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The Role Government Policy and Supports Play to Stimulate Economic Growth

Jeffrey Yi-Lin Forrest[1*], Abdou K. Jallow[1], Chao Wen[2], Juehui Shi[3], Huan Guo[4]

[1)] *Slippery Rock University, Slippery Rock, PA, USA*

E-mail: Jeffrey.forrest@sru.edu; Abdou.jallow@sru.edu

[2)] *Ohio Northern University, Ada, OH 45810, USA*

E-mail: c-wen@onu.edu

[3)] *Angelo State University, San Angelo, TX, USA*

E-mail: juehui.shi@angelo.edu

[4)] *Jianghan University, Wuhan, China*

E-mail: guohuan.2007@163.com

Abstract: This paper studies the reason why policy tools might work, if they do, what the functional mechanism is, and why government's policies and supports are necessary for stimulating economic growth. By employing systems thinking and methods and the logical reasoning as that commonly used in mathematics and natural science, this paper establishes 6 formal and generally true propositions on these related issues. At the conclusion, we provide a whole list of recommendations for policy makers and government officers in terms of when and how their implemented policies will lead to their desired outcomes. At the conclusion, this paper provides directions and open problems for future research.

Keywords: economic agent, feedback, market, momentum, policy tool, system

1. INTRODUCTION

Fast development of communication technology in recent decades has prompted a score of leading nations to introduce policies and provide supports in order to transform their industries. To maintain their leadership in the globalizing world, these nations challenge themselves to elevate their industries from automated manufacturing to intelligent manufacturing, such as Industry 4.0 [1]. Hence, the following questions arise naturally: why are policy tools expected to work in an economic system? Why are government policy tools and supports fundamentally necessary for stimulating economic growth?

Answers to these questions are both theoretically and practically important for all nations from around the world. Developed nations, at least some of them, attempt to preserve their leading positions in the increasingly globalizing world economy. Developing and underdeveloped nations with their miserable failures of modernization experienced in the past one hundred plus years [2] face the likelihood of tumbling further behind the developed nations economically, socially, and politically.

Although many scholars have worked on these and other related questions since before the time of Adam Smith, the relevant debates have come and gone in waves without achieving anything definite other than producing inconsistent and uncompromising suggestions [3.4]. Other than filling a gap existing in the literature on whether or not governmental policies and supports are necessary in economic development, by addressing these questions and related issues, this work also tempts to answer Rostow's [4] call for an

[*] Corresponding author: Jeffrey.forrest@sru.edu

appropriate methodology for such investigations in order to actually produce scientifically sound and dependable results.

In particular, in terms of how policies actually work, Wieczorek and Hekkert [5] consider how policy instruments can improve the function of an innovation system. By considering which channel is likely to amplify the effects of monetary policy, Auclert [6] empirically finds that the following three channels work - the earnings heterogeneity channel from unequal income gains, the Fisher channel from unexpected inflation, and the interest rate exposure channel from real interest rate changes. Boeckx et al. [7] examine the effectiveness and transmission mechanism of the Euro-system's credit support policies. Boeckx et al. [7] find successes of policies in stimulating credit flows from banks to the private sector. Rebei [8] empirically looks at the crowding-in effect of government spending on private consumption and finds that in early times government spending increasingly crowded in private consumption, while this relation was reverted in recent times. Cúrdia and Woodford [9] investigate consequences of a variable credit spread optimal policy responses and find that a simple target criterion provides a good approximation to optimal policy. Jaehrling et al. [10] provides insights on negotiations and outcomes of labor clauses across different stages of policy process, demonstrating the importance of alliances among local politicians, unions and employers.

Enriching the literature, this study demonstrates why governmental policies are important, when a government is able to align business objectives of a large proportion of individual economic agents, and what policy tools can help accomplish the goal.

As for why governmental policies and supports are necessary in economic development, the literature is naturally divided into two camps: (i) Yes, they are necessary; (ii) no, they don't work generally. For example, Andreoni and Chang [3] provide a framework for strategically coordinating packages of interactive industrial policy measures. Howell et al. [11] argue that the future of US competitiveness in international markets depends on realistic federal, industry, and company policies with regard to microelectronics. Conversely, Jomo [12] studies eight Asian economies (i.e., Japan, South Korea, Taiwan, Singapore, Hong Kong, Malaysia, Thailand, Indonesia), which achieved a statistically unlikely rapid economic growth between 1965 and 1990. Although government interventions played a role, he notes that the gains from industrial policies are ambiguous. Regarding how well the Advanced Manufacturing Initiative for America's Future, a concerted US government effort, would harmonize with the Obama administration, Hemphill [13] finds that the answer is not well.

Comparing to what is summarized above, this study contributes to the literature by establishing several generally true results. For example, it shows why a nation needs to provide policy supports to maintain an extant economic growth momentum, when an implemented policy will positively affect the economic performance of manufacturing enterprises, and why different policies are needed to promote economic growth in different geographical regions. Epistemologically speaking, all results established in this paper do not suffer from the constraints of data- and anecdote-based approaches, as commonly employed in the literature, and avoid the methodological pitfall experienced by rounds of debate on whether or not governmental policies are necessary for economic development since the time even before Adam Smith [3] and by rounds of studies on what was really underneath the occurrence of the Industrial Revolution [4]. In particular, the former respectively produced inconclusive and noncompromising reasons for and against the use of policies based on anecdotes and statistics. And the latter led to questionable lists of factors that were underneath the occurrence of the Industrial Revolution [2,4]. In comparison, results developed in this work are scientifically definite.

For the following reasoning to flow smoothly, assume that each business firm is established to satisfy a market niche so that the firm is operationally maintained by a positive cash flow as a consequence of its business conducts in the marketplace. And by consumers, it means end users of market offering; by customers those firms that employ their inputs to

produce their outputs. When both consumers and customers coexist, they are jointly known as customers.

The rest of this paper is organized as follows. Section 2 studies the functional mechanism of policy tools. Section 3 investigates why governmental policies and supports are necessary in economic development. Section 4 concludes the paper with practical recommendations and open questions for future research.

2. FUNCTIONAL MECHANISM OF POLICY TOOLS

This section investigates why policy tools are expected to work in the focal economic system?

2.1. A Systemic Modeling of the Economy

By system, it means such a notion that models an organization or a structure as a collection of components or objects and associations among the objects. The components have been conventionally treated as isolated in classical sciences, while the associations help make the components into an organic whole (or system) [14]. Hence, the concept of systems really appears everywhere in life. For example, each family is a system; each business firm is a system; … As a matter of fact, a main characteristic of the world is the systemness of various kinds of organizations (and structures). This realization explains why the concept of systems can be appropriately applied in investigations of business-related matters and issues, see [4,15,16].

Symbolically, a system is an ordered pair $S = (M,R)$ with M containing all the isolated objects of system S and R relations that connect the objects in M into a whole [14]. For example, each business organization consists of a set of components, such as employees, properties, equipment, etc. And, these objects are connected together through particular relations, because of which the whole is acknowledged as an organization. In this junction, one should note that each object in M can also be a system again, just as in the case that a family consists of people as its objects, and each person is a biological system, made up of various organs; each organ is again a system of even smaller parts, … At the same time, a relation in R does not have to be numerical. For example, it will not be appropriate to express the relationship that two people x and y are brothers, unless one only likes to capture this relationship partially.

Given system $S = (M,R)$, another system $S_1 = (M_1,R_1)$ is said to be a partial system of S, if M_1 is a subset of M and for any relation $r_1 \in R_1$ there is relation $r \in R$ such that

$$r_1 = r|M_1.$$

That is, the relation r_1 of the system S_1 is the restriction of a relation r in the system S. A system $S = (M,R)$ is multi-leveled, if there is at least one object $S_1 \in M$ such that $S_1 = (M_1,R_1)$ is a system, and there is at least one object $S_2 \in M_1$ such that $S_2 = (M_2,R_2)$ is a system, …, where S_1 is known as a first-level object system, S_2 a second-level object system, … A system $S = (M,R)$ is said to be centralized if each object in S is a system and there exists a system $C = (M_C,R_C)$ such that $M_C \neq \emptyset$ and for any distinct objects $x, y \in M$, say $x = (M_x,R_x)$ and $y = (M_y,R_y)$,

$$M_C = M_x \cap M_y \text{ and } R_C \subseteq R_x|M_C \cap R_y|M_C,$$

where $R_x|M_C = \{r|M_C : r \in R_x\}$ and $R_y|M_C = \{r|M_C : r \in R_y\}$. The system C is called a center of the centralized system S. Speaking in non-mathematical terms, a system S is centralized, if and only if there is another system C that is a partial system of every object system in S.

To address the question stated above, let us model the economy of the focal nation as a system that consists of all economic agents as component parts, such as consumers, families,

business firms, economic sectors, and markets, and associations that connect the component parts into a functional economy. In this model, the associations reflect how money, information and knowledge flow within the economy, how the magnitudes and types of supplies and demands constantly change, how consumer's preference and tastes evolve, etc. Each family is a system that consists of family members; each business firm is a system that is made up of members of various families; each economic sector is composed of many firms; and each market connects individual consumers and firms through exchanges of goods, information, money, etc. That is, our focal economy can be well modeled as a multi-leveled system. Within this systemic model of the economy, the government represents a formal structure that supports the stable existence and smooth operation of the economic system with the top level of the government serving as the center, as seen in the concept of centralized systems. Any slight change in the center affects most areas of the economic system. The formal structure of the government can be imagined as the three-dimensional hierarchy of individuals, such as consumers on the bottom, whose consumption drives all other layers of the economy, business firms as the next layer upward, each of which serves a segment of consumers, … and markets on the top, where eventual exchanges of information, knowledge, money, goods, etc., take place. The government guarantees the economy operates smoothly through laws, regulations, and related reinforcements.

2.2. The Importance of Governments

As a multi-leveled, large-scale complex system, a nation's economy surely satisfies the following theoretical fact:

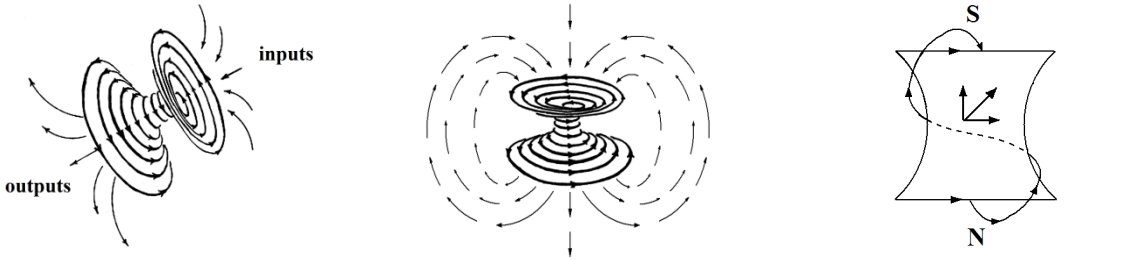
Theorem 1:

Under ZFC let cardinality κ *be infinite and* $\theta > \kappa$ *regular, satisfying that for any* $\alpha < \theta$, $|\alpha^{<\kappa}| < \theta$. *If S = (M,R) is a system with each object* m *also a system* $m = (M_m, R_m)$, *satisfying*

- $|M| \geq \theta$,
- $|M_m| < \kappa$, *for each object* m *in S, and*
- *There exists such an element G that belongs to at least* θ *objects in M,*

then there exists a partial system B of S satisfying that

- *The object set of B is of cardinality* $\geq \theta$,
- *G belongs to each object of B, and*
- *The partial system B forms a centralized system.*



(a) Eddy motion of a general system (b) Meridian field of the yoyo model (c) Typical trajectory of how matters return

Fig. 1. The yoyo model for a general system

For the proof of this result, see Appendix. This theorem implies that within a nation's economy, although there might be areas the government has either no or little influence, there is at least one portion of the economy that is of roughly the same scale of the entire economy, over which the government can influence. To better understand this explanation, the following yoyo model helps us intuitively imagine what a system is and how systems

evolve and possibly interact with each other. In particular, every system can be seen as an abstract yoyo in Fig. 1 [14]: each system is a multi-dimensional entity that spins about its axis. If we fathom such an entity in our 3-dimensional space, such a structure, as shown in Fig. 1(a), appears. The input side pulls in '*things*' (e.g., materials, information, investment, and human talents). After funneling through the "neck", things are spit out in the form of outputs (e.g., products, services, etc.). Some things, spit out as outputs, never return to the other side and some will, Fig. 1(b), where Fig. 1(c) depicts the trajectory of how things return. Due to its general shape, such a structure is known as a *yoyo*.

From this systemic model, it can be seen that the government plays a non-negligible role in the nation's economy as indicated by the center arrow in the yoyo body that provides the orientation for the system and influences component elements (industries/companies) of the abstract systemic model of the economy. Speaking differently, when the government advocates and seeks after the goal of advancing the economy by increasing the degree of marketization, deepening political reform, and encouraging dramatic rise of private enterprises, its use of policy tools will be most likely successful. The reason why this approach practically works is that the government can effectively impose its will and desired outcome on a large segment of the economy through employing policy tools, as guaranteed by Theorem 1 that characterizes centralized systems. So, the following conclusion follows:

Proposition 1:

Each government's commitment stands for a process of social influence and support in which relevant governmental officials can gather the assistance and support of a large number of economic agents in the accomplishment of a determined national objective. Such governmental commitment eventually creates a harmonious way for individual economic agents to work jointly and collectively to accomplish the desired outcome.

A similar but more narrowly stated conclusion than this proposition has been empirically confirmed by [17] in the name of leadership and by [18].

By goal orientated system, it means such a system that focuses on a certain determined collection of tasks and consequences. The study on goal-oriented systems is voluminous. Typical examples of goal-oriented systems are [19]: regulation, control, self-organization, learning, autopoiesis, self-reproduction, self-correction, adaptation, evolution, etc. By combining this concept and the systemic study of leadership [20], one has:

Proposition 2:

The importance of the government is reflected in its ability to adjust the nation's underlying organizational structure as a goal-oriented system so that most of individual economic agents will be able to adjust their orientations and operations without much difficulty.

Systemically speaking, there naturally exist development unevenness and imbalances among different regions of any nation, as shown by the evolution of flow patterns in the dishpan experiment [21]. In particular, a dishpan, filled with fluid, can model a nation's economy with the "fluid" modeling the movement of such things as "money, information, goods, and others" within the economy. Then the flow pattern, seen from either the input or output side, alternates between a uniform one, Fig.1(a), and a chaotic one, Fig. 2, demonstrating the fact that imbalances in economic development are commonly seen phenomena.

Fig. 2 depicts why this proposition holds true, where the entire economy is modelled as a spinning yoyo with fields around. The large dark-colored arrows through the middle stands for the orientation of the overall system, as desired by the government. If the orientation of a

local spin field, say A_1, is not in agreement with that of the overall yoyo body, then A_1 will be either dissolved under the joint effects of its adjacent fields or marginalized by forced to the periphery of the overall yoyo field, as indicated by Theorem 1. So, A_1 will not be any part of the centralized partial system *B* of the original economic system *S*.

2.3. Conditions When Policy Tools Will Work

Proposition 3:

If a government can employ its organizational influence by using policy tools to obtain aids and supports of other economic agents, be they large or small, in accomplishing a determined national objective that will benefit a large number of economic agents, there will appear a joint ambition that potentially involves a major portion of the economy.

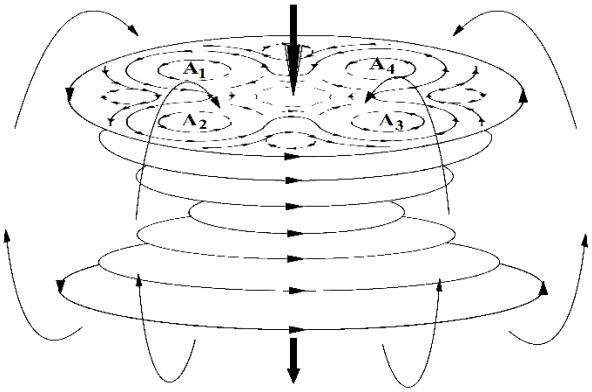


Fig. 2. The structure of a goal-oriented system

This is a restatement of Theorem 1. The if-condition matches that the system $S = (M,R)$ satisfies. Therefore, the conclusion follows from the existence of the centralized partial system *B*. For a relevant but different study, see [17].

Proposition 4:

If a government is effective in terms of implementing its policies, then it will be able to align the business objectives of a large proportion of individual economic agents, even though they follow their respectively different and often opposing business strategies. Hence, a united front of effort will be formed.

This follows from Theorem 1 and Fig. 2, where the local fields located in the adjacent areas between A_1, A_2, A_3, and A_4, spin in directions opposite to those of A_1, A_2, A_3, and A_4. Differences in directions reflect that businesses, even employing opposing strategies, can peacefully coexist.

Proposition 5:

T*he initial concept of further advancing the nation's economy can become an extraordinary reality through implementing appropriate policy tools.*

This result follows jointly from Propositions 2 – 4 above.

The importance of these propositions is that no matter what policy tool(s) are adopted and which implementation approaches are used, they need to be rooted in the outcome of benefiting a large economic segment for the policy and approach to actually work. Such consistent, conceptual and practical specifications provide a common goal for a large proportion of economic agents to aim at and a cheering point for the citizens of the nation to feel excited about.

Generalizing Theorem 3 in [22] produces the following, which describes how a market signals its need for innovations and additional competition. The proof is given in Appendix.

Theorem 2:

In Nash equilibrium, if the consumer surplus of the market described below is larger than the loyal-customer base of one incumbent company, then the market calls for new innovation and additional competition. If a company answers the call by entering the market with its version of substitute offer, then its expected profit can be potentially larger than that of at least one incumbent company. Here, the market satisfies the following conditions:

- *It is served by a number of companies with their horizontally differentiated offers;*
- *Its operation is only affected by market forces, such as demand and supply, and consumers' forever evolving preferences and tastes;*
- *Each incumbent company has a base of loyal customers if the price is not more than their reservation price.*
- *There are switchers who make purchases based on whose price/value is lower; they are collectively known as consumer surplus; and*
- *All companies' pricing strategies are known to the incumbent companies who respond by playing Nash equilibria through untainted self-analyses.*

For the market considered above, it generally means that the technology and management used in production have been standardized. Hence, for a company to profitably enter the market, it must have introduced a more efficient technology and/or managerial routine that can significantly reduce its business expenditure in making its product of increased sophistication and functionality, as Christensen et al. [23] confirms empirically.

3. THE NECESSITY OF GOVERNMENTAL POLICIES AND SUPPORTS

3.1. Linkage Mappings within a Supply-Chain Ecosystem

To address why government policy tools and supports are fundamentally necessary for stimulating economic growth, Theorem 2 indicates that when recognizing a market signal innovatively, a firm is in a competitive position over its competitors. However, in practice, the consequent enhanced performance of the firm really depends on other players in its supply-chain ecosystem [24]. In particular, to produce the offering to satisfy an innovatively recognized demand, a firm has to obtain its needed supplies from its suppliers. That can be a challenge to the supply-chain ecosystem. Even after having met such challenge and created the expected value, the firm can still be hampered in its capturing of value. That might well depend on infrastructures necessary for the firm to reach consumers in the marketplace [24].

The supply-chain ecosystem of any firm consists of upstream components, such as suppliers, and/or downstream complements, such as customers, supporters and assistants, known as complementors, who help to make the firm's product usable by consumers [24]. Although outside the firm's direct supply chain, complementors help connect the firm's offering and consumers by constructing infrastructures. For example, governments, regulators, etc., are complementors that help build and maintain, for instance, roads necessary for transportation or specifications of new safety procedures, etc.

The systemic structure of this supply-chain ecosystem is given in Fig. 3. The focal firm utilizes inputs, called components, from n supplies and delivers its outputs to customers with the support and assistance of m complementators, $m, n = 1, 2, 3, \ldots$ Other than the shown first-tier components and complements, this structure in real life needs to extend leftward and rightward along the value-creation chain to include other tiers, such as suppliers' suppliers, customers' customers, complementors' complementors, etc. By including the full

range of different tiers, the systemic characteristics of this ecosystem can be vividly seen, where the focal firm internally focuses on providing organizational supports so that its employees can innovatively integrate components into market offerings. For similar systemic constructs, see, for example, [24,25].

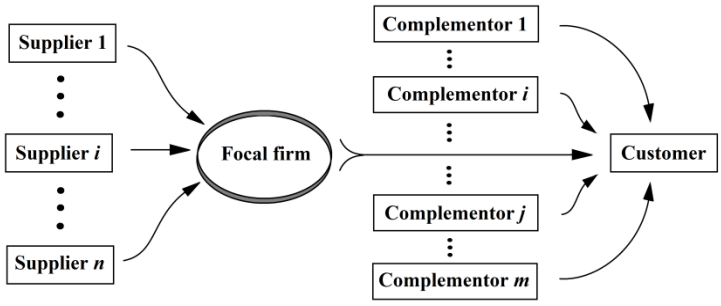


Fig. 3. The supply-chain ecosystem of a focal firm

Let E denote the supply chain of a firm. Model firm i in this chain as an abstract system $S_i = (M_i, R_i)$. Assume the index set of these firm systems is T, satisfying that for any $t \in T$, there is a unique firm system $S_t = (M_t, R_t)$ in the supply-chain ecosystem; and for any firm system $S_s = (M_s, R_s)$ in the supply-chain ecosystem, there is a unique index $s \in T$ that labels the system S_s. Then, E can be modeled as a hierarchy $E = \{S_k : k \in T\}$of firm systems S_k, for $k \in T$.

Let $S_i = (M_i, R_i)$, i = 1, 2, be systems and h: $M_1 \to M_2$ a mapping. For each relation $r \in R_1$, define $h(r) = \{h(x) : x \in r\}$. Without confusion, write h: $S_1 \to S_2$. A mapping h: $S_1 \to S_2$ is said to be partial, if for some object $x \in M_1$, $h(x)$ is not defined. The identity mapping $id: S_1 \to S_1$ is defined by $id(x) = x$, for $x \in M_1$.

Theorem 3:

Assume that the hierarchy $E = \{S_k : k \in T\}$ does not include such systems S_{k_1} and S_{k_2} that some outputs of S_{k_1} are used as inputs of S_{k_2}, while some outputs of S_{k_2} are employed by S_{k_1} as inputs. Then the supply-chain ecosystem $E = \{S_k : k \in T\}$ can be made into a partially linked hierarchy $\{E, \ell_{ts}, T\}$ of systems by a family $\{\ell_{ts} : S_s \to S_{it} : t, s \leq T, s \geq t\}$ of partial linkage mappings of E.

The proof is given in Appendix.

3.2. Maintenance of an Existing Momentum of Economic Growth

To investigate how an existing momentum of economic growth can be maintained, let us first look at the concept of feedback systems [14]. Assume that X and Y are two linear spaces X and Y and $S: X \to Y$ and $S_f: Y \to X$ and linear functions from X to Y and from Y to X, respectively. Then the feedback system of S by S_f is defined as the input-output system S' such that the following expression holds true

$$(x, y) \in S' \leftrightarrow (\exists z \in X)\left((x + z, y) \in S \text{ and } (y, z) \in S_f\right).$$

In our current context, Theorem 3 means that the existence of a large magnitude consumer surplus, as provided in the assumptions of Theorem 2, represents the fact that the incumbent firms of the market can no longer satisfy the forever changing consumer preference and tastes. In real life, of course, this fact (or market call) can be understood in many different ways. If our focal firm innovatively deciphers the market call by introducing its original product, then that implies that each tree-like subset of the partially ordered set T in terms of the order relationship $\leq$ contains minimal elements, consisting of various market demands, and that every player in the supply-chain ecosystem of the focal firm will be

challenged to provide their correspondingly innovative supplies in order to jointly answer the market call. Even though the initial market call might not be answered adequately by a single firm's reply with its new product, the aggregate of all relevant original products offered by various entrepreneurial firms will definitely satisfy the market demand. So, this discussion combined with the concept of feedback systems leads to the following fact regarding the importance of government's policies.

Proposition 6:

To maintain the extant economic growth momentum, assuming that such a momentum already exists, a nation has to constantly provide "fuels" through policy supports for the prevailing feedback system, which reinforces the horse race between market demands and manufacturing production so that the race will continue to intensify, to continuously function.

In fact, what is discussed in the previous paragraphs indicates that market exchange stimulates manufacturing production, while the production encourages consumers to alter their preferences and tastes. This cyclical evolution continues and helps both market exchange and manufacturing production enter into a horse race against each other. That is, an operational feedback system appears. In this feedback system, forever changing market demands provide stimuli for manufacturers to produce more products and make better products. And the growing magnitude of manufacturing production forces firms to hire more employees with rising salaries. Such mutual reinforcements further strengthen the population's purchasing power, which in turn pushes market demand onto a higher level; …

To keep the prevailing feedback system functional smoothly, the economy (or the government) has to encourage as many entrepreneurial firms as possible to answer various market calls by providing their original products. However, many of these original products will not be readily usable by the consumers of the marketplace unless adequate infrastructures are constructed and maintained by forces supported either directly or indirectly by the government. Speaking differently, the reason why policy supports are needed to fuel the prevailing feedback system in order for it to function smoothly is because the system is too colossal for any individual economic enterprise to handle, while the government can reach and mobilize a large proportion of the economic system (Theorem 1). Hence, the government can at least help coordinate many individual firms in very large scales to join their efforts, resources, etc., by utilizing policy tools and supports. For example, the literature shows that to stimulate economic growth the government can use policy tools to

- Promote the ideology of commercialization at various societal levels, especially in rural areas [2,26];
- Encourage entrepreneurship and risk taking [27]; and
- Provide the freedom for people to move geographically and professionally and to make career choices [28],

and can provide various supports [2,4,16,29,30], such as

- development of the necessary domestic and international markets of sufficient depth and distribution networks of appropriate sophistication;
- smooth operations of these markets and networks;
- financial and politically stability;
- construction of necessary infrastructures (such as roads, irrigation systems, energy supplies, etc.);
- smooth flows of knowledge and information that promote coordination and specialization of labor;

- educational programs for necessary skill trainings;
- resources and needed coordination of resources;
- and others.

Moreover, the discussion in the previous sections elucidates why further development of the focal nation's economy needs to pay equal attention to increasing degree of marketization, continuously deepening political reform, and dramatically raising the magnitude of market sector of private enterprises.

In particular, by increasing the degree of marketization, market demands can be freely and adequately signaled through market phenomena and forces. By dramatically raising the magnitude of the market sector of private enterprises, entrepreneurs can individually and differently comprehend market signals and take their respectively appropriate actions by designing and offering their varied original products and services to the marketplace. By continuously deepening political reform, the government's way of conducting its business can be brought closer to the current state of the accelerating horse race between the market demands and manufacturing productions. Only by synchronizing the political system that is underneath the composition and operation of the government with the prevalent working state of the feedback system of the economy, which reinforces the horse race between market exchanges and manufacturing productions through raising purchasing power of the population, the overall organizational structure of the focal nation, seen as an entity that is simultaneously political, economic, social, etc., will stay as a stable, smoothly functional system.

4. CONCLUSION

Because of the use of systems science and methodology, this work is able to scientifically address: (1) Why are policy tools expected to work in an economic system? (2) why are government policy tools and supports fundamentally necessary for stimulating economic growth? And (3) several other relevant issues.

Historically, there had been three rounds, plus the current round for a total of four rounds, of debate that directly attempted to address these questions from different angles. However, due to the fact that only data/anecdote-based approaches were employed, what achieved turned out to be theoretically inconsistent and uncompromising suggestions that are practically unreliable [3]. The entire situation is similar to that reflected in the literature on the Industrial Revolution [2,4] but with such a major difference that for the latter Rostow recognized the need for introducing an appropriate methodology in order for relevant studies to escape from the trap of not being able to produce consistent conclusions. By comparing these two lines of related but different studies, this paper develops generally-true conclusions by innovatively employing logical reasoning based on results established rigorously. In particular, among others, the following main results are established:

- If a government is able to introduce and implement appropriate policy tools, then the determination of further advancing the nation's economy can become an extraordinary reality. It is because (Propositions 2 – 5) in this case the government is able to adjust the economy's underlying organizational structure as a goal-oriented system within which most individual economic agents will be able to adjust their orientations and operations without much difficulty.
- To maintain an existing momentum of economic growth, a nation needs to constantly provide policy supports for the prevailing feedback system, which reinforces the horse race between market demands and manufacturing production so that the race will continue to intensify, to continuously function (Proposition 6).

Because of the particular methodology employed here, the established theoretical conclusions provide policy makers with dependable bases to make their decisions. For example, the general recommendations below for a national government follow naturally:

(1) It needs to constantly maintain its capability to make adjustment(s) to the underlying organizational structure of its economy. Only with such capability, the government is able to fine-tune and to redirect the development and evolution of the economy (Proposition 2).

(2) It needs to frequently identify objectives of economic development that potentially benefit most economic agents. By accomplishing such a goal, the policy makers of the nation will be able to develop a national ambition supported by a majority of the nation (Proposition 3).

(3) If all possible, it needs to find effective ways to implement its policies in order to practically materialize the goal of further advancing the nation's economy from the present state (Propositions 4 and 5).

(4) It needs to create and maintain a functional feedback mechanism that intensifies the horse race between market demands and manufacturing production (Proposition 6). First, by creating such a feedback mechanism from scratch, an originally impoverished nation can potentially evolve into an economy of proto-industrialization [16,30], where local handicraft productions, alongside commercial agriculture, will be developed to such a level that, beyond local markets, can also satisfy external markets. Secondly, by maintaining such an existing feedback mechanism, a developed economy will be carried to a higher level of economic development [2].

There are also some limitations to this work. First, although conclusions of this paper depend heavily on the methodology of systems science, we only applied one of the many tools available that are developed for analyzing organizations, their evolutions and interactions [31]. So, when other tools of systems science are employed one by one in studies of business-related issues and problems, we will be able to establish finer and reliably applicable conclusions. Second, all reasonings used in this work assume why a firm exists – it attempts to satisfy a particular market niche with its operation financially maintained by a positive cash flow as a consequence of its business conducts. Although this assumption is conventionally true in the past [32], it is no longer the case in the present business landscape. For example, some e-business operations have focused on pumping up their future promises and potentials to continuously attract sufficient venture capitals by placing emphasis on increasing their market shares, although they have been losing money year after year since their inception [33]. Hence, any violation of this assumption can realistically stand for why applications of our general conclusions developed in this paper fail to work in practice, if the firms of concern exist for purposes other than what is assumed. These limitations, along with others not listed here, of this current work provide directions for future research.

Appendix: Proofs of theorems

For related terminologies and symbolic expressions used in these proofs, see [14].

Proof of Theorem 1. For convenience, assume that $|M| = \theta$ and that there is a common element in all the object systems in *M,* which implies

$$|\cup \{M_z : x = (M_z, R_z) \in M\}| \leq \theta. \tag{1}$$

Without loss of generality, for each object $z = (M_z, R_z) \in M$, assume

$$\bigcup \{M_z : z = (M_z, R_z) \in M\} \subseteq \theta. \tag{2}$$

So, for each $z = (M_z, R_z) \in M$, the order type $< \kappa$ of M_z is a subset of θ. Because θ is regular and $\theta > \kappa$, there exists a $\rho < \kappa$ so that $M_1 = \{z \in M: M_z$ has order type $\rho\}$ has cardinality θ. Let us fix such a ρ and deal only with the partial system $S_1 = (M_1, R_1)$ of *S,* where R_1 is the restriction of the relation set *R* on M_1.

For each $\alpha < \theta$, $|\alpha^{<\kappa}| < \theta$ implies that less than θ objects of the partial system S_1 have object sets as subsets of α and $\bigcup\{M_z : z = (M_z, R_z) \in M_1\}$ is cofinal in θ. If $z \in M_1$ and $\xi < \rho$, let $M_z(\xi)$ be the ξth element of M_z. Because θ is regular, there is some ξ such that $\{M_z(\xi): z \in M_1\}$ is cofinal in θ. Let ξ_0 be the least such ξ. Then the condition that there exists a common element in each system in M_1 implies that $\xi_0 > 0$. Let

$$\alpha_0 = \bigcup\{M_z(\eta) + 1 : z \in M_1 \text{ and } \eta < \xi_0\}. \tag{3}$$

Then $\alpha_0 < \theta$ and $M_z(\eta) < \alpha_0$ for all $z \in M_1$ and all $\eta < \xi_0$.

By transfinite induction on $\mu < \theta$, pick $z_\mu \in M_1$ so that $M_{z_\mu}(\xi_0) > \alpha_0$ and

$$M_{z_\mu}(\xi_0) > \max\left\{\alpha_0, \bigcup\{M_{z_v}(\eta) : \eta < \rho \text{ and } v < \mu\}\right\}. \tag{4}$$

Let $M_2 = \{z_\mu : \mu < \theta\}$. Then $|M_2| = \theta$ and $M_{z_1} \cap M_{z_2} \subseteq \alpha_0$ whenever $z_1 = (M_{z_1}, R_{z_1})$, $z_2 = (M_{z_2}, R_{z_2}) \in M_2$ are distinct objects. Because for each $\alpha < \theta$, $|\alpha^{<\kappa}| < \theta$, there exists an $r \subset \alpha_0$ and a $B \subset M_2$ with $|B| = \theta$ and for each $z \in B$, $M_z \cap \alpha_0 = r$, $S_2 = (B, R_B)$ forms a centralized system, where R_B is the restriction of the relation set R on B.

Proof of Theorem 2. Assume that the market is occupied by n incumbent companies, $n = 1,2,3,\ldots$ The, individually different boundary conditions of companies can be normalized so that the production cost is 0, customer's reservation price 1, price P satisfies $0 \le P \le 1$, loyal-customer bases of the incumbent companies are of the same percentage scale u with $v = 1 - nu$ being the scale of the consumer surplus. Assume that the entering company randomizes its price between its cost 0 and consumer reservation price 1.

To protect their established territories, each incumbent sets its price by considering all competitors. So, the equilibrium indifference condition of incumbent Company k is

$$uP + vP\prod\nolimits_{j\neq k}^{n}(1-P)[1-F_j(P)] = u. \tag{5}$$

where $F_j(P)$ is the price distribution of Company j; and in Nash equilibrium, the incumbents do not have any pure pricing strategy [22]. Hence, for the incumbents, their symmetric equilibrium pricing is

$$F(P) = 1 - \left(\frac{u}{vP}\right)^{\frac{1}{n-1}}. \tag{6}$$

The assumption $v \ge u$ implies that equation (6) defines a mixed strategy for each incumbent for $u/v \le P \le 1$. Because $F(P)$ experiences a jump of $[u/v]^{\frac{1}{n-1}}$ at $P = 1$, the expected profits of the entrant are:

$$E_e(\Pi) = \int_0^{u/v} vP dP + \int_{u/v}^{+\infty} vP[1-F(P)]^n dP \tag{7}$$

$$= \begin{cases} \dfrac{-nu^2}{2v(n-2)} + \dfrac{n-1}{(n-2)}\left(\dfrac{u^n}{v}\right)^{\frac{1}{n-1}} + v\left(\dfrac{u}{v}\right)^{\frac{n}{n-1}}, & \text{if } n \ge 3 \\ \dfrac{u^2}{2v} - \dfrac{u^2}{v} ln\dfrac{u}{v} + v\left(\dfrac{u}{v}\right)^{\frac{n}{n-1}}, & \text{if } n = 2 \end{cases} \tag{8}$$

The first term on right-hand side of equation (7) is equal to the entrant's expected profits when it charges a price lower than the incumbents and captures all switchers, and the second term the entrant's expected profits when it directly competes with the incumbent companies. The expected profits of an incumbent are

$$E_m(\Pi) = \int_{u/v}^{1} \left\{ uP + vP(1-P) \prod_{j \neq i}^{n} [1 - F(P)] \right\} dF(P) + u\left(\frac{u}{v}\right)^{\frac{1}{n-1}} = u. \tag{9}$$

Because $\frac{\partial}{\partial u}[E_s(\Pi) - E_m(\Pi)] > 0$, and when $v = 1/(n+1) = u$, $E_s(\Pi) - E_m(\Pi) > 0$, there is $u^* \in (0, 1/(n+1))$ so that when $u = (1-v)/n \geq u^*$, $E_s(\Pi) > E_m(\Pi)$. That is, the entrant can actually expect to make more profits in the said market than some incumbent.

Proof of Theorem 3. In fact, the input-output relationship among the firms in E implies that the index set T can be ordered partially: For $s, t \in T$, $s \geq t$ if, and only if, some outputs of firm system $S_s = (M_s, R_s)$ are used as inputs of firm system $S_t = (M_t, R_t)$. For $s, t \in T$, if $s \geq t$, define a partial (linkage) mapping ℓ_{ts} from firm $S_s = (M_s, R_s)$ into customer firm $S_t = (M_t, R_t)$ by

$$\ell_{ts}(m_s) = m_t \in M_t, \tag{10}$$

for any $m_s \in M_s$ such that system S_s's output m_s is applied as a component in S_t's product m_t.

Because for any $r, s, t \in T$, satisfying $s \geq r \geq t$, we have

$$\ell_{ts} = \ell_{tr} \circ \ell_{rs}, \text{and } \ell_{tt} = id_{S_t}. \tag{11}$$

This systemic modeling implies that we can treat the supply-chain ecosystem E of any firm as a partially-linked hierarchy of firm systems $\{E, \ell_{ts}, T\}$.

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