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A Systems Approach to Institutional Diffusion in Taiwan's Food Traceability System

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ABSTRACT

A food traceability system is an institution that aims to reduce information asymmetry among producers, retailers, and consumers through public disclosure of information about the origin, production, and sales of agriproducts. System effectiveness depends on the changes that result from diffusion. In this study, we use Taiwan's traceable agricultural products system to integrate mental models of multiple stakeholders to simulate interactions among institutional quality, adopter profitability, profit distribution, and institutional diffusion from a system dynamics perspective. It thus provides a framework for institutional diffusion and change and elucidates the process of institutional diffusion for the causal relations among many critical factors.

***Keywords**: Dynamic change; Food traceability; Institutional diffusion; System dynamics.*

1 Introduction

In recent years, some suppliers along the food supply chain have damaged the reputation and economic stability of food manufacturers and the entire industry by violating consumers' right to know (Coff et al., 2008) about the food products they buy and consume—for example, the horsemeat incident of 2013 (Barnett et al., 2016). Hence, unethical behavior by members of the food supply chain has become an important risk factor. Food traceability systems have been determined to reduce these risks in the food supply chain by preventing food adulteration, spread of misleading information, and use of excessive additives (Aung and Chang, 2014). Food traceability policies require farmers, fisheries, ranchers, and manufacturers to identify the businesses they supply to as well as those from whom they purchase supplies so that food chain input can be traced to their immediate suppliers (EC 2002).

In addition to disclosing upstream and downstream information, Taiwan's traceable agricultural products system (TAPS) requires that participants comply with Taiwan's Good Agricultural Practices (GAP) standards (https://taft.coa.gov.tw/rsm/Orgintro.aspx). For supply chain actors to achieve self-management and abide by regulations governing consumers' rights to truthful information, TAPS must generate higher participation from third-party certification bodies, producers, processors, retailers, and consumers. For members within the food supply chain, strategic responses to voluntary regulation (e.g., TAPS) should be dynamic in accordance with the interactions between macro–micro environments (Gray et al., 2015; Oliver, 1991; Cho and Choi, 2019).

Viewed through a theoretical lens, the isomorphic logic of institutional theory aids supply chain members in understanding how an institution diffuses change by coercive, mimetic, and normative isomorphism (DiMaggio and Powell, 1983; Greenwood et al., 2010; Oliver, 1991; Thornton and Ocasio, 2008); however, it overlooks the causes of its dynamic changes (Beckert, 2010) and endogeneity (Semadeni et al., 2014). Therefore, to comprehensively understand change resulting from institutional diffusion, some institutionalists highlight the complexity of the institutional structure (Greenwood et al., 2011; Jarzabkowski et al., 2013; Niosi, 2011; Sayed et al., 2017). Further, Steinmo (2008) and Thornton and Ocasio (2008) indicate that institutional structure is composited by mental models of members and how members thus perceive their interactions with stakeholders. Therefore, extending the three logical elements of isomorphism, this study's research question lies on how an institutional structure built in mental models of stakeholders affects institutional adoption by members of the food supply chain.

System dynamics (SD) is a way to describe complex institutional structures that uses many variables to build integrated mental models of stakeholders. Although several qualitative and quantitative research methods are already utilized in the context of institutional adoption, a simulated study using SD is also necessary. Earlier quantitative studies have confirmed the determinants of institutional adoption using a statistical method, whereas qualitative research reveals the process of how actors adopt institutions within specific contexts. SD is regarded as a bridge between quantitative and qualitative methods. It expands on the problem that quantitative research is overly simplified by elucidating the causal relations among determinants. Moreover, SD confirms the validity of qualitative works using real-life simulations (Goodin et al., 2006). The core argument of this study, from an SD perspective, is that change brought about by institutional diffusion depends on institutional structure, which is composited by the mental models of members and how those members thus perceive their interactions with stakeholders.

This study makes three contributions to the understanding of institutional diffusion and change. First, by integrating the perspectives of SD and institutional isomorphism, it uses a feedback perspective to develop a framework to holistically understand changes resulting from institutional diffusion over a specific period that can be used to supplement earlier studies of institutional diffusion that disregarded the possibility of gradual change or effects of member perspectives on institutional change (Campbell, 1997; Peters, 2011). With TAPS as an example, this study integrates the mental models of multiple stakeholders to elucidate the interactions among actors in terms of institutional quality, adopter profits, profit distribution, and institutional diffusion. Extending on ambiguities of institutional structure (Greenwood et al., 2011), this study also addresses complexity and shows that it can be clarified by understanding changes in institutional quality under a regulatory mechanism, adopter profits under a market mechanism, and profit distribution under a social network mechanism. Second, this study considers many variables to construct a qualitative model and uses the relationships among variables from a literature review and expert interviews to design the quantitative model (Cockerill et al., 2009; Coyle, 1997; Hsiao, 2014; Sterman, 2000). It not only resolves endogenous problems caused by the closed boundaries around the system (Richardson, 2011) but also confirms the validity of the quantitative model for real-world implementation by comparing the historical and simulation results (Coyle, 1997; Finnemore, 1996; Friedland and Alford, 1991; Hsiao, 2014).

Finally, the sensitivity analysis provides suggestions for institutional adopters and policymakers alike: (1) institutional adopters must continue to monitor institutional quality to provide dynamic responses, and (2) the best strategy to trigger institutional diffusion should also diminish conflicts among stakeholders.

This study begins with Section 2, which provides an overview of the background of TAPS in Taiwan. Section 3 proposes a framework to integrate the SD perspective and logical elements of isomorphism to dissect the complexity of institutional structure. Based on this framework, Section 4 identifies three structures that use the SD approach to describe the underlying structure driving TAPS institutional isomorphism and change processes. The quantitative model is described in Section 5. Section 6 confirms model robustness and shows the simulations. Policy simulations are outlined in Section 7. Finally, Section 8 discusses key findings and conclusions as well as recommendations for further research.

2 Traceable agricultural products system in Taiwan

Food traceability is determined to reduce the risks inherent in industrial-scale food production, such as use of excessive additives (Williams and Hammitt, 2001) and misleading information (Trevisan, 1986) that can result in manufacturer and distributor distrust of upstream agriproducts, raise suspicions about regulatory efficacy, and generate public concerns about food quality (Hennessy et al., 2003). Most governments regard food traceability systems as a management tool to enhance self-management within the supply chain, as a government tool to ensure antifraud/verification of product attributes and liability, and as a communication tool to capture the value of food quality for informing consumers (Coff et al., 2008). Sample testing cannot eliminate these types of risks; however, food traceability programs that involve tracking and disclosing production information at each step can slightly reduce them (Hsu, 2008).

In addition to providing information disclosure, TAPS is a voluntary regulation system in Taiwan to protect the environment and human health (Sparling and Sterling, 2004; Wang et al., 2009). In 2003, the Taiwan Council of Agriculture (COA) began to examine food traceability systems in Japan and the EU, after which it implemented the Management Measures on Agricultural Products Production and Validation in 2007, which specified the standards for farming, production, risk management, and operational controls and later came to be known as GAP. Consequently, the COA adopted GAP for its basic TAPS standards, which have developed into a voluntary regulatory system committed to safe agriculture and sustainable environment through information disclosure and traceability (Bradu et al., 2014; Chen and Huang, 2013).

Applicants in the TAPS certification process include farmers, distributors, and marketing associations. Farmers can independently adopt the TAPS system. In addition, distributors or marketing associations can enroll their members as a group to apply TAPS. Through TAPS processing (Fig. 1), applicants apply to have their produce, products, and processes validated on-site by a third-party certification center, and approved applicants are annually audited and tested to receive TAPS certification labeling to display on their packaging (https://taft.coa.gov.tw/rsm/Orgintro.aspx). TAPS offers assurances to producers and the public about the safety, quality, and quantity of agricultural products (Bradu et al., 2014) through third-party GAP certifications and public disclosure about the processing, production, circulation, transportation, and sale of all food products (Hsu, 2008). Perceived market pricing premiums for TAPS products are decided by consumer trust in the institution of TAPS (Yuan, Wang, & Yu, 2020).

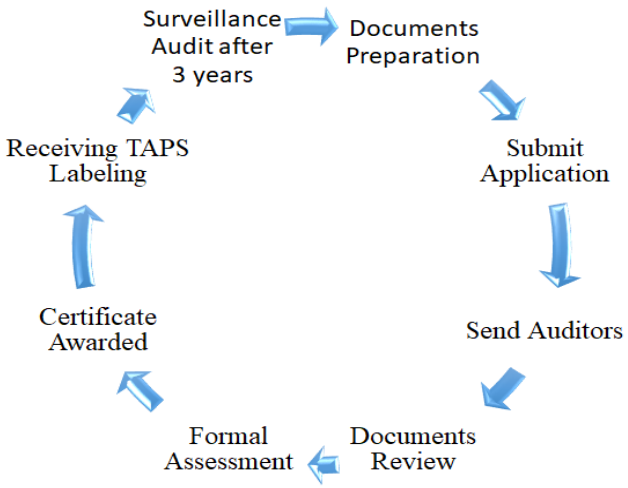


Figure 1. TAPS processing

3 General framework for institutional diffusion and change

Institutions are basically sets of formal and informal rules that influence member behaviors, i.e., institutions become established when most members adhere to the rules. Institutional scholars consider each member to be embedded in the social system; therefore, most members tend to exhibit the same behavior following three types of logic, namely, coercive, mimetic, and normative isomorphism (DiMaggio and Powell, 1983; March and Olsen, 1983). Among these, coercive isomorphism means that firms tend to adopt regulations with greater control (Oliver, 1991; Pfeffer et al., 1978). The control power of the institution implies its quality. Changes in institutional quality are embedded within regulatory resources, such as the way in which the authority or quality of a third-party certification can encourage many members to adhere to its requirements. Overall, members tend to adopt TAPS when TAPS can use certification to control misbehavior by numerous members in the supply chain. Moreover, mimetic isomorphism is rooted in market mechanisms; for example, most members tend to benchmark growing peers, especially under uncertain conditions; i.e., in situations where a clear course of action is unavailable (e.g., adopting a decision on voluntary regulation), members will tend to adopt TAPS if they perceive that their peers receive adequate benefits by doing so. Finally, based on the social network mechanism, normative isomorphism develops from cognitive consistency among members by frequent interactions within the group (Croucher and Woelert, 2018). Therefore, members are more likely to adopt TAPS when other members of the supply chain agree on its adoption.

However, from a strategic perspective, member responses on institutional adoption should change in reaction to variations in isomorphism processes based on shifts in institutional resources, market profits, or social interactions (Greenwood et al., 2011). These shifts are sometimes caused by member responses following the rational calculation of multiple institutional pressures (Greenwood et al., 2010; Greenwood and Hinings, 1996). However, at times, it is possible for these shifts to evolve from an institution's structural instability. Both influences can result in institutional complexity (Amenta, 2005; Mahoney and Rueschemeyer, 2003). The sections that follow deconstruct complex instructional structures by their sources of institutional pressure to show the changes that result from institutional diffusion.

3.1 Coercive isomorphism and change under regulatory mechanism

Coercive isomorphism describes a state where mass members tend to adopt an institution due to coercive pressure. An institution exerts coercive pressure through formal and informal forces to control member behavior in the field through a regulatory mechanism (DiMaggio and Powell, 1983). For example, Liu (2016) considers percentage improvement within a specific period in response to mislabeling penalties in the packaged rice industry as an indicator of the control power of regulatory inspections. However, resource scarcity can also cause institutional change (Sherer and Lee, 2002). The control effects of regulatory resources gradually become diluted when more members become involved in the institution and wait to be screened, consequently impacting the controlling effect of the institution on members. In other words, a feedback loop appears between a regulatory resource and institutional diffusion under regulatory mechanism.

When the control effect of a regulatory mechanism is high, a higher level of institutional adoption can appear, diluting the consequent control effects of the regulatory resource for each adopter. This indicates that change in coercive isomorphism results from the loop of a dynamic interactive process between institutional diffusion and a regulatory resource.

3.2 Mimetic isomorphism and change under the market mechanism

Mimetic isomorphism means that firms tend to imitate the actions of their peers, particularly when making risk-involved decisions, such as voluntarily adopting to regulatory schemes (DiMaggio and Powell, 1983; Lieberman and Asaba, 2006). Because individual members have a limited ability to predict future profits from adopting the institution (Simon, 1947; Simon, 1990), members tend to reference the current profits of members who have adopted the institution. Haveman (1993) found that when (1) most members operating in new markets are similar to a potential entrant or (2) most members in new markets are successful, a potential entrant tends to follow the logic of mimetic isomorphism when determining whether to enter the market. However, once many homogeneous members have appeared within a market, the market mechanism adopts two effects: effective supply will increase members' profits, and excessive supply will cause a decline in members' profit (Schmalensee, 1989). These two effects reveal the change in adopter profits related to market demand and supply mechanisms (Caracciolo and Cembalo, 2010). This indicates that changes in mimetic isomorphism are the result of loops of a dynamic interactive process between institutional diffusion (the number of adopters) and adopter profits.

3.3 Normative isomorphism and change under the social network mechanism

Normative isomorphism emphasizes that members of the supply chain have similar worldviews from having undergone similar training or having frequent interactions within the same group. Members with similar ideas tend to adopt a homogeneous response to an institution (Campbell and Pedersen, 2001). Within a social network, consistent cognition is caused by more highly expressive and instrumental networks (Fombrun, 1982). First, the expressive network is based on trust in shared values resulting from a stable relationship, shared values, and interaction norms (Swedberg and Granovetter, 1992). Due to the trust in the mechanisms of the social network, beliefs and cognitions gradually dovetail (Putnam, 2000). In addition, an instrumental network is established to seek resources or information (Umphress et al., 2003). To meet the expectation of reciprocal exchanges, members conceptually tend to be on the same page. The existing number of adopters reinforce more members to adopt in the next period (Liu, 2016). In short, there is a feedback loop between cognitive consistency and institutional diffusion within the social network mechanism. By integrating the interactions of institutional response logic among multiple members, mechanisms of the social network mechanism can trigger higher cognitive consistency among members and higher proportion of institutional adoption, enhancing the consequent cognitive consistency of members. However, within the social mechanism, conflicting goals diminish the rate of institutional adoption and cognitive consistency of members. This indicates that changes in normative isomorphism result from a loop of a dynamic interactive process between institutional diffusion and cognitive consistency.

3.4 Framework for institutional diffusion and change

As noted earlier, this study provides a framework for institutional diffusion and change (Fig. 2). Extending the concept of unclear structures in complex institutions (Greenwood et al., 2011), this study finds that complexity can be explored through deduction from regulatory, market, and social network mechanisms. This study argues that (1) within a regulatory mechanism, changes in coercive isomorphism are revealed by the loop between regulatory resources and institutional adoption; (2) based on the market mechanism, changes in mimetic isomorphism can be disclosed through a loop between adopter profits and institutional adoption; and (3) in mechanisms of a social network, changes in normative isomorphism are revealed by the loop between cognitive consistency and institutional adoption. In short, changes that result from institutional diffusion depend on dynamic changes in the loops involved in interactions among the various isomorphism processes in relation to interactions among regulatory, market, and social network mechanisms. For a member, an institution's strategic response should change following a dynamic change in institutional structure.

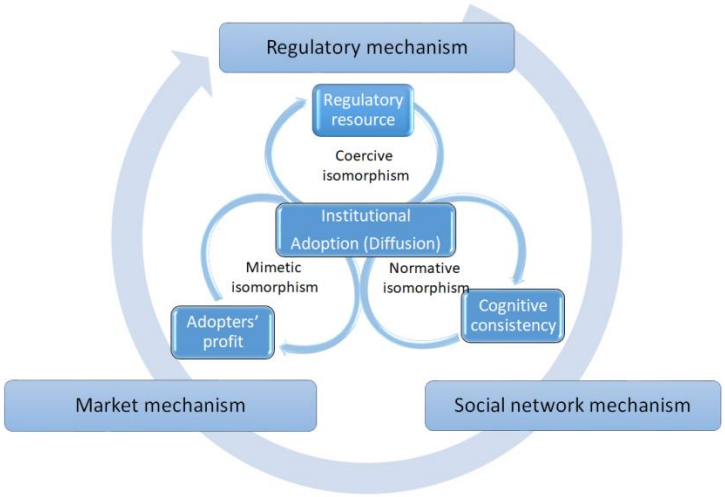


Figure 2. Framework for institutional diffusion and change

The logic of isomorphism relates to institutional diffusion due to homogenization of individual behavior (DiMaggio and Powell, 1983; Meyer and Rowan, 1977), but it does not provide a suitable explanation for the attenuation of institutional legitimacy (DiMaggio, 1998; Mulé, 1999). Earlier studies have found that institutional diffusion disregards the possibility of gradual change or member effects on institutional change (Campbell, 1997; Peters, 2011). Using a feedback perspective built on SD, this study provides a way to explain the interactive effects of institutional isomorphism and change.

4 Institutional isomorphism and change: Taiwan's traceable agricultural products system

To explore the institutional complexity, this study considers TAPS as an example to expose the institutional structures behind isomorphic logic. Based on the proposed research framework, this study has employed SD to identify the underlying structure of the three major stakeholders within the food supply chain, namely, the auditors of third-party certifiers, farmers, and distributors; in this case, the behavior of each member influences other members' behaviors. This institutional structure, established through a series of causal feedback mechanisms and time delays, can be used for analysis and simulation to provide a reference for decision-makers in institutional adoption and change. The research methodology and results are described in the sections that follow.

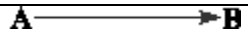
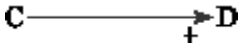
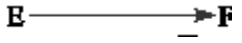
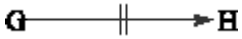
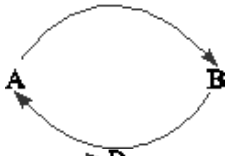
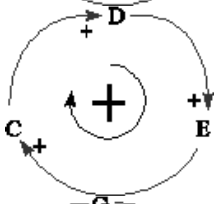
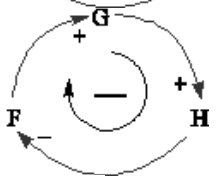
4.1 Methodology

In strategy research, the main thesis retains logical causation given a reasonable definition of the main explanatory variable. Arend (2003) highlights that the strategy theory is falsifiable when the implied assumptions of the theory are exploited and the endogeneity of their explanatory variables is considered. SD is designed to tell the endogenous story by the interactions of variables inside the model boundary (Forrester, 1968). It deals with the endogenous problem in the framework for institutional diffusion and change by considering a large number of variables inside the model boundary and elucidating the causal relationships among those variables.

SD is considered a way to combine system analysis, information feedback, and decision-making theory. As SD is process-oriented and suitable for exploring a "large number of variables and high-level nonlinearity" (Forrester, 1997), it could be rather suitable for showing changes resulting from institutional diffusion by clarifying the complex structures embedded in various types of logic.

Causal loop diagrams (CLDs) are often used in SD models to describe systematic behaviors that indicate dynamic changes in institutional adoption as well as interactions among and between farmers, auditors, and distributors. In CLDs, arrows are used to connect system variables and establish causal loops. These arrows reflect the causal relationships among variables and the influences of time delay. The concepts of volume and traffic are also used in constructing quantitative models through stock and flow diagrams (SFDs). Table 1 explains the symbols used in SD.

Table 1.
Symbols used in system dynamics. (Revised from Sterman, 2000.)

Symbol	Explanation
Arrow of Causal Relationship 	Causal relationship between Variable A (cause) and Variable B (effect)
Arrow of Positive Relationship 	Variable C (cause) has a positive relationship with Variable D (effect)
Arrow of Negative Relationship 	Variable E (cause) has a negative relationship with Variable F (effect)
Time Lag Between Cause and Effect 	Variable G only affects Variable H sometime after its occurrence
Reciprocal Causation 	The causal feedback loop wherein variables A and B interact as both the cause and the effect (reciprocal causation) and the behavior of Variable A is affected by self-controlled circumstances
Positive Loop 	Any changes in any variable prompt the changing variable to positively expand its changeable range, creating self-reinforcing and self-changing effects, which is also known as the snowball effect
Negative Loop 	Any changes in any variable prompt the changing variable to negatively depress the change effects, thereby self-balancing
Stock/Level Variable 	Variable G is a variable that accumulates with time
Flow/Rate 	A variable that influences the state of volume variable through inflow and outflow

Using institutional diffusion as an example, this study explains the modeling of SD as follows. Adoption rate has a positive effect on the number of new applicants, and a greater number of new applicants can lead to a larger number of institutional adopters. Additionally, a larger number of institutional adopters lead to a higher number of new applications, thus forming a positive loop. The number of exits has a negative effect on the number of institutional adopters, and a larger number of institutional adopters result in a higher number of exits. This forms a negative loop that restrains the total number of institutional adopters. CLDs for institutional diffusion (i.e., the total number of institutional adopters) are shown in Fig. 3.

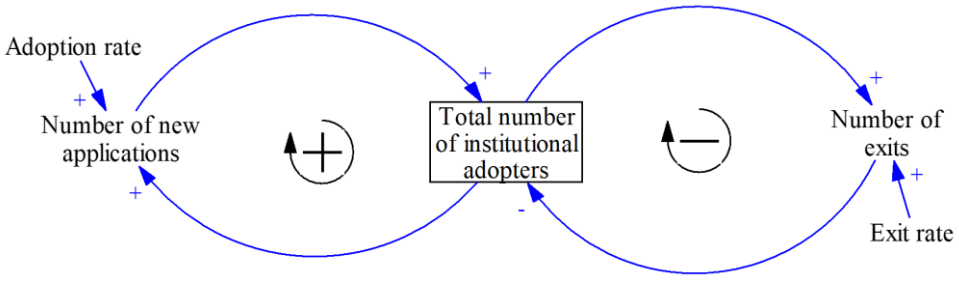


FIG. 3. Causal loop diagrams of institutional diffusion

In the quantitative model, the number of new applicants and exits is a function of the total number of institutional adopters. For this total number, the two rate variables, namely, the number of new applicants and exits, can indicate the numerical values of institutional adopter inflows and outflows over a certain period. In the expression of SD methodology, wires form SFDs to indicate changes from institutional diffusion.

Based on the study by Roberts (1978), the systematic procedural steps in SD modeling are as follows:

(1) Define the problems to solve and goals to achieve. This study integrated the mental models of farmers, retailers, and third-party certification organizations for adopting TAPS to reveal the institutional structure of TAPS.
(2) Describe the system with a causal loop/influence diagram. We clarify the major variables and causal relationships by public information or group model building.
(3) Formulate the model's structure. This study develops the flow diagram for systematizing symbols, arrow designator, and format of SD modeling in the form of VEMSIM equations.
(4) Collect the initial or base data needed for model operation from either historical data or discussions with executives/planners who have knowledge about and experience in the system under study. In this study, nonlinear functional relationships between the variables are established from expert interviews and literature reviews (Andersen et al., 1997; Ansoff and Slevin, 1968).
(5) Confirm model validity. Using qualitative and quantitative methods, this study depends on the modeler and experts to jointly identify the related variables and their causal relations to formulate the causal loop models and review them to assess the degree of compliance between simulation and reality. If the actual and simulated value of a critical variable is close, it indicates that the simulated model has essentially unfolded the actual structure, confirming all the relationships among the variables in the simulated model (Coyle, 1997; Finnemore, 1996; Friedland and Alford, 1991; Hsiao, 2014).
(6) Policy simulations. We simulated some situations to show the dynamic changes that can result from institutional diffusion.

4.2 Traceable agricultural products system isomorphism and change under various mechanisms

4.2.1 Coercive isomorphism vs. institutional change: Institutional quality

Members may tend to adopt a coercive institution to control any misbehavior of members. TAPS regulatory content was developed based on public distrust arising from repeated food safety incidents (Hall, 1986; Ikenberry, 1988; Krasner et al., 1984; Krasner, 1988). Therefore, high coercive pressure of TAPS was due to its effectiveness in diminishing misbehavior by members (such as adulteration, misleading information, or excessive use of additives) in the food supply chain, which is the measure of institutional quality used in this study. The institutional quality of TAPS depends on validation. In an interview, Shih-yu Chang, the general manager of the TAPS ECO-garden certification center, highlighted two key influencing factors, namely, number of applications for TAPS membership and auditors' ability to thoroughly screen applications. Because of detailed on-site inspection and documentation review requirements, auditors can only validate around two cases per week, and screening a greater number could erode audit credibility and TAPS institutional credibility. However, as the workload is a function of the number of capable auditors, whether TAPS serves its purpose and maintains credibility depends on having a sufficient number of capable auditors.

Figure 4 depicts the system structure for the two causal loops with opposing effects on diffusion. In the first loop, institutional quality has been observed to enhance diffusion by attracting TAPS membership applicants. The increase in applications raises the income of the certification industry, which is then able to hire additional auditors and perform more audits, leading to improved institutional quality, growth in the income of already validated farmers (known as TAPS farmers), and higher numbers of TAPS applications. In the second loop, excessive TAPS applications increase the number of applicants to be screened, which reduces institutional quality, income of TAPS farmers, and numbers of TAPS applications. Therefore, in this loop, too many applications will result in the weakening of institutional quality and diffusion.

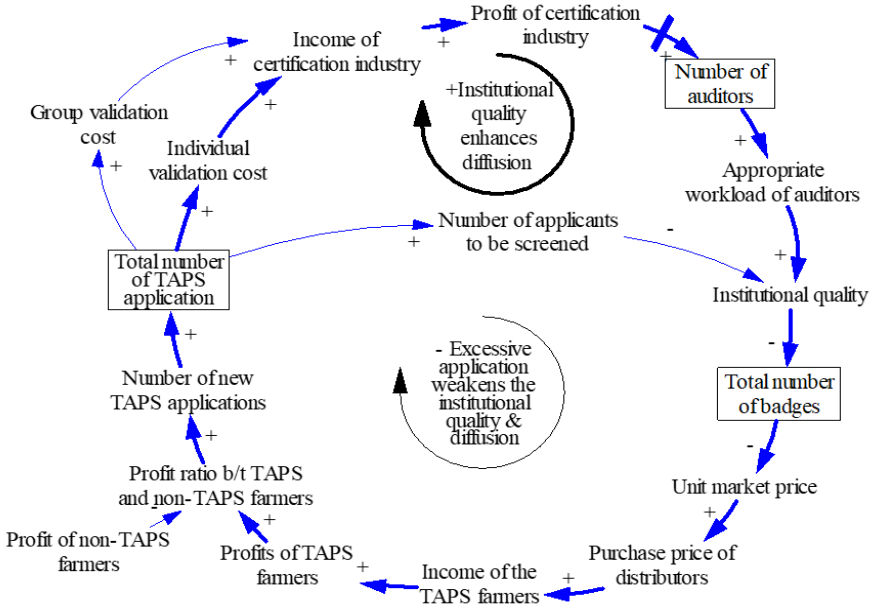


Figure 4. Institutional quality vs. diffusion subsystem

The presence of two loops between institutional quality and number of TAPS applications can cause the number of TAPS applications to dynamically change. In other words, higher institutional quality guides two loops: (1) more TAPS applications, increased income of the certification industry, and more auditors to maintain institutional quality; and (2) an increasing number of applicants waiting to be screened, which diminishes institutional quality. Overall, institutional quality is constantly changed by the loops among the numbers of TAPS applications, applicants to be screened, and auditors. This shows that institutional quality and diffusion have a nonlinear interaction. Elucidating the mechanism that drives changes in institutional quality is necessary to build consumer confidence in the system (Zhang, Mankad, & Ariyawardana, 2020).

4.2.2 Mimetic isomorphism vs. institutional change: Adopter profits

In the supply chain, individual members have limited ability to predict future profit changes that result from adopting TAPS (Simon, 1947); they tend to reference the current profits of farmers who have adopted TAPS. In other words, farmers adopt TAPS when they perceive that farmers who adopted TAPs receive adequate benefit. As TAPS discloses information about the food chain and confirms quality using third-party certification, it is intended to multiply benefits throughout the supply chain (Weingast, 2002) by, for example, reducing information asymmetry. When members believe that an institution can offer benefits in excess of their costs, they are more willing to adopt the institution, and the institution is thus successfully diffused (Friedland and Alford, 1991; North, 1990; Shepsle, 1986). Therefore, mimetic isomorphism implies that TAPS diffusion depends on the loops between the profits of TAPS farmers and number of TAPS applications.

To deconstruct the logic of mimetic isomorphism's effect on institutional diffusion, Fig. 5 shows the costs and benefits for farmers who participate in TAPS, from which it can be seen that their benefits are influenced by the balance validation cost loop and the reinforcing market forces loop. This system model indicates that institutional benefit constantly changes because (1) cost is changed through gross production, and income is changed by market price and sales, and (2) farmers need to pay validation costs first and then receive income after they sell their products.

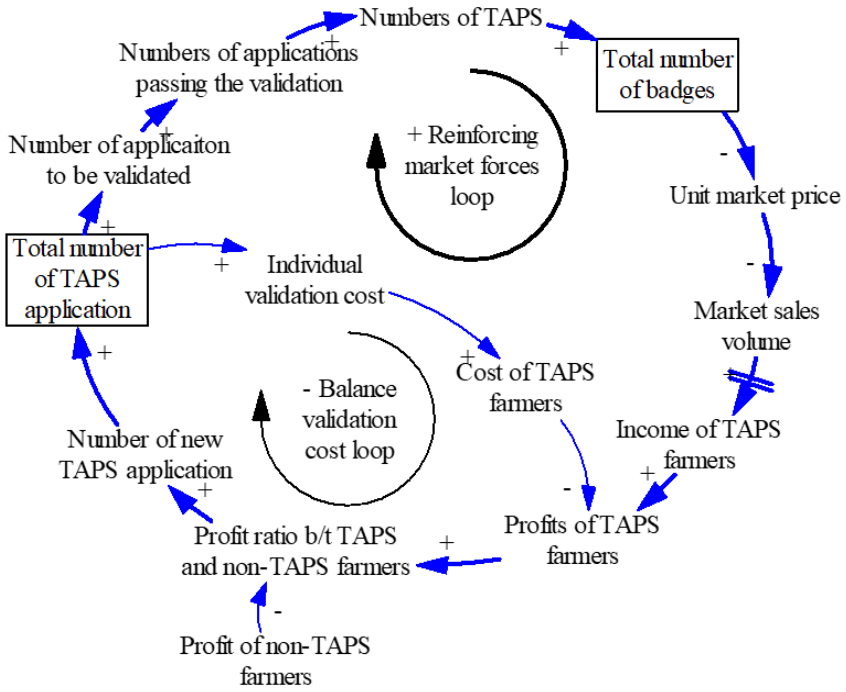


Figure 5. Institutional benefits vs. diffusion subsystem

Compared with the loop of adopting cost, the loop of adopting benefit has a time delay effect. After farmers join TAPS, their validation costs eat into their short-term profits (Oh, 2013). In the long term, the profit changes because of the dynamic prices of the TAPS market (Knight and North, 1997). This can lead to two insights: (1) potential members who are fixated only on short-term benefits could disregard long-term benefits and drop out of TAPS after the eligibility period expires, which would hamper TAPS diffusion, and (2) the strategic responses of farmers should continue to change following profit changes in adopted TAPS.

4.2.3 Normative isomorphism vs. institutional change: Profit distribution

When members of the supply chain have similar worldviews because they have undergone similar training or have had frequent interactions within the same group, they tend to adopt TAPS in response to mass adoption of TAPS by other members of the supply chain (Campbell and Pedersen, 2001).

In TAPS development, the COA encourages farmers, distributors, and marketing associations to enroll their members as a group to reduce validation costs and receive approval and affirmation by the association. In the system structure (Fig. 6), two causal feedback loops can influence group applications and institutional diffusion. First, as Fu-ta Tzeng, retail manager for Carrefour, Taiwan's largest TAPS distributor, noted in the interview, "When the selling of [TAPS-certified] products can improve our brand and then increase profits, we will lead a greater number of farmers in the group application increases," which results in a reinforcing loop of group interests, thus triggering institutional diffusion. Furthermore, although higher unit market prices for TAPS products motivate distributors to buy from TAPS-certified farmers, the higher market prices guide higher purchase prices and lower profits for distributors, thus dissuading distributors from supporting group certification (Chen and Gao, 2010). The conflicting interests of distributors and farmer reluctance block TAPS diffusion.

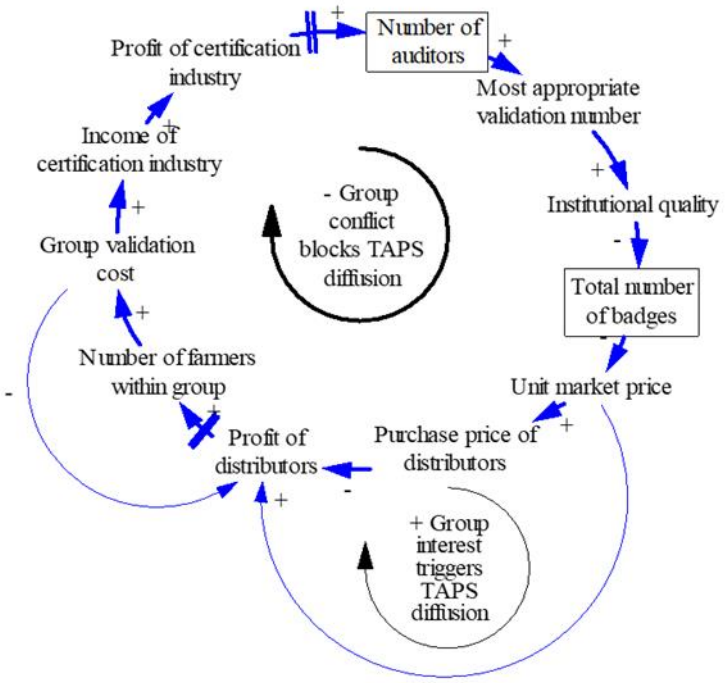


Figure 6. Institutional legitimacy vs. diffusion subsystem

To dissect the logic of normative isomorphism in institutional diffusion, Fig. 6 illustrates how TAPS diffusion depends on the cognitive consistency of participators in a social mechanism. Greater expressive and instrumental networks lead to higher purchase prices by distributors for farmers (Fombrun, 1982) and enhance TAPS adoption (number of TAPS farmers within the group); however, goal conflicts (i.e., lower purchase prices) decrease the proportion of TAPS adoption through the number of farmers within the group (Campbell and Pedersen, 2001).

5 Quantitative Model

Based on the diffusion model of TAPS, this study models the system using primary sources (e.g., interviews with local experts) and secondary sources (including data/documentaries from government and scholars). All the relationships have been generated based on literature and interviews with local experts (including farmers, distributors, and certifying associations).

To break down the elements of isomorphism logic, this study regards changes in isomorphism as dependent on the institutional structure composited by the intersecting loops of institutional quality, TAPS farmer profits, and group conflicts (i.e., purchase prices of distributors). This study consulted TAPS participators—adopted and nonadopted farmers, the general manager of a TAPS certification center, a retail manager for Carrefour (Taiwan's largest TAPS distributor), and a policy promoter (COA, Executive Yuan)—to acquire reliable data and understand the mental models of members.

The number of TAPS applications, profits of TAPS farmers, purchase prices of distributors, and level of institutional quality are discussed in the sections that follow.

5.1 Number of traceable agricultural products system applications

The number of TAPS applications has been defined as a level variable that shows the difference of *Number of new TAPS applications − Exit*. The dynamic flow chart is provided in Fig. 7, and the formula is set as Equation (1):

Total number of TAPS applications = Number of new TAPS applications – Exits (1)

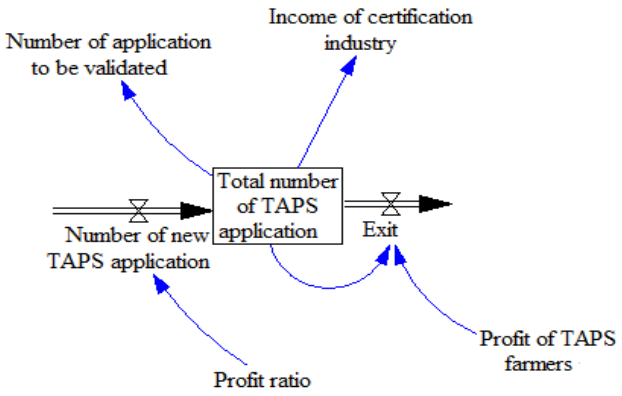


Figure 7. Dynamic flow chart for the total number of TAPS applications

In setting the formula for the number of the new TAPS applications, applicants for TAPS most likely base their continual participation in TAPS on their yearly profits. Therefore, this study adopts random sampling for farmer interviews and finds that 0.005 % of the farmers are willing to adopt TAPS if their profit after adopting TAPS would increase by more than 10 %. Therefore, the formula is set as follows:

Number of new TAPS application= (IF THEN ELSE (Profit ratio>1.1, 5.5e-005 Number of farmers across Taiwan (Time), 0))* (2)

In setting exit quantity, 19.11 % of farmers in TAPS may want to exit if they earn less profit for the year (Oh, 2013). Therefore, the formula is set as follows:

Exit = (IF THEN ELSE (Overall profits of TAPS farmers<=0, 0.1911 Total number of TAPS application, 0))* (3)

5.2 Farmer profits in traceable agricultural products system

The *Profits of TAPS farmers* are obtained as the difference between the income and cost of TAPS farmers. Therefore, the formula is set as follows:

Profits of TAPS farmers = Incomes of TAPS farmers—Overall costs of TAPS farmers (4)

To calculate the profit of TAPS farmers, *Income of TAPS farmers* is obtained by multiplying the market sales volumes and purchase prices of distributors. First, the formula for market sales volumes was designed by the actual state of the operation of the Taiwan TAPS system: (1) about 9 % of the farm produce of TAPS was purchased as food ingredients by tracing restaurants and was thus not distributed to the market, while the remaining 91 % was circulated in the market (interview with policy promoter); (2) market sales volume was often influenced by GAPS certification, which exhibited cross-elasticity and price elasticity of TAPS. In a study examining the demand for safely demonstrated farm produce, Huang (2010) mentioned that the cross-elasticity of GAP on TAPS was −0.26803, and the price elasticity of TAPS recorded was −0.49966; hence, market sales were influenced by price; and (3) production is usually measured in kilograms, and the selling price is for a 250-gram package. Hence, after unit conversion, the formula for *Market sales volume* was set as follows:

Market sales volume = 0.91((Total number of badges *250)/1000) + (−0.26803*Price of farm produce in GAP(Time))*
+ (−0.49966 Market unit price)* (5)

According to experts (such as the retail manager for Carrefour, Taiwan's largest TAPS distributor) and the discussion and assessment in this study, the purchase prices of distributors are about 57 % of the wholesale market prices; in previous years, this price was acquired from the trading website of the farm produce wholesale market (http://www.tapmc.com.taipei/Pages/Transi). Therefore, the formula for purchase prices of distributors was set as follows:

Purchase price of distributors = 0.57 unit market price* (6)

In addition, the overall *cost to farmers* includes the validation burden and the average production cost of farmers multiplied by the actual number of farmers (apart from the number of farmers within group):

Costs of TAPS farmers = Average production cost of farmer (Time) Number of TAPS*
+ Individual validation burden Number of TAPS * (1 - Group proportion)* (7)

First, the average production cost to each farmer was determined using the data for agricultural statistics released by the COA on its website (https://agrcost.afa.gov.tw/pagepub/AppInquiryPage.aspx). In addition, the validation burden was determined as a summary between the validation expenses for one-time and retest costs every three years. Data on validation expenses were captured from the website of COA (https://taft.coa.gov.tw/rsm/Orgintro.aspx).

5.3 Institutional quality

With regard to institutional quality, the general manager of the certification center noted that "if the quantity of validation is too large for a validation staff member, the quality of his/her validation will decline." Hence, the formulas for institutional quality are as follows:

Institutional quality = Most appropriate number of validations/Number of applications to be validated (8)

Of these, the most appropriate number of validations was inferred by the number of full-time auditors. Shih-yu Chang, general manager of a TAPS ECO-garden certification center, expanded on this during the interview:

> *The upper limit for them is eight cases/month/person. Of the five working days in a week, they need to take a business trip for on-the-spot auditing for two days, while handling paperwork for the remaining three days. This is a good tempo.*

Therefore, the most appropriate validation number is obtained by multiplying the number of auditors by eight cases/month/person. Specifically, the number of auditors includes the number of part-time and full-time auditors. Hence, this study sets the formula for the most appropriate number of validations as Equation (10). In addition, the number of applications to be validated is equivalent to the number of TAPS applications:

*Most appropriate number of validations = (Number of part-time auditors + Number of full-time auditors)*12*8* (9)

6 Results and Simulations

6.1 Model verification

To confirm whether our model elucidates the actual situation of TAPS diffusion, model robustness was tested qualitatively and quantitatively (Coyle, 1997; Hsieh, 1980). First, to test qualitative robustness from the evidence and theories collected from research and domain experts' insights and judgments, the model was iteratively adjusted from a series of discussion meetings until the proposed models have accurately explained the reference modes and satisfied the applicable criteria suggested by Forrester and Senge (1996) and Barlas (1996).

Second, a prior study on quantitative robustness was consulted to assess the degree of compliance between the model and reality (Coyle, 1997), with the assessment of model effectiveness focusing more on actual trends. To test the TAPS diffusion model's robustness using the critical indicators, the number of TAPS badges was seen as the index for institutional diffusion (Finnemore, 1996; Friedland and Alford, 1991). Figure 8 compares the simulated and actual number of TAPS badges for TAPS-certified products (http://amis.afa.gov.tw/main/Main.aspx), from which it was found that the trends in the number of recorded insignias were deemed consistent (Forrester and Senge, 1996), thus confirming the robustness (validity) of the simulation (Hsieh, 1980).

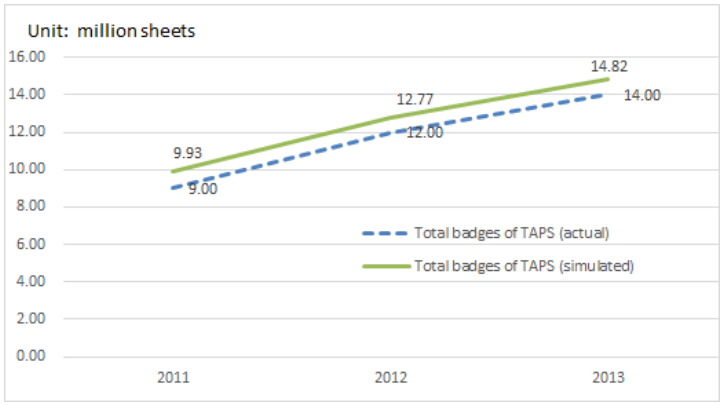


Figure 8. Trend of total badges of TAPS (Actual vs. Simulated)

6.2 Simulation results

6.2.1 Changes in coercive isomorphism: Traceable agricultural products system quality and number of badges

Changes in TAPS diffusion (i.e., change in the number of badges) have been determined to be related to changes in TAPS quality. Figure 9 shows that most trends in TAPS diffusion (i.e., number of badges) and TAPS quality are inversely related. In 2014–2015, institutional quality was observed to decline, and reduction in the number of total badges slightly increased (see Fig. 9).

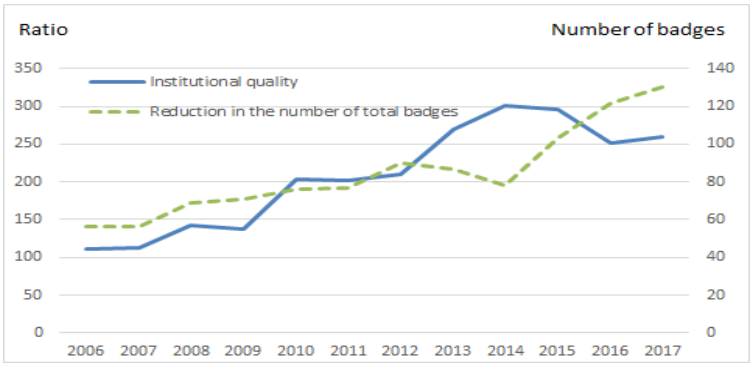


Figure 9. Reduction in the total badges and TAPS quality

Figure 10 shows that changes in TAPS quality are related to the changes in TAPS regulatory resources (called the growth rate of the appropriate auditor workload) and of TAPS diffusion (as measured by the growth rate of the number of applicants to be screened). In 2006–2014, institutional quality kept increasing, as the growth rate of the appropriate auditor workload was larger than the number of applicants to be screened. Conversely, from 2014 to 2016, the growth rate of the number of applicants to be screened was larger than that of the appropriate auditor workload, thereafter declining institutional quality. This indicated that changes in TAPS quality are caused by interactions between the number of applicants to be screened and the appropriate auditor workload.

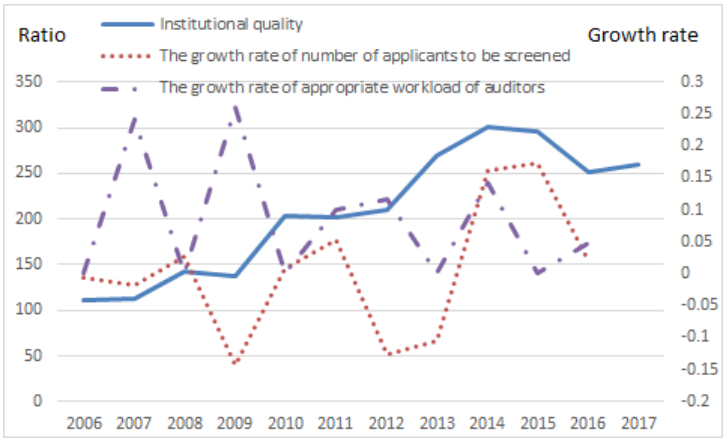


Figure 10. Changes in TAPS quality

6.2.2 Change in mimetic isomorphism: Traceable agricultural products system profit and total badges

Changes in TAPS diffusion (i.e., change in total badges) have been determined to depend on changes in the profits of TAPS members. Figure 11 shows that the increment in the total number of badges decreased in 2006–2013, when TAPS profit was negative. Starting from 2014, the increment of total badges increased because TAPS farmers generated profits in 2013. This shows the positive effect on TAPS profits from changes that resulted from TAPS diffusion.

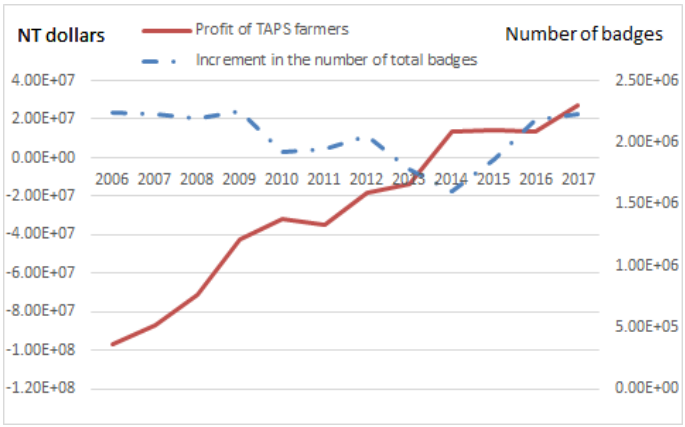


Figure 11. Increment in total badges and TAPS profit

Figure 12 represents the changes in TAPS profits related to changes in TAPS cost and income. For a TAPS farmer, over a short period, the total cost is larger than the income incurred. Until 2014, for a TAPS farmer, the cost (including validation cost) was covered by TAPS income.

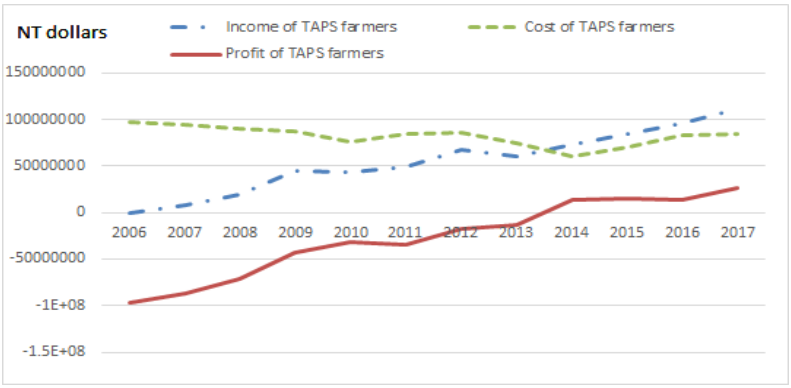


Figure 12. Changes in TAPS farmers' profit

6.2.3 Change in normative isomorphism: Interest conflict and farmer group

In the development of TAPS diffusion, the COA encourages distributors to enroll their suppliers (i.e., farmers) as a group to adopt TAPS. Within a group, the purchase price of distributors seems to be the factor that generates conflicts. In the agrifood supply chain, the distributor has more bargaining power than the farmer. The higher purchase price of a distributor implies willingness to share more profit with the farmer within the group. Consequently, high purchase price indicates that conflicts of interest within the group are low. In Fig. 13, from 2006 to 2017, the purchase prices of distributors were observed to have changed synchronously with the number of farmers within the group. This shows that the changing of TAPS diffusion within a group relies on interest sharing within the group (i.e., low group conflict).

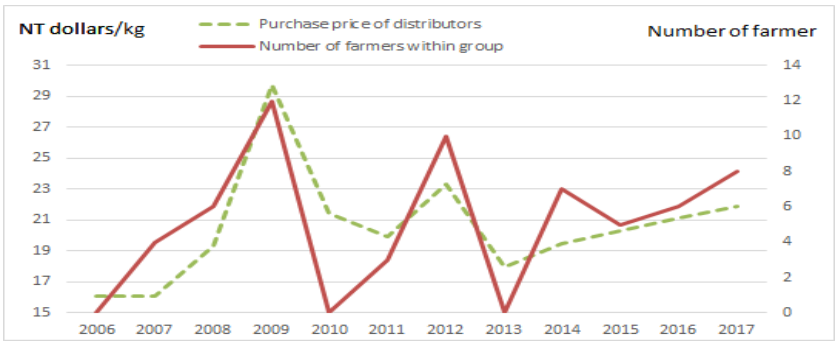


Figure 13. Change in group diffusion vs. goal conflict

7. Policy Simulations

To extend managerial implication for members or policymakers, this section focuses on two policy simulations. The first is the recent case of TAPS promotion, i.e., the school lunch program with TAPS initiated by the COA and Taiwan's Ministry of Education (MOE) in 2016. The second scenario is government subsidies for the purchase of TAPS products to reduce conflict between farmers and distributors. The following sections not only show the effects of these scenarios in institutional quality, benefit, and legitimacy but also discuss the managerial implications for decision-makers in policy promotion and institutional adoption.

7.1 School lunch programs with the traceable agricultural products system

The MOE subsidizes elementary school lunch programs in selected cities (Hsu, 2008; Wong and Chang, 2012); however, meals are often substandard because the purchased bulk ingredients are stale or dated. In 2016, the COA and MOE require that elementary schools buy TAPS-certified agriproducts for their lunch programs. The original intention of this TAPS promotion was to control the quality of the lunch program and to enhance the diffusion of TAPS through increased demand. By simulation, the following sections show the trends in adopter profits, institutional quality, and legitimacy under the school lunch program.

7.1.1 Increasing institutional benefit: Improved participant profits

To examine the economic effect of the school lunch on TAPS program, we calculated the daily number of vegetables used in the lunch program by the number of elementary school students in Taiwan and included the daily number into market sales volume, from which it was found that profits increased for TAPS participants (Fig. 14).

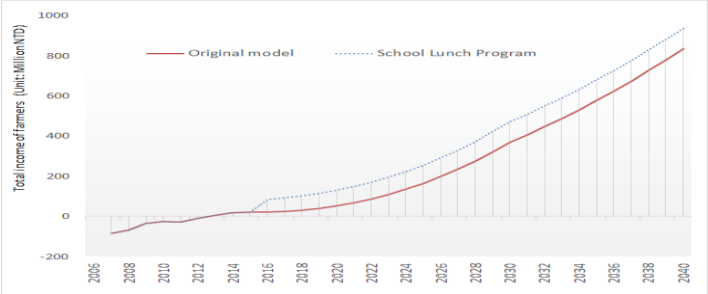


Figure 14. Trend of TAPS Participants Profits under School Lunch Program

7.1.2 Diminishing institutional quality: Sales exceeding supply

The sales and supply ratio is an indicator representing TAPS market efficiency. The TAPS market is considered efficient when sales equal supply (ratio = 1). However, the TAPS market is considered inefficient when sales are less than the supply (ratio < 1, i.e., some TAPS stock is still in the market) or sales are greater than the supply (ratio > 1, i.e., there are several fakes in the market).

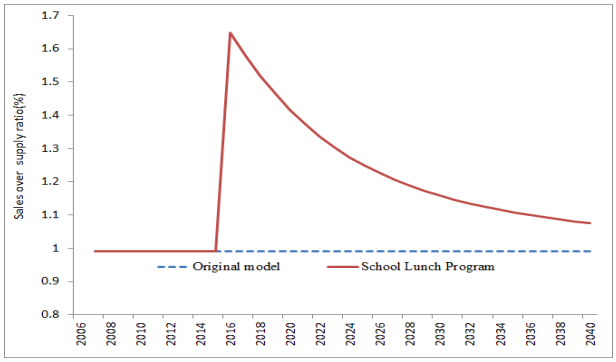


Figure 15. Trend of TAPS sales and supply ratio under school lunch program

Figure 15 shows that the supply of TAPS-certified agriproducts was sufficient to meet the inputs required by the school lunch program in its early years. However, our simulation suggested that within a few years, the lunch program would require a 60–70 % greater volume of agriproducts than TAPS-certified producers could supply, which, in turn, would lead to the entry of fraudulent products. This result supported the concerns of Taiwanese media, which speculated that the growth rate of program demands would be greater than the rate of supply of TAPS-certified products and that fraudulent products could damage the institutional quality of TAPS (https://www.newsmarket.com.tw/blog/87576/).

7.1.3 Limited growth in institutional legitimacy

At the onset, TAPS-certified producers can supply the lunch program needs, and increased demand attracts more TAPS participants, and more certification insignias are issued. However, over the medium and long term, program needs outstrip the TAPS-certified products available, and fraudulent products appear and erode confidence in TAPS; therefore, the simulation showed that the lunch program alongside the application of TAPS-certified agriproducts would benefit TAPS only in the short term, and thus the long-term impact would be limited (Fig. 16).

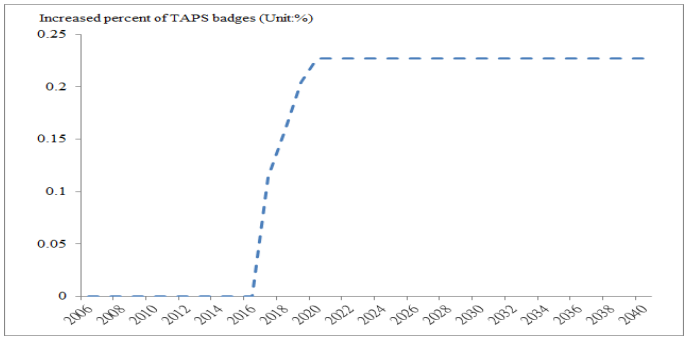


Figure 16. Change in TAPS badges under School Lunch Program

7.1.4 Strategic response to adoption of traceable agricultural products system in school lunch programs

The school lunch program for TAPS promotion should lead to the adoption of TAPS by more decision-makers as it increases the demand for TAPS agriproducts and the profits of TAPS adopters by mimetic isomorphism. However, the institutional structure of TAPS indicates that the program limits diffusion of TAPS over the long term (around 2020) because it leads to the entry of fraudulent products. Hence, for TAPS adopters, the school lunch program can enhance profits but will not do so for the long term. Consequently, we must decide to keep adopting or abandon TAPS after assessing its quality.

7.2 Subsidies for products certified by the traceable agricultural products system

When distributors prevail, the purchase price is deemed lower; thus, their loop determines institutional diffusion. However, if farmers gain higher prices, their diffusion loop prevails. Our study suggests that the government could initiate both loops simultaneously and encourage TAPS diffusion by subsidizing purchase prices for distributors. Then, the trends of adopter profits, institutional quality, and legitimacy under the subsidizing TAPS-product were simulated as follows.

7.2.1 Increasing institutional benefit: Improved participant profits

It was assumed that in 2016, the government has subsidized distributors 10 % of the price they pay for TAPS agriproducts to farmers. After promoting TAPS in such manner, TAPS farmer incomes reportedly increased, while TAPS distributors did not have to bear more purchase costs (Fig. 17).

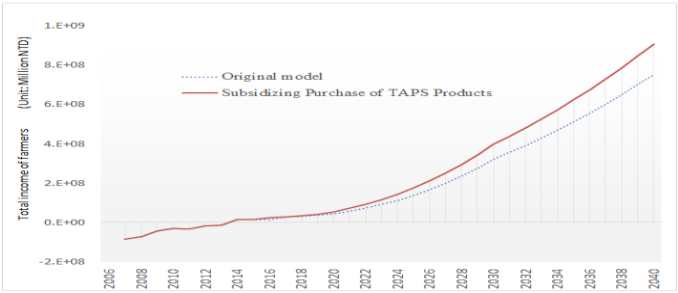


Figure 17. Trend of TAPS participants' profits under subsidizing TAPS-certified products

7.2.2 Stabilization of institutional quality: Balanced supply and demand

Subsidies boost profits for distributors and farmers, stimulating the supply of TAPS-certified products, at the same time balancing supply and sales. Therefore, in Fig. 18, the sales and supply ratio gradually grows (close to 1), but oversupply of TAPS products (sales over supply ratio larger than 1) never occurs. This shows that the policy of subsidizing TAPS products would enable greater market efficiency for TAPS products.

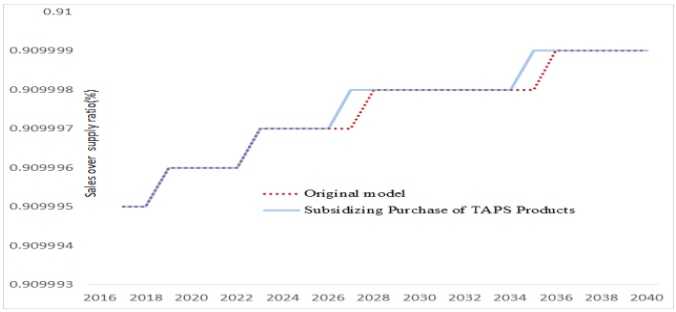


Figure 18. Trend of TAPS sales and supply ratio under subsidizing TAPS-certified products

7.2.3 Stable growth in institutional legitimacy

Figure 19 illustrates that the number of TAPS badges rises steadily after subsidizing TAPS-certified products.

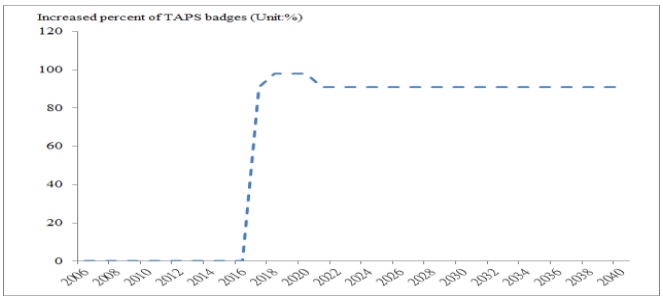


Figure 19. Change in TAPS badges under subsidizing TAPS-certified products

7.2.4 Institutional diffusion strategy for traceable agricultural products system: Subsidies for TAPS-certified products

Because individual behavior is embedded in the policy, market, and social systems (Thompson, 1991), for policymakers, a strategy of institutional diffusion should be designed to support the understanding of the institutional structure to avoid the development of partial perspectives in relation to the circumstances (Forrester, 1992; Forrester, 1997).

Based on the institutional structure built by integrating the mental models of stakeholders, this study suggests that a strategy to trigger institutional diffusion should diminish the conflicts among stakeholders. Therefore, this study further suggests that the government could start both loops simultaneously and encourage TAPS diffusion by subsidizing purchase prices for distributors. The simulation shows that subsidizing TAPS-certified products not only enhances TAPS adoption but also maintains institutional quality and growth.

8. Conclusions and managerial implications

Institutional studies regard industrial norms arising from institutional diffusion as having been built by members' isomorphic behaviors in the field. However, this view overlooks the causes of the dynamic changes that result from institutional diffusion (Beckert, 2010; Campbell, 1997; Peters, 2011). By integrating the mental models of stakeholders in the field, this study emphasizes that changes in institutional isomorphism are based dynamically on the institutional structures embedded in isomorphism logic. Unfolding of previous literature regards isomorphism logical elements (such as coercive, mimetic, and normative isomorphism logics) as processes of conscious calculation; this study employed an SD perspective to capture the following insights: (1) changes in coercive isomorphism are a result of the loop of a dynamic interactive process between institutional diffusion and the regulatory resource, which is related to the institution; (2) changes in mimetic isomorphism are a result of the loop of a dynamic interactive process between institutional diffusion and TAPS farmer profits; and (3) changes in normative isomorphism are a result of a dynamic interactive process between institutional diffusion and cognitive consistency. Overall, changes in isomorphism are based on the interactions between the conscious pressures of adopters (such as coercive, mimetic, and normative pressures) and structural instability (embedded in regulatory, market, and social mechanisms).

As far as managerial implications for policy promoters and institutional adopters, this study highlights that the institutional response of participators and institutional diffusion should be dynamically altered by the institutional structure composited by the mental models of stakeholders. In Section 7, this study separately shows the different effects of two kinds of policy promotion (i.e., school lunch with TAPS program and subsidies for TAPS-certified products) on institutional profit, quality, and legitimacy. These findings were as follows: market driving, such as the school lunch program, triggers an institutional benefit in the short term but sacrifices institutional quality and legitimacy in the long term. From the viewpoint of SD, by slowing down the conflict point among stakeholders, sustainable growth can be achieved that includes institutional benefit, quality, and legitimacy in the long term. For an institutional adopter, a comprehensive understanding of the effects of institutional structure on institutional profit, quality, and legitimacy aids in the dynamic adjustment of response strategies.

Finally, the recommendations for future research came from study limitations. First, the effect of other TAPS labels was not considered. Second, the relationship between the variables in the topic is relatively hidden, and the data remain limited. By interviewing and summarizing the experience of experts, this study clarifies the relationships among variables. For example, variables such as verification quality in the promotion system are difficult to define directly. Therefore, this study uses only the expert opinions from interviews as the measurement method. Nevertheless, based on the relationships among the indices of expert opinions and literature review, the validity of our model is verified by agreement between simulated and actual historical trends (Barlas 1996). As the preferences of target consumers vary (Tessitore, Iraldo, Apicella, & Tarrbella, 2020), in future studies, more or diverse determinants (e.g., alternative label, consumer preference) should be involved to clarify the diffusion of TAPS, and multiple cases among different countries should be analyzed with regard to the factors, pathways, and reasons of institutional diffusion.

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