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ARTICLES

COMMENTS

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The Philippine Review of Economics

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Industrial policy and complexity economics

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Mainstream theory underlying industrial policy highlights the neoclassical and structuralist approaches. The discussion on structuralist theories readily segues to complexity economics where industrial policy foments structural transformation by creating reinforcing feedback loops, particularly among manufacturing, exports, and investment. Empirical evidence is provided by applying panel cointegration analysis to investigate coevolution patterns among the following variables: investment-GDP ratio, exports-GDP ratio and manufacturing-GDP ratio. Econometric estimates show that there is indeed a long-run relationship that is bidirectional among the three variables. However, this is only a necessary condition for reinforcing feedback loops to materialize. Idiosyncratic factors in each country determine whether industrial policy has led to growth-oriented feedback loops. In the Philippines, despite interventions to boost manufacturing, no growth-oriented loop was established because of inadequate investment, particularly in infrastructure. Moreover, exports were hampered by the poor record in latching on to regional production networks. The Republic of Korea has had more success than Malaysia because it strengthened its innovation system. The missing link in Malaysia is own-technology creation.

JEL classification: L52, L53, O14, O25, O53, O57
Keywords: industrial policy, complexity economics, coevolution, feedback loops

1. Introduction

Mainstream theory has invariably attributed the malaise of the Philippine economy primarily to protectionist policy (Bautista et al. [1979]; Balisacan and Hill [2003]; ADB [2020]). A similar refrain has been offered for the relatively poor record of the economies in South Asia and Latin America (Nayyar [2019]; ADB [2020]; Coatsworth and Williamson [2004]; Armendáriz and

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Larraín [2017]). Indeed, many practical difficulties and costs have resulted from protectionist policy.[1] One, prices of imports and import-substitutes have exceeded the average world price. The price distortion led to economic inefficiency as the composition of aggregate consumption deviated from optimal. Two, markets became fragmented because of an incentive structure that favored small-scale production. Three, reduced competition from foreign firms conferred monopoly power on domestic firms and lowered consumer welfare. Finally, trade protection opened up opportunities for rent-seeking and corruption which added to input and transaction costs.

Lately, however, industrial policy—of which protectionism is a key component—has been viewed with less skepticism. This is in no small measure attributable to the actions of the administrations of Presidents Trump and Biden, which culminated in the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act, a law that provides incentives like subsidies and tax concessions to encourage renewed production of advanced semiconductors in the US. While the law has not been without criticism (Dollar [2023]; Hardwick and Tabarias [2023]; Lovely [2023]), and it is too early to evaluate its full impact, the manifest act of protectionism by the largest free-market economy in the world has reduced the stigma associated with industrial policy. The emphasis, of course, is on the recent period since this is not the first time US industrial policy has been critiqued for its double standard [Keller and Block 2015] and the debate on industrial policy has been ongoing for decades (Naudé [2010]; Oqubay et al. [2020]).[2]

Meanwhile, the more important source of support for industrial policy has been empirical in nature. Recent econometric studies have validated the usefulness of industrial policy (Juhász et al. [2023]; Criscuolo et al. [2022b]). Moreover, historical evidence is usually interpreted in favor of industrial policy, particularly with regard to the experience in East Asia (Reinert [2020]; Nayyar [2019]; Cherif and Hasanov [2019]; Felipe [2015]). Box 1 gives a general idea of the complementary side of the discussion. However, the heart of the debate on industrial policy remains to be the variable outcomes. As Nayyar [2019:19] describes it: "Why did some Asian countries perform so well with unorthodox institutions, and why did other Asian countries with very similar institutions not perform well? The puzzle extended beyond institutions to policies. Similar economic reforms did well in some countries and did not perform well in other countries." This enigma extends beyond Asia.

Industrial policy can be defined as "the application of selective government interventions to favor certain sectors so that their expansion benefits the economy's productivity as a whole" [Memiş and Montes 2008:x]. The present study acknowledges that there are theoretical and empirical justifications for the application of industrial policy. At the same time, as intimated in the previous paragraphs,

[1] Lin [2012:18].
[2] See Reinert [2022] for a historical perspective.

industrial policy did not yield the same positive results in the Philippines compared with some of its Asian neighbors. There are various explanations, depending largely on the theoretical framework that is applied. The different theories are outlined in the next section. The main objective of this study is to analyze the mixed record of industrial policy in Asia from the lens of complexity theory. In particular, the co-evolution of sectors and feedback mechanisms between them provide a useful platform to explain both the success and failure of industrial policy. In the process, various country experiences will be highlighted including that of the Philippines. Approaching industrial policy via complexity theory can provide new insights on historical performance and policy prescriptions.

BOX 1. Countervailing views on industrial policy

"Whether it is in trade, macroeconomics, labor markets, property-rights, education, or microfinance, there is no unique correspondence, as the Washington Consensus and other general recipes suppose, between policies and outcomes" [Rodrik and Rosenzweig 2010:xvi-xvii].

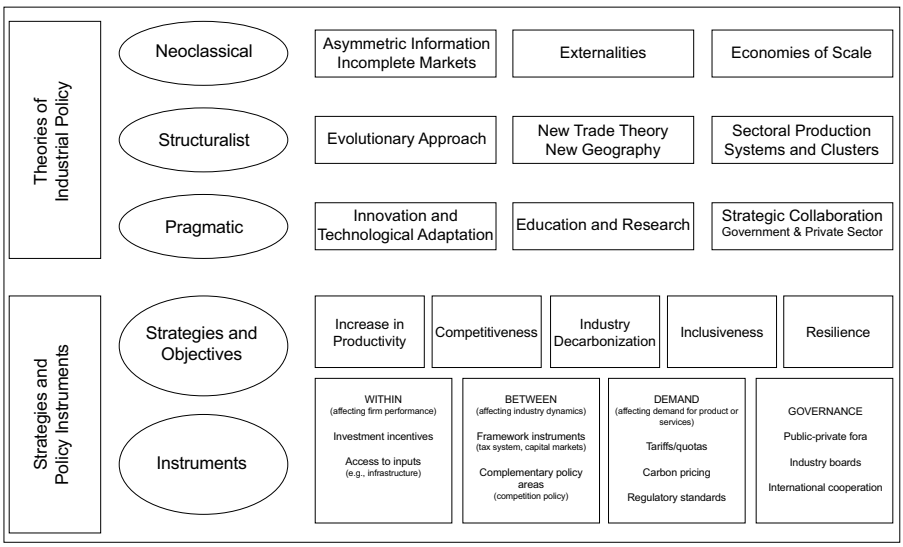
"Countries like South Korea and Taiwan had to abide by few international constraints and pay few of the modern costs of integration during their formative growth experience in the 1960s and 1970s…. So these countries combined their outward orientation with unorthodox policies: high levels of tariff and nontariff barriers, public ownership of large segments of banking and industry, export subsidies, domestic-content requirements, patent and copyright infringements, and restrictions on capital flows (including on foreign direct investment). Such policies are either precluded by today's trade rules or are highly frowned upon by organizations like the IMF and the World Bank. China also followed a highly unorthodox two-track strategy, violating practically every rule in the guidebook (including, most notably, the requirement of private property rights)" [Rodrik 2001:59].

"The real miracle of East Asia may be political more than economic: why did governments undertake these policies? Why did politicians or bureaucrats not subvert them for their own self-interest? Even here, the East Asian experience has many lessons, particularly the use of incentives and organizational design within the public sector to enhance efficiency and to reduce the likelihood of corruption. The recognition of institutional and individual fallibility gave rise to a flexibility and responsiveness that, in the end, must lie at the root of sustained success" [Stiglitz 1996:174].

2. Framework: theories and policy instruments

The various theories underlying industrial policy are succinctly summarized by Cohen [2006] and a condensed version is presented in Figure 1. A recent survey is contained in the second chapter of the *Oxford handbook of industrial policy* [Oqubay et al. 2020]. After a brief foray into the neoclassical approach, the discussion focuses on the structuralist theories outlined by Cohen and highlighted by Oqubay [2020]. This allows the analysis to segue to complexity economics (e.g. Arthur [2013]).

FIGURE 1. Industrial policy framework



Source: Cohen [2006] and Figure 1 of Criscuolo et al. [2022a].

2.1. Neoclassical approach

Neoclassical theory rationalizes industrial policy through market failures (largely emanating from information asymmetries and incomplete markets), externalities, and increasing returns to scale. Advances in economic theory have justified the potential role of the state. In particular, high development theory[3] has been modeled more effectively (e.g., Murphy et al. [1989]). Despite this expanded structure, neoclassical theory has been unable to explain how, and why, economies

[3] The role of the state in mainstream economics became prominent in the late 1940s to the 1950s with the advent of high-development theory (HDT), described as the nexus among the concepts of scale economies, external economies, strategic complementarity, and economic development [Krugman 1993]. HDT is also labeled by some experts as the structuralist approach to economic development [Lin 2012]. The authors consider it as the interface between neoclassical theory and late structuralism. HDT's zenith roughly covers the period between the advent of the Big Push model conceptualized by Paul Rosenstein-Rodan in 1943 and the publication of Albert Hirschman's "The Strategy of Economic Development" in 1958.

undergo structural transformation over time. As Gabardo et al. [2017] observe, incorporating structural change into growth theory has proven to be difficult. The primary reason is that neoclassical theory is saddled by the requirement to have a unique, stable, and reachable equilibrium. The equilibrium assumption is fundamental to neoclassical theory. General equilibrium theory determines the level of prices and quantity of goods that are produced and consumed that would align or be in equilibrium with the overall structure of prices and quantities in the various sectors of the economy. The outcome should not create incentives to change the aforementioned overall structure.

A strand of the literature on industrial policy—primarily under the rubric of the structuralist approach—has dealt directly with structural change. The approach has been aptly associated with realism [Gibson 2003]. A detailed elaboration occupies the rest of this section. However, these explanations are "developed in an inductive, multidisciplinary fashion, largely driven by common sense and original thought but without a formal general theory backing it" [Cameli 2023:9]. Hence, after the extensive discussion on the structuralist approach to industrial policy, a framework based on complexity economics (CE) is proposed. The main feature is a non-equilibrium approach that readily explains structural transformation over time.

2.2. The structuralist approach

The structuralist theory of industrial policy as defined by Cohen examines the interface of the new theories on the knowledge-based economy, international trade, and corporate behavior on the one hand, and emerging issues about competitiveness, specialization, and regional integration on the other. Renewed interest in industrial policy was spurred by the integration of the European Union. Important issues were raised about incentives to cooperate, how R&D influences the configuration of a production system, and the geographical and sectoral impact of establishing the Single European Market.

Two branches of the structuralist approach that are particularly important to this paper are: i) the evolutionary approach to technological trajectories and national innovation systems; and ii) theories of sectoral production systems and clusters. The Schumpeterian evolutionary tradition emphasizes technical change as the driver of capitalism, highlighting the importance of learning and capability development for firm competitiveness. In an ever-evolving economy, the levels of R&D and innovation do not offer a static explanation of competitiveness. Instead, the real determining factor is the dynamism in the production of knowledge transformed into new products.

That countries which have different policies and institutions are able to achieve similar results indicates that one size does not fit all. The concept of an "optimal" way to achieve a preferred result is not realistic. Evolutionary theory sheds light on the importance of country-specific characteristics for innovation to prosper. In particular, national innovation systems (NIS) that comprise

education, R&D, and government support are vital to build absorptive capacity that is required for innovation and technological capability. From this standpoint of national distinctiveness and institutional dynamism, industrial policy acquires new validity, particularly with regard to learning.

Learning, both at the firm and policy level, is central to late development. Successful catch-up involves different strategies at various stages of industrialization, including imitation, learning from forerunners, and developing innovation capabilities. Enhancement of technological and innovation competencies highlights the synergetic and dynamic connection between technological learning, industrial policy, and catch-up. This can be reinforced through a clear and strategic plan that targets critical dynamic industries and new technologies. Such a plan will promote learning through consistent and comprehensive support to R&D, technology commercialization, education, and skills development. Overall, evolutionary theory and the NIS concept underscore the importance of capacities and competences in innovation processes, shaping contemporary approaches to micro- and macroeconomic competitiveness.

Meanwhile, the cluster approach, related to industrial districts and geographical agglomeration phenomena, emphasizes the development of industrial sub-systems around specific factors such as tertiary education systems, financial systems, and the linkages between firms. Recognition of these factors is necessary for designing policy interventions for strengthening firm-level competitiveness. The cluster approach focuses on interdependent relationships between institutions in an industrial system. Effective industrial policy promotes the creation of specific institutional arrangements for each cluster, rather than horizontal national programs that avoid necessary specificity.

Active sectoral policies build competitive advantages through specialization, enabling firms to take risks and adapt. Successful policies depend on companies' actions and collaboration with the policy framework, making bottom-up approaches more effective than top-down policies. Thus, industrial policies based on general instruments are less effective than those attentive to specific industry needs, improving competitiveness through sector-specific support. Policies to support development of clusters include bringing in appropriate human capital, attraction of start-ups, successful spin-outs, and formation of networks.

2.3. Structural transformation

Industrial policy has to be linked to structural transformation and concepts such as nurturing of infant industry and the state-market mechanism. Instruments of industrial policy may vary as shown in Figure 1. The goal is primarily to build technological capability through learning and innovation that enhances firm-level competitiveness leading to structural change. The latter involves significant sectoral shifts, sustained productivity growth, technological spillover, and changes in demand, occupations, income levels, and socio-economic institutions.

Structural transformation entails transitioning from low- to high-productivity activities and sectors, diversifying into new activities and industries, and deepening and upgrading industrial capabilities.

The special properties of manufacturing, which include generating linkage effects, increasing returns to scale, and productivity gains, are critical for long-term economic dynamism. Growth laws associated with Kaldor [1980] emphasize manufacturing's special contribution to economic growth and productivity, highlighting three key relationships:

- strong causal relation between the growth of manufacturing output and GDP growth;
- positive causal relation between manufacturing output growth and productivity growth within manufacturing (Verdoorn's law); and
- positive causal relation between the expansion of the manufacturing sector and productivity growth outside manufacturing due to diminishing returns in other sectors.

Manufacturing enhances economic dynamism through technical change, investment, and the accumulation of technology and capital. Kaldor [1980] emphasizes the role of technology and demand in determining capital intensity and overall economic evolution. Knowledge intensity and technological advancements are key measures of development.

2.4. Manufacturing, exports, and structural transformation

Manufacturing industries complement agriculture and services, fostering strong intersectoral linkages. Early industrialization transforms agriculture through increased productivity and technological advances. Manufacturing also stimulates the growth of services by outsourcing activities and enhancing competitiveness through knowledge-intensive services.

Meanwhile, there are differing views on the role of exports. A market-friendly perspective advocates for liberalization and international competitiveness, while another view emphasizes the strategic importance of how countries engage in international trade. Straddling both views is the argument that exports are critical for overcoming market size limitations, addressing balance-of-payments constraints, and fostering high efficiency and quality standards.

Exports and international trade positioning are pivotal for growth and structural transformation, particularly in manufacturing. A strategic export-led industrialization (ELI) approach, synchronized with import-substitution industrialization (ISI), accelerated industrialization in latecomer economies like Japan, the Republic of Korea, Taiwan, Singapore, and China. ELI, in conjunction with ISI, fosters industrial learning and competitiveness.

Perspectives on structural transformation have significant implications for industrial policy in three key areas:

- reinforcing the strategic importance of export-led industrialization for sustained growth and economic transformation, regardless of market size;
- emphasizing a sectoral approach for targeting specific industrial sectors and activities based on technological intensity, linkage effects, and demand elasticity; and
- aligning instruments to support high-productivity activities and investments, with exports serving as a pressure mechanism for learning and performance monitoring.

2.5. Linkages and complementarities

Hirschman [1992] was responsible for the pioneering work on linkage effects as they relate to industrialization. He argued that linkage is a conceptual tool that facilitates "detecting how one thing (activity) leads or fails to lead to another", and is the " more or less compelling sequence of investment decisions occurring in the course of industrialization and, more generally, of economic development" [Hirschman 1992:56]. Recognizing the linkage effect enables selection and support of priority sectors whose interaction would accelerate structural transformation, Hirschman posited that the key constraint in developing countries is not lack of resources but the lack of knowledge and capability to take action to promote investment and generate productive activities. This is directly related to the cluster approach defined by Cohen [2006] and discussed earlier. The concept of linkages also dovetails with the role of feedback loops in the context of complexity economics, which is discussed in the next section.

By encouraging investment that supports interdependencies and complementarities, agglomeration economies can emerge. Agglomeration economies and cluster dynamics promote division of labor and specialization, efficiency gains and rising productivity, innovation and learning, and linkages, performing the role of critical drivers of positive externalities. Three principal issues are relevant in terms of crafting the overall development strategy. First, policymakers have to consider the nexus between export-led and import-substitution industrialization. A second interdependent and complementary relationship is that between manufacturing and agriculture. However, lately the discussion has shifted to a debate between manufacturing and services [Rodrik and Sandhu 2024]. The likely best approach is to search for a framework that maximizes the synergy among manufacturing, services, and agriculture. A third important aspect of industrial policy is the relationship between foreign direct investment (FDI) and domestic firms, particularly in the context of the experience of East Asia with regard to regional production networks.

3. Complexity economics, industrial policy, and structural change

The previous section highlighted key elements of the structuralist approach to industrial policy: the process of innovation, the role of the manufacturing sector,

the importance of exports, and the ultimate goal of structural transformation. CE allows these elements to be combined in a framework along with the concepts of clustering, agglomeration, linkages, and complementarities. The proposed unifying framework is underscored by feedback mechanisms in systems and the process of co-evolution.

3.1. Complexity theory and complexity economics

Complexity theory is the science of complex systems. According to Serrat [2017:349], "its origins lie in biology, ecology, and evolution as a development of chaos theory. It is the theory that random events, if left to happen without interference, will settle into a complicated pattern rather than a simple one." Complexity theory highlights holism, uncertainty, and nonlinearity as opposed to reductionism, predictability, and linearity.

A reductionist framework or a realist philosophy has underpinned traditional sciences wherein an entity is reduced to its smaller parts. Analyzing the functions of the smaller parts allows the comprehensive understanding of the whole. Complexity science expands on the reductionistic framework by not only understanding the parts that contribute to the whole but by understanding how each part interacts with all the other parts and emerges into a new entity, thus having a more comprehensive and complete understanding of the whole [Turner and Baker 2019]. The spontaneous materialization of macro-patterns from local, nonlinear interactions occurring at the micro level is the broad purview of complexity science.

Meanwhile, Arthur [2021:136] notes that "even before Adam Smith economists observed that aggregate outcomes in the economy, such as patterns of trade, market prices and quantities of goods produced and consumed, form from individual behavior, and individual behavior, in turn, reacts to these aggregate outcomes. There is a recursive loop. It is this recursive loop that makes the economy a complex system." The central idea on which the CE approach is built is the economic system as a complex adaptive system.

3.2. Complexity economics and industrial policy

A novel approach has been to propose CE as the theoretical foundation for modern industrial policy [Cameli 2023].[4] A summary of the relationship between industrial policy and CE is shown in Table 1. Complexity theories have led to significant progress in endogenizing the process of structural change associated with industrial development. Cameli points to the work of Stuart Kauffman, a renowned biochemist and complexity theorist who applied to economics his theory of co-evolution and the idea of the "adjacent possible." This in turn set the stage

[4] Cameli uses the term "21st century industrial policy." This paper prefers the term modern industrial policy following Felipe [2015].

for "economic complexity" wherein the concept of product space is an application (Hidalgo and Hausmann [2009]; Balaoing-Pelkmans and Mendoza [2024]).

TABLE 1. Aligning elements of complexity economics and industrial policy

Approach to policy as derived from complexity economics	Approach to policy as stated in core of modern industrial policy
- Radical uncertainty: impossible to know how the system will react to a given stimulus	- Unknowability ex ante of policy outcomes
- Solutions to economic problems as evolutionary paths on an unknown fitness landscape	- Solutions to problems in the productive sphere as a search process in an unknown territory
- Bounded rationality of public and private actors, impossibility to use deductive logic	- Imperfect information both from the side of government and from the side of private firms and industries
- Industrial metabolism as a systemic concept encompassing the whole variety of transformation activities carried out inside an economy	- Industry does not mean uniquely manufacturing, call for a more comprehensive approach
- 'Cultivation' paradigm, symbiotic connection between public and private, focus on setting the eco-structure	- Strategic cooperation between government and private industries, focus on designing settings able to implement this
- Government, markets and social institutions result from self-organization. Complementarity between state and private actors	- 'Embeddedness' paradigm: Government is not insulated but deeply embedded into a net of social institutions

Note: Radical uncertainty is characterized by obscurity, ignorance, vagueness, ambiguity, and lack of information. It gives rise to "mysteries" rather than to "puzzles" with defined solutions. Cultivation paradigm is used to contrast with "control." While the control approach focuses mainly on objectives and neglects the process, the cultivation approach, instead, is concerned with getting the process right. This table is reprinted from Cameli [2023].

One advantage of CE is its ability to use more sophisticated models to explain the process of the emergence of new products and the manner in which the socioeconomic milieu is rearranged accordingly. However, in order for policy to get more traction, there has to be an interface of the socioeconomic sphere with a biophysical approach making it possible to have a more complete process that is consistent with the fundamental laws of nature. This would include endogenous evolutionary dynamics and basic thermodynamic processes. Hence, Cameli [2023:174] proposes the following operating definition for industrial policy: "any attempt carried out by the State to modify national industrial metabolism while supporting the process of exploration of the 'adjacent possible' of industrial goods and services." The term "metabolism" links the expansion of the product space in an economy to the biological and chemical reactions in the human body.

Meanwhile, CE also supports the most important feature of modern industrial policy which is the cooperation between public and private actors. Modern industrial policy explains the importance of public-private partnership by adopting from political economy the paradigm of embedded autonomy. An

embedded state maintains different institutionalized channels through which the government is able to interact constructively with the private sector in pursuit of economic development. However, there is the risk that an embedded state will be captured by the entities and interests it seeks to guide and promote. Therefore, the state must also be autonomous. This implies that the state should be independent, above the fray and beyond capture by vested interests. Accordingly, Rodrik [2009:20] concludes that "the right model for industrial policy therefore lies in between the two extremes of strict autonomy, on the one hand, and private capture, on the other." Cameli elucidates how this concept can benefit greatly from the complexity approach. One of the most relevant aspects of the complexity approach is its capacity to skillfully manage the discord between state-interventionist and market-fundamentalist positions. In the CE framework, "the public authority itself can be thought of as a result of the self-organization of the socioeconomic system, just like markets and any other social institution. This allows CE to transcend the neoclassical narrative that sees markets as something 'natural' and the government and its interventions something 'external' to the socio-economic system, which threatens its natural functioning with distortionary, i.e. unnatural, interventions" [Cameli 2023:174].

3.3. The role of feedback loops and co-evolution

The shift from the reductionist framework to a systems approach and eventually to complexity theory takes into consideration the environment and the feedback information. Two types of feedback processes exist in socioeconomic systems: positive (reinforcing) loops and negative (balancing) loops [Radzicki 2021]. The first type represents self-reinforcing processes and causes the growth or decline of systems. "Economic growth trends, multiplier processes, accelerator relationships, wage-price spirals, speculative bubbles, bandwagon effects, increasing returns, path dependent processes, and anything that can be described as a vicious or virtuous circle can be represented with positive feedback loops" [Radzicki 2021:2-3]. Negative loops, on the other hand, reflect goal-seeking activities and many types of deliberate behavior. They represent mechanisms such as the process of general equilibrium in the neoclassical approach described earlier.

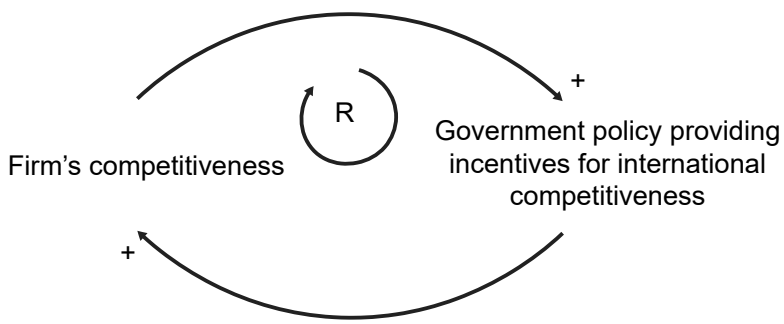
The presence of positive and negative types of feedback in combination is an important component of complex systems. If a system contains only negative feedback, e.g., diminishing returns in economics, it will eventually converge to equilibrium and exhibit a steady-state pattern. If a system contains only reinforcing loops, it expands rapidly and tends toward explosive behavior. With a mixture of both, it shows "interesting" or "complex" behavior.

In the market economies that have developed since the industrial revolution, many of the most important characteristics are due to feedback processes [Joffe 2021]. These common features generate patterns that are essential in trying to explain how the economy works, echoing the perspective of Arthur [2021] on

recursive loops. Analyzing the patterns generated by feedback and other system properties provides a dependable basis for systematic study. This is an alternative framework to the traditional one of imposing predictability on human behavior by assuming strict rationality and optimization, which has become unrealistic in view of the conclusions of behavioral economics.

Joffe [2021] examines both positive and negative loops. A type of reinforcing feedback is related to complementarity, an important instance of which is path dependence and technological lock-in, the consequence of increasing returns. This is directly related to the earlier discussion on Hirschman's concept of linkages and complementarities. For this study, the more relevant example of a reinforcing-feedback cycle from Joffe's paper occurs in the policies of different governments in relation to foreign trade, and specifically, international competitiveness (Figure 2). East Asian governments such as Japan, Taipei, China and the Republic of Korea have prominently nurtured their domestic firms to become competitive at a global level, using industrial policy. The firms responded and contributed to high and sustained levels of economic growth. On the other hand, as mentioned in the introductory section, Latin America relied on ISI, reflecting a lesser ability of their firms to address the challenge of international competitiveness—or a lack of governments' confidence in their ability to do this. The complementarity here is between governments and firms, and as discussed earlier, this can be established successfully with embedded autonomy.

FIGURE 2. Feedback loop: increasing returns and path dependence

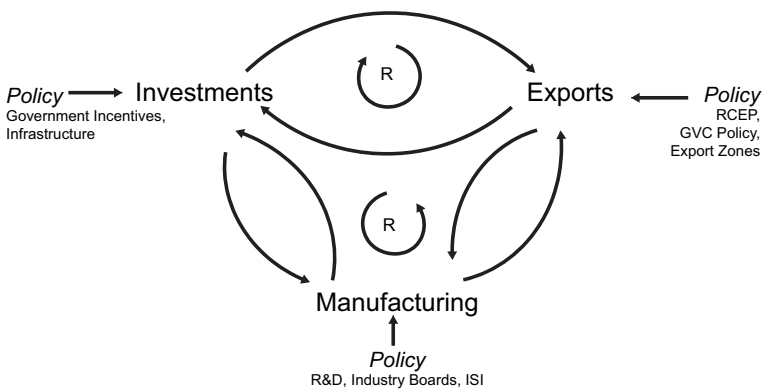


Source: Reprinted from Joffe [2021].

This example can be extended following the concept of co-evolution. In complexity theory, co-evolution relates largely to biological sciences. When adaptable autonomous agents or organisms interact intimately in an environment, such as in predator-prey and parasite-host relationships, they influence each other's evolution. This effect is called co-evolution, and it is the key to understanding how all large-scale complex adaptive systems behave over the long term [Ramalingam et al. 2008]. In general, the evolution of one domain or entity is partially dependent on the evolution of other related domains or entities.

In this study, the dynamics of structural change is considered to be driven by the co-evolution of investment, manufacturing, and exports (Figure 3). In statistical terms, co-evolution means that a set of two-way relationships linking together the set of variables in the vector **Y** of a VAR(p) model can be established. The framework indicates that industrial policy will be successful if it can trigger a reinforcing loop among investment, manufacturing, and exports, specifically one that leads to growth of the system. A necessary condition for a reinforcing loop to materialize is for there to be a significant set of two-way relationships among the three variables, i.e., the three variables co-evolve. However, even if co-evolution can be established, either a negative or balancing loop or a reinforcing loop that leads to the decline of the system may emerge, therefore rendering industrial policy ineffective. The country case studies identify idiosyncratic factors that have led to either reinforcing or balancing loops.

FIGURE 3. Industrial policy and feedback loops



Note: Authors' illustration.

4. Econometric analysis[5]

The objective of the econometric analysis is to determine the validity of the framework in Figure 3. This paper adopts the methodology by Castellacci and Natera [2013] that employs cointegration analysis to examine the long-run relationship of variables co-evolving over time in a panel data setting. Two variables X_t and Y_t are said to co-evolve if 1) these variables are cointegrated and if 2) there exists a Granger bidirectional causality between X_t and Y_t. The variables in the model are the investment-GDP ratio (*INV/GDP*) the exports-GDP ratio (*EXP/GDP*), and the ratio of manufacturing valued added to GDP (*MAN/GDP*).

[5] Only a summary of the data, methodology and results are discussed in this paper. A complete version can be found in Yap and Turla [2024].

4.1. Data

Data for the empirical analysis consist of a panel of eight Asian economies, namely Indonesia, Japan, Malaysia, the Philippines, the Republic of Korea, Singapore, Thailand, and Vietnam. The data were obtained from the UN Statistical Division for the period 1970-2022. China was excluded because of missing data for value added in manufacturing for the period 1970-2003.

4.2. Methodology and results

Castellacci and Natera [2013] follow a four-step procedure to determine whether the data show evidence of co-evolution patterns. The first step is to conduct a battery of panel unit root tests to determine whether the time-series variables of interest are integrated of order one or stationary after removing the time trend by first-differencing. The panel unit root tests by Breitung [2000], Choi [2001], Levin et al. [2002], and Im et al. [2003] are employed. All test statistics for the differenced variables were shown to be significant at the conventional levels.

Following the framework of Engle and Granger [1987], panel cointegration involves testing whether the residuals of a linear combination of nonstationary time-series variables are stationary in a dynamic panel data setting. In this paper, the Pedroni [1999;2004] and Kao [2009] panel cointegration tests are applied. If the residuals are stationary, then the variables of interest are cointegrated. The next step is to estimate a Vector Error Correction Model (VECM). Table 2 shows the relevant empirical results.

TABLE 2. Panel VECM short-run and long-run causality

Dependent Variable	Sources of Causation (Independent Variable)			
	Short-Run			Long-Run
	ΔINVGDP	*ΔEXPGDP*	*ΔMANGDP*	ECT
ΔINVGDP	-	0.254188 (0.6141)	5.913121** (0.0150)	-0.041608*** (0.0006)
ΔEXPGDP	18.39998*** (0.0000)	-	19.09979*** (0.0000)	-0.002296** (0.0321)
ΔMANGDP	15.19556*** (0.0001)	6.009840** (0.0142)	-	-0.053310*** (0.0000)

Note: Above values under short-run causation are chi-square statistics. ECT represents the coefficient of the error correction term. Number in parentheses are p-values.
Significance levels: *** one percent; ** five percent; * ten percent

The negative and significant coefficients of the error correction terms show a cointegrating relationship among the three variables. Meanwhile, results from the Granger causality test indicate a bidirectional relationship between manufacturing-to-GDP and investment-to-GDP ratios and between manufacturing-to-GDP and

exports-to-GDP ratios (Table 2). The same test shows that there is a unidirectional relationship only between the investment-to-GDP and exports-to-GDP ratios in which the latter Granger causes the former. However, the Dumitrescu-Hurlin [2012] test, which is used to detect Granger causality in a panel data setting, indicates bidirectional causality among all three variables (Table 3).

TABLE 3. Pairwise Dumitrescu-Hurlin panel causality tests

Null hypothesis	W-Stat.	Zbar-Stat.	Prob.
INVGDP does not homogeneously cause EXPGDP	4.24669	2.78651	0.0053*
EXPGDP does not homogeneously cause INVGDP	3.62442	1.98218	0.0475**
INVGDP does not homogeneously cause MANGDP	3.76740	2.16699	0.0302**
MANGDP does not homogeneously cause INVGDP	3.82929	2.24699	0.0246**
EXPGDP does not homogeneously cause MANGDP	8.73274	8.58506	0.0000***
MANGDP does not homogeneously cause EXPGDP	6.27560	5.40902	6.E-08***

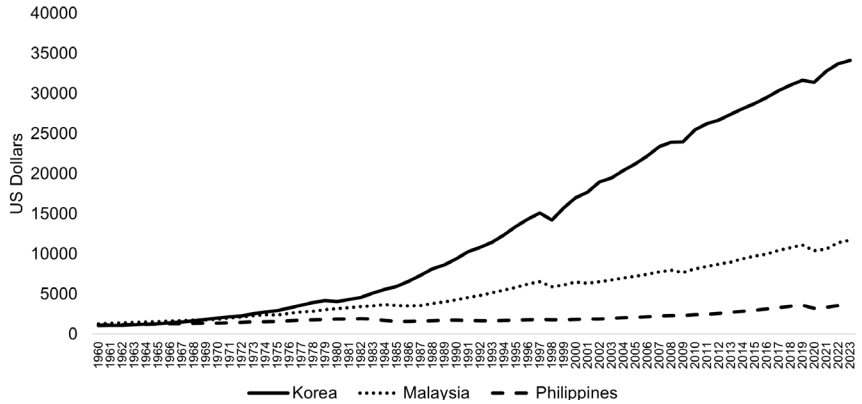
Note: The lag length applied in these tests is two.
Significance levels: *** one percent; ** five percent; * ten percent

The empirical results support the validity of the framework in Figure 3. There is evidence of co-evolution among the three variables. Not only is there a long-term or equilibrium relationship among them, the relationship is generally bidirectional. This is a *necessary* condition for the emergence of positive feedback loops. A question may arise about the inconsistency of the concept of an "equilibrium" relationship and complexity theory which emphasizes non-equilibrium outcomes that are driven by feedback or recursive mechanisms. It should be noted that the empirical results do not provide proof of the existence of positive feedback loops, but merely that conditions for their occurrence are present. Emergence of positive feedback loops is determined through the actual experience of countries with regard to industrial policy as discussed in the next section.

5. Country case studies

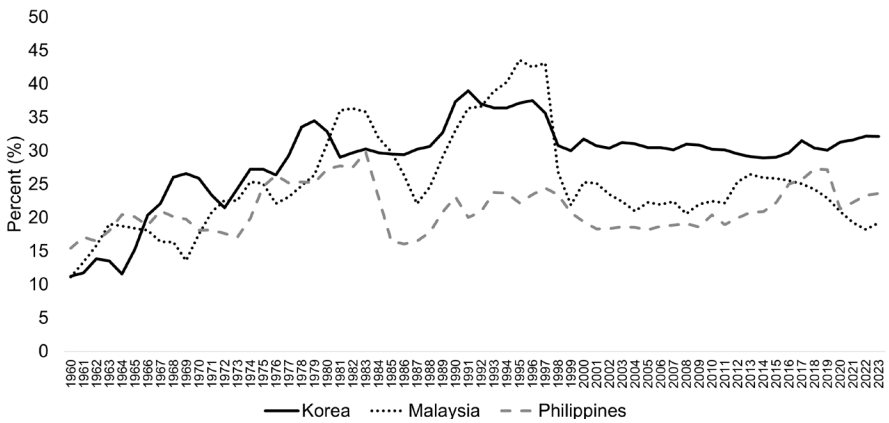
This section explores the experience of three countries to illustrate how industrial policy has led to structural transformation. The role of feedback mechanisms through the three major sectors is emphasized. Figures 4 to 7 compare the economic performance of the three countries using per capita GDP and the three aforementioned variables.

FIGURE 4. Per capita gross domestic product (constant = 2015 prices), 1960 to 2023



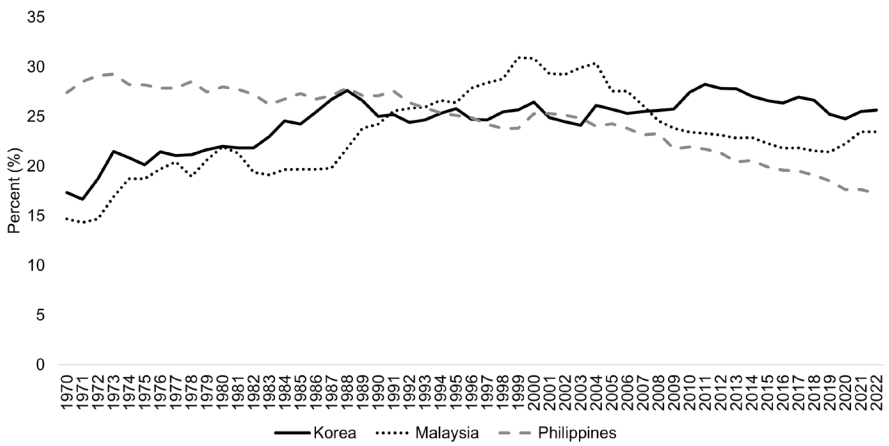
Source: World Bank World Development Indicators.

FIGURE 5. Gross fixed capital formation as a percent of GDP, 1960 to 2023



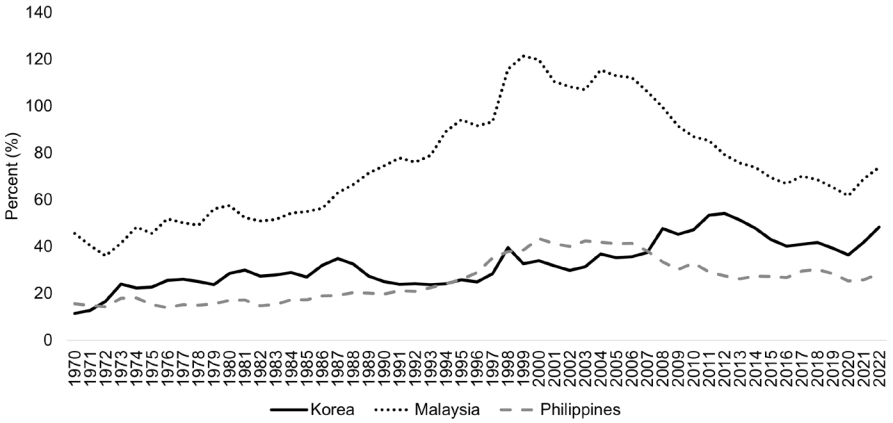
Source: World Bank World Development Indicators.

FIGURE 6. Gross value added of manufacturing as a percent of GDP, 1970 to 2022



Source: United Nations Statistics Division.

FIGURE 7. Exports of goods and services as a percent of GDP, 1970 to 2022



Source: United Nations Statistics Division.

5.1. The Republic of Korea

The Republic of Korea represents the most remarkable economic transformation in East Asia. In less than two decades after World War II, the country transformed itself from an agricultural economy to a major global manufacturer. Industrial policy was a crucial component of this process.

Much of the discussion in this section is based on Felipe and Rhee [2015a;2015b]. They argue that the progression in Korea's industrial policy is a good example of how the government modifies its role depending on the different stages of development. In the years after the Korean War, government was the primary decision-maker, specifically the president in tandem with the ministers of the various industries and their policy aides. However, private and public enterprises jointly selected specific export industries. The government provided assistance, mainly in the form of subsidies, to the relevant entities if they achieved certain targets. In the 1970s, a government-led industrial targeting policy was implemented to support six heavy and chemical industries (HCIs). But this was carried out only after intensive consultation with private companies. The increasing role of the private sector in the sector selection process persisted after the 1970s. Decisions to move into information and communications technology in response to advances in technology were led by the private sector.

The industrial tools applied by the Korean government also evolved in tandem with the latter's shifting role. Preferential export credits and special export zones were the country's primary policy tools in the 1960s when processing trade was a major target of industrial policy. When the domestic industrial based emerged in the 1970s, the government established special industrial complexes largely through policy loans and this provided modern transportation and energy infrastructure to domestic firms. In the aftermath of the two oil shocks, the government programs in the 1980s focused on industrial restructuring, facilitated by fiscal incentives for

corporate reforms, a low interest rate policy, and the depreciation of the won to spur exports.

When Korea reached the threshold of a high-income country, the government shifted the target of industrial policy to the promotion of a knowledge economy. Special funds were allocated for R&D and education in the 1990s. Meanwhile, because of their emerging role as a source of innovative growth, SMEs gained additional support through various credit guarantees. In place of traditional industrial policies, financial tools that supported risk sharing, R&D, education and SME development became more useful.

The experience of Korea belies the pessimism that selective governmental industrial promotion policies can be very costly when applied to capital-intensive or high-technology areas. While it is true that Korea's heavy chemical industries suffered from structural difficulties caused by over-investment, over-leveraging and over-competition, the government was able to launch a huge restructuring drive that involved closing down and merging several large companies [Felipe and Rhee 2015a]. As a result, economic growth of Korea in the 1980s declined only slightly to an average of 8.8 percent from 9.4 percent in the 1970s.

This experience highlights the three crucial characteristics of Korea's industrial policy. First, is the government's decisiveness in abandoning or overhauling interventions that do not yield the expected results. Second, implementation of an effective monitoring and evaluation mechanism that allowed granting of performance-based incentives. For example, if export targets were not met by firms, subsidies were either reduced or import licenses withdrawn. The monitoring and evaluation (M&E) system was instrumental in enabling the government to respond effectively to the emerging crisis in the heavy and chemical industry sector in the early 1980s.

Perhaps the most important component of Korea's success story is the understanding by the government that active intervention is needed to achieve technological development [Felipe and Rhee 2015a]. Technology does not transfer automatically after opening up to foreign trade and capital flows. In other words, technology is non-tradeable [Pack and Westphal 1986]. The government of Korea had a wider array of policies geared toward stimulating market demand for technology, increasing the country's science and technology base, and creating effective linkages between the demand for and supply of technology.

5.2. Malaysia

Malaysia has had a more deliberate industrial policy than other economies in Southeast Asia. This partly explains its higher per capita income, second only to Singapore in the region. Tham [2015] analyzes Malaysia's attempts to diversify its economy and the role that industrial policies played. The structural transformation in Malaysia consisted of a shift from agriculture towards manufacturing and can be partially attributed to measured government policies. The pragmatic approach

is consistent with the country's underlying development philosophy of active government support and direction, combined with free enterprise. To implement industrial targets, Malaysia had formulated three Industrial Master Plans (IMP): IMP1 (1986-95), IMP2 (1996-2005), and IMP3 (2006-2020), and the Economic Transformation Plan of 2010.

Malaysia chose to follow the path of Singapore by relying heavily on foreign direct investment (FDI) and to this end it provided significant incentives to multinational companies. Along with other Southeast Asian economies, Malaysia was able to latch on to global supply chains. However, it has not produced any global, Malaysian-owned and -designed products, in the sense of a Sony, Samsung or Huawei. This is a clear indication that Malaysia's indigenous technological capability is relatively low.

Tham [2015] argues that while strategies to become an industrialized economy have had partial success, they fell short of expectations. Because the targets of Malaysia's economic plans were very broad, they had a tendency to be inadequately implemented and were not monitored effectively. Furthermore, the country lacked human capital resources; technology policies overemphasized supply-side public institutions and failed to sufficiently respond to demand for technology from private firms; and linkages between firms and universities have been weak. The rate of technology transfer in Malaysia's economy has not been enough to overcome these weaknesses. Therefore, at that time, Tham considered it unlikely for the country to achieve its goal to become a knowledge- and innovation-led economy by 2020.

Policies implemented in the electronics and automobile sectors are illustrative of the challenges confronting Malaysia. The electronics sector has been a driver of Malaysia's economic transformation. However, it has not been able to graduate into the more knowledge-intensive stages of the electronics value chain. This can be attributed to Malaysia's policy of relying on cheap labor from abroad and the inability to undertake R&D at the domestic level. Meanwhile, Malaysia's failed attempt to develop Proton as a global brand is an example of a failed old-style industrial policy. Ill-targeted subsidies and other privileges granted to the car industry were not able to turn this uncompetitive industry around. Unlike Korea, the Malaysian government did not impose conditions on the subsidies such as sunset clauses or performance requirements.

5.3. The Philippines

Economic development in the Philippines during the post-Second World War period can be described as enigmatic. Despite generally favorable conditions, a decent stock of human capital, relatively abundant natural resources, and a democratic form of government, the economic record of the Philippines has paled in comparison with its neighbors in East Asia. Using per capita GDP measured in constant prices as a metric, the Philippines was overtaken by Korea in 1965,

Thailand in 1985, Indonesia in 1994, China in 1999, and Vietnam in 2021 [Yap 2024]. Some experts refer to this disappointing performance as the "Philippine development puzzle."

The country's experience with industrial policy can partly explain the dismal economic performance. Felipe and Rhee [2015a] provide a useful comparison between the Philippines and Korea with regard to the practice of industrial policy. The primary difference is that the Philippines did not have the economic independence to pursue a strategic industrial policy. At that time the Philippines was bound by a dependent relationship with the US that resulted from the Bell Trade Act. This lopsided alliance lasted until 1974. Apart from granting reciprocal free trade, the arrangement prevented the Philippines from adjusting its exchange rate until 1955. As a result, the currency became overvalued and a balance-of-payments crisis ensued due to lack of foreign exchange required to support rehabilitation of the economy shortly after the war. In response to the crisis, and not as a strategic measure, the Philippine government imposed import and exchange controls. Because of the protection bestowed by these trade controls, the share of the manufacturing in terms of value added rose from 12.5 percent of GDP in 1950 to 17.5 percent in 1960.[6] Economic growth was particularly rapid during the period 1950-55 when market value added (MVA) in manufacturing increased by an average of 12.1 percent per annum.

The growth was concentrated in the consumer goods sector which could not be sustained because of the required importation of capital goods. An alternative would have been to move into the second stage of import substitution which involved backward integration into intermediate and capital goods. Or else, like Korea in the 1960s, the Philippines could have embarked on export-led industrialization. Unfortunately, apart from the substantial US presence, economic and political power in the Philippines at that time was concentrated in a small number of wealthy landed families who had little interest in reforming trade and exchange rate policies to support sustained industrialization. In 1962, policymakers abandoned economic protectionism and instituted the decontrol program, which involved the dismantling of the foreign exchange and import controls. As a result, the industrialization of the country was derailed as the government could not prevent the surge in imports and the large repatriation of foreign capital and profits.

Meanwhile, the oligarchic nature of the Philippine economy persisted. During the Martial Law period, industrial policies implemented by President Marcos generally favored a small group of cronies. While export promotion measures were enacted, because of the overall illiberal trade regime, these only encouraged the processing of industries based on imported materials and cheap labor [Abrenica 2013]. The prominent examples of this type of commodities were semiconductors and garments.

[6] Data are quoted directly from O'Connor [1990].

The post-Martial Law period has been described as a double whammy on the Philippine economy [Yap 2024]. The first strand relates to how the Philippines pursued a different path toward an internationally competitive industrial sector compared with its Southeast Asian neighbors. While the six more advanced countries were restructuring their economies through state intervention in the mid-1980s, the Philippines embarked on an ambitious trade and import liberalization program starting in 1984, establishing a new path anchored on the long-running domestic debate on eliminating the disincentives created by protection measures [Montes 2018]. In a series of structural adjustment programs under the direction of the Bretton Woods institutions, the program progressively reduced quantitative restrictions and tariff rates, seeking to encourage private sector involvement.

The Philippine experience can be contrasted with Đổi Mới of Vietnam in 1986 which is an example where policymakers modified, adapted, and contextualized their reform agenda at the same time calibrating the sequence of, and the speed at which, economic reforms were introduced [Nayyar 2019]. This is described as strategy-based reform as opposed to crisis-based reform, which is often initiated following an external shock or internal convulsion, or imposed by conditionality of the IMF and World Bank. Crisis-based reform is more difficult to sustain and less likely to succeed because its preordained template is neither context-specific nor sequenced [Nayyar 2019]. Similar to its experience in the 1960s, the Philippines did not pursue a strategic industrial policy and instead was forced by circumstances to resort to crisis-based reform in 1984.

The second strand relates to outward orientation and structural transformation in Southeast Asia in the period 1985-1995 which were largely driven by the surge of FDI from Japanese companies seeking low-cost labor following the realignment of the world's major currencies in the mid-1980s. Success in attracting FDI depended on state policies to provide these investments with a suitable location to profitably operate production activities for export. From the supply side, the choice to break down the production process into components was prompted by Japan's priorities to protect its growing dominance in global automobile and electronics markets by transferring labor-intensive tasks offshore in the face of an abrupt exchange rate adjustment. Economic and political crises in the 1980s—partly driven by the ill-conceived liberalization program—and a severe power shortage in the early 1990s prevented the Philippines from fully benefitting from the boom in the Asia Pacific driven by regional economic integration.

5.4. Comparison from the lens of complexity economics

A comparison of the economic performance of the three countries can shed light on the effectiveness of the industrial policies that were implemented. Figure 4 shows per capita GDP in constant 2015 USD from 1960 to 2023. Korea overtook the Philippines in 1965 and Malaysia in 1970 and thereafter surged past them. In just six decades, the standard of living of Korea expanded tenfold compared with

that of the Philippines. When comparing the effectiveness of policies based on the framework in Figure 3, Korea is therefore a useful benchmark. How policies engendered positive feedback loops among investment, manufacturing and exports will be analyzed.

Korea comes closest to what is considered "true industrial policy" or more precisely technology and innovation policy [Cherif and Hasanov 2019]. It consists of three key principles [Cherif and Hasanov 2019:6]: "(i) state intervention to fix market failures that preclude the emergence of domestic producers in sophisticated industries early on, beyond the initial comparative advantage; (ii) export orientation, in contrast to the typical failed 'industrial policy' of the 1960s–1970s, which was mostly ISI; and (iii) the pursuit of fierce competition both abroad and domestically with strict accountability."

Korea's promotion of technological development underpinned its strategy for industrial development and increased competitiveness. This was complemented by subsidies to spur investment and strong support for exports. An effective monitoring and evaluation mechanism ensured the effectiveness of performance-based incentives. For example, if export targets were not met by firms, subsidies were either reduced or import licenses withdrawn. Figure 5 shows that Korea generally had a higher investment rate than Malaysia and the Philippines. Its manufacturing sector also flourished between 1960 and 1988 when it reached a secondary peak (historical peak is in 2011, but only slightly higher). Meanwhile, the export-GDP ratio of Korea is lower than that of Malaysia but this can be attributed to the latter's higher participation rate in both regional and global value chains. Nevertheless, Korea definitely outstrips Malaysia in terms of volume of exports. The evidence clearly points to positive feedback loops with growth outcomes having been generated by industrial policy in Korea.

After being surpassed by Korea in 1970, Malaysia fell significantly behind. For instance, what took Malaysia more than 50 years to reach about 40 percent of US GDP per capita in 2014, took Korea only about 20 years (Cherif and Hasanov [2019]). The missing link in Malaysia compared to Korea—and also Taipei, China—is own-technology creation. A focus on multinational corporations and technology transfer rather than encouraging domestic innovators contributed to the lack of innovation in Malaysia. As an example, the Malaysian electronics cluster lacked the 'packaging and integrating' capabilities of Singapore and product development and technology management capabilities of Taipei, China.

The limited technological development in Malaysia has constrained the growth component of positive feedback loops. Malaysia also did not have an effective monitoring and evaluation mechanism which would have allowed for restructuring or even termination of an industrial policy if warranted by circumstances. The Proton saga is an example of an industrial policy that outlived its usefulness. The Malaysian government did not have the decisiveness to quickly end the support for the car industry. Thus, even if Malaysia benefited from its participation in

regional and global value chains, the manufacturing-GDP ratio experienced a decline since 1999. This has caused exports-GDP to decline, too.

If Korea is the poster child for true industrial policy, the Philippines is the opposite. One major constraint in the Philippines has been the investment rate. Among the ASEAN+3 economies, only the Philippines and Cambodia never reached the 30 percent threshold in any year during the period 1960-2023 [Yap 2024]. The reasons have been discussed extensively elsewhere (e.g., Balisacan and Hill [2003]). Meanwhile, a major reason the export-GDP ratio in the Philippines has faltered is its inability to latch on to regional and global value chains as intensively as many of its neighbors. As explained earlier, the Philippines did not benefit from the surge of Japanese FDI in the mid-1980s and early 1990s. Unsurprisingly, efforts to boost the manufacturing sector did not fare well. It is quite revealing that when Korea reached a secondary peak in the manufacturing-GDP ratio in 1988, the value for the Philippines was slightly higher. Following the framework in Figure 3, feedback loops in the Philippines tapered off relatively quickly—they became negative or balancing loops—because of investment constraints and the inability to shift to greater export-orientation.

Finally, the Philippines can be described as a soft state, wherein governments are not willing or able to do what is necessary to attain development objectives because they can neither withstand nor compel powerful vested interests [Nayyar 2019]. An oft-cited factor for the inadequate economic progress in the Philippines is the lack of collective action, which can be traced to weak institutions [Fabella 2018] or what is essentially a soft state. Hence, embedded autonomy has not been established, which has been an important feature of the Korean experience. Policymakers in the Philippines were hampered in abandoning or overhauling interventions that did not yield the expected results leading to widespread rent-seeking activities.

6. Summary and conclusion

Empirical evidence and country experiences have supported the record of industrial policy. Recently, political economy factors emanating from pronouncements of advanced economies have given a boost to the reputation of industrial policy. The sharpest critique of industrial policy has generally stemmed from theoretical debates. Neoclassical growth economists have had a bias towards one-sector growth models and have contended that there are no special properties for any sector. They also argued that industrial policy created "rent-seeking" opportunities [Oqubay 2020]. However, the emphasis of neoclassical theory on the equilibrium condition limited its practicality. Meanwhile, the structuralist approach highlighted industrial policy as a driver of structural transformation and a conduit of technological catch-up, underlining the strategic role of exports and of sectors with higher dynamic efficiency [Oqubay 2020]. However, as argued

earlier, these explanations are developed in an inductive, multidisciplinary fashion, largely driven by common sense and original thought but without a formal general theory backing it [Cameli 2023].

Complexity economics has made significant progress in endogenizing the process of structural change associated with industrial development. The process of co-evolution and associated feedback loops of the elements involved are what is highlighted in CE. In this study, the dynamics of structural change is considered to be driven by the co-evolution of investment, manufacturing and exports (Figure 3), which are variables emphasized by the structuralist approach. In statistical terms this means that a set of two-way relationships linking together the set of variables in the vector **Y** of a VAR(p) model can be established. The framework suggests that industrial policy will be successful if it can trigger a reinforcing loop among investment, manufacturing, and exports that leads to growth in the system. Apart from a cointegrating relationship, another necessary condition is that there is a significant set of two-way bidirectional relationships among the three variables.

Empirical evidence based on data from eight countries establishes the necessary conditions. Country case studies are then presented to identify idiosyncratic factors that either bolstered feedback loops or curtailed them. In the case of the Philippines, it had a relatively robust manufacturing sector in the 1960s and 1970s. But this could not be sustained because of relatively weak investment, inability to expand exports, and the absence of embedded autonomy.

Extending the framework can provide pathways for industrial policy to generate more favorable results. For example, a policy option to address emerging constraints to industrial policy is that from Kuroiwa [2016]. He proposes a global value chain (GVC)-oriented strategy in order to overcome two major limitations to the efficacy of industrial policy: shrinking policy space that stems from international agreements like the WTO and the constraints on state capabilities. This is similar to the recommendation that local firms and conglomerates in the Philippines enter the slipstream of large global players in the traded goods sectors, a strategy labeled as "slipstream industrialization" [Fabella 2018].

The GVC-oriented development strategy consists of two phases—participation and an upgrading phase. In the first phase, developing countries seek to participate in GVCs. The general approach is to attract value chain activities that were previously located in developed countries by leveraging their abundant labor force and lower labor costs. Meanwhile, upgrading within GVCs is the essence of the second phase of the GVC-oriented development strategy. There are several avenues by which upgrading can be achieved, but the most practical is to focus on upgrading in value chains at the firm level. This is reflected in the policy instruments available to support upgrading at the firm level. Kuroiwa [2016] highlights the following: the importance of macroeconomic stability; credit at affordable rates of interest; basic education for the workers and education for the engineers and technical staff that are needed in particular for the transition to original design manufacture (ODM);

and addressing the problems of market imperfection, uncertainty, the cumulative nature of investment decisions and path dependency that cause under-investment in upgrading efforts. The GVC strategy dovetails with the framework in Figure 3: there is an investment component (macroeconomic stability and credit); direct support for manufacturing (basic education and cheap labor); and an export component (direct participation in GVCs).

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