mode, workers are narrowly classified, market demands are met by using buffer inventories, information flows from the top of the hierarchy to the shop floor, and the separation of coordinating tasks and operating tasks facilitates hierarchical control by management. Mode B is popularly identified with Japanese firms. In B mode, workers typically practice job rotation, the just-in-time system is used to minimize the cost of inventories, market demands come from dealers directly to the head of the assembly line, and decisions are made and coordinated by the workers on the shop floor. Moreover, the major shareholders of B firms include banks and other corporations. The intercorporate stockholding leads to an exclusive, stable and long-term relationship in B groups.

The two modes have different relative efficiency, depending on the economic environment and the relative prevalence. The economic environment affects the relative efficiency in many aspects. If demand favors varieties of goods, the external shocks are moderate and frequent, workers learn rapidly, and the cost of inventories are high, the B mode is relatively more efficient than the A mode.

Relative prevalence affects efficiency in two ways, the network effects and the glut effects. The network effects characterize the externality on the production cost due to the closer long-term supplier-distributor relationship among B firms. The stronger the network effects, the more the profits of B firms increase with the prevalence of B firms. Glut effects are due to the demand side of the firms' outputs. Since outputs of A firms and outputs of B firms are not perfect substitutes, the greater prevalence of B firms decreases the price of B good and decreases the profit for B firms relative to A firms. The profit of B firms increases with greater prevalence of B firms when the network effects are stronger than the glut effects.

3.2 Autarky

Consider an isolated country with $N \geqslant 2$ identical firms. A fraction s of firms adopts B mode for organization and a fraction $(1-s)$ of firms employs A mode, where $s \in [0,1]$. The output quantity chosen by an A firm is x_A, and the output quantity chosen by a B firm is x_B. The goods produced by firms adopting different modes are imperfect substitutes. The market demand for good A and good B are given by:

$$P_A = \alpha_A - \beta X_A - \gamma X_B$$

$$P_B = \alpha_B - \beta X_B - \gamma X_A$$

where $X_A = \sum x_{Aj}$ and $X_B = \sum x_{Bj}$ represent the total industry outputs for goods produced by A firms and B firms, respectively.

A firms and B firms both have zero fixed costs. A firms have constant marginal cost, $c_A > 0$; B firms have the marginal cost of $c_B - bs$, where $b \geqslant 0$ represents the rate of cost reduction as the proportion of B firms rises. In equilibrium, the symmetric Cournot-Nash outputs are given by:

$$x_B = \frac{[(1+(1-s)N]\beta(\theta_B + bs) - \gamma(1-s)N\theta_A}{\Delta}$$

$$x_A = \frac{(1+sN)\beta\theta_A - \gamma sN(\theta_B + bs)}{\Delta}$$

where $\Delta = (1+sN)[1+(1-s)N]\beta^2 - sN(1-s)N\gamma^2$, $\theta_A = \alpha_A - c_A$, and $\theta_B = \alpha_B - c_B$. The short-run equilibrium profits are $\pi_A = \beta(x_A)^2$, and $\pi_B = \beta(x_B)^2$.

3.3 Trade

Consider two countries, home and foreign (in this case, the US and Japan). There are N^* firms in the foreign country and a fraction s^* of foreign firms adopt B mode, $s^* \in [0,1]$. The superscript d indicates domestic production, the superscript e indicates export, and the asterisk refers to the foreign country. Each firm has to decide how much to produce for the domestic market and how much for export.

Goods produced by firms adopting the same mode are perfect substitutes. The inverse demands in each market are given by:

$$
\begin{aligned}
P_A &= \alpha_A - \beta(X_A^d + X_A^{*e}) - \gamma(X_B^d + X_B^{*e}) \\
P_B &= \alpha_B - \beta(X_B^d + X_B^{*e}) - \gamma(X_A^d + X_A^{*e}) \\
P_A^* &= \alpha_A^* - \beta(X_A^{*d} + X_A^e) - \gamma(X_B^{*d} + X_B^e) \\
P_B^* &= \alpha_B^* - \beta(X_B^{*d} + X_B^e) - \gamma(X_A^{*d} + X_A^e)
\end{aligned}
$$

Given the market demands and the profit functions, the Cournot-Nash outputs in the home country are:[5]

$$
x_A^d = \frac{\left[\begin{array}{c} \beta[\beta^2((1-s^*)N^*+1)(sN+s^*N^*+1) \\ -\gamma^2(1-s^*)N^*(sN+s^*N^*)]\theta_A^d \\ -\beta^2\gamma sN(\theta_B^d+bs)+\beta(1-s^*)N^*[\gamma^2(sN+s^*N^*) \\ -\beta^2(sN+s^*N^*+1)]\theta_A^{*e}-\beta^2\gamma s^*N^*(\theta_B^{*e}+b^*s^*) \end{array}\right]}{\Delta}
$$

$$
x_B^d = \frac{\left[\begin{array}{c} -\beta^2\gamma(1-s)N\theta_A^d+\beta[\beta^2(s^*N^*+1)((1-s)N \\ +(1-s^*)N^*+1)-\gamma^2 s^*N^*((1-s)N+(1-s^*)N^*)](\theta_B^d+bs) \\ -\beta^2\gamma(1-s^*)N^*\theta_A^{*e}+\beta s^*N^*[\gamma^2((1-s)N+(1-s^*)N^*) \\ -\beta^2((1-s)N+(1-s^*)N^*+1)](\theta_B^{*e}+b^*s^*) \end{array}\right]}{\Delta}
$$

$$
x_A^e = \frac{\left[\begin{array}{c} \beta(1-s^*)N^*[\gamma^2(sN+s^*N^*)-\beta^2(sN+s^*N^*+1)]\theta_A^{*d} \\ -\beta^2\gamma s^*N^*(\theta_B^{*d}+b^*s^*)+\beta[\beta^2((1-s^*)N^*+1)(sN+s^*N^*+1) \\ -\gamma^2(1-s^*)N^*(sN+s^*N^*)]\theta_A^e-\beta^2\gamma sN(\theta_B^e+bs) \end{array}\right]}{\Delta}
$$

$$
x_B^e = \frac{\left[\begin{array}{c} -\beta^2\gamma(1-s^*)N^*\theta_A^{*d}+\beta s^*N^*(\gamma^2((1-s)N+(1-s^*)N^*) \\ -\beta^2((1-s^*)N^*+(1-s)N+1))(\theta_B^{*d}+b^*s^*)-\beta^2\gamma(1-s)N\theta_A^e \\ +\beta[\beta^2(s^*N^*+1)((1-s)N+(1-s^*)N^*+1) \\ -\gamma^2 s^*N^*((1-s)N+(1-s^*)N^*)](\theta_B^e+bs) \end{array}\right]}{\Delta}
$$

[5]The expressions for the foreign country are the same with asterisked and non-asterisked variables interchanged.

where $\Delta = \beta^2(\beta^2(sN+s^*N^*+1)((1-s)N+(1-s^*)N^*+1)-\gamma^2(sN+s^*N^*)((1-s)N+(1-s^*)N^*))$; $\theta_A^d = (\alpha_A - c_A)$; $\theta_A^e = (\alpha_A^* - c_A - t_A)$; $\theta_B^d = (\alpha_B - c_B)$; $\theta_B^e = (\alpha_B^* - c_B - t_B)$; $\theta_A^{*d} = (\alpha_A^* - c_A^*)$; $\theta_A^{*e} = (\alpha_A - c_A^* - t_A^*)$; $\theta_B^{*d} = (\alpha_B^* - c_B^*)$; and $\theta_B^{*e} = (\alpha_B - c_B^* - t_B^*)$.

The short-run equilibrium profit for firm A and firm B in the home country are $\pi_A = \beta(x_A^d)^2 + \beta(x_A^e)^2$ and $\pi_B = \beta(x_B^d)^2 + \beta(x_B^e)^2$, respectively. The evolutionary equilibrium is governed by the signs of profit differences $\pi_D = \pi_B - \pi_A$ in the home country and $\pi_D^* = \pi_B^* - \pi_A^*$ in the foreign country.

4 The Evolutionary Equilibrium

The short-run equilibrium is not necessarily the stable steady-state. When the state is not stable, it will evolve to the evolutionary equilibria in the long run. The different sets of the parameter values determine the evolutionary equilibria. Since the 1990s, the expansion of the Japanese economy has slowed, and the demand is shrinking due to the stock adjustment, the tightening monetary policy, and the Gulf crisis. Moreover, the structural adjustment has taken place as well. The characteristics of Japan's business groups such as lifetime employment, main banks, the just-in-time system, and cross-shareholders are challenged, and the network effects are weakening over the last decade. This section focuses on finding the evolutionary equilibria regarding the macroeconomic changes.

4.1 Autarky

Based on the parametric model derived in Section 3.2, we simulate the choices of organizational modes of firms when the demand is shrinking and the network effects are weakening in the absence of trade.

4.1.1 The Change of Network Effects

The greater the network effects, the lower unit costs the B mode firms have with the prevalence of B firms. We start the analysis with very strong network effects in Figure 1. With very strong network effects ($b = 15$ in Figure 1), B firms have higher profits when there are more than fraction s^1 of firms choosing B mode as their organizational mode.[6] As the network effects weaken, for example, $b = 12.5$ in Figure 2, $b = 10$ in Figure 3, and $b = 7.5$ in Figure 4, B firms have higher profits when there are more than fraction s^2, s^3, and s^4 of firms choosing B mode, respectively. We can easily find that $s^1 > s^2 > s^3 > s^4 = 0$ in Figure 1 to Figure 4. The basins of attraction of the evolutionary equilibrium $s = 1$ are smaller with the weaker network effects, which imply that B mode is less likely to prevail in the long run when the network effects are weak. Moreover, the co-existence of A mode and B mode are not observed whether the network effects are strong or weak in these four cases.

Proposition 1 *In a closed economy, ceteris paribus, the weaker network effects lead to smaller basins of attraction of the evolutionary equilibrium $s = 1$, but not necessarily lead to an interior evolutionary equilibrium, i.e., $s = \widehat{s} \in (0, 1)$.*

4.1.2 The Change of Demand

Figure 5 to Figure 8 investigate the cases of *ceteris paribus* decrease in the parameter characterizing the demand from $\alpha_A = \alpha_B = 150$ to $\alpha_A = \alpha_B = 135$. The results indicate that when the demand of the imperfect substitute goods A and goods B shrink together, the evolutionary equilibria will not be affected. In our cases, the evolutionary equilibria are $s = 0$ and $s = 1$, i.e., the firms will all adopt either A mode or B mode in the long run regardless of the change in demand.

Proposition 2 *In a closed economy, the change in demand does not have any significant effect on the evolutionary equilibrium.*

4.2 Trade

We previously showed that neither the network effects nor demand necessarily lead to the co-existence of A and B modes in autarky. These effects are further

[6] The set of $s \in (s^1, 1]$ is the basin of attraction of the evolutionary equilibrium $s = 1$.

discussed in the environment of two countries with trade in this section.

4.2.1 The Change of Network Effects

Figure 9 to Figure 12 demonstrate different sets of the choice of organizational modes based on different magnitudes of network effects. Figure 9 to Figure 12 show the cases in which the US starts with the weak network effects and Japan starts with the strong network effects, and the *ceteris paribus* decrease in the values of parameter b^* which characterize the network effects in Japan.

The zero-profit differential loci $\pi_D = 0$ and $\pi_D^* = 0$ are plotted in $s - s^*$ space and divide the square into four regions. Define Regime A (Regime B) as the set of points in the square $[0,1]^2$ strictly northeast (southwest) of $\pi_D = 0$ and northwest of $\pi_D^* = 0$, and define Regime C (Regime D) as the set of points in the square $[0,1]^2$ strictly southwest (northeast) of $\pi_D = 0$ and southeast of $\pi_D^* = 0$ in Figure 9 and Figure 10. Define Regime A (Regime B) as the set of points in the square $[0,1]^2$ strictly northeast (southwest) of $\pi_D = 0$ and southwest of $\pi_D^* = 0$, and define Regime C (Regime D) as the set of points in the square $[0,1]^2$ strictly southwest (northeast) of $\pi_D = 0$ and northeast of $\pi_D^* = 0$ in Figure 11 and Figure 12.

Two evolutionary equilibria $(s, s^*) = (0, 1)$ and $(s, s^*) = (\overline{s}, 0)$ can be observed in Figure 9 to Figure 11 ($(s, s^*) = (0, \overline{s^*})$ and $(s, s^*) = (\overline{s}, 0)$ in Figure 12). The sets of points in Regime A are the basins of attraction of the evolutionary equilibrium $(s, s^*) = (0, 1)$ and $(s, s^*) = (0, \overline{s^*})$ in Figure 9 to Figure 11 and Figure 12, respectively. The set of points in Regime C is the basin of attraction of the evolutionary equilibrium $(s, s^*) = (\overline{s}, 0)$ in Figure 9 to Figure 12. The basin of attraction of the evolutionary equilibrium $(s, s^*) = (0, 1)$ are smaller with weaker network effects. Since the areas of Regime C are very small in these four cases, it is reasonable to ignore the evolutionary equilibrium$(s, s^*) = (\overline{s}, 0)$. For the same reason, the evolutionary equilibrium $(s, s^*) = (0, \overline{s^*})$ is not discussed, either. We will only focus on the corner equilibrium $(s, s^*) = (0, 1)$. The basins of attraction for the corner equilibrium shrink with the weaker network effects and ultimately disappear in Figure 12. In other words, the equilibrium that all firms in the US specialized in A modes and all firms in Japan specialized in B modes is destabilized with the weaker network effects. Moreover, the new evolutionary equilibrium $(s, s^*) = (0, \overline{s^*})$ which displaces the corner equilibrium does not have large enough basins of attractions to make any conclusive predictions.

Proposition 3 *The corner equilibrium of A mode dominating in the US and B mode dominating in Japan is destabilized with the weaker network effects in Japan.*

4.2.2 The Change of Demand

Let us consider a *ceteris paribus* expansion of demand in the US, and investigate the impacts on the evolutionary equilibria. Beginning with the same demand ($\alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150$) in both the US and Japan, the two evolutionary equilibria are $(s, s^*) = (0, 1)$ and $(s, s^*) = (\overline{s}, 0)$ in Figure 13. We then consider the *ceteris paribus* expansion of demand in the US.

Figure 13 to Figure 16 show that the locations of zero profit differential loci $\pi_D = 0$ and $\pi_D^* = 0$ only have tiny differences in the $s - s^*$ space when the demand changes. Therefore, the expansion of demand in the US does not have any significant effect on the evolutionary equilibria, and the basins of attraction with respect to the equilibria.

Proposition 4 *A ceteris paribus expansion of demand in the US will not have any significant effect on the evolutionary equilibria.*

4.2.3 The Opening of Input Markets

With the emergence of e-commerce and FDI, the input markets in the US and Japan are not as isolated as before. With the trade in outputs and inputs, the impacts of trade involve transitional network effects and glut effects. The cost externality in the home country of B firms can be expressed as $b(\frac{Ns+yN^*s^*}{N+yN^*})$. The value $y=0$ means no trade in inputs, and the value $y=1$ means free trade in inputs. The expression for the foreign country is the same with asterisked and non-asterisked variables interchanged, and uses the same value y.

When the input markets are isolated from each other ($y=0$), the evolutionary equilibria are $(s,s^*)=(0,1)$ and $(s,s^*)=(\overline{s},0)$ in Figure 17. When trade barriers in the input markets are lower and the value of y increases to 0.1, 0.2, and 0.3 in Figure 18, Figure 19, and Figure 20, respectively, the basins of attraction of the corner equilibrium $(s,s^*)=(0,1)$ (Regime A) are smaller with the opening of input markets, but do not have very significant changes.[7] The opening of the input markets do not have significant effects on the determination of the evolutionary equilibria when there still exists high barriers in the input markets.

Proposition 5 *When there are high trade barriers in the input markets, the opening of input markets does not have any significant effect on the evolutionary equilibria.*

4.3 The Case of the US and Japan

At the beginning of the adjustment process in the 1990s, the network effects were strong in Japan and weak in the US. The bank reform, the adjustment in lifetime employment, and the emergence of e-commerce are decreasing the network effects in Japan. Moreover, the demand in the US has expanded and the trade barriers in the input markets have been lower during this period. All these factors have been discussed separately in the previous sections. We now consider the changes of these factors simultaneously.

We roughly define time period 1 as 1989-1991, period 2 as 1992-1994, period 3 as 1995-1997, and period 4 as 1998-2000. Figure 21 characterizes the economies in period 1, in which the network effects are very strong in Japan and very weak in

[7]The discussion of the equilibrium $(s,s^*)=(\overline{s},0)$ is omitted due to the small basins of attraction.

the US, the input markets are not open, and the demand is hypothesized as equal in both countries. Two evolutionary equilibria $(s, s^*) = (0, 1)$ and $(s, s^*) = (\overline{s}, 0)$ are observed. Since the basins of attraction of the equilibrium $(s, s^*) = (\overline{s}, 0)$ are very small, this equilibrium can be reasonably ignored. Therefore, all firms in the US adopting A modes, and all firms in Japan adopting B modes are observed in period 1.

Figure 22 characterizes the economies in period 2. Compared with period 1, the network effects are weaker in both the US and Japan, the demand in the US is expanded, and the trade barriers in the input markets are lower. The evolutionary equilibria are still the same as in the last period; however, the basins of attraction of equilibrium $(s, s^*) = (0, 1)$ are smaller.

Following the trend of the change of parameter set, the basins of attraction of equilibrium $(s, s^*) = (0, 1)$ are very small in Figure 23. In Figure 24, the two evolutionary equilibria $(s, s^*) = (0, 1)$ and $(s, s^*) = (\overline{s}, 0)$ do not survive in the long run. The interior equilibrium $(s, s^*) = (\overline{s}, \overline{s^*})$ is the only equilibrium surviving in the long run, which implies that both A modes and B modes prevail in the US and Japan.

Proposition 6 *With a combination of weaker network effects in both countries, expansion of demand in the US, and the lower trade barriers in the labor and capital markets, neither system can dominate in the US and Japan. The co-existence of both modes in the US and Japan will be the only equilibrium in the long run.*

5 Concluding Remarks

The success of the *Keiretsu* has attracted a lot of interest since the 1980s. Many authors suggested that the *Keiretsu* system would displace the traditional western style of manufacturing. But now, the *Keiretsu* system has become a costly relationship. The structure of *Keiretsu* is being forced to change, but the restructuring process is slower than it should be.

This paper discusses how the economic factors influence the choices of the organizational modes. Based on the simulation results, none of the changes in the weaker network effects, the expansion of demand in the US, and lower trade barriers in the input markets alone can lead to an evolutionary equilibrium with large basins of attraction. The 1980s equilibrium, in which the *Keiretsu* system dominates in Japan and the traditional western system dominates in the US is still the equilibrium with large basins of attraction when the changes of economic environment happen separately. Because none of these single factors alone can determine the system, this explains why the restructuring process is slow.

When these changes happen simultaneously, this model predicts an interior equilibrium, i.e., the co-existence of the *Keiretsu* system and the tradition system in both countries. Only with a combination of weaker network effects, expansion of demand in the US, and lower trade barriers in the input markets, the 1980s equilibrium is destabilized and the interior equilibrium is observed.

Appendix

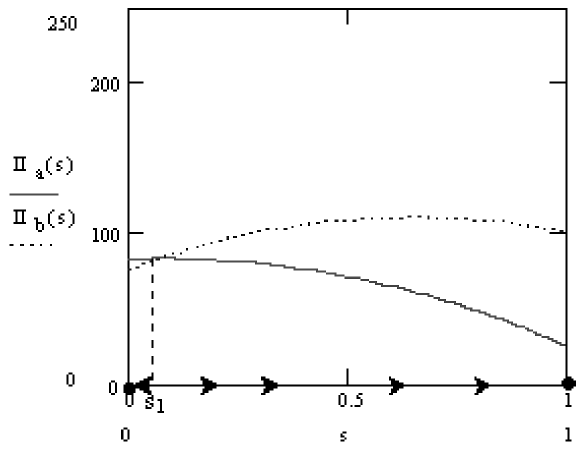

Figure 1: The Change of Network Effects in Autarky

$b = 15; (N = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = 150, c_A = 50, \theta_B = 55)$

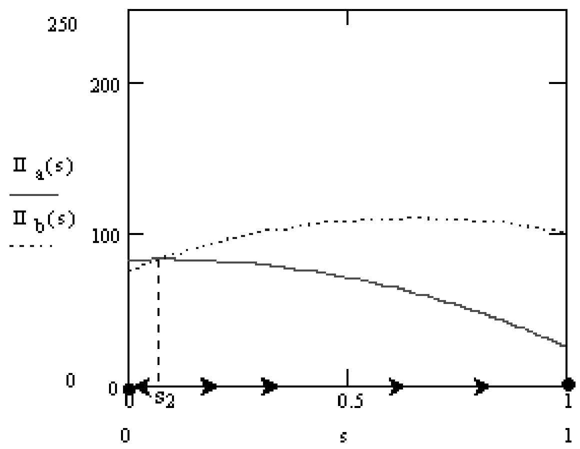

Figure 2: The Change of Network Effects in Autarky

$b = 12.5; (N = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = 150, c_A = 50, \theta_B = 55)$

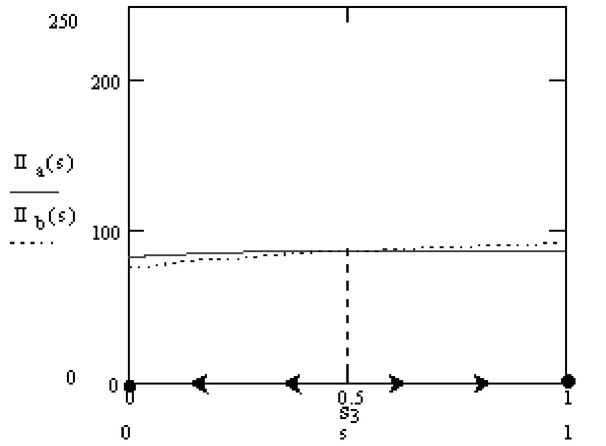

Figure 3: The Change of Network Effects in Autarky

$b = 10; (N = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = 150, c_A = 50, \theta_B = 55)$

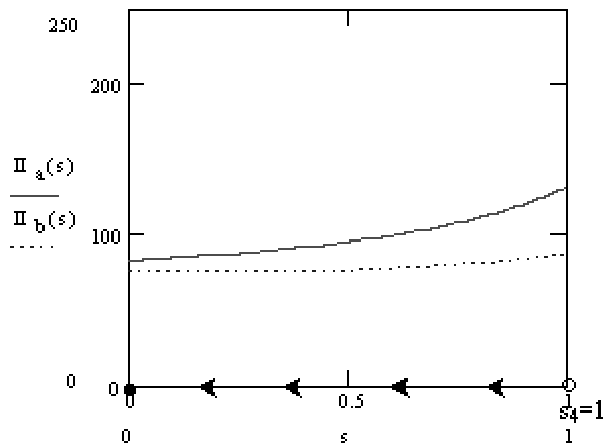

Figure 4: The Change of Network Effects in Autarky

$b = 7.5; (N = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = 150, c_A = 50, \theta_B = 55)$

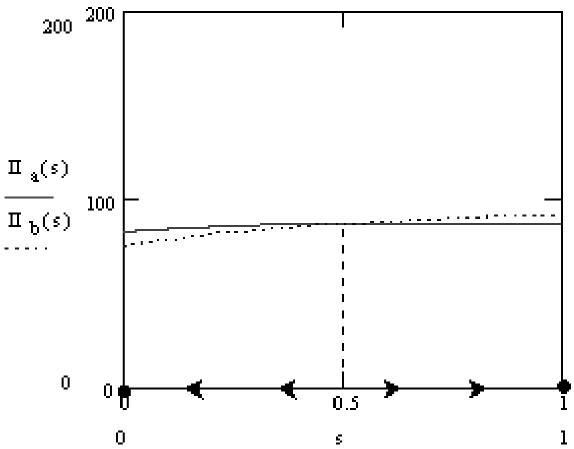

Figure 5: The Change of Demand in Autarky

$\alpha_A = \alpha_B = 150; (N = 10, \beta = 1, \gamma = 0.95, c_A = 50, \theta_B = 55, b = 10)$

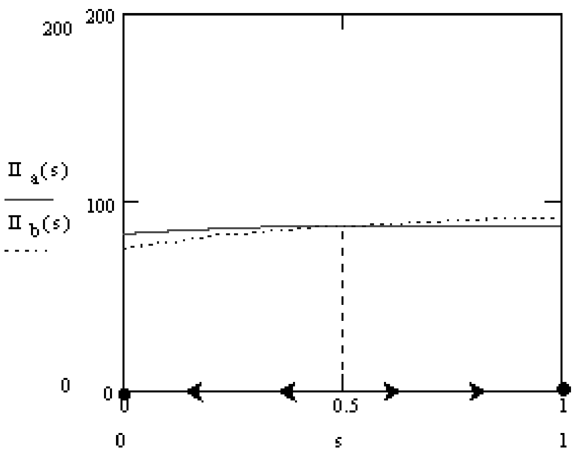

Figure 6: The Change of Demand in Autarky

$\alpha_A = \alpha_B = 145; (N = 10, \beta = 1, \gamma = 0.95, c_A = 50, \theta_B = 55, b = 10)$

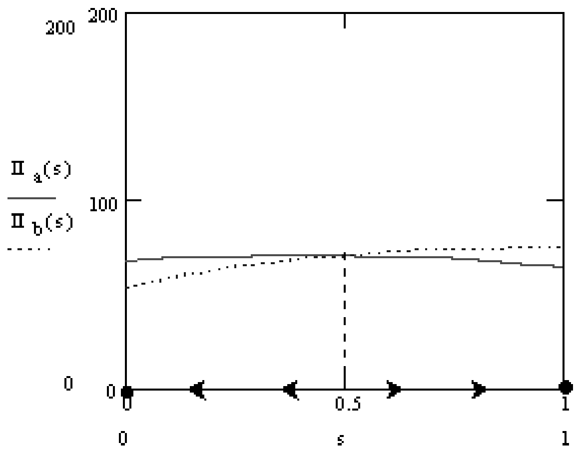

Figure 7: The Change of Demand in Autarky

$\alpha_A = \alpha_B = 140; (N = 10, \beta = 1, \gamma = 0.95, c_A = 50, \theta_B = 55, b = 10)$

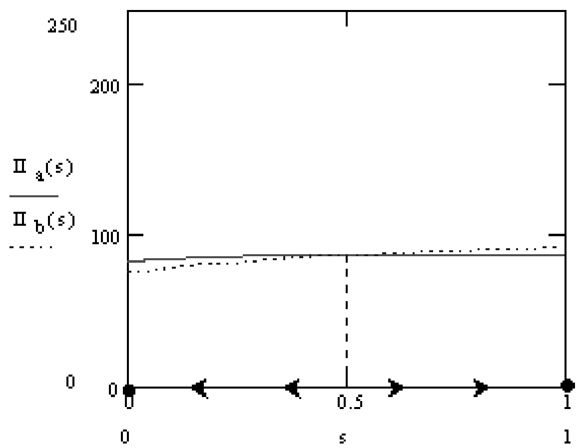

Figure 8: The Change of Demand in Autarky

$\alpha_A = \alpha_B = 135; (N = 10, \beta = 1, \gamma = 0.95, c_A = 50, \theta_B = 55, b = 10)$

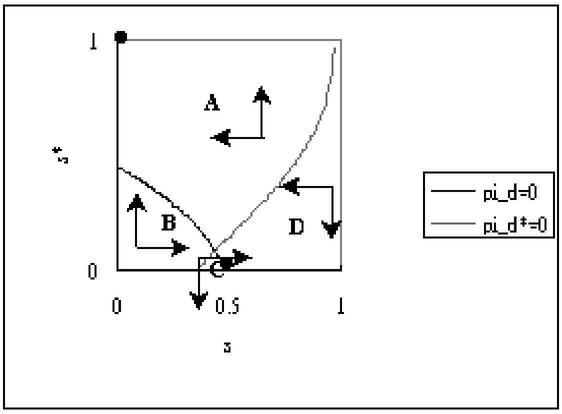

Figure 9: The Change of Network Effects with Trade

$b = 2, b^* = 7; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

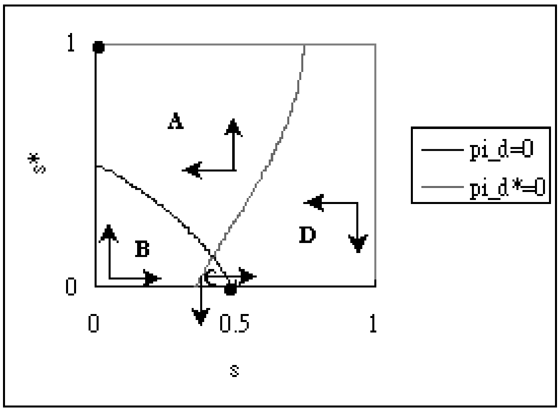

Figure 10: The Change of Network Effects with Trade

$b = 2, b^* = 5; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

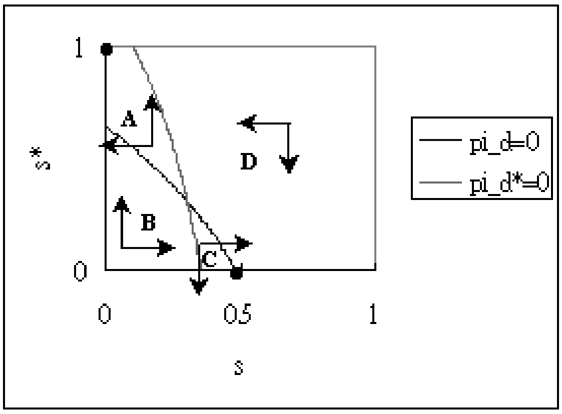

Figure 11: The Change of Network Effecs with Trade
$b = 2, b^* = 2; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

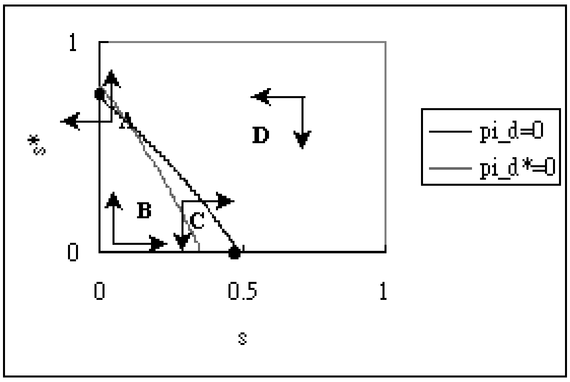

Figure 12: The Change of Network Effects with Trade
$b = 2, b^* = 1; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

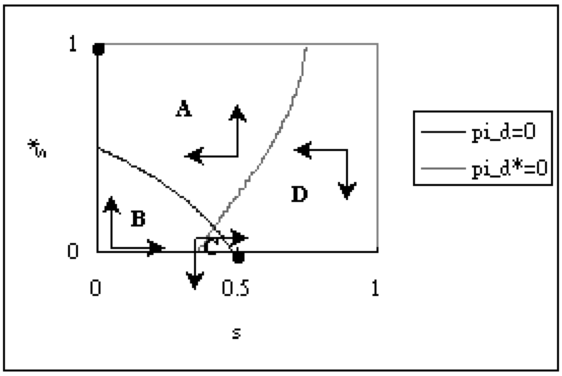

Figure 13: The Change of Demand with Trade
$\alpha_A = \alpha_B = 150, \alpha_A^* = \alpha_B^* = 150; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 5,, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

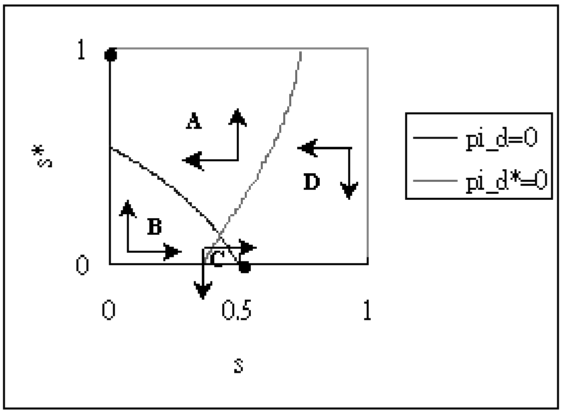

Figure 14: The Change of Demand with Trade
$\alpha_A = \alpha_B = 160, \alpha_A^* = \alpha_B^* = 150; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 5,, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

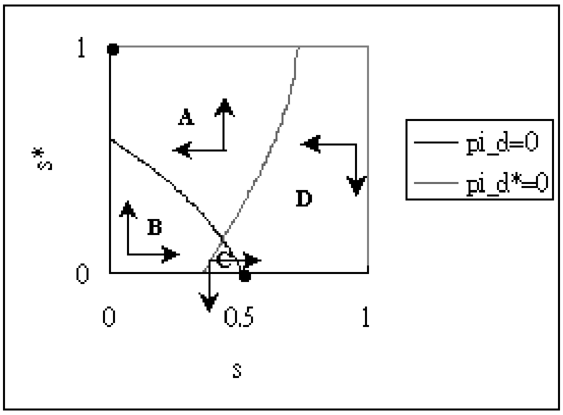

Figure 15: The Change of Demand with Trade
$\alpha_A = \alpha_B = 170, \alpha_A^* = \alpha_B^* = 150; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 5, , c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

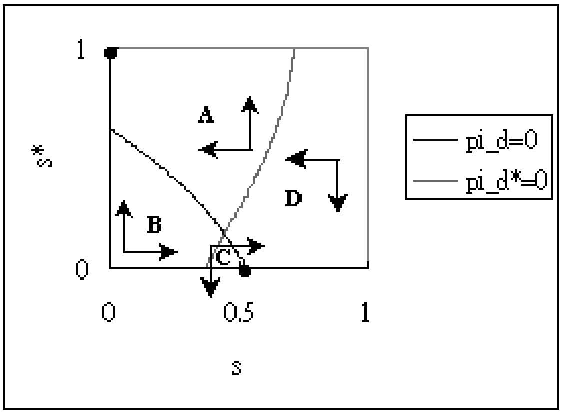

Figure 16: The Change of Demand with Trade
$\alpha_A = \alpha_B = 180, \alpha_A^* = \alpha_B^* = 150; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 5, , c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

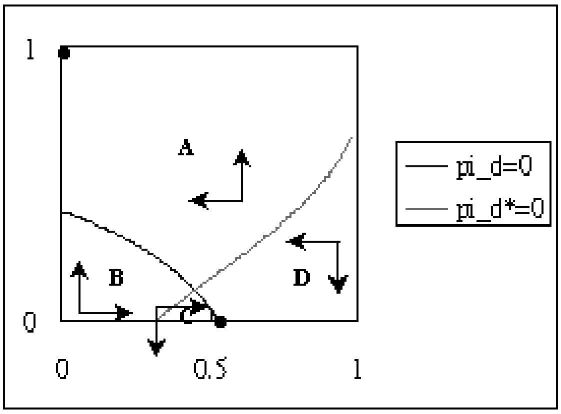

Figure 17: The Opening of Input Markets

$y = 0; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 8, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 0)$

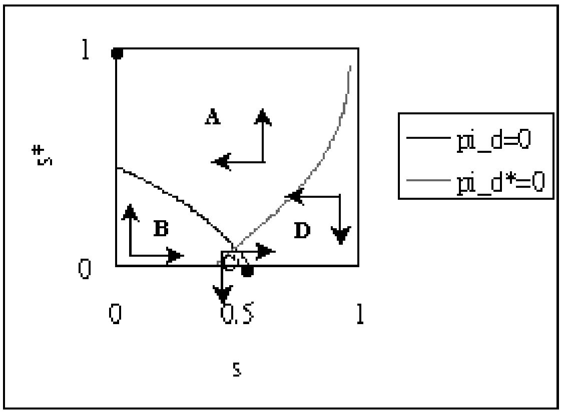

Figure 18: The Opening of Input Markets

$y = 0.1; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 8, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 0)$

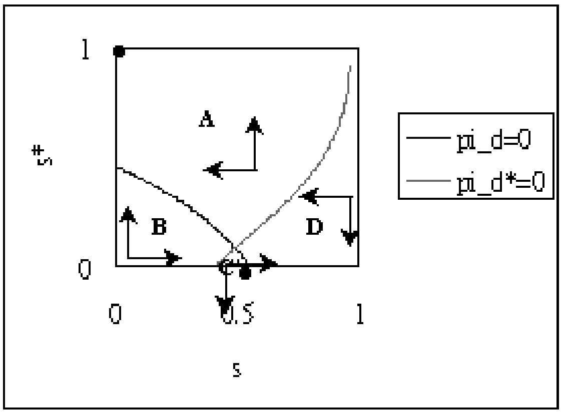

Figure 19: The Opening of Input Markets

$y = 0.2; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 8, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 0)$

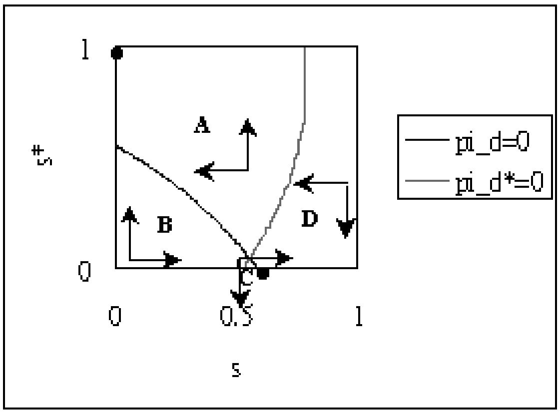

Figure 20: The Opening of Input Markets

$y = 0.3; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, b = 2, b^* = 8, \alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 0)$

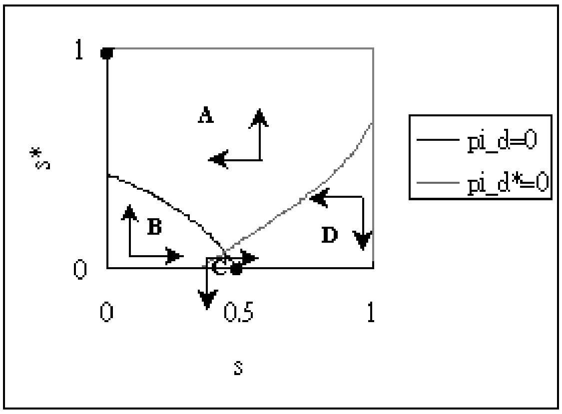

Figure 21: The Case of the US and Japan

$\alpha_A = \alpha_B = \alpha_A^* = \alpha_B^* = 150, b = 2, b^* = 8, y = 0; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

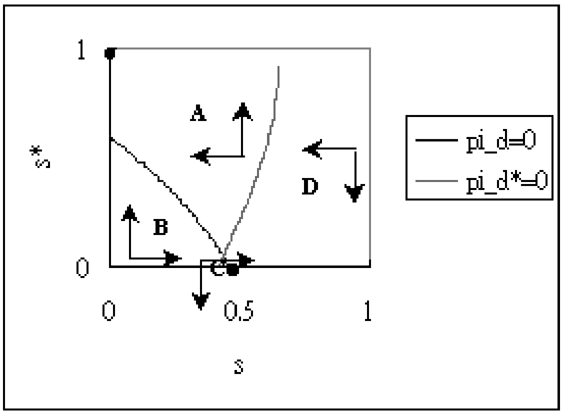

Figure 22: The Case of the US and Japan

$\alpha_A = \alpha_B = 160, \alpha_A^* = \alpha_B^* = 150, b = 1.5, b^* = 5, y = 0.07; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

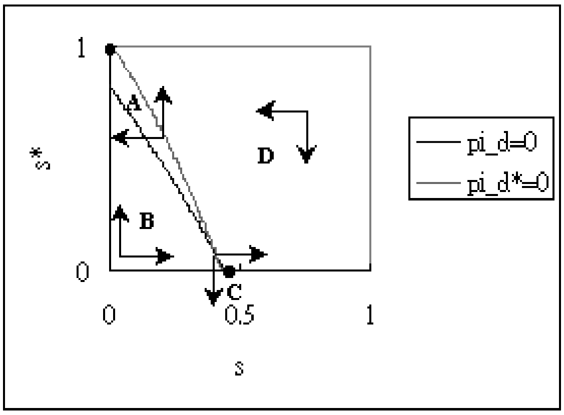

Figure 23: The Case of the US and Japan

$\alpha_A = \alpha_B = 170, \alpha_A^* = \alpha_B^* = 150, b = 1, b^* = 2, y = 0.15; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

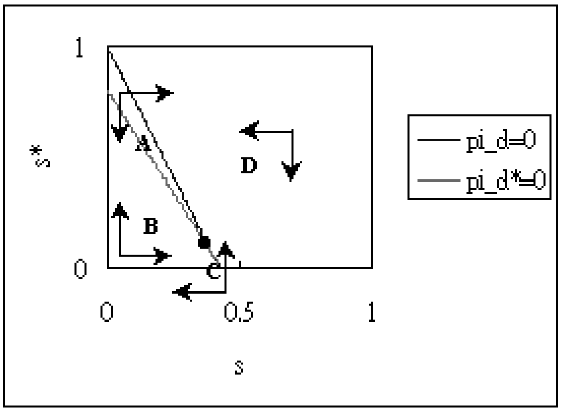

Figure 24: The Case of the US and Japan

$\alpha_A = \alpha_B = 180, \alpha_A^* = \alpha_B^* = 150, b = 0.5, b^* = 0.6, y = 0.2; (N = 20, N^* = 10, \beta = 1, \gamma = 0.95, c_A = c_A^* = 50, c_B = c_B^* = 52.5, t_A = t_B = t_A^* = t_B^* = 2.5)$

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