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Market Competition and Economic Effects of Government Policies

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ABSTRACT

By utilizing systems methodology and thinking logic, this paper derives a general theorem to characterize when and how a market signals for additional competition from market players. Then, it establishes conditions for when government policies actually work in real life, where firms' performances are effectively promoted no matter what offer the firms produce. Among others, the established conditions include improving managerial and resource efficiencies, promoting information and knowledge sharing, joining in organizational networks, forming manufacturing agglomerations, and localizing economic policies. By using the difference-in-difference method, a real-life case analysis with data from China is used to confirm the six formal propositions established systemically in this paper. In the conclusion section, recommendations for policy makers, such as government officers, are provided regarding when and how adopted policies will potentially produce anticipated results, while directions and unsettled questions are also posted for the forthcoming academic endeavors.

KEYWORDS

Closed Market, Economic Performance, Manufacturing, Nash Equilibrium, Network, Supply-Chain Ecosystem

1. INTRODUCTION

Since the start of this new century, various leading nations have engaged in industrial transformations from automated manufacturing to intelligent manufacturing. The so-called fourth industrial revolution has been seen (Industry 4.0) as reflected in a manufacturing sector backed by much more advanced intelligence; manufacturing firms will adopt intelligent manufacturing technologies and processes, including cyber-physical systems (CPS), the internet of things (IoT), cloud computing, cognitive

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computing and artificial intelligence (AI). Based on a lesson learned from the past successes of several rounds of industrial revolutions (Rostow, 1960; Wen, 2016), these nations have been actively orchestrating their desired transformations by introducing and implementing various policies and providing governmental supports. Examples of those efforts include the following:

- Since 2011, the USA has launched a series of strategic plans and acts, such as the "Advanced Manufacturing Partnership Program" (PCAST, 2012), "Revitalizing the US Manufacturing and Innovation Act 2014", the "National Manufacturing Innovation Network Strategic Plan" (OWH, 2016), and established the "Industrial Internet Alliance" in 2014;
- In 2013, German industry and academia jointly proposed and advocated for such a platform known as "Industry 4.0";
- In 2015, the concept of ultra-smart "Society 5.0" appeared in Japan (Government of Japan, 2015) in an effort to ensure Japan's dominance in manufacturing. The materialization of this concept was expected to rely on the nation's superior technology and relevant systemic foundations;
- In 2015, China announced "Made in China 2025" (State Council of the PRC, 2015). In the following year, China put forward the "Guiding Opinions on Deepening the Integral Development of Manufacturing Industry and Internet" (State Council of the PRC, 2016) and "Development Plan of Intelligent Manufacturing (2016-2020)" (MIIT, 2016a); and
- In 2017, the government of the United Kingdom made a plan for "Growing the Artificial Intelligence Industry in the UK" (Hall & Pesenti, 2017).

With these developments transpiring, the following research question arises naturally: how do government policies affect the economic performance of manufacturing firms? Answers to this question are important for developed nations, because these nations desire to maintain their leading positions in the world economy. Simultaneously, answers to this question are also important to developing and undeveloped nations, because they face a strong possibility of further trailing behind the developed nations economically, socially, and politically. To address this question, the current work attempts to provide relevant answers by using the logic and methodology of systems science. In terms of the literature, this logic and methodology represents an unconventional approach.

The logic and methodology used here merits special attention, in particular due to their contrast with other approaches to answering the same or similar questions. The logic parallels the logical reasoning used in mathematics (Kline, 1972) and are not constrained data and/or anecdotes (Kuhn, 1962). By contrast, empirically developed conclusions are tethered to specific data, making extrapolation to other facts potentially less reliable. Thus, the goal of the propositions established below is to allow generation of reliable policy recommendations – instead of suggestions. As for systemic reasoning, an increasing number of business studies, such as Porter (1985), Mazzei et al. (2017), Forrest (2018), etc., have employed such an approach.

The remaining five sections of this paper are organized to review relevant literature (Section 2), to establish six general propositions regarding the economic effects of government policies (Section 3), and to confirm some of the conclusions established in this paper through the analysis of some real-life data (Section 4). In the conclusion section, other than recommendations expectedly useful for practical purposes, we also point out a few important questions for the following research endeavors (Section 5).

2. LITERATURE REVIEW

Borrás and Edquist (2013) argue that mixed varieties of innovation policies should be introduced to address issues faced in any innovation system. By reviewing approaches used by six communities in Idaho, Oregon and Utah to mitigate wildfire risk at two points in time, Stidham et al. (2014) find that

the policy tool consistently utilized across these communities was capacity-building. By examining interest rate, exchange rate and bank lending channel for the transmission mechanism of monetary policy in the USA, Endut et al (2018) suggest that lending channels of banks played a nonignorable role until early 1980s. Without assuming policy targets are rational utility maximisers, Howlett (2018) proposes a new research and practice agenda that focus on better matching tool mixes and target behaviors.

By investigating the effects of various shocks and optimal policy responses to those shocks, Cúrdia and Woodford (2016) find that simple target criteria continue to provide a good approximation to optimal policy. By assessing the impact of unconventional monetary policies in Europe on financial market, Fratzscher and colleagues (2016) suggest that these monetary policies boosted the prices of equities, while decreasing the disintegration of the bond market, while positively influencing equity markets and market confidence. Kirchner and van Wijnbergen (2016) study fiscal policy, sovereign debt, financial fragility, and their interactions. They find that when banks invested heavily in sovereign debt, fiscal stimuli lost their effectiveness and relevant gains dropped significantly when interest rates were at the Zero Lower Bound. Through examining how labor clauses address issues in public supply chains, Jaehrling et al. (2018) demonstrate the importance of alliances of local politicians, unions and employers in ensuring socially responsible procurement.

Enriching this literature, this study theoretically develops circumstances for manufacturing firms to improve their economic performance. Additionally, the systemic reasoning used herein helps avoid the methodological pitfall experienced by rounds of debate on whether or not governmental policies are necessary for the healthy development of an economy. As well discussed in (Andreoni & Chang, 2019), these rounds of debate had been started even before Adam Smith's time. In particular, the rounds of debate respectively produced inconclusive and inconsistent reasons either for or against the adoption of economic policies based on anecdotes and statistics, while, in the contrast, results established herein are scientifically sound without being limited by data and anecdotes.

3. HOW ECONOMIC POLICIES OF THE GOVERNMENT AFFECT MARKET COMPETITION

This section first investigates how a person with entrepreneurial spirit can decipher market signals for additional competition and new innovations. Second, it examines how government policies might produce expected economic consequences.

3.1. The Competitive Dynamics of the Market

Forrest and colleagues (2018) articulate a new definition of innovation, which represents a set of one activity or several that are necessary for the proposal and manufacture of such a market offer that leads to exceptionally added value for a firm when compared to other activities that are taking place at the same time in the same economic sector. Put simply, innovation refers to all associated actions that are needed for the introduction and market presentation of either a much-improved product or an original offer, where, of course, finding particular patterns of demand and supply is critically important (Tanantong & Ramjan, 2021). Although Forrest et al. (2018) only recently rephrased the concept of innovation, how important innovation is has indeed been well recognized since at least the time of Adam Smith (1776). However, the following theorem is the first of its kind that spells out the exact reason for why innovation is so important in terms of creating value.

Theorem 1. For the closed oligopoly market of free competition defined below, in the Nash equilibrium, if the percentage of consumers who are not loyal to any particular firm, is greater than that of any incumbent firm's loyal customers, then a new company will competitively and profitably invade the market with its version of offering while the invader can expect to make more than at least some of the incumbent firms.

The market, cited in Theorem 1, satisfies the following assumptions: (1) There are *m* incumbent firms, $m = 1, 2, \ldots$, that serve the market with their varied offerings, which are substitutes of each other. (2) The costs of production and marketing for each incumbent firm is constant. (3) Each incumbent firm is followed by a base of loyal customers. These customers first consider the offer by their favorite firm, when the price of the product is within their financial allowance or no more than their reservation value. (4) The incumbent firms compete over the market surplus, consisting of those customers, called switchers, who switch from the offering of one firm to that of another depending on whose price is more competitive. (5) The incumbent firms enjoy an information transparancy. That is, every company's pricing strategy is known to all market participants who in turn respond by pure self-analysis and by reaching the ideal Nash equilibrium.

Proof. Let i, C_i and M_i respectively denote an incumbent firm, its costs of production and marketing and the reservation price of its loyal customers. Let $L_i\left(x_1, x_2, x_3, \ldots\right)$ and $U_i\left(x_1, x_2, x_3, \ldots\right)$ respectively be the lower and upper bounds of Firm i's boundary conditions. The variables x_1, x_2, x_3, … represent all the factors tangled in the firm's production and marketing of the offer, for $i = 1, 2, \ldots, m$. Then there are real numbers α_i and β_i satisfying $0 \le \alpha_i, \beta_i \le 1$, and that the price P_i and the magnitude N_i of Firm i's base of loyal customers satisfy respectively

$$P_i = C_i + \alpha_i\left(M_i - C_i\right) \tag{1}$$

and

$$N_i = L_i\left(x_1, x_2, x_3, \ldots\right) + \beta_i\left[U_i\left(x_1, x_2, x_3, \ldots\right) - L_i\left(x_1, x_2, x_3, \ldots\right)\right], \tag{2}$$

for $i = 1,2,\ldots$ That is, to compete with one another, the incumbent firms adjust their α_i-values and increase β_i-values, $i = 1,2,\ldots$ Without causing confusion, in the rest of the proof, α_i will be identified with the price P_i; and β_i with the magnitude N_i; and instead of α_i and N_i, both P_i and β_i will be used correspondingly. Then, the price P_i falls between the cost 0 and reservation price 1, the magnitude β_i satisfies $0 \le \beta_i \le 1$, and $\beta = 1 - \sum_{i=1}^{m} \beta_i$ represents the proportion of the switchers in the market place.

According to Forrest et al. (2020b) (the proof of Theorem 3.2), it follows that the game these incumbent firms play by using price strategies does not have any pure strategy in the Nash equilibrium. Assume that $F_k\left(P\right)$ is the price distribution of Firm k in the Nash equilibrium. Then, the objective function of Firm k is to choose such a $F_k\left(P\right)$ that maximizes its expected profits:

$$E\left(\square_k\right) = \int_{-\infty}^{+\infty} \left\{\beta_k P + \prod_{i=1, i\neq k}^{m} \left[1 - F_i\left(P\right)\right]\beta P\right\} dF_k\left(P\right), \tag{3}$$

where $\square_k$ is Firm k's profits. The equilibrium indifference condition for Firm k is

$$\beta_k P + \prod_{i=1, i\neq k}^{m} \left[1 - F_i\left(P\right)\right]\beta P = \beta_k, k = 1,2,3,\ldots \tag{4}$$

If the i th equation in equation (4) is divided by the j th equation, for i , $j = 1, 2, \ldots, m$, $i \neq j$, we produce

$$1 - F_j\left(P\right) = \frac{\beta_i}{\beta_j}\left[1 - F_i\left(P\right)\right]. \tag{5}$$

So, equations (4) and (5) jointly produce

$$F_k\left(P\right) = 1 - \frac{1}{\beta_k}\left(\frac{\left(1-P\right)\prod_{i=1}^{m}\beta_i}{\beta P}\right)^{\frac{1}{m-1}}, k = 1, 2, 3, \ldots \tag{6}$$

satisfying

$$F_k\left(1\right) = 1 \text{and} F_k\left(\frac{\beta_k}{\beta_k + \beta}\right) = 0. \tag{7}$$

What is established so far implies that with all the normalizations given above, in the Nash equilibrium, the normalized magnitudes of the incumbent firms' loyal-customer bases are equal to each other. If not, let $\beta_k = \max\left\{\beta_1, \beta_2, \ldots \beta_m\right\}$ and choose k_0 satisfying $1 \leq k_0 \leq m$ and $\beta_k > \beta_{k_0}$. Now equation (3) implies that in the Nash equilibrium, Firm k expects to produce the following amount of profits

$$E\left(\square_k\right) = \left(\prod_{j=1, j\neq k}^{m}\beta_j\right)^{\frac{1}{m-1}}. \tag{8}$$

The definition of loyal consumers means

$$E\left(\square_k\right) = \left(\prod_{j=1, j\neq k}^{m}\beta_j\right)^{\frac{1}{m-1}} \geq \beta_k = \left(\overbrace{\beta_k\beta_k \ldots \beta_k}^{m-1 \text{ times}}\right)^{1/(m-1)}. \tag{9}$$

However, for every $j = 1, , 2, \ldots, m, j \neq k, j \neq k_0$, we have $\beta_j \leq \beta_k$ and $\beta_{k_0} < \beta_k$, which makes the left-hand side of equation (9) less than the right-hand side. A contradiction. This contradiction implies that the normalizations, given above, help standardize the incumbent firms' loyal-customer bases to the same size.

The conditions of the given oligopoly market jointly imply that all relevant technologies and business operations have been well developed and standardized for efficiency and for the maintenance of the prevalent mutual forbearance of the market (Bernheim & Whinston, 1990). So, for a new firm to enter this market competitively and profitably, the firm must have acquired a new way to be more efficient than the incumbent firms, such as the adoption of an innovative technology or managerial process or something else.

Based on this realization, assume that an entering firm comes into the closed economic market of free competition by employing such a strategy that it randomizes its price P uniformly over the interval [0,1], which in fact represents the interval from the total cost of business to the maximum selling price that can be possible charged. The objective of this entrant firm is to survive the rivalry from the incumbent firms while trying to make some profits on the average. That is, the entering firm is willing to provide its offering to the market at any price as long as no loss is incurred. As discussed above in equations (1) and (2), this new entering company can normalize the marginal cost and the maximum expected selling price respectively to 0 and 1.

By considering all new entrants collectively as one aggregated firm, we can assume that only one firm actually enters the described market. Simply by entering the market, the new entrant threatens to abruptly disrupt the mutual forbearance existing in the marketplace, as established by the incumbent firms' interactions with each other over time. In response, each incumbent firm sets its price after considering the prices of the new firm and all other incumbent firms. So, the equilibrium indifference condition of Firm k is

$$\alpha \times P + \beta \times P \prod_{j \neq k}^{m} \left(1 - P\right)\left[1 - F_j\left(P\right)\right] = \alpha \times 1. \tag{10}$$

By solving equation (10) the following symmetric equilibrium pricing strategy of the incumbent firms emerges:

$$F\left(P\right) = 1 - \left(\frac{1-\beta}{\beta m P}\right)^{\frac{1}{m-1}}. \tag{11}$$

The assumption that the consumer surplus $\beta \geq \left(1-\beta\right)/m$ (= the magnitude of an incumbent firm's base of loyal customers) implies that equation (11) is a well-defined mixed strategy for each incumbent firm for any price P satisfying $\left(1-\beta\right)/\left(\beta m\right) \leq P \leq 1$, and $\left(1-\beta\right)/\left(\beta m\right)$ is the lowest price these firms can afford to charge their customers.

For the rest of the proof, it suffices to show that the entrant can actually expect to make more profits in this market than any of the incumbents under all the normalizations employed earlier. Because

$$\lim_{P \to 1^{-}} F\left(P\right) = 1 - \left(\frac{1-\beta}{\beta m}\right)^{\frac{1}{m-1}} \neq F\left(1\right) = 1, \tag{12}$$

the cumulative price distribution function $F\left(P\right)$ has a mass point of size $\left[\left(1-\beta\right)/\left(\beta m\right)\right]^{\frac{1}{m-1}}$ at the reservation value $P = 1$. So, the expected profits of the entrant firm are:

$$E_e\left(\Pi\right) = \int_0^{\left(1-\beta\right)/\left(\beta m\right)} \beta P dP + \int_{\left(1-\beta\right)/\left(\beta m\right)}^{+\infty} \beta P \left[1 - F\left(P\right)\right]^m dP \tag{13}$$

$$= \int_0^{(1-\beta)/(\beta m)} \beta P dP + \int_{(1-\beta)/(\beta m)}^1 \beta P\left[1-F\left(P\right)\right]^m dP + \beta\left(\frac{1-\beta}{\beta m}\right)^{\frac{m}{m-1}} \tag{14}$$

$$= \begin{cases} \dfrac{-\left(1-\beta\right)^2}{2\beta m\left(m-2\right)} + \dfrac{m-1}{\left(m-2\right)}\left[\dfrac{\left(1-\beta\right)^m}{\beta m^m}\right]^{\frac{1}{m-1}} + \beta\left(\dfrac{1-\beta}{\beta m}\right)^{\frac{m}{m-1}}, & \text{if } m \geq 3 \\ \dfrac{\left(1-\beta\right)^2}{2\beta m^2} - \dfrac{\left(1-\beta\right)^2}{\beta m^2} ln\dfrac{1-\beta}{\beta m} + \beta\left(\dfrac{1-\beta}{\beta m}\right)^{\frac{m}{m-1}}, & \text{if } m = 2 \end{cases} \tag{15}$$

where the first term in the right-hand side of equation (13) is the expected profits of the entrant firm when it charges the lowest price in the market place and captures the entire segment of the switchers, and the second term of equation (13) is the firm's expected profits when it is in direct competition with the incumbent firms.

The expected profits of any incumbent firm are

$$E_m\left(\Pi\right) = \int_{(1-\beta)/(\beta m)}^1 \left\{\frac{1-\beta}{m}P + \beta P\left(1-P\right)\prod_{j\neq i}^m\left[1-F\left(P\right)\right]\right\} dF\left(P\right) + \frac{1-\beta}{m}\left(\frac{1-\beta}{\beta m}\right)^{\frac{1}{m-1}}$$

$$= \int_{(1-\beta)/(\beta m)}^1 \frac{1-\beta}{m} dF\left(P\right) + \frac{1-\beta}{m}\left(\frac{1-\beta}{\beta m}\right)^{\frac{1}{m-1}} = \frac{1-\beta}{m}. \tag{16}$$

It is ready to check that,

$$\frac{\partial}{\partial\alpha}\left[E_e\left(\Pi\right) - E_m\left(\Pi\right)\right] > 0, \tag{17}$$

where $\alpha = \left(1-\beta\right)/m$, and that when $\beta = 1/\left(m+1\right)$, $E_e\left(\Pi\right) - E_m\left(\Pi\right) > 0$. Hence, there is $\alpha^* \in \left(0,1/(m+1)\right)$ such that when $\alpha = \left(1-\beta\right)/m \geq \alpha^*$, $E_e\left(\Pi\right) > E_m\left(\Pi\right)$. So, the conclusion of Theorem 1 follows. This ends the proof.

3.2. Adoption of Government Policies and Consequent Economic Effects

In economics, the term 'product' means any market offer or offering. That can be a tangible or an intangible thing, such as a physical item as a chair or a promise as an insurance policy; a tangible service, such as a user-operated laundry facility; or a good that consists of different pieces of information, such as an advice on investment options. However, in management and marketing and related investigations, 'product' seems to stand only for a tangible, physical item that can be potentially traded in the marketplace (Porter, 1985; Stabell & Fjeldstad, 1998; Rayport & Sviokla, 1995). For our purposes here, we define the concept of products with the following understanding. A product can be either a tangible or intangible thing that is produced by a business entity and in demand by

consumer(s), as given by Forrest et al. (2020a). To apply this general definition to the context of manufacturing, 'product' refers to such a thing a business firm designs, and/or produces (or both), and offers to the market. For example, any firm that produces physical things for the product market is seen as a manufacturing firm. But under this definition of products, an insurance company can be also seen as a manufacturer, because such a company designs and produces intangible products – insurance policies – to customers, where each policy is made up of various promises a customer can rely on when predetermined circumstances appear. Similarly, under this definition, any firm that introduces and/or offers services is also seen as a manufacturing firm, because each of these services can be enjoyed by one or more customers. The same idea and understanding hold for financial firms, because such firms are also considered as a manufacturing firm that offers investment recommendations, produced by the firm through the production process of data collection, organization, analysis, followed by relevant recommendations.

For the following logical reasoning to go smoothly and plausibly, any firm considered in this paper is assumed to exist to satisfy a market niche by the means of creating sufficient cash flows from the marketplace through selling its products to consumers or customers. Traditionally, this assumption is generally true for most manufacturing firms (Sobel, 1999). However, recent developments in the world of business suggest that this norm is not absolute (Li & Ma, 2015) as some of the most known business entities have been staying afloat through attracting life-support of venture capitalists.

Proposition 1. If a manufacturing firm can improve its efficiencies of management and resources, then there is a potential for the firm to advance its economic performance.

This result follows readily from Theorem 1. In particular, to potentially improve its economic performance within the extant market a firm has to make its operation and/or production increasingly more efficient than before. Otherwise, Theorem 3.2 in Forrest et al. (2020b) indicates that pricing strategies alone cannot prevent the firm from experiencing stagnant or falling levels of expected profits. At the same time, the market surplus realistically consists of dissatisfied customers. So, to compete over this market segment and to prevent new competitors to enter the market, Theorem 1 implies that no matter incumbent firms' state of mutual forbearance, each of these firms has to improve the efficiency of its managerial routines and of its available resources. Only by doing so, the costs of production and marketing can be potentially lowered, the possible maximum selling price can be raised, and the range of boundary conditions can be expanded. In short, to fortify its existing market territory, the firm has to transcend pricing strategies by finding ways to improve its efficiencies of management and resources (Manjunatha & Suresh, 2021).

By attempting to fortify its existing market territory through improving its efficiencies of management and resources, the firm will simultaneously be capable of finding potentials of entering new markets. According to Theorem 1, one way to discover a potential new market to enter competitively is to identify instance when the market surplus experiences a rapid increase in its magnitude. Such quickly expanding market surplus can be a consequence of fast market expansion or a call for innovative new products. Given the present era of transient competitive advantages (McGrath 2013), entering new markets competitively and profitably, as implied by Theorem 1, brings forward potentials to improve a manufacturing firm's economic performance (Wagner, 2012a,b).

Proposition 2. If a manufacturing firm can engage in information and knowledge sharing, then a potential exists for the economic performance of the firm to improve.

By definition, innovation implies that innovative creativities lead to exceptionally added value. And innovation can appear in any aspect of business operations, such as new procedures for more effectively producing existing products, improved design of existing offers and creative design of

new and original products, the creation and consequent development of new markets, discovery of previously unknown resources, etc. (Schumpeter, 1934). Although recent theoretical studies (Yang, 2018) show that innovative ideas can be very well logically and systemically generated, the recorded history still practically suggests that innovations seem to occur when people with prepared minds unexpectedly and erratically run into some bright ideas (Ridley, 2016; Ye at el., 2012). Now, what Theorem 1 implies is that when a market invites competition through revealing an increasing percentage of switchers in the marketplace, many decision makers with entrepreneurial spirits will jump on the opportunity to design and produce their imagined offerings to meet their deciphered market invitation. However, because these entrepreneurially spirited individuals have their respectively different knowledge structures and backgrounds, they generally produce their individually different offerings; each of these offerings might satisfy some aspects of the market demand. So, if a manufacturing firm can engage in information and knowledge sharing, it will be able to holistically compare all these individually different entrepreneurial attempts to come up with such an encompassing product that meets more customers' needs at once. That explains why the capability to share information and knowledge represents a potential and resource for a firm's economic performance to improve.

Firms used to compete autonomously with one and another in the product market for advantages in general and for profits in particular. That era is largely gone; and firms in the present globalized economy are proactively participating in activities of various inter-organizational networks. They collaborate socially and opportunistically to form and to maintain a state of mutual forbearance (Galaskiewicz & Zaheer, 1999).

By a strategic network, it represents an established network of inter-firm ties strategically established to develop certain advantages for all partners (Gulati et al., 2000; Takhom et al., 2020). For example, as an input-output system, each firm is naturally a part of its supply-chain ecosystem (or network), consisting of upstream components and downstream complements (Adner & Kapoor, 2010). In such a scenario, suppliers belong to the totality of upstream components; customers, supporters and assistants are downstream complements, where the so-called supporters and assistants are those individuals or firms that help make a market offering available to the end users. Even though supporters and assistants are literally not any part of the ecosystem, their importance cannot be overlooked, because they have to invest and develop the necessary infrastructure for market offerings to practically reach the ultimate consumer.

Proposition 3. When a firm is strategical in terms of how it can be simultaneously involved with several different supply-chain ecosystems, that is, it can be part of a network of business entities from a range of supply chain, then there is a great potential for the firm's economic performance to improve.

To be *strategically* involved in such a network of organizations, as described, a firm has to attempt to achieve certain well-formulated objective. Theorem 1 implies that members of each supply-chain ecosystem generally work collectively to meet a particularly identified market demand in a specified way. Thus, as a member of such a network, the firm improves its chance of learning and access to information (Shapiro & Varian, 1999). In particular, such membership helps the firm learn how different companies have developed their different understandings of the market demand and how various solutions different companies have developed. And such membership provides the firm with contacts to different markets, and with the access to the knowledge of relevant and/or more advanced technologies (Gulati et al., 2000). Additionally, the firm will be able to share risk, participate in economies of either scale or scope or both (Shapiro & Varian, 1999). All reciprocal kindness of the members of the network help fellow member firms reap the resultant benefits, as confirmed by Blankenburg et al. (1999). Therefore, Proposition 2 implies that there is a great potential for the firm's economic performance to improve from its strategical membership in a network as described.

Proposition 4. If a nation adopts a policy that stimulates individual firms to raise the efficiencies of their managements and resources, then the firms' economic performance will be positively affected by the policy.

This conclusion follows directly from Proposition 1. Practically, such efficiencies mean that manufacturing firms are encouraged to share information and knowledge, such as those regarding market calls, by involving internally and externally in strategically beneficial networks and to improve productivity through introducing new and more efficient equipment. By virtue of Propositions 2 and 3 collectively, improved managerial efficiency, beneficial collaborations and more efficient equipment positively influence the economic performance of manufacturing firms.

In practice, the performance of a firm is dependent of that of other members in the firm's supply-chain ecosystem (Adner, 2006). For instance, to produce its imagined offering to satisfy an innovatively recognized market demand, a firm must consider whether its suppliers can provide the needed components. Even if suppliers can meet the need of particular demand, the firm still has to contemplate the question of whether or not its offering(s) can successfully and eventually reach the targeted customers in the marketplace. That end depends on the ability of downstream complementors to provide the necessary infrastructures, which, according to Adner (2006), might become an obstacle the firm cannot overcome.

Proposition 5. Assume that a nation adopts a policy that assists the formation of a manufacturing agglomeration, then the policy will more positively affect the economic performance of manufacturing enterprises than other policies that do not foster industrial agglomeration.

This conclusion follows naturally from how a firm's supply-chain ecosystem is defined, Proposition 3 above and the herd effects of organizations' behaviors and decisions (Banerjee, 1992; Burtch, 2011). Therefore, manufacturing enterprises are able to improve their economic performance.

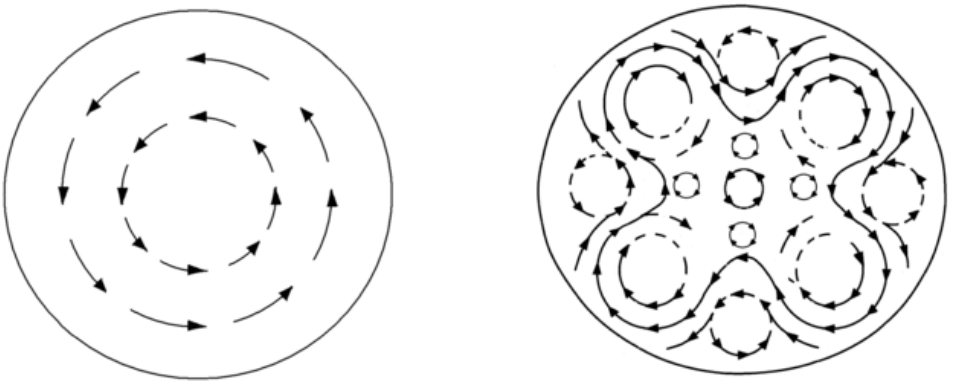
Additionally, this generally-true conclusion confirms what Ciccone and Hall (1996), Martin (2001) and Helsley (2004) find empirically that economic growth could be promoted by industrial agglomeration(s), which in turn generate knowledge and technology spillover effects and improve the productivity of various labors (Brulhart & Mathys, 2008).

As for the economic development of a nation, the systemic model below confirms the existence of economic unevenness between different regions: If a nation and its economy are modelled respectively by the dish and fluid within the dish in the famous dishpan experiment, for details, see Fultz et al. (1959), then the development of the economy can be vividly modelled by the spin of the dish. Now, the fluid flows alternatively in a uniform pattern and in a chaotic pattern, Figure 1(a) and (b), where unevenness appears in flow directions.

In this systemic modeling, the imagined 'fluid' models all factors, such as "money, information, goods, and others" that move around the economy of concern. The alternation in the pattern of flows demonstrates the fact that it is a common phenomenon for an economy to experience unevenness and imbalance in its development. For example, anecdotally, Lyson and Falk (1993) present the uneven development in rural America, while Pike and Tomaney (2009) attempt to investigate the governance of economic development in the post-devolution UK by addressing uneven development. All of this supports the general conclusion that imbalanced rates of economic development exist among distinct geographical regions. To this end, Frank (1978) demonstrates how uneven economic development appears as a consequence of imbalances that exist in multilateral merchandise trade.

An extension of this reasoning reveals that regardless of which economic policy a nation adopts, different regions within the nation will be affected differently by the policy, creating different incentive effects. Thus, manufacturing firms located in a comparatively undeveloped or less developed area will need to be supported by different preferential policies and fiscal assistants in order for the firm to improve their efficiencies of management and production. For these enterprises, the marginal

Figure 1. Evolution of flow patterns in dishpan experiment



(a) Uniform flow pattern (b) Chaotic flow pattern

contribution of adopted policies will be relatively high. On the contrary, because enterprises in areas of high levels of economic development have already enjoyed a salutary level of managerial and production efficiencies, a newly adopted policy may not contribute as significantly to their economic performance. Therefore, the marginal contribution of economic policies to firms located in relatively developed areas may be comparatively low. Based on this systemic reasoning, the result below emerges.

Proposition 6. Regardless of the economic policy that a nation adopts, geographical and regional differences will influence the policy's effect on manufacturing firms' economic performance. Notably, an economic policy's positive effect will be more pronounced for firms located in comparatively underdeveloped regions than it will be for those located in comparatively developed areas.

4. A NUMERICAL CASE ANALYSIS

Real-life data from China will be employed in this section to confirm our established results in this paper, especially Propositions 1 – 6.

4.1. The Data and Empirical Model

In response to a national strategy, China's Ministry of Industry and Information Technology (MIIT) has been conducting "The China's pilot projects for intelligent manufacturing (IM)" since 2015. These projects aim at sticking to the following goals: (i) making manufacturing intelligent, (ii) optimizing the standard system of intelligent manufacturing, (iii) promoting the level of intelligence of China's manufacturing industry, and (iv) preparing for the future adoption of a nationwide intelligent policy.

This section will use the difference-in-difference (DID) method, for more details, see Card and Krueger (1994), to evaluate how this pilot project policy impacts manufacturing firms' performance. To avoid the problem of endogeneity we only use those firms that are listed on Shanghai and Shenzhen Stock Exchange. In particular, this research adopts the pilot IM firms published in 2015-2017 by MIIT, and the companies' annual report data available from China's Securities Regulatory Commission for 2011-2020. Also, it uses the annual report data of these ten years from Shanghai Stock Exchange (http://www.sse.com.cn/), Shenzhen Stock Exchange (http://www.szse.cn/), the Ministry of Industry and Information Technology (https://www.miit.gov.cn/), and these individual companies. Then, the experimental grouping variables (intel) are divided into two groups – the 'treatment group' and

'control group'. There are 89 IM companies in the 'treatment group', each of which is assigned the value of 1; and the 'control group' contains 100 manufacturing companies randomly selected from Shanghai Stock Exchange, each of which is assigned the value of 0. After eliminating repeats that appear in both groups, 92 firms remain in the 'control group'.

Depending on the time the IM policy is applied with selected pilot firms, the variable (time) assumes values for before or after the implementation. By considering when individual pilot firms were chosen, each pilot firm is assigned with the value of 1 for the year and afterwards when it was selected and the value of 0 for the years before the selection. Hence, there are four quadrants for the entire sample, as detailed below:

- "treat" for the time before policy implementation, where intel = 1 and time = 0,
- "treat" for the time after the policy implementation, where intel = 1 and time = 1,
- "control" for the time before the policy implementation, where intel = 0 and time = 0, and
- "control" for the time after the policy implementation, where intel = 0 and time = 1.

For the interaction of the two variables – division of groups and separation of time – we use the term (intel × time) to represent the net effect of implementing the IM policy. We introduce another variable, named 'did', for the pilot IM policy, and develop the fixed-effect model below to check the impact of the IM policy on manufacturing firms' economic performance.

$$roa_{it} = \alpha + \beta_1 did_{it} + \beta_2 lcv_{it} + \beta_3 manage_{it} + \beta_4 ocf_{it}$$
$$+\beta_5 top1_{it} + \beta_6 age_{it} + \beta_7 tan_{it} + \delta_{it},$$

where roa_{it} represents a firm's return of assets in region *i* and time *t*, did_{it}, the core explanation, is the dummy variable of the IM policy, $\mathrm{lcv}_{\mathrm{it}}$, $manage_{it}$, ocf_{it}, $\mathrm{top1}_{\mathrm{it}}$, $\mathrm{age}_{\mathrm{it}}$, $\mathrm{tan}_{\mathrm{it}}$ are respectively the control variables for the asset-liability ratio, asset management capacity, operating cash flow ratio, equity concentration, company age, and fixed assets. And α, β and δ are respectively the constant term, the coefficient of a variable, and the residual.

The response variable roa_{it} is defined by dividing a firm's net profit by its total assets. The core explanatory dummy variable did takes a value according to the "Public Manufacturing Pilot Demonstration Project List," as published by MIIT 2015-2017 (MIIT, 2015; MIIT, 2016b; MIIT, 2017), and the financial data, according to when a firm was selected as a pilot IM firm.

According to Hoyt and Liebenberg (2011), the asset-liability ratio lcv can be employed to study the effect of risk management policies on corporate values. Hence, we expect it to have a negative effect on a firm's performance. Asset management capability ($manage$) reflects how well an enterprise earns profits by using assets. According to Higgins (1981), this capability is computed as the ratio of operating income over total assets. As suggested by Forrest and Nightingale (2017), '$manage$' is expected to positively affect a firm's performance.

The ratio ocf of operation cash flow reflects a company's ability for invested capital to create cash. It is defined as the ratio of cash flow from operating activities over total assets. The equity concentration $top1$ equals the proportion of a company's equity the largest shareholders control. Makhija and Spiro (2000) and Lins (2003) show that it is significantly correlated to firm performance in developing countries. We expect, according to Forrest et al., (2019a), that variable $top1$ is negatively correlated to the performance of a listed company. Also, we expect, according to Forrest et al., (2019), that enterprise age age does not have much impact on a company's performance. The fixed assets ratio tan is calculated by dividing fixed assets over total assets and is expected to have a negative impact on the performance of a company.

4.2. The Regression Analysis

The results of benchmark regression are shown in Table 1. From column (1) of the table, it can be seen that the coefficient of the core explanatory variable ' did ' is positive, and significant at 1% level. That means that the implemented national policy of IM did produce obviously positive effects on the performance of business firms, which empirically confirms our Proposition 4 above. At the same time, from how the sample was selected, it follows that each enterprise considered in this paper is an IM pilot entity recognized by the national government. These enterprises had enjoyed relatively high levels of improvements in management quality and the efficiency of resource utilization, information sharing and the spillover of knowledge. And, most of these enterprises were involved in varied degrees in the organizational networks of different supply-chain ecosystems. Therefore, these enterprises considered in this paper coincide highly with the assumptions of Propositions 1 – 3 so that the results of benchmark regression also indirectly confirm the correctness of these propositions.

Beyond what is discussed above, the regression results in column (1) of Table 1 also indicate that

- An enterprise's debt-to-asset ratio and fixed asset ratio could negatively affect the performance of the enterprise. When the debt-to-asset ratio is too high, it means that the enterprise bears relatively high levels of risk, which is not good for the healthy development of the company. When the fixed asset ratio is high, it could limit the firm's capital flow so that the economic performance of the firm is adversely affected.
- For an enterprise, its asset management capability, operating cash flow ratio and the degree of equity concentration play a significantly positive role in its performance. The significance of asset management capability and cash flow ratio to corporate performance is self-evident. As for the positive influence of the degree of equity concentration on a manufacturing business, a possible explanation is that when actively undergoing intelligent transformation, manufacturing firms that are controlled by large stakeholders could to a large degree guarantee their operational stability during the transition.
- An enterprise's age does not have any clear effect on the firm's performance. Because each enterprise considered in this paper was a selected pilot IM entity, its management philosophy and operation mode were all among the advanced levels when compared to others in China. Hence, no matter whether it is a well-known enterprise with a long history or a recently emerging newbie, age does not represent a key factor underneath the firm's performance.

To assure the reliability of our regression results, we need to confirm that before the implementation of the IM policy, both the control group and the treatment group had similar trends of development. To this end, we assume respectively that the IM policy was implemented three years before and three years after the actual time. Then, the effects of the policy are regressed respectively under these assumptions, respectively. The corresponding results are given in columns (2) and (3) in Table 1 and indicate that before the policy implementation, the core explanatory variable '*did*' did not bear clear effect on the firm's performance. However, after the policy implementation, it clearly influenced the performance. That implies that our regression results can be considered highly credible.

In order to check whether or not the agglomeration of enterprises affects the outcomes of implementing the IM policy, we partitioned the sample into two parts, one with one pilot enterprise in one province, labeled as "without agglomeration", and the other with multiple pilot enterprises in one province, labeled as "with agglomeration." We then performed regression tests respectively to these parts with outcomes given in Table 2, which shows that no matter whether there is the phenomenon of agglomeration, the IM policy bears a significant effect on firms' performance. The empirical conclusion is different from that of Proposition 5 for the possible reason that intelligent transformations of manufacturing firms do not depend on business agglomerations. Instead, they are more affected by capital investments, improvement in management philosophy and the elevation of operation mode.

Table 1. The benchmark regression and counterfactual test

roa	**(1)** **Benchmark regression**	**(2)** **counterfactual test** **(three years ahead)**	**(3)** **counterfactual test** **(three years after)**
did	0.0092*** (0.0032)	0.0067 (0.0049)	0.0128*** (0.0026)
lcv	-0.0745*** (0.0075)	-0.0735*** (0.0075)	-0.0753*** (0.0075)
manage	0.0194*** (0.0039)	0.0193*** (0.0039)	0.0194*** (0.0039)
ocf	0.3558*** (0.0218)	0.3620*** (0.0218)	0.3454*** (0.0216)
*top*1	0.0153* (0.0083)	0.0150* (0.0083)	0.0152* (0.0082)
age	0.0000 (0.0003)	-0.0001 (0.0003)	0.0002 (0.0003)
tan	-0.0686*** (0.0078)	-0.0697*** (0.0077)	--0.0655*** (0.0077)
cons	0.0666*** (0.0076)	0.0680*** (0.0075)	0.0644*** (0.0076)
N	1529	1529	1529
r^2 -adjusted	0.3385	0.3356	0.3458

Note: (1) All parenthesized numbers represent standard errors; (2) The superscripts ***, **, and * designate respectively passing the significance tests of 1%, 5%, and 10%; And (3) symbol *N* is the size of the sample used in the study. For all following tables the same conventions are assumed.

Although this empirical result cannot definitely confirm Proposition 5, it still provides a clear support for that intelligent upgrades play an active role in the performance of manufacturing firms.

To compare the regional effects of the IM policy, without including Hong Kong, Macao and Taiwan, the remaining 31 provinces, autonomous regions and those municipalities directly under the administration of the central government are categorized into two regions: the central/western region, which is considered as less developed, and eastern region, which is seen as more developed[1]. From there, the regional heterogeneity of the pilot IM projects is tested with results shown in Table 3. It can be seen that for the less developed region – the central/western region, the considered policy has a significant positive impact on the selected enterprises' performance (through a 10% significance test) with the coefficient of effect equal to 0.0135 (through a 1% significance test). As for the developed region – the eastern region, the IM policy's effect on firms' performance did not pass the significance test. Jointly, these results mean that the effect of the IM is greater for less developed regions for the following possible reason: The manufacturing firms in developed regions had reached relatively high levels in terms of their capability of intelligent production so that the marginal effect of implementing the new IM policy is small. However, for less developed regions, due to their relatively low levels of intelligent capability, the implementation of the IM policy greatly promoted the development of their manufacturing sector. That led to the greater visible policy effect. Such results confirm the feasibility of Proposition 6.

Table 2. Heterogeneity test on agglomeration

	(1)	(2)
roa	with industrial agglomeration	without industrial agglomeration
did	0.0084**	0.0146***
	(0.0039)	(0.0042)
lcv	-0.0750***	-0.0857***
	(0.0091)	(0.0102)
manage	0.0147***	0.0251***
	(0.0040)	(0.0048)
ocf	0.3590***	0.3205***
	(0.0242)	(0.0279)
*top*1	0.0238***	0.0363***
	(0.0090)	(0.0125)
age	0.0003	0.0014**
	(0.0003)	(0.0006)
tan	-0.0700***	-0.0686***
	(0.0096)	(0.0124)
cons	0.0614***	0.0337***
	(0.0087)	(0.0124)
N	1321	1030
F	24.30	32.85
r^2 -adjusted	0.3192	0.3142

Note: same with Table 1.

4.3. Discussion

This section employs the difference-in-difference (DID) method (Card & Krueger, 1994) to confirm how effective the pilot IM policy has been to the manufacturing companies' performance of China. And through heterogeneity analyses, it examines how the IM policy affects a firm in terms of its agglomerative association with other enterprises and whether or not it is located in a developed geographical region. Our empirical confirmation in this section produces the following main results:

(1) The pilot IM policy is significantly, positively correlated to the performance of manufacturing firms. Because such a policy aims at improving the intelligence level of manufacturing and promoting relevant firms' efficiency of management and resource utilization, the positive effects of this policy on manufacturing companies' performance confirm the conclusion of Proposition 4.

Table 3. Regional regression

roa	**(1)** **midwest**	**(2)** **east**
did	0.0135***	0.0030
	(0.0039)	(0.0056)
lcv	-0.0916***	-0.0534***
	(0.0093)	(0.0132)
manage	0.0219***	0.0177***
	(0.0050)	(0.0062)
ocf	0.3096***	0.4339***
	(0.0268)	(0.0421)
*top*1	0.0310***	0.0093
	(0.0106)	(0.0154)
age	-0.0001	0.0009
	(0.0004)	(0.0006)
tan	-0.0637***	-0.0914***
	(0.0099)	(0.0159)
cons	0.0657***	0.0592***
	(0.0090)	(0.0140)
N	908	627
r^2 -adjusted	0.3951	0.2896

Note: same with Table 1.

(2) In terms of the sample used in this study, all selected enterprises come from the "Public Manufacturing Pilot Demonstration Project List" from 2015 to 2017, for details, see MIIT (2015; 2016b; 2017). These companies share the following common characteristics: they enjoy relatively high efficiency levels of management and resource utilization, relatively high levels of information exchange and knowledge spillover; and they are part of the organizational networks of one or several supply-chain eco-systems. Because of these characteristics, the selected enterprises mostly satisfy the assumed conditions of Propositions 1 – 3. That explains why our regression results also indirectly confirm the conclusions of these propositions.

(3) Through respectively regressing specifically partitioned samples according to whether or not there is an agglomeration of enterprises, it is found that the effects of the IM policy are not influenced by such an environmental character. A possible explanation is that the effects should be dependent on individual firms' investments in R&D, elevations of management quality and transformations of operational modes. Therefore, our empirical results cannot confirm the conclusion of Proposition 5.

(4) By checking the homogeneity across geographical regions, it is found that the IM policy had more visible effects on less developed regions than developed areas. That might be because the intelligence levels of the manufacturing firms in developed regions had already been relatively high so that the marginal effects of the policy are small. However, for less developed areas, the initial low levels of manufacturing intelligence, management quality and the efficiency of resource utilization were greatly promoted by the implementation of the IM policy, leading to visibly improved economic performance of the relevant manufacturing firms. Hence, the conclusion of Proposition 6 is empirically confirmed.

5. CONCLUSION, MANAGERIAL RECOMMENDATIONS AND IMPORTANT OPEN QUESTIONS

By employing the logical reasoning and methodology of systems science, this paper studies the conditions under which national policies will positively affect business firms in terms of their economic performances, if these firms provide the market produce goods, services and/or information goods. The main contribution this paper makes to the literature is that it systemically establishes conditions for manufacturing firms to improve their economic performance, while avoiding the uncertainties existing in the conclusions obtained from case studies and empirical analyses. And speaking practically, the conclusions developed in this paper provide government officials with reliable recommendations so that they can introduce and implement such economic policies that are more conducive to stimulating the potentials of manufacturing firms. Hence, the overall economic landscape of a region can be improved. Other than systemically and symbolic reasoning, this paper also provides an empirical analysis based on a case from China, which offers a different basis to confirm our conclusions. Other than a list of generally true conclusions, this paper establishes the following main results:

(1) Speaking from the angle of business firms, if any one of the following conditions holds true, then the economic performance of the firm can be improved (Propositions 1 – 3). The firm can (i) improve the present level of efficiency for its management and resources; (ii) participate in exchanges of information and knowledge; and (iii) strategically join the organizational networks of different supply-chain ecosystems.
(2) Speaking in the angle of administrative governance, if a nation adopts such a policy that is conducive to bringing additional efficiency to individual firms' management and resource utilization, then the policy will be positively correlated to the economic performance of the business entities in the manufacturing sector. Additionally, such policies produce more visible effects to the manufacturing sector in less developed areas than to those in developed regions (Propositions 4 and 6). Based on these conclusions, we recommend that when a national government introduces and implements an economic policy, it needs to
    (a) aim at promoting firms' management quality and efficiency of resource utilizations (Propositions 1 and 4);
    (b) encourage firms to exchange information and to share knowledge (Proposition 2);
    (c) focus on the reasonable construction of an industrial system, help manufacturing firms position themselves and emerge into the organizational networks of various supply-chain ecosystems (Proposition 3); and
    (d) pay attention to a balanced development among geographical regions by introducing and implementing localized policies (Proposition 6).

Looking ahead to potential future research ideas, we share the following observations. Regarding methodology, the logical reasoning underneath this research represents actually a preliminary portion of systems research. Within systems science one can find many system-thinking based methodological tools constructed for investigating systems (or organizations or structures), how organizations evolve

over time and interact with each other, for details, see Forrest et al., (2013). So, it will be a worthy effort to utilize other well-developed methodological tools developed in systems science to the study of economic policies, their interactions and effects. Secondly, we need to point out that conclusions derived in this work hold true on an exclusive assumption about the purpose for a business firm to exist. Indeed, what is assumed in this regard really holds true in the landscape of the world business in the recent past (Sobel, 1999). However, as indicated by Li and Ma (2015), in the present business world, this assumption may need to be loosened up. In other words, future efforts of research may scrutinize whether or not conclusions, similar to those developed in this paper, can be established for business enterprises that are brought into being for other purposes instead of the one assumed herein. One immediate research idea is to examine why Proposition 5 is not empirically confirmed in the case study of this paper.

CONFLICT-OF-INTEREST

The authors of this publication declare there is no conflict of interest.

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ENDNOTE

[1] The eastern region includes 11 provincial and administrative regions, including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. And there are 20 provincial and administrative regions in the central/western region, including Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Tibet, Xinjiang, Guangxi, and Inner Mongolia.

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