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# STRUCTURAL SHIFT AND INCREASING VARIETY IN KOREA, 1960–2010: EMPIRICAL EVIDENCE OF THE ECONOMIC DEVELOPMENT MODEL BY THE CREATION OF NEW SECTORS

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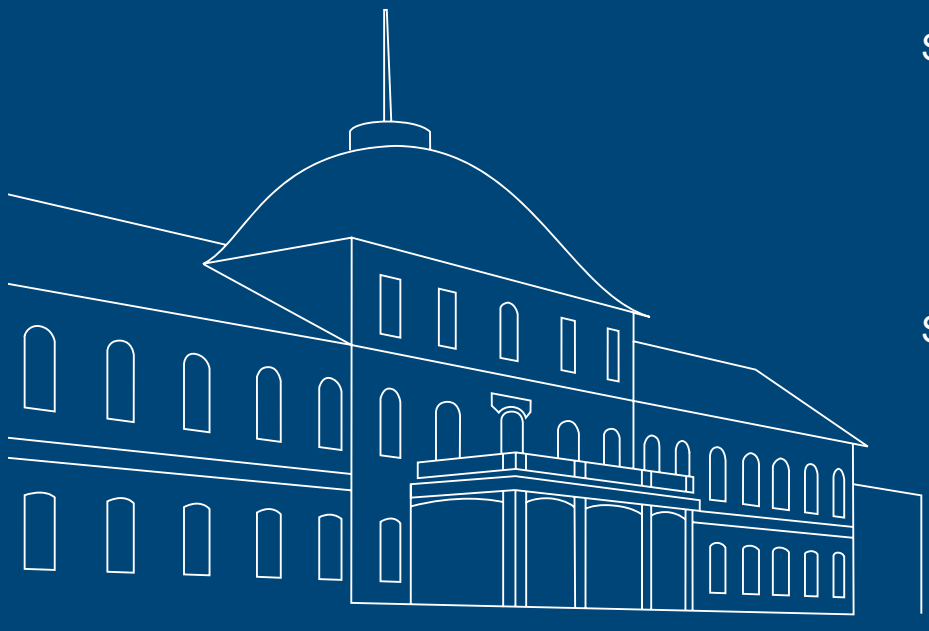

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# Structural shift and increasing variety in Korea, 1960–2010: Empirical evidence of the economic development model by the creation of new sectors

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## Abstract

In this paper, we examine the experiences of the Korean economy alongside theoretical knowledge of economic development and structural change. To demonstrate the generalized hypotheses on structural change, input–output tables of Korea, from 1960 to 2010, were analyzed. Our interest in taking time series of input–output tables originates from the following two issues. Firstly, we raise the question of whether Korean industrial structure changes have followed a certain pattern of structural shifts as well as increasing variety. Secondly, if so, it is questioned how the meso-level conditions for economic development could be explained from such a pattern. To search for answers, we adopt a model of the economic development by the creation of new sectors, named TEVECON, as our theoretical framework. Using this growth model, we derive hypotheses about how the structural change could affect economic development, and then we determine how the empirical analysis of the Korean economy verifies and deepens our understanding of structural change and economic development. This paper contributes to the empirical validation of the theoretical knowledge of economic development by the emergence of key sectors and the creation of new industries.

**Keywords** Structural change; Increasing variety; Unrelated variety; Input–output table; Korean economy; TEVECON model; Economic development; Economic growth

## 1. Introduction

Without doubt, an important challenge of economics is to elucidate the nature and causes of economic growth and long-term development. The theory associated with such issues, thereby, has been constantly modified and evolved into more explanatory forms, following the critical moments in economic history. Thus, many scholars have tried to define the moment when the existing production structure was dramatically transformed by the industrialization at the beginning of the 19th century, or when the worldwide economy was in deep recession during the 1920s. Now, we require a new economic explanation for today's so-called knowledge-based society, meaning that the creation of new products and new industries becomes natural and ordinary as a result of innovation. Subsequently, such explanation of the recent transition can contribute to advancement in the field of growth and development theories once again. In this paper, we interpret the emergent phenomenon of knowledge-based industries as the compositional change of the economic system, and we revisit the studies on structural changes and economic development. In order to verify and complement the theoretical discussion thus far, this study redefines structural change with respect to two different consequences and focuses more on the relationship between 'increasing variety' at the industrial level and economic development in an empirical analysis.

Structural change has been on the agenda of economics since the evolution of classical economics. However, in the wake of the marginal revolution at the turn of the 20th century, the focus of economic theory changed from the national level of production and distribution toward the micro level of market balance and pricing mechanisms. With the advent of neoclassical economics, the factors related to structural issues tended to be assumed away (Harris 1982). Nonetheless, as the world economy experienced various fundamental shocks and transformations in the 20th century, scholars began to deliberate on economic growth and structural development once again. In this movement of modern economics, several different perspectives on economic growth have been developed into three branches of the growth and development theory: the first branch is the new growth theory (Lucas, 1988; Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt 1992), the second branch is the innovation-driven growth theory in an evolutionary perspective (Dosi and Nelson, 1994; Saviotti and Pyka, 2004; Metcalfe, Foster, and Ramlogan, 2006), and the third branch includes the field of development economics and others (Lewis, 1954; Rostow 1959; Chenery 1960).

In this study, we cover the first and second strands of growth theories in accordance with how they incorporate structural changes into their frameworks. By reviewing key studies in the literature on growth theory, a model of economic development by the creation of new sectors, named TEVECON (Saviotti and Pyka 2004, 2008), is applied as the theoretical framework for this study. We also formulate three hypotheses on structural changes and economic growth from the literature review. For testing the hypotheses, we collected and analyzed input–output tables of Korea, which have been published from the Bank of Korea on the quinquennial base from 1960 to 2010. According to S. Kuznets (1973) and Chenery (1960), gross-output (GO) values in input–output tables are more suitable for observing overall structural changes because GO values capture intermediate

consumption as well as final goods transactions. Thus, this study encompasses the broader range of structural changes analysis in comparison to a myriad of previous examples from the literature using value-added data (e.g. GDP).

In order to systematically analyze structural changes on the view of economic development, we must start by redefining the structural change as a combination of structural shift phenomena and increasing variety phenomena. Moreover, by making use of the compositional characteristics in aggregated GO values, we decompose the overall structural change into three components along two dimensions of functionalities for long-term economic growth: the necessary requirement for the growth by intermediates and exports for structural change, and the consequences from the growth by private consumption for structural change. By doing this, we can shed new light on the relationship between changes in the industrial structure and economic growth.

This paper is organized as follows: In section 2, we review previous studies on two aspects, respectively, structural shifts and the increasing variety following our definition of structural change. In addition to this, we narratively describe the key mechanism of the TEVECON model in order to specify the theoretical background of this study. Section 3 deals with details of the research design, including the subjects of analysis and methodology. Section 4 presents the results of the analysis. Finally, we conclude with the contributions and implications of this study.

## 2. Structural Change in Economics: Literature Review

Economists have been interested in structural change and the economic progress of nations since the emergence of classical economic growth theory (Harris, 1982). In the meantime, the scope of ‘structure’ and the definition of 'structural change’ have been discussed in different ways depending on the historical and academic background. Thus, it is necessary to create an agreement between the scope and focus in this study before going into further discussion. We redefine structural change as the combination of *structural shift* between sectors and the *increasing variety* of the economic structure. In this respect, the scope of ‘structure’ is confined to ‘industrial structure’ constituting the total economic production of the economy.

Although both aspects, s*tructural shift and increasing variety,* are measured by the same compositional changes, the messages from the two aspects are significantly different. Nevertheless, structural change has been generally defined as “the long-term persistent changes in the composition of an aggregate” (Syrquin, 2010). However, with the new definition in this study, we can clarify exactly what kind of functionalities could be exerted on the economy via “compositional changes”. In detail, the aspect of structural shift will be discussed based on the average impact on the aggregated national productivity. The main point of structural shift is to figure out which sector holds the largest majority in a constant set of industries. In this point of view, the so-called “structural bonus hypothesis”,

meaning that the average productivity growth via structural changes leads to the economic growth, has been empirically verified (Fagerberg, 2000; Timmer and Szirmai, 2000; Peneder, 2003). This was primarily accomplished by applying the shift-share analysis using value-added data and labor productivities for each sector.

The aspect of increasing variety is more related to the emergence of a new sector and the increase in the number of total industries. In this regard, previous studies emphasized the creation of new products, new demands, and new industries as playing a determinant role in economic growth (Kim and Heshmati, 2014; Saviotti and Pyka, 2004; Montobbio, 2002). In particular, Saviotti and Pyka (2004) and Montobbio (2002) presented new growth models to capture the importance of economic variety at the industrial level. Their growth models have been highlighted due to their contribution to incorporating evolutionary perspectives not just on the result but more on the process of structural change. Such efforts on formal theory could fill the gap between micro- and macro-models of economic growth by considering "meso-level"[1] phenomena.

In short, under the new definition of this study, structural shift and increasing variety reflect two different points of structural change: the specific contribution of certain industries' productivities and the overall picture composed by emerging and declining industries. In section 2.1, we revisit literature that is more related to structural shift.. In section 2.2, we review previous studies on increasing variety. In section 2.3, we discuss the TEVECON model in depth as the theoretical framework for this study of structural change and economic development.

### 2.1. Structural change and economic growth and development

Until recently, the economic structure of national production has been steadily receiving attention from policy makers because of the high correlation with the aggregate productivity growth. Here, the aggregate productivity means the average value of all industrial productivities when each industry (or sector) has a different productivity. Consequently, we can make the argument that changes toward certain industrial structure combinations can guarantee long-term economic growth due to the higher aggregate productivity. In fact, we witnessed a specific sector overwhelming others by a commanding lead on productivities during the global industrialization of the 20$^{th}$ century. Therefore, many early studies noted that the transformation toward the manufacturing economy enabled accelerated economic growth (Fisher, 1939; Fabricant, 1940; Clark, 1960). In other words, early research on structural changes mainly focused on the *structural shift* phenomenon.

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[1] Dopfer, Foster, and Potts (2004), and Dopfer (2011) insisted on the importance of the meso-level consideration to the economic process, so they developed the analytic framework of micro–meso–macro architecture. In addition, according to Hanusch and Pyka (2007), the meso-level appreciation between the micro and the macro levels of economic analysis is necessary to understand the decisive structural and qualitative changes.

In one of the most classic studies on economic structural shifts, Fisher (1939) stressed that it is necessary to classify the economic production as primary, secondary, and tertiary sectors. According to him, the classification of economic production would "give a lead in answering about what direction is desirable at this stage of our history to accelerate the rate of economic development" (Fisher, 1939, p. 30). Afterward, scholars have studied how the majority of the economic production succeeds along the sectoral development path (Baumol, 1967; Kuznets, 1973)[2] and investigated into the importance of manufacturing sectors as growth engines (Cornwall, 1977; Szirmai, 2012). Furthermore, recent studies on structural changes and economic growth (Fagerberg, 2000; Peneder, 2003; Timmer and Vries, 2008) have extended their focus to the correlation between aggregate productivity and the technological advancement rates of industries. They have conducted comparative studies at the country level so as to explain the divergent patterns of economic growth, based on the subdivided classification of industries in accordance with different innovation rates[3].

In a nutshell, many studies on structural changes have tried to elucidate the high relevance of economic growth and structural shift by means of an average productivity, and the studies have mainly been carried out as a form of appreciative theorizing (the terminology of Nelson and Winter, 1985, p.46) based on empirical inferences and intuitive understandings. Ironically, however, it seems that scholars in the field of formal theories on the economic growth model have given slight consideration to structural change thus far. Although several endogenous growth models (Romer 1990; Grossman and Helpman ,1991; Aghion and Howitt, 1992; Ngai and Pissarides, 2007) have made an attempt to integrate the structural features of multi-sectoral economies, they mostly failed to capture key aspects of structural changes due to the following limitations.

First of all, Romer (1990) presented the product-variety model, taking multi-sectoral production of intermediates into account. Concerning structural changes, the model has contributed to extending growth theory from a one-sector economy to a structured economy. However, it has logical distance from structural changes on the real industrial level that such diversified sectors of intermediates end up with only one kind of final good. Meanwhile, the quality-ladder model of Grossman and Helpman (1991) complements the variety and quality problem by incorporating the obsolescence relation across sectors of intermediate production. In other words, the model explains "quality-upgrading" economic growth by introducing vertically differentiated products. However, the quality-upgrading growth confines the qualitative change within sectors, creating so-called intra-sectoral differentiation. This model describes only a proportional growth of a single industrial economy. Thus, it is difficult to find the full-fledged consideration of meso-level growth dynamics.

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[2] In particular, Kuznets (1973) pointed out that the third characteristic of modern economic growth is related to structural change of shifting away from agriculture to non-agricultural pursuits, and then from industry to services. His perspective explicitly shows the structural shift aspect.

[3] This approach originated from Salter (1966), who stated that "the interindustry patterns of growth", which could be interpreted as structural change, were explained by "uneven rates of productivity growth" across industries with empirical proof.

Aghion and Howitt (1992) also presented an advanced endogenous growth model by adopting the concept of creative destruction and labelling it a Schumpeterian model. Despite modeling the creation of new sectors in the model, however, the symmetric assumption among sectors resulted in a constant composition of each sector. Subsequently, it precluded further discussion on the *structural shift* of majority shares by measuring a compositional change. Additionally, the model also has no correlation with the *increasing variety* at the meso-level since the number of created new sectors was set identical to the number of extinct old sectors.

On the other hand, multi-sectoral growth models at the level of final consumption goods have been also introduced (Ngai and Pissarides, 2007; Foellmi and Zweimüller, 2008). In the model of Ngai and Pissarides (2007), as an example, the multi-sectoral structure was applied to deepen the hypothetical knowledge of Baumol (1967), which was directly related to structural change issues. They tried to theorize the appreciative argument on employment share growth in the stagnant sector as a consequence of further economic growth. In this case, however, the model hardly conveyed the new insights on structural change, despite the fact that it modeled structural shift phenomenon into an endogenous growth model.

In summary, traditional studies on structural changes have usually focused on the structural shift aspect, and endogenous growth models of multi-sectoral systems were only to provide possibilities to theoretically describe such phenomena by means of technology and innovation within a constant set of production. In consequence, we can raise questions about the productivity-enhancing effects of the structural shift and the correlation of sectoral features (e.g. high-technology base). Hence, the first hypothesis of this study can be synthesized as below.

> **Hypothesis 1.** Structural shift, *leading to the growth of emerging industries*, contributes to the long-term economic growth when emerging industries show higher productivities than other existing industries.

### 2.2. Increasing variety and economic growth and development

In the history of economic growth and development, we have experienced that “a very large number of new sectors have been created since the industrial revolution, and examples of these sectors are those producing cars, aircraft, computers, radios, television, refrigerators, plastics, etc.” (Saviotti and Pyka, 2013). From this point of view, we can also discuss structural changes by changing a constitutional set of economic structures within various industries. This exactly represents the increasing variety phenomenon of structural change. Interestingly, however, this point has not been highlighted in the traditional research strands of structure changes. Thus, we introduce evolutionary growth theories as theoretical frameworks for increasing variety issues in this section.

One of the distinctive features of evolutionary growth theories is an appreciation of the emergence and saturation of technological regimes and sectoral specificities in patterns of

technological advancement. In other words, evolutionary theories explain that innovation-driven economic growth has been the continuation of resource reallocation from old industries with a slower rate of advance toward emerging new industries with a higher rate of advance (Dosi and Nelson, 2010). In this process of cumulative changes in a multi-sectoral economy, some old industries were replaced by new industries while other old industries remained in the economic system. Based on this understanding, the changing of industrial structures could be properly guided by evolutionary growth theories on the perspective of *increasing variety*.

The study by Pasinetti (1981) is one of the most cited studies in the field of evolutionary growth theories and structural changes. Pasinetti argued that long-term economic progress should be perceived as "a never ceasing transformational process" (Sryquin, 2010). In Pasinetti's (1981) scheme, the relationship between structural change and long-term growth was systematically analyzed from the technological advancement on the supply side to the change of final demand composition on the demand side. This point has been mostly characterized as a combination of the classical and Keynesian perspectives, and it tends to be better explained by a type of technical progress for improving labor productivities within a vertically integrated structure of industries.

Pasinetti (1981) also provided an important clue to understanding the increasing variety aspect in the process of structural changes in a multi-sectoral system. In his theoretical framework, he also tried to encompass the other type of technical progress for introducing new goods and consequently new sectors into the system. Specifically, by replacing the number of sectors with the time-variant variable, e.g. from *n* to *n(t)*, he tested the impact of the increasing variety in the production structure of commodities as an effect of such a product innovation (Pasinetti, 1981, p. 89). In this respect, Pasinetti's theory of structural change and economic growth definitely brings up a crucial question about the increasing variety aspect, although there are methodological limitations and difficulties in the application to empirical studies (Krüger 2008).

Saviotti and Pyka (2004) took over the essence of this mechanism of creating new sectors followed by the introduction of new products in a formal theory of evolutionary economics, and elaborated it into TEVECON. This model basically embodies the causal loop from the innovation activities of firms (micro-level) to the creation of new sectors (meso-level), and the economic development (macro-level) in TEVECON is described as the cumulative result from the causal loop. In this process of economic development, it is assumed that old sectors remain in the economic system instead of extinction or substitution[4]. Therefore, as the economic growth is progressing over time, the number of total industries increases while the relative weight of old sectors decreases. This exactly shows the *increasing variety* phenomena of structural change, and this growth model captures the concept of variety as a necessary requirement for the long-term growth. More detailed descriptions of

[4] According to Saviotti and Frenken (2008), the Schumpeterian concept of creative destruction can be reconsidered in that there is more creation than destruction at the industrial level under historical observations, and the assumption here is in line with this perspective.

TEVECON will be presented in section 2.3.

Montobbio (2002) presented a theoretical model applying the relationship between structural change and aggregate productivity growth on the evolutionary perspective. He suggested the standard replicator model for a multi-sectoral economy. The model is an extension of Metcalfe's (1994) model for the single industrial dynamics on the macro level. The standard replicator model is characterized by understanding the diversity of multi-sectoral economies on the industrial dynamics perspective. One of the most interesting points in this study is that he mentioned the emergence of "sectoral variety" (Montobbio, 2002, p. 407) plays an important role in structural change and economic growth. In the model, therefore, he tried to incorporate the factor of sectoral variety by setting it in relation to key variables: the degree of substitutability across sectors, the sector-specific unit cost average, and the income elasticity of demand. Unfortunately, although the model did not successfully draw out simulation results to show the impact of sectoral variety on aggregate growth[5], his study is of great theoretical significance in considering the emergence of sectoral variety in the inter-sectoral context.

On the other hand, the increasing variety aspect was also discussed by Kim and Heshmati (2014), who suggested the new analytic framework of the accelerating economic growth, named the "expansive reproduction system". According to Kim and Heshmati (2014), three different production structures were clearly identified in agricultural, commercial, and industrial economy relevantly. Among these three systems, it is only the expansive reproduction system in industrial economies that guaranteed the sustained accelerating economic growth. In particular, they highlighted the importance of the creation of new demand. This is because the creation of new demand generated a qualitative development of the existing production structure through the advancement of products as well as industrial structures (Kim and Heshmati, 2014, p. 78). In this context, a qualitative advancement of industrial structures means the increase in inter-sectoral variety as well as intra-sectoral variety.

Finally, we can conclude that the increasing variety aspect of structural change should be significantly considered on the basis of many theoretical grounds as discussed above. Nevertheless, the empirical validation of these growth models in terms of increasing variety has been seldom conducted so far in comparison to the myriad of empirical studies on structural shift aspect. Thus, our next question concerns how to empirically verify the increasing variety aspect. Of course, counting the number of total industries could be the most direct way to measure the variety. However, since the overall phenomenon of increasing variety entails compositional changes as well, it is reasonable to quantify the degree of increasing variety as an aggregated index of sectoral proportions together with the number of total industries. In this regard, a good example of empirical approach to economic varieties could be found in the field of regional economic growth studies such as Frenken et al.(2007).

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[5] In fact, the model showed that the variety is "eroded" due to the initial number of firms and sectors is given (Montobbio, 2002, p. 405), and it seems more apt to describe the transitional properties of structural changes.

Hence, it is still necessary to briefly review and discuss their methodological ways, although the main concerns in the studies of regional growth and economic varieties are dissimilar to our points.

The study by Frenken et al.(2007) is a recent work discussing whether the industrial structure should be diversified or specialized for regional economic growth (Imbs and Wacziarg, 2003; Klinger and Lederman, 2004; Rodrik, 2007). The main concern of the studies is the inter-industrial spillover effect to promote further innovation due to the technological proximity across manifold sectors, the so-called Jacobs externalities. In order to clarify the growth-promotion effect of increasing variety, Frenken et al. (2007) suggested two different levels of the variety index, unrelated and related variety, in accordance with the sectoral proximity. Accordingly, the entropy of unrelated variety (UV) and related variety (RV) were measured and discussed by taking industrial-level data with different aggregation levels of classification. Finally, he concluded that the related variety of industrial structure effectively leads to Jacobs externalities. As mentioned above, because the main idea of Frenken et al. (2007) is beyond the scope of what we verify in this study[6], we only benchmark the empirical methodology to measure the economic variety from their work. In section 3.3, the entropy of industrial structures in this study will be specified and used as the index for the degree of economic varieties.

### 2.3. A model of economic development by the creation of new sectors, TEVECON model

The goal of this study is to empirically verify and compensate for our theoretical knowledge of structural changes and economic development. In this case, in order to stylize theoretical findings from previous studies, it is important to select the reasonable lens of theoretical approach and then design the empirical analysis. Thus, the TEVECON model is chosen to serve as the theoretical framework in this study, especially in order to more thoroughly encompass the increasing variety issue. In this section, we introduce the TEVECON model in depth, not presenting specific equations but focusing on the theoretical meanings of the mechanism[7]. Following the main perspective of the TEVECON method, two more hypotheses will be set up.

The TEVECON model is constituted by the inter-correlated logic, including why new sectors emerge and how such an emergence generates structural change, as well as how structural change contributes to economic development. First of all, we describe the model “search activities” of firms. Search activity, which is generally called research and development (R&D) activity as innovation input efforts, is endogenized as a part of driving forces for economic growth, and the economy is set to

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[6] The relation between economic variety and spillover effect continues to be actively discussed and debated, so consensus on the effect has not been reached (Boschma and Iammarino, 2007; Castaldi et al. 2015; Aarstad et al., 2016). Furthermore, according to Pyka et al.(2009), since the variety of industrial structure is a kind of involuntary environment in which to interact, the spillover effect could be less significant for promoting further innovation than the voluntary interaction.

[7] The detailed model description with equations is referenced by Saviotti and Pyka (2004) and Pyka and Saviotti (2011).

progress through the continuous local equilibrium, not through the optimization process. The local equilibrium in this model means the market adjustment stage between actualized demand in the market and production capacity to support needs from the market. Here, the variables for actualized demand and production capacity are varied again with the degree of the search activities of firms. From this point of view, the model is called an “innovation-driven” economic growth model, embodying innovation activities as the fundamental contribution for economic progress.

On the mechanism of creating new sectors in TEVECON, it is necessary to understand the early situation after a certain radical innovation. Owing to the pervasiveness of radical innovations, a potential market of new products is able to open, and firms start to actualize such possibilities to the real demand in the market by producing new products. Then, it begins to grow as a new sector in the economic system. In this process, the “adjustment gap” is established as gauging the difference between the maximum potential demand and the actual demand in the market. As firms are eager to take advantage of the new market opportunities through search activities to internally differentiate products[8], the actual demand becomes saturated along a logistic curve. This means that the adjustment gap is narrowing, and it signals decreasing rates of profit. Consequently, firms need to open up other new opportunities by setting up a niche. In the meantime, when innovation efforts of firms converge with an increase in the “fundamental research activity”, the so-called public R&D, a new radical innovation is about to appear in the system. Subsequently, it drives the economic system, repeating the process of creating a potential market and then a new sector. During the process, existing sectors remain in the economic system, although the growth rate of sectoral production is already diminishing along the S-curve. Therefore, all new and old sectors are cumulated and keep producing relevant products so that the economy at the aggregate level grows quantitatively and qualitatively.

In summary, the TEVECON model elaborately demonstrates economic development with structural change in terms of the creation of new sectors and the accumulation of innovation activities. Figure 1 shows the representative results of the TEVECON model (Pyka and Saviotti, 2011). In Figure 1(a), each S-curve shows a dynamic of the sectoral output, and Figure 1(b) shows the growth of aggregated income. Figure 1(c) relevantly shows an increasing trend of economic variety at the inter-sectoral level by means of an informational entropy function.

[8] In the TEVECON model, a “sector” is defined as the collection of firms that produce differentiated products. Here, the differentiation of products means intra-sectoral differentiation in terms of quality improvement and internal modification, so differentiated products should not be confused with newly introduced products, which leads to the creation of new sectors thereby increasing inter-sectoral variety.

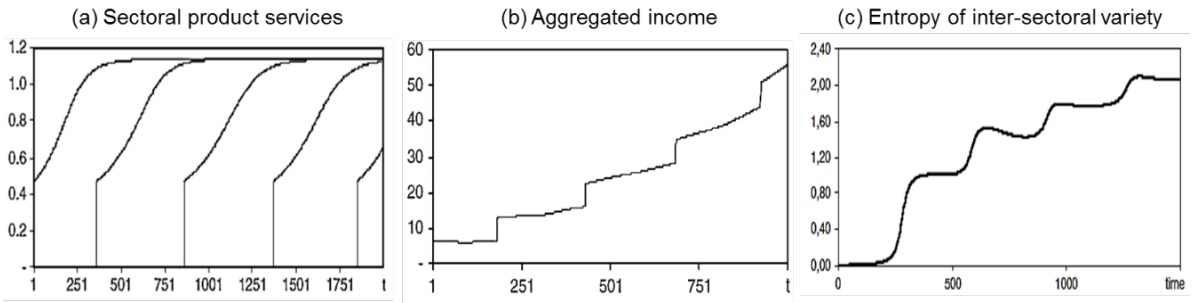


**Figure 1.** Simulated results* of TEVECON model: (a) Dynamics of sectoral product services, (b) Dynamics of aggregated income, and (c) Dynamics of inter-sectoral variety

As shown in Figure 1, the simulation resulted in reasonable trends of economic growth and structural changes. In particular, it raises substantive issues in relation to increasing variety and economic development due to the great compatibility with the history of economic growth. Nevertheless, the theoretical understanding of TEVECON has not been empirically tested or calibrated. Thus, we formulate two hypotheses based on the perspective of the TEVECON model as below[9], and verify the hypotheses empirically.

**Hypothesis 2**. The structural change by the creation of new sectors, called increasing variety, is a necessary requirement for long-term economic development.

**Hypothesis 3**. Long-term economic development is a combinational process of structural shift and increasing variety as a complementary relation.

## 3. Research design

### 3.1. Case of Korean economy, 1960 to 2010

The Korean economy has long been known as an exemplary case in terms of rapid economic growth with successful structural changes (Kuznets, 1988; Cho, 1994; Lee, 1999; Fagerberg 2000; Singh, 2004; Timmer and Vries, 2008; Mao and Yao, 2012). This makes Korea a suitable candidate for the empirical verification in this study. Both the history and the statistical data of the Korean economy, the time-series set of input–output tables from 1960 to 2010, are eligible for the analysis of the long-term economic growth in accordance with the changes in industrial structures. Input–output tables of Korea have been released every 5 years on average since 1960. The Bank of Korea has

[9] Based on two hypotheses in Saviotti and Pyka (2008), hypotheses 2 and 3 are re-stated in this paper, in accordance with the main focus and context of this study.

tried to capture internal changes of the economic structure into statistics as far as possible, through several modifications on the industrial classification (The Bank of Korea, 2014). Therefore, we chose the case of the Korean economy for the empirical verification, and use the time-series set of input–output tables in this study. We analyzed economic data beginning from the year 1960, as this marked the initial point of fully fledged economic development in Korea (Cho, 1997; Lee, 1999), to 2010 due to the limitation of data. In this section, we shortly describe the economic development history of Korea as the preliminary background, focusing on the perspective of industrial policies and industrial structures.

First, we divided the 50 years of the analysis period into three phases as shown in Figure 2, based on the moment when regimes of political and economic policies reached a breaking point. Phase 1 (1960–1981) is the first period of the government-led development plan, and so-called "growth-first" policies were aggressively implemented. Phase 2 (1982–1997) is the second period of the government-led development plan, but during this period, the government became aware of need for balance between government and private sectors. In this period, therefore, the government attempted to create the cornerstone of "modern industrial policies" and simulate the adjustment of the market distortion step by step, which was caused by the previous industrial policies (Shin 2012). The first few years of Phase 3 (1998–present) was the period of full-scale transformation into the market-driven economy in the wake of the IMF crisis. The detailed descriptions of each Five-Year Economic Development Plan and other remarkable industrial policies are as follows.

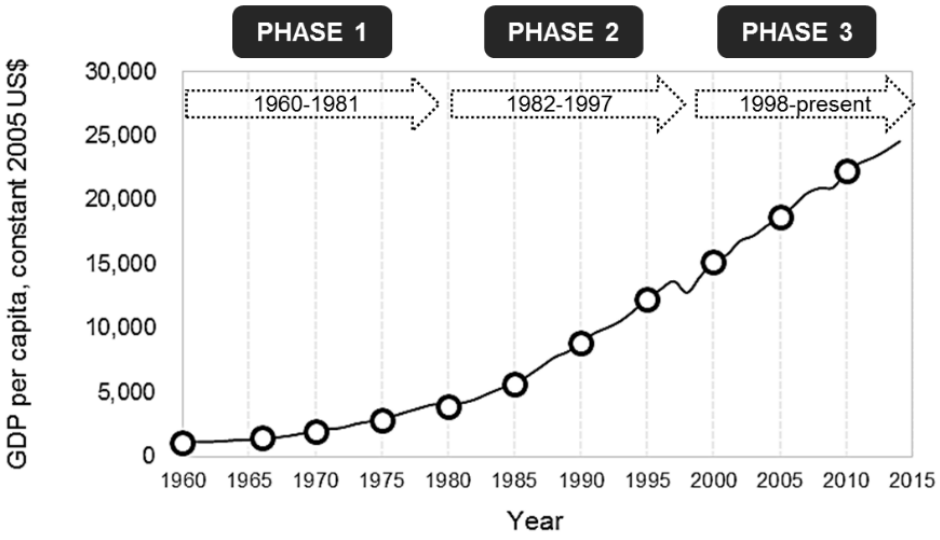


**Figure 2.** The 3-Phase classification of Korean economic development history (Data: GDP per capita (constant 2005 US$), from World Development Indicators)

Before the IMF crisis in Korea, the Korean economy was strongly controlled by government leadership. The Five-Year Economic Development Plan, which began in 1962 and has now been

carried out seven times, primarily targeted industrialization and modernization of the economy. The "industrial" structure of Korea took shape mainly due to the implementation of industrial policies alongside the development plan. The first and second plans (Phase 1-1, 1962–1971) aimed to establish independence in terms of economic production and consumption. The government during that period tried to foster the growth of light industries under the title of "export-driven strategy" to secure investment resources for the further advancement in industrial structure. Also, in order to deploy such resources, the government implemented policies for setting social framework conditions, for example, financial systems and training systems for engineers (Shin, 2012). Through the third and fourth plans (Phase 1-2, 1972–1981), the increase in exports as well as in quality of economic growth became the main concern for designing industrial policies. In order to sustain a growing trend in exports, the government selected the six strategic industries for highly contributing to economic growth, and enacted policies to promote infant industries by tax incentives and financial subsidies. In this respect, the six strategic industries were mostly heavy industries. Thus, the 1970s were known as a period of heavy and chemical industrialization (Heo, 2012).

During the first stage of Phase 2 (1982–1991), the fifth and sixth plans were conducted to enhance export competitiveness, and the government slowly became aware that export competitiveness could be achieved by a close cooperation with private sectors. In that time, the Korean economy unexpectedly started to leap in gross production owing to the favorable conditions of the internal and international economies[10]. Using this momentum, the government took the chance to embrace more of the private sector's own strategies into the policies, especially for the strategic industries, such as electronics or automotive sectors (Shin, 2012). Afterward, the seventh plan (1992–1997) was specifically enforced to be much open to the private sector-led economy and demand-oriented innovations. Meanwhile, the Uruguay Round negotiation in 1993 was also influential in the industrial policy regime, and Korea was confronted with a wide range of trade liberalization. Therefore, the government was almost forced to switch the basis of industrial policies from directly promoting strategic industries, such as "export-driven" industries, toward securing core technological competencies for promising industrial activities.

In 1997, the Korean economy was severely affected by the financial crisis, so the government finally asked for support from the IMF. The IMF approved the loans under the requirement of deregulating market conditions even in the financial market, so the government had to start revising the slogan of the explicit government-led development plan. In this way, the Korean economy entered Phase 3 (1998–present), facing the inevitable flow of liberalization and globalization. Thus, the government established "innovation policy" as the new keyword for the next development plan. This was based on strengthening the capability of science and technology. One notable accomplishment in this period was the growth of information and communication industries in Korea. This was mainly

[10] Internally, the government sought price stability, and externally the Korean economy benefited from low interests, low oil prices, and the depreciation of the dollar (Shin, 2012).

because the government, under President Kim Dae-jung (1998–2002), pursued the promotion of technology-based small and medium-sized enterprises (SMEs) by the aggressive investment in the high-speed Internet infrastructure and market. Recently, government policies related to industrial activities have become broadened and transformed in an indirect manner. The descriptions of Phases 1, 2, and 3 can be summarized as shown in Table 1.

**Table 1.** Description of the 3-Phase classification of Korean economy

| | **PHASE 1** | | | **PHASE 2** | **PHASE 3** |
|---|---|---|---|---|---|
| | **1-0** | **1-1** | **1-2** | | |
| **Data** | 1960 | 1966, 1970 | 1975, 1980 | 1985, 1990, 1995 | 2000, 2005, 2010 |
| **Keyword** | Initial state | Export-drive | Increase in export | Export competitiveness | Science and technology base |
| **Features** | Mainly agricultural industries | Promoting light industries[1] | Promoting 6 strategic *industries*[2] | Technologically advancing in competitive industries[3]<br><br>Developing the competitiveness in the automotive industry | Promoting industries related to 6 promising *technologies*[4]<br><br>Supporting industry convergences |

[1] Simple assembly industries of imported intermediates and simple processing industries; [2] Iron and Steel, Chemical, Non-Ferrous Metals, Machinery, Shipbuilding, and Electronics; [3] e.g. Electronics, Machinery industries; [4] IT(Information Technology), BT(Bio Technology), NT(Nano Technology), ET(Environmental Technology), ST(Space Technology), CT(Cultural Technology)

### 3.2. Data

We used input–output tables published by the Bank of Korea. Input–output tables of Korea started being officially published on a regular basis in 1960 as a benchmark year. The primary purpose of publishing the data was to provide the baseline information for policy makers. Thus, the Bank of Korea has tried to ensure that the significant changes of the industrial structure should be reflected on input–-output tables by carrying out several modifications to the industrial classifications (The Bank of Korea, 2014). In addition to every benchmark year[11], the Bank of Korea often releases

[11] Here, the benchmark years are 1960, 1966, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010.

the extended tables by applying the RAS method to each benchmark table. However, extended tables keep the same industrial classification as the actual surveyed tables in the benchmark year. Therefore, we concluded that actual surveyed tables of each benchmark year were appropriate to apply to this study of structural changes. We collected 11 sets of input–output tables and determined that every year took the modified standard on the industrial classification, except the year 2000. In order to quantitatively analyze the time-series of all benchmark tables, it is necessary to reconstruct the tables with consistency for the quantitative analysis as follows.

All input–output tables are total transaction tables based on producer's price. In a transaction table, as in a matrix, each row represents how each sector's production is distributed to intermediates and final demands, and each column represents how each sector's gross output (GO) is composed of factors of intermediate inputs and primary inputs. Every set of input–output tables has three versions in accordance with three different aggregation levels of industries, which are called transaction tables of top-class, mid-class, and sub-class. The top-class level of aggregation is compared to the high-level classification of the fourth revision of the International Standard Industrial Classification (ISIC Rev.4), which is known with the labels A to U in total 21 sectors. However, the manufacturing group in terms of ISIC Rev.4 is subdivided into more detailed industries in the top-class level of this study. As an example, the top-class transaction table for 2010 represents 30 sectors of industrial production, including primary and service sectors as a whole. The mid-class level of aggregation is compared to the two-digit level classification of ISIC Rev.4, and the mid-class transaction table for 2010 consists of 82 sectors in total. The sub-class level of aggregation is compared to the three-digit level classification of ISIC Rev.4, and the number of total sub-class industries was 161 in the sub-class transaction table for 2010. Detailed information of the industrial classifications for all benchmark years is summarized in Table 2.

**Table 2.** The number of industries, according to the level of aggregation

| **Year** | | **1960** | **1966** | **1970** | **1975** | **1980** | **1985** | **1990** | **1995** | **2000** | **2005** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class** | Top-class | - | - | - | - | 19 | 20 | 26 | 28 | 28 | 28 | 30 |
| | Mid-class | 43 | 43 | 56 | 60 | 64 | 65 | 75 | 77 | 77 | 78 | 82 |
| | Sub-class | 109 | 117 | 153 | 164 | 162 | 161 | 163 | 168 | 168 | 168 | 161 |

In this study, we discuss structural changes on the inter-sectoral level (Saviotti and Pyka, 2013) or the unrelated variety level (Frenken et al., 2007), so the hypotheses are tested using top-class transaction tables. Nevertheless, the re-aggregation of all mid-class tables into top-class tables with respect to the same standard is required to reconstruct the data set with consistency. On this point, the 2010 version of the industrial classification definitely captures the newest industrial structure of Korea so that it covers the widest variety of industries as well as the most specific industrial productions. Therefore, we prepared the consistent data set of 11 top-class input–output tables based

on the 2010 version of the industrial classification (Table A1). In this process, we also used the sub-class tables for the separation of merged industrial productions, and we treated some values for nonexistent or unspecified industries in the former classification by zero[12].

### 3.3. Method

In input–output tables, as mentioned in the previous section, the sum of each column represents the sectoral GO, and each row shows the distribution structure of this sectoral GO into other sectors and institutions of final demands. In this respect, we can conduct the step-by-step analysis on structural change. First of all, it is possible to trace the compositional change of each section in total economic production by means of sectoral proportions in aggregated GO values. It provides us the insight of overall phenomena of long-term economic growth in quantitative, as well as qualitative, points of view. Secondly, we can segment such overall changes on the basis of the distribution structure of sectoral GO into three main parts: intermediates (INTM), private consumption expenditures (PCE), and exports (EXP), as shown in Figure 3.

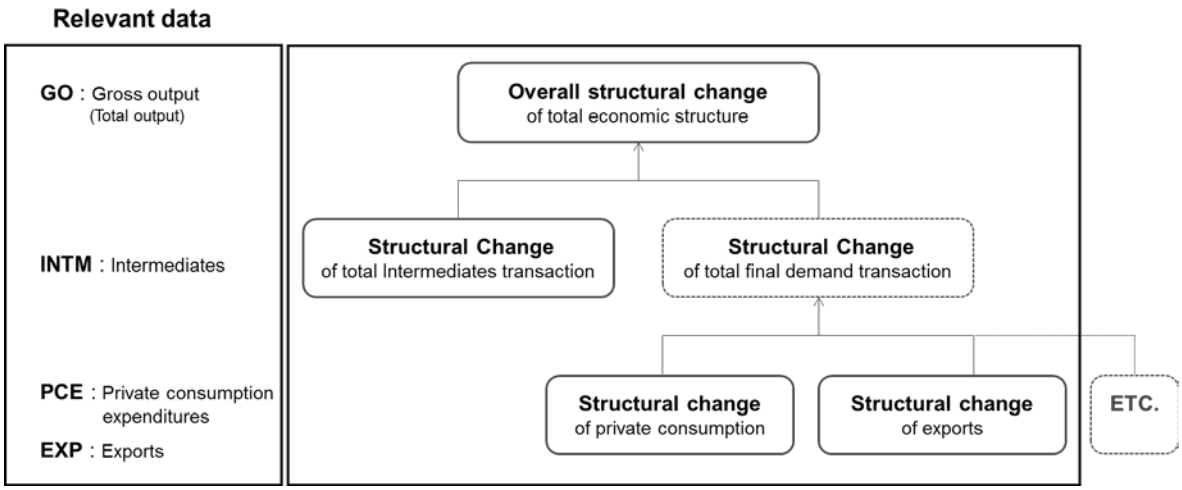


**Figure 3.** The Scheme of the empirical verification on structural changes

As a matter of fact, the decomposition analysis on structural changes, which includes the contribution of intermediate goods, is quite a distinctive feature of this study in comparison to other empirical studies, which are usually based on GDP. For the first segment of overall change, Figure

[12] For example, the industry of precision machinery and instruments did not exist until 1996 but first emerged on the classification in 1970. Therefore, the production of this industry in 1960 and 1966 could be treated by zero. The industry of research and development was not specified until 1975 in the mid-class tables, and it started to be measured but just as the industry of education and R&D from 1980 to 2000. In this case, based on the output ratio in the detailed industries of the sub-class tables, we divided one merged value into the two separate industries. Table A2 shows which industries were merged or unspecified in each benchmark year by the number of industries.

4(a) shows the importance of including the production and distribution of INTM (INTM) into the analysis of structural change. Throughout the history of Korean economic progress, the proportion of INTM in the GO composition has gradually grown to 50%. Thus, considering only the final demand perspective sometimes means to lose the other half majority for shaping the industrial structure. Figure 4(b) shows the rationale to pick up the second and third segments of overall changes. Among other institutions[13] of final demands, PCE and EXP explained most of the final demand composition. We exclude private fixed capital formation (PFC) from the decomposition analysis. This is because the composition of the majority tends to be invariant so that it is distant from structural change issues despite having a large share[14].

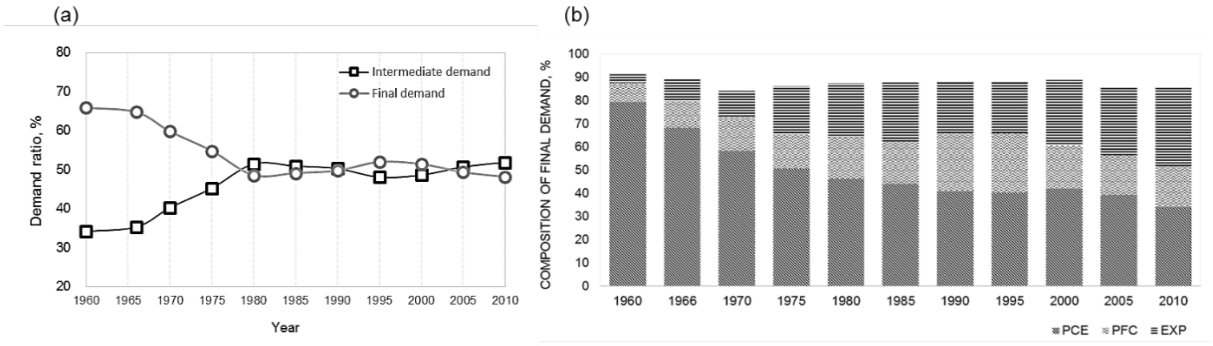


**Figure 4.** (a) Relative ratio of intermediate and final demands, and (b) Relative ratio of private consumption expenditures (PCE), gross private fixed capital formation (PFC), and exports (EXP) in the total final demand

In addition to the scheme of this study, we designed a methodological way to test three hypotheses in accordance with our definition of structural change. On this purpose, we take the industrial configuration for “top 70% aggregated output”, not the whole aggregated production. This is because it is more reasonable to monitor the production majority for a growing economy as well as to discuss the influence of variety level upon such production majorities. Moreover, by confining the changes of industrial variety only to the composition of production majority, we can also observe how the creation of a new sector plays a complementary role to the structural shift process by introducing a new industrial type. When it comes to the specific cutline, which is 70%, we attempt to embody the process of modern economic growth ‘from necessities to imaginary worlds’ (Saviotti and Pyka, 2013). Thus, based on the Engel’s coefficient in the 1960s (Heo, 2012), we set the level of 70% as a

[13] Generally, the final demand is structured by private consumption expenditures (PCE), government consumption expenditures (GCE), gross private fixed capital formation (PFC), gross government fixed capital formation (GFC), and exports (EXP).

[14] Although not shown in this paper, we determined that 90% of private fixed capital formation has been invariantly assigned in the industries 17, 10, 13, and 11 since 1970.

reference for the primary stage of modern economic growth in Korea, where the production majority was almost entirely for necessities. Along with Korea's economic growth, it is naturally shown how the composition of the top 70% of production has evolved and varied from fundamental to advanced.

Taking all this into account, we first analyzed how the industrial configuration of top 70% aggregated output evolves over time, and discussed structural shift issues by determining the major industrial type of the composition. Secondly, we estimate annual entropy indices for each segment of structural change within top 70% production, and thereby discuss increasing variety issues. As for the measure of economic variety, the entropy index (H) is used in this study. In fact, many scholars have modified and revised the methods of entropy calculation according to their own purposes based on the origin of the information entropy function (Theil, 1972; Grupp, 1990; Boschma and Iammarino, 2007; Castaldi et al., 2015). Among them, we adopted the method of Frenken et al. (2007) as illustrated below, for the entropy at the top-class aggregation level, or unrelated variety.

**Equation 1**

$$H = \sum_{g=1}^{G} P_g \log_2\left(\frac{1}{P_g}\right)$$

In Equation 1, let $g = 1,2,\cdots,G$ stand for the number of total industries on the top 70%, and $P_g$ represents the normalized share of industry $g$ where $\sum_{g=1}^{G} P_g = 1$. By adopting the index in this way, we can reasonably quantify increasing variety, including the differences in the total numbers of industries and relative weights of each industry. The value of H is bounded from zero to the theoretical maximum 4.39, which is attained if all $P_g$ are identical where $G = 21$ on the top 70%.

## 4. Results

### 4.1. Preliminary test: The case of Korea, through the lens of the TEVECON model

In this section, we preliminarily evaluate whether the perspective of TEVECON model can be reasonably applied to the Korean economy as an empirical verification subject. Thus, we compare the simulated results of the TEVECON model and the equivalent statistics of the Korean economy. For this purpose, we apply the previous research of the TEVECON model to a control experiment. According to Saviotti and Pyka (2013), the TEVECON model successfully reproduced two featured paths of economic development by experimenting with the rate-determining parameters for the core mechanism. Thus, we discuss how much the experimental paths from the growth model correspond with the consequences of Korean economic development. By doing this, we confirm this method of understanding Korean economic growth through the lens of a model of economic development by the creation of new sectors at the meso-level.

The main idea of Saviotti and Pyka (2013) was strongly triggered by the economic development followed by the emergence of new industries since the Industrial Revolution, from the economy of

necessities to the economy of various products beyond basic needs. In this respect, they pointed out the evolutionary process of economies could be bifurcated due to the differences in generating output variety and improving product quality. Accordingly, the TEVECON model experiment was designed to give different values to the parameters in relation to “search activity” and the product differentiation process. As a result of this experiment, two types of economic development were reproduced in accordance with the level of innovation opportunity and quality, as shown in Figure 5(a). One is called “LQ-type”, which is short for the “low-quality type of economic development,” and the other is called “HQ-type,” which is short for the “high-quality type of economic development.” The LQ-type economy shows the diminishing rate of gross income growth because of the lower chance for innovation activities, while the HQ-type economy shows the self-accelerating curve of gross income growth owing to the higher chance for innovation activities. In that case, the HQ-type economy is finally overtaking the LQ-type economy, as shown in Figure 5(a), although both economy types present all sustained aggregate growths. Therefore, it may be concluded that the two economy types become divergent unless the qualitative change has undergone through the structural shift.

In order to take LQ- and HQ-type economies as a control experiment and compare them to a real economy with different groups of industries, we first need to devise the proper comparison methodology for the case of Korea. Therefore, we suggest, for this purpose, to classify sectoral activities into two groups of LQ-type and HQ-type with respect to the technology intensity of industries[15]. In addition to this, we add one more group for necessity-type productions by aggregating agricultural, forest, and fishery industries. Figure 5(b) presents the growth paths of three different groups. In comparison with Figure 5(a), the growth path of HQ-type industries almost corresponds with the self-accelerating shape, and the growth rates of necessity and LQ-type industries are much slower and smaller than the growth rate of the HQ-type group.

[15] According to Annex 1 of ISIC Rev. 3 (OECD), the definition of technology intensity is presented in terms of low, medium-low, medium-high, and high technology. In regard to the sectoral output data at the top-class aggregation level, we match industries 3, 4, 5, and 14 with the LQ-type group, and match the industries 10, 11, 12, and 13 with the HQ-type group.

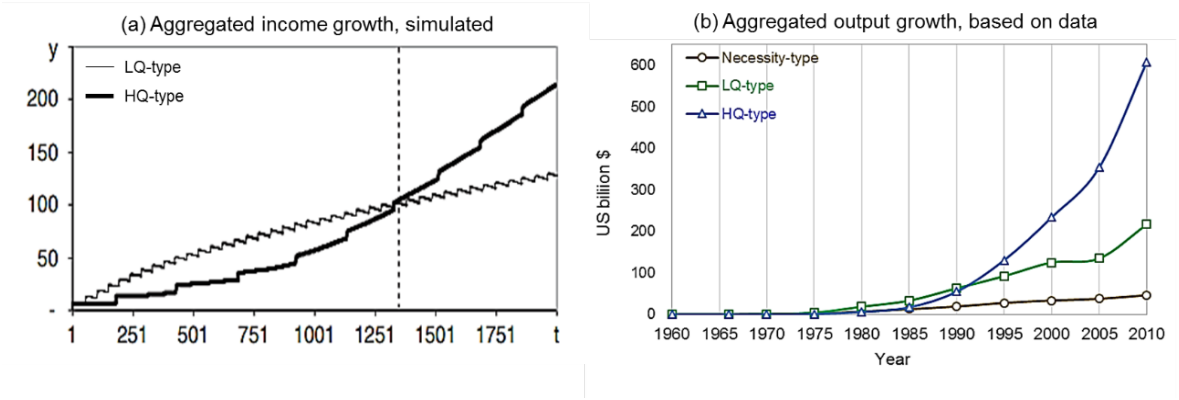


**Figure 5.** Economic development paths: (a) theoretical results from TEVECON model*, and (b) observed results from the empirical data of Korea

However, the groups of necessity and LQ-type industries turned out not to follow the self-limiting shape of growth in the actual statistics. In this way, it is noted that the theoretical model is assumed as a pure constitution of low-quality sectors or high-quality sectors as a single economy, which is unlike three groups within one real economy. Therefore, we can argue that the self-accelerating growth of HQ-type industries exerts the production inducement effect on the group of LQ-type industries in the real economy. In the real economy, which is generally combined with LQ and HQ-type industries, the generation of general purpose technology (GPT) is simultaneously used to influence upon total industrial performances by raising aggregate productivities. For this reason, the group of LQ-type industries can offset the self-limitation effect in the Korean economy. Moreover, as mentioned also in Saviotti and Pyka (2013), since the real economic system has gone through the structural shift from the LQ-type to the HQ-type economy, the empirical evidence is likely interpreted to take the combination of two development paths of the theory in a cumulative sense of structural change.

For the overtaking phenomena in simulated results, we clearly observed similar events in the Korean trajectory of economic growth. As shown in Figure 6, when passing through each phase of economic development, the production of relatively “lower”-quality groups was overtaken by the production of “higher”-quality groups. During the time of Phase 1, the necessity-type production caught up with the LQ-type production first, and the LQ-type production showed a significant growth after 1970. During the time of Phase 2, the HQ-type industries started to overtake the performance of necessity-type industries in 1985, and thereafter surpassed the LQ-type production in 1995. Finally, the HQ-type industries have sustained the accelerating growth in Phase 3. In conclusion, we confirmed that the experience of the Korean economy is well described by the theoretical appreciation of the TEVECON model.

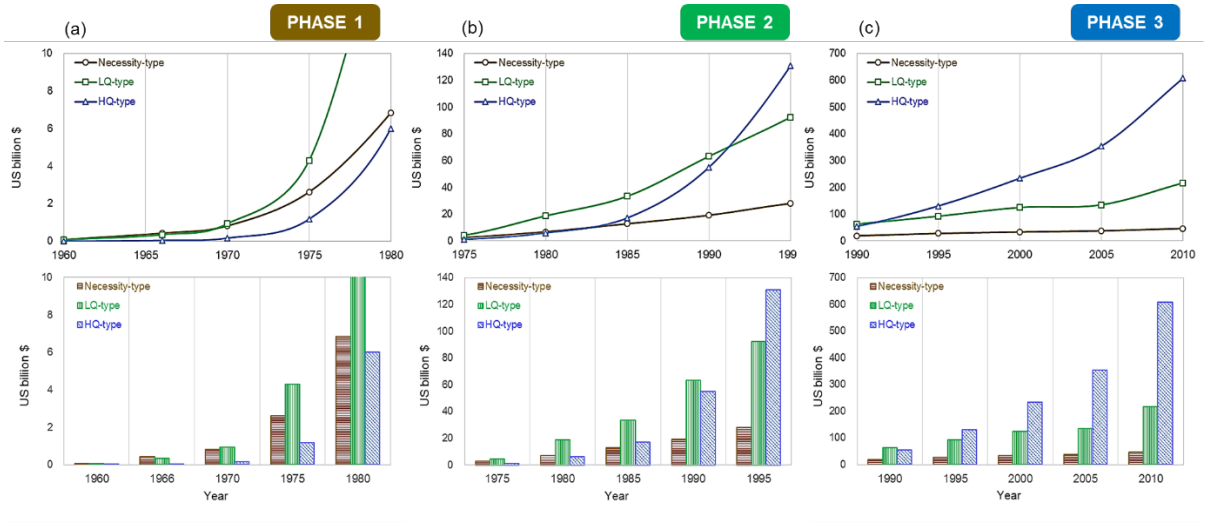


**Figure 6.** The observed overtaking phenomena, along with (a) Phase 1, (b) Phase 2, (c) Phase 3 of Korean economy

### 4.2. Overall structural change: The dynamics of gross output

The aggregated GO of Korea in total transaction tables has been exponentially growing in the same trend with GDP growth[16]. Needless to say, with this progress of quantitative growth, the compositional change of aggregated industrial structure has been entailed as well. In this section, we analyze the overall structural change of the Korean economy by presenting the configuration of the top 70% for each benchmark year. The detailed values are presented in Table A3, and the average cut-off percentage was 71.5 ± 1.1 % over the total years.

Figure 7 shows the overall structural change in terms of the structural shift. As shown in the first column for 1960 of Figure 7(a), the Korean economy used to be specialized in the low value-added sectors before the launch of the government-led development plan in 1962. The industrial configuration in 1960 was mostly composed of primary industries and simple manufacturing industries as the production majority[17]. Then, the distinctive transition within the production majority was caused by the emergence of the petroleum and chemical industries in 1970, so the middle part of Figure 7(a) represents the structural shift toward the heavy industrial economy. In 1985, the emergence of electronic and electrical equipment industries made another critical change in the industrial configuration. Afterward, the structural shift to the high-tech industrial economy took shape, followed by the emergence of the automotive and transportation equipment industry. The emergence pattern of key industries into the production majority is shown in Figure 7(b), and it definitely confirms

[16] However, the gap between GO and GDP began to increase and then doubled in 2000 due to the increase in the share of intermediates (Figure A1).

[17] In this point, the simple manufacturing industries mostly refer to the domestic manual industry of textile and leather products.

Hypothesis 1. We also observed the emergence of the finance and insurance service industries in 1990, and these will be discussed in the next section.

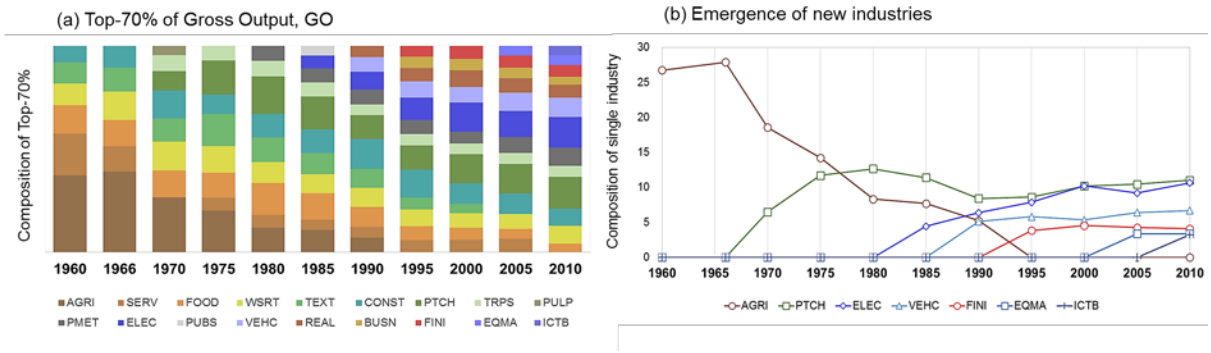


**Figure 7.** Structural shift phenomenon: (a) The compositional change of top-70% of gross output(GO) and, (b) The emergence of new industries into top-70% of GO

Meanwhile, we determined that the substitution between creation and destruction of industries rarely appeared in the empirical evidence of the top-class level data. Although agricultural, forest, and fishery industries began lagging behind and were finally excluded from the production majority in 1995, such changes did not accompany any simultaneous or equivalent emergence of industries. Besides the agricultural sector, most of the industries which were once included in the production majority tend to remain in the economic system and adjust their contributions in the majority. At this point, we also need to understand this observation by means of the entropy index. The blue line of Figure 8(a) directly shows the increasing trend in the number of total industries on the top 70%, and Figure 8(b) presents the entropy estimation accordingly. For the first 25 years, the entropy was drastically influenced by the increasing total number of industries, while the index for the last 25 years varied within a small range of fluctuation because of the changes in sectoral relative proportions. In this respect, Hypothesis 2 could be discussed with the increasing trend of the entropy. Moreover, when considering the changes of the industrial composition by the emergence of key industries and then the increase of the entropy, we can confirm Hypothesis 3 regarding the correlation between the structural shift and increasing variety.

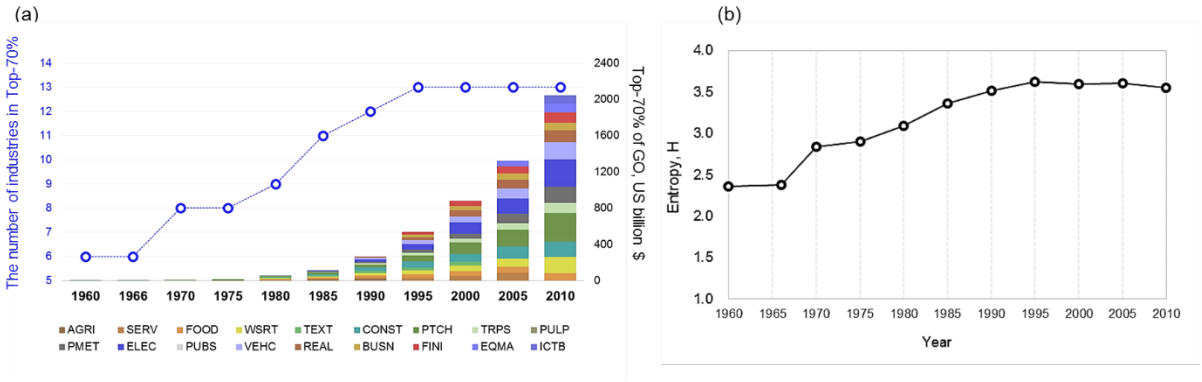


**Figure 8.** Increasing variety phenomenon: (a) The number of industries in top-70% of gross output and, (b) The entropy change of top-70% of gross output

### 4.3. Decomposition of structural change: intermediates, private consumption expenditures, and exports

So far, we have discussed the theoretical knowledge based on overall structural changes, but it could be better characterized as a phenomenological approach. Thus, we need to verify the unsolved issues of structural change, for example the emergence of finance and insurance service industries or the difference between the emergence of this kind of industries and key industries for the structural shift, in more analytical ways. In this section, we delve deeper into the functional role of segmented parts, in terms of the three main components in aggregated industrial productions and the long-term economic development. Therefore, we follow the decomposition procedure of Figure 4 by taking the sectoral level data of INTM, PCE, and EXP.

Firstly, the structural change of INTM entails more specific information of key industries in inter-industrial activities because it is based on domestic transactions across industries. The same methods and criteria are applied to the sectoral level data of INTM demand. The average cut-off percentage was 72.1 ± 1.3 %. In Figure 9(a), the petroleum and chemical industries emerged one period ahead, in the year of 1966, in comparison to the phenomenon of overall structure change (Figure 7). As the industry involved in mining and quarrying was introduced into the production majority in 1975, the domestic inter-industrial transaction became dominated by the heavy industries. Accordingly, the intermediate demand of so-called light industries was diminished and finally excluded from the inter-industrial transaction majority in 1995. Afterward, the industrial structure of the Korean economy began to be further modernized with the growing proportions of the electronic, machinery, and automotive industries. In this respect, the decomposition analysis for intermediate demand supports Hypothesis 1 and complements the explanation about the structural shift as well. We also determined the similar trend of increasing variety along with the decomposed structural change. Nonetheless, the degree of increase was moderate in comparison to the increase in overall structural change, and it could be interpreted as the increasing complexity and modernization of industrial production.

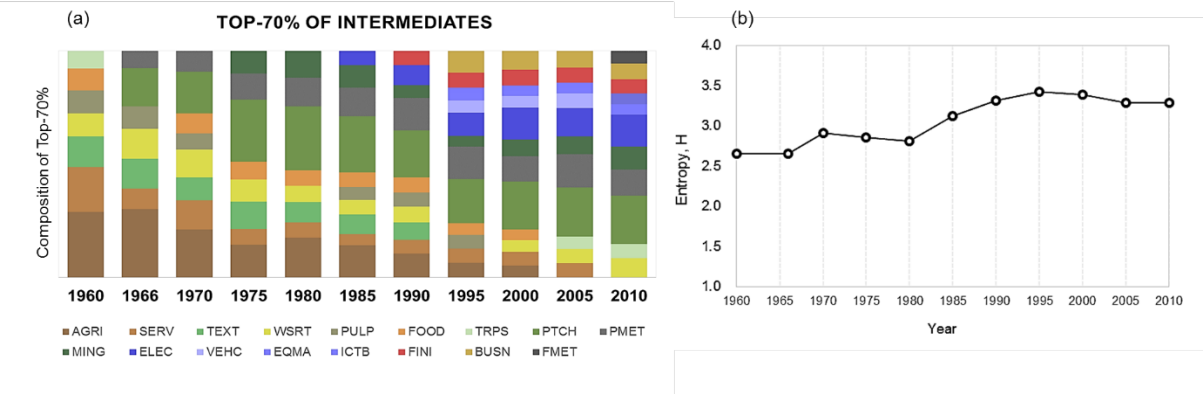


**Figure 9.** (a) The compositional change of top-70% of intermediates and, (b)The entropy change of top-70% of intermediates

Secondly, we analyzed two main institutions of final demand, PCE and EXP. Based on the meaning of PCE, the structural change of PCE can be treated as the way consumers' needs in the domestic market have changed over time. In the case of EXP, on the other hand, we must remember that the main concerns of industrial policies in Korea have been closely related toward "export-driven" growth. Therefore, we expect that the functional roles of the decomposed structural changes in final demands are different from each other. For the analysis of EXP and PCE, the same methodological way is applied to the sectoral level data of EXP and PCE respectively. The average cut-off percentages were 71.7 ± 2.3 % for EXP and 72.7 ± 1.2 % for PCE. Figure 10 shows the result of the structural change analysis on the export transaction. On the one hand, Figure 10(a) presents the structural shift aspect as a result of fostering the six strategic industries through the industrial policies (Table 1); on the other hand, it is difficult to identify the increasing variety of EXP with the top-class level data. In Figure 10(b), the entropy tends to decrease after shifting toward higher value-added industries. In this respect, it is expected that the decreasing variety of EXP originates from the aggregation level of the data. As a matter of fact, the export competitiveness strategy was implemented in terms of sub-class product level, for example electric home appliances, cars, and large vessels. Therefore, such varieties cannot be captured in the top-class level data because they are considered as intra-sectoral varieties in this study. This could be supplemented with further studies focusing on export variety (Saviotti and Frenken, 2008).

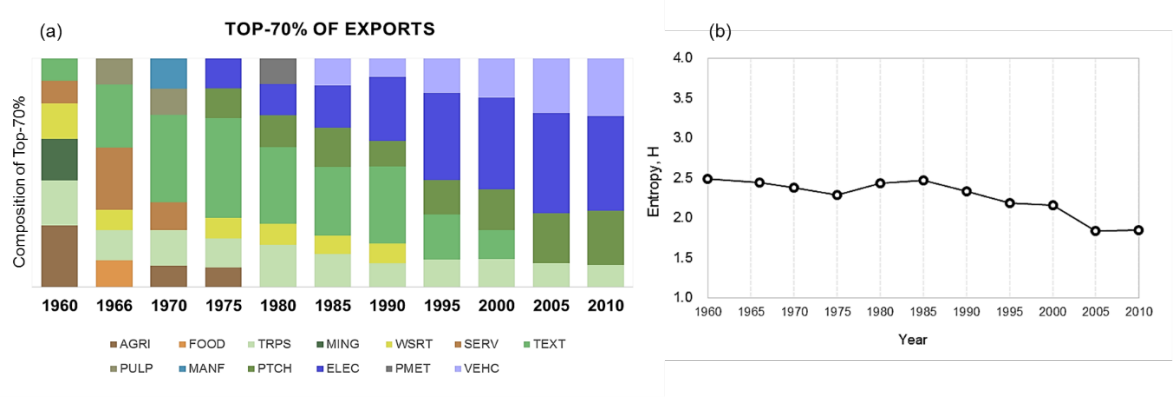


**Figure 10.** (a) The compositional change of top-70% of exportsand, (b)The entropy change of top-70% of exports

In Figure 11, the structural change of PCE shows significantly different patterns. First of all, the industrial configurations of the top 70% generally corresponded with the hierarchy of needs, so the structural shift in term of the private transaction majority processed from agricultural, fishery, and food industries to clothing, shelter, and retail industries. In particular, the industries of education, healthcare, and finance have emerged into the private transaction majority since 1990, and this precisely illustrates how the income increase from the previous economic progress improved the quality of life. Finally, the full-scale expansion into the consumer service industries started to contribute the overall industrial structure as shown in Figure 7(b). Interestingly, following the rapid economic growth of Korea, the entropy of PCE showed the most dramatic increase. In conclusion, for the decomposition of final demand, the structural shift of EXP indicates the complementary role of economic growth while the structural change of PCE better represents the consequential change of economic growth.

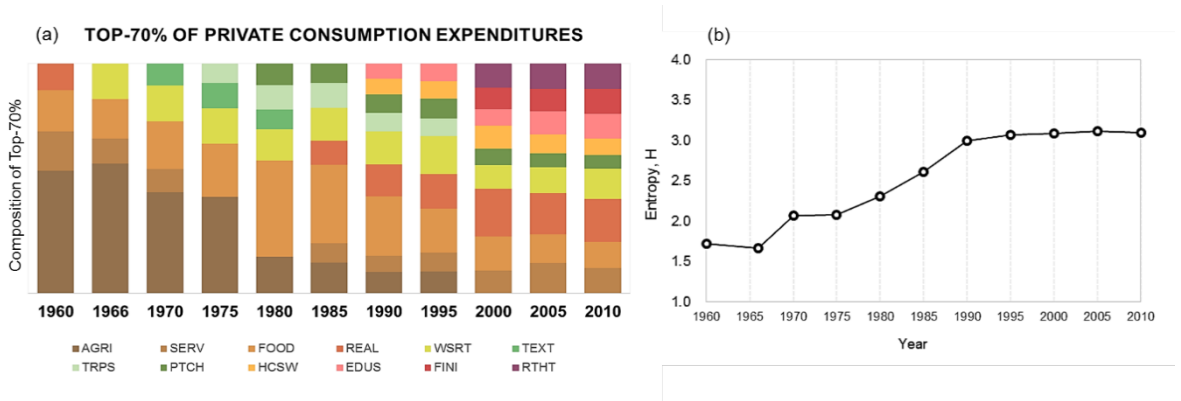


**Figure 11.** (a) The compositional change of top-70% of private consumption expenditures(PCE) and, (b)The entropy change of private consumption expenditures(PCE)

## 5. Summary and concluding remarks

In this paper, we attentively reviewed the previous studies on structural changes and economic development and synthesized three hypotheses as generalized theoretical knowledge. Accordingly, we confirmed the hypotheses by analyzing input–output tables of Korea from 1960 to 2010 in terms of the structural shift and increasing variety. In this process, we focused more on the relationship between “increasing variety” at the industrial level and economic development on the empirical analysis. Figure 12 shows the summary of this study. This figure emphasizes that the overall structural change entails two different functional changes. One is the structural change as a necessary requirement for the long-term growth featured by intermediate transaction and export, and the other is the structural change as a consequence of the long-term growth featured by PCE. Unfortunately, we cannot identify the increasing variety in the structural change of EXP due to the aggregation level of the treated data, so it remains a topic for further research. In addition, the presented empirical results provide a starting point to expand the evolutionary growth model into a history-friendly model, bridging the gap between the artificial world of formal theory and the real world of historical experiences. In this regard, this paper contributes to the identification and enhancement of empirically theoretical understandings of economic development by the emergence of new sectors.

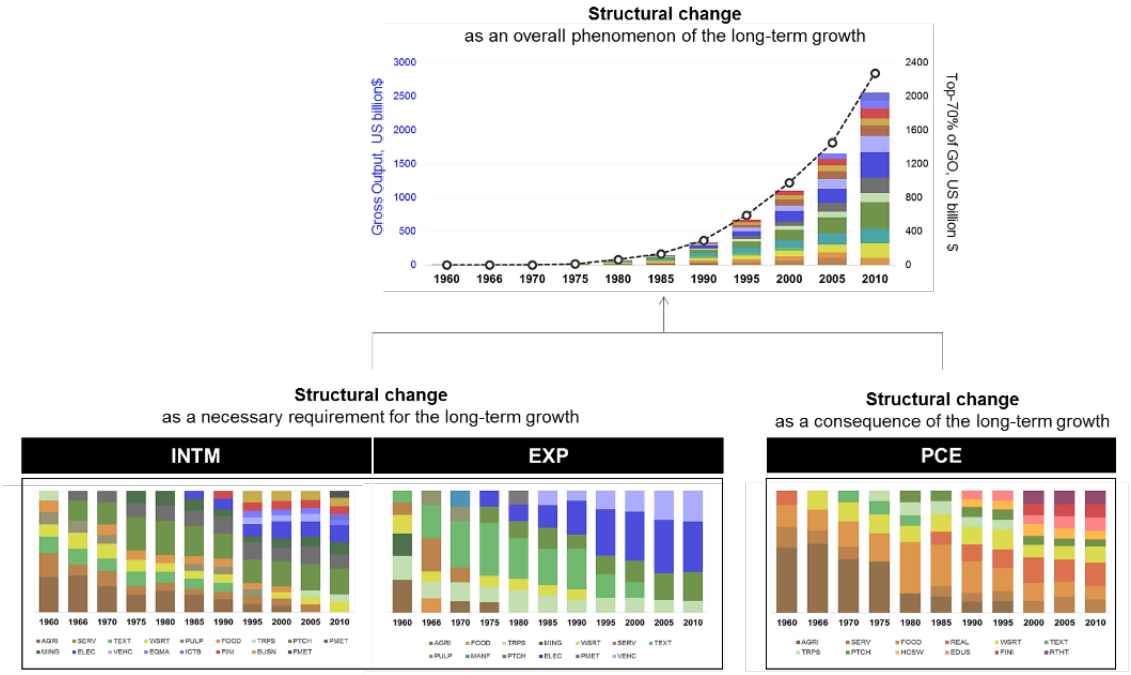


**Figure 12.** Summary of the result on Structural change and economic development

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**Appendix Figure and Tables**

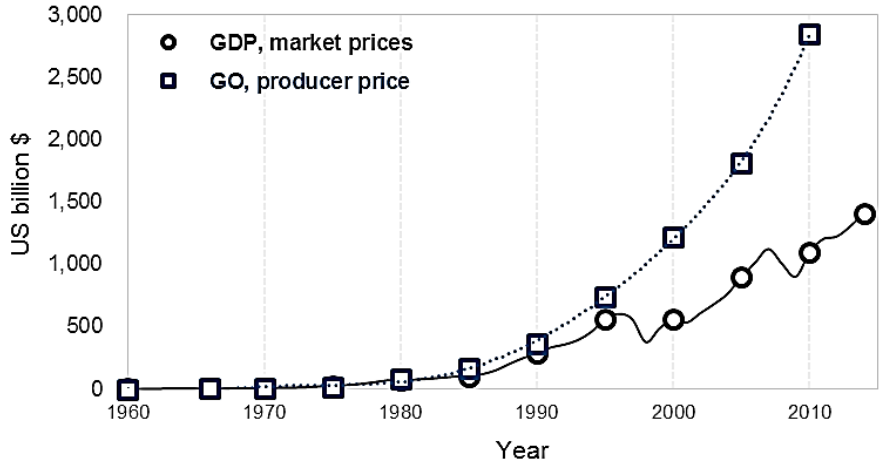


**Figure A1.** GDP and GO growth of Korea from 1960 to 2010

**Table A1.** Industrial classification at the level of top-class aggregation

| No. | Abbr. | Name | No. | Abbr. | Name |
|---|---|---|---|---|---|
| 1 | AGRI | Agricultural, forest, and fishery goods | 16 | WATS | Water supply, sewage and waste management |
| 2 | MING | Mined and quarried goods | 17 | CONST | Construction |
| 3 | FOOD | Food, beverages and tobacco products | 18 | WSRT | Wholesale and retail trade |
| 4 | TEXT | Textile and leather products | 19 | TRPS | Transportation services |
| 5 | PULP | Wood and paper products, printing | 20 | RTHT | Food services and accommodation |
| 618 | PTCH | Coal, petroleum and chemical products | 21 | ICTB | Communications and broadcasting |
| 7 | NMET | Non-metallic mineral products | 22 | FINI | Finance and insurance |
| 8 | PMET | Basic metal products | 23 | REAL | Real estate, leasing and rental services |
| 9 | FMET | Fabricated metal products, | 24 | RNDS | Research and development |
| 10 | EQMA | Machinery and equipment | 25 | BUSN | Business-supporting services |
| 11 | ELEC | Electronic and electrical equipment | 26 | PUBS | Public administration and defense |
| 12 | PMCH | Precision machineries and instruments | 27 | EDUS | Educational services |
| 13 | VEHC | Automotive and transportation equipment | 28 | HCSW | Health and social welfare services |
| 14 | MANF | Other manufactured products | 29 | SERV | Cultural and other services |
| 15 | ENRG | Electricity, gas, and steam supply | | | |

[18] Here, in contrast with the original classification of 2010 version, we merge the industry of coal and petroleum and the industry of chemicals into a single industry, No. 6. Therefore, the total number of industries is 29 sectors, not 30 sectors.

**Table A2.** Industries which are unspecified or merged in each benchmark year by the number of industries as Table A1

| Type | 1960 | 1966 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Unspecified or Non-exsistent | 12, 20, 21, 24, 25, 26, 27, 28 | 12, 20, 24, 25, 26, 27, 28 | 20, 24, 25 | 24, 25 | 25 | - | - | - | - | - | - |
| merged | ( 22 & 23 ) | | ( 27 & 28 ) | | ( 24 & 27 ) | | | | | - | - |

**Table A3.** Composition (relative weight) of top-70% of gross output (GO)

| No. | Abbr. | 1960 | 1966 | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AGRI | 26.7 | 27.9 | 18.5 | 14.2 | 8.3 | 7.7 | 5.2 | - | - | - | - |
| 29 | SERV | 14.5 | 8.9 | 0.0 | 4.4 | 4.4 | 3.6 | 3.7 | 4.2 | 4.3 | 4.8 | - |
| 3 | FOOD | 9.9 | 8.9 | 9.0 | 8.7 | 10.8 | 9.1 | 7.0 | 5.0 | 4.2 | 3.5 | 3.0 |
| 18 | WSRT | 7.5 | 9.9 | 9.8 | 9.0 | 7.1 | 6.6 | 6.6 | 5.9 | 5.0 | 5.1 | 6.2 |
| 4 | TEXT | 7.5 | 8.3 | 7.8 | 11.1 | 8.4 | 7.3 | 6.8 | 4.1 | 3.4 | 0.0 | 0.0 |
| 17 | CONST | 5.7 | 7.5 | 9.5 | 6.7 | 8.0 | 8.1 | 10.5 | 9.8 | 7.1 | 7.3 | 6.0 |
| 6 | PTCH | - | - | 6.5 | 11.7 | 12.7 | 11.4 | 8.4 | 8.6 | 10.2 | 10.4 | 11.0 |
| 19 | TRPS | - | - | 5.4 | 5.0 | 5.2 | 4.8 | 3.8 | 4.0 | 3.7 | 3.8 | 3.9 |
| 5 | PULP | - | - | 3.1 | - | - | - | - | - | - | - | - |
| 8 | PMET | - | - | - | - | 5.1 | 4.9 | 5.1 | 5.0 | 4.1 | 5.7 | 6.3 |
| 11 | ELEC | - | - | - | - | - | 4.4 | 6.4 | 7.9 | 10.2 | 9.2 | 10.6 |
| 26 | PUBS | - | - | - | - | - | 3.3 | - | - | - | - | - |
| 13 | VEHC | - | - | - | - | - | - | 5.1 | 5.8 | 5.4 | 6.4 | 6.7 |
| 23 | REAL | - | - | - | - | - | - | 4.0 | 4.6 | 5.9 | 5.0 | 4.5 |
| 25 | BUSN | - | - | - | - | - | - | - | 4.0 | 4.0 | 3.9 | 2.9 |
| 22 | FINI | - | - | - | - | - | - | - | 3.8 | 4.6 | 4.3 | 4.1 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | EQMA | - | - | - | - | - | - | - | - | - | 3.4 | 3.4 |
| 21 | ICTB | - | - | - | - | - | - | - | - | - | - | 3.2 |
| Total (%) | | 71.9 | 71.4 | 69.6 | 70.7 | 70.0 | 71.2 | 72.7 | 72.7 | 72.1 | 72.7 | 71.8 |
| Average | | 71.5 ± 1.1 % | | | | | | | | | | |

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