

**Is Japanese Manufacturing Style (so-called *Monozukuri*) really robust?
- Causal Loop Diagram and Modeling Analysis -**

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Abstract: This paper tries to analyze the structure of Japanese manufacturing style (herein after called *Monozukuri*), by applying causal loop diagram method of systems thinking. Three layers of positive feedback loops that strengthen *Monozukuri* are identified: (1) professional spirits on *Monozukuri* at an individual level, (2) trust-based style of management at a corporate level and (3) trust-based transactions on R&D and parts-supplier-network (*Keiretsu*) at an inter-corporate level. However, these strong features are shown to be easily turned into weak ones. This paper identifies five exogenous factors that turn the strength into weakness: (1) monetary incentives, (2) pressure from another management policy, (3) pressure from another transaction policy, (4) technological standardizations, and (5) foreign competitive efforts. Effects of factors (1) (2) (3) are analyzed as a whole represented by management mode and (4) are analyzed in detail. Then, social feedback loop is brought to the model to re-reverse these weakening trends. It is posed that the trust-based management based on *Monozukuri* together with social feedback is superior to the contract-based management in the long run.

Keywords: causal loop, manufacturing, capability, quality, *Monozukuri*, *Kaizen*, *Keiretsu*

1. Introduction

*Monozukuri*¹ (Japanese Manufacturing Style) is said to be one of the specialties of Japan as Ezra F. Vogel pointed out in his "Japan as Number One. (Vogel, E [1979]) In his study of Japan, Ezra F. Vogel concluded that the Japanese strong point lies in pursuing knowledge as a group. Steven K. Vogel, Ezra's son, proposed the Japan model as an interacting one between a micro system at a corporate level and a macro system at a national level. (Vogel,S[2006]). Taiichi Ono proposed Just in Time (JIT) system as a production system.(Ono[1978]). Many researchers have been studying the strong points of Toyota Motors. One of these is Mutoh's research which points out that the company's strengths lies in the product design system among the car manufacturer, the parts suppliers and the mold manufacturers based on IT infrastructure, and persevering improvement.(Mutoh[2005]). MIT Industry Productivity Committee concluded that the source of the strong point of Japanese industry consists in Japanese style management on HRM (Human Resource Management) such as in-house training, and inter-enterprise collaborative system and dynamic network such as the relationship between assembly manufacturers and parts suppliers.(Dertouzous [1989]). Takahiro Fujimoto proposes a concept of three-layer organizational capability; that is, integration, improvement and evolution, and concludes that the strong point of *Monozukuri* is derived from a tight relationship between the organizational capability² and product architecture.(Fujimoto[2004]) Kakuro Amasaka and his team propose a new concept "New *Monozukuri* Theory - Beyond JIT-" (Amasaka[2008]). J.N.Baron et al identify a feature of "High commitment HRM" as a Japanese style of HRM that can be applied to the quality-sensitive jobs which needs continuous improvement in spite of its feature of high cost.(Baron [1999]). Nobuo Takahashi explained a Japanese style of HR development as "By rewording with the next job". In other words, an intrinsic motivation is mainly used in Japan as the HR development (Takahashi[2007]). Edward L.Deci identified two elements which improve intrinsic motivation, that is, autonomy and competence (Deci[1995]). In conclusion, several studies on *Monozukuri* have been done in the fields of social systems, enterprise systems, production systems, and psychology, but only S. Vogel discussed the interacting effects of these areas.

¹ *Monozukuri*: Fujimoto defines "*Monozukuri*" as the duplication of design data into a material (Fujimoto [2004]).

² Capability: Warren defines the capability as strategic resources to perform the business. Warren (Warren [2002]). Fujimoto defines three levels of capability as static capability, improvement capability and evolutionary capability (Fujimoto [2004]). In this paper, "capability" is used as being defined by Warren from a viewpoint of system dynamics. Yet, it also covers the above three levels of classification by Fujimoto.

2. Reexamination of *Monozukuri* Studies

With the application of causal loop diagram analysis in systems thinking, this paper tries to analyze a system structure that gives strength and weakness of *Monozukuri*. Before presenting our model, we have reexamined two previous studies to make our model more comprehensive.

2.1 The Report by JACE

Let us first examine the *Monozukuri* study presented in the report published by JACE (Japan Association Corporate Executives) (JACE [2008]). It analyzed the strength of *Monozukuri* from a viewpoint of Japanese top-management. Nine features are listed in the report as strong points of *Monozukuri*, out of which we have picked up several keywords and refined them to reconstruct their analysis with causal loop diagram (CLD). The results are shown in Table 1 and Figure 1.

Table 1 Features that create strong points of *Monozukuri* mentioned in JACE [2008]

Factors mentioned in the Report	Keywords for CLD
(1) Corporate culture that unites itself with partners: The sense of values that industry is a virtue has been rooted. It is going to unite with a customer demand thoroughly.	Capability for Adaptation to customer needs
(2) Management of long-term vision: Based on the confidential relation for steady employment.	Long-term management view
(3) No. 1 on-site power and group power of the world: teamwork by talented people who are comparatively homogeneous with higher education and finish things with particular efforts.	Organizational Capability
(4) Inter-organizational network: The existence of powerful Small and Medium Enterprises (SMEs): The <i>Monozukuri</i> network accumulation into Japan. It has superior technology and can respond flexibly.	Inter-organizational <i>Keiretsu</i> Collaboration
(5) Highly concentrated power for technical development: Highly integrated type of technical development	Technical Development Power
(6) No. 1 quality of the world: Quality supported by QC circle and TQM et al.	<i>Monozukuri</i> Quality
(7) Highly demanding Japanese market : The highest level of demand by end users and customers for quality, price and services et. al.	Requirement Level by Japanese market
(8) Enough <i>Monozukuri</i> human resources: Talented people suitable for <i>Monozukuri</i> with tenacity and cooperativeness.	<i>Monozukuri</i> Human Resources
(9) The personnel training system in a company	In-house training

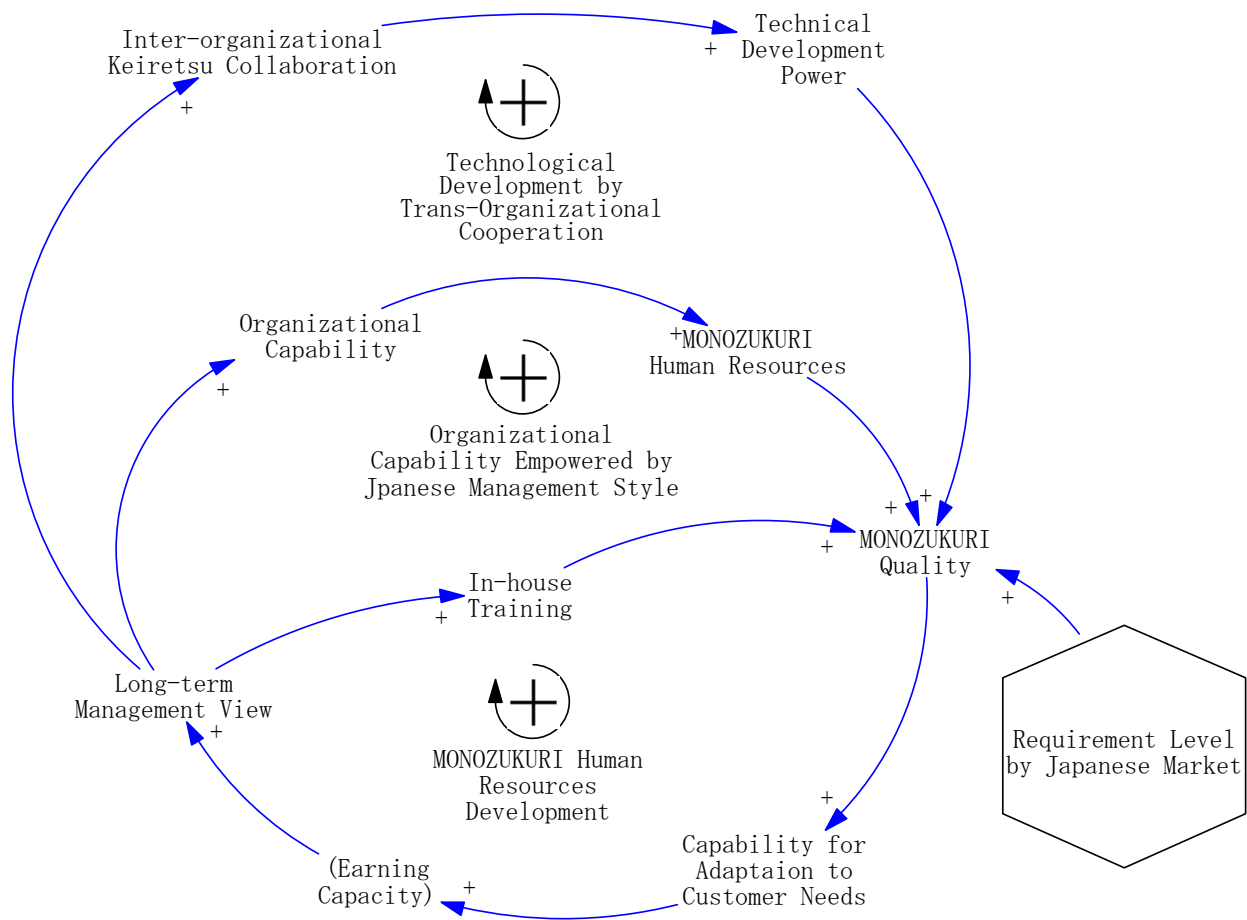


Figure 1 Causal Loop Diagram of Robustness in *Monozukuri*

This study captures the structure of *Monozukuri* from a viewpoint of Japanese executives with an emphasis on technological-innovations by the inter-organizational partnership. Yet, it seems to be missing a feedback loop by open-technological-innovations, which is by nature universal.

2.2 A Questionnaire by Toyota Group's Executives

Secondly let us examine the study derived from the questionnaire by Toyota Group's Executives. It is published by Amasaka (Amasaka [2008]). The questionnaire identified the following keywords as technologically essential issues for its *Monozukuri* management:

(1) intensive resource, (2) focusing issue, (3) technology for global ecology, (4) innovating organizational system, (5) proposal style of new products, (6) utilization of information, (7) establishing vision, (8) customer's voice, (9) development of marketing methodology, (10) next generational production system, (11) SCM/optimized procurement, (12) transferring technology and skill, (13) speed/efficiency, (14) collaborative development, (15) training, (16) apply for change, and (17) viewpoint of customer-first. We have drawn a causal loop diagram based on these keywords in

Figure 2, in which four reinforcing loops are identified, that is, (1) strengthening *Monozukuri* people power, (2) development of organizational capability, (3) strengthening technological development power and (4) strengthening technological production power.

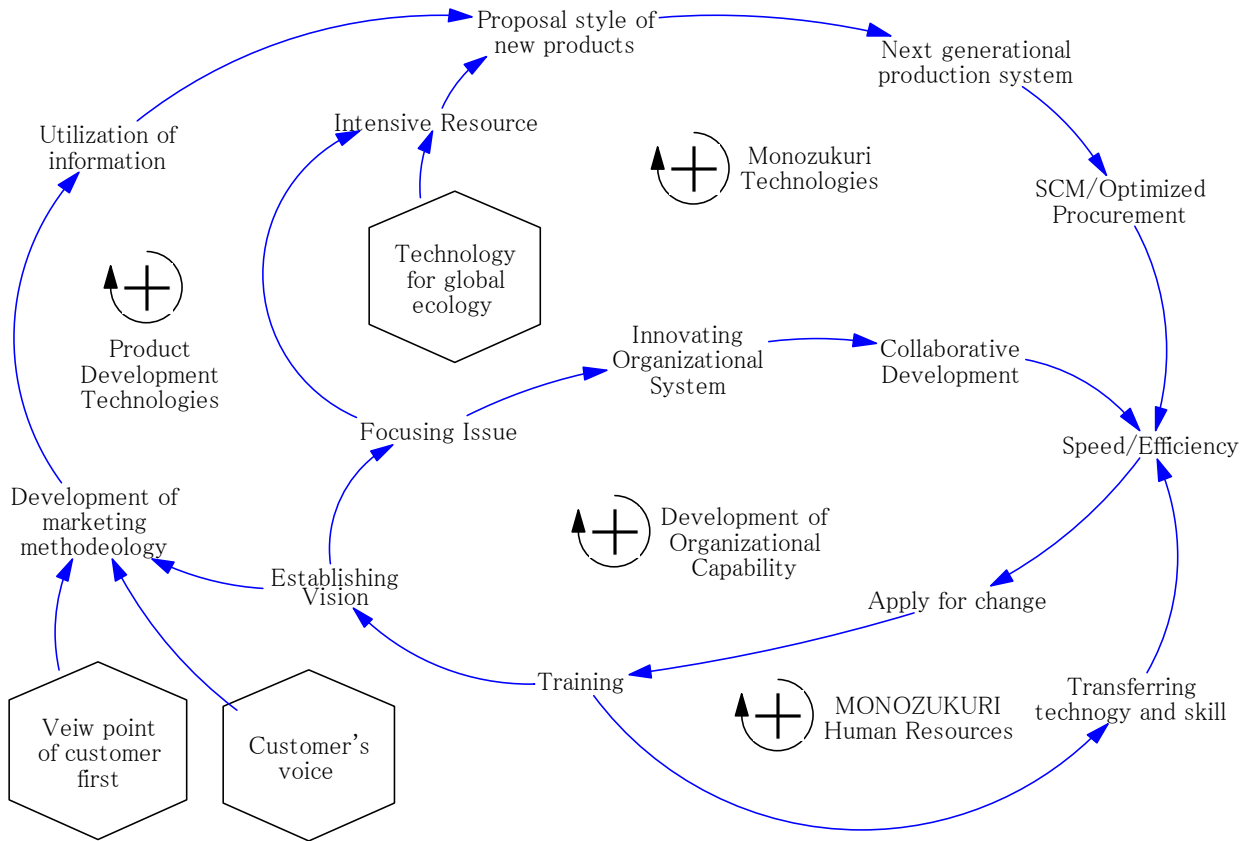


Figure 2 Causal Loop Diagram of Japanese strength in *Monozukuri*

This study well analyzes the structure of *Monozukuri* which has a tight relationship between technologies and operational capability. Yet, it seems to be missing a feedback loop by the inter-organizational cooperation, because the loop may be too self-evident for Toyota group to recognize as an essential subject.

3. Development of the Causal Loop Diagram of *Monozukuri* System

Having reexamined the above two studies, we have expanded our investigation further to identify essential keywords for developing our own model of the *Monozukuri* system. Specifically, using the reference sources such as the white papers published by METI (Ministry of Economy, Trade and Industry). (METI [2006], METI [2007], METI [2008]), and the literature mentioned in the introduction, we have identified keywords for the *Monozukuri* model as listed in Table 2. Let us explain them by illustrating reinforcing feedback loops one by one below.

Table 2 Keywords in the *Monozukuri* System

Keywords	Description
<i>Monozukuri</i> Quality	Individual skills, organizational capability and inter-organizational capability that produce good characteristics and features for the production of goods and services, and lead to customer satisfaction.
Care for Quality	Mental state of feeling and desire for pursuing high quality in a development design and manufacturing.
Profitability	Earning capability of manufacturing industries relative to those in foreign countries.
Management Mode	An index variable of management policy which ranges between contract-based value of 0 in Europe and America, and trust-based value of 1 in Japan.
Lifetime Employment	Human resource management of high commitment to employment
Motivation	Mental attitude in <i>Monozukuri</i> spirits that is cultivated through in-house training and corporate culture.
<i>Kaizen</i> -based Activities	An execution-level of continuous improvement activities for increasing capabilities as a team.
Inter-Personal Feedback Level	Team capability for performing development, design and production of products toward high level <i>Monozukuri</i> quality.
Commercial Transaction Mode	An index variable of transaction policy which ranges between market-based value of 0, and trust-based value of 1
<i>Keiretsu</i> -based Feedback Level	Inter-organizational capability to pursue <i>Monozukuri</i> quality in designing and manufacturing products
R&D	Investment for technology related to <i>Monozukuri</i>
Cost	Cost incurred from development, design and production.

3.1 A Strengthening Loop at an Individual Level

Figure 3 illustrates a reinforcing loop, built by using the keywords in Table 2, that strengthens *Monozukuri* at an individual level. "Care for Quality" is an important stock for understanding this CLD. It is a mental state of feeling for pursuing high quality in a process of product development, design and manufacturing. Its level determines a total capability of "*Monozukuri* quality", together with other levels that are related to organizations and networks of organizations. It is an integrated capability level that creates good characteristics and features for producing goods and services, and leads to customer satisfaction. The higher the level is, the more the profitability will increase. Such a relation depends on the architecture of

products. That is, if a product has an integral architecture, the relation of profitability with *Monozukuri* quality becomes high, because an integral architecture needs more delicate activities for product development, design and production than a modular architecture. Profitability thus attained enables an operation of trust-based management which is as an value of management mode, even though it is more costly than that of contract-based management. By "trust-based management" we mean trust comes first and contract becomes secondary. Human resource management (HRM) under the trust-based management tends to use high-commitment HRM; lifetime employment is one of its typical practices of trust-based management in the mental model of employees. The organization operating under the high-commitment HRM or lifetime employment tries to cultivate mental attitude and spirits of *Monozukuri* among employees through the in-house training and corporate culture. The motivation becomes a cause of care for quality in the mental models of employees. This reinforcing loop is accompanied by a balancing loop, originating from the lifetime employment, due to its high-cost operation compared with the HRM under contract-based management.

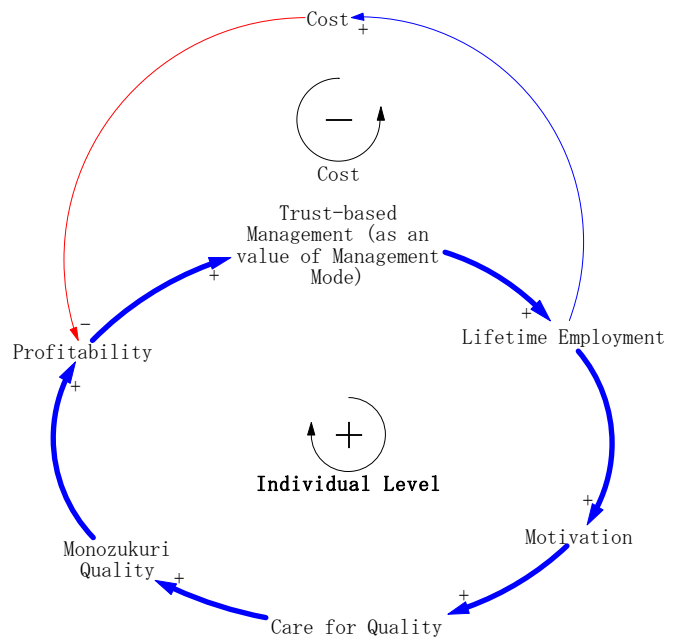


Figure 3 CLD of the Individual Level

3.2 A Strengthening Loop at an Organizational Level

Figure 4 illustrates an reinforcing loop, built by using the keywords in Table 2, that strengthens *Monozukuri* at an organizational level. "Inter-personal feedback level" is an important stock for understanding this CLD. It is a team capability to perform product development, design and production of products with a high level of *Monozukuri* quality. Its level determines the total capability of "Monozukuri quality", together with other levels related to individuals and networks of organizations.

The *Monozukuri* quality and profitability have a positive relationship in CLD, as well as profitability and trust-based management. Organizations that adopt trust-based management tend to invest resources to the process improvement activities, because managers think the *Kaizen*-based activities effectively achieve their business goal from bottom-up than the reform from top-down. The *Kaizen*-based activities in turn trend to build up the inter-personal feedback level. This loop also produces a balancing loop, originating from the *Kaizen*-based activities, due to its high cost operation. The *Kaizen* activity is a costly investment for productivity, because it does not contribute to the increase in outputs immediately. With time lag, it works for increasing the productivity in the long run.

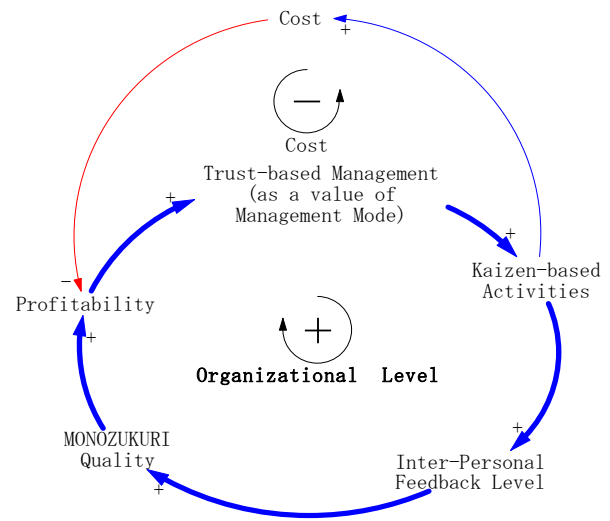


Figure 4 CLD of the Organizational Level

3.3 A Strengthening Loop at an Inter-Organizational Level

Figure 5 displays a reinforcing loop, constructed by using the keywords in Table 2, that strengthens *Monozukuri* at an inter-organizational level. "Keiretsu-based feedback level" is an important stock for understanding this CLD. It is an inter-organizational capability for performing product development, design and production of products with a high level of *Monozukuri* quality. Its capability is the same as the organizational one mentioned above, but the capability

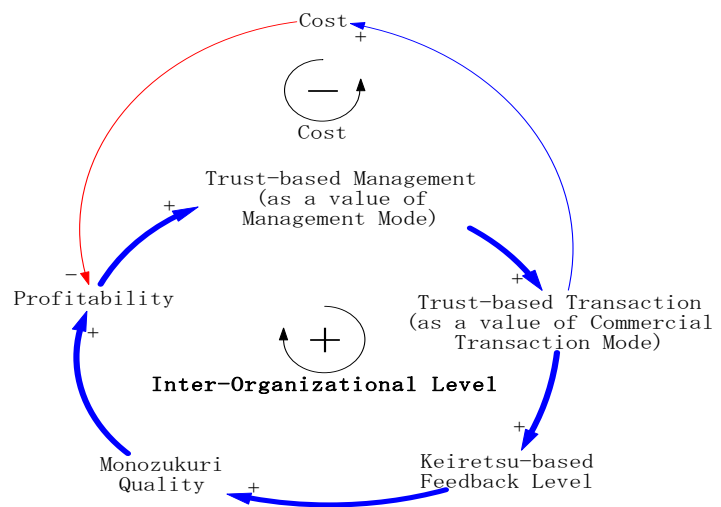


Figure 5 CLD of the Inter-Organizational Level

mentioned above is basically based on the business process within an organization. The capability here is based on a process through business transaction such as a subcontract in R&D and procurement in production. Its level determines the total capability of "*Monozukuri* quality", together with other levels related to individual and organization. The *Monozukuri* quality and profitability have a positive relationship in CLD, as well as profitability and trust-based management. Organizations that have adopted trust-based management tend to consider long-term business connections more important than market-based competitions such as prices. The trust-based transaction is a value of an index variable of transaction policy, which is named commercial transaction mode. The variable ranges between market-based value of 0, and trust-based value of 1. The trust-based transaction is more costly in short run than market-based transaction. But the accumulations of knowledge with their partners enable higher performance in relation with Quality, Cost and the time of Delivery (QCD)³ of products and services in the long run. That is to say, the trust-based management increases the trust-based transactions and promotes to build up *Keiretsu*-based feedback level. A balancing loop also originates from the trust-based transaction, because its operation becomes more costly in the shot run than the one under the market-based transaction.

3.4 A Strengthening Loop of Technological Innovation

Figure 6 illustrates a reinforcing loop, using the keywords in Table 2, that strengthens *Monozukuri* through technological innovation. "Profitability"⁴ is an important stock for understanding this CLD. It is an earning capability relative to the one in foreign countries. When profitability improves, the investment for R&D will also increase, and consequently technological innovation prospers, which in turn improves the *Monozukuri* quality. Technological innovation discontinuously brings bigger improvement to *Monozukuri* quality rather than the improvement by "care for quality", "inter-personal feedback level" and "*Keiretsu*-based feedback level". In this sense, it is a destructive innovation. (Christensen [2000]). Usually, it is quite

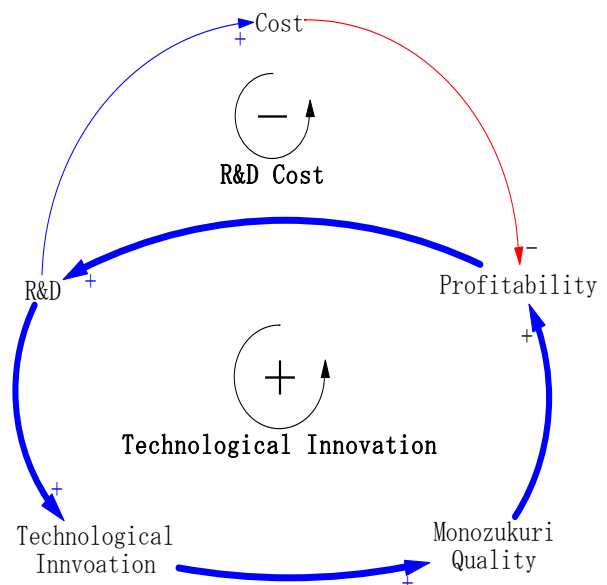


Figure 6 CLD of the Technological Innovation

³ In Japan the concept of QCD is quite often used among manufactures as an indicator for measuring performance in continuous improvement activity to meet their customer satisfaction.

⁴Profitability: MIT Industry Productivity Committee defined product performance for comparison of strength of an industry or a company among countries: productive performance. Productive performance is defined as a total index which not only shows the productivity traditionally used as labor productivity, but also quality, timely service, organizational flexibility, speed of technological innovations and strength of strategic technology. In this paper "Profitability" is defined in the sense of productive performance as a result of competition.

difficult for an organization to prepare as evolutionary capability that adopts to the destructive innovation. It seems that the technological innovation depends on "Capabilities not linked to resource building". (Warren [2002]). Further arguments may be required about this CLD. However, it is not the central issue in this paper, because the loop is not specific to *Monozukuri* but very universal.

The effect of this loop is thus quite neutral for the discussion of the competitiveness in Japan. A balancing loop here appears from the investment for R&D, because it is costly in short run.

3.5 A CLD of *Monozukuri* System

Figure7 illustrates our integrated causal loop diagram of *Monozukuri* system, consisting of four reinforcing loops discussed so far.

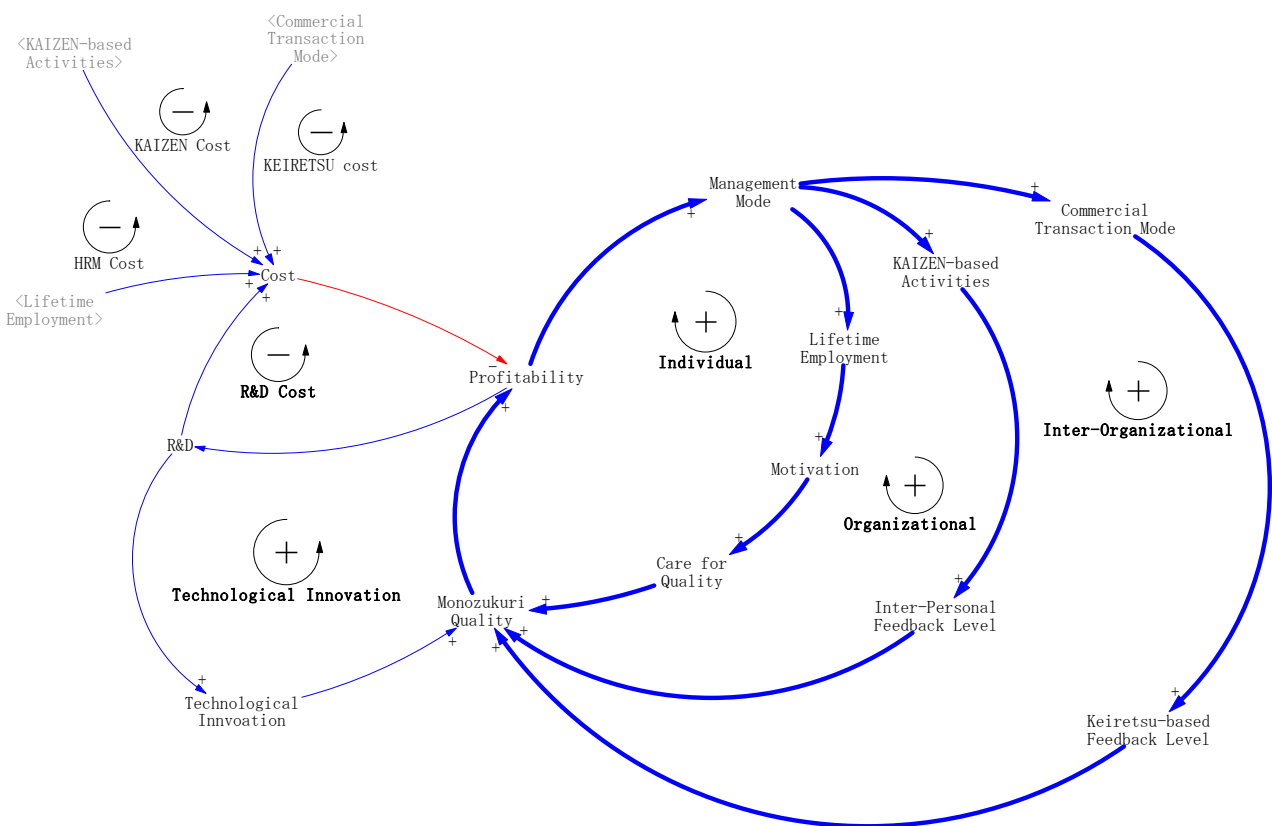


Figure 7 The Causal Loop Diagram of *Monozukuri* System (whole)

That is to say, (1) a strengthening loop at an individual level, (2) a strengthening loop at an organizational level, (3) a strengthening loop at an inter-organizational level, and (4) a strengthening loop through technological innovation. The diagram can be roughly separated by the arrow between "*Monozukuri* Quality" and "Profitability" into right-hand and left-hand portions. Right-hand portion describes problem-solving activities such as continuous improvement for pursuing *Monozukuri* quality by individuals, company and country. Left-hand portion indicates an activity that raises quality through destructive innovation.

3.6 Comprehensiveness of the *Monozukuri* Diagram

Let us compare our causal loop diagram developed here with the two previous studies discussed in section 2. The results of comparison are shown in table 3. The report by JACE lacks an analysis of the open-innovation. On the other hand the analysis of inter-organizational level is missing in the study of Toyota. In this sense, our analysis based on causal loop not only integrate them successfully, but also attains more comprehensive structure as an analysis of Japanese manufacturing system. This was made possible by the application of systems thinking.

Table 3 the Comparison of three CLD

Elements derived from the report by JACE	Elements derived from Amasaka(2008)	Elements identified as the <i>Monozukuri</i> system
(1) <i>Monozukuri</i> Human Resources Development	(1) Strengthening <i>Monozukuri</i> Human Resources	(1) Strengthening in Individual level
(2) Organizational Capability Empowered by Japanese Management Style	(2) Development of Organizational Capability	(2) Strengthening in Organizational level
(3) Technological Development by Inter-Organizational Cooperation		(3) Strengthening in Inter-Organizational level
	(3) Strengthening Product Development Technologies (4) Strengthening <i>Monozukuri</i> Technologies	(4) Strengthening by Open-Innovation

3.7 The *Monozukuri* System

The left-hand portion of Figure 7 illustrates three loops that are related with technological innovations. Yet, they do not specifically characterize the Japanese manufacturing style, and can be observed universally. Accordingly, we pose that the right-hand portion of the Figure 7 can only characterize the Japanese manufacturing style, or *Monozukuri*. Figure 8 illustrates the *Monozukuri* system, consisting of three-layer structure of the reinforcing loops; that is, (1) a loop of Individual Care for Quality, (2) a loop of Organizational Inter-Personal Feedback Level and (3) a loop of Inter-Organizational *Keiretsu*-based Feedback Level.

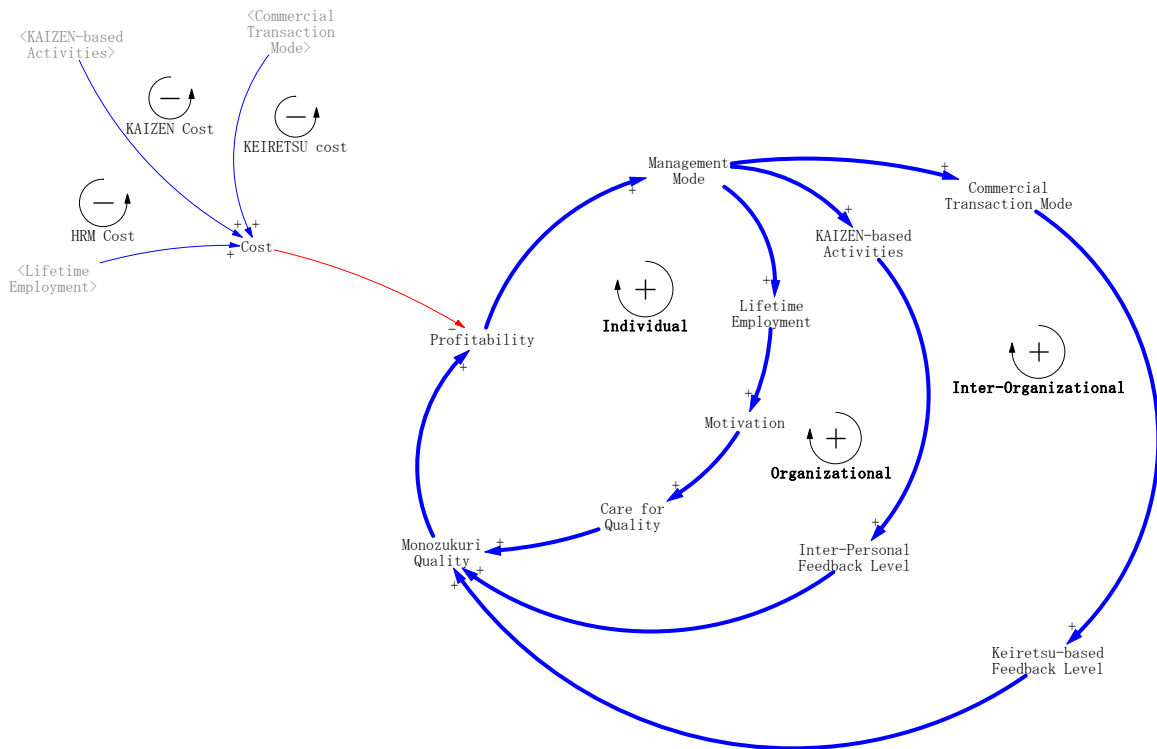


Figure 8 the *Monozukuri* System

3.8 Exogenous Variables of Reversing Behaviors

It is well known in system dynamics that a reinforcing loop is generally bi-directional, that is, it may drive a system into a positive (or increasing) direction, or into a negative (or decreasing) direction. How can it be reversed when it is driving the system into a growing direction? We have identified five factors that make the *Monozukuri* system reverse its growing direction into weakening direction.

They are indicated as five hexagon-shaped exogenous variables in Figure 9; that is, monetary incentive, pressure from other management policy, market pressure, technological standardization, and foreign country's competitive effort. Let us briefly discuss these exogenous factors one by one.

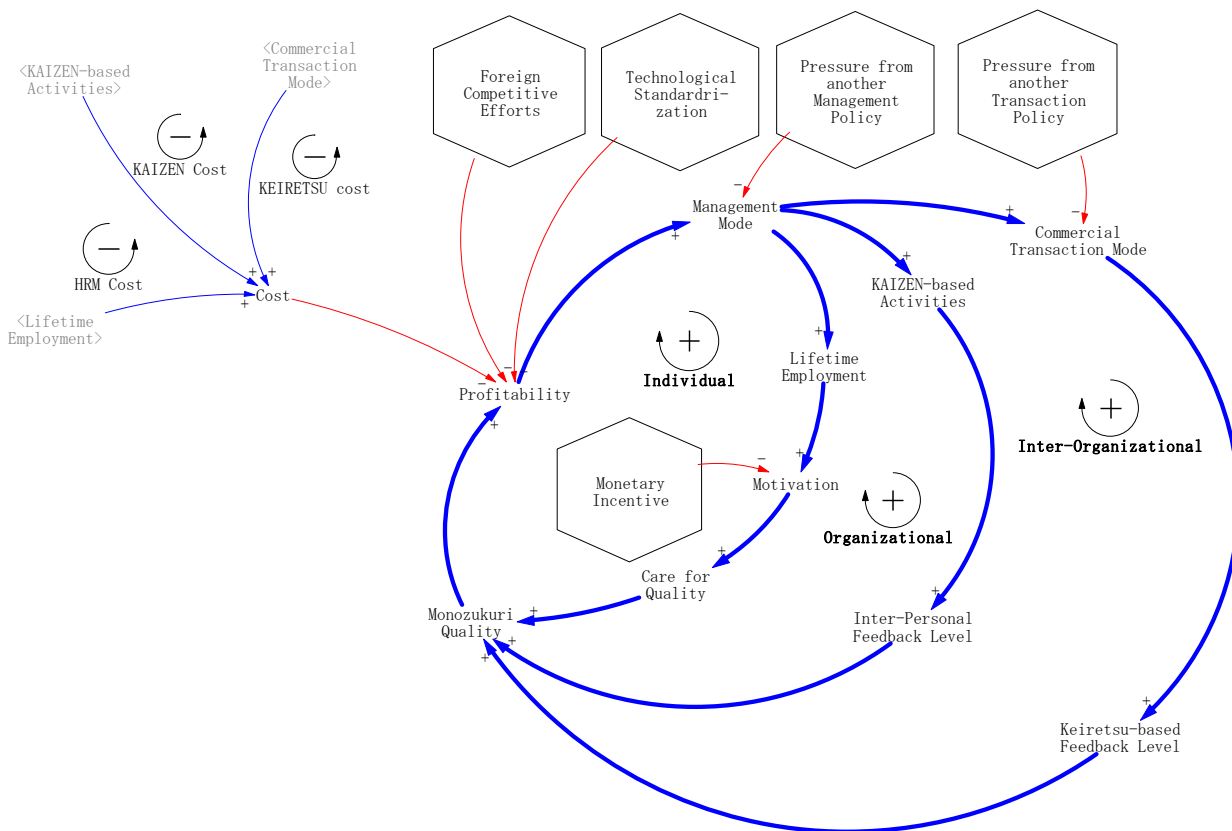


Figure 9 Exogenous Variables of Reversing Behaviors

3.8.1 Monetary Incentive

Japanese style of HR development is occasionally called "rewarding by the next job". It is based on "high-commitment HRM". (Baron [1999]). In other words, the intrinsic motivation is a driving force for Japanese HR development. It enforces "Care for Quality". Under the circumstances, a monetary incentive, when introduced, tends to weaken the intrinsic motivation, because monetary incentive is too strong to maintain the linkage between job performance and job satisfaction. (Takahashi [2007]).

3.8.2 Pressure from another Management Policy

Corporate management usually reflects opinions of various stakeholders. When a company, managing under trust-based management, is forced to change its management policy into contract-based management policy by stakeholders, its competitive power becomes weakened because coherence of its management is forced to be split into fragmented policies.

3.8.3 Pressure from Market-based Transaction

Japanese inter-organizational or highly integrated transaction known as *Keiretsu* transactions has been criticized by foreign countries that support market-based transaction⁵. Market-based transaction has a merit of reducing costs in the short run. When introduced, however, it may weaken a competitive power of *Monozukuri* system in the long run due to a rise in transaction cost, an increase in the product development lead time, and spoilage of products quality caused by a shortage of sharing knowledge among business partners.

3.8.4 Technological Standardization

By technological standardization we mean a common interface of industry-wide specification on a basis of modular architecture. Technological standardization is in a sense a "black box" in *Monozukuri*, out of which anyone can obtain production parts and assemble them to attain almost the same product quality. For example, a technological standardization named "AUTOSAR"⁶ is now progressing in the automotive industry. It provides modular architecture for automobile production. When applied, it may weaken a competitive power of a Japanese automotive industry, because everyone can make products by assembling "black box" parts irrespective of *Monozukuri* quality. If the technological standardization advances to its high level, *Monozukuri* quality system may no longer be needed.

3.8.5 Foreign Competitive Efforts

Profitability is used in this paper as an earning capability in manufacturing industries relative to the one in foreign countries. By definition, foreign country's competitive efforts weaken the profitability of Japan.

⁵ An Example is the criticism of non-tariff barriers by Reagan Administration in 1984.

⁶ AUTOSAR, which stands for AUTomotive Open System Architecture, is an consortium, which aims to make a software platform for automotive e industry. It is jointly developed by automotive manufactures and suppliers. See <http://www.autosar.org/> for details.

4 A System Dynamics Model of *Monozukuri*

We are now in a position to present our model of *Monozukuri* system as presented in Figure 10. The model is surely not aimed to perform numerical predictions of its system behavior. Its purpose is to understand how exogenous factors discussed above affect system behaviors of *Monozukuri*, specifically its profitability at a highly abstract level of analysis. The initial values of the parameters and stocks in the model are indicated in Table 4 and 5, respectively.

For simplicity in our model the first three exogenous variables: (1) monetary incentives, (2) pressure from another management policy and (3) pressure from market-based transactions, are assumed to be represented by another exogenous variable: management mode. Hereafter, it is explained why management mode represents these three exogenous variables. One of our main purposes is to make it obvious how the behavior of the system is changed when the system, which is operating under trust-based management, is affected by the external pressure of the contract-based management. We can assume that these three exogenous variables as a whole change "management mode" from trust-based management to contract-based management. So we can analyze how the behavior of the system is changed by the management mode. Accordingly, the management mode is assumed to play an important role.

Figure 11 (a) (b) (c) illustrates its functional relations with three different outputs such as (a) HRM of lifetime employment, (b) *Kaizen*-based activities and (c) commercial transaction mode. Figure 11 (d) (e) illustrates the functional relations of *Monozukuri* quality with two different outputs such as (d) sales⁷ and (e) failure cost⁸. These functional relations can be freely modified during the simulations to observe changes in the behavior of the system.

In the following sections we run two simulations for the newly defined exogenous factors such as (1) management mode and (2) technological standardization. Factor (1) is more specifically presented by trust-based management vs. contract-based management⁹. Next, the effect of an exogenous factor "technological standardization" is examined under the trust-based and contract-based management.

Exogenous factor of foreign competitive efforts is left unanalyzed in this paper due to a limited space.

⁷ Sales mean the excess sales yielded by the quality of products.

⁸ Failure cost means the excess expense caused by the failure of products.

⁹ Of course contract and trust are too essential features for business activities. By contract-based management we mean contract comes first and trust become secondary. By trust-based management we mean trust comes first and contract becomes secondary.

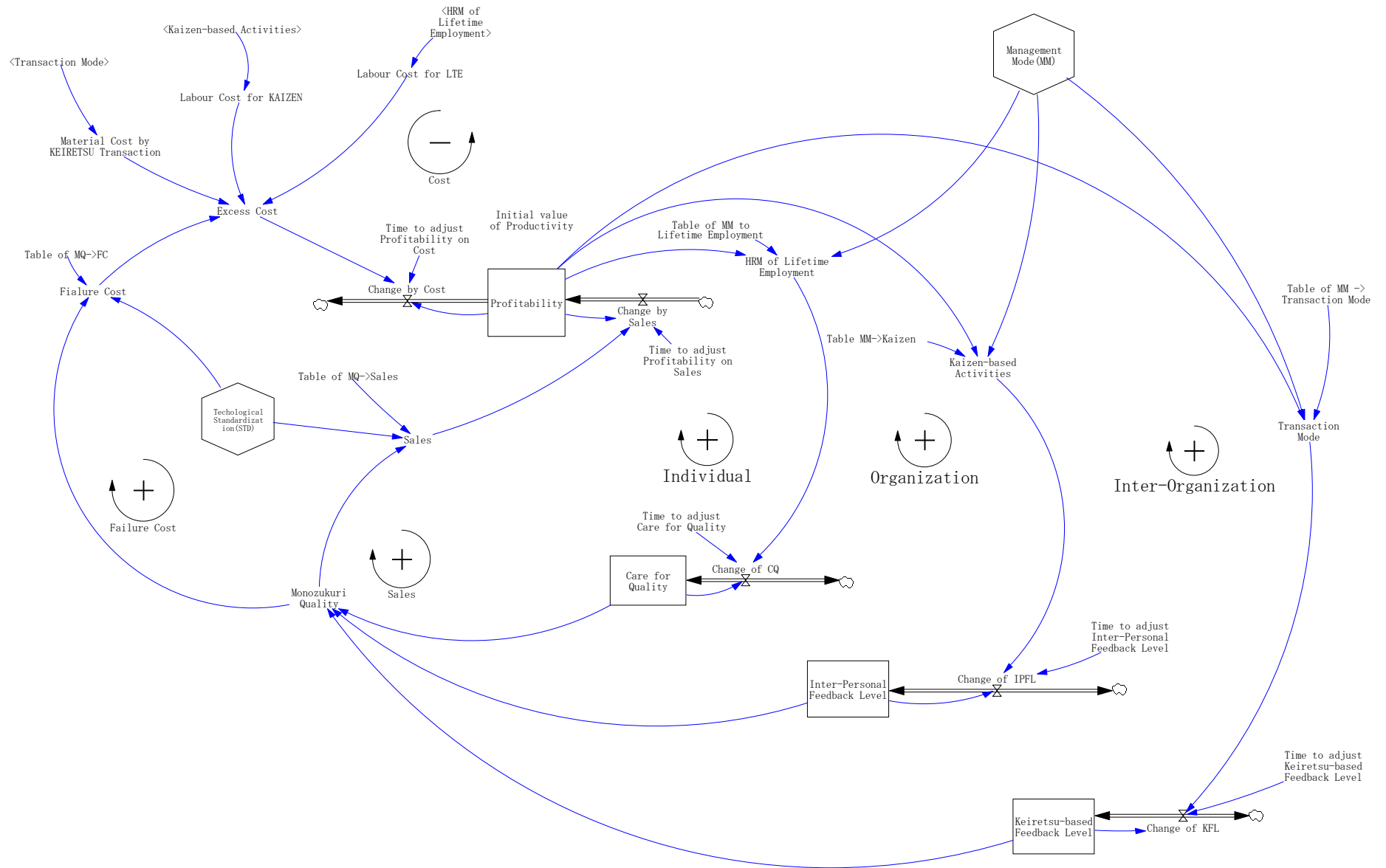


Figure 10 the SD (System Dynamics) Model

Table 4 Initial value of parameters DML: Dimensionless

Parameter	Value	Parameter	Value
Time to adjust Profitability on Cost	1 Year	Time to adjust <i>Keiretsu</i> -based Feedback Level	10Years
Time to adjust Profitability on Sales	3 Years	Technical Standardization(STD)	0.5(DIML)
Time to adjust Care of Quality	1 Year	Management Mode (MM)	0.7(DIML)
Time to adjust Inter-Personal Feedback Level	5 Years		

Table 5 Initial Level

Level	Initial Value	Level	Initial Value
Profitability	0.60	Inter-Personal Feedback Level	0.5
Care for Quality	0.5	<i>Keiretsu</i> -based Feedback Level	0.5

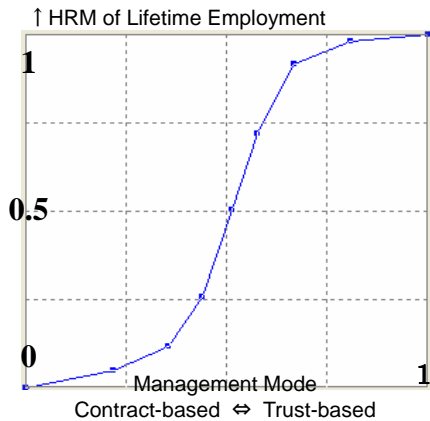


Figure 11(a) HRM of Lifetime Employment

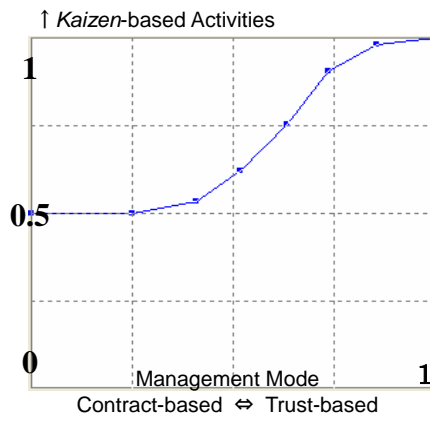


Figure 11(b) Level of *Kaizen*-based Activities

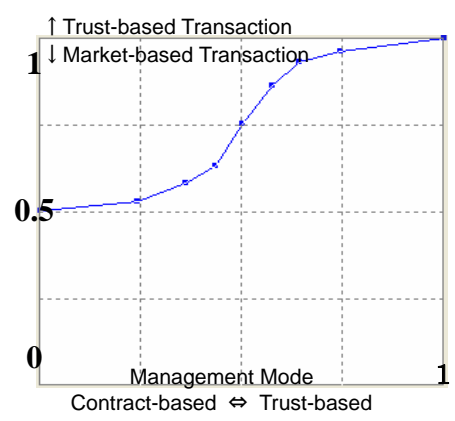


Figure 11(c) Transaction Mode

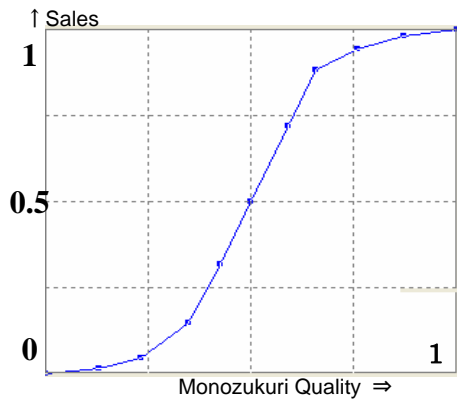


Figure 11(d) Monozukuri Quality - Sales

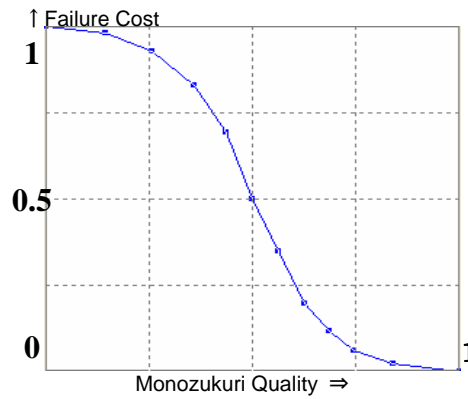


Figure 11(e) Monozukuri Quality - Failure Cost

Figure 11 Initial Values of Table Functions

4.1 Trust-Based Management vs. Contract-Based Management

Figure 12 shows the result of two simulations by blue lines and by red lines.

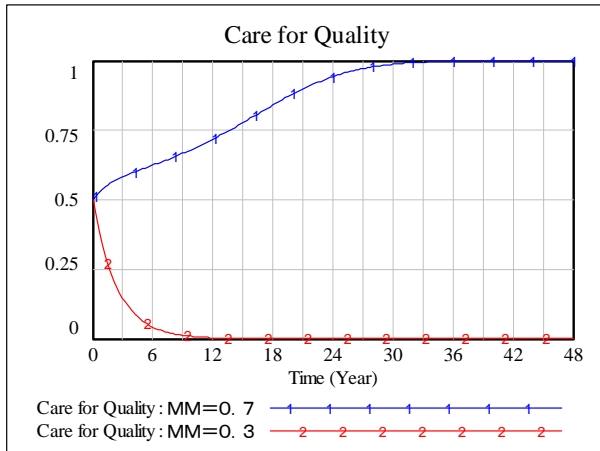


Figure 12(a) Care for Quality

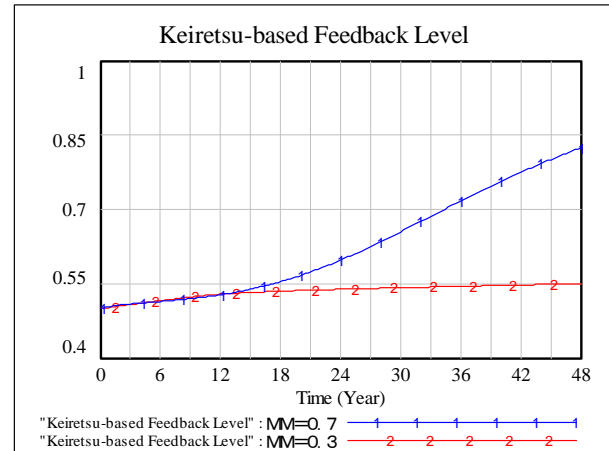


Figure 12(c)
Keiretsu-based Feedback Level

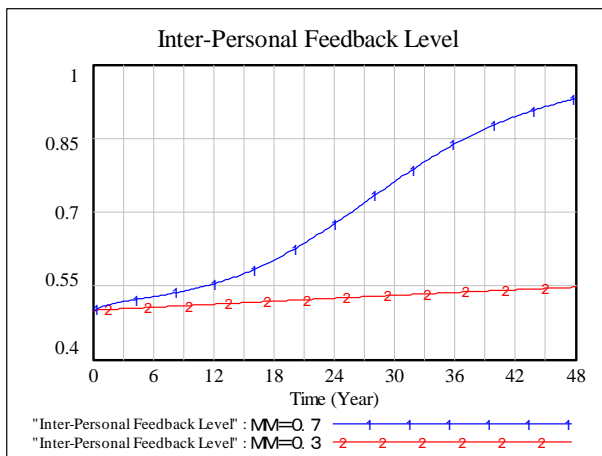


Figure 12(b)
Inter-Personal Feedback Level

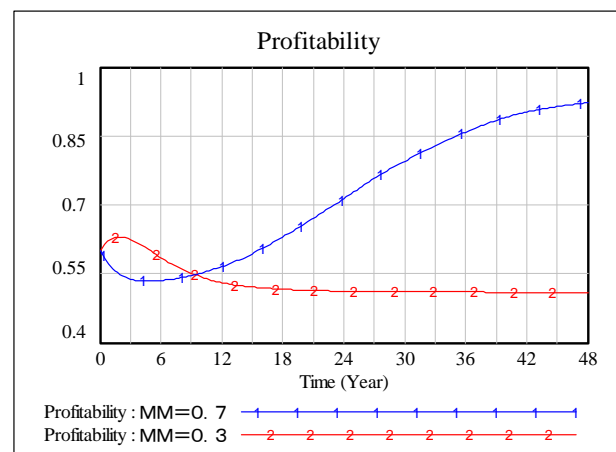


Figure 12(d) Profitability

The blue lines indicate the result of the behavior of the system performed under the condition of "trust-based management", which is controlled by a parameter named "management mode" valued at 0.7. The red lines indicate the result of the behavior of the system performed under the condition of "contract-based management", which is controlled by the same parameter valued at 0.3. In the model, the management policy is defined by the parameter values between 0 and 1. The procurement policy is also a variable with a range between market-based transactions and trust-based transactions. In Figure 12, the blue lines describe the behaviors controlled by "trust-based management", and red lines show the behaviors by "contract-based management". In the case of trust-based management, three levels, that is, the individual care for quality (see Figure 12(a)), the organizational inter-personal feedback level (see Figure 12(b)) and the inter-organizational *Keiretsu*-based feedback level (see Figure 12(c)) are accumulated at a high level. Therefore, *Monozukuri* quality has reached to a high level. Moreover, high profitability is attained by *Monozukuri* quality. (See Figure 12(d)). In the case of contract-based management, the values of three stocks become low gradually. And the additional cost of *Monozukuri* quality, that is, the additional expense for lifetime employment HRM, the expense for continuous improvement and additional expense of *Keiretsu*-based transactions all become lower than the case of trust-based management. The situation of the so-called "better-before-worse" dynamics is observed in

the early time zone near time 0. The profitability, then, gets lower and lower, because three reinforcing loops are going to work predominantly into a bad direction. Figure 13 simultaneously shows the result of two simulations by blue lines and by red lines.

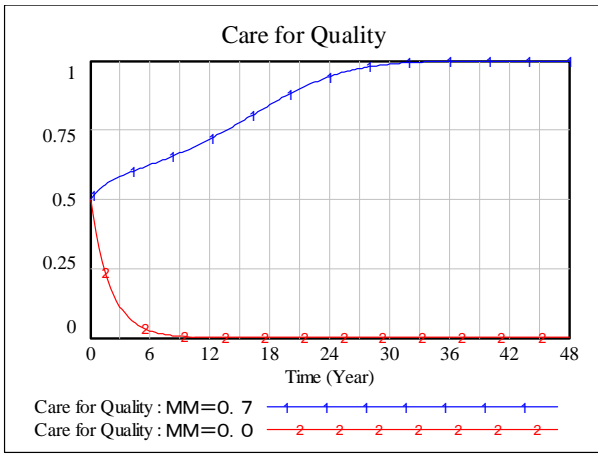


Figure 13(a) Care for Quality

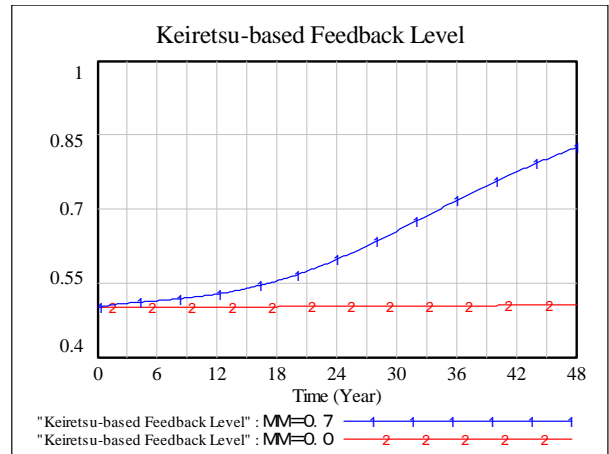


Figure 13(c)
Keiretsu-based Feedback Level

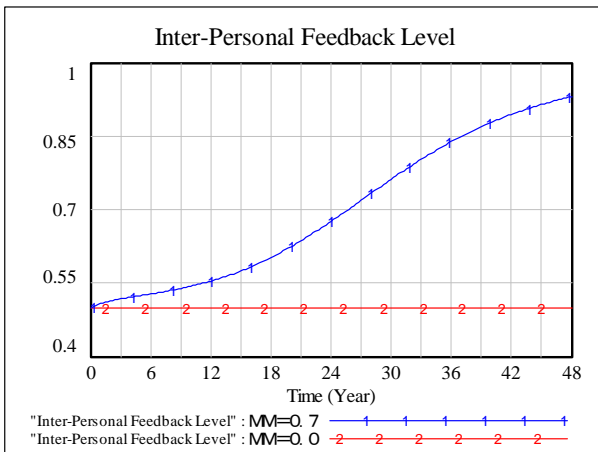


Figure 13(b)
Inter-Personal Feedback Level

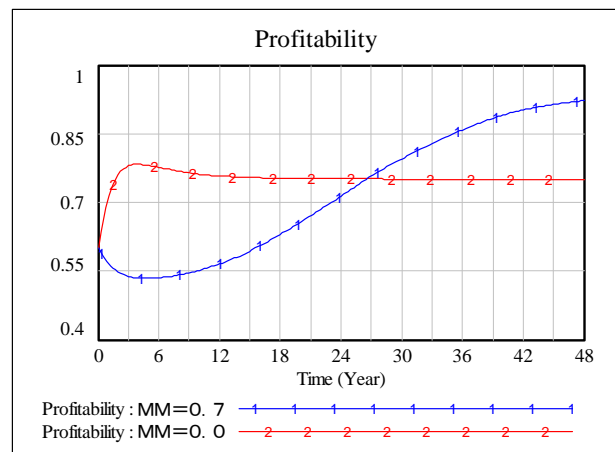


Figure 13(d) Profitability

The blue lines indicate the behavior under the conditions of trust-based management which is the same as the blue lines of Figure 12. Red lines indicate the typical contract-based management controlled by a parameter "management mode" valued at 0.0. In this case, care for quality falls quickly, because the HRM for lifetime employment keeps low under the contract-based management. And inter-personal feedback level and *keiretsu*-based feedback level keep flat because *kaizen* activities and transaction mode keep neutral. As a result the *Monozukuri* quality falls gradually, but the profitability keeps high, because expenses for operating organization under the contract-based management is lower than the case of trust-based management. So a typical contract-based management mode (valued 0.0) attains higher profit than a trust-based management mode (valued 0.7). But profit in the trust-based management mode passes that of contract-based management mode, due to the accumulation of capability in organization.

4.2 Technological Standardization

Figure 14 displays the influence of technological standardization under the condition of trust-based management. *Keiretsu*

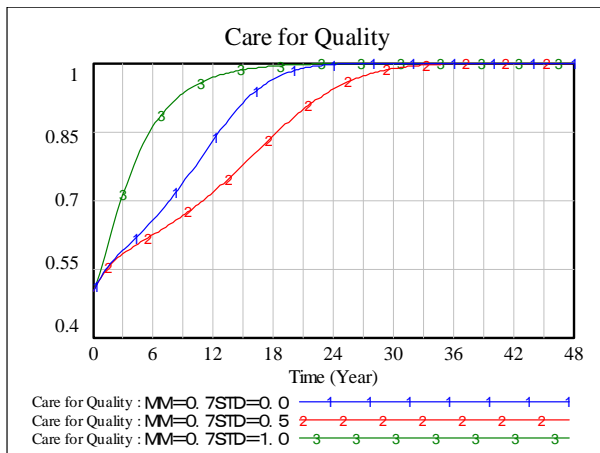


Figure 14(a) Care for quality

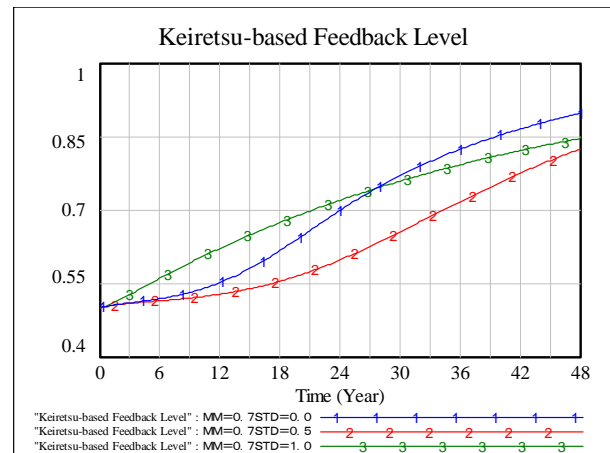


Figure 14(c)
-based Feedback Level

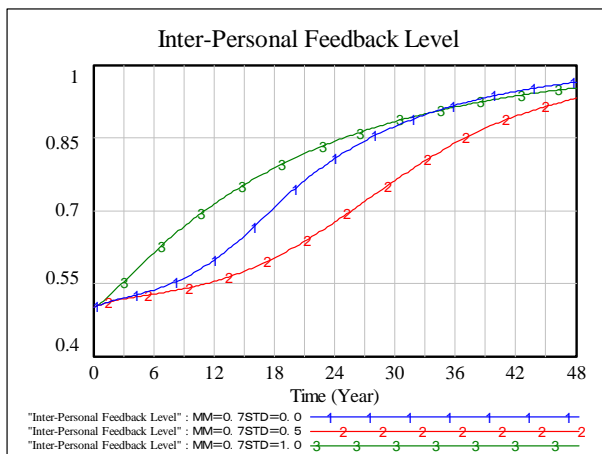


Figure 14(b)
Inter-Personal Feedback Level

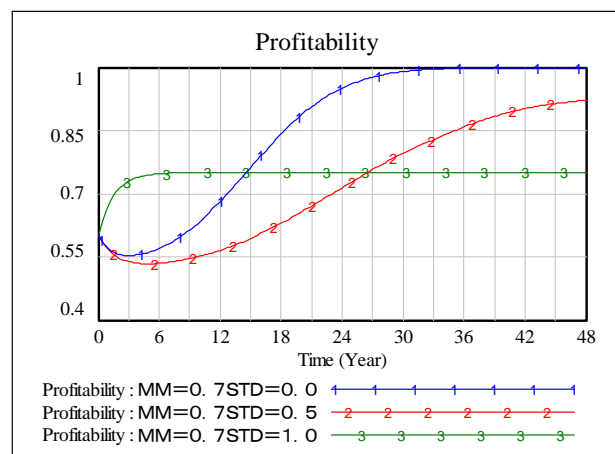


Figure 14(d) Profitability

The simulation is performed by changing the value of technological standardization three times; that is, a low level, a middle level and a high level. The blue lines indicate the behavior of the system under a condition of a low level. The red lines indicate the behavior under a middle level, and the green lines indicate the behavior under a high level. These simulations are performed under the condition of trust-based management. The three stocks supporting *Monozukuri* quality have the same trends, which gradually increase. (See Figure 14(a) (b) (c)). The case of low standardization is the most profitable one among three cases. Next one is the case of the middle standardization. The lowest one is the case of high standardization. As a result of the same behavior of the three stocks, the *Monozukuri* quality and its expense show almost the same behavior among three cases. The difference of the profitability (See Figure 14(d)) is caused by a relationship between the *Monozukuri* quality and the architecture of products. If the technological standardization is at a low level and the product has an "integral architecture", the *Monozukuri* quality is effective for increasing profitability. On the contrary, if the technological standardization is at a high level and the product has a "modular architecture", the *Monozukuri* quality is worthless for profitability. Consequently the profitability in the case of high level technological standardization is lower than that in the case of low level technological standardization or middle level.

Figure 15 shows the influence of technological standardization under the contract-based management.

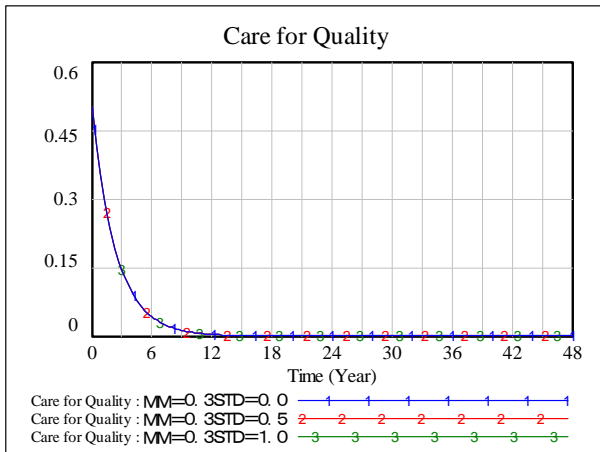


Figure 15(a) Care for quality

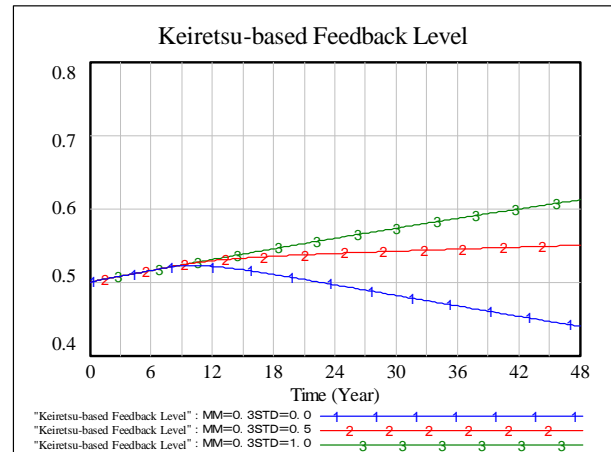


Figure 15(c)
Keiretsu-based Feedback Level

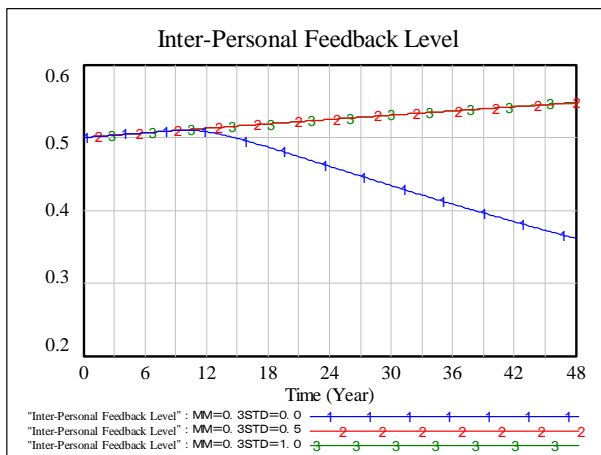


Figure 15(b)
Inter-Personal Feedback Level

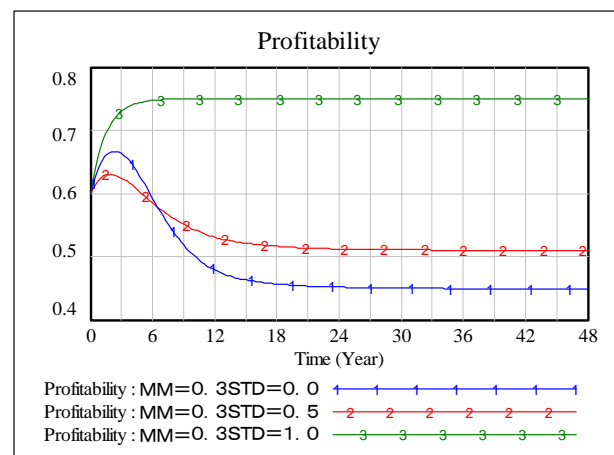


Figure 15(d) Profitability

The simulations are performed by changing the value of the contract-based management three times just like the above simulation. The results are presented in Figure 15. The blue lines indicate the behavior of system under the condition of low level technological standardization. The red lines indicate the behavior at a middle level, and the green lines indicate the behavior at a high level. In contract-based management, the three stocks supporting *Monozukuri* quality are low or neutral at most (see Figure 15(a)(b)(c)), and the *Monozukuri* quality is at a low level, because of insufficient investment for building these capabilities that support the *Monozukuri* quality. As a result, *Monozukuri* quality is at a low level in these three cases, but the profitability is different one another. The profitability gradually increases in the case of a high level of technological standardization. (See Figure 15(d)). It gradually decreases in the case of a low level or a middle level of Technological Standardization. In the case of a low level of technological standardization, the *Monozukuri* quality becomes a critical factor for success in competition, because the product has "integral architecture". Consequently the profitability is at a low level and the reinforcing feedback loops work toward a weakening direction. In the case of a high level technological standardization, the profitability increases, because *Monozukuri* quality is worthless in the case of a high level of standardization, that is, products have a "modular architecture".

4.3 Sensitivity Analysis

Finally, we have performed sensitivity analysis for profitability against the technological standardization, which takes random values for the range between 0 and 1.

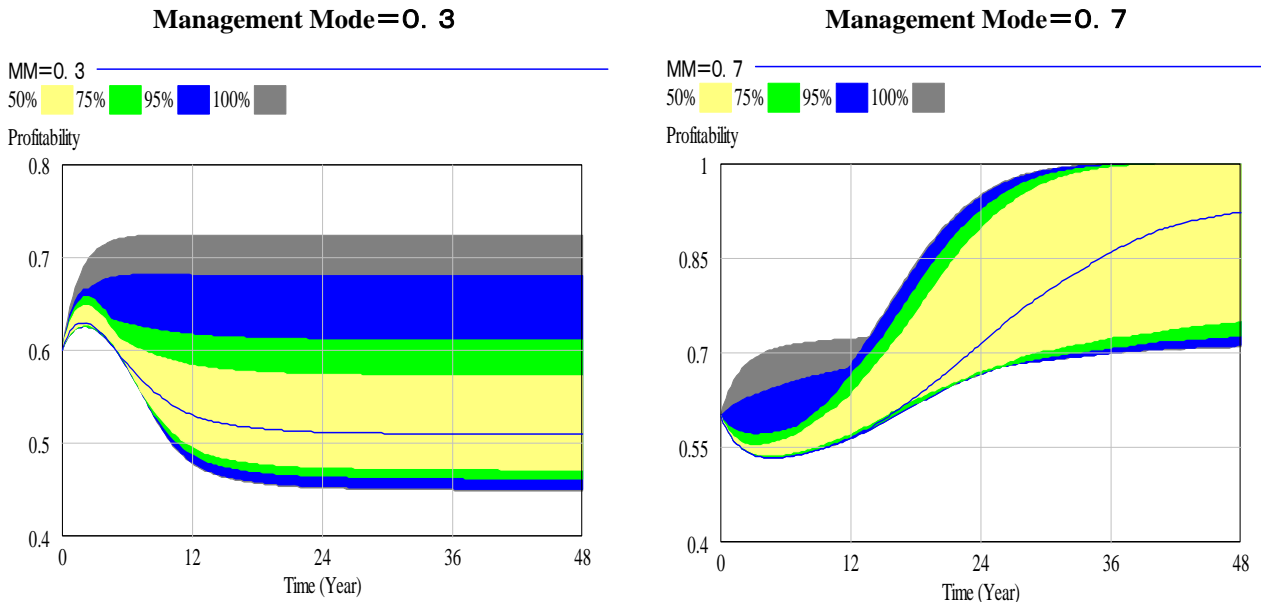


Figure 16(a) Contract-Based Management

Figure 16(b) Trust-Based Management

Figure 16 the Sensitivity of Profitability to the Standardization

Figure 16(a) demonstrates a large distribution of the profitability to the change in technological standardization. On the contrary, Figure 16(b) demonstrates a relatively small distribution of profitability. The profitability under a trust-based management has more robustness to the change in the technological standardization level than a contract-based management. The capabilities which support *Monozukuri* quality are to be built when the company adopts a trust-based management, but they are not in the case of a contract-based management. When technological standardization is kept at a low level, that is, a product keeps "integral architecture", the company which adopts contract-based management will fail into a competition because of the lack of *Monozukuri* quality. A company which adopts a trust-based management will keep high competitiveness by the *Monozukuri* quality in the same scenario. This indicates that a company under trust-based-management has robustness and a company under contract-based management has vulnerability. In conclusion, the high technological standardization possibly reverses a direction of the *Monozukuri* system from a strengthening direction into a weakening one.

5. Social Feedback

So far we have analyzed how the strong features of *Monozukuri* system get weakened by exogenous factors such as management mode and technological standardization. (The effects of first three exogenous variables are analyzed as a whole represented by management mode and the last is being left unanalyzed in this paper due to a limited space.)

During the period of the so-called “Lost Decade” of 1990’s, Japanese economy had suffered from an unprecedented recession and Japanese executives seem to have lost their confidence in Japanese management in face of a prospering American economy. Many executives began to abandon a trust-based management in favor of a contract-based management. This transition has been reinforced by the revised Worker Dispatch Law in 2004 which enabled to employ contract-based temporary workers in the production site of many Japanese companies.

As we have examined above, such a transition from trust-based to contract-base management has worsened the performances of Japanese companies. Accordingly, unemployment has steadily increased. This worsening trend seems to have climaxed in 2008, following the bankruptcy of the Wall Street investment bank of Lehman Brothers. The Japanese society began to have been split into two classes; the rich “haves” of the established workers and the poor “haves-not” of temporary workers.

Gradually social discontent against such discrepancies began to arise through media reports, and even the powerful leading executives of the Japan Business Federation expressed their concerns in the public. Management pendulum now seems to be swinging back to a trust-based management little by little. This social repercussion convinced us of the existence of social feedback loop as an extended part of *Monozukuri* system. Figure 17 illustrates an expanded part of the system presented in Figure 10.

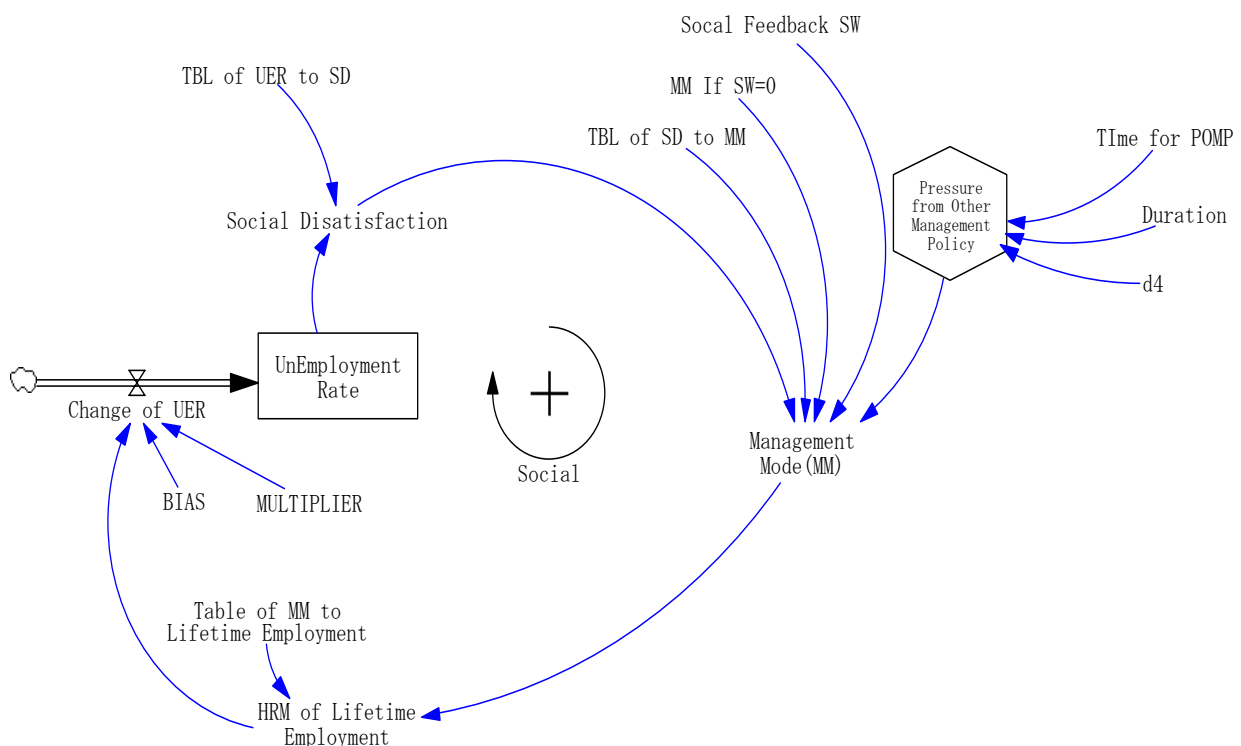


Figure 17 Adding Social Feedback Loop

To this expanded model, we have brought unemployment data of Japan between 1962 and 2009 as a reference, and tried a calibration run to estimate parameters such as BIAS and MULTIPLIER in the

inflow equation of $\text{Change of UER} = (\text{HRM of Lifetime Employment} + \text{BIAS}) * \text{MULTIPLIER}$.
 Table 6 displays its result.

Table 6 Initial value of parameters

Parameter	Value	Parameter	Value
BIAS	1.142	MULTIPLIER	0.03455

Figure 18 illustrates our simulation result together with reference data.

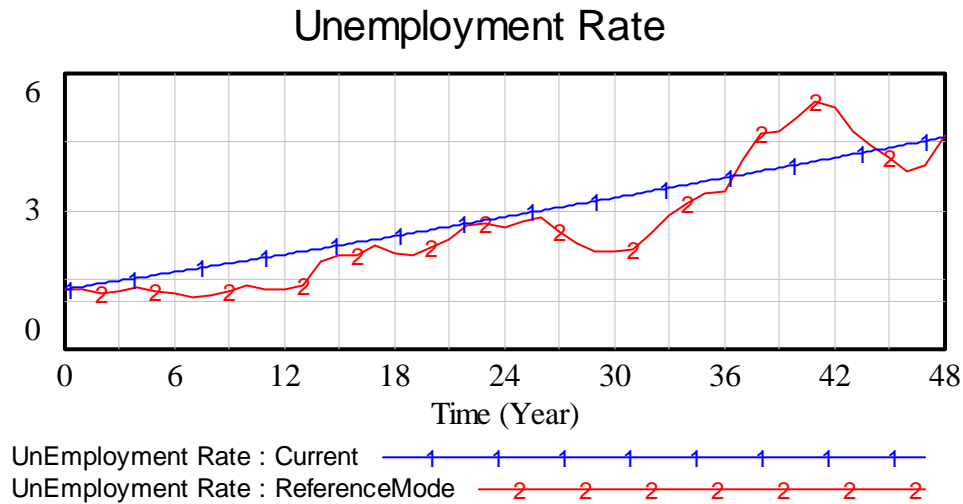


Figure 18 Calibration by referencing Unemployment Rate of past 48 years

Based upon this extended structure, we have constructed another table functions such as the one between Unemployment Rate and Social Dissatisfaction in Figure 19(a), and the one between Social Dissatisfaction and Management Mode (MM) in Figure 19(b).

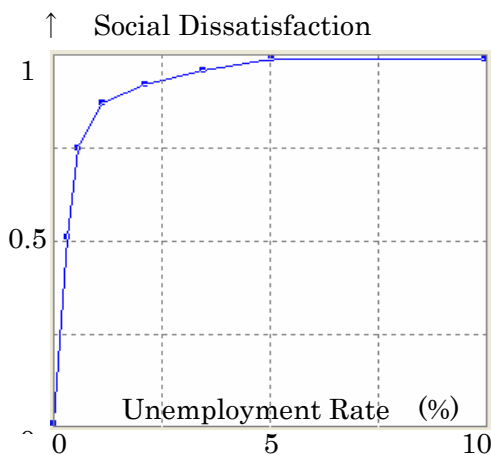


Figure 19(a) Unemployment Rate-Social Dissatisfaction

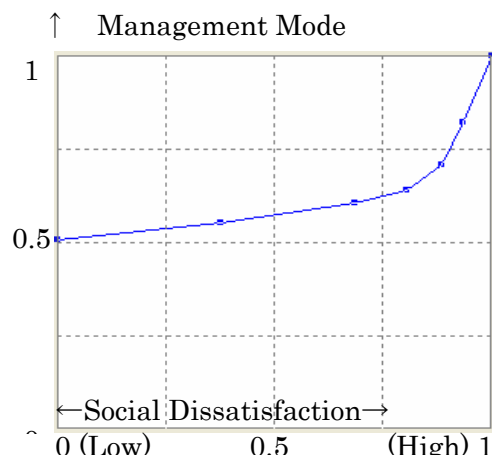


Figure 19(b) Social Dissatisfaction-Management Mode(MM)

Figure 19 Initial values of Table functions

Figure 20 displays our simulation for profitability when Management Mode (MM) is set at a value of 0.7, that is, under a trust-based policy. It is observed to be increasing as time passes.

Figure 21 shows that Management Mode decreases by 0.3 toward a contract-based policy at time=20. This reflects a case briefly discussed above in which Japanese economy is forced to adopt contract-based management under a strong pressure of economic reforms from the American government during 1990's. As a result of this management policy change, profitability seems to have improved immediately. Unfortunately, however, it turned out to be declining again in the long run.

Finally we are now in a position to demonstrate how social feedback re-reverses the situation that was once reversed under a foreign pressure. In Figure 22 it is shown that, as unemployment rate increases, social dissatisfaction increases to a point where social feedback swings back a pendulum from contract-based management to a trust-based management little by little. Accordingly, lifetime employment is reinforced, and profitability begins to go up.

6. Conclusions

Is Japanese Manufacturing Style (so-called *Monozukuri*) really robust? – this is a question we posed in this paper. In the beginning *Monozukuri* system was structured as having three layers of individuals, organizational and inter-organizational levels. Accordingly we intuitively thought that the answer could be negative, because it seems very vulnerable to outside shocks or pressures such as five such factors we identified in this paper. In fact, we found that these factors can easily reverse strong features of *Monozukuri* to weak ones.

As our research gets deepened, however, we found that this reversing force could be re-reversed when a social feedback loop is introduced to the *Monozukuri* system. In other words, if a social feedback loop is

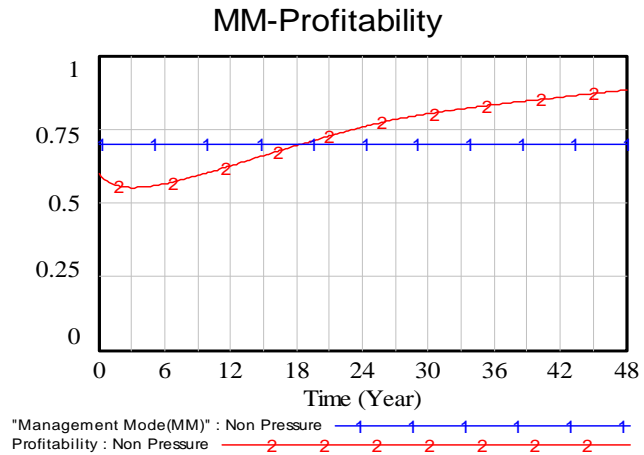


Figure 20 Management Mode – Profitability without pressure from other management policy

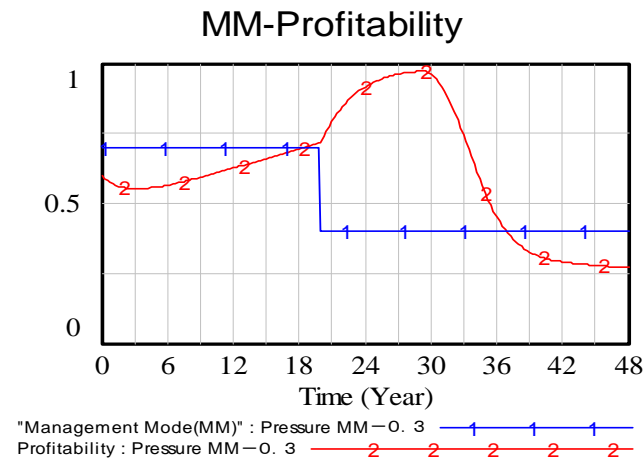


Figure 21 Management Mode – Profitability with pressure (-0.3) from other management policy at time=20

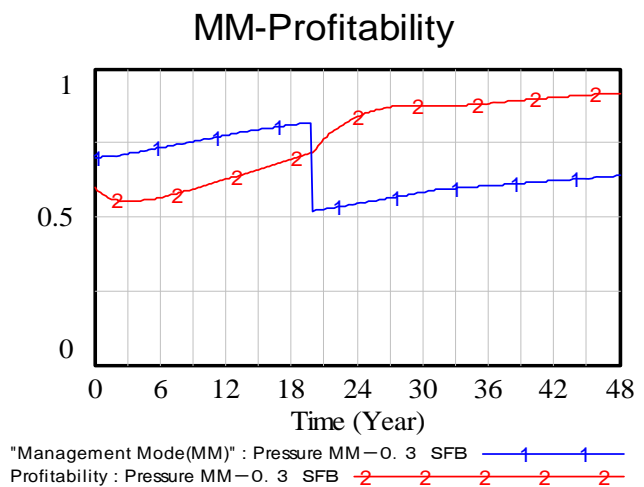


Figure 22 Management Mode – Profitability with social feedback

augmented as a fourth layer of the *Monozukuri* system, the answer could be surely affirmative. It depends on how seriously the Japanese society regards a social feedback as essential to the *Monozukuri* system. It could be a contribution of this paper to point out the importance of social feedback for enhancing the *Monozukuri* system, irrespective of outside shocks against the system, in the long run.

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