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A joint publication of the UP School of Economics (UPSE)
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Philippine industrial policy journey: transforming the economy in the new digital age

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This paper examines the Philippines' evolving industrial policy in light of the accelerated digital transformation catalyzed by the COVID-19 pandemic. The pandemic laid bare vulnerabilities in supply and value chains, prompting a shift towards adopting Fourth Industrial Revolution or Industry 4.0 technologies.

As the country prepares for the new digital age, implementing a new strategy is imperative to build a more competitive economy. The new science, technology, and innovation (STI)-driven industrial policy leverages Industry 4.0 to support digital transformation and enhance resilience, agility, and productivity. This necessitates integrating the country's production systems across manufacturing, agriculture, and services. The new industrial strategy focuses not only on advancing manufacturing but also on its convergence with services and agriculture, embracing "mindfacturing"—a pathway that integrates intellectual work, creativity, and innovation into modern manufacturing.

To achieve this, it is crucial to accumulate investments and STI capabilities while transforming industries to increase the share of STI-driven sectors in GDP. Aligning the Strategic Investment Priority Plan of the Corporate Recovery and Tax Incentives for Enterprises (CREATE) Act with STI-driven initiatives is essential for driving industrialization and economic recovery. Sustaining the momentum of digital transformation efforts requires a more permanent budget allocation. Additionally, implementing the Philippine Industry Skills Framework is necessary to equip the workforce with future-ready skills.

Nationwide establishment of Regional Inclusive Innovation Centers (RIICs) is also recommended to foster collaboration among stakeholders in innovation and entrepreneurship ecosystems. These centers will address societal issues and industry challenges through market-oriented research, facilitating the translation and commercialization of innovations into products and services.

JEL classification: L5, O2, O14
Keywords: industrial policy, digital age, Philippine industry

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** The views expressed in this article are those of the author and do not represent the official position of the Department of Trade and Industry.

1. New industrial policy: setting the context

Philippine industrial policy started in the 1950s through the adoption of trade and investment policies as the major policy tools of industrialization. To promote the manufacturing industry, the government imposed protective policies, provided generous investment incentives, and implemented government regulations to control prices, domestic supply, and market entry in selected industries. Over time, the protectionist policies came to impose barriers to resource mobility and competition and became associated with the protection of entrenched incumbents and rent-seeking behavior.

In 1979, the government launched eleven major industrial projects across different regions in the country consisting of the following: copper smelting (Isabel and Leyte); phosphate fertilizer (Isabel and Leyte); aluminum smelting (Mindanao); diesel engine, cement expansion, coconut fatty alcohol (Northern Mindanao); integrated pulp and paper mill, petrochemical, and naphtha cracker (Bataan); heavy engineering (foundry to make large castings, huge forge and fabricating equipment), integrated steel, and alcogas. While most of these projects failed to take off, the government-owned Philippine Associated Smelting and Refining Corporation in Leyte, which was established in 1983 and privatized in 1999, was able to survive the internal and external changes in its operating environment. The National Steel Corporation in Iligan was privatized in 1995 but had to shut down after the 1997 Asian financial crisis. Other manufacturing activities that were intended to support the eleven industrial projects and that were already in the pipeline of the Board of Investments (BOI) for implementation were all withdrawn by the private sector following the regime change in 1986.

Assessing the country's protectionism and import substitution in the late seventies, Bautista, Power and Associates [1979] concluded that the policies did not lead to the creation of an efficient mechanism for allocating domestic resources in the economy. The restrictive trade regime created unintended effects that affected competitiveness and prevented the growth of dynamic economic activities. Medalla [2002] characterized this policy regime as import-dependent import substitution, which (i) discouraged backward linkages and encouraged the use of artificially cheap imported inputs; (ii) penalized exports; and (iii) artificially cheapened capital which promoted greater capital intensity among domestic industries.

In the 1980s, the government embarked on a trade liberalization program to reduce tariff and non-tariff barriers. This was followed by policy reforms in the 1990s that liberalized investments particularly in areas previously reserved only for Filipinos, and privatized and deregulated services such as financial, telecommunications, power, water, air transport, and shipping. All these aimed at removing barriers to competition, promoting factor mobility, attracting investments, and attaining sustainable economic growth.

While the trade liberalization programs from the eighties till the early 1990s were pursued on a unilateral basis, the succeeding liberalization episodes were carried out on a bilateral or regional basis through free trade agreements that the Philippines had signed. Towards the mid-1990s, the tariffication and removal of import restrictions were achieved through the General Agreement on Tariffs and Trade-World Trade Organization (GATT-WTO). In the 2000s, further tariff liberalization was implemented as the Philippines signed free trade agreements with the Association of Southeast Asian Nations (ASEAN) Economic Community, ASEAN-Japan, and ASEAN-Korea. Other free trade agreements entered into by the Philippines include the Japan-Philippines Economic Partnership Agreement (JPEPA), Philippines-European Free Trade Association (EFTA) Free Trade Agreement, ASEAN+5 (Japan, South Korea, Australia, New Zealand, China), and more recently, the Regional Comprehensive Economic Partnership (RCEP) Agreement and the Philippines-South Korea Free Trade Agreement.

Amid liberalization and other market-oriented reforms, the government through the Department of Trade and Industry (DTI) tried to revive industrial policy in 1998 through the formulation of the Industrial Development Plan. Focusing on technology and skills upgrading, the Plan focused on developing 16 priority industries: copper products, decorative crafts, electronics, fertilizer, footwear and leather goods, fresh fruits, furniture, garments and textile, industrial tree plantation and rubber products, iron and steel, metal products, marine products, motor vehicles and components, oleochemical, petrochemical, processed food and carrageenan. The Plan was not implemented due to the changes in political administration and the Asian financial crisis.

In 2012, the DTI made another industrial policy attempt by collaborating with industry groups and the Philippine Institute for Development Studies (PIDS) in the formulation of industry roadmaps. The research work centered on the identification of the most binding constraints to industry growth and solutions to address these issues (see Aldaba [2014]). Consultations and focus group discussions with industry players, academe, government agencies, civil society, labor groups, and other stakeholders took place not only in Metro Manila but as well as in the regions. The process yielded long lists of industry issues and recommendations covering measures to enhance firm productivity, strengthen supply chains to enable firms to move up the technology scale, link domestic firms with multinational companies, aggressively court more investments, and establish a coordination mechanism to allow more interaction between government and industry. Based on these recommendations, the Comprehensive National Industrial Strategy (CNIS) provided the framework for the implementation of the sectoral roadmaps to support the growth and development of globally competitive and innovative industries.

Through horizontal and vertical measures to enhance productivity, the CNIS aimed to build a strong and modern industrial base that would enable the real economy to lead the country's high level, inclusive, and sustainable growth.

A coordination mechanism, led by BOI industry champions together with representatives from industries, was designed to allow more interaction between government and industry in identifying obstacles to growth and determining the most appropriate interventions. Auto and auto parts, tool and die, furniture, iron and steel, metal casting, motorcycle and parts, petrochemicals, and shipbuilding were among the priority manufacturing industries identified for development.

Building on the CNIS, the DTI in 2016 finetuned and implemented the country's new industrial policy known as Inclusive Innovation Industrial Strategy (i3S). The strategy placed innovation at its front and center as the country adapted to changing market trends and developments such as the entry of the Fourth Industrial Revolution (Industry 4.0) technologies. Industry 4.0 presented opportunities to improve productivity, and move up the global value chain (GVC).

Amid the implementation of i3S, COVID-19 broke out and triggered a major global economic crisis. As the government reopened the economy, renewing the Philippine industrial policy was crucial not only to overcome the impact of the crisis due to the pandemic but also to set the country back on the economic development path. The current strategy, known as science, technology, and innovation (STI)-based industrial policy focuses on the adoption of digital technologies and policies to accelerate a transformative recovery and facilitate the investments to achieve structural change and industrialization.

This paper aims to revisit the new industrial policy experience of the Philippines, identify the challenges and opportunities arising from the entry of the Industry 4.0 technologies, and articulate the next steps and way forward especially amid the new digital age. The next section presents the structure and performance of industries, the impact of the pandemic on industries, and how industrial policy was used in helping industries survive the health and economic crises. Section 3 analyzes the current state of technology utilization in the manufacturing industry and the implications of Industry 4.0 on the country's economic development. Section 4 discusses the underlying industrial policy framework and its elements along with the major strategies in the implementation of the STI-driven industrial policy. Section 5 proposes some ways forward to support the country's industrial transformation in the digital era and outlines the role of a new industrial policy.

2. Economic recovery towards accelerating industrialization

2.1. Impact of COVID-19 and the need for economic restructuring

Prior to the pandemic, the Philippines was growing at an average of 6.6 percent during the period 2016 to 2019 (Table 1). Manufacturing and services contributed substantially to this strong growth with average manufacturing growth at six percent while services posted 7.4 percent. Within the services sector; wholesale and retail trade, financial and insurance and professional and business services

were the major sources of growth. In the case of agriculture, forestry and fishing, however, growth had been declining and registered an average of only 1.4 percent during the same period.

TABLE 1. GDP growth performance (2001-2023, in percent)

Major economic sector	2001-2005	2006-2010	2011-2015	2016-2019	2020	2021-2023
Agriculture, forestry, and fishing	4.1	2.9	2.4	1.4	-0.2	0.5
Industry	3.9	4.5	6.0	7.0	-13.1	6.2
Mining and quarrying	13.5	6.4	2.4	3.3	-18.6	4.1
Manufacturing	4.2	2.8	5.4	6.0	-9.8	5.0
Electricity, steam, water, and waste management	4.6	5.0	4.9	6.6	-0.4	5.1
Construction	0.5	11.1	9.6	10.5	-25.5	10.3
Services	5.3	5.8	6.9	7.4	-9.1	7.2
Wholesale and retail trade; repair of motor vehicles and motorcycles	4.9	4.9	5.6	6.9	-6.1	6.1
Transportation and storage	2.6	2.8	9.4	7.9	-30.6	14.4
Accommodation and food service	4.2	4.3	6.9	9.4	-45.5	20.9
Information and communication	19.1	6.3	6.0	6.3	5.1	7.2
Financial and insurance activities	7.5	9.2	9.1	9.4	5.6	6.9
Real estate and ownership of dwellings	2.8	4.7	7.8	4.9	-16.7	3.8
Professional and business services	13.2	14.3	11.0	7.9	-9.6	7.4
Public administration and defense; compulsory social activities	3.3	4.2	3.6	11.4	4.5	4.0
Education	3.1	4.1	3.1	6.8	-10.2	7.4
Human health and social work activities	6.8	2.7	7.4	4.6	-5.1	8.5
Other services	3.6	9.1	7.3	5.1	-41.0	17.1
GDP	4.7	5.0	6.0	6.6	-9.5	6.3

Source: Philippine Statistics Authority [n.d.].

The COVID-19 crisis in 2020 interrupted the robust growth performance of the country and led to a severe contraction of the economy. With the quarantines and lockdowns which halted business operations, manufacturing and services registered negative growth rates. The gradual reopening of the economy in the third quarter of 2020 and the arrival of vaccines started to restore business and consumer confidence. Table 1 shows recovery as the economy grew by 6.3 percent in 2021-2023. Manufacturing expanded by five percent while services posted a 7.2 percent growth; however, agriculture, fishing and forestry remained

weak at -0.5 percent due to the onslaught of the African Swine Disease and series of typhoons that adversely affected the sector's recovery.

Table 2 presents the structure and changes in contribution of the major economic sectors covering the same period. The average share of agriculture, fishing and forestry continued to decline from 15 percent during the years 2001-2005 to 9.9 percent for the years 2016-2019 and to nine percent in the more recent 2021-2023 period. The average contribution of manufacturing also dropped from 22 percent to 19 percent and 18.6 percent during the same years under study. With an average share of 53 percent for the period 2001-2005, services' share went up steadily to almost 60 percent for the period 2016 to 2019 driven by wholesale and retail, financial, and professional and business services. This increased further to 61.4 percent in the years covering 2021-2023.

TABLE 2. Economic structure (2001-2023, in percent)

Major economic sector	2001-2005	2006-2010	2011-2015	2016-2019	2020	2021-2023
Agriculture, forestry, and fishing	15.2	14.3	12.4	9.9	10.2	9.0
Industry	31.4	30.0	29.7	30.4	29.2	29.6
Mining and quarrying	1.0	1.1	1.0	0.9	0.8	0.8
Manufacturing	22.3	20.6	19.4	19.1	18.6	18.6
Electricity, steam, water, and waste management	3.3	3.2	3.1	3.1	3.4	3.3
Construction	4.9	5.1	6.2	7.3	6.4	6.9
Services	53.4	55.8	57.9	59.8	60.7	61.4
Wholesale and retail trade; repair of motor vehicles and motorcycles	18.2	18.3	17.9	17.8	18.7	18.5
Transportation and storage	3.8	3.3	3.4	3.8	2.9	3.3
Accommodation and food service	2.0	1.9	1.9	2.2	1.3	1.6
Information and communication	2.0	2.9	2.9	2.8	3.3	3.4
Financial and insurance activities	5.1	6.4	7.4	8.2	10.1	10.1
Real estate and ownership of dwellings	6.6	6.4	6.7	6.5	5.9	5.6
Professional and business services	2.3	4.0	5.3	6.3	6.1	6.2
Public administration and defense; compulsory social activities	4.6	4.2	4.0	4.1	5.2	5.0
Education	5.0	4.6	4.2	3.9	3.9	4.0
Human health and social work activities	1.8	1.8	1.7	1.7	1.7	1.9
Other services	1.9	2.0	2.4	2.3	1.5	1.7
GDP	100.0	100.0	100.0	100.0	100.0	100.0

Source: Philippine Statistics Authority [n.d.].

Table 3 looks at the employment contribution of industries during the same years under study. With the failure of manufacturing to create sufficient employment for new entrants to the labor force as well as those who move out of the agricultural sector, the services sector has emerged as the most important employment provider as it continued to absorb the unemployed workers especially in wholesale, retail, and repair of vehicles and appliances which constituted the bulk of services employment. Services average employment share rose steadily from 51 percent during the period 2008-2010 to 57 percent in 2016-2019 and to 57.9 percent in 2021-2023. Amid the lockdowns and supply chain disruptions arising from the pandemic, the average contribution of manufacturing declined from 8.6 percent in 2016-2019 to 7.8 percent in 2021-2023. Meanwhile, agriculture continued to account for a substantial share of total employment although its contribution had fallen from 34.3 percent in 2008-2010 to 24.7 percent in 2016-2019 and to 24 percent during the years 2021-2023.

TABLE 3. Employment structure (2008-2023, in percent)

Major economic sector	2008 - 2010	2011 - 2015	2016 - 2019	2020	2021-2023
Agriculture, forestry, and fishing	34.3	31.2	24.7	24.8	24.0
Industry	14.8	15.6	18.6	18.3	18.0
Manufacturing	8.4	8.3	8.6	8.1	7.8
Services	50.9	53.3	56.7	56.9	57.9

Source: Philippine Statistics Authority [n.d.].

Comparing the country's manufacturing performance against its neighbors in the region for the period 2000-2022, Figures 1 and 2 indicate that the Philippines lags behind Korea, Thailand, Malaysia, Vietnam and Indonesia in terms of contribution to GDP. In terms of the contribution of manufacturing to employment, the Philippines is also at the bottom. Thailand, Indonesia, and Malaysia are experiencing declining manufacturing shares to GDP after reaching a peak of around 30 percent share in 2007-2008 in Thailand, 28 percent in 2003-2005 in Indonesia, and 30 percent in Malaysia in 2000-2004. Korea was able to manage and sustain its manufacturing share; the same holds for Vietnam particularly in the more recent period. Vietnam is the only country with an increasing manufacturing employment contribution for the entire period.

In terms of the country's trade integration with the world, the trade to GDP ratio was rising but after reaching a peak of almost 95 percent in 2000, it started to fall (Figure 3). A declining trade to GDP ratio indicates a less open and more inward-oriented economy. In the more recent years, some recovery was observed as the ratio rose from 46 percent in 2015 to 56 percent in 2022.

FIGURE 1. Manufacturing contribution to GDP: 2020-2022

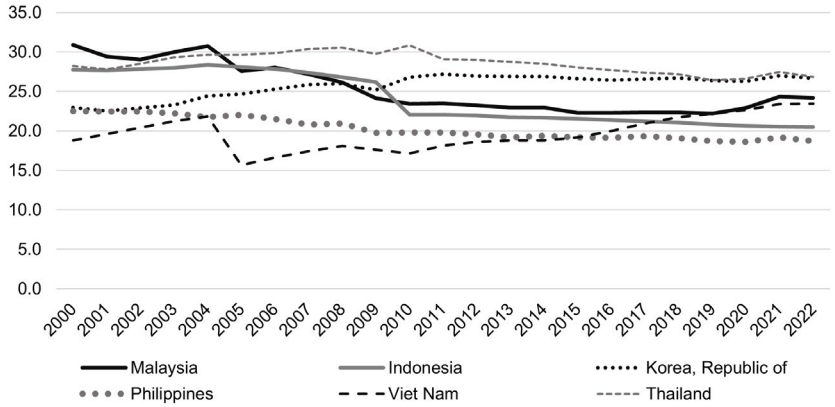
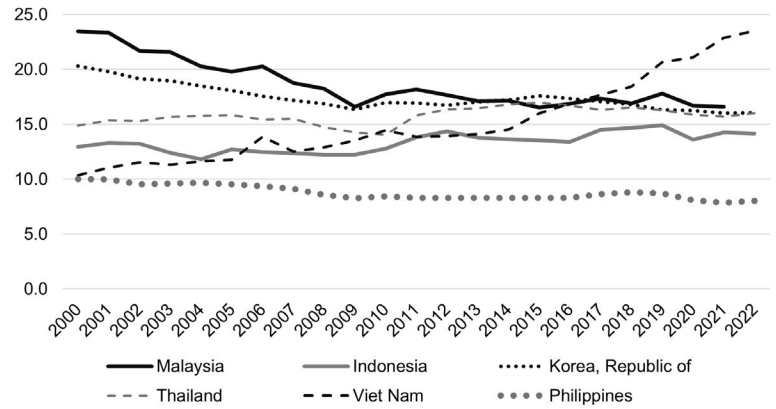
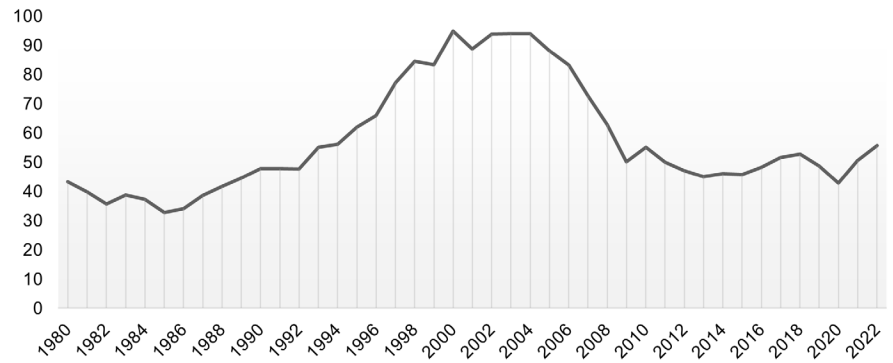


FIGURE 2. Manufacturing contribution to employment: 2000-2022



Source of basic data: ADB Key Economic Indicators

FIGURE 3. Trade as percentage of GDP



Source: UNCTAD Statistical Portal. [n.d.].

The country's export structure in Table 4 indicates that the country's exports have become less diversified. In the 1980s, Philippine exports were composed of light manufactures such as metalliferous ores and metal scrap with an average share of 8.4 percent of total exports, vegetable oils and fats (8.3 percent), fruits and vegetables (6.9 percent), clothing (six percent), electrical machinery (5.7 percent), sugar and sugar preparations (4.6 percent), wood lumber and cork (3.6 percent), fish and fish preparations (3.5 percent), and special transactions which accounted for 26.9 percent of the total. In the 1990s, a huge shift towards electrical machinery (30 percent) and machinery other than electric (eight percent) was evident. This continued in the next period (2000-2009) as the electronics sector now dominated the country's exports with electrical machinery accounting for an average of 48 percent of total exports while machinery other than electric accounted for an average share of 21 percent. During this period, emerging sectors such as transport equipment and scientific and control instruments registered average shares of four percent and 2.3 percent, respectively.

TABLE 4. Structure of exports: average shares (in percent)

SITC Code	Product Description	1980-1989	1990-1999	2000-2009	2010-2019	2020-2023
1	Meat and meat preparations	0.0	0.0	0.0	0.1	0.0
2	Dairy products and eggs	0.0	0.0	0.2	0.1	0.1
3	Fish and fish preparations	3.5	3.2	1.1	1.4	1.2
4	Cereals and cereal preparations	0.4	0.2	0.2	0.2	0.3
5	Fruit and vegetables	6.9	3.8	2.1	3.3	3.9
6	Sugar, sugar preparations and honey	4.6	0.9	0.3	0.4	0.1
7	Coffee, tea, cocoa, spices, and manufactures	1.5	0.2	0.0	0.0	0.0
8	Feedstuff for animals, excluding unmilled cereals	1.3	0.4	0.1	0.2	0.1
9	Miscellaneous food preparations	0.1	0.2	0.2	0.4	0.4
11	Beverages	0.1	0.1	0.1	0.1	0.0
12	Tobacco and tobacco manufactures	0.6	0.3	0.3	0.6	0.7
22	Oil seeds, oil nuts and oil kernels	0.5	0.1	0.0	0.0	0.0
23	Crude rubber including synthetic and reclaimed	0.1	0.1	0.1	0.1	0.2
24	Wood, lumber and cork	3.6	0.2	0.1	0.2	0.4
25	Pulp and paper	0.2	0.2	0.1	0.2	0.2
26	Textile fibers, not manufactured	0.6	0.2	0.1	0.1	0.1
27	Crude fertilizers and crude mineral	0.1	0.1	0.0	0.0	0.0
28	Metalliferous ores and metal scrap	8.4	2.1	1.2	3.1	4.0
29	Crude animal and vegetable material	0.5	0.5	0.2	0.4	0.4
32	Coal, coke, and briquettes	0.0	0.0	0.0	0.4	0.8
33	Petroleum and petroleum products	1.1	1.2	1.6	1.6	0.4

TABLE 4. Structure of exports: average shares (continued)

SITC Code	Product Description	1980-1989	1990-1999	2000-2009	2010-2019	2020-2023
34	Gas, natural and manufactured	0.2	0.5	0.1	0.1	0.0
42	Fixed vegetable oils and fats	8.3	3.3	1.4	2.1	1.9
43	Animal and vegetable oils and fats	0.2	0.1	0.1	0.1	0.2
51	Chemical elements and compounds	1.3	0.5	0.5	0.8	0.5
52	Crude chemicals from coal, petroleum	0.1	0.0	0.0	0.5	0.2
53	Dyeing, tanning, and coloring materials	0.0	0.0	0.0	0.0	0.1
54	Medicinal and pharmaceutical produce	0.1	0.1	0.1	0.1	0.1
55	Perfume materials, toilet and cleansing preparations	0.1	0.2	0.2	0.5	0.3
56	Fertilizers, manufactured	0.7	0.7	0.2	0.1	0.0
57	Explosives and pyrotechnic products	0.1	0.0	0.0	0.4	0.4
58	Plastic materials, etc.	0.3	0.3	0.3	0.2	0.4
59	Chemical materials and products, n.e.s.	0.3	0.2	0.1	0.4	0.3
61	Leather, leather manufactures, n.e.s.	0.0	0.1	0.0	0.0	0.0
62	Rubber manufactures, n.e.s.	0.0	0.2	0.3	0.4	0.5
63	Wood and cork manufactures	2.7	1.2	1.0	3.2	0.4
64	Paper, paperboard, and manufactures	0.1	0.3	0.3	0.2	0.2
65	Textile yarn, fabrics, made-up articles, n.e.s., and related products	1.0	1.2	0.6	0.3	0.4
66	Non-metallic mineral manufactures, n.e.s.	0.6	0.7	0.6	0.3	0.4
67	Iron and steel	0.7	0.4	0.3	0.2	0.1
68	Nonferrous metals	3.0	2.1	1.8	2.1	3.2
69	Manufactures of metal, n.e.s.	0.3	0.5	0.4	1.1	0.9
71	Machinery, other than electric	0.3	8.3	20.8	11.3	9.0
72	Electrical machinery, apparatus and	5.7	29.6	47.9	38.1	49.2
73	Transport equipment	0.6	1.3	4.0	5.1	2.7
81	Sanitary, plumbing, heating and lighting fixtures and fittings, n.e.s.	0.1	0.1	0.1	0.1	0.1
82	Furniture	1.8	1.6	0.7	0.5	0.5
83	Travel goods, handbags and similar containers	0.2	0.7	0.4	0.5	0.8
84	Clothing	6.0	9.6	5.8	2.2	1.0
85	Footwear	0.9	1.0	0.1	0.1	0.1
86	Scientific and control instruments	0.2	0.9	2.3	3.2	3.1
89	Miscellaneous manufactured articles	2.9	3.4	1.5	1.9	1.9
93	Special transactions and commodities not classified according to kind	26.9	17.0	0.1	4.6	0.0

Source: World Bank [n.d.].

In the more recent periods covering 2010-2019 and 2020-2023, the overall export structure remained unchanged and characterized by the high concentration in electronics with its average share rising from 38 percent to 49 percent. Except for fruits and vegetables, metalliferous ores, and nonferrous metals, most of the sectors experienced reductions in their average shares. Machinery other than electric dropped from 11 percent to nine percent, transport equipment from five percent to three percent, wood and cork from three percent to 0.4 percent, and clothing from two percent to one percent. Scientific and control instruments' average share was maintained at three percent during the same periods under review.

Based on the research and analysis of the Harvard Growth Lab [n.d.], the Philippines diversified into a sufficient number of products starting in 2006 and added 30 new export products in the next 15 years with a total value of USD 4.68 billion. The volume, however, has been too small to contribute substantially to growth. In the same period from 2006 to 2021, Vietnam was able to introduce 41 new products valued at USD 145 billion while China had 20 products with a total value of USD 45.2 billion. The Growth Lab recommended the following products to support the country's diversification path and enter into more complex production: apparatus and equipment for photographic laboratories n.e.c.,[1] chemical elements for electronics, machines n.e.c., instruments for physical or chemical analysis, appliances for thermostatically controlled valves, ball or roller bearings, equipment for temperature change of materials, telephones, batteries, primary cells and primary batteries, computers, parts for electrical apparatus, parts of motorcycles or wheelchairs, electrical lighting equipment used for motor vehicles, games, and insulating fittings for electrical machines.

2.2. Coping through innovation and adoption of new technologies[2]

The pandemic highlighted the critical role that new technologies and innovation have played in keeping societies functional in times of quarantines or lockdowns and in responding to the global crisis, recovery and protecting the workers. One important realization is the need for countries to adopt new technologies, pursue digital transformation, and focus on innovation, sustainability, and resilience. While the use of artificial intelligence or AI, for example, could displace some workers, at the same time, these new technologies could lead to innovation effects where new jobs arising from new tasks and new products could emerge.

Ionics is a Filipino electronics manufacturing services company that invested in a smart factory prior to the pandemic. It reduced its workers by 90 percent in one production line but its output increased by 100 percent. At the same time, it increased its engineering and computer science staff by 200 percent while its profitability went up between ten to 20 percent. Ionics indicated that while the

[1] N.e.c. stands for not elsewhere classified.
[2] This draws from Aldaba [forthcoming].

COVID-19 crisis has affected them significantly, the impact of the pandemic on their business would have been far much worse had it not been for their smart factory which enabled them to operate.

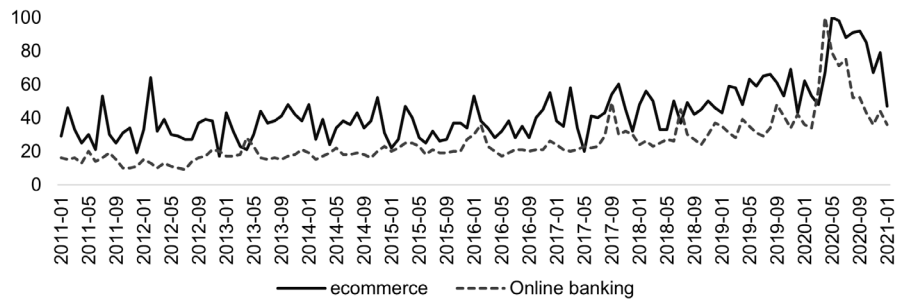
Another example is Union Bank (UB) which is the first 5G-powered bank in the country. Applying digital initiatives to promote financial inclusion, UB implemented i2i, an open finance platform to bring digital financial services to unbanked and underbanked individuals in financially underserved communities. i2i connects financial institutions and community-based financial services nationwide including remittance centers. During the pandemic, usage volumes of i2i rose by over 3,000 percent in the last six months of 2020. i2i's network also helped expedite the disbursement of the Department of Social Welfare and Development's Social Amelioration Program to beneficiaries. UB's digital branch called The ARK has no bank tellers, no long lines, and has completely paperless banking transactions. UB indicated that it did not close any of its branches; the tellers were not replaced but were reskilled to become marketing ambassadors. At the same time, they hired new people with various backgrounds, specifically on telecommunications, technology, and data analytics.

Along with micro and small enterprises, the pandemic affected startups' financial stability, market dynamism, and talent productivity. Despite the crisis, startups responded to the issues arising from the public health emergency by offering solutions through the creation of new products, services, and processes. Based on a survey done by PricewaterhouseCoopers [2020], 49 percent of Filipino startups explored new product/services and more than 20 percent of the startups said that they experienced an increasing demand for their services and products particularly in logistics, education technology, enterprise services, financial technology, and healthcare by a startup company, DWARM Technologies.

Using new technologies, startups provided support to government through contact tracing apps, personal and community health monitoring, chatbots, along with social distancing and online marketplaces. For instance, RC143, a contact tracing app was developed for the Red Cross; DWARM Technologies built AI thermal scan solutions mounted on drones which were used as non-contact thermal scanners at expressway checkpoints; while the Remote Sensing and Data Science (DATOS) Project of the Advanced Science and Technology Institute used geographic information systems, remote sensing, AI and data science to provide maps and other information for disaster risk reduction applications. The University of the Philippines National Institute for Health created GenAmplify COVID-19 test kit which was manufactured by Manila HealthTek. Other innovative startups emerged to provide tech solutions to address issues in health, agriculture, education, finance, multimedia, supply chain and logistics. In 2021, the Philippines saw its first unicorn, fintech company Mynt with a value of over USD two billion. In 2022, Voyager Innovation, owner of e-wallet PayMaya and digital bank Maya Bank, became the second unicorn.

The increasing use of technology to work, buy, and stay connected during the pandemic shaped new digital habits among consumers in the country. This forced traditional enterprises and startups to create new digital business models to diversify revenue streams. As Figure 4 shows, searches for "e-commerce" and "online banking" from 2011 to 2021 skyrocketed to its maximum index of 100 beginning January 2020. At the height of the lockdown, the number of online business registrations went up significantly from 1,753 during the months January to March 2020 to 82,100 in October 2020.

FIGURE 4. Google searches for e-commerce and online banking



Source: Google Trends [n.d.].

The crisis also expedited the adoption of fintech solutions in many economies, including the Philippines. It led to the shift from cash payments to digital payments. For the first eight months of 2020, the value of InstaPay rose almost 400 percent, while that of PESONet jumped 100 percent year-on-year. It also accelerated the demand for education technologies and online learning solutions as the world shifted to distance learning amidst the ongoing threat of the virus. Nielsen [2020] indicated a 60 percent increase in the amount of video content watched globally as people stayed at home due to lockdowns and quarantine restrictions. The same shift in consumer behavior was observed in the country as demand increased for online sources of entertainment such as online games, online movies, and other online entertainment applications.

At the same time, the pandemic sparked a boom in the country's digital economy. Based on the digital economy report by Google et al. [2021], the Philippines was seen as the fastest growing market in Southeast Asia with gross value of USD 17 billion in 2021. The same report showed that Southeast Asia's small and medium enterprises adopted technology with focus on digital platforms, financial services, and digital tools.

Like other countries, the pandemic exposed weaknesses in the Philippine supply and value chains, particularly the lack of medical devices that were urgently needed by the healthcare system. The surge in demand for personal protective

equipment (PPE) led to a huge shortage in its supply. The DTI implemented a manufacturing repurposing program and called on manufacturers to repurpose their facilities for the production of COVID critical products. In response, a group of companies[3] from the garments and electronics bonded themselves together and repurposed their manufacturing plants for the production of medical masks and coveralls. They invested USD 35 million to bring in medical grade raw materials and equipment and built clean rooms for the production of PPEs. At the same time, they were also able to create 7,450 new jobs.

The pandemic moreover provided an impetus to fast track the adoption of the Fourth Industrial Revolution or Industry 4.0 technologies and innovation with greater focus on resilience and sustainability. The crisis presented new Industry 4.0 opportunities that could be leveraged to discover new, better, and more resilient ways of doing things. Enterprises with greater innovation emerged resilient and even recorded gains amidst the economic slowdown. New and powerful technologies such as AI, Internet of Things (IoT), blockchain, robotics, e-commerce, and digital trade were expected to play an important role in shaping the post-crisis landscape especially in ensuring the survival of more companies and organizations.

Furthermore, the pandemic emphasized major lessons learned such as customizing production and supply systems to accommodate shifting consumer behaviors and leveraging advanced technologies to enhance production agility. It also brought to light the need for new approaches to enhance workforce adaptability and resilience. To address these challenges, initiatives focused on workforce development, including reskilling and upskilling programs, are essential to prepare employees for the demands of Industry 4.0. In terms of industry development priorities, the pandemic underscored the urgency of strengthening domestic supply chains, particularly in addressing deficiencies related to the manufacturing and distribution of essential goods such as food, PPEs, medical supplies, and online healthcare and educational services.

3. Embracing Industry 4.0 technologies[4]

There have been various waves of technological advancement that have affected economic and industrial development of countries. In the First Industrial Revolution, mechanization emerged from the discovery of steam power and water. The Second Industrial Revolution was characterized by mass production through assembly lines made possible by the discovery of electricity. During the Third Industrial Revolution or Industry 3.0, automation through electronics and

[3] The Confederation of Philippine Manufacturers of PPEs (CPMP) consisted of Reliance Producers Cooperative, Medtecs International Corporation, EMS Components Assembly, L&T International Group, Tacca Philippines, and Integrated Micro Electronics.

[4] See Aldaba [forthcoming].

information technology was introduced. Industry 4.0 evolved from Industry 3.0 technologies, but what differentiates it is the machines' connectivity, flexibility, and functionality in executing tasks. These machines can collect and transmit data through the Industrial IoT. With big data analytics, the processing of vast quantities of data in near real-time becomes possible. Industry 4.0 is based on cyber-physical systems, merging the physical and virtual worlds. This becomes possible through smart, networked systems using embedded sensors, processors, and actuators designed to sense and interact with the physical world and provide real-time support.

Traditional manufacturing is being disrupted as operations are undergoing digital transformation using AI, machine learning (ML), big data analytics, cloud computing, 3D printing, and other technologies towards smart manufacturing. The new digital production technologies consist of the following elements which combine both old and new generations of digital technologies:

- Hardware: tools, tooling and complementary equipment of modern industrial robots and intelligent automated systems, robotic arms, cobots (robots cooperating with workers in the execution of tasks), 3D printers for additive manufacturing, others
- Software: active design and manufacturing software, computer-aided manufacturing (CAM), computer-integrated manufacturing (CIM), and computer-aided design (CAD); information and communications technologies, and cyber-physical systems (CPS), machine-to-machine radio frequency identification (M2M RFID), CPS with data analysis
- Connectivity: Industrial IoT

The different generations of digital production applied to manufacturing production from analog to digital are described in Table 5. Analog production does not make use of digital production technologies (DPT) in any area of the company. Rigid production applies digital technologies for specific purposes and in isolation from each other. Smart production is characterized by the use of digital technologies with information feedback to support decision making and implies the use of advanced communications devices, robotization, sensorization, big data, and artificial intelligence. UNIDO [2019] indicated that evolving from generation 1.0 to 2.0 does not require major organizational changes but evolving from generation 2.0 to 3.0 requires substantial changes. To successfully move up the innovation ladder, latecomer countries should take into account factors such as capabilities, endowments, organizational characteristics, technological efforts, and infrastructural and institutional conditions. One important historical insight is that latecomers need not invent new technologies; instead, their main entry point could be to rapidly adopt emerging technologies or adapt them to local conditions through innovation.

TABLE 5. Digital production technology characteristics

Generation	Characteristics
4.0 Smart Production	DPTs allow for fully integrated, connected, and smart production processes, where information flows across operations and generates real-time feedback to support decision-making (such as use of smart sensors and machine-to-machine communication, cobots, big data analytics, cloud computing, artificial intelligence and 3D printing)
3.0 Integrated Production	DPTs integrated across different activities and functions, allowing for the interconnection of the whole production process (such as use of enterprise resource planning systems, fully "paperless" electronic production control system, industrial robots)
2.0 Lean Production	DPTs involve and connect different functions and activities within the firm (such as use of CAD-CAM linking up product development and production processes; basic automation)
1.0 Rigid Production	DPTs limited to a specific purpose in a specific function (such as use of CAD only in product development; use of machines operating in isolation)
0.0 Analog Production	No DPTs used throughout the whole production process (such as personal or phone contact with suppliers; use of machinery that is not microelectronic based)

Source: UNIDO [2019].

These new technologies could serve as drivers to achieve an inclusive, resilient, and sustainable industrial development. Through the use of AI, for example, new products and services can be created leading to jobs and income opportunities, as well as new activities. Adopting smart manufacturing could increase productivity; new technologies could reduce material and energy use. The use of IoT for asset management could generate the following benefits: increased operational efficiency and productivity, more efficient safety and compliance checks, automation of maintenance and repair operations, more efficient use of resources, better control over the sales lifecycle, easy identification of growth opportunities, and a responsive smart ecosystem [Siemens 2021].

The McKinsey Global Institute [2018] highlighted that AI techniques and solutions have the potential to create from USD 3.5 trillion to USD 5.8 trillion in value in 19 industries led by retail especially e-commerce, transport and logistics, travel, healthcare, consumer packaged goods, auto and assembly, and other activities. In assessing the readiness of countries for future production, the World Economic Forum [2018] indicated that the Philippines is among the legacy countries characterized by a strong production base but with unfavorable drivers of production that are at risk for the future. The report recommended legacy countries like the Philippines to focus their policies on reskilling and upskilling the work force, upgrading technology platform, and fostering innovation.

In terms of the potential impact on jobs, the McKinsey Global Institute [2017] estimated that 48 percent of activities in the Philippines could be automated. This is equivalent to 18.2 million jobs with six million in agriculture, 3.4 million in retail, and 2.4 million in manufacturing. Similarly, Francisco et al. [2019] showed that the agriculture, forestry, and fishing sector has the highest probability of jobs

being automated; financial insurance has a probability of 79 percent; mining and quarrying, 78 percent; construction, 76 percent; accommodation and food service, 72 percent; manufacturing, 65 percent; public administration, 40 percent; human health, 33 percent; and education, 15 percent. Most reports indicated that low-skilled, low-educated, and routinized jobs are the most vulnerable to the adverse effect of technological change.

AI and robots could lead to both the destruction and creation of jobs through the following: displacement and income effects. The displacement effect is due to humans losing their jobs to robots. However, there are cost savings from the use of AI and robots which allow firms to lower their prices and in turn increase the consumers' real income and spending. This income effect increases demand for goods and services which then forces firms to hire more workers as they expand their capacity. The adoption of new technologies could lead to the creation of new jobs arising from new tasks that emerge from these new technologies. The future of work will depend on the balance between labor replacing technologies and labor augmenting technologies particularly the emergence of new tasks at which humans have a comparative advantage.

Based on a 2019 survey[5] of manufacturing companies across the country, the Philippine manufacturing industry is still at a very low level of technology utilization with most companies still using manual and spreadsheet management or a standalone database management system with legacy applications. Technology utilization is measured in eight major manufacturing dimensions characterized by the following:

- Equipment maintenance: 44 percent have no maintenance system and repairs are carried out reactively
- Shopfloor visibility: 31 percent have shopfloor status pushed via scheduled report
- Quality: 35 percent control documents, connective and preventive action (CAPA) and data collection using paper-based approach; 35 percent use excel sheets but not integrated with manufacturing systems
- Cybersecurity: 46 percent have no established cybersecurity procedures and programs
- Manufacturing activity management: 53 percent control and track manufacturing activities manually through a paper-based system

[5] The survey of manufacturing companies' technology utilization was based on the Manufacturing Enterprise Solutions Associations (MESA) Smart Manufacturing Maturity Index focusing on eight dimensions covering the manufacturing process: 1) planning and scheduling; 2) manufacturing activity management; 3) equipment connectivity and data management; 4) material management and handling; 5) equipment maintenance; 6) shopfloor visibility; 7) quality; and 8) cyber security. Of 1,276 survey questionnaires sent out through email, 144 companies responded.

- Planning and scheduling: 31 percent start work orders based on demand and only 6 percent start work orders via an advanced planning and scheduling system interfaced with Manufacturing Execution System/predictive analytics
- Equipment connectivity and data management: 58 percent have no manufacturing equipment connected to the network
- Material management and handling: 44 percent have their raw materials pulled into the shopfloor via an unstructured request system (paper, email, verbal)

The highest technology utilization is in the areas of cybersecurity, quality, and manufacturing activity management. The lowest scores are in equipment maintenance and equipment connectivity and data management. Across the different manufacturing sectors, the highest technology utilization is in other non-metallic products, paper and paper products, computer, electronic and optical products, motor vehicles, and pharmaceutical products. The lowest technology utilization is in textile, leather, beverages, wearing apparel, repair and installation of machinery and equipment, and food products.

TABLE 6. Technology utilization in the Philippine manufacturing industry by firm size

	No Tech	Very Low	Low	High	Very High	Total
Micro	4	14	4	0	0	22
Small	2	28	18	3	2	53
Medium	0	8	8	1	0	17
Large	0	8	21	14	5	48
Total	6	58	51	18	7	140

Note: Levels: 0: purely manual; 1: with widespread management; 2: Stand-alone DB Management System with Legacy Applications; 3: Manufacturing Execution System (MES), and 4: MES + Industry 4.0 technologies like Industrial IoT, Big Data, Machine Learning, Robotics, and others

In terms of characteristics, firms that are large, with foreign equity, operate inside ecozones, and that are exporting have the highest technology utilization scores. Micro and small enterprises have the lowest technology utilization scores. In terms of geographic distribution, the highest technology utilization is still in the National Capital Region, Central Luzon, and CALABARZON which are the country's key economic centers contributing over 60 percent of the GDP. It is important to provide the necessary digital infrastructure and support to industries located in areas outside of these regions especially to micro, small and medium enterprises to ensure that the adoption of new technologies would not widen the digital divide in the country.

The results showed that the surveyed firms are open to adopting Industry 4.0 technologies. Seven out of ten micro enterprises and six out of ten small and medium enterprises are familiar with Industry 4.0. Their primary considerations for Industry 4.0 transformation are improvement in productivity and competitiveness, cost of investment and funding, innovation, and technological advancement. The firms perceive the following as barriers to adopting new technologies: financial capability, market conditions, and poor digital infrastructure. To overcome these barriers, firms are formulating their internal corporate strategies, studying prospective loan applications; and investing in research and development (R&D).

4. Transforming Philippine industries and enterprises

4.1. Major empirical findings: trade, productivity, innovation, and firm survival

Given the substantial trade liberalization that the Philippines carried out from the early 1980s till the 2000s, assessing the impact of trade on productivity is crucial in crafting the country's industrial policy. The theoretical literature on trade and productivity provides conflicting results on the impact of trade liberalization on productivity [Aldaba 2012a]. Trade liberalization can lead to productivity gains through increased competition, exit of inefficient firms and reallocation of market shares in favor of more efficient firms, increasing scale efficiency, or through learning by exporting effects. However, as Rodrik [1988,1992] argued, there are no reasons to believe that protection discourages productivity improvement. It is import liberalization that retards productivity growth by shrinking domestic sales and reducing incentives to invest in technological effort. Thus, whether liberalization really improves efficiency in less developed countries is ambiguous and has remained an empirical question.

Using Philippine micro data from 1996 to 2006, Aldaba [2012a] examined the impact of trade on productivity growth. In the presence of firm heterogeneity, the results provide some evidence that trade liberalization leads to productivity gains. Trade liberalization allows more productive firms to expand while less efficient firms either exit or shrink. Tariff reduction drives the process of restructuring and reshuffling of resources within and across sectors of the economy such that unprofitable activities contract while profitable ones expand. Epifani [2003] indicated that, in general, the productivity of firms exposed to international trade, i.e., exporters and import-competing firms, grows much more than that of firms in the non-traded sectors.

In a separate paper, Aldaba [2012b] assessed the impact of firm entry and exit in spurring a reallocation of resources across firms. Controlling for firm characteristics, the results showed that tariffs have a highly significant negative effect on firm exit suggesting that trade liberalization increases the probability of exit of a given firm. Moreover, firms with high productivity are more likely to survive as tariffs are reduced. This is consistent with the findings of Melitz [2003]

that trade liberalization induces the exit of less productive firms. Aldaba [2012b] also found that apart from high productivity, firm characteristics matter with larger, older, foreign-affiliated and export-oriented firms having a lower probability of exit.

Utilizing the same panel dataset, Aldaba [2020] examined the relationship between trade and innovation applying a two-stage approach where trade and innovation are linked via competition. The results show that trade liberalization has a significant positive impact on innovation through competition. A reduction in tariffs leads to an increase in competition due to the increase in the number of players in the domestic market. As competition increases, profits fall while the productivity threshold above which firms can profitably operate increases. This forces inefficient firms out of the market and resources are reallocated from exiting firms to the higher productivity surviving firms which innovate at a faster pace.

Aldaba [2020] indicated that despite the more than two decades of implementing liberalization policy, competition and productivity growth remained weak not only due to the presence of structural and behavioral barriers to entry, but also to the country's inadequate physical and institutional infrastructure. Due to the fundamental weakness of competition in many of the major economic sectors, the gains from liberalization remained limited which slowed down the growth of manufacturing.

Weak competition reduces the pressure on firms to adopt new technology or innovate, resulting in low growth of productivity and a loss of competitiveness. In an open market environment, the government should focus on designing an overall industrial policy and strategy that would ensure competition, innovation, and productivity growth of firms. At the same time, the strategy must implement programs to enable industries to face increased competition from imports and take advantage of opportunities such as bigger export markets and increased foreign direct investment flows. Other important determinants of innovation including human capital, infrastructure, institutional factors and other elements comprising the innovation ecosystem must be taken into consideration along with their interaction with trade policy reform indicators.

To increase the probability of survival in an open trade regime, government's industrial policy should be designed towards measures that would enhance firm productivity, link domestic parts manufacturers with multinational companies (MNCs) and attract more foreign direct investment [Aldaba 2020]. MNCs are an important source of international capital and technology, their entry can facilitate the transfer of technical and business know-how resulting in productivity gains and competitiveness among local firms. Furthermore, deepening linkages with MNCs' international production networks and global value chains would be important in increasing gains from trade.

Policies geared towards providing export assistance would also be necessary along with measures crafted to boost the survival of new entrants particularly small and medium enterprises (SMEs). Making small and medium manufacturers internationally competitive is a major challenge that would require government

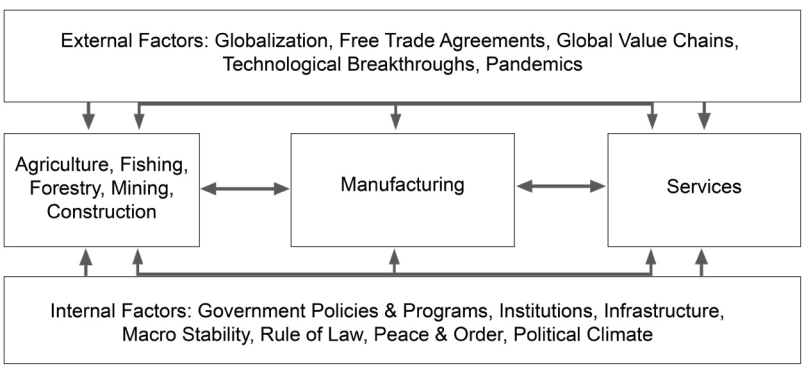
support and close coordination between government and industry. Addressing constraints preventing the growth of SMEs would also be crucial. These include financing issues like inadequate working capital, insufficient equity, difficulties of credit financing and prohibitively expensive credit cost.

Improving the technological capabilities and strengthening domestic supply chains are necessary to enable SMEs to move up the technology scale as well as to create and enhance existing linkages with global value chains (GVCs). Participation in regional/global value chains provides domestic firms not only access to export markets but to newer technologies as well. Leading MNCs provide their local affiliates and local suppliers with more rapid technological upgrading and greater attention to quality control, cost control and human resource development. Aldaba [2020] also highlighted the potential for SMEs, in light of rising globalization and increasing economic integration in East Asia, to be suppliers of outsourced parts and services and to provide the link to the export sector and/or GVCs, particularly in manufacturing sectors such as automotive, machinery, electronics, food and garments.

4.2. Comprehensive National Industrial Strategy (CNIS)

Overall, Philippine experience shows some evidence that increasing competition from trade liberalization could enhance both innovation and productivity. In light of the above empirical findings, the country's CNIS is underscored by the relationship between competition, innovation, and productivity. As Figure 5 shows, firms and industries operate in a market environment affected by external and internal factors. Meanwhile, firms and industries are connected through supply and production chains. The interplay of internal and external factors could affect firm or industry growth through the competition, innovation, and productivity channels. Any changes in these internal and external factors would affect the process of competition, innovation, and productivity which in turn determines the growth of industries.

FIGURE 5. Comprehensive National Industrial Strategy framework



Source: Aldaba [2014].

External factors include multilateral, bilateral, and regional trade agreements that bring about trade and investment liberalization. The international environment also encompasses globalization and GVCs which are forms of industrial organization particularly in industries like automotive, electronics, machinery, food and garments. New technologies such as AI, automation, robotics, machine learning, or IoT and pandemics can pose both risks and opportunities to firms and industries. The removal of trade and investment barriers through free trade agreements can provide opportunities such as bigger export markets and increased foreign direct investment flows. At the same time, the entry of competing imports or more competitive global players in the domestic market would increase competition which might pose risks to the survival of relatively smaller, less competitive and what used to be highly protected firms in the domestic economy.

Internal or domestic factors include macroeconomic conditions, political situation, peace and order, infrastructure, and government policies, regulations, and industry development programs. Within the domestic environment, there are industry-specific or internal factors affecting the growth and development of firms and industries. These include trade and investment policies such as tariffs and import restrictions, investment incentive measures like income tax holidays, tax and duty exemptions on imports, subsidies, grants, and soft loans along with human resource development, capability building and training support programs along with government regulations affecting the operations of firms and industries.

4.3. Key impediments preventing industry growth and development

Table 7 summarizes the most binding constraints preventing industry growth and entry of new activities. Firms continue to face major challenges such as poor infrastructure and logistics; lack of domestic raw material suppliers, parts and components; bureaucracy, red tape, policy inconsistency; and lack of highly skilled workers. Furthermore, manufacturers have continued to suffer from the unabated entry of smuggled and substandard products.

Broken linkages in the supply/value chain characterize Philippine industries. The lack of materials processing has severely affected the competitiveness of parts and supplies industries and hampered the ability of high-technology industries to move up the value chain. Due to weak backward linkages within the manufacturing industry, automotive and electronics have continued to rely on imported parts and remained at the assembly stage of the supply chain. The development of the domestic parts and suppliers would be crucial to deepen the firm and industry linkages within the economy.

TABLE 7. Summary of most binding constraints

Major area	Main bottlenecks
Infrastructure and logistics	High cost and unpredictability of power High cost of domestic shipping
Governance and regulation	Smuggling, corruption, bureaucracy and red tape Lack of streamlining/automation of interrelated business procedures
Small and medium enterprise development	Access to finance, weak absorptive capacity to technology and knowledge transfers, inability to comply with product standard regulations
Human resource development	Lack of skilled workers, skills-jobs mismatch
Low level of technology utilization	Most companies, MSMEs in particular, are still utilizing purely manual operations, spreadsheet management system or stand-alone data management system with legacy applications
Innovation and entrepreneurship	Fragmented innovation and entrepreneurship ecosystem, growing but still limited industry-academe linkages, low R&D expenditures
Supply/value chain gaps	Absence of raw materials (upstream); weak parts and components sector (mid-stream)
Weak domestic market expansion	Weak economies of scale due to limited domestic production and heavy dependence on imports

Source: Aldaba [2014].

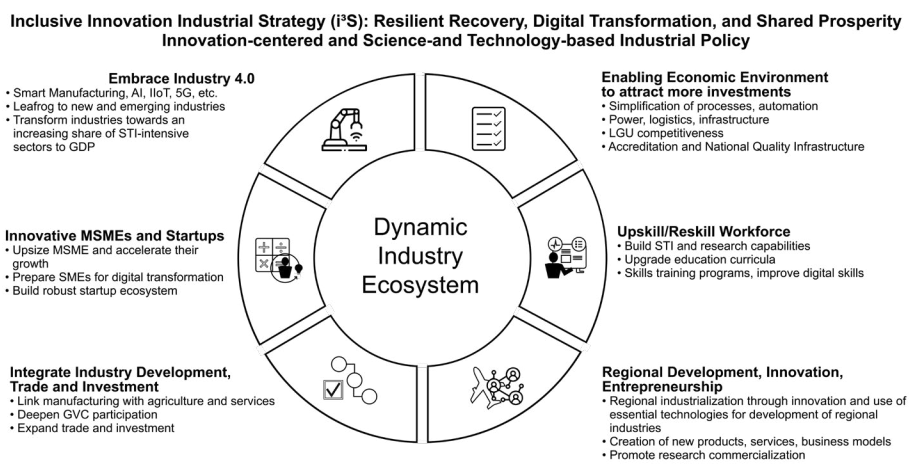
In the iron and steel industry, which is critical for the manufacture of parts and equipment, competitiveness issues have remained due to the high cost of raw materials apart from the high costs of power and logistics, smuggling and entry of sub-standard products. The local tool and die industry has to compete heavily against imported dies and molds while its backward linkages are weak due to the unavailability of most raw materials, equipment, and software. Special steels and castings, general and specialized metal machining equipment, and software are all imported. Though the country has natural resources that would provide important metals like iron and copper, there are no processing plants (capital-intensive blast furnace, steel making facility) to produce the form of metal that the industry requires. There is no reliable aluminum casting facility for molds used in molding large plastic components like refrigerator liners.

In the export-oriented copper industry, firms have hardly any linkage with the domestic economy. Copper ores are all exported and although the country has a copper smelting facility, it imports 100 percent of its copper ore requirements and exports 100 percent of its output due to the absence of a copper rod facility. Manufacturers of wiring harness, a major export product and user of copper rods, import all of their copper rod requirements.

4.4. Science, technology, and innovation (STI)-driven industrial strategy

To strengthen the competitiveness of Philippine industries and address the most binding constraints preventing their growth and development, the DTI has implemented an innovation-centered industrial policy through the i3S. This is a growth model where a modern industrial sector will play a key role in generating investment and employment. i3S has evolved into its current form known as science, technology, and innovation (STI)-driven strategy. Science and technology-driven innovation is at the heart of the new industrial policy. The vision is to grow globally competitive and innovative industries by transforming industries into a more dynamic industry ecosystem characterized by continuous innovation, collaboration, agility, and resilience. This would provide the foundation for industrial transformation that would generate quality jobs and investments, create new products and services, and drive sustainable and inclusive growth. With science and technology-driven innovation at the front and center of the country's strategic policies and programs, industries would be in a better position to face competition in both domestic and export markets. Innovation is crucial as the Philippines embraces automation, robotics, AI and other new technologies arising from Industry 4.0.

FIGURE 6. STI-driven industrial strategy pillars



Source: Pascual [2022].

The government and the private sector would collaborate towards the implementation of industry activities and programs to enhance the productivity of local firms and industries through innovation. While the private sector is seen as the major driver of growth, the government plays an important role in coordinating policies and necessary support measures to address the obstacles to the entry and growth of domestic firms. The government must create the right policy framework to encourage the development of the private sector along the

lines of the country's comparative advantage and industry priorities. These entail programs and policies to address the high cost of power, high cost of domestic shipping and logistics, inadequate infrastructure, and complex government rules and regulations affecting business operations. Equally important are more specific strategies for the development of human resources and skills training as well as creation of innovative startups and micro, small, and medium enterprises (MSMEs).

To achieve industrial transformation, the country's new STI-driven industrial policy focuses on embracing Industry 4.0, supporting digital transformation, and ensuring resilience and agility in production through advanced technologies. It integrates industrial policy with trade, investment, and innovation policies to address supply chain gaps and support new and emerging industries. The strategy emphasizes investing in human capital development, reskilling, and upskilling the workforce to meet future job demands. It fosters the growth of innovative startups and MSMEs by enhancing their access to finance, technology, and skilled workers and promoting collaboration and digitalization. Regional industrialization is encouraged through innovation and entrepreneurship, bridging gaps between academia and industry, and accelerating research commercialization. Finally, the strategy seeks to create a more enabling business environment by strengthening regulatory frameworks, improving infrastructure, attracting foreign investments, and providing targeted fiscal incentives (Annex A contains descriptions of more specific measures).

The major priorities for industry development focus on four major clusters. First, the industrial manufacturing and transportation (IMT) priorities include the auto industry, semiconductor manufacturing, electronic manufacturing services, and aerospace parts and aircraft maintenance. Second, the telecommunications, media, and technology (TMT) sector emphasizes the transformation of information technology and business process management (IT-BPM), creative industries, innovation and R&D, and the digital economy, with applications in smart and resilient technologies and vehicle tech. Third, the health and life sciences (HLF) priorities cover pharmaceuticals, biotechnology, medical devices, and digital health. Lastly, modern basic needs and resilient economy (MBNRE) activities target chemicals, integrated iron and steel, textile and garments, agriculture and agribusiness, infrastructure and logistics, and climate change and environment-friendly products and services. These clusters aim to drive sustainable growth, innovation, and resilience across the economy (see Annex B for the detailed list of activities).

5. Current initiatives, plans, and ways forward

The industrial policy debate in the country has gradually shifted from whether this is the correct development strategy to achieve the country's industrialization goal to discourses on the appropriate level of intervention and design of industrial policy programs. On the whole, there is an acceptance in government of the need for industrial policy for inclusive and sustainable industrialization and to achieve

this, a whole-of-government-and-society approach is crucial. To successfully develop an industry, government needs to play a facilitative role. As Lin [2011] pointed out, in starting a new industry, the government has a crucial role to play in providing or coordinating investments particularly in addressing the lack of necessary infrastructure and complementary inputs for attracting new industries.

The pandemic has accelerated the use of digital technologies and highlighted the crucial role of innovation in ensuring quick responses to the crisis along with business continuity, economic recovery, and worker protection. As the country prepares for the post pandemic future, implementing a new industrial policy is an imperative to build a more competitive economy. The country's post-pandemic industrial policy (a STI-driven strategy) focuses on building capacity, addressing the huge gaps in the supply and value chains, integrating production systems, and ensuring that the industrial recovery will not leave anyone behind. Through innovation and use of essential digital technologies, the country's strategy identified priority industries to foster industrial development. It also prioritizes improving support for MSMEs and startups, human resource development and capacity building, regional industrialization, and creating an enabling environment for business, especially investments in digital and health infrastructure.

The integration of the country's production systems requires efficient supply and value chains that interconnect manufacturing, agriculture, and services to drive structural change and enhance industrial competitiveness. Agricultural development is necessary in order to transform regional economies from traditional agriculture to more modern agribusiness. Meanwhile, the services sector, which provides direct inputs to economic activities, plays a vital role in linking value chain activities together. Manufacturing, agriculture, and services must be integrated, strengthened, and developed to enable the country to pursue a more advanced and balanced industrial structure. To achieve this, the country's STI-driven industrial policy should focus on the following imperatives:

- Accumulation of investments and STI capabilities through the adoption of new technologies and advanced digital production; investment in innovation infrastructure and R&D; and building new and future skills along with research capacity of the workforce to increase productivity and production efficiency.
- Transformation of industries towards an increasing share of STI-intensive sectors to GDP through the adoption of Industry 4.0 technologies, clean and efficient production, and integration of production systems that would lead to new jobs, new economic activities, income opportunities, and higher GDP.

Drawing from the insights and empirical findings on the relationship of trade, competition, innovation and productivity, the following measures are proposed to be integrated into the new industrial policy to bring the Philippines closer to a better future through inclusive and sustainable industrial transformation.

5.1. Transformation from manufacturing to "mindfacturing:"[6] a new pathway

The STI-driven industrial policy should consider the current metamorphosis of the manufacturing industry which is being fueled by three major factors. First, today's manufacturing industry is no longer powered by gears and machines alone, but rather by new production techniques using new technologies which change the industry's long-standing traditional processes and business models. Second, it is increasingly becoming evident that industrial development is not centered on the growth of manufacturing industry alone, but rather on its convergence not only with services but also with other industries, amplifying the importance of strengthening collaboration and linkages across sectors and tapping new sources of value, growth, and employment. Lastly, the world is entering an age where the significance of creativity, innovation, and the human intellect is ever-expanding in a modern manufacturing ecosystem. Hence, manufacturing is expected to evolve towards integrating more intellectual work which highlights physical goods that increasingly rely on knowledge and creative outputs like biotechnology, renewable energy, and R&D outputs like patents and hybrids that combine physical goods and services such as tech companies producing both hardware and software. As the new industrial policy focuses on harnessing Filipino ingenuity, creativity, and innovativeness to drive industrial development and economic growth, articulating mindfacturing in the country's strategy and priorities would be an important pathway to pursue.

5.2. Alignment of the Strategic Investment Priority Plan of the Corporate Recovery and Tax Incentives for Enterprises (CREATE) Act with the STI-driven industrial policy and making CREATE a driver for Philippine industrialization and recovery

The CREATE Act reduced the corporate income tax rate from 30 percent to 25 percent for large companies and to 20 percent for small and medium enterprises. Incentives were harmonized across the different investment promotion regimes granting income tax holidays from four to seven years, five percent special corporate income tax rate based on gross income earned from five to ten years, and enhanced deductions such as depreciation allowance, labor expense, R&D expenditures, training expenses and domestic input expenses, among others. The CREATE Act also empowers the President to modify the mix, period or manner

[6] Mindfacturing refers to the seamlesss integration of intellectual capabilities and advanced technologies to transform the manufacturing landscape towards more agile and adaptive processes to drive innovation, efficiency, and customization across various industries. Examples include the use of 3D printing technology to create tissues and organ prototypes for medical research and potential future transplants; use of AI to analyze genetic data and develop personalized treatment plans; use of digital twins and IoT to create a virtual replica of a company's manufacturing process; and use of robotic systems and AI to produce custom footwear on demand with customers designing and sending design specifications directly to automated factories for production.

of availing incentives and to craft financial support package for highly desirable projects based on a sustainable development plan, inclusive business approach, high level of sophistication, and innovation.

With close coordination among government agencies and alignment of priority industries with the new industrial policy, CREATE could serve as tool to drive the country's recovery and industrialization. CREATE incentives could help develop industries with existing, emerging and latent comparative advantage; integrate production systems and link manufacturing, agriculture, and services; deepen and upgrade GVC participation, and enable digital transformation. Through time-bound, performance-based, and transparent incentives, CREATE could address market failures, prepare industries as they adopt Industry 4.0 technologies, create more innovative industries, generate spillover effects, support innovative MSMEs and integrate them in GVCs, and foster competitive industries particularly in the regions.

5.3. Acceleration of digital industrial transformation

Digital transformation is a journey towards embracing a culture of innovation in all facets of production involving people, technology, and organization. The drive towards digital transformation would lead to more innovation and application of new technologies in addressing social, economic, environment, and health problems. Smart technologies applied to agriculture or manufacturing could result in more efficient, productive, and resilient production. The adoption of Industry 4.0 technologies can make industries more efficient and scalable and leapfrog to inclusive, resilient, and sustainable industrialization.

New technologies like AI are here to create new jobs and change what work looks like, augment human intelligence and skills and make workplaces safer. The wide use of AI represents a big window of opportunity for the Philippines to leverage on existing comparative advantage especially in the global IT-BPM sector and expand to key international AI markets in the future. AI can address development issues leading to the creation of innovative goods and services to finally eradicate poverty. AI can provide solutions to problems and challenges faced by MSMEs, large enterprises, including government agencies.

One of the most recent initiatives of the DTI is the Artificial Intelligence Roadmap which focuses on uplifting the lives of the Filipino people, industries and the economy, and making the Philippines an AI center of excellence. AI adoption can enable the country to tap vast opportunities to help maintain the regional and global competitiveness of industries, prepare the future workforce for the jobs of the future, and attract the AI R&D of multinational and big tech companies to locate in the Philippines.

To accelerate innovation and MSME digitalization, one of the major recommendations of the roadmap is the establishment of a Center for AI Research. The plan is to make the AI Center a public-private partnership that would serve as hub for data scientists and researchers to perform collaborative AI R&D,

consultancy services, create AI tech products, conduct data literacy programs, and attract leading global firms to set up their R&D activities in the country. The Center would focus on key areas utilizing AI such as precision farming to improve the productivity of the agriculture sector, smart manufacturing, healthcare services, AI-powered business process outsourcing, cybersecurity, and resilient technology.

Other Industry 4.0 initiatives are geared towards supporting firms and industries shift to industry transformation. The DTI is also planning to build an Industry 4.0 pilot factory to serve as platform for a collaborative learning environment to teach and demonstrate Industry 4.0 management and production technology (robots, automation, IoT, smart factory), R&D and prototyping for companies especially MSMEs, universities and researchers and co-maker and co-working space.

To implement these Industry 4.0 plans, a more permanent budget is necessary to sustain government digital transformation efforts for industrial change and development. The recently legislated Tatak Pinoy Act which institutionalized the country's industrial policy along with the Philippine Creative Industry Development Act provide the legal framework, including sustainable financing, for the development of priority industries that could pave the way for industrial development.

5.4. Implementation of the Philippine Industry Skills Framework to prepare the workforce for the jobs of the future

While many jobs will be lost as a result of automation, new jobs will emerge through the adoption of technologies that will increase worker productivity. Tapping these benefits will require increasing investments in skills development along with greater efforts by companies to upskill their workforce to perform new and higher order roles complementary with machines. Current systems of learning and signaling job-fit do not provide the agility that lifelong learners will require. Shifting to a skills-based system can not only provide more efficient mechanisms by which employers can identify the talent they need for business to flourish but can also create fairer labor markets where individuals are able to rapidly transition between roles, have greater access to learning opportunities, and be matched to employment through unbiased and skills-based evaluation.

In 2021, the DTI launched the Philippine Skills Framework, a new initiative which serves as a common reference or language that employers and workers share in order to ensure the match between jobs and skills. The skills framework describes the skills, knowledge and competencies required in different jobs. It also provides sectoral information, occupations/jobs and roles, skills description, career pathways, and training programs needed. Using the skills framework, employers can identify the necessary skills and competencies while job seekers are able to define ways forward or upward in a particular industry. For educational institutions, the framework is used to revise existing curricula and design new

courses to bridge the skills and competencies of the workers as they upgrade to desired occupations. Among the priority sectors for the development of the skills frameworks are manufacturing, construction, logistics and supply chain, health and wellness, food and agriculture, creatives, tourism, and IT-BPM.

5.5. Support for the development and scale-up of innovative startups and MSMEs

Start-ups have emerged as key drivers of economic recovery, inclusive and sustainable growth, and job creation. Startups are also seen as catalysts for disruptive innovation. To accelerate the growth of the Philippine tech startup ecosystem, the DTI is implementing four major strategies: (i) growing the number of startups through a larger, more coordinated ecosystem and promotion of technology entrepreneurship; (ii) increasing early stage funding by attracting more private angels and angel investors[7] in the Philippines and the implementation of a fund of funds program to support early stage financing; (iii) building startup quality by strengthening founder know-how, deepening market reach, and increasing talent quality; and (iv) expanding global connectedness by engaging with foreign partners by connecting the Philippine startup ecosystem with other global ecosystems through investment and knowledge exchange programs among angel investors, venture capitalists, startup founders and enablers from other countries.

To help startups grow and scale up their business operations, the DTI is implementing three major startup programs: the Incubation, Development and Entrepreneurship (IDEA) Program for startups with minimum viable products and Acceleration, Valuation, and Corporate Entrepreneurship (ADVANCE) Program for startups that are in their commercialization stages, and a Global Acceleration Program (GAP) to immerse and expose Philippine startups to the global ecosystem and enable them to pursue global business development and raise funds.

5.6. Building Regional Inclusive Innovation Centers (RIICs) all over the country

With the innovation focus of the new industrial policy, the DTI, in collaboration with other government agencies, is building RIICs which serve as innovation networks or platforms linking together the different stakeholders in the innovation and entrepreneurship ecosystems towards market-oriented research that addresses societal issues and industry problems. The stakeholders include startups, spinoffs, and MSMEs with other stakeholders such as universities, funders, R&D and S&T parks, accelerators and incubators, government, and other services providers. They will be nurtured by the collaboration of government, industry, and education/academia through policies, programs and projects that continuously develop human capital, ensure access to funding and other sources of financing, and provide the needed support mechanisms and services to accelerate the commercialization of research.

[7] Angel investors are private investors that provide initial financing for small business ventures using their own funds in exchange for an equity stake.

Pilot RIICs were established in 2019 in Cebu, Davao, Legaspi, and Cagayan de Oro. Four more RIICs were added in 2021 covering Zamboanga, Batangas, Tuguegarao, Cagayan, and Central Luzon. There are currently 13 RIICs located across different regions in the country. In the near future, the RIICs which are seen as the linchpin of the country's new industrial policy, will drive regional development and economic transformation leading to new investments, job generation, higher incomes, improved quality of life, and shared prosperity for the Filipino people.

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Annex A: Strategic pillars of the Philippine STI-driven industrial policy[8]

Embrace Industry 4.0 to enable industrial transformation and leapfrog to inclusive and sustainable industrial development

- Support industries' shift towards digital transformation and craft and implement people-centered digital transformation plans and programs with focus on inclusive growth.
- Design support measures and programs to help firms increase resilience and become more agile in production and supply systems enabled by advanced technology and automated processes.
- Ensure that the digital and future skills demanded by companies and industries would be sufficiently provided and would enable all people at every level of society to participate in building an innovative and creative future.

Integrate industrial policy with trade, investment, and innovation policies

- Craft industry programs to address gaps and linkages in domestic supply and value chains by linking services activities such as design, R&D, engineering, IT and digital services, marketing, financing, and after-sales with manufacturing, agriculture, and other sectors.
- Support the growth of new industries and activities to bridge gaps in the supply and value chains of industries like copper, nickel, iron and steel, electronics, automotive, manufactured parts and components, textile, agricultural crops, and processed food.
- Expand government support to new and emerging industries to increase their domestic market base; help them attain economies of scale and realize their export potential and deepen participation in global value chains.

Increase investment in human capital development and workers' reskilling and upskilling

- Design human resource development and training programs to improve skills and establish tie-ups with universities and training institutions.
- Develop skills framework to identify the skills and competencies needed to address jobs-skills mismatch, prepare the workforce for the jobs of the future, and ensure that the skills demanded by companies would be sufficiently provided

Foster the growth and development of innovative startups and MSMEs

- Support the expansion of production capacities and digitalization of MSMEs.
- Enhance MSME programs to improve their access to finance, technology, and skilled workers.

[8] See Pascual [2022].

- Accelerate innovation and MSME digital transformation, link MSMEs with startups especially those that could help address their digital challenges, and connect MSMEs as well as with large domestic enterprises and multinationals; promote inter-firm and academe collaboration.
- Establish common service facilities and support for efficient storage and logistics services.
- Support startup growth and development by crafting and implementing programs to build the startup ecosystem, create common understanding on the startup journey and ecosystem development among government agencies towards the alignment and harmonization of startup policies and programs, provide strong focus on promoting innovation and entrepreneurship, and create a more enabling business environment for startups and allow more foreign participation.

Promote regional industrialization through innovation and entrepreneurship

- Establish inclusive innovation centers to bridge the gaps between academe and industry.
- Accelerate commercialization of market-oriented research, equip universities to carry out research relevant to industries, promote intellectual property protection.
- Provide R&D incentives like tax credit, accelerated depreciation, and innovation spaces to serve as networking hubs and R&D shared facilities for rapid prototyping and demonstration.

Create a more enabling business environment

- Continue to strengthen the institutional and regulatory framework by addressing smuggling and eliminate bureaucratic red tape by streamlining and automation of government procedures and regulations.
- Strengthen mechanism for coordinating business registration, application for permits and licenses, and investment promotion with local government units and other national government agencies.
- Scale up investments in digital infrastructure and improve investments in building other physical infrastructure like roads, power, logistics, modern and efficient air and sea infrastructure, including education and heath infrastructure.
- Implement aggressive promotion and marketing programs to attract more foreign direct investments especially those that would bring in new technologies.
- Address market failures by providing fiscal incentives that are well-targeted, performance-based, transparent, and time bound.
- Promote the establishment of domestic ecozones that would allow activities catering to both domestic and export markets.

Annex B: Priority clusters for industrial transformation

In terms of the priority sectors, the following industry clusters have been identified for development:

Industry clusters identified for development

Cluster	Priorities
Industrial Manufacturing and Transportation	• Auto and auto parts: auto electronics, advanced driver assistance systems (ADAS) components, engineering services outsourcing, electric motor powertrains like battery, public utility vehicles, electric vehicles • Semiconductor manufacturing service: integrated circuit (IC) design, R&D, wafer fabrication • Electronic manufacturing services: auto electronics, aerospace electronics, consumer electronics, medical devices, telecommunications equipment, power storage • Aerospace parts and aircraft maintenance, repair and overhaul (MRO): flight control actuation systems, servo actuators, servo valves, galley inserts, structures and equipment, seat parts, lavatories, interior fit-out, panel assembly, electronics, airframes and sub-assemblies; MRO base and line maintenance
Telecommunications, Media, and Technology	• IT-BPM: activities to support the Philippine IT-BPM's transformation from voice-enabled and linear customer support services to complex, digitized, end-to-end customer experience (CX) services consisting of complex services business process outsourcing (BPO), knowledge process outsourcing in health, medical, financial, and legal services; animation, game development; engineering services outsourcing (ESO), software development, shared services, data analytics, legal process outsourcing, health information management (preventive health, remote), IT services, global-in-house, services embedded in manufacturing • Creative industries: traditional and cultural expressions (arts, crafts, festivals, celebrations), cultural sites, visual arts, performing arts, publishing and printed media, audiovisuals, design, new media (digital animation, game development, software development) and other creative services • Innovation and R&D activities: commercialization of registered intellectual property products, R&D centers, adoption of innovative processes such as smart manufacturing or predictive agriculture • Digital economy: new products or solutions using digital technologies like artificial intelligence, robotics, augmented reality, virtual reality, mixed reality, 5G connectivity, Internet of Things (IoT) ◦ Smart technology: applications in buildings, homes, factories, agriculture, cities, interconnected products and services, voice assistants embedded in TV sets, cars home appliances, smart home devices, home robots ◦ Resilient technology: disaster preparedness/mitigation, cyber security, renewable energy ◦ Vehicle technology: flying cars, self-driving cars, multimodal transportation, electric vehicles (EV) ◦ Audio, video, education technology ◦ E-gaming: console and pc gaming software, mobile gaming; immersive audio and advanced communication capabilities; cloud gaming platforms; gaming accessories

Industry clusters identified for development (continued)

Cluster	Priorities
Health and Life Sciences	• Pharmaceuticals, life sciences, and biotechnology • Medical devices and digital health: personal health wellness technology products, smart watches, lighter health wearables, more precise sensors, therapeutic systems addressing chronic diseases, telemedicine solutions and AI-assisted diagnoses
Modern Basic Needs and Activities to Promote a More Resilient Economy	• Chemicals: petrochemicals, acyclic alcohols and derivatives, metallic salts and peroxyl salts of inorganic acids, cyclic hydrocarbons, oleo chemicals • Iron and steel, tool and die: integrated iron and steel • Integrated textile and garments: design, textiles using natural fibers and locally available materials • Agriculture and agribusiness: coffee, cacao, coconut, fruits and nuts, tropical fibers, rubber and other high value crops • Infrastructure and logistics: roads, railways, bridges, ports, airports, land, air, and water transport construction and services, warehousing and support facilities for logistics; energy, hospitals and other health facilities, education, testing laboratories, low-cost housing, digital infrastructure • Climate change and environment-friendly products and services: goods and services that improve the quality of life while minimizing the use of resources and inputs including energy and the emissions of pollutants and wastes

Source: Pascual [2022].

The Philippine Economic Society

Founded 1961

The Philippine Economic Society (PES) was established in August 1962 as a nonstock, nonprofit professional organization of economists.

Over the years, the PES has served as one of the strongest networks of economists in the academe, government, and business sector.

Recognized in the international community of professional economic associations and a founding member of the Federation of ASEAN Economic Associations (FAEA), the PES continuously provides a venue for open and free discussions of a wide range of policy issues through its conference and symposia.

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